IAEE Energy Forum

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International Association for Energy Economics

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INTERNATIONAL ASSOCIATION for ENERGY ECONOMICS

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Editor: David L. Williams

President's Message

Dear fellow members of IAEE,

This year we are hosting our 40th International Conference in Singapore, June 18th – 21st, marking the 40th anniversary of the time a group of visionary energy experts in Washington, Boston, and Cambridge (UK) joined to create this wonderful organization. Our International Association for Energy Economics (IAEE) has grown steadily, and today it has more than 4100 members in over 100 countries with 30 regional affiliates. Each year IAEE holds an international conference, and through its affiliates, regional conferences. IAEE publishes two leading journals in the field, *The Energy Journal* published since 1980 and *The Economics of Energy & Environmental Policy* since 2012, and a newsletter, *The Energy Forum*, since 1985. During all these years, IAEE has been an open platform for communication and knowledge among those interested in energy economics, bringing together industry professionals, government officials, academia, students and the press, and has been an important contributor to the understanding of the economics underlying all energy issues. As we celebrate 40 years since the first seed of IAEE was planted, we pay tribute and offer sincere gratitude to IAEE's founding fathers, and to all those who have served and contributed to the success of this remarkable organization, known as the IAEE family.

Since those first days, many things have changed. World population has reached 7.4 billion, and 1.6 billion more are expected by 2040. Further, in the last decade and early in this one, we have seen a decline in the number of people living in extreme poverty, dropping from 1.8 billion in 1990 to 836 million in 2015. However, and regrettably, 1.2 billion people still don't have access to electricity, and 2.8 billion rely on wood or other biomass to cook and heat their homes. Future economic growth is expected to increase energy demand as well: energy demand is projected to increase almost 50% by 2040, mostly in non-OECD countries. This will require more than US $40 trillion in energy investments by 2040, enough only to achieve the necessary incremental energy supply, close the gap in energy access and fuel economic development. An additional investment of US $20 trillion will optimize the use of this new energy through energy efficiency (EE) measures. Without affordable energy sources, it will be difficult to close the gap in energy access and to promote sustainable economic development.

To bring in this needed investment, many economies face the challenge of improving their energy institutions and regulatory regimes. This is an area where there is a lot of opportunity for improvement, and where, worldwide, we see a wide diversity of business models in the energy sector, with different roles being assigned to the State and the private sector; and different practice levels in the pricing of energy services, energy subsidies, the rule of law, the exercise of property rights, the design and grant-

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President's Message (continued from page 1)

ing of operating and concession contracts, and the fiscal impact of resource rents and the management of sovereign wealth funds. Governance of the energy sector is therefore a big issue. In developing countries, especially, the institutional part needs to be better understood, as well as how to implement governance reforms. In addition, there is a need to determine the kind of incentives and mechanisms that should be set in place to integrate more private capital in the energy industry, in the production and distribution of energy.

The financial, economic and technical challenges faced by the energy sector are surrounded by the political environment, by an increasingly demanding civil society, and by the natural environment, including questions of sustainable development, GHG emissions and the links with climate change. There is a clear need to further advance our knowledge of mitigating the impacts the different energy projects have on the environment, locally and globally. Improving the engagement within energy developers, local communities, the Civil Society, and special interest groups is needed. Finding new approaches to enable energy projects that benefit both current and future generations are challenges of increasing complexity. The granting of proper concession and/or operating contracts, under a regulatory regime that allows the transformation of energy rents into wealth while protecting them from capture by interest groups is an issue. And at times, as is well known in the oil industry, the biggest risks are over the ground and not under the ground.

As we have observed in recent years, technological innovation is one of the biggest drivers of the change in the energy markets, and it is expected to stay so. Today, access to non-conventional fossil fuels (NC) and renewables (RE) are the result of game-changing technological innovations, uncovering energy resources that a few decades ago were uneconomic if not unknown. Today we see more energy sources than were foreseen 20 years ago, in fossil fuels (FF) and renewables, and there are challenges to better understand the role that nuclear energy can play in the future energy mix. We need to improve our economic knowledge of how these energy sources compare with conventional energy sources (CE) for different environments, where issues of intermittency and energy security are part of the equation. An ongoing issue is identifying the proper and efficient incentive mechanisms that should be put in place for an efficient deployment of RE and the development of NC. If these resources are put to work in a smart, efficient and sustainable way, the international community has a great opportunity to develop an efficient, affordable and sustainable energy system. There are great complementarities within the different energy sources, but the big challenge in many regions is to strengthen energy integration in a manner that does not jeopardize energy security.

The transmission grid allows the transportation of electricity from power plants located at far distances, but transmission also is an important enabler of new energy projects, and in many cases energy investment lags because of the deficient electricity transmission infrastructure. And, for many economies, the lack of suitable institutions, planning, and pricing schemes to enable a timely and efficient expansion of the transmission grid and other energy infrastructure, such as pipelines, has not been solved. While, in other economies, the questions today are on the design of smart systems to take advantage of new technologies, and the greater interaction that it is expected between producers and consumers. Also, there is a recent trend, where small producers, even households or small companies, can sell electricity surpluses as distributed generators (net billing and net metering schemes). This is putting pressure on the standard electric utility` business model, raising questions regarding the role of the grid and who, and how to pay for it.

Worldwide we not only need more energy and to harness properly the different energy resources, CE, NC and RE, but also, we need to learn how doing more with less, in a more sustainable way. Some major improvements have been achieved, such as in transport, which uses more than 50% of the oil, where we are seeing big changes in automotive performance, measured in miles per gallon, or the increasing fleet of electric vehicles, reducing our need of oil while increasing our need for power generation. Also, no more than a few decades ago a few countries started to look at energy efficiency as an additional source of energy. This is an area where most economies lag as it is not clear what are the best practices, as applied, in some of the more advanced economies. The promotion of EE programs in productive and commercial activities, and at the household level, are a key part of the do-list for many economies.

As highlighted by the previous examples, the world faces a wide set of challenges in the energy sector. IAEE has played an important role in the past, and we expect that as population and economic growth continues, and technology enables new energy sources while others are depleted, the role of IAEE will be increasingly important as an open forum for economic ideas in the search for better solutions for the energy sector.

Finally, allow me to thank all those who have contributed to the great success of IAEE, past presidents, former council members, and those whose term in the Council ended last year, Omowumi Iledare, Jurgis Vilemas, Christophe Bonnery, Lori Smith Schell, Anthony D. Owen, Gerardo Ariel Rabinovich, James Smith, Lisa Marina Koch. Let me thank too, for a demanding and committed work, the editors of our Journals, Adonis Yatchew and Christian von Hirschhausen, and their editorial boards; our Executive Director, David Williams, and his staff; and our General Counsel, John W. Jimison. But, overall, I want to thank you as IAEE members, because you are the ones who give life to this Association, sharing your analyses and research, participating in the different activities we have, and creating a unique environment for the exchange of ideas and networking on the topics of energy economics. You are the ones that make us in the Council eager to determine how to serve you better, serve better the purposes of this association, and promote its further development in an environment that every day brings forth new challenges. I invite you to actively participate in the activities that IAEE has prepared for you during this year, to stay alert to the news, information and our publications, let us know how we can improve our work, and, above all, continue to generate your own contributions to our great communal effort to understand the economics of energy.

Lastly, let me express my appreciation and gratitude to each of you for the vote of trust that you gave me to lead this organization in 2017, certainly a great privilege and honor for me.

Ricardo Raineri Bernain

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International Association for Energy Economics

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

In late summer of last year IAEE held a very successful regional conference in Baku, Azerbaijan. We include a number of the papers presented there in this issue. In addition, a detailed report on the North American Conference held last fall is also included.

Yoshiki Ogawa analyzes PV and battery connections in the commercial and residential sectors to determine the most optimum. The target of zero purchased electricity is inefficient; the balance between purchased and sold PV electricity is crucial. The balancing between economics and battery capacity is also important. The cost reduction of batteries is indispensable.

Thomas Geissmann notes that the question of the economic viability of nuclear energy in today's increasingly liberalized western energy markets has not yet reached a consensus in the energy community. The estimation of a power project's economic viability by calculating the levelized cost of energy (LCOE) is a fundamental initial instrument for investment decisions. He sets forth a novel approach to calculate the LCOE using a probabilistic model that accounts for endogenous input parameters. The approach is applied to the example of a nuclear power project. Monte Carlo simulation results show that correlation in input parameters has a significant effect on the model outcome. By controlling for endogeneity, a statistically significant difference in the mean LCOE estimate and a change in the order of input leverages is observed.

Zauresh Atakhanova and **Peter Howie** discuss Kazakhstan's growing household coal use noting that reducing this requires reforming energy subsidies, incentivizing weatherization, and developing renewables. They estimate the effects of increasing coal prices and growing income on household coal demand.

Robert Brooks addresses the question whether it is possible to compensate for loss of Russian gas pipeline exports through Ukraine to Europe with the currently envisioned new gas pipeline and LNG import projects, with particular emphasis on gas sourced from the Caspian region.

Ulrike Lehr, Anke Mönnig, Rachel Zaken and **Edi Bet-Hazadi** illustrate the economic effects of increasing energy efficiency in Israel. Applying a macro-driven Input-Output-Model, the economic implications under three scenarios are simulated: a baseline, business-as-usual scenario and two efficiency scenarios. The effects of the efficiency scenarios on GDP and employment are positive.

Aiymgul Kerimray, Rocco De Miglio, Luis Rojas-Solórzano, and **Brian Ó Gallachóir** review residential energy consumption trends in Kazakhstan. Thye discuss the energy efficiency potential in buildings as well as the incidence of energy poverty across the regions of the country.

Brantley Liddle models energy demand at several different levels of aggregation by analyzing U.S. state-based panel data. Nonlinear relationships between energy consumption and income and possible asymmetric relationships with respect to income growth and price are considered as well.

Hongbo Duan, Jianlei Mo, Ying Fan and **Shouyang Wang** posit that without taking any further policy measures, it is almost impossible for China to peak its carbon emissions in 2030, and the probability of carbon emissions peaking does not reach 50% until 2040. They discuss the effect of a subsidy policy for renewables and a carbon tax policy each separately and then together and conclude that the policy mix of carbon tax and renewable energy subsidy is more effective.

Nathaniel Babajide notes that given the Caspian region is an important net oil exporting area, it is highly vulnerable to oil shocks, and the consequent impact on economic growth and competitiveness of member economies. His studies show that diversification of foreign earning sources is essential for meaningful economic and energy security amongst the region's economies. In addition, a large investment in renewable energy technologies (wind, solar, hydro and biomass) is required to reduce the Caspian's heavy dependence on oil.

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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				
April 3-5	6th ELAEE Conference *New Energy Landscape: Challenges For Latin America*	Rio de Janeiro	ALADEE	Luciano Losekann luciano.dias.losekann@gmail.com
April 23-25	10th NAEE/IAEE International Conference *Theme to be Announced*	Abuja, Nigeria	NAEE	Wumi Iledar wumi.iledare@yahoo.com
June 18-21	40th IAEE International Conference *Meeting the Energy Demands of Emerging Economic Powers: Implications for Energy And Environmental Markets*	Singapore	OAEE/IAEE	Tony Owen esiadow@nus.edu.sg
September 3-6	15th IAEE European Conference *Heading Towards Sustainability Energy Systems: by Evolution or Revolution?*	Vienna, Austria	AAEE/IAEE	Reinhard Haas haas@eeg.tuwien.ac.at
November 12-16	35th USAEE/IAEE North American Conference *Riding the Energy Cycles*	Houston, TX, USA	USAEE	David Williams usaee@usaee.org
2018				
June 10-13	41st IAEE International Conference *Security of Supply, Sustainability and Affordability: Assessing the Trade-offs Of Energy Policy*	Groningen, The Netherlands	BAEE/IAEE	Machiel Mulder machiel.mulder@rug.nl
September 19-21	12th BIEE Academic Conference *Theme to be Announced*	Oxford, UK	BIEE	BIEE Administration *conference @biee.org*
2019				
May 26-29	42nd IAEE International Conference *Local Energy, Global Markets*	Montreal, Canada	CAEE/IAEE	Pierre-Olivier Pineau *pierre-olivier.pineau@hec.ca*
August 25-28	16th IAEE European Conference *Energy Challenges for the Next Decade: The Way Ahead Towards a Competitive, Secure and Sustainable Energy System*	Ljubljana, Slovenia	SAEE/IAEE	Nevenka Hrovatin *nevenka.hrovatin@ef.uni-lj.si*

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Scenes From the 1st IAEE Eurasian Conference August 28-31, 2016









IAEE Baku Conference Summary

Editor's note: We're pleased to have British journalist and energy analyst, John Roberts, do the summry of the Baku conference for us.

How do you cover the plethora of energy issues that link China to the European Union and Russia to the Middle East and OPEC? In a sense, that was the scope of the first Eurasian Conference of the International Association for Energy Economics held in Baku from 28-30 August 2016. But it was not so much the geographical range of the conference organizers' ambitions so much as the universal approach adopted by so many of the 60-odd speakers and panel chairmen as they tackled climate change, emissions reduction and the role of renewables alongside such well trodden paths as revenue management, market regulation, energy security and oil price volatility.

Time and again the presenters would use examples from their own countries or regions to make far broader points. And time and again participants from the host country, Azerbaijan, would bring the subject back to the key energy issue facing the country: the development of its gas sector and its plans to secure a major stake in European markets.

Yet Azerbaijani officials took great pains to stress their country's role in both regional and global energy issues. "Azerbaijan should benefit from the real opportunity that energy resources should bring to many countries and play a role as a crucial bridge between Europe and Asia," said Deputy Minister of Energy Natiq Abbasov in his keynote address.

What's more, while Abbasov is a minister in a government largely dependent on income from hydrocarbon exports, he also had some very pertinent things to say about other energy issues, notably the need to promote energy efficiency. "Many countries see energy efficiency as a priority. It's quite feasible and effective way to rebrand the economy." However, in Azerbaijan, "unfortunately, the abundance of energy resources has overshadowed issue of efficiency. Efficiency should be increased."

Naturally Abbasov focused on is country's role in providing the core resource for the massive $40 bn string of projects known as the Southern Gas Corridor (SGC) which from 2018 will carry 6 bcm/y of Azerbaijani gas to Turkey and from 2020 onwards a further 10 bcm/y to the European Union via Greece, Albania and Italy. In particular, he saw the construction of one of the SGC's most important elements, the 1,850-km Trans-Anatolian pipeline (TANAP), as the development of a key piece of infrastructure that might some day enable Iranian and Iraqi gas to access European markets.

Naturally the SGC, for which Azerbaijan's own state oil company is responsible for raising roughly more than a quarter of total costs, was the subject of several presentations. Azerbaijan's most eminent geologist, the veteran First SOCAR First Vice President Khoshbakht Yusifzade, focused on the array of fields that Azerbaijan was in a position to develop in order to contribute a second wave of gas for inputting into an expanded SGC, not least through the early development of the offshore Absheron field by France's Total, for which a development programme is currently being prepared. And while Yusifzade tempered his enthusiastic approach by noting that there was a problem with the availability of rigs for both exploration and production, his natural ebullience came to the fore as he indicated that Turkmen gas might also enter the system via a linkup with Azerbaijan's own infrastructure. "We have pipelines stretching to the middle of the Caspian Sea which are at a small distance from Turkmenistan," Yusifzade said.

A somewhat more cautious approach came from the noted Azerbaijani energy scholar, Gulmira Rzayeva, a research fellow at the Oxford Institute for Energy Studies. In a panel on Unlocking Caspian Energy Potential, Ms Rzayeva considered that the current low price environment meant one should be careful about anticipating just when some of the next wave of Azerbaijani fields might actually come on line. From a broader perspective, British energy analyst John Roberts, in a presentation on the limits of economics, noted the political obstacles that had to be overcome if other countries were to be able to join Azerbaijan in fuelling the SGC. These ranged from Turkmenistan's dependence on China to boundary disputes in the Eastern Mediterranean and Russia's plans for its Turkish Stream pipeline and the question of whether it might seek to pre-empt some of the available capacity in the SGC to the possibility that internal discord in Turkey could cause major problems for transit pipelines and thus for European energy security. Addressing the question of just what constituted Europe's optimal energy infrastructure, Philipp Hauser of Dresden Technical University, asked: "Is Turkey a reliable partner? Or will be we dependent in Europe on Turkish politics or on Russian politics?"

If the interaction of gas and politics was recurrently stressed, so too were the connections between gas and the environment.

It was scarcely surprising that Dr Mohammad Hossein Adeli, Secretary General of the Gas Exporting Countries Forum, should have promoted gas, but perhaps what was less expected was that he should have adopted an approach that focussed both on market dynamics and on social needs. "Pollution is becoming serious. There are political dimensions, social dimensions" Dr Adeli said. According to the World Health Organisation, he added, "eight million people (a year) pass away prematurely because of pollution; indoor pollution as well as outdoor pollution. This presents an opportunity for gas: the more gas produced; the less CO2 emission." Nonetheless, there were "doubts and uncertainties as no-one knows what is going to happen," he cautioned; adding: "Are the main polluters -- the US, China, Russia, India -- going to commit themselves to reduce the Co2 emission" as targetted at last year's United Nations Climate Change Conference in Paris.

Dr Adeli, naturally, made a strong pitch for the world to look to gas. Gas, he argued, was abundant, accessible, and economically advantageous; it was good for transforming energy to power, and had a competitive cost structure. It was particularly good at enhancing access to energy for communities that lack such access, and thus improved human welfare.

Gas, he said, was "environmentally friendly, affordable; so it doesn't need subsidies in producing or consuming."

When Dr Adeli then added "we have to reduce the subsidies actually" he certainly struck a chord – not least since the GECF Secretary-General is a former Iranian diplomat, and Iran has had tremendous difficulties reforming its extensive energy subsidies. Asked about this, he replied:

- "One. It's an economic and social problem. This needs a good political and social environment. In an environment which is conflicting you cannot implement subsidy plans because is it would end in disaster, an uprising.
- "Two. Subsidy (reform) should be gradually implemented. The reduction of subsidy should not be shock therapy as prescribed by some international organisations such as the IMF. Shock therapy has not worked; it should be gradually done.
- "Three: Any subsidy reduction should be accompanied by a package that would put the country into much more internationalisation of the economy, then it can create more jobs, more opportunities and compensate for the problems that face ordinary people and SMEs (small and medium-sized enterprises).

"This is why it is a complicated issue which needs a sophisticated package for implementation."

Ambassador Halil Ibrahim Akca, Secretary General of the Tehran-based Economic Cooperation Organisation, said there were two priorities for the ECO region, which extends from Turkey, Iran and Pakistan to include a cluster of Caspian and Central Asian states. "First, most of our member states need to pay attention to energy efficiency. This is vital for every country but more vital for ECO region. There is a lack of energy efficiency in our region. Second, we need to focus on renewables." However, Akca said, it was not his remit to advise countries as to what specific measures they should take. ECO's role was to bring countries together so they could work out a consensus on what they should do, and then implement such measures on their own.

Secondly, he said, they have to focus on renewables. However, he acknowledged later, "it is hard to give recommendations to governments to change policies. But there is a problem in adapting to changing conditions."

Akca's fellow countryman, Alpay Ünal, the CEO of Turkey's Yatirim Holdings, highlighted Turkey's potential to harness renewables, not least by indicating how much had yet to be used. Turkey, he said, could still harness 70% of its hydropower and 78% of its geothermal resources. Overall, he considered, his country could generate a further 100 to 130 GW from hydropower; 91 GW from solar; 4 GW from geothermal and 0.4 GW apiece from wind and biomass.

That renewables could have a massive impact is demonstrated by Germany. Dr Georg Erdmann of the Berlin University of Technology began by observing that the increase in renewable electricity had reduced German wholesale power prices and was challenging the economics of gas-fired power generation. Indeed, Erdmann put forward a thesis that there us no real future for natural gas in Europe because German pricing mechanisms will ensure that it makes little sense to build new gas-fired powered stations in Germany itself while German electricity exports will have a similar impact on **its** neighbours. Germany, Erdmann noted, is now a net exporter of electricity, increase to more than 8%

of national generation.

This challenges the economics of gas fired power stations throughout Europe, as Europe becomes increasingly interconnected, Erdmann argued. Germany, he considered, was now caught in its own subsidy trap. "I see in the next 10 years a standstill in German energy policy because of this," he said. The German government faces the dilemma in that once subsidies are introduced, they cannot be halted, and yet there is constantly a need to replace existing subsidies with new subsidies for alternative innovations. With Germany looking to rely on renewables for no less than 80% of its primary energy supply by 2050, and with its development of renewables based on subsidies, it was far from clear just how German energy policy would evolve. However, Erdmann added, largely because of the commitment to renewables, "there is a chance that in Germany there will be no large scale investment in the gas-fired power, despite growing demand for electricity."

No energy conference would ever be complete without some consideration of those perennial interlinked favourites: the role of OPEC and the volatility of international oil prices. James Smith, of Southern Methodist University in Texas, addressed both issues. Until 2014, he he argued, Opec had been "dancing along with a regime of compromise that united their members." Since then, however, the Saudis considered they were carrying an unfair burden under that compromise and were not going to bear the burden any more. "The Saudi agreement to bear that burden is now history," Smith declared. The Saudis, Smith argued, have seen how high prices help Opec only in the short term, but in the long run they bring far more competitors to market, notably shale oil. As for the oil price issue, Smith simply commented that for the Saudis price reduction "is a process of trial and error."

There were, as one would hope, some great aphorisms, with the GECF's Adeli producing the finest: "Oil is dating and gas is getting married. You can produce oil and sell it on the spot market, but when you produce gas you need a long-term commitment. You don't produce it until you get it sold."

Suitable Combination of Photovoltaic Cell and Electricity Storage System in the Smart Community Connecting the Commercial and Residential Sectors

By Yoshiki Ogawa

OVERVIEW

The Paris agreement on post Kyoto GHGs reduction was finally approved by many countries including various developing countries in December 2015. In 2015, Japanese Government also determined the new target of GHGs to achieve 26% reduction from the emission level in 2013 up to 2030. This target seems to be somewhat mild. However, in the long-run, Japan must basically strengthen her GHGs reduction measures, because she already committed 50% (or 80%) reduction of GHGs in 2050.

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The GHGs emissions in Japan have increased to the large extent up to 2014 from the 1990 level (the base level in Kyoto Protocol). Especially, the continuous increases in GHGs emission in the commercial and residential sectors were remarkable and largely influenced to the whole increases in Japan.

In recent years, the storage system of electricity such as Lithium ion, NAS and redox flow batteries is also being made a large progress. The smart community connecting both commercial and residential sectors is widely noticed. Therefore, in this study, we would like to analyze suitable capacity combination of photovoltaic cell (PV) and electricity storage system (ESS, battery) in the smart community connecting the commercial and residential sectors.

METHODS

In this study, we made various simulations on the introduction of smart facilities such as PV and ESS as important functions of smart community connecting the commercial and residential sectors. First of all, the average electricity demand pattern in the commercial and residential sectors was estimated by month based on the METI report [1], EDMC data [2] and Cogeneration Comprehensive Manual [3]. We also surveyed present situations on PV and ESS on the basis of NEDO and METI reports [4, 5]. The average daily pattern of PV generation was estimated by month using NEDO Sunshine Database [6].

The number of households in the residential sector (abbreviated to RES in the figures) was assumed to be 1,000 and the total floor area in the commercial sector (abbreviated to COM in the figures) was also assumed to be 25,000 m2. The capacity of PV for each house in the residential sector was assumed at 4 kW.

As for surplus PV electricity, the direct supply to the own sector, the direct supply to the other sector, the charging into the ESS and the selling to the outside electricity company has a higher priority in this order. Thus, the last remaining surplus PV electricity was sold to the outside electricity company. The charging of electricity storage system is made from 0:00 to 6:00 for cheap purchased electricity in midnight if necessary and from 6:00 to 18:00 for surplus PV electricity, and the discharging of electricity storage system is made in necessary hours judging from electricity consumption.

The cost of PV was assumed to be 350,000 Yen/kW for the house use (small scale) and 300,000 Yen/kW for the mega solar use (large scale). The cost of ESS was assumed to be 200,000 Yen/kWh. The differences in electricity charge between daytime and night were assumed. Final surplus electricity generated by PV was assumed to be sold at FIT (Feed in tariff) price of 33 Yen/kWh for the residential sector and the 27 Yen/kWh for the commercial sector (actual FIT prices in 2014).

The investment return of smart facilities is checked by the simple payback years which is calculated by dividing the net initial cost (excluding cost covered by the subsidy) of required equipment by the annual profit brought by the reduction of purchased electricity and the sales of PV electricity to outside.

In the simulation, first, we determined the starting point in which purchased electricity from the power company outside could be made absolutely zero (a kind of extreme case). There were two cases: one was PV maximum case (PV capacity 40,000 kW and ESS capacity 20,000 kWh) and the other was ESS maximum case (ESS capacity 39,000 kWh and PV capacity 5,500 kW). Second, we analyzed suitable capacity combination of PV and ESS starting from the ESS maximum case by checking various performance indicators. Finally, we considered the future issues and subjects of smart community.

RESULTS

Comparison of two starting points (absolutely zero purchased electricity cases)

In the PV maximum case, in order to reduce the electricity purchased from the outside power company to absolutely zero for all months in the year, extremely large size of mega-solar is installed in the commercial sector and almost all the PV electricity generated is sold to the outside power company using FIT (Feed in Tariff) system.

The quite small part of PV electricity generated is supplied to the own sector firstly, supplied to the other sector secondly, and supplied to the ESS for charging thirdly. The electricity charged into the ESS is discharged for the consumption in the residential and commercial sectors from the evening to the early morning. As a result of these supplies, the electricity purchased from the outside electricity company becomes absolutely zero for all months in the year.

In the ESS maximum case, different from the PV maximum case, in order to reduce the electricity purchased from the outside power company to absolutely zero for all months in the year, the almost doubled large capacity of ESS is installed and the large part of remaining surplus PV electricity is charged into the ESS.

The quite large part of PV electricity generated is supplied to the own sector firstly, supplied to the other sector secondly, and supplied to the ESS for charging thirdly. Then the small part of PV electricity finally remained as the last surplus is sold to the outside electricity company using FIT system. The electricity charged into the ESS is discharged in the same way as the PV maximum case. As a result of these supplies, the electricity purchased from the outside electricity company also becomes absolutely zero for all months in the year.

The results of PV maximum case are brought especially by the special favorable treatments using higher FIT prices. Because the required size of PV capacity to generate PV electricity sold to the outside is quite large, the various risks on the investment recovery are also expected. If we pursue the sound developments of smart community connecting the residential and commercial sectors, the large dependence on investment recovery to the FIT revenue is not always desirable. Thus, in the next step, we focus only on the ESS maximum case.

Simulations on ESS maximum case and the suitable combination

Figure 1 shows various ratios related to purchased and sold electricity by the smart community. At the starting point of ESS maximum case, though the purchased electricity can be reduced to absolutely zero at any time, the payback year of 29.5 in this case is too long and the final remaining PV electricity sold to outside is also large. As judging from the balance ratio of purchased and sold electricity in the smart community shown in Figure 1, the purchased electricity from outside is almost balanced with the sold PV electricity to outside throughout the year if the installed PV capacity is 4,100 kW.

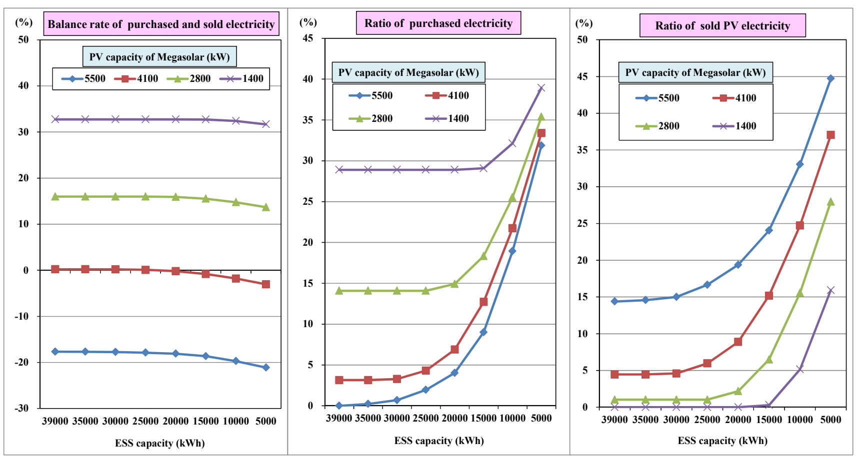

Figure 1 Changes in various ratios related to purchased and sold electricity

Figure 2 shows various ratios related to ESS performances. If the capacity of ESS is positioned at between 39,000 and 20,000 kWh, various ratios shown in Figs. 1 and 2 are not changed so largely. If the capacity of ESS is lower than 20,000 kWh, these ratios are changed drastically. The payback year of smart community is more improved as the capacity of ESS is lowered.

Based on these results, the PV capacity of 4,100 kW and the ESS capacity of 20,000 kWh would be the suitable combination. The payback year of this case is lowered to 21.6 and the operation rate of ESS rises to 61.6% as shown in Fig.1. Figure 3 shows the electricity supply pattern of the commercial and residential sectors and the electricity storage system on the suitable PV (the large scale of 4,100 kW finally reached in the commercial sector and 1,000 [Max] houses installed the small-scale of 4,000 kW) and ESS (20, 000 kWh finally reached) installation case.

It is quite difficult and not efficient to reduce the electricity purchased from the power company outside to absolutely zero in the winter season and summer season, as shown in Figure 3.

CONCLUDING REMARKS

First, the special environment brought by the preferable acceptance price of PV electricity by FIT makes large distortion to the decision making of investments to smart community. We need to reconsider desirable and sustainable FIT system more carefully. The special treatments by FIT are not suitable for the sound developments of smart community.

Second, the absolutely zero purchased electricity at any time is often pursued in the smart community as an achievable target. But the realization of this target is quite difficult and extremely inefficient. Instead of this target, the balancing between the purchased electricity and the sold PV electricity would be an important target which should be considered.

Third, we also need to consider the balancing between the economics of smart community and the role of installed ESS capacity. In order to reduce purchased electricity more, the larger ESS installed capacity would be required. However the economics of smart community becomes worse rapidly as the ESS capacity becomes larger.

Forth, under the present cost conditions, the economics of smart community would not be so preferable. For the expansion of smart community connecting the commercial and residential sectors, the cost reduction of smart facilities, especially for ESS, would be quite important.The quite lower price of electricity storage system announced by TESLA is gratifying information for smart community. As for the large-scale ESS (Batteries), Japanese companies also have advanced technologies such as NaS (Nihon Gaishi) and redox flow (Sumitomo Denki) batteries.

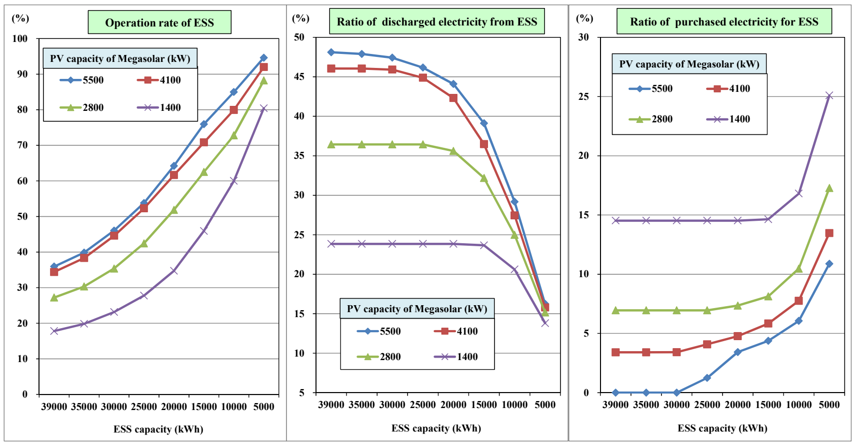

Figure 2 Changes in various ratios related to ESS performances

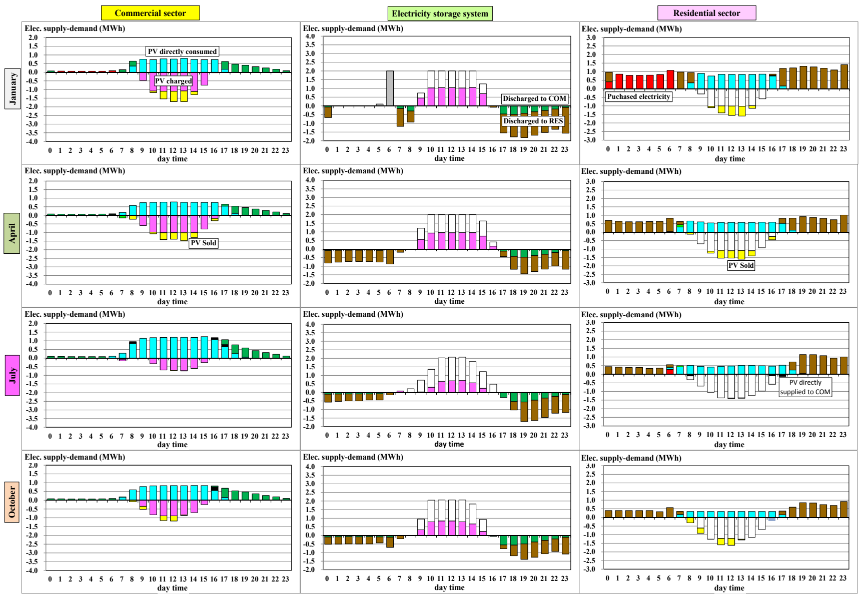

Figure 3 Electricity supply patterns in the suitable installation case (ESS: 20 MWh, PV: COM = 4.1 MW, RES = 1,000 houses)

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SAEE Builds Constructive Dialogue Between Energy and Industry

The energy market is on the verge of a major transition, and this requires collaboration and exchange of experience, we could hear in the opening part of En.economics & Industry 016, the first conference organised by the Slovenian Association for Energy Economics (SAEE) and Energetika.NET, which was held at the Faculty of Economics, Ljubljana, on 29 September. This transition and digitalisation are giving rise to new market trends, and according to the speakers who represent the market, this is a good opportunity to consider what these new challenges actually mean, and whether companies can tackle them by themselves or whether they would be more successful by working together. Meanwhile, the role of the state is to consider all the possible visions (of the future of energy) and single out those that can become part of a realistic strategy, emphasised a Slovenian government representative, adding that targets should be proportional to capacities.

The vital importance of collaboration and exchange of experience between various stakeholders of the Slovenian energy landscape was both a thread of the En.economics & Industry 016 conference programme, as it is a guideline in all SAEE activities.

Together with conference guests, which included representatives of the Slovenian infrastructure ministry, the Slovenian Energy Agency, the Faculty of Mechanical Engineering Ljubljana, the energy sector and industry players, we examined the pressing challenges posed in the relations between energy and industry in Slovenia.

Representatives of industry, the state (Ministry of Infrastructure), the Slovenian Energy Agency, energy players (operators, traders), industry institutions (such as WEC, WPNT Communications Europe, Energy & Natural Resources for EMEA & MEE, E&A Law, Faculty of Electrical Engineering Ljubljana, Natural Gas Distribution Association), financial institutions (EBRD, SID banka), and many others, discussed the workings of the International Association for Energy Economics (IAEE) as an organisation which can offer examples of good practice in energy investment, and the opportunities provided in industry by the energy sector.

The invited speakers tackled topics such as Cost Assessments of European climate-energy policy (Dr Gürkan Kumbaroglu, IAEE), Future energy & industry projects as the answer to climate challenges (Maher Chebbo, Energy & Natural Resources for EMEA & MEE), and The Role of the energy industry in the EU and the World (Dr Georg Erdmann, IAEE). In the latter, Erdmann extended and continued his presentation from the first SAEE session in January 2016.

The conference saw the first public presentation of the first Energy Economics Manifesto (MEE). By bringing together energy stakeholders, using interdisciplinary knowledge and applying the principles of energy economics, the document aims to contribute to sustainable development of the energy sector and the Slovenian economy. MEE encompasses proposals for measures in the fields of development policy, business environment, tax policy, staffing policy, and internationalisation, with the goal of implementing at least five measures by 2021.

MEE was drafted by the SAEE Executive Committee in collaboration with a consultation group. The presentation was held by SAEE President Sarah Jezernik and Vice-President Nevenka Hrovatin, who went through the set of measures and announced a public consultation aimed at forging a broad public consensus before the document is ultimately adopted.

Dr Hrovatin also announced SAEE's first science conference, which will take place at the Faculty of Economic, Ljubljana on 25 November 2016, and informed the audience that Dr Boyko Nitzov, a long-time member of IAEE, had signed a donation agreement with SAEE and the Faculty of Economic, making a donation to the fund for the Best Student Submission Award. His generous example was followed by Energetika.NET with a donation for the runner-up submission.

Tina Štrukelj and Energetika.NET (www.energetika.net/see)

Computation of the Levelized Cost of Electricity under Uncertainty and Endogeneities in Inputs

By Thomas Geissmann

INTRODUCTION

Aside security issues and the level of political support, the question of the economic viability of nuclear energy in today's increasingly liberalized western energy markets has not yet reached a consensus in the energy community. In the past, nuclear projects in western countries tended to exceed their projected costs significantly. A similar picture is given by the two nuclear plants currently under construction in Europe: the EPR (European pressurized water reactor) plants in Olkiluoto (Finland) and Flamanville (France). Both construction projects have been surpassing their projected costs since start of construction in 2005 and 2007 by a multiple. These cases exemplify the inherent uncertainty in projected costs of nuclear plants in the western world.

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See footnotes at end of text.

The estimation of a power project's economic viability by calculating the levelized cost of energy (LCOE) is a fundamental initial instrument for investment decisions by companies and for policy makers. However, the methodology bears a range of drawbacks. A prominent difficulty to which the energy literature has repeatedly pointed at is that the LCOE is highly sensitive to investment costs, which, especially in the case of nuclear power, often form one of the biggest component to overall costs. Separate—though very relevant issues when weighing against alternative technology options—are so-called endogeneity issues: for instance, the failure to take into account the correlation between fuel prices and electricity prices or the volume of new investments in the market.[1] In the following, sensitivity issues of LCOE computations will be addressed by accounting for uncertainty in input variables and potential endogeneities among these uncertainties by simulating a range of alternative project courses through the Monte Carlo simulation (MCS) method. These issues have been neglected in previous studies.

This paper is organized as follows: part 2 summarizes the relevant literature, with a special focus on the accounting for risks in project appraisal. Part 3 describes the model and the parameters' distributional assumptions. The results are analyzed in part 4. Part 5 concludes.

LITERATURE

Most of the literature estimating the LCOE of power plant technologies provide single point estimates and sensitivity analyses based on switching values. Especially in the case of nuclear power, the literature disagrees greatly on the future costs, however, with a trend towards higher cost estimates, given the recent experiences made with new nuclear projects in western countries. The number of peer as well as non-peer reviewed studies using MCS methods or accounting for different discounting options or external costs is relatively small (see Table 1). To emphasize is the tendency of the literature to overlook the role of endogeneities. Roques et al. (2006) mention the possibility to control for such correlations, but no study yet effectively accounts for correlations when applying MCS techniques to estimate LCOE.

Source	Technology	MCS	Discounting options	External costs
Branker et al. (2011)	Solar	—	yes	—
Short et al. (1995)	Renewables	—	yes	—
Du and Parsons (2009)	Nuclear/Coal/Gas	—	—	—
Darling et al. (2011)	Solar	yes	—	—
Anderson (2007)	General	yes	—	—
Hogue (2012)	Nuclear/Coal/Gas	—	—	yes
Feretic and Tomsic (2005)	Nuclear/Coal/Gas	yes	—	—
Roques et al. (2006)	Nuclear/Coal/Gas	yes	—	—
Linares and Conchado (2013)	Nuclear	—	—	—
Ahmad and Ramana (2014)	Nuclear/Gas/Solar	—	—	—

Note: The table summarizes which power generating technologies a study considered, whether a MCS method was used and whether discounting options or the role of external costs were discussed.

Table 1: Overview of selected literature

MODEL

This study formulates a business oriented LCOE model, i.e., potential external costs of the technology are not internalized. The methodology applied to the LCOE calculation is based on Du and Parsons (2009). The authors define LCOE as the constant real wholesale price such that debt lenders and electric utilities are compensated their re-quired rate of return, i.e., the LCOE is based on corporate finance's central concept of zero economic profit. Hence, the LCOE represents the price of electricity required, whereby the price is subject to inflation, such that the project yields a net present value of zero. The key benefit of this procedure, where the weighted average cost of capital (WACC) is applied to the unlevered after-tax cash flow, is that even though the debt-to-equity ratio changes over time, the implied risk premium remains constant (see Du and Parsons (2009), p. 20). The model is demonstrated for the case of a nuclear power project in Switzerland. The LCOE in 2014 prices is given on busbar level. Variable descriptions are given in Table 2.

A deferred costs accounting is implemented, i.e., fees for post-closure, decommissioning and final waste disposal costs are collected during the operational phase. It is assumed that a real, tax free interest rate can be earned on these accumulated fees. The compounded provisions match expected future costs at the end of the operational phase. Post-closure cost, decommissioning cost and final waste storage cost provisions (PCP, DCP and FWCP) are constant over time and compounded yearly (emphasized by the exponent *y*). The interest earned on provisions implies some of the costs being covered by working capital. Finally, the LCOE is represented by the electricity price (ElPrice) that yields a net present value of the project equal to zero. By this procedure, the cost and revenue cash flows are discounted at the same rate, implying that both cash flows face the same risks.

Distributional assumptions represent the inherent uncertainty in some variable specifications. They are based on subjective judgment and therefore represent subjective probabilities, accommodating for the modest insight that there is a bounded set of information to build upon. Construction is planned such that the plant could start producing electricity around 2030, approximately the time when half of the Swiss nuclear capacity will have been taken off grid. The nuclear technology is assumed to be of type generation III+ EPR, i.e., the same type that is currently under construction in Olkiluoto (Finland) and Flamanville (France), and which is in discussion to be built in Britain at Hinkley Point. The parameter specifications used for the LCOE simulations are listed in Table 2. The assumptions listed in Table 2 yield a best estimate (the model's static results without running MCS) of total overnight costs of USD 10.4 billion for the nuclear project. The LCOE formula given in the previous section is now embedded it into a Monte Carlo setting using Latin hypercube sampling, which applies the technique of stratified sampling without replacement[2]. The simulation procedure is depicted in Figure 1. Endogeneities account for the probability of some variables to vary in a systematic way. Predefined correlations between variables are introduced into the simulation process by using Spearman's rank-order correlation. Given that the number of iterations is known beforehand, the variable pairs to be correlated are drawn, i.e., the scores are generated, and then ranked in advance of the simulation in a fashion that yields the predefined correlation value.[3]

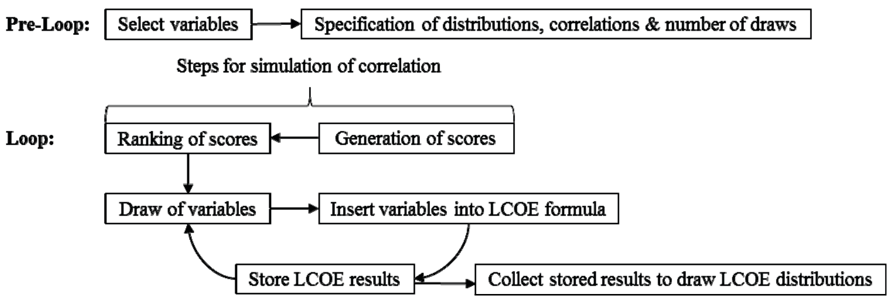

Figure 1: Simulation procedure.

RESULTS

If the best estimates given in Table 2 are used, i.e. if no MCS is applied, the LCOE of the nuclear plant amounts to 13.17 cents per kWh. The 2014 present value of after tax capital costs, including construction costs, incremental capital costs, post-closure, decommissioning and final waste disposal costs form 74 percent of the total lifetime costs of the project. These ratios signify the high capital intensity of nuclear power. MCS is based on $3 \cdot 10^5$ replications. Figure 2 depicts the estimated LCOE probability density functions for the project under a consideration of correlations.

The power market would have to sustain a uniformly distributed real electricity price of at least 13.61 cents per kWh for 60 years for the project to yield a non-negative net present value. Additional insights are gained via a sensitivity analysis, visualized in Figure 3, with the center line indicating the mean LCOE value. Depicted are the factors driving risk by their relative importance, i.e., how much LCOE mean value estimates change when a single input is varied over its predefined range. Awareness of those effects will help to reduce the risk of either project.

The importance of accounting for endogeneities between input variables is exemplified by correlating the two variables construction costs and construction time. For demonstrating purposes, it is assumed that the initial investment costs and the construction time are positively correlated. In this paper, a correlation of 0.9 is assumed. Of course, many other potential endogeneities can be thought of, e.g., between fuel costs and inflation rates or interdependencies due to policies simultaneously affecting several variables. A comparison between Figure 2 (accounting for endogeneities) and Figure

Parameter	Unit	Nuclear
Electrical capacity (net)	[MW]	1600
Capacity factor	[%]	PERT(80, 90, 95)
Hours per year	[h]	8760
Heat rate	Btu/kWh	10400
Initial investment (overnight)	[$/kW]	Tr(5500, 6500, 7500)
Fixed O&M	[$/kW/a]	Tr(120, 140, 155)
Variable O&M	[$/MWh/a]	Tr(.95, 1.1, 1.4)
O&M real escalation	[%/a]	0.75
Intermediate waste disposal	[$/kW/a]	Tr(45, 55, 80)
Fuel costs	[$/MMBtu]	Tr(.35, 0.43, .5)
Fuel costs real escalation	[%/a]	0.5
Capital increment (1st half)	[$/kW/a]	1% of overnight costs
Capital increment (2nd half)	[$/kW/a]	2% of overnight costs
Post-closure phase costs	[$/kW]	Tr(515, 575, 725)
Decommissioning costs	[$/kW]	Tr(950, 1100, 1450)
Final waste disposal costs	[$/kW]	Tr(2600, 3200, 4200)
Equity ratio	[%]	PERT(40, 50, 50)
Equity rate (nominal)	[%/a]	Tr(8, 10, 12)
Debt rate (nominal)	[%/a]	6.5
WACC	[%/a]	8.25*
Discount rate	[%/a]	= WACC
Inflation rate	[%/a]	2
Real interest on provisions	[%/a]	2
Corporate tax rate	[%/a]	21
Depreciation time	[a]	16
Construction time	[a]	Discrete years=[6; 7; 8; 9; 10] prob=[.1; .4; .2; .15; .15]
Plant lifetime	[a]	60

Note: Tr(A; B; C) ≡ Triangle distribution ; PERT(A; B; C) ≡ Beta-PERT distribution, whereby A ≡ lowest possible value, B ≡ highest probability value and C ≡ highest possible value ; Tp(A; B; C; D) ≡ Trapezoidal distribution, whereby B and C span the range of the highest probability ; $N(\mu,\sigma^2)$ ≡ Normal distribution ; prob ≡ probability. All values are given in real USD 2014 terms. Choices of values and distributions are described in greater detail in the appendix.

* Given the highest probability values of the two debt and equity rate triangular distributions. The WACC varies according to: WACC = Equity rate · Equity ratio + Debt rate · (1 – Equity ratio).

Table 2. Parameter and distribution assumption

4 (not accounting for endogeneities) illustrates the correlation's effect on the estimated LCOE values.

The mean LCOE estimate is 1.5 percent higher than under negligence of the single correlation, with the difference being statistically highly significant at a level of 1 percent. Also, the ordering of the variables' leverage on the mean LCOE estimate changes considerably. Before, investment costs and construction time formed the pair of most influential variables in terms of their leverage on the mean. However, under the negligence of any endogeneities, the equity rate ranks first, followed by the investment costs. Construciton time falls behind in its importance on fourth place.

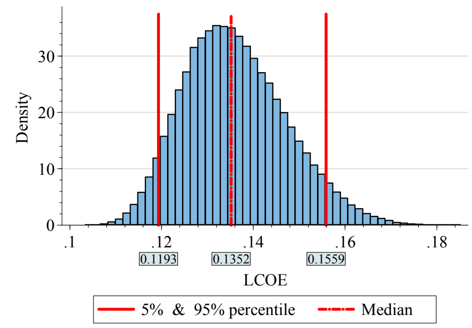

Figure 2. Nuclear LCOE probability density

Mean	**0.1361**	**Median**	**0.1351**
Std Dev	**0.0111**	**Variance**	**0.0001**

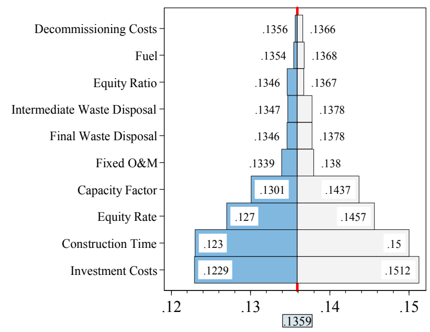

Figure 3. Inputs sorted according to influence on nuclear LCOE

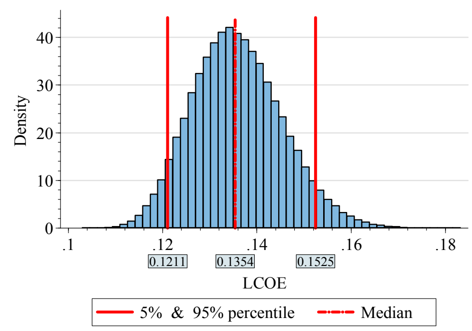

Figure 4. Nuclear LCOE probability distribution without accounting for endogeneities

Mean	**0.1359**	**Median**	**0.1354**
Std Dev	**0.0100**	**Variance**	**0.0001**

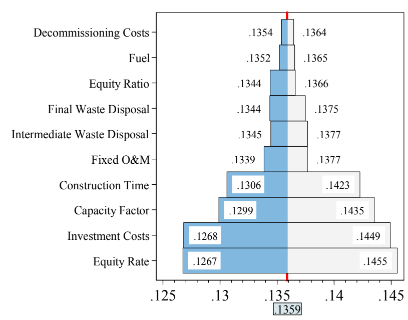

Figure 5. Inputs sorted according to influence on nuclear LCOE without accounting for endogeneities

CONCLUSION

LCOE estimation are based on a range of assumptions to which a varying degree of uncertainty is attached. Using probability distributions, these uncertainties are approximated, quantified and translated into cost risks. MCS subsequently yields comprehensive results about possible project outcomes. In this paper, the traditional approach of calculating LCOE is extended by not only implementing a probabilistic model applying MCS to account for project risks, but also by introducing endogeneities between inputs. The results allow for several insights. First, given current and past electricity prices, a nuclear project hardly would be economically viable in a liberalized Swiss power market. The LCOE estimates are higher than in most former studies on the LCOE of nuclear projects but in line with the cost estimates for current projects in Finland, France and the UK. Several single parameters are found to be decisive for the project's economic viability: first, keeping capital costs under control will be detrimental, implying a construction schedule not sheering off path. The consideration of endogeneities between inputs is important. By controlling for only a single correlation a statistically significant difference in the mean LCOE estimate and a changing order of the leverage of inputs thereon is observed.

Footnotes

[1] See Linares and Conchado (2013) for a general discussion of the economics of new power plants in liberalized electricity markets.

[2] For further details of this method see Vose (2000), for instance.

[3] Balcombe and Smith [26] highlight the issue of serial correlation (also known as cycles) and the need to increase forecast variance over time. However, in what follows, only the possibility for a simple correlation between individual variables will be considered.

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Econometric Analysis of Household Coal Demand in Kazakhstan

By Zauresh Atakhanova and Peter Howie

Residential sector energy policies are important for addressing key economic, social, and environmental challenges in Kazakhstan. In 2012, the share of households that used coal as a primary source of space heating energy was 70% in rural areas and 32% nation-wide. In addition, between 2002 and 2012 average household annual consumption of coal increased by 44%. Even though coal price was estimated to be subsidized at 60% of full cost, space heating accounted for 35% of an average household's energy budget.

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Our study fills in a considerable gap in literature on household coal demand. Using Kazakhstan's household budget survey data from 2002-2012, we estimate a cross section and a dynamic panel data models of coal demand. We find that climatic factors, coal price, and household income are the main drivers of coal demand. Efficiency improvements have a modest impact on coal demand as low coal prices provide little incentives to undertake weatherization. We find that in the absence of relevant policies an average rural household will not be able to switch away from coal. However, we demonstrate that financing rural households' adoption of a clean alternative requires less funds than the current coal subsidy. Finally, we believe that the proposed rural energy policies will stimulate development of Kazakhstan's exceptional renewable energy potential.

HOUSEHOLD COAL DEMAND FUNCTION

We model coal demand of household i in a given period as a function of that period's coal price, income, access to alternative heating systems, observed dwelling characteristics, observed characteristics of the household, the expected length of the heating season and associated outdoor temperature, and other unobserved factors. As a result, the cross-section econometric model of household coal demand is specified as follows:

$$\begin{aligned} log(coal\ quantity) = \beta_0 + \beta_1 log(coal\ price_i) + \beta_2 log(income_i) + \beta_3 alt\_access_i \\ + \beta_4 dwelling\_variables_i + \beta_5 household\_variables_i \\ + \beta_6 heating\_season\_variable_i + \epsilon_i \end{aligned} \qquad (1)$$

Under model specification (1) coefficient estimates represent estimates of elasticity for those explanatory variables that are in the natural logarithm form. Specifically, elasticity of coal demand, Q, with respect to any continuous variable, *X*, is defined as $\% \Delta Q/\% \Delta X = dlogQ/dlogX = \beta$. Elasticity is a measure of sensitivity of demand to changes in values of the variable X. If X is a dummy variable, its proportionate impact on Q is calculated as ($exp\beta-1$). In addition, we are interested in analyzing changes of properties of coal demand over time. However, our data (described in the following section) represents annual surveys of different sets of households. As a result, in our dynamic model we cannot use a household as a unit of analysis. Therefore, we use average coal consumption per household in a relevant region to specify the following dynamic panel model of coal demand for region j and time period t as follows:

$$\begin{aligned} \Delta log(coal\ quantity_{jt}) = \Psi_0 + \Psi_1 \Delta log(coal\ price_{jt}) + \Psi_2 \Delta log(income_{jt}) \\ + \gamma \Delta log(coal\ quantity_{j,t-1}) + \Psi_{jt} \end{aligned} \qquad (2)$$

This model relies on the assumption of capital stock (captured by the lagged dependent variable) as a determinant of the level and the growth rate of demand and the degree of substitution flexibility. Under model specification (2) variables would represent region averages while estimates of Ψ_i and $\Psi_i/(1-\gamma)$ are interpreted as estimated short-run and long-run elasticities, respectively.

THE DATA

Data on household *annual coal expenditures* are collected by the Household Budget Survey (HBS). Like in many national HBSs, household-level data on energy prices and quantities consumed are not part of Kazakhstan HBS. As a result, we use data on average coal prices in region centers.

We use three separate variables to capture efficiency characteristics of a dwelling. First, we use the *post-1990*, a dummy variable for dwellings built in 1990 or later, as a proxy for the original energy efficiency of the dwelling. 1990 was chosen as threshold period to account for the structural changes that

Variable name	Coefficient	Standard error	t-statistic
ln coal price	0.787	0.072	10.990
ln income	0.345	0.020	17.390
alt_access	-0.161	0.057	-2.820
ln area	0.116	0.026	4.380
Apartment	0.019	0.031	0.610
semi-detached	-0.022	0.027	-0.800
post_1990	-0.055	0.028	-2.010
Rental	0.140	0.042	3.330
Pensioners	0.043	0.021	2.060
Children	0.049	0.020	2.430
ln HDD	0.805	0.067	12.020
Constant	-8.069	1.123	-7.180

R^2 = 0.1278; Number of observations = 3209.
Test of endogeneity:
Durbin score chi2 (1)= 70.69 (p-value:0.00);
Wu-Hausman F (1, 3196) = 71.99 p-value (0.00)

Table 1. Characteristics of coal-consuming rural households in 2012

began in Kazakhstan as a result of the breakup of the Soviet Union and transition from central planning to market economy. Next, similar to other studies, we use dummies for *tenant-occupied properties*. The assumption is that such dwellings would be characterized by lower efficiency as tenants often have no capacity and landlords have no incentive to invest in efficiency improvements. Lastly, we consider dummy variables for a *type of dwelling*: an apartment, semi-detached, and detached house. Data on these three variables are available from the HBS.

Furthermore, household coal demand depends on the outdoor temperature and the length of the heating season. Thus, we use heating degree days *(HDDs)* which represent the product of the number of days when average daily temperature is less than 65 degrees Fahrenheit and the absolute value of the difference between 65 degrees Fahrenheit and the actual average daily temperature.

Finally, *household monetary income, dwelling area,* and a dummy variable for *pensioners* are obtained from the HBS. The latter variable is indicative of the time spent at home and thermal comfort levels of household members. To summarize, all data other than coal prices and HDDs are from the HBS and reported at the household level. *Household monetary income, annual coal expenditures,* and *living area* are determined on a per-capita basis. Summary statistics are presented in Table 1.

ESTIMATION PROCEDURE AND RESULTS

Our empirical framework is set up based on Kazakhstan's HBS data which do not have information on household-level coal prices and quantities. Therefore, for the initial stage of our analysis we use annual household expenditures on coal as the dependent variable. Applying cross-section model (1) above to the 2012 household level dataset – with coal expenditures substituted for coal quantities – we obtain parameter estimates obtained by applying Ordinary Least Squares (OLS) estimation procedure (See Table 2). We justify using the OLS procedure by the assumption of the perfectly elastic coal supply curve faced by an individual household.

By dividing household coal expenditures by the coal price we may obtain the imputed household quantity of coal consumed as shown in model (1). In such a case, the only coefficient estimate that differs from the results reported in Table 2 is the one related to the price variable. This specification allows us to compare our findings to those from other studies that use coal quantity as their dependent variable. Specifically, our estimated price and income elasticities of coal demand are -0.50 and 0.47, respectively (See Table 4). The estimate of price elasticity of coal demand is close to the value of -0.38 reported for the residential coal demand in China reported in Zhang and Kotani's (2012) cross-section study. However, the unit value of income elasticity reported by that study is much higher than our estimate of 0.47. Differences in per capita income in Kazakhstan versus China may be the reason of discrepancies in the associated income demand elasticity estimates. In addition, the fact that in China coal is used for both cooking and heating while in Kazakhstan it is used primarily for heating purposes may be another reason for differences in estimated demand elasticities.

Next, we estimate long-run price and income elasticities according to specification (2). As the specification of the residential demand equation introduces correlation between the errors and the lagged first-differenced endogenous variable, we use the Arellano-Bond System GMM approach (Arellano and

Variable name	Coefficient	Standard error	t-statistic
ln coal price	0.787	0.072	10.990
ln income	0.345	0.020	17.390
alt_access	-0.161	0.057	-2.820
ln area	0.116	0.026	4.380
Apartment	0.019	0.031	0.610
semi-detached	-0.022	0.027	-0.800
post_1990	-0.055	0.028	-2.010
Rental	0.140	0.042	3.330
Pensioners	0.043	0.021	2.060
Children	0.049	0.020	2.430
ln HDD	0.805	0.067	12.020
Constant	-8.069	1.123	-7.180

R^2 = 0.1278; Number of observations = 3209.
Test of endogeneity:
Durbin score chi2 (1)= 70.69 (p-value:0.00);
Wu-Hausman F (1, 3196) = 71.99 p-value (0.00)

Table 2. Coal Expenditures Model Estimation Results (2012 Cross-Section Household Level Model)

Bond, 1991; Blundell and Bond, 1998). Under this approach we include second through eleventh lags of all variables as GMM-style instruments. Here variables represent averages across households in a given region. Estimation results are obtained for the period of 2001-2012 and 12 regions (See Table 3). Results indicate that short-run income elasticity of coal demand estimated at the region level is 0.34 and associated short-run price elasticity is -0.65. Corresponding long-run income and price elasticities are 0.60 and -1.15, respectively.

Variable name	Coefficient	Robust Standard error	z-statistics
Δln coal price	-0.653	0.276	-2.37
Δln income	0.340	0.198	1.72
Δln living area	1.128	1.362	0.83
ΔLagged endogenous variable	0.430	0.128	3.37
Constant	-1.527	3.276	-0.47

Wald χ^2-statistic = 266.04; Number of observations = 132.
Test of overidentifying restrictions:
Hansen's J-statistic: 12.76 p-value (0.174)
Test of stationarity of dependent variable:
Levin–Lin–Chu panel unit root (t-statistic): -2.226 p-value (0.013)
Test for autocorrelation:
Arellano–Bond test of AR(1) in residuals (z-statistic): -3.06 p-value (0.002)
Arellano–Bond test of AR(2) in residuals (z-statistic): -1.84 p-value (0.065)

Table 3. Dynamic Panel Data Coal Quantity Model Results: Arellano–Bond System GMM

POLICY IMPLICATIONS AND CONCLUSIONS

Model	Price elasticity	Income elasticity
Dynamic panel data model	Short-run: -0. 65 Long-run: -1.15	Short-run: 0.34 Long-run: 0.60
Cross-section model	-0.21	0.35
Cross-section model (Zhang & Kotani, 2012)	-0.38	1.00

Table 4. Demand elasticity estimates

Our study provides the following implications for energy policies aimed at reducing coal use by rural households:

1. *Raising of coal prices will have a limited impact on household coal.* If we assume that real income grows at 2% and real coal prices grow at 9.5% per year then coal demand would decrease by only 4.7-6.2% in the short run. In that case the current coal subsidization rate of 60% (IEA, 2013) will be eliminated over ten years. This limited ability of households to adjust to rising coal prices may be related to the fact that during the heating season the indoor temperature in rural areas is low and cannot be further decreased to allow a household to economize on coal expenditures. However, the primary reason for the low price elasticity of household coal demand is lack of substitute fuels. Of all rural households for whom coal represents the primary source of space heating energy only 3% have access to central heat or network natural gas. Wood burning is not a viable alternative for most households due to the scarcity of fuel wood: forest area as share of all land area in Kazakhstan represents only 1.2%.
2. *Government plans to expand the natural gas network will be of limited consequence for rural coal-using households*. Currently, alternatives in the form of network natural gas and central heat are restricted to urban areas and some rural locations along natural gas pipelines. The government plans to achieve increasing the share of population with access to network gas from 42% to 56% by 2030. This program would benefit some of the current coal users who represent 32% of population. However, provision of access to gas in many rural areas would be extremely costly due to large distances between communities and low density of population in Kazakhstan.
3. *Electricity based space heating systems may represent a viable alternative to coal in rural areas*. There may exist several attractive technologies such as geo-thermal, direct solar, or bio-gas based heating systems suitable for application in Kazakhstan. Of all possible technologies we focus on electricity-based systems because such technologies are actively penetrating the market for heating equipment in Kazakhstan. Electric boilers are becoming popular due to the possibility of using them overnight when electricity tariffs are low. (For example, in Kostanai region in Northern Kazakhstan, 2015 tariffs were 2.6 and 11.8 US cents/kWh for night time and day time, respectively). The price of such boilers varies between $200 and $1000. Such electric boilers have 98% efficiency and require 1 kW of electricity to heat 10 m^2 of an energy efficient house for one hour, assuming that outdoor temperature is -20ºC and indoor temperature is +20ºC. As a result, the cost of electricity required to heat an energy efficient house of an average size of 70 m^2 in Northern Kazakhstan would be $45 per month if overnight tariff is used. The boiler would be on for only 8 hours during the night and the rest

of the time hot water would be circulated through the radiator system requiring minimum energy. This estimate may be compared to the cost of heating an average (low efficiency) house in Northern Kazakhstan using a combination of coal and wood which accounts for $57 per month.

4. *Conversion to electric heat is not affordable for an average rural household*. The cost of electric heating system should include expenses on purchasing the boiler, a thermostat, radiators and pipes, heat collector, and electronic meters. In addition, weatherizing the house needs to be financed. Howie and Pak (2015) estimated that the cost of purchasing and installing electric boiler heating system in Kazakhstan in 2014 was $2700. In addition, the authors estimated that the cost of weatherizing a 70 m^2 house built prior to 2000 at $7700. (Note that 94% of houses of rural coal-using households were built prior to 2000.) This means that to finance conversion to electric heat a total of $10,400 would be required compared to $9,500 which represented average rural household income in 2014.
5. *Phasing out coal price subsidies generates sufficient funds to support coal-to-electricity conversion by rural households.* Let us estimate the costs of subsiding conversion to electric heating system by rural coal users who represent around 1.586 million households. Assuming that the 50% of the weatherization cost is financed using a 15-year government bond at a 7.5% annual interest rate, the annuity equivalent payments would be $0.7 billion. Let us compare their size to the amount of annual coal subsidy in Kazakhstan. In 2011 coal price subsidy in Kazakhstan represented $5.3 billion on a post-tax basis (IMF, 2013). Since households account for roughly 19% of all coal consumed in Kazakhstan (Kazakhstan Government, 2008), the current annual coal post-tax subsidy directly attributed to household consumption is $1 billion. In other words, ignoring its inflationary effect phasing out of coal subsidies would generate sufficient funds to finance transition of rural households to electric heat. Reduced health hazard, lower pollution levels, increased thermal comfort, and released labor input necessary to serve the coal furnace represent co-benefits of avoided public spending from phasing out coal price subsidies.
6. *Developing Kazakhstan's renewable electricity potential and declining export demand for its coal will make coal-to-electricity conversion more feasible.* Phasing out coal subsidies will lead to higher electricity prices as 75% of power in Kazakhstan is generated from coal. However, an expected decline of coal exports from Kazakhstan may dampen the upward pressure on electricity prices from reducing coal subsidy. Currently, Kazakhstan exports 30% of its coal production to Russia accounting for 20% of Russian coal-firing generation needs. However, many of the Russian coal-fired plants using coal from Kazakhstan are likely to be decommissioned within the next 10 years. More importantly, Kazakhstan has exceptionally high potential of generating electricity from renewable sources. More than 50% of Kazakhstan's territory has a wind speed of 4-5 m/s at 30 meters height. Industrial scale wind farms are being developed in locations with wind speed of 8-10 m/s at 30 meters height. Average annual insolation in Kazakhstan is 1,300-1,800 kW/m^2 and average annual insolation duration is 2,200-3,000 hours. Currently, wind, solar energy, and small hydro plants account for only 0.6% of 19TW of installed capacity in Kazakhstan. However, technical potential for installed renewable electricity capacity is 354TW for wind energy and 3,760TW for solar PV (UNDP, 2014). As a result, promotion of small-scale heating technologies based on on-site heat or electricity generation should be considered. Our study shows that there is a large hidden demand for these sources of renewable energy associated with space heating needs of households in rural areas.

To summarize, our study represents the first attempt to identify and quantify determinants of household coal expenditures and coal demand in Kazakhstan. Our results indicate that, on the one hand, continued economic growth will be associated with increasing rates of coal use. On the other hand, raising coal prices will achieve moderate reduction of coal use in rural areas. As a result, addressing coal use in rural areas requires a concerted policy effort aimed at phasing out coal subsidies, designing programs supporting coal-to-electricity conversion, and promoting renewable energy technologies in rural areas.

(See references on page 39)

What Will Happen if Gazprom Stops Transiting Gas Across Ukraine?

By Robert E. Brooks

OVERVIEW

The European Union has five main sources for natural gas: indigenous production (mostly the Netherlands), Norway, North Africa (Algeria and Libya), Russia and LNG. According to Navigant Consulting's Global Market Intelligence Database, the total amount of gas consumed in the European Union amounted to about 433 billion cubic meters (BCM) in 2015, an increase of 3.9% over 2014. Of this amount 26.6% was produced in Europe and 73.4% imported. As can be seen in Figure 1, the single largest supplier of natural gas to Europe in 2015 was Russia. Of the remaining non-domestic supply, 26% came from Norway, 6.3% came from Algeria and Libya, and 10.4% as LNG from Qatar, Algeria, Nigeria and other countries.

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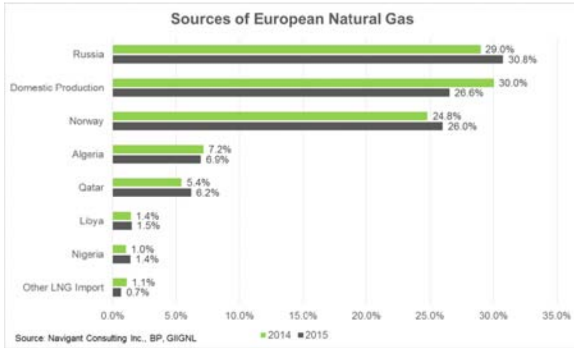

Figure 1: Sources of natural gas for EU 28 countries.

Gas from Russia entered Europe via pipelines through Belarus, Ukraine, and the Baltic Sea. The amount transiting Ukraine and entering the European Union in 2015 was 15% of total imports or a bit over 47 BCM.

The delivery of this gas to Europe is based on a transit contract with Ukraine which expires December 31, 2019. As reported in Oxford Institute for Energy Study's recent report "Russian Gas Transit across Ukraine Post-2019: pipeline scenarios, gas flow consequences, and regulatory constraints", Gazprom's earlier threats to refuse to renew or negotiate a new transit agreement have more recently been replaced with a more conciliatory attitude.

Yet Gazprom is moving forward with strategies aimed at the eventual total bypass of Ukraine.

The strategy includes two alternate routes: one north and one south of Ukraine. The north route follows the existing Nord Stream 2-string pipeline system and involves simply doubling its capacity under a new name: Nord Stream 2. The southern route was dubbed South Stream and involved a pipeline from Russia to Bulgaria across the Black Sea. Fierce opposition to this Ukraine-bypass resulted in its cancellation. It was subsequently revived as the Turkish Stream Pipeline (also known as TurkStream). In this variant, the Black Sea route skirts Bulgarian waters and lands in far Northwest Turkey where it connects with the Turkish national system (Botaş) and perhaps in the future to other pipelines moving gas into Southeast Europe.

Figure 2: Gazprom pipelines to Europe

Complicating this picture further is a pipeline which is already being built to bring gas from the giant Shah Deniz field in the Caspian Sea to consumers in Turkey, Greece, and Italy.

This project is called the Southern Gas Corridor. It consists of the giant Shah Deniz gas field in the Caspian, the South Caucasus Pipeline Expansion, the Trans-Anatolian Pipeline, and the Trans-Adriatic Pipeline. Principal owners of the project are Azerbaijan's SOCAR, Turkey's Botaş, and BP. Gas produced in Shah Deniz is contracted to supply Turkey, Greece, and Italy. Additional pipes such as the Greece-Bulgaria Interconnector (IGB) and the Ionian Adriatic Pipeline (IAP) will expand the reach of Caspian gas to growing markets in the Eastern and Western Balkans.

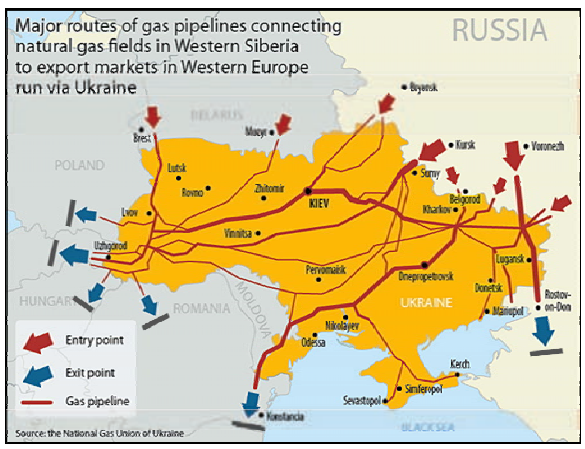

Figure 3: Gazprom entry points into Europe through Ukraine

Not only is there a lot of gas in Shah Deniz (1,000 BCM), but there is substantial gas in other fields in the Caspian as well as gas across

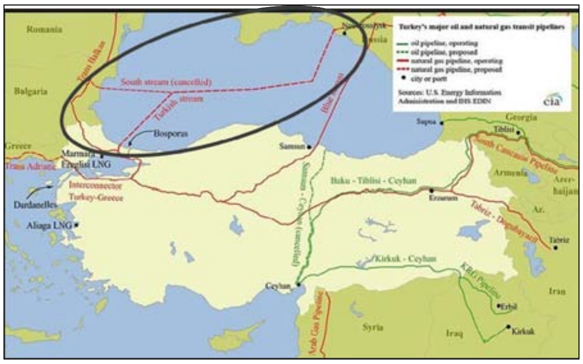

Figure 4: South Stream and Turkish Stream pipeline routes

the Caspian in Turkmenistan which could potentially become part of the solution to Europe's goal of gas supply diversification. This could be accomplished by building the Trans-Caspian Pipeline from Turkmenistan on the east side of the Caspian to the Trans-Caucasus Pipeline on the west. Significant further expansion of the Southern Gas Corridor project would be required to move this gas to Turkey and on to Europe.

Given this situation, the question presents itself: if Gazprom carries through with its threat to stop gas transit into Europe via Ukraine, can the proposed new pipelines moving new gas supplies from the Caspian fill the void? If so, at what cost? And, if not, what would be the likely impact in terms of supply shortfall and price impact?

In order to answer these questions, the author undertook a study involving a set of market evolution scenarios using the G2M2™ Global Gas Market Modeling System developed by RBAC, Inc. (www.rbac.com).

Figure 5: Southern Gas Corridor

G2M2 is a monthly model which can be used to run scenarios out to 2050 or beyond. It contains information allowing backcasting and calibration from 2006 through 2015. Over 100 countries are represented in the model, included all natural gas and LNG producers as well as all countries which receive gas by pipeline or LNG tanker. Large countries such as the United States, Canada, Russia, and China are divided into sub-country regions. Pipelines connect the regions together in integrated national networks. Over 400 pipelines and seven LNG tanker classes are included in the base model. Users can add their own representations of proposed or hypothetical new transportation infrastructure. Base case supply and demand curves are included with G2M2. Users can replace these with their own assumptions to create their own base cases as well as alternative scenarios.

SCENARIO DESIGN

For this study we designed a Base Case and several alternative scenarios. The base case might be called the "Business-As-Usual" scenario. In it we assume that Gazprom and Ukraine work out their differences and the transit agreement is extended on the same terms as currently exist from 2020 through the end of the forecast period (2040).

Base Case

These are the basic assumptions for the base case:

- Gas supply and demand forecasts
  By Navigant Consulting based on IEA outlooks, World Bank population growth trends, and BP reserves and production data
- LNG liquefaction and re-gas capacity growth
  Based on approved projects and those projected by Navigant Consulting to be built
- Gazprom and Ukraine Agree to extend transit to 2040
- Opal continues to be constrained to 50% capacity
- Southern Gas Corridor (SGC)
  16 BCM line in-service 2019 (Turkey), and 2020 (Greece, Italy)
- SGC expansions
  24 BCM in 2023 and 32 in 2026
- Trans-Caspian Pipeline does not get built
- Turkish Stream and Nord Stream 2 do NOT get built

G2M2 is a trademark owned by RT7K, LLC, and is used with its permission.

Alternative Scenarios

A set of alternative scenarios were generated to forecast the effect of a cessation of Russian pipeline transit through Ukraine. In the most severe scenario, no additional new pipelines or LNG terminals are built and in service during the forecast horizon, beyond the Southern Gas Corridor and the Ionian Adriatic Pipeline. This is the “No UKT” – No Ukraine Transit or “Do Nothing” scenario.

The other alternative scenarios comprise various combinations of additional pipelines including Turkish Stream (TS), Nord Stream 2 (NS2), Trans-Caspian (TC), and a hypothesized Southern Gas Corridor Expansion (SGCX). The alternative scenario details are shown below:

No UKT:

No Ukraine transit + SGC (16 - 32 BCM, 2019-2020) + Ionian Adriatic Pipeline (5 BCM, 2029)

No UKT + TS:

No UKT + Turkish Stream (2020)

No UKT + TS + NS2:

No UKT + Turkish Stream (2020) + Nord Stream 2 (2020)

No UKT + TC + SGCX:

No UKT + Trans-Caspian Pipeline (2029) + SGC Expansion (to 64 BCM, 2029)

No UKT + TS + TC + SGCX:

No UKT + Turkish Stream (2020) + Trans-Caspian Pipeline + SGC Expansion (2029)

SCENARIO RESULTS

Figures 6 and 7 show the Base Case results for total European gas supply by source and wholesale market prices to Europe and other regions of the world from 2011 to 2040. A significant reduction in European gas production is offset by increases in pipeline and LNG imports. Total supply grows to its 2011 level by 2025 and holds there until slowly declining after 2030.

The convergence of global prices is forecast to be a temporary phenomenon with divergence occurring in the 2020’s due to a continuing growth of demand in Asia, expiration of existing LNG contracts, and a tightening of the LNG market due to cancellation of long lead projects in the period to 2020.

The effect of the cessation of gas transit through Ukraine is to reduce availability of Russian pipeline gas into Europe. One would predict that this reduction would tend to increase demand for higher priced LNG and thus to increase the average wholesale market price, which it does. See Figures 8 and 9.

As expected the biggest jump occurs in the “No UKT – Do Nothing” scenario. The initial increase is about 125 USD/MCM (approx. $3.50/mmbtu), rising to almost 200 USD/MCM ($5.50/mmbtu) by the mid 2030’s. The least impact scenario, which includes both Turkish Stream (at 32 BCM) and Nord Stream 2 (at 64 BCM), results in a much lower price impact of 95-105 USD/MCM or about $2.50-3.00/mmbtu.

Higher gas prices in Europe have one positive effect: they attract more LNG imports. Additional supplies from North America increase total European LNG imports by 25 – 50% for the various “No UKT” scenarios in comparison with the Base Case.

But LNG imports cannot make up for the loss of pipeline imports through Ukraine.

Figure 10 shows the change in total imports into Europe for the “No Ukraine Transit” scenarios when compared with the “Business-As-Usual” base case. The scenario which includes both the Turkish Stream and the Nord Stream 2 pipeline does best, but it still delivers between 13 and 25 BCM/Y less than the base case in the years

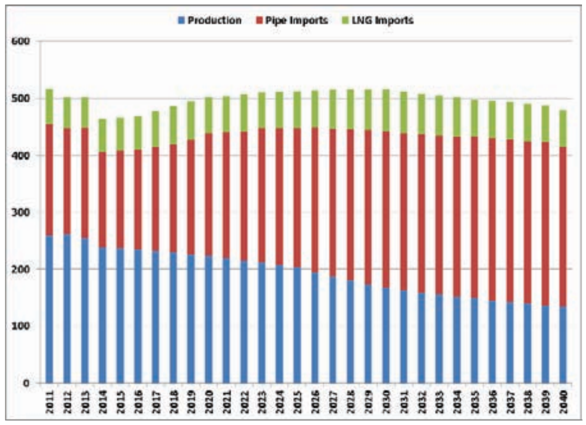

Figure 6: European Gas Supply 2011-2040 (BCM/Y)

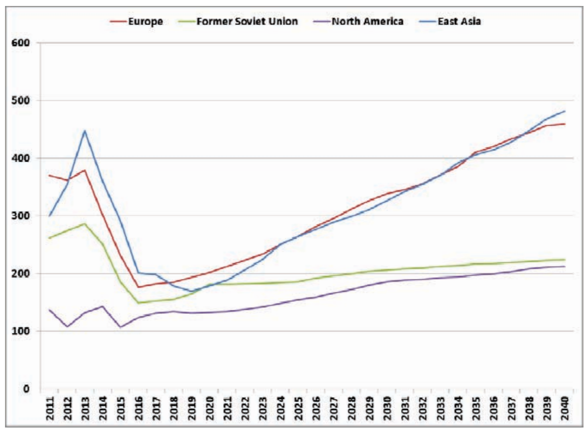

Figure 7: Average Annual Gas Price (USD/MCM)

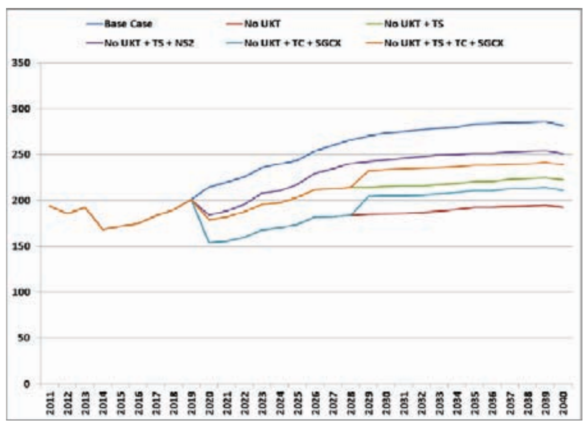

Figure 8: Pipeline deliveries to Europe (BCM/Y)

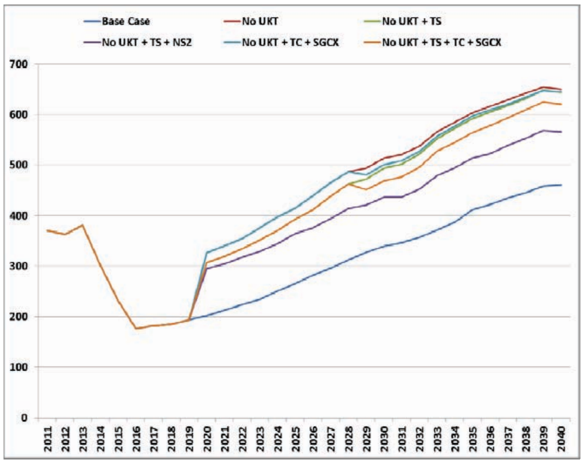

Figure 9: Average wholesale delivery price in Europe (USD/MCM)

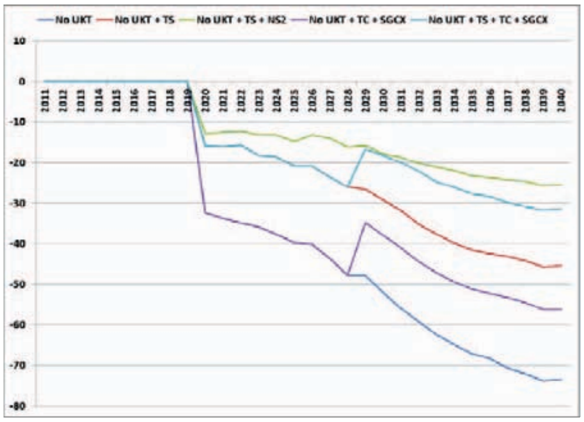

Figure 10: Total imports compared to base case (BCM/Y)

from 2020 to 2040. These projects cannot replace the lost gas due to the end of Ukraine transit.

CONCLUSIONS

From the scenarios we have run, the effect of a shutdown in gas transit across Ukraine leads to the following conclusions:

1. Europe needs Caspian gas from Azerbaijan

a. Supplies intended for Europe are needed in all scenarios, including the Business-As-Usual scenario
b. SGC and its expansions will be highly utilized
c. Faster ramp-up of SGC would be helpful

2. Gas from Turkmenistan will also be needed

a. Reduced supplies from Russia mean Europe will need Turkmen gas transported by the Trans-Caspian Pipeline and an additional expansion of the Southern Gas Corridor

3. Turkish Stream will help

a. But it needs a new downstream pipe to take gas further to Central and Western Europe

4. More LNG will be needed

a. LNG imports increase in all scenarios, but not enough to make up for lost Russian gas

5. Much higher prices will be required

a. to attract additional pipeline gas and LNG to Europe

6. But all proposed pipeline solutions will not be sufficient

a. They cannot make up for all the gas lost to Europe if the Ukraine transit issue is not resolved

The scenario results show that even with the expected low growth of the European market, where much of this growth is centered in Turkey, the cessation of gas transit across Ukraine into central and southeast Europe would have a substantial negative effect on both gas supply and price.

The building and expansion of planned pipelines such as South Caucasus Expansion, Trans-Anatolian Pipeline, and Trans-Adriatic Pipeline is insufficient to make up the loss. Completion of new pipelines such as Turkish Stream, Trans-Caspian Pipeline, and Nord Stream 2 would help, but not be sufficient.

Something else is needed. If a new transit agreement between Gazprom and Ukraine is not achieved, a doubling of Turkish Stream to 64 BCM/Y coupled with the completion of the proposed Nabucco West Pipeline between Turkish Stream and Austria or the ITGI Poseidon Pipeline between Turkish Stream and Italy might compensate for the loss in European gas supply. (In a follow-up study, we intend to run this scenario to see if it could make up for this loss and, if so, at what cost.)

There are many political obstacles to making such a hypothetical solution happen. From our study we conclude that the best outcome for Europe and Russia is the "Business-As-Usual" scenario where Russia/Gazprom and Ukraine/Naftogaz design a new transit agreement which both can live with. This solution would best promote the energy security which both Europe and Russia long have sought.

ACKNOWLEDGMENTS

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Navigant team members Gordon Pickering, Ed O'Toole, Angelo Lan, and Jeff Van Horne are particularly thanked for their assistance in model and results evaluation, data research, data compilation, demand modeling, and LNG and pipeline transportation insights.

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Their contributions made this study possible.

Energy Efficiency and Jobs –a case Study of Israel

By Ulrike Lehr, Anke Mönnig, Rachel Zaken and Edi Bet-Hazadi

OVERVIEW

For many years, Israel had few domestic conventional energy resources. The discovery of large gas reserves in the Mediterranean and the exploration of said reserves has changed the picture. Israel developed from a country which meets its fossil fuel needs fully from imports to a country considering gas exports in the near future. Electricity generation plants today run increasingly on natural gas as opposed to coal several years ago.

However, the new natural gas findings are not limitless with a volume of approximately 900 billion cubic meters. Electricity demand is growing and will continue to grow in the future, driven mainly by three factors.

- Population growth: Israel's population is still growing with high fertility rates;
- Increasing degree of being equipped with electrical devices: Rising living standards of social groups, which are thus far underequipped with electric appliances parts and changing climatic conditions due to climate change lead to the projection of increasing percentages of households being equipped with e.g., air-conditioners. Israel already experiences increased temperatures and frequency of heat waves.
- Additionally, temperature peaks during the summer days requires more electricity for cooling office spaces, but also hospitals, schools and universities.

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Increasing energy efficiency can be regarded as a source of energy. As such, it is among the least environmentally harmful sources of energy and the least expensive. Reducing electricity consumption saves primary energy inputs, decreases a country's energy dependence and hence a country's dependence from imported fuels, if it not self sufficient. Acknowledging this, the Ministry of National Infrastructures, Energy and Water Resources in Israel has developed the NEEP, the National Energy Efficiency Program. This program aims at reducing electricity consumption between the years 2010-2020, and it states: "this will save the construction of power plants with an overall capacity of 3,400 Megawatts, and will allow us to meet the government's efficiency objectives. In economic terms, this means the saving of approximately U.S$ 4.25 billion." (NEEP 2010). Today, in 2015, as half of the time horizon of the program has passed, it is time to evaluate the economic impacts of the past five years and estimate the upcoming development. While the energy savings are stated clearly in the NEEP, economic effects in terms of jobs and value added are not included. Therefore, this contribution focuses on estimating employment from energy efficiency according to the NEEP, considering additional investment in energy efficiency triggered by the measures described in the NEEP.

MODELING ECONOMIC EFFECTS OF MORE EFFICIENCY

Additional investment in energy efficiency, as any other investment, leads to additional demand for certain goods and services. Energy savings free budgest and trigger further economic effects. Figure 1 gives an overview of the economic effects of increased energy efficiency. Investment may change relative prices, as the cost for investors are recovered through unit costs or, in the case of buildings, higher apartment rents. Investment in energy efficiency could also crowd out alternative investment purposes, which might have led to larger economic benefits. Energy savings reduce energy imports, lower individual energy expenditures and free budget for non-energy expenditures. The reduction of imports improves the trade balace. Lower energy demand, however, has negative effects on industries, whose main source of income is energy supply. Higher demand for non-energy products increases production of these goods. If they are produced domestically, this increases employment in the respective country, otherwise it leads to more imports and

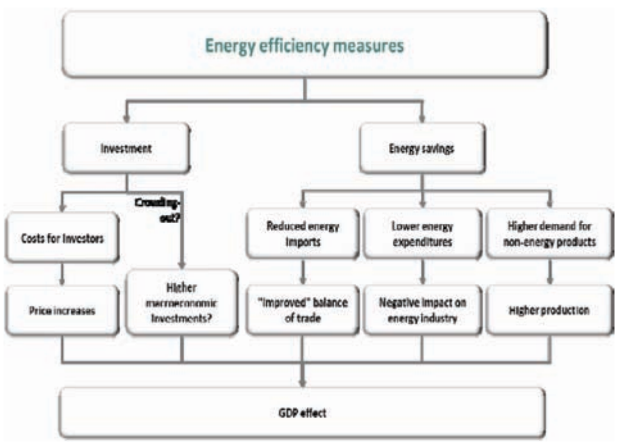

Figure 1: Economic effects of increased energy efficiency
Source: GWS, own graph

more jobs abroad.

To quantify economic effects of increased efficiency, we follow suggestions by OECD/IEA. OECD and IEA have issued a comprehensive volume on the economic effects of energy efficiency (OECD/IEA, 2014). The chapter on macro-economic effects states: "(….) economy-wide effects occur at national, regional and international level in relation to impacts that result from energy efficiency policies. (...) In general, the macroeconomic impacts of energy efficiency are the product of two types of effects associated with energy efficiency measures:

- investment effects being the results derived from increased investment in energy efficiency goods and services
- energy demand or cost reduction effects, which comprise the effects arising from the energy demand reduction (or reduced costs) associated with actually realizing an improvement in energy efficiency.

OECD/IEA (2014) then gives an overview of the type of models being used to capture the economic effects of additional energy efficiency. They list models based on different approaches, but most include the use of input-output-tables to model the impact of efficiency measures on the level of industries and economic sectors. This is in accordance with the literature on measuring employment effects of renewable energy increases (for an overview and methodological recommendations on RE see IEA-RETD 2013).

The approach applied in the following is also based upon IO-theory. Employment from additional investment in energy efficiency is estimated as direct employment (investment* labor intensity of the respective sector) and indirect employment from the Leontief approach (see below) using input-output–tables. This allows to take a deeper look into the economic structure of Israel and the interlinkages of production between different sectors. Thus, the approach not only yields estimates for direct employment from additional investment, but takes into account local value chains and indirect employment through the provision of inputs. The more a country is industrialized – and integrated, the more relevant this aspect. A simple model can be derived from these ideas, being based upon statistical data including input output data, employment data, national accounts and projection on GDP growth and population development.

The results of this modeling exercise cannot simulate all effects in Figure 1, because price adjustments are not included. However, it can give a first round estimate to investment effects and effects from energy saving. Further, the difference between impacts from different policy measure targeting different sectors can be identified. For a full assessment, price mechanisms have to be included in the analysis.

The inputs to domestic production and services are obtained from Israel's input-output tables, provided by the Central Bureau of Statistics. Input-output tables provide information on the inter-industrial linkages of production in an economy and thus allow for the calculation of indirect employment. The underlying idea is that additional production in one sector triggers production in all sectors which produce intermediary input for this production. The effect perpetuates through the economy. Solar water heaters produced in Israel, for instance, are built with inputs from other industries (tank: metal fabrication and coating, glass: cover, electrical devices: cables) which partly are produced in the country, too. Solar water heater expansion therefore leads to additional employment in these industries. Additional effects come from installation, wholesale and planning, plus the inputs to these services. We developed a simple macro driven IO- model for Israel (e3.isr) to estimate and forecast future employment.

For the ex-post analysis, capacities installed in the past are observable. Future installations are taken according to the NEEP. Investment, i.e., the costs of new equipment or of the improvement of buildings, the share of imports and domestically produced goods and the costs of sales were estimated with the help of experts from Israel. Our thanks goes in particular to Rachel Zaken and Edi Bet-Hazavdi from the Division for Resources Infrastructure Management, Ministry of Energy and Water Resources in Israel.

The COP21 negotiations and their globally welcomed results lead to the definition of a second scenario, called the Post Paris Scenario, because the Government of Israel has pledged additional support and funds for measures which exceed the scope of the NE. However, since the use of the funds is not yet as detailed as the NEEP, the Post Paris Scenario should be read more as a sensitivity.

RESULTS

Annual investment in measures to increase the efficient use of electricity in households, public administration, buildings, industry, trade, agriculture and the water sector on average amounts to 1.4 billion NIS. The amount increases over time. Almost 2/3 of the investment goes to new energy efficient buildings, residential and commercial. The remaining third is spent on efficient appliances in the private, commercial, industrial and public sector. A large share of these appliances are imported so that the economic impact of efficient appliances comes from installation and wholesale of the equipment. Most appliances such as fridges or stoves do not need operation and maintenance from an expert, thus employment effects in O&M are also low.

The other important driver of economic effects is the additional budget from energy savings. Without detailed data on the use of this additional budget, we assume that part of it is spent according to the historic consumption pattern in the households' case. Industry and public domain use the savings to refinance the investment in energy efficiency.

With these assumptions the measures from NEEP and cross sectional activities lead to a plus of 5,645 people in the year 2020. The additional employment rises with increasing investment along the time path, and increasing returns from energy savings. The impact on economic sectors reflects the heavy focus on buildings: the largest effect is in the construction sector.

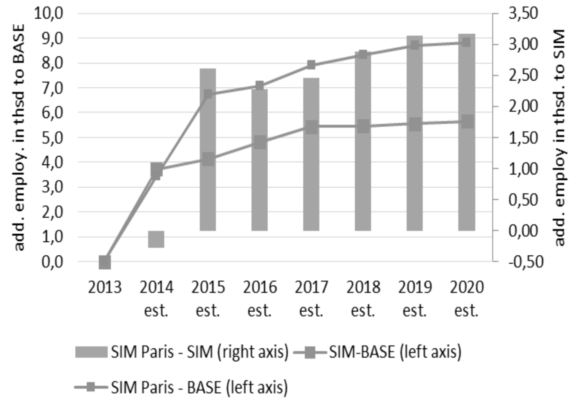

Figure 2: Employment from additional efficiency, two simulations compared to base and to each other.
Source: Own calculation.

The Post Paris scenario assumes additional investment in energy efficiency, but mainly targeting industry, local authorities, commercial and public purposes. For energy efficient household appliances, a new regulation is planned and this will lead to a slower deployment of the efficient appliances than before. Monetary support has led to early replacements in the NEEP scenario. Without further data, we assume that the additional funds and support are distributed in the same pattern as before – without the support of household appliances. The Post Paris Scenario leads to additional employment of almost 3,200 people, so that the overall employment from increased efficiency and energy savings reaches 8.8 thousand jobs. Additional employment is found in the construction sector, wholesale and trade as well as all entertainment, sports and cultural activities. The construction sector is involved in several activities: energy efficient buildings, installation of appliances and improvement of energy efficiency in hotels, local authorities, public and commercial buildings. Wholesale and trade is gaining from two drivers: firstly, all appliances have to be imported/ sold and traded and secondly, the additional budgets are spent on consumptive uses. The latter three sectors are good examples of this: additional household budget are spent on cultural or sporting events and entertainment.

CONCLUSIONS

The effects compare well to the literature. For Germany, effects from efficiency increase were estimated to be around 200,000 persons (Pehnt et al. 2012), but additional investment amounted to more than 20 billion Euro per year at the peak. Tunisia, on the other hand, has an efficiency component in its Solar Plan. The Solar Plan creates 6,000 additional jobs, from roughly 1 billion Tunisian Dinar (around 400 million Euro) investment. This, however includes renewables as well. The Tunisian labor productivity is much lower than labor productivity in Israel, therefore employment effects from roughly the same amount (1.3 billion NIS convert into roughly 300 million Euro) are relatively low.

At least two conclusions can be drawn from this exercise and the international comparison: Firstly, producing energy efficiency equipment tailored to the special needs of Israel could lead to more job opportunities in the respective industries. As long as most equipment is imported, effects on the labor market are low. Secondly, given the challenge of increasing energy demand, the effort of the energy efficiency plan is not ambitious enough. Energy security is not about resources and reserves alone. It also is about infrastructure, investment in additional capacities and enhancing the grid. Especially at peak times this can be a costly challenge and energy efficiency the less costly option.

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Household Energy Consumption and Energy Poverty in Kazakhstan

By Aiymgul Kerimray, Rocco De Miglio, Luis Rojas-Solórzano, and Brian Ó Gallachóir

INTRODUCTION

Lack of access to modern fuels, high fuel prices, poor building insulation, and income poverty are among the underlying causes of current global energy problem. Kazakhstan may be particularly highly affected by this phenomenon due to the high heating demand and the severe continental climate, as well as due to the high use of coal and biomass in some of its regions. On the other hand, Kazakhstan is rich with energy resources and prices for energy remain low and not reflective of the true cost of supply.

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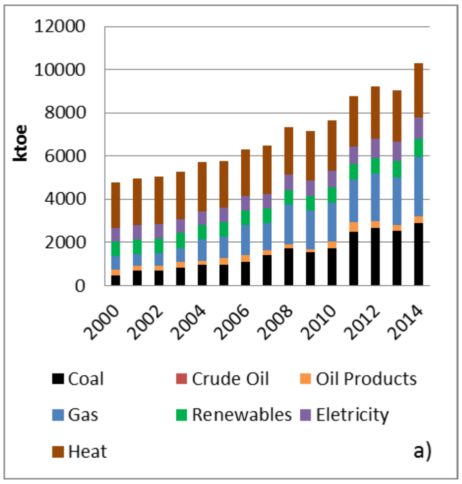
Despite widespread access to district heating and natural gas networks in urban areas, many households in remote regions still use solid fuels for heating purposes in Kazakhstan. Residential coal consumption per capita in Kazakhstan is one of the highest in the world (IEA, 2015). A 30% share of all households used coal as a primary source for heating, increasing to 67% in rural areas (Atakhanova and Howie, 2013). Incidences of deaths due to carbon monoxide poisoning in households in Kazakhstan are reported periodically during winter time in the local media. However, there are very few studies on indoor air pollution and household energy consumption in Kazakhstan. It is essential for decision makers and the general public to understand the patterns, determinants and implications of household energy consumption. This paper reviews residential energy consumption trends in Kazakhstan, energy efficiency potential in buildings as well as the incidence energy poverty across the regions of the country.

RESIDENTIAL ENERGY CONSUMPTION TRENDS

Between 2000-2014, energy consumption in the residential sector has grown rapidly, with the average annual 6.3% growth rate (Figure 1) (Kerimray et al., 2016a). The growth has been mainly driven by income growth, penetration of household appliances, as well as expansion of household living spaces. With the economic development of the country dependent mainly on oil and gas revenues, average household income has grown by a factor of 3.4 (Committee of Statistics of the Republic of Kazakhstan, 2015) during that period of time (2000-2014). Low energy prices and lack of interest in energy efficiency measures have also contributed to the rising energy consumption. Population growth affected energy consumption to a lesser extent, since during the same period it has grown only by 17% (Committee of Statistics of the Republic of Kazakhsta, 2016a). Policies to stimulate energy efficiency improvements such as installation of heat metering devices, mechanisms for financing building retrofits have been adopted recently in 2013 and the impacts may still not be evident from 2000-2014 energy consumption trend.

Coal and network gas were the highest growing fuels in the final consumption of the household sector (Figure 1). Coal is the least expensive energy source and there are large reserves of coal in Kazakhstan. The growth of network gas consumption is explained by expansion of natural gas distribution pipelines in the communities located near the main pipeline in the West and South Kazakhstan. District heating system gross participation remained nearly constant between 2000-2014 since the district heating system was not expanded significantly. (Figure 1). District heating is generated at CHP plants (55%) and heat plants (45%), with coal used as a fuel in 64% of total heat generation (Kerimray et al., 2016a).

In 2013 total residential energy consumption per capita in Kazakhstan almost reached the average OECD level, while electricity consumption per capita in the country remains 3.5 times lower that OECD average (IEA, 2015). High consumption of non-electricity commodities in Kazakhstan is due to several reasons. Heating is one of the basic living needs in Kazakhstan due to severe continental climate, and it is the largest end-use energy demand in residential buildings. The heating season is more than half a year long in most of its regions and resulting in approx. 6,000 heating-degree days in its Northern and Central regions. The annual building energy consumption for heating is 270 kWh/m2 on average, which is more than two times higher than average European levels (100-120 kWh/m2) (Government of the Republic of Kazakhstan, 2013). Severe climatic conditions coupled with dilapidation of housing stock and poor penetration of energy efficiency technologies contribute to the high energy consumption. In urban areas, inefficient district heating system, and absence of customized heat supply stations



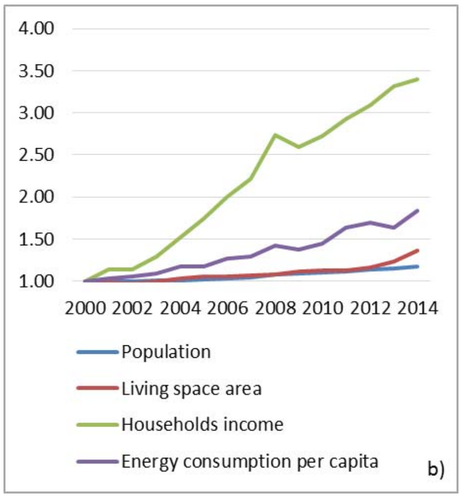


Figure 1 – a) Residential energy consumption trend in Kazakhstan 2000-2014 (Reclassified Energy Balance NU-NLA, Kerimray et al., 2016a) and b) Indices of population, living space area, households income (constant prices) and energy consumption (2000=1) (Committee of Statistics of the Republic of Kazakhstan, 2015)

often lead to overheating. Furthermore, the results from Households Survey demonstrated that electricity is rarely used for heating purposes, despite 100% electrification rate in the country and relatively low electricity prices.

HOUSEHOLD FUELS USE. INSIGHTS FROM HOUSEHOLDS LIVING CONDITIONS SURVEY

This study combines and analyses data for the year 2013 from the Households Survey on Living Conditions and Households Budget Survey (Kerimray et al., 2016b). These surveys are administered by Committee of Statistics of the Republic of Kazakhstan. The households were selected by random sampling based on Population Census. The survey covered 12000 households representative at urban/rural and regional level.

The electricity access rate in Kazakhstan is 100%, although access to network gas and district heating system remains largely uneven between urban/rural households. Rural households in Kazakhstan have lower access to district heating and to the gas network, hence these areas mainly rely on coal, wood and LPG for heating and cooking (Figure 2). Notably, 33% of surveyed households used more than 2 fuels during the year, the use of which varies by quarter.

The highest number (2636) of households in the survey use central heating and gas, mainly in urban areas. The second most popular fuel combination is coal, LPG and firewood, used mainly by rural households having no access to gas or district heating. A further 1656 households, mainly in rural areas, use a combination of coal and LPG. Importantly, combinations with central heating are mainly urban, and combinations with coal are mainly rural. LPG penetration is significant in the country and it is used by 54% of all surveyed households.

Regional disaggregation of the survey results helps to provide insights into the underlying reasons for fuel choice, as shown in Figure 3. Most of the oil and gas reserves of the country are located in Western regions and gasification of these regions is the highest in the country with nearly zero coal consumption (except for Aktobe region). The survey result demonstrate that 40% of all surveyed households use coal. There is a strong (up to 91%) dependence on coal in rural areas of North, Central and some South regions. Analysis of income levels of coal users demonstrated that 23-34% of the richest income deciles (8-10) still used coal, indicating that there is a lack of access to other cleaner alternatives and/or low awareness of negative health effects from solid fuels combustion and on benefits of cleaner alternatives.

Analysis of quarterly variations of energy expenditures has shown that coal and firewood are mainly used for heating during cold seasons, while LPG and electricity are used throughout the year. Importantly, firewood and coal were commonly used together with LPG, with the last being used mainly for cooking purposes.

BUILDING ENERGY EFFICIENCY. INSIGHTS FROM BUILDINGS ENERGY AUDIT REPORTS

To explore energy efficiency potential, 586 residential building energy audit reports conducted across the country were collected and analysed. The results depicted that most of the buildings had high potential for energy efficiency improvement since most of them had poor insulation properties, heating pipes were uninsulated, automated heat supply stations were absent, among many other defficiencies.

The heat transfer coefficient of building walls (U value) in Kazakhstan is significantly higher than in European countries with similar climates. Within European countries, U values of walls range from 0.2 W/m²K to 0.8 W/m²K (IEA, 2008). In Kazakhstan by contrast, despite its more severe climatic conditions walls have poorer insulation properties, with U value of 0.85-1.2 W/m²K.

From the 586 buildings energy audit reports being analysed, the energy efficiency options which were proposed in the majority of buildings were listed as: installation of heat metering device (469), insulation of heat distribution station and heating pipes (445), installation of automated heat supply station (384) and replacement of incandescent lamps with energy saving units (378). This clearly indicates that even the basic energy efficiency measures and energy monitoring are not utilized currently in Kazakhstan. These measures have a payback period of less than 10 years. While, such measures as the insulation of walls, installation of automated heat supply station, insulation of roofs and the replacement of general windows have a payback period of more than 40 years and, therefore, are unlikely to be implemented by homeowners, without supporting mechanisms from the Government. Importantly, the prices for energy used by energy auditors assume gradual increases as planned by the Government.

Low energy prices, lack of energy metering devices and, as a consequence, low interest of homeowners to pay for refurbishment and low effectiveness of mechanisms for maintenance and refurbishment of buildings are the main barriers for energy efficiency improvement in Kazakhstan (Government of the Republic of Kazakhstan, 2013). In 2012 the Government created a fund for the development of housing and utilities with the aim to provide credits for housing and utilities projects with a return financing mechanism. However, up to now there is no information of progress towards achieving this target and the effectiveness of the fund. Removing energy subsidies and the rise of energy prices alone may impact on low income, energy poor population. In this regard, effective financial subsidies and government interventions are necessary to achieve energy efficiency improvements in residential buildings.

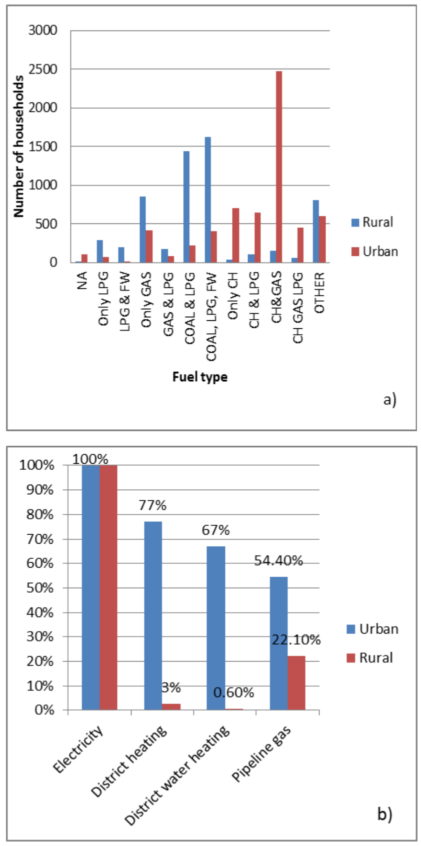


Figure 2 – Number of households by fuel combinations used by urban/ rural divide (CH- central heating, GAS-distribution network gas, LPG- liquefied petroleum gas, FW – firewood) and b) Households access to energy services in 2014 (Committee of Statistics of the Republic of Kazakhstan, 2015)

ENERGY POVERTY

Within the EU, the most commonly used metrics for determining whether households are experiencing fuel poverty are the ratio of energy expenditure (necessary to heat homes to a comfortable level) and household income (Pye et al., 2015). The IEA (2010) provided a definition of energy poverty as a lack of access to clean and commercial fuels, efficient equipment and electricity, and a high dependence on traditional biomass. In the case of Kazakhstan both definitions may be applicable: fuel poverty from energy affordability perspective and energy poverty taking into account fuel cleanness.

One of the main challenges in estimating fuel poverty in Kazakhstan is the lack of data and the need for complex modelling. Thus, 10% income indicator to Kazakhstan requires estimating the "theoretical" energy consumption required to heat a home to the comfortable level (according to WHO recommendations). Pye et al. (2015) highlight that modeling of households energy requirement is complex, and it requires understanding of the building stock, household composition, occupancy and geographical location. In Kazakhstan the specifically dedicated Households Energy Consumption Survey has not been conducted, which makes it very complex to perform such analysis. In this study, based on the Households Budget Survey data, the households spending on energy (all energy sources) more than 10% threshold were filtered to analyze energy affordability aspect as a first estimate of energy poverty. Thus, this paper uses "actual" energy expenditure instead of "required" energy expenditure, due to data limitation.

Applying "10% household income expenditure on energy" metric to data for Kazakhstan, resulted in 28% of surveyed households being energy poor, with the majority (68%) located in rural areas. Results indicate that despite relatively low energy prices and energy resourses abundance in the country, there are still issues of energy affordability in many households due to combination of income inequality, high heating demand and buildings inefficiencies. Figure 4 below compares income poverty (first three income deciles), Gross Regional Product (GRP), energy poverty (10% indicator) and coal users by regions of Kazakhstan. The survey results demonstrate that there are significant differences in income poverty and GRP by regions of Kazakhstan.

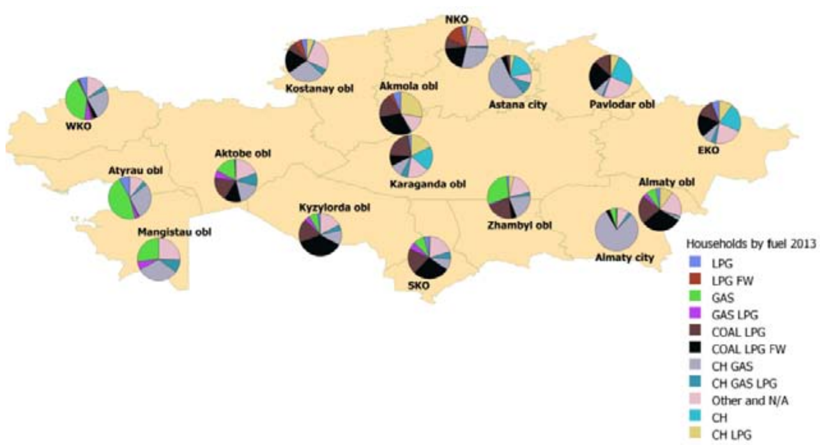


Figure 3 - Share of households by fuels used by regions of Kazakhstan (CH- central heating, GAS-distribution network gas, LPG- liquefied petroleum gas, FW – firewood)

In most of the regions there is a strong cor-

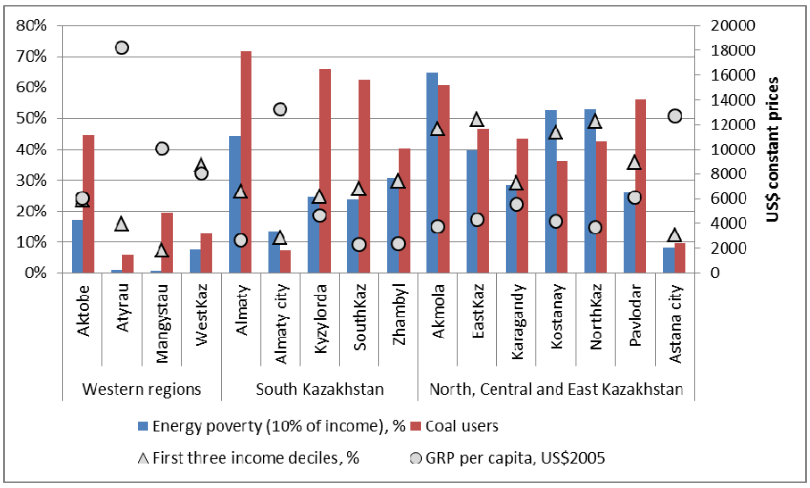


Figure 4 - *Percentage of households energy poor, percentage of households in the first three deciles in 2013 (with 10% indicator and clean fuel* **access indicator) (left axis); GRP per capita, US$ 2005 (right axis) (Committee of Statistics of the Republic of Kazakhstan, 2016).**

relation between income poverty and energy affordability. Thus, richer western regions (oil and gas producers) and two cities have low incidence of energy poverty and coal users, while there is much higher prevalence of income poverty, energy poverty and coal users in the North, Central Kazakhstan. Thus, diversification of the economy, regional economic development and reducing income inequality should play a crucial role in alleviating incidence of energy poverty in the country.

CONCLUSIONS

Kazakhstan is a country rich in energy resources with energy prices considerably lower than in developed nations, but with very particular conditions that affect the level of energy poverty in its population. Household survey results and analysis including energy audits depicted that there are problems with energy affordability and with access to clean energy in Kazakhstan, which can be summarized as:

- 40% of surveyed households used coal, with 21% of them being in the richest three deciles;
- 28% of surveyed households were energy poor according to "10% of income"indicator.
- Nearly absent penetration of basic energy efficiency options such as heat metering devices, heating pipes insulation and energy efficient ligting system.
- There are large disparities in fuel use, household income, and energy affordability between regions of Kazakhstan.
- In most of the regions there is a strong correlation between income poverty and energy affordability. Households in the West are generally richer, while the higher number of poor households are in North and Central Kazakhstan. Households located in the North Kazakhstan, Central and East Kazakhstan mainly suffer from lack of cleaner fuel options, income poverty, longer and colder winters as well as energy affordability.

Therefore, from the analysis presented in this paper, the authors suggest the following list of actions to be considered in further detail in upcoming studies in order to tackle the energy problem in the country:

- Development of more relevant to local realities "composite" metrics and definition of energy poverty for Kazakhstan, which considers important aspects including energy affordability, clean fuel access and fuel poverty "depth". Future work should be conducted to model required fuel use and costs. Specifically dedicated surveys which take into account housing conditions, heating technologies and thermal comfort are needed to identify energy poor and to conduct targeted interventions for energy poor.
- Development of effective programs to stimulate energy efficiency improvements in households.
- Improvement of regional economic condition and reduction of income poverty in the poorer regions should become one priority.
- Extension of gas network will improve the access to cleaner alternatives, but higher gas prices may worsen affordability aspect. Since gas pipeline construction is timely and costly and if finally realized will not cover all the remote regions, support schemes and other alternatives such as renewable and alternative energy sources of heat (e.g., heat pumps, LPG, solar thermal) should be implemented.
- Regionally specific intervention programs and indicators are crucial due to vast disparities in climate, economy and access to energy among the regions of Kazakhstan.

See references on page 58

Modeling Disaggregated Energy Consumption: Considering Nonlinearity, Asymmetry, and Heterogeneity by Analyzing U.S. State-level Panel Data

By Brantley Liddle

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OVERVIEW

This project models the demand of energy consumption at several different levels of aggregation by analyzing U.S. state-based panel data and by using methods that address both nonstationarity and cross-sectional dependence. In addition to considering possible nonlinear relationships between energy consumption and income, possible asymmetric relationships between energy consumption and both income and price are allowed and calculated. U.S. state data is rich since the (i) there is diversity among the states; and (ii) the states are (mostly) geographically connected, share institutions, and exhibit free movement of people, capital, and goods. Previous work has argued that price changes may be asymmetric (eg., Gately and Huntington 2002). More recent work has considered that the impact of income on carbon emissions may be asymmetric as well (e.g., York 2012; Burke et al., 2015).

DATA & METHODS

The U.S. Energy Information Agency (EIA), as part of the State Energy Data System (SEDS), collects state-level data of disaggregated energy consumption and the corresponding prices at those levels of disaggregation. The Bureau of Economic Analysis (BEA) collects data on real GDP per capita and economic structure, also at the state-level. These two data sets are combined to create a panel of the 50 U.S. states over 1987-2013. The following five dependent variables are analyzed: total energy consumption per capita, industrial sector's energy consumption per capita, transport sector's energy consumption per capita, and the electricity consumed per capita in the residential and commercial sectors.

Since not all manufacturing is energy intensive, the industry energy consumption regression includes the share of industry GDP that is derived from the most energy intensive sectors (e.g., mining, non-metallic minerals, primary metals, paper products, and chemicals, petro-chemicals, and rubber). Also, because electricity consumption in buildings is impacted by weather, the residential and commercial electricity regressions include the average heating degree days and the average cooling degree days (data from the National Oceanic and Atmospheric Administration). Lastly, since population density has been demonstrated to be negatively correlated with transport (e.g., Liddle 2013a), the transportation energy regression includes population density.

Given the stock-based nature of the data and the fact that the U.S. states are not independent, we expect the data to exhibit both cross-sectional correlation and nonstationarity, in addition to heterogeneity. Thus, we employ a heterogeneous panel estimator that addresses both nonstationarity and cross-sectional dependence, i.e., the Pesaran (2006) common correlated effects mean group estimator (CMG). The CMG estimator accounts for the presence of unobserved common factors by including in the regression cross-sectional averages of the dependent and independent variables. The CGM estimator is robust to nonstationarity, cointegration, breaks, and serial correlation.

The Pesaran (2004) CD test, which employs the correlation coefficients between the time-series for each panel member, rejected the null hypothesis of cross-sectional independence for each variable considered (at the 0.1% level). Furthermore, several of the absolute value mean correlation coefficients ranged from 0.8-1.00 (results not shown, but are available upon request). The Pesaran (2007) panel unit root test allows for cross-sectional dependence to be caused by a single (unobserved) common factor; the results of that test suggest that most of the variables are nonstationary in levels (results not shown, but are available upon request).

MAIN RESULTS AND DISCUSSION

The results of the initial five regressions are shown in Table 1. For all five dependent variables, GDP per capita is statistically significant and well below unity—a saturation effect is expected for energy consumption in highly developed states. Prices are also significant and negative—suggesting taxes could be used to reduce energy consumption. Both heating and cooling degree days are positive and significant for the

Dependent Variable	Total Energy	Industrial Energy	Transport Energy	Residential Electricity	Commercial Electricity
GDP pc	0.19**** [0.07 0.31]	0.40*** [0.10 0.69]	0.31**** [0.18 0.45]	0.12*** [0.03 0.20]	0.18** [0.03 0.34]
Price	-0.39**** [-0.48 -0.30]	-0.30**** [-0.44 -0.16]	-0.43**** [-0.61 -0.26]	-0.14**** [-0.18 -0.09]	-0.08* [-0.17 0.01]
Heating degree days	0.11**** [0.08 0.14]			0.23**** [0.19 0.26]	0.08*** [0.02 0.14]
Cooling degree days	0.03**** [0.02 0.05]			0.10**** [0.07 0.12]	0.07**** [0.05 0.09]
Population density	-0.66*** [-1.12 -0.19]		-0.13 [-0.66 0.40]		
Share of energy intensive industries	0.001 [-0.02 0.02]	0.04 [-0.03 0.11]			
Observations	1296	1350	1350	1296	1296
x-sections	48	50	50	48	48
RMSE	0.012	0.04	0.026	0.012	0.043
Order of integration	I(0)	I(0)	I(0)	I(0)	I(0)
CD (p)	-1.5 (0.14)	0.1 (0.94)	-1.3 (0.19)	5.9 (0.00)	4.2 (0.00)
Mean rho	0.20	0.19	0.18	0.23	0.22

Notes: All variables logged. All dependent variables in per capita. Statistical significance level of 10%, 5%, 1% and 0.1% denoted by *, **, *, and ****, respectively. 95% confidence intervals in brackets. Diagnostics: Order of integration of the residuals is determined from the Pesaran (2007) CIPS test: I(0)=stationary. Mean rho is the mean absolute correlation coefficient of the residuals from the Pesaran (2004) CD test. CD is the test statistic from that test along with the corresponding p-value in parentheses. The null hypothesis is cross-sectional independence.**

Table 1 Disaggregated energy demand equations. Pesaran (2006) CMG estimator. Panel 48/50 U.S. states, 1987-2013.

building electricity consumption regressions. Whereas population density was significant and negative for the total energy consumption regression, it was insignificant for the transportation energy regression—a result that went against expectations. The industry GDP share of the most energy intensive sectors was highly insignificant—perhaps, not surprising since this share was substantially above 10% only for states with large mining sectors (e.g., Alaska, West Virginia, and Wyoming). In addition, the regression diagnostics were good—all of the residuals were stationary, and cross-sectional independence in residuals could not be rejected for all but the electricity regressions. However, in the two building electricity regressions, the resulting mean correlation coefficient was small suggesting that, at least, dependence was mitigated.

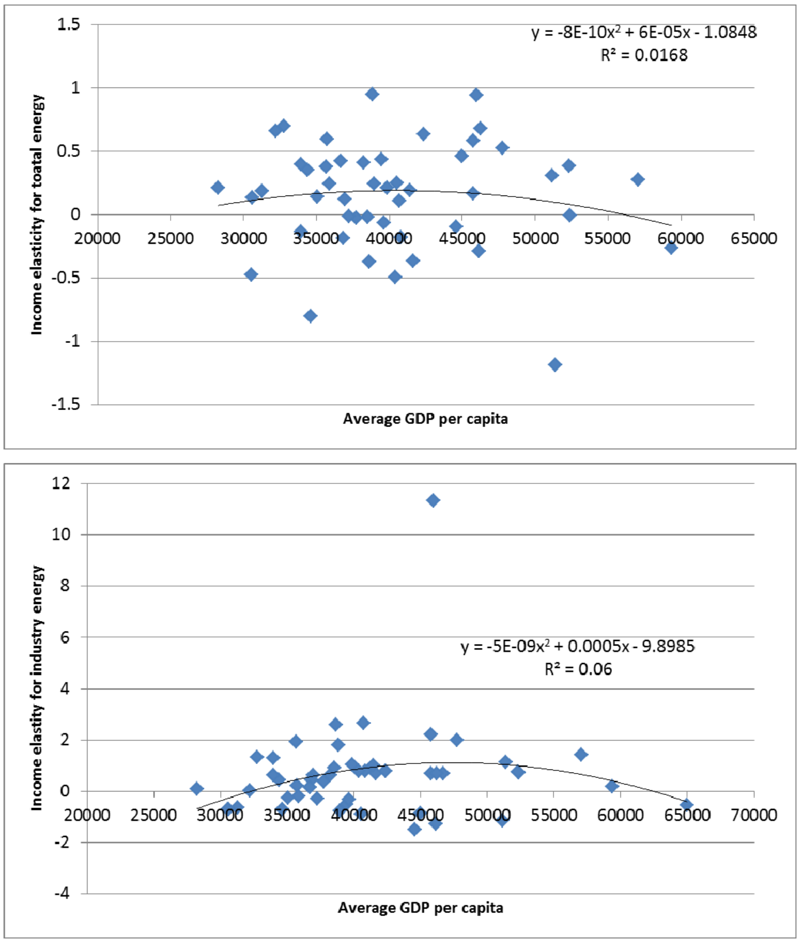
Comparing the estimations across dependent variables, the income elasticities were smaller for residential and commercial electricity; yet, the displayed confidence intervals suggest that those estimations were likely not significantly different at the 5% level. By contrast, the lower price elasticities for residential and commercial electricity likely are significantly different (as suggested by the confidence intervals). Low price elasticities for electricity use in buildings is not surprising given how electricity is typically billed—high fixed costs and rather underutilized marginal/peak pricing. The elasticity for heating degree days is significantly larger (in absolute terms) for residential electricity compared to commercial electricity. This result may be expected since commercial buildings are primarily occupied during daylight hours, and thus, would have lower heating demand. Yet, it is somewhat surprising for residential electricity that the heating degree days elasticity is significantly greater than the cooling degree days elasticity. This is surprising since air conditioning may be more energy intensive than heating, and air conditioning is very likely more electricity intensive than heating since not all heating uses electricity. Perhaps, this surprising relationship suggests that for the geography/climate of the U.S., heating buildings is more important than cooling in determining electricity consumption; alternatively, it may reflect differences in occupancy intensity, i.e., people may be at home more during the winter.

NONLINEARITIES

Whether there is an inverted-U relationship between GDP per capita and some environmental impact measure per capita has become one of the most popular question in environmental economics/social science. The so-called EKC/CKC literature posits that environmental impact first rises with income and then falls after some threshold level of income/development is reached. Of course, one might expect not to find such an inverted-U relationship for energy consumption—a normal consumption good; indeed, we might expect a leveling of the income elasticity (as determined for CO_2 emissions in Liddle 2015). (Although, some studies have determined such an inverted-U relationship for energy consumption or the highly related CO_2 emissions, e.g., Agras and Chapman 1999.) Yet, it is possible that higher income states may have less industry/manufacturing (and thus, less energy consumption in that sector); so, we test whether the individual state income elasticity estimates vary according to the level of income for total energy and industrial energy consumption.

Inverted-U studies typically model energy/emissions as a quadratic function of GDP per capita (an inverted-U between emissions per capita and income is said to exist if the coefficient for GDP per capita is statistically significant and positive, while the coefficient for its square is statistically significant and negative). However, it is incorrect to make a nonlinear transformation of a nonstationary variable in ordinary least squares (income was determined here to be nonstationary, as it often is). Furthermore, this polynomial model has been criticized for lacking flexibility (e.g., Lindmark 2004). Hence, we employ a method used in Liddle (2013b) that takes advantage of the heterogeneous nature of the estimations (i.e., elasticities are estimated for each state) by plotting those state-specific income elasticity estimates against the individual state average income for the whole sample period.

Those plots are displayed in Figures 1-a&b (Figure 1-a for total energy and Figure 1-b for industry energy). There is some evidence that the GDP per capita elasticity for both total energy and industrial energy consumption rises and then falls with average GDP per capita (thus forming an inverted-U); however, the R-squares for both simple trendlines were very small.



Figures 1-a&b. Individual state income elasticity estimates for total energy (Figure 1-a) and for industry energy (Figure 1-b) and the state average GDP per capita for the sample period. Trend line and R-squared also shown.

PRICE ASYMMETRIES

Several papers have decomposed price movements in order to test for asymmetric price responses, and thus, potentially capture induced technical change in energy demand (e.g., Gately and Huntington 2002). Price is decomposed into the historic high price and the cumulative price increases and cumulative price decreases in such a way that these three new price variables sum to the original price series as shown in Equations 1-4.

$$p_{max,t} = max(p_1, \dots, p_t) \quad (1)$$

$$p_{up,t} = \sum_{t=1}^{t} \max\{0, (p_t - p_{t-1}) - (p_{max,t} - p_{max,t-1})\} \quad (2)$$

$$p_{down,t} = \sum_{t=1}^{t} \min\{0, (p_t - p_{t-1}) - (p_{max,t} - p_{max,t-1})\} \quad (3)$$

$$p_t = p_{max,t} + p_{up,t} + p_{down,t} \quad (4)$$

Post estimation, one can test whether asymmetries exist by coefficient pairs difference of means tests. If the null hypothesis that the individual price elasticities are the same is rejected, one expects that in absolute terms elasticity for the maximum price would be greater than the elasticity for price increases, which would be greater than the elasticity for price declines (Gately and Huntington 2002). Table 2 displays the results for the price asymmetry regressions.

For total energy, industry energy, and transport energy all three price terms had significant and

Dependent Variable	Total Energy Energy	Industrial Energy	Transport Energy	Residential Electricity	Commercial Electricity
GDP pc	0.20**** [0.09 0.31]	0.15 [-0.07 0.36]	0.31**** [0.19 0.47]	0.09** [0.003 0.18]	0.12* [-0.000 0.25]
Price up	-0.52**** [-0.65 -0.39]	-0.34*** [-0.54 -0.14]	-0.45*** [-0.71 -0.19]	0.01 [-0.15 0.17]	-0.02 [-0.24 0.20]
Price down	-0.47**** [-0.64 -0.28]	-0.31*** [-0.52 -0.10]	-0.65**** [-0.90 -0.41]	-0.15** [-0.28 -0.02]	-0.36*** [-0.60 -0.11]
Price high	-0.51**** [-0.64 -0.39]	-0.30**** [-0.44 -0.16]	-0.47**** [-0.68 -0.25]	-0.20**** [-0.25 -0.15]	-0.11** [-0.21 -0.003]
Heating degree days	0.13**** [0.09 0.17]			0.23**** [0.19 0.26]	0.08**** [0.03 0.12]
Cooling degree days	0.03**** [0.02 0.05]			0.09**** [0.07 0.11]	0.07**** [0.05 0.09]
Observations x-sections	1296 48	1350 50	1350 50	1296 48	1296 48

Notes: All variables logged. All dependent variables in per capita. Statistical significance level of 10%, 5%, 1% and 0.1% denoted by *, **, ***, and ****, respectively. 95% confidence intervals in brackets.

Table 2. Disaggregated energy demand equations and price asymmetry. Pesaran (2006) CMG estimator. Panel 48/50 U.S. states, 1987-2013.

negative elasticities. However, the elasticities were never significantly different, i.e., no price asymmetries—high prices, upward movement prices, and downward movement in prices all impacted demand similarly. For residential electricity, upward price movements had an insignificant elasticity. Again, all three price coefficients were not significantly different.

By contrast, for commercial electricity some of the price coefficients were significantly different, but contrary to the expected directions. The coefficient for high price was smaller (in absolute terms) than the coefficient for downward price movements at the 10% level of significance (test statistic was 1.84 and p-value 0.065). Also, the coefficient for downward price movements was larger (in absolute terms) than the corresponding coefficient for upward price movements (which was insignificant) at the 5% level of significance (test statistic was 1.98). Since residential and commercial electricity demand was the least sensitive to prices (from Table 1), perhaps it is not surprising that some of the decomposed price components would not be significant.

INCOME GROWTH ASYMMETRIES

Recently, there has developed a discussion on the effects of the business cycle on CO_2 emissions and whether the income elasticity of emissions differs at times of economic growth and contraction (e.g., York 2012; Burke et al., 2015). To see whether such an asymmetric relationship may hold for U.S. energy consumption, we take first differences of all series (thus, converting them to growth rates). Then we separate the years with positive income growth from the years with negative income growth. For most years, very few states experienced negative income growth; however, there were a few years in which the majority of states did (1991, 2007, 2008). Since the negative income growth variable will have few observations for most states, heterogeneous methods are no longer appropriate; hence, we employ a pooled fixed effects with state and time dummy variables model.

In general, there was very little evidence of asymmetric income growth effects. Indeed, the variables representing positive and negative income growth were never both statistically significant (results not shown, but are available upon request). Only for residential electricity were the coefficients statistically different—in that case, the coefficient for positive income growth was highly insignificant (p-value of 0.62).

SUMMARY

This paper modeled the demand of total, industrial, and transport energy consumption and residential and commercial electricity consumption by analyzing U.S. state-based panel data and by using methods that address both nonstationarity and cross-sectional dependence. Most of the results conformed to expectations. Buildings (residential and commercial) electricity had the smallest income and price elasticities. Both heating and cooling degree days were important for building electricity demand, but population density was insignificant for transport (perhaps, greater resolution than the state-level is necessary to capture the population density-mobility demand relationship). Lastly, limited to no evidence of nonlinearities and asymmetries were uncovered. The three decomposed price elasticities—the historical high price, cumulative price drops, and cumulative price increases—were rarely statistically significantly different. Similarly, energy consumption growth reacted symmetrically to positive vs. negative GDP growth, i.e., the difference between the estimated coefficients for positive and negative GDP growth were rarely statistically significant.

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Scenes from the 34th USAEE/IAEE North American Conference October 23-36, 2016


USAEE

Report on the Tulsa USAEE/IAEE Conference

CONFERENCE OVERVIEW

The 34th USAEE/IAEE North American conference was held in Tulsa, Oklahoma. There were 213 attendees representing 19 distinct countries, 43 of whom were students, and 46 of whom were welcomed as new members to the organization. The backgrounds of the delegates included, but were not limited to, academia, the U.S. federal government, oil and gas companies, utilities, and research and consulting groups. The theme of this year's conference was "Implications of North American Energy Self-Sufficiency". As the third largest natural gas producing and fifth largest crude oil producing state in the United States, Oklahoma provided a timely and appropriate location for this year's conference, particularly in the current environment of increased production. Throughout the conference delegates had the opportunity to attend a variety of plenary sessions where expert panels discussed issues ranging from the future of oil and gas prices to consumer-facing demand-side issues. The Tulsa conference additionally saw some new elements introduced to the program including a specialized Government Track and discussants in concurrent sessions. Student members were able to compete in events for cash prizes such as the Case and Poster competitions and all members were given extensive opportunities to network with other members from a variety of backgrounds. With a combination of plenary sessions, concurrent sessions, networking opportunities, interesting lunch speakers, tours of local energy facilities, and technical workshops, this year's conference provided attendees with a comprehensive first-hand exposure to the state of the North American energy sector.

SUNDAY OCTOBER 23RD

GRAND RIVER DAM AUTHORITY TOUR

On Sunday morning prior to the opening of the conference a number of USAEE members participated in an interesting tour of the Grand Dam River Authority facility. Throughout the day attendees toured the main Grand Dam River Authority facility, Salina Pumped Storage facility, and Pensacola Dam. Presentations were given to the group by the Chief Executive Officer, Chief Operating Officer, and several General Assistant Managers. The trip provided an extremely informative and up-close look at the workings of the Grand Dam River Authority as well as interesting presentations on topics including, but not limited to, the economics of building new units, storage capability and ancillary services of a pumped storage plant.

CASE COMPETITION

[Written by Parth Vaishnav, Carnegie Mellon University]

2016 marked the fifth time the USAEE Case Competition ran since its start in 2012. The competition casts participating teams in the role of consultants with clients from government or industry who need them to do a quick, first-order analysis to inform a complex energy-related problem, usually with a technical, economic, and political component. This year, students were asked to advise a minster about the feasibility and wisdom of transitioning much of Saudi Arabia's electricity generation to solar photovoltaic. Participating teams, each consisting of 2-5 students, submitted an 8,000-word report with their recommendations in April. Of these participating teams, three teams were then selected to present in Tulsa to compete for first ($2500), second ($2000), and third ($1500) prizes. An additional prize for those selected to come present in Tulsa was the waiving of the registration fee for the conference for two members of the winning teams.

Generous sponsorship for the competition came from the King Abdullah Petroleum Studies and Research Center (KAPSARC). The Case Competition was organised by Parth Vaishnav (Carnegie Mellon University) and David Hobbs (KAPSARC), Walid Matar (KAPSARC), Lester Hunt (KAPSARC), and Michael Canes (LMI) acted as judges.

This year, Joe Nyangon and Nabeel Alabbas of the University of Delaware shared the first prize with Pritham Aravind, Stephanie Beels, Suyash Kela, Raafe Khan, and Apratim Vidyarthi of Carnegie Mellon University. The third prize was taken by Arash Saboori and Ben White of the University of California, Davis.

An additional exciting development in the Case Competition this year was that the USAEE Council decided to open future competitions to students from all over the world; not just the United States. The Case Competition has a history of strong teams and solutions and we are looking forward to even more high-quality, creative entries in the coming years.

MONDAY OCTOBER 24TH

OPENING PLENARY (ENERGY POLICY- COMPETING VISIONS FROM THE TWO PARTIES)

On Monday morning Jim Smith (Professor of Finance, Southern Methodist University and USAEE President), welcomed everyone to the 34th USAEE/IAEE North American Conference in Tulsa, Oklahoma, extending thanks to all who helped make the conference happen. Gürkan Kumbaroglu, president of the IAEE, then spoke to the recent success the international organization has had in expanding to regions such as the Balkans and the Middle East, emphasizing the global nature of the organization and putting the conference's theme, 'Implications of North American Energy Self-Sufficiency' in a broader context. Delegates were then addressed by Ron Ripple, University of Tulsa, and Tom Robins, Deputy Secretary of Energy at the Oklahoma Secretary of Energy and Environment, who spoke to the significance of Oklahoma in the wider energy picture.

The opening remarks were followed by an enlightening session on the formation of the North American Energy Security and Infrastructure Act of 2016, a pending piece of legislation, by key staffers on both sides of the aisle whose senators serve on the Senate Energy and Natural Resources Committee. Christine Tezak (Managing Director, Research, Clearview Energy Partners LLC) chaired a wonderfully interesting discussion between Angel A Becker-Dippmann (Democratic Staff Director, Senate Energy and Natural Resources Committee) and Colin Hayes (Republican Staff Director, Senate Energy and Natural Resources Committee) that covered topics ranging from infrastructure to the impact of lower energy prices on the political process and concerns about the Strategic Petroleum Reserve. Delegates were exposed to an insightful description of the difficulties of creating legislation in a divided Congress, but also how much time and effort is spent to make workable compromises and find common ground. From the discussion it was clear that while there were obvious differences between the parties on many specifics, both sides were committed to the common goal of an updated framework for federal energy policy. However, it was also emphasized that the federal nature of such legislation makes it a 'very blunt' instrument and there will be a lot of very important discussions at the regional and state-level.

GOVERNMENT TRACK (TRANSITIONS)

The 34th USAEE/IAEE North America Conference hosted the debut of the Government Track sessions. The inaugural session, 'Transition from the Point of View of the Incoming Political Party', was held on Monday morning and was about transitions in government. Abe Haspel (President, Cogent Analysis Group LLC) presided over an expert panel of Brain Waidmann (Chief of Staff, American Council of Life Insurers), Elgie Holstein (Senior Director for Strategic Planning, Environmental Defense Fund), and Ross Swimmer (Partner, Native American Fund Advisors LLC). Haspel started the session with an extremely informative overview of the transition process, emphasizing the point that with a new Administration over 4,000 political appointee positions will turn over and 50% of incoming appointees are likely to not have a background in government. Transition is therefore an enormous undertaking and involves not only the outgoing and incoming appointees, but also a specific transition taskforce. On the panel, both Waidmann and Holstein have had extensive experience as members of the transition teams of George (W.) Bush and Barak Obama. Swimmer, on the other hand, was a political appointee himself and therefore was able to provide insight from that side of the process. Waidmann started the panel off by describing transition as affecting 'virtually all of the senior leadership of every agency of government'. The next hour and a half was filled with phenomenally interesting insight from each of the panellists about their experiences as both transition members and political appointees. The discussion was wide ranging and quite frank at times providing for great insight into an extremely important process. For conference delegates that either work in or liaise with any government agency the inaugural government track provided extremely valuable insight that would be extremely hard to obtain anywhere else.

AWARDS LUNCHEON

At lunch on Monday the USAEE Adelman Frankel Award was given to Fereidun Fesharaki (FACTS Global Energy) and USAEE Senior Fellow Awards were given to Mary Lashley Barcella (IHS Markit), John Felmy (Midnight Energy Economics), and Ronald Ripple (The University of Tulsa). The IAEE Outstanding Contributions to the Profession Award was then given to Richard O'Neill. Also at the Monday Awards Luncheon, Robert (Bob) Borgstrom (Independent Consultant) was honored for his service to the USAEE/IAEE as the Editor of *USAEE Dialogue.*

DUAL PLENARY (MANAGING IN A LOW-PRICE ENVIRONMENT)

The plenary session 'Managing in a Low-Price Environment' was presided over by Bob Tippee (Editor, Oil & Gas Journal) and the panel consisted of David Chenier (Chief Procurement Officer, ConocoPhillips), Randy Foutch (Chairman and CEO, Laredo Petroleum Holdings Inc), and William Lawson (Vice President, Corporate Development and Execution, Williams Company). Chenier started the discussion by giving some historical context for the current low oil and gas prices. He pointed out that this is not the first time we have been in a low price environment and that actually major oil and gas companies have even performed relatively better in periods of price weakness. The 2014 supply shock was, he cited, the largest annual increase in U.S. oil production ever therefore helping the U.S. become the top oil and gas producer, above even Saudi Arabia. In a low price environment we are able to pull on three levers he said: standards, planning & execution, and suppliers. He then finished his presentation by highlighting a portfolio of contracting strategies that we should be pursuing in various combinations in such an environment. Foutch's presentation reinforced the idea that companies have had experience in similar low-price environments and the key to success in such times is appropriate long-term planning. Reducing risk, collecting data early, and investing in forward-looking infrastructure were all highlighted as strategies. The panel was rounded out by Lawson who gave insight into the natural gas industry. Supply is on the increase and prices are low, and demand is increasing steadily. Lawson gave insight into what he believes the gas market needs now including continued cost control, improved political climate, staffs sized to handle 'lower for longer' price environments, and an engaged supporter base to advocate infrastructure, among other things. The panel was concluded by calling for vigilance in driving down costs, safe and reliable operations and the expansion of demand driven infrastructure. Overall the message was clear: that prices are low in oil and gas markets is not unprecedented and if we are smart we can move through the depressed price period.

DUAL PLENARY (CHALLENGES AND OPPORTUNITIES IN THE TRANSPORT SECTOR)

The plenary session 'Challenges and Opportunities in the Transport Sector' was presided over by Ben Schlesinger (President, Benjamin Schlesinger & Assoc LLC) and the expert panel was comprised of Sanya Carley (Associate Professor, Indiana University), Ken Gillingham (Assistant Professor of Economics, Yale University), and Nancy Homeister (Manager, Green Gas and Fuel Economy Regulatory Strategy, Ford Motor Company). The discussion was kicked off by Carley who gave a '2016 perspective' of the developments that have taken place in the industry since the 2012 Corporate Average Fuel Economy (CAFE) Standards were released. Since 2012 much has been learned about the benefits and challenges of the policy, particularly in the wake of the lower oil and gas prices. Gillingham built upon Carley's presentation by emphasizing many of the unintended consequences of such economically 'second-best' policies. Both Carley and Gillingham dug into the cost-benefit analysis behind the standards and illustrated how quantification on both sides is difficult and has shifted since they were first undertaken. Homeister's presentation complemented Carley and Gillingham's by giving the perspective of an automotive company. The standards have a great impact on automotive companies and many of them are worried about potential negative implications of 'getting the policy wrong'. To Homeister technology is not so much the issue, but rather making the cars that consumers want to buy. She emphasized the fact that there are many other things that consumers care about much more than fuel economy when purchasing a vehicle. Moving forwards the panel gave attendees a sense that there is much we still have yet to understand about the demand-side of the automotive market, particularly in such a low oil price environment, and its potential impact and relation to the CAFE standards. Electric vehicles were also touched upon as having potential to become a much larger share of the automotive market than they currently are. From the discussion one thing was absolutely clear- the transportation sector is an extremely dynamic one at this point in time and there are likely to be many important developments (potentially game-changing ones) in the coming years.

POSTER SESSION

The student poster session, organized and chaired by John Holding (Independent Energy Analyst), is an opportunity for students to present their work to a broad audience in an interactive manner. This year the posters were showcased during the coffee breaks before the poster session so that delegates could have more time to look around all the projects that were being presented. During the Monday night networking reception the poster competition actually took place where students stood by their posters and answered questions, including those of anonymous judges who made their rounds throughout the evening.

This year's competition had ten posters representing a diverse set of projects. Topics covered by posters this year included the efficacy of energy retrofits in buildings, electricity demand forecasting, integrated assessment model diagnostics, royalty rates, renewable energy integration, gasoline price dynamics, vertical and horizontal wells, global LNG outlook, energy storage grids coupled with expanded wind energy, and shale oil producer hedging policies and firm value.

The winner of this year's poster competition, and a check for $1000, was Mark Agerton (Rice University) whose poster was entitled 'Drivers of Royalty Rates and Primary Terms in Private U.S. Mineral Leases'.

TUESDAY OCTOBER 25TH

DUAL PLENARY (U.S. OIL AND NATURAL GAS EXPORTS- HOW HAVE THE ECONOMICS CHANGED?)

[Written by Kelly Ann Stevens, PhD Student, Syracuse University]

The plenary session, "U.S. Oil and Natural Gas Exports – How have the Economics Changed?" chaired by Tina Vital (President, TJV Consulting), featured an enlightening discussion by Kathleen Eisbrenner (Founder, Chairman & CEO, NextDecade), John Felmy (Consultant, Midnight Energy Economics), and Chris Pedersen (North American LNG Analyst, S&P Global Platts) on Tuesday morning. The discussions focused on paradigm shifts in natural gas and oil markets in the U.S. and abroad, and expectations on how the markets will respond in the future. John Felmy provided a brief history of the events and perceptions of our supply of natural gas and oil that have severely limited the ability of the U.S. to export as it should. The following discussions focused more on the recent paradigm shift in natural gas markets due to the shale gas revolution, and future swings to come stemming from the development and use of new technologies. Eisbrenner stressed how the current LNG oversupply is overshadowing recent LNG milestones such as the first exports from the Gulf Coast to Europe and Asia in 2016. Despite the current low price setbacks, the panelists believe LNG and floating storage regasification units (FSRUs) are the next game changer for U.S. natural gas exports. Pedersen discussed the advantages and market for FSRUs to meet growing energy demand for natural gas in the developing world. These new units come with a low risk of investment since they are mobile, and will quickly expand locations for LNG demand while decreasing regasification costs. There was a sense of optimism that a demand pull for gas is imminent, which the U.S. is well positioned to respond to given our current infrastructure, recent improvements in extraction processes, and abundance of gas in places such as the Alpine High in Texas. However, the panelist seemed to agree that while LNG in global gas markets is tightening price margins, regional variations in infrastructure, transportation costs, and demand will prevent global price convergence from occurring anytime soon.

DUAL PLENARY (CHALLENGES AND OPPORTUNITIES FOR RENEWABLES)

The plenary session 'Challenges and Opportunities for Renewables' was presided over by Stephen Munro (U.S. Policy Analyst and Editor, Bloomberg New Energy Finance). The expert panel was comprised of Scott Vogt (VP of Energy Acquisition, Comed), JT Smith (Director, Policy Studies, MISO), and Mario Hurtado (Executive Vice President Development, Clean Line Energy Partners). Munro started the session off with a great overview of the current state of renewables, highlighting the fact that the levelized costs of electricity (LCOE) for many technologies have decreased in recent years allowing for greater renewable penetration. Munro emphasized federal and state support as key drivers in the industry and also provided some global context for costs. Hurtado followed Munro's introduction with a discussion focused on infrastructure investment, particularly transmission lines. His presentation focused heavily on opportunities for arbitrage over transmission lines in connecting areas of low electricity demand and high renewable resource potential with those of high demand and lower resources. Smith was able to then give an ISO perspective. His talk gave attendees some context for what renewables mean to an ISO and the paradigm shift that has accompanied increased penetration. Finally, Vogt gave a complementary utility perspective with a focus specific to his company's service territory: the role of nuclear power plants in the context of renewable energy credits. Vogt cited the key challenges as meeting customers' desire for clean energy and self-generation while also meeting mandates. By the end of the session it was clear that the paradigm shift referenced by Smith is one that is being experienced across the electricity sector and there is still much to be seen as to what kind of role renewables will play and how.

AWARDS LUNCHEON

At Tuesday lunchtime delegates were treated to a keynote speech by the Secretary of Energy and Environment for the State of Oklahoma, Mike Teague. Teague's talk focused on the issues Oklahoma has been having with induced seismicity due to the injection of produced water in disposal wells. At the beginning of his talk Teague asked for a show of hands from delegates of who believed that hydraulic fracking was a cause of increased seismic activity. He then explained that while there is a relationship between the two, it was not the cause of the problems they were having in Oklahoma. In Oklahoma, they have a water disposal problem. Teague's talk was extremely interesting and informative. He walked delegates through the efforts that the State of Oklahoma has been undertaking in order to tackle the problem head on. The State's approach is grounded in reaching out to the best minds across all sectors in order to take advantage of the state-of-the-art knowledge in induced seismicity. Teague summed up his talk with a few key points: that that State of Oklahoma has a problem, a big problem, but they are working hard to do what they can to better understand and manage it.

Also at the Tuesday lunch, the IAEE Journalism Award was given to Russell Gold. Mark Agerton of Rice University was awarded first prize in the Poster Competition for his poster entitled 'Drivers of Royalty Rates and Primary Terms in Private U.S. Mineral Leases', and The Dennis J. O'Brien USAEE Best Student Paper Award was awarded to Jen Z. He of the University of Maryland for her paper entitled 'Heterogeneous Responses and Differentiated Taxes: Evidence from the Heavy-Duty Trucking Industry in the U.S.'. Troy Thompson (Chevron) was honored as the most recent Past President of the USAEE and gifts of appreciation were awarded to Tina Vital (TJV Consulting), Sanya Carley (Indiana University), John Holding (Independent Energy Analyst), Ron Ripple (The University of Tulsa), Parth Vaishnav (Carnegie Mellon University), Better Simkins (Oklahoma State University), Mike Troilo (The University of Tulsa), and Tom Drennen (Hobart and William Smith Colleges). Finally, Brant Liddle (Energy Studies Institute, NUS) was presented with the Working Paper Award.

DUAL PLENARY (SHALE AND THE FUTURE OF WORLD OIL)

[Jim Smith reviewed and added to the following paragraph]

The plenary session entitled 'Shale and the Future of World Oil' was presided over by Jim Smith (Professor of Finance, Southern Methodist University and USAEE President). The expert panel was composed of Philip Verleger Jr (President, PK Verleger LLC; Visiting Fellow, Colorado School of Mines), Marianne Kah (Chief Economist, ConocoPhillips), James Griffin (Professor and Bob Bullock Chair in Public Policy and Finance, Texas A&M University), and Harold Hamm (Chairman and Chief Executive Officer, Continental Resources Inc). Verleger started the panel off by highlighting the fact that we are in a different market today than in the past and demand swings being more critical than swing producers. Today we have many more opportunistic buyers and sellers, both paper and physical traders. Increased activity by paper trading opportunists shifts the supply-of-storage curve for crude oil, despite research that traditionally has suggested there to be no link between paper traders and oil prices. Additionally, today's market of "fuzzy" demand and supply makes it much more difficult to control prices. Kah's presentation complemented Verleger's by giving an overview of the oil and gas supplies globally and in the U.S. Inventory changes, she claimed, are likely to become the short-term balancing mechanism as the U.S. tight oil supply response time is not as short as may have been believed. Additionally, she claims that, absent OPEC's active management of supply, oil prices will become more volatile as prices are the primary signal for building/drawing down inventories and ramping U.S. tight oil up or down. Kah emphasized that tight oil is produced by a technology that is still evolving, with significant cost reductions still in the offing. Beyond the resilience and relatively low cost of shale oil, Kah noted that a large part of the global surplus in crude oil supplies is due to the substantial increase in production volumes coming out of the Persian Gulf during the past two years. Griffin proceeded to give a presentation on 'The New Normal' in which he sees the oil price most likely remaining in the range of $30 to $70 per barrel. Griffin disputes the notion that Saudi Arabia made a big mistake in failing to cut their production. The cost to the Saudis of defending $100 oil, in his opinion, would have been even greater (and longer lasting) than the damage that has resulted from the oil glut. Griffin observed that part of the uncertainty regarding future oil prices stems from the fact that oil field service and supply costs will undoubtedly rise as the industry regains its footing, but no one knows by how much those costs will rise. He also notes that OPEC can be expected to come together again in defense of the oil price, albeit at a lower price level in the new normal. At the end of the day, however, Griffin believes that fracking will discipline OPEC's price ceiling. Hamm described in some detail the nature of technological advances that gave rise to the tight oil revolution, with horizontal drilling techniques perhaps playing the starring role--even beyond the impact of fracking, which is not new to the industry. The same technological developments, he observed, have transformed the U.S. natural gas industry (emphasis on the Marcellus basin) with profound impact on the global natural gas market. He attributes the dramatic drop in the price of oil to a huge miscalculation on OPEC's part regarding the resilience of U.S. shale oil supplies and the scope of low-cost production. He, like Kah, cited repeal of the U.S. crude oil export ban as having played a key role in sustaining the U.S. oil industry.

DUAL PLENARY (CLEAN POWER PLAN- IMPLICATIONS AND STRATEGIES)

The plenary session entitled 'Clean Power Plan- Implications and Strategies' was presided over by Eric Hittinger (Assistant Professor, Rochester Institute of Technology). The expert panel was composed of Christine Tezak (Managing Director, Research, Clearview Energy Partners LLC), Charles Rossmann (Forecasting & Model Development Manager, Southern Company), and Erica Bowman (Chief Economist, American Petroleum Institute, API). The goal of the panel was to discuss the critical issues and implications of the Clean Power Plan unveiled in 2015 by the U.S. Environmental Protection Agency (EPA). Hittinger gave some context to the panel by giving a background of the Clean Power Plan. Tezak followed by giving a broad overview of the political landscape emphasizing the global trends of fragmentation and the large role energy efficiency has played in recent decades. Shifts in Congress and the potential for tax reform were highlighted as issues on the horizon and emphasis was placed on heterogeneity across states in their compliance strategies. Rossmann then provided a viewpoint on behalf of a utility. In his presentation he highlighted the 'multiple worlds' the EPA was creating in the sense of the multitude of systems that individual states could choose to achieve their targets. Rossmann's discussion centered on the differences between a rate-based or a mass-based world in terms of the relevant standards and instruments pertaining to each. Rossmann's perspective was particularly interesting because the utility that he works for spans several states and therefore there is a chance that there may be different 'worlds' in terms of regulatory instruments within its service territory. Bowman rounded out the discussion by presenting a data-driven analysis carried out by the American Petroleum Institute. Findings from this study included conclusions that the EPA was underestimating the resource base for natural gas and overestimating the role of energy efficiency. Later in the session the differences between EPA and API modelling assumptions were discussed in light of these findings. Overall it is clear that in the current political landscape, discussion about the implications of the Clean Power Plan is extremely timely. Attendees left with a better sense of the overall picture as well as valuable insight into some of the specific concerns of various stakeholders and a look 'under the hood' of some of the modelling efforts surrounding the policy.

WEDNESDAY OCTOBER 26TH

DUAL PLENARY (ACROSS THE BORDERS- UPDATES FROM CANADA AND MEXICO)

The plenary 'Across the Borders- Updates from Canada and Mexico' was presided over by Peter Hartley (Professor and Baker Institute Scholar, Rice University). The expert panel was composed of Andre Plourde (Dean Faulty of Public Affairs, Carleton University), Juan Rosellon (Professor, CENACE (Mexican ISO)), and Alejandra Elizondo (Research Fellow, Center for Research and Teaching in Economics (CIDE)). The aim of the panel was to discuss the recent developments in Canada and Mexico and how they may affect North American energy markets and trade in oil, natural gas, and electricity. Plourde started the panel off by discussing Canadian energy policy and politics, with a focus on the politics of oil sands exports. After an overview and brief history, he described the situation in 2010 and then reflected upon what had, or had not changed, from then to now (2016). One thing that has not changed is that Mexico is still not a large factor in North American energy relations from the Canadian perspective. However, the growth in U.S. crude oil production and the politics surrounding the Keystone Pipeline have been major shifts in the last six years. Something else that has changed is the development of climate policy in Canada, particularly pertaining to the tar sands. Rosellon's presentation shifted geographic focus southward to the reforming of the Mexican electricity market. His talk covered critical issues in the restructuring such as market design, nodal pricing, transmission, renewable integration, and implications for policy making in Mexico. Elizondo finished the panel by also presenting on Mexico, but the energy reform for oil and gas rather than electricity markets. She provided an overview of both the old and the new system commenting on the short and long term benefits of the shift. The major short-term benefit, she claimed, was increased energy security. Issues that are still pending, on the other hand, are things like carbon emissions, subsidies and carbon taxes, regionalization, social issues, and North American Regulatory Harmonization. Overall it is clear that there are many developments occurring both North and South of the U.S. that will have great impacts on the structure and functioning of the domestic energy industry. Much has changed in the past decade, and it is clear that there are likely to be many more changes in the coming decades as all three countries work towards self-sufficiency.

DUAL PLENARY (ON THE OTHER SIDE OF THE METER- DEMAND SIDE ISSUES)

The plenary 'On the Other Side of the Meter- Demand Side Issues) was presided over by Melanie Craxton (PhD Candidate, Stanford University). On the panel were Jim Sweeney (Director of the Precourt Energy Efficiency Center, Professor, Stanford University), Seth Blumsack (Associate Professor, Penn State University), and Jeff Brown (Energy Efficiency & Consumer Programs Manager, Public Service Company of Oklahoma). The aim of this session was to shed light on the demand-side of the electricity market, focusing on the policies, programs, and consumer behaviors 'behind the meter'. The panel was kicked off by Sweeney who gave an excellent overview of the role energy efficiency has played across the energy system in recent decades. In his presentation Sweeney also was able to highlight a variety of consumer-facing programs and policies as well as what some of the concerns are on the demand side going forward. Blumsack followed on by presenting an experiment carried out in Vermont that tested consumers' reactions to Critical Peak Pricing days with penalties or rebates associated with them depending on the treatment group. Insights from Blumsack's presentation included that penalizing people, rather than rewarding them for 'good' behavior, is more effective, though perhaps unsurprisingly politically unpopular, consumers *do* respond to incentives, but not persistently enough to have much retail or capacity value, and the key to inducing desired actions on the part of the consumer is making it extremely easy for them. Brown provided a complementary view of the demand side from the perspective of a utility. He highlighted many of the programs (past and present) his company has run and provided interesting comments on their efficacy therefore providing an interesting comparison to the study presented by Blumsack. All three panellists were asked before the session what they believed the most important demand-side development would be in the next ten years. All three panellists seemed to agree that information dissemination was going to be critical and finding creative ways to carry it out, whether it be smart meters or other information-based apps, was going to be key for furthering the broader impact of the demand side.

CLOSING PLENARY (OUTLOOK AND GLOBAL PERSPECTIVES)

[Contributed by Melanie Craxton and David Knapp]

The 34th USAEE/IAEE North American conference's main agenda ended with the Closing Plenary entitled 'Outlook and Global Perspectives'. The session was chaired by David Knapp (Chief Energy Economist, Energy Intelligence Group). The expert panel was comprised of Jeff Currie (Global Head of Commodities Research, Global Investment Research Division, Goldman Sachs), Fereidun Fesharaki (Chairman, Facts Global Energy), and Adam Sieminski (Administrator, Energy Information Administration). Fesharaki and Sieminski are past presidents of the IAEE/USAEE respectively. Fesharaki is a much followed expert on China and offered a number of interesting insights on the country during the panel discussion and Q&A, while Curie substantially expanded the discussion on the financial side of energy markets. Sieminski was there to enhance the focus on the US, but offered a number of observations on the broader oil market. The purpose of the session was to pull together key themes from the conference primarily related to oil markets – with the three key questions addressed focusing on whether the market is rebalancing, where are oil prices going and what are the key influences beyond the oil market that those involved in the market directly or professionally watching the market need to know about.

The discussion that followed also provided an interesting insight into how each of the panellists broadly view the global future for energy and, in particular, how it will impact the United States. Knapp kicked off the discussion by asking Fesharaki for his take on where we are now and his thoughts on what lies ahead. Fesharaki's response focused on the fact that free markets may be something that economists historically love, but they also "make things really tough" -- particularly with regards to forecasting. The answer to where things might settle, he claims, is still very much up in the air. Knapp followed up on Fesharaki's comments by highlighting the supposed importance of 'energy independence' and the decades old conversations about energy security, despite the still relevant concept of comparative advantage suggesting importing cheap oil and processing it into higher priced refined products, petrochemicals and other higher value-added derivatives to sell back to the original producers and others.

That led into an interesting discussion by Jeff Currie of critical role of the dollar as part oil's role as a dollar-based commodity, like copper and others. Oil price's high correlation with the dollar index, largely driven by three macro-drivers -- oil market development, the Fed, and China, allows oil transactions, particularly outside the U.S. a source or sink for global liquidity. Curie excluded the U.S. because of an effective regulatory apparatus meant to control the supply of money. The convergence of low oil prices, a tightening Fed and a weakening China all work against liquidity

Sieminski then spoke of three important sources of uncertainty: global economic (and not just in China, but in the United States and Europe as well), geopolitics, and, in the longer term, climate policy. Such uncertainty makes forecasting difficult, and Sieminski highlighted, with a slight amount of humor intended, that he could say with 95% confidence that the crude oil price in 2017 would be between $25 and $90 a barrel and natural gas prices would be between $1.50 and $6. The panel then went on to discuss issues ranging from rebalancing trade, inventories, technology development, energy access, the differences in developing countries, and the potential for electric cars and how that would affect the future.

The prime takeaways from the session were the high level of uncertainty about the state of rebalancing (not there yet) and the likely effectiveness of Opec's latest market management attempt (leaning toward negative) and oil prices (moving higher but not by too much too soon). Milestones to watch included an end-October Opec planning meeting, now unsuccessfully concluded, and Opec's November 30th full meeting about which the sense of the panel could be characterized as dubious. China policy, Venezuela and Nigerian politics also bear close scrutiny as does Saudi signalling in advance of Saudi Aramco's Initial Public Offering purportedly coming in 2018 although at least one panellist, Fesharaki, expressed scepticism. The various counter force are expected to bat oil prices around in the $40s and $50s over the next year with an upside tendency toward the end of the decade when supply shortages may loom.

WORKSHOPS (THE CAUSE AND CONSEQUENCE OF INDUCED SEISMICITY AND GLOBAL ENERGY RISK MANAGEMENT: TURNING RISK INTO A COMPETITIVE OPPORTUNITY)

After the Closing Plenary some USAEE Members stayed on to attend workshops on induced seismicity and energy risk management. The Society of Petroleum Engineers put on a workshop entitled 'The Cause and Consequence of Induced Seismicity' sponsored by the Center for Energy Studies at Rice University's Baker Institute. Ken Medlock (Director, Center for Energy Studies, Rice University's Baker Institute for Public Policy) presided over presentations by Linda Capuano (Fellow in Energy Technology, Center for Energy Studies, Rice University's Baker Institute for Public Policy), Jeremy Boak (Director, Oklahoma Geological Survey, University of Oklahoma), and Kyle Murray (Hydrogeologist, Oklahoma Geological Survey, University of Oklahoma). The workshop explored the technical elements of deep injection disposal wells and induced seismicity. It also covered policy issues and discussed technical solutions.

The second workshop, 'Global Energy Risk Management: Turning Risk into a Competitive Opportunity', was presided over by Glenn Labhart (Chairman of Energy Oversight Committee of GARP ERP Program & Senior Partner Labhart Risk Advisors). Speakers included Joe Byers (Senior Director of Risk Management, Direct Energy) and Bob Broxson (Managing Director, BDO Consulting). Topics covered in the workshop included the basics of energy risk management, real option valuation to address risk and value added strategies, hedging strategies to add extrinsic value to a company's asset structure, and developing leadership skills of managing assets and value added strategies.

THURSDAY OCTOBER 27H

CUSHING TOUR

The final activity on Thursday of the 34th USAEE/IAEE North American Conference was a technical tour in Cushing, Oklahoma sponsored by the American Petroleum Institute. On the tour, attendees visited crude oil tank farm storage and pipeline handling facilities in Cushing, OK; the pricing point for the NYMEX crude oil futures contract. Members on the tour also visited an operating lease site and oil and gas production research facilities at the University of Tulsa. Over the course of the day attendees were exposed to cutting-edge research in production performance, an actual producing lease, and the handling and storage of crude oil. It was an extremely interesting and informative end to an interesting and informative conference.

Melanie Craxton

The Timing of China's Carbon Peaking under an Uncertain Future

By Hongbo Duan, Jianlei Mo, Ying Fan and Shouyang Wang

INTRODUCTION

According to the Sino-US joint statement on climate change in 2014, China is committed to peaking its carbon emissions in 2030, at which time the share of non-fossil energy in China will account for over 20%; China's Intended Nationally Determined Contributions (INDC) plan, which was submitted to the United Nations in 2015, reaffirms this commitment. Although plenty of work has been done to prove the rationality and feasibility of these targets for economic development, energy consumption as well as for energy restructuring, there remain different opinions on the commitments at home and abroad. Some argue that these targets are pretty ambitious, and that China has to deal with very daunting challenges, while the others believe that the goals committed to may not be so difficult to reach, costing less than expected. It is likely that the multiple uncertainties embedded in the process of carbon mitigation are largely responsible for this divergence. There remain around 15 years for China to deliver on its commitments, during which time a great many uncertainties involving economic growth, energy efficiency enhancement and low-carbon transition, etc., will comingle and significantly affect the feasibility, policy options and costs of fulfilling the goals; these uncertainties mainly manifest themselves as uncertainties regarding labor productivity, substitutions among different production factors, energy efficiency improvement, and learning about the effect of renewables, all of which complicate judgments about future carbon emission trajectories and energy transition trends.

Hongbo Duan and **Shouyang Wang** are with the School of Economics and Management, University of Chinese Academy of Sciences. **Jianlei Mo** and **Ying Fan** are respectively Assistant Professor and Professor with the Institute of Policy and Management, Chinese Academy of Sciences, and School of Economics and Management, Beihang University. The authors acknowledge the financial support of the National Natural Science Foundation of China (Grant No. 71503242).

On this basis, it is of great importance to investigate China's energy restructuring and economy decarbonizing issues under multiple uncertainties. Specifically, we try to answer these questions: How challenging will it be for China to reach the carbon-peaking target it has committed to? What is the likelihood that China will reach its targets under different policy scenarios? What will be the corresponding peak values? To have a high probability of reaching the targets, what policy measures should be taken? What is the relationship between the carbon-peaking target and the energy-restructuring target, and how will the influences of carbon tax and subsidy policy on achieving these two targets differ?

MODELLING APPROACH

The proposed stochastic 3E-integrated model in this work is essentially based on the prior 3E system model, CE3METL, a Chinese version of the E3METL model. Characterized by its core technology diffusion mechanism, i.e., multi-logistic curves instead of conventional constant elasticity substitution (CES) method, the E3METL model consists of macro economy, energy technology and climate sub-modules, which is consistent with the typical frameworks of 3E-integrated models. The E3METL and CE3METL models have been employed to conduct climate-relevant research since they were built in 2013. By incorporating multiple uncertainties and employing Monte-Carlo simulation methods, we have extended the framework of the CE3METL model and developed a stochastic 3E-integrated model.

MAIN RESULTS

Based on the current policy and the outlook for future policy development, three sets of policy scenarios have been formulated: the single carbon pricing policy, the single subsidy policy for renewable energy, and the policy combination of carbon pricing and renewable energy subsidies. For each of these three policy scenarios, we set different levels of the carbon price and subsidy. Specifically, the subsidy rate levels are set as 0, 20% and 40%, respectively, and the carbon price levels are set ad valorem as 0, 200 USD/tC, 400 $/tC, 600 USD/tC, and 800 USD/tC, respectively, based on which we can obtain 15 policy scenarios.

With carbon mitigation efforts made by the Chinese government in the baseline scenario, the probability for carbon emissions to peak before 2030 is very low, only about 11.5%, and it does not reach 50% until 2040. This means that it is almost impossible for China to realize its carbon peaking target in 2030 without making further efforts. With the carbon tax and subsidy increasing, the distribution of the

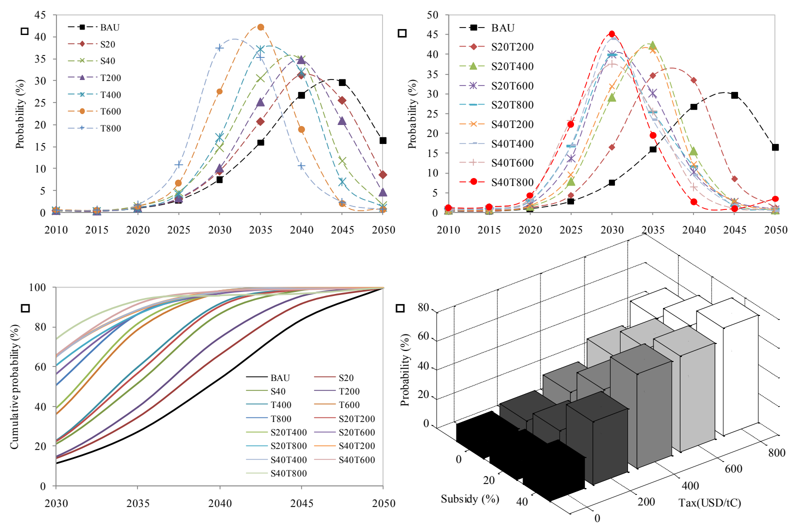

Figure 1. Probability and cumulative probability distribution of optimal time for CO_2 emissions to peak. a and b show the results under single policy scenarios and the policy mix scenarios; c and d denote the cumulative probability distribution of CO_2 emission peaking time and the probability of CO_2 emissions peaking before 2030, respectively.

time for carbon emissions to peak moves to the left, and the peaking time becomes earlier. Specifically, with a subsidy of 40% being introduced, carbon emissions mainly peak between 2035 and 2040, and the probabilities are 30.5% and 34.8%, respectively. While with a carbon tax of 800 USD/tC being introduced, the carbon emissions mainly peak between 2030 and 2035, and the probabilities are 37.6% and 35.4%, respectively (Figure 1). It followed that the carbon tax policy has a more significant effect on carbon emissions than does the subsidy policy; on the other hand, these results show that the single carbon tax and subsidy policy cannot guarantee with a high probability that carbon emissions will peak, and that a policy mix is needed. For the policy mix scenarios, several curves overlap with each other, and the curves become thinner and the time to peak becomes more concentrated; when further increasing the carbon tax and subsidy, the curves however do not move to the left significantly, which implies that the marginal effect of policy would diminish. Under the most stringent policy mix scenario (S40T800), carbon emissions would peak before 2030 with a cumulative probability of 73.9%. Thus, carbon emission management and policy-making should be implemented from the perspective of risk management, and policy makers can take corresponding policy measures based on the degree of confidence required; if they hope to realize the target with a higher degree of confidence or a higher probability, increased efforts should be made.

It is almost impossible for China to realize the non-fossil energy deployment target in 2030 under the current policy environment; and the contribution of the single subsidy policy to achieving the 20% non-fossil energy target is also quite limited (Figure 2). As for the single carbon tax policy, only when the carbon tax is high enough does the effect start to emerge and become remarkable, for example, as the carbon tax level increases from 200 to 800 USD/tC, the probabilities will expand from 1.42% to 82.2%, respectively. It should be noted that the policy mix has a more significant effect on energy transformation and decarbonization. To be specific, with the subsidy of 40% and the carbon tax of 200 USD/tC being implemented, the probability reaches 48.29%, when doubling the policy efforts, the corresponding probability will approach 100% (Figure 2). Therefore, one single subsidy policy is insufficient to ensure achievement of the 20% non-fossil energy target, and a policy mix is necessary. In addition, the synergistic effect of carbon tax on non-fossil energy development is also significant and should not be neglected; especially when a high carbon tax is implemented, the non-fossil energy target can be realized as a side effect of the carbon tax.

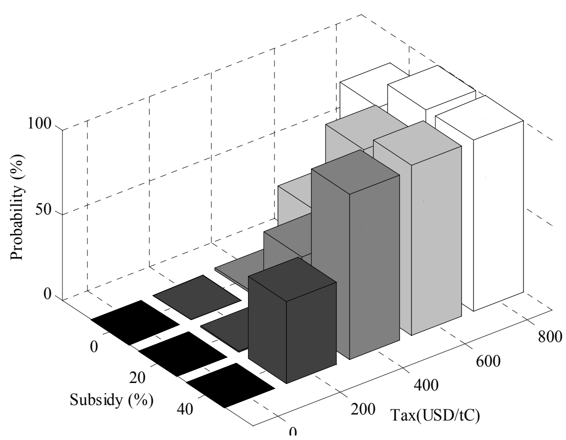

Figure 2. Probability to realize the 20% non-fossil energy target in 2030.

CONCLUDING REMARKS

Without taking any further policy measures, it is almost impossible for China to peak its carbon emissions in 2030, and the probability of carbon emissions peaking does not reach 50% until 2040. The effect of the single subsidy policy for renewables on carbon emissions is rather limited, and the probability of carbon emissions peaking before 2030 is only 21.3% in the presence of a 40% subsidy. While the carbon tax policy has more remarkable effect on carbon emissions, and the probability of peaking reaches 51.1% with a carbon tax of 800 USD/tC being implemented. The policy mix of carbon tax and renewable energy subsidy has a more significant effect on carbon emissions, and with a carbon tax of 800 USD/tC and a subsidy of 40% being introduced simultaneously, the target-realizing probability before 2030 reaches up to 73.9%.

Also, the simulation results reveal that carbon tax policy and renewable subsidies have a more significant effect on the energy mix change than on carbon emission evolution. Specifically, with a carbon tax of 800 USD/tC being introduced, the probability of realizing the non-fossil energy target is 82.5%, which is much higher than the probability of realizing the target of carbon emission peaking, i.e., 51.1%. Additionally, with a policy mix of 800 USD/tC and a 40% subsidy being implemented, the probability of realizing the non-fossil energy target would approach 100%, 26.1% higher than the probability for carbon emissions to peak. It can be inferred that it is easier to realize the non-fossil energy target, and some additional efforts and measures are needed to peak China's carbon emissions.

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WELCOME NEW MEMBERS

The following individuals joined IAEE from10/1/16 to 12/31/16

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Christopher Ball
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Energy Security and Economic Performance of the Caspian Region: How Vulnerable is the Region to the Falling Oil Price?

By Nathaniel Babajide

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See footnotes at end of text.

INTRODUCTION

Given the prime position of oil in Caspian economy, change in oil prices has become a crucial issue with significant implications on the development of the economies in the region. The oil and gas producing states in the Caspian region have experienced meaningful economic growth under high energy prices in the last decade. Now with the recent sudden and precipitous drop in global crude oil prices, it is imperative to examine the degree of vulnerability of the Caspian states economy to oil shocks, together with the associated economic and environmental challenges. This paper attempts to achieve this aim.

OVERVIEW OF CASPIAN REGION

With total surface area of about 371,000 km^2 (143,200 sq mi) (excluding Garabogazköl Aylagy) and volume of 78,200 km^3 (18,800 cu mi), the Caspian Sea is regarded as the world's biggest enclosed inland water body and the largest lake cum full-sized sea on the planet (EIA, 2013; Stratfor Global Intelligence, 2014). As an endorheic basin (without seepages), this landlocked sea sits at the border between Europe and Asia, bounded by Russia in the northwest, Azerbaijan in the west, Iran in the south, Turkmenistan in the southeast, and Kazakhstan in the northeast. These five major countries are accordingly considered in this study to constitute the Caspian region.

Apart from the rich biological diversity, the major economic importance of the Caspian region lies in its strategic position with massive energy and mineral resources endowment. According to 2015 British Petroleum (BP) statistics, the region holds about 17.6%, 46.4% and 21.4% of global proven reserves of oil, natural gas and coal, respectively (see table 1). This, accordingly, makes all Caspian littoral states a significant homeland of energy resources.

	Oil		Natural Gas		Coal	
	Billion Barrels	**R/P Ratio**	**Trillion Cubic metres**	**R/P Ratio**	**Billion Tonnes**	**R/P Ratio**
Azerbaijan	7.0	22.6	1.2	68.8	-	-
Iran	157.8	>100	34.0	>100	-	-
Kazakhstan	30.0	48.3	1.5	78.2	33600	309
Russia	103.2	26.1	32.6	56.4	157010	441
Turkmenistan	0.6	6.9	17.5	>100	-	-
Region Total (% of World)	298.6 (17.6%)		86.8 (46.4%)		190.6 (21.4%)	
World	1700.1	52.5	187.1	54.1	891.5	110

Table 1: Fossil Energy Reserve of Caspian Region, 2014

Source: BP, 2015

OIL PRODUCTION, CONSUMPTION AND EXPORT

Estimates from BP revealed that the Caspian region produced a total of 17.24 million b/d of crude oil, around 19.4% of the total world supply of 88.7 million b/d in 2014. Oil production in Russia and Iran stood at 10.8 and 3.6million b/d (63% and 21% of region total), respectively in 2014. This shows that the recorded annual production ceiling of 1.7mb/d in Kazakhstan, 848 thousand in Azerbaijan plus 239,000b/d in Turkmenistan accounts for just 14% of the total volume of oil produced in the area. However, the total oil consumption in 2014 stood at 5.74 million b/d, reflecting a net export margin of 11.5 million b/d, implying 66.5% of total production. Exports grew in the Caspian by 0.9% in 2014 over a 2013 value of 11.4 million b/d, due mainly to increased production in Russia and Iran.

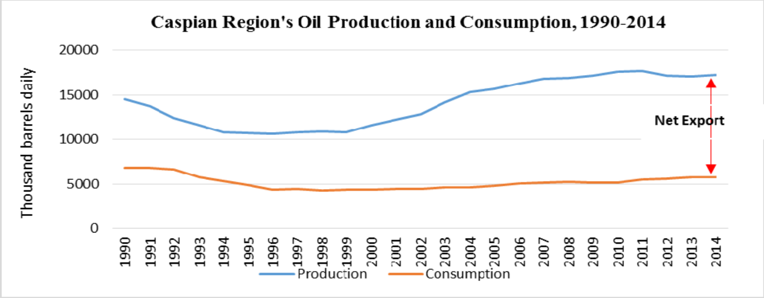

Figure 1: Caspian Region's Oil Production and Consumption, 1990-2014
Source: BP, 2015

In sum, the Caspian economies export between 40-80% of their total oil production. Russia is the biggest exporter supplying about 66.4 % of the region's export total in 2014, followed by Iran (13.8%), Kazakhstan (12.4%), Azerbaijan (6.50%) whereas Turkmenistan accounts for the remaining less than 1%. Nevertheless, Asia and European countries like Germany, The Netherlands and Poland are some of the leading destinations or importers of Caspian oil (IEA, 2013). Similarly, Caspian states export a substantial volume of natural gas, estimated at nearly 235 billion cubic meters (bcm), denoting about 18% of global total exports in 2014. Of this total volume, Russia accounts for around a whopping 72.1%, followed by Turkmenistan 17.7%; while Kazakhstan, Azerbaijan and Iran jointly contribute the remaining modest 10.2% of total Caspian natural gas export volume in the same year.

In light of the above, oil and gas revenue represents over 50% of federal budget revenues and about 70% of total exports in the region. It can, therefore, be inferred that the Caspian's thriving economic growth over the years has been driven primarily by commodity exports which consequently makes it extremely vulnerable to boom and bust cycles associated with volatile swings in global prices.

ECONOMIC OUTLOOK OF CASPIAN REGION

The Caspian region is historically one of the world's leading producers and exporters of oil and natural gas and its economy strongly depends on proceeds from hydrocarbons exports. Russia and Iran are the two largest economies of the region. Both countries constitute about 70.17% and 19.42% of region's total GDP (in constant 2005 US$), respectively. On a purchasing power parity (PPP) basis, the economy of Russia was $3.75 trillion in 2014 and accordingly ranks as the fifth largest economy globally after China, United States, India and Japan (World bank, 2016). As illustrated in Figure 2, the region's economic growth has been intermittent, averaging 7.3% from 2000-2014. The growth was, however, largely hampered by the 2008-09 global economic crisis during which oil prices sporadically dropped and the foreign credits relied upon by a majority of Caspian banks and firms dried up. The economy recuperated in subsequent years and recorded an average annual GDP growth of 3.0% and 4.3% in 2012 and 2014 respectively.

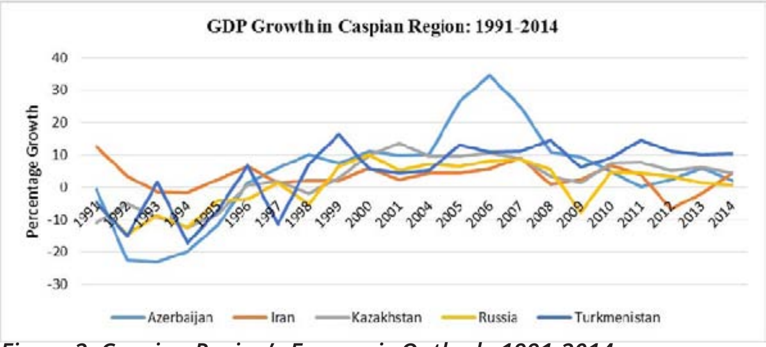

Figure 2: Caspian Region's Economic Outlook, 1991-2014
Source: Worldbank (2015)

This intermittent economic growth has over the years been driven primarily by commodity exports and makes the region extremely vulnerable to boom and bust cycles associated with volatile swings in global prices. This erratic fluctuation originates primarily from a combination of historical, geopolitical and economic factors among others. Of utmost concern is the recent downturn as crude oil prices dropped from an annual average of $110.42 a barrel in 2013 to $98.95 in 2014. This was exacerbated between June 2014 and January 2016 as the global crude price dropped dramatically from around $110 to below $50, indicating a whopping 60% fall within two years, thereby causing heavy revenue shortfalls for constituent oil exporting nations in the Caspian region.

CASPIAN'S ENERGY RELATED CO2 EMISSIONS

The major problem associated with huge fossil fuel utilization is the GHGs emissions arising from its combustion, specifically carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NO_x) and Methane (CH_4) which are highly detrimental to human health and environment. Historical trends show a high volume of CO_2 emission in the Caspian region, as shown in Figure 3, which has fluctuated erratically from 1990 to 2014. In sum, Caspian states emitted 2607.7 million tonnes (Mt) of CO_2 (7.4% of global emission) in 2014. Of this, 1657.2 mt came from Russia, 650.4 mt from Iran, 188.6 mt from Kazakhstan, 78.1 mt from Turkmenistan and 33.5 mt from Azerbaijan. Russia and Iran were the major emitters of

CO_2 in the region, accounting for over 88% of the CO_2 emitted in 2014. This resulted principally from environmental pollution through large scale oil and gas production and consumption cum gas flaring in the region.

To this end, the Caspian's heavy fossil fuel reliance portends enormous GHGs danger, principally CO_2 emissions, with possibly severe impacts upon global climate change. Also, the indiscriminate discharges of petrochemical and biological pollutants (transboundary contaminants) via enormous transport activities (principally through the Volga River) coupled with existing and planned massive oil and gas pipelines projects in the Caspian sea, further increase the region's ecological menace.

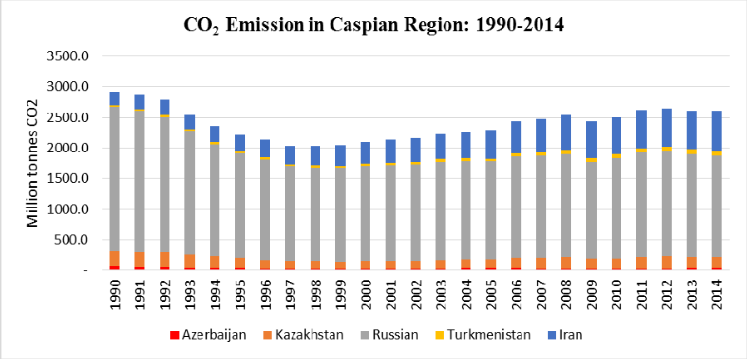

Figure 3: Caspian's Energy Stimulated CO2 Emission: 1990-2014
Source: BP, 2015

VULNERABILITY OF CASPIAN REGION TO OIL PRICE SHOCKS

To investigate the vulnerability of the Caspian economy to oil price shocks, this study employs the Vulnerability Indicator (Ratio of Net Value of Oil Exports to GDP) as presented below.

$$\text{Vulnerability} = \frac{\text{Net Oil Exports (NOEX)}}{\text{GDP}}$$

$$\left(\frac{\text{NOEX}}{\text{GDP}}\right) = P * \left(\frac{\text{volume net oil exports}}{\text{Total oil use}}\right) * \left(\frac{\text{Total oil use}}{\text{Total energy use}}\right) * \left(\frac{\text{Total energy use}}{\text{GDP}}\right)$$

Where: NOEX is Net Oil Export, GDP is Gross Domestic Products and P is price of oil

$$\text{Vulnerability Impact} = \text{ \% price change} * \text{ (Share of oil exports in GDP)}$$

Ultimately, this indicator was adopted as a tool to gauge the Caspian economies' vulnerabilities to the recent fall in global oil prices and identify potential options for curtailing associated risks in future. Moreover, as the degree of vulnerability is a combination of different factors; the study further examines the region's Diversification of primary Energy Supply (DPES) and Carbon Free Energy Portfolio (CFEP)

DIVERSIFICATION OF PRIMARY ENERGY SUPPLY (DPES)

This index is employed as it considers both the significance of diversification in terms of abundance and equitability of energy supply sources. This according to APEC (2007) is calculated as;

$$\text{DPES} = {}^{\beta}/_{\text{Ln}\ \eta} \qquad But \quad \beta = -\sum(Q_i LnQ_i)$$

Where

β is the Shannon's bio-diversity Index, Q is the share of energy source in TPES, Ln is the natural log, i is the sources of energy and η is the number of energy sources used.

The final estimate from this metric is normalised on a scale of 0-100. Values closer to zero depict a country's dependency on one energy source while that closer to 100 signifies even distribution among the main energy sources. Hence, the lower the DPES value, the higher the risk of energy supply security.

CARBON FREE ENERGY PORTFOLIO (CFEP)

This evaluates the degree of carbon concentration in the region's energy mix thus highlighting the need for the switch away from a carbon intensive fuel mix. The measure considers the proportion of non-fossil sources like hydro, nuclear, solar, wind, geothermal, etc. in the nation's overall energy mix. The indicator is computed as follows:

$$CFEP = \frac{\text{PES}_{\text{hydro}} + PES_{nuc} + PES_{renew}}{PES_{total\ energy}}$$

The final result obtained from this metric is expressed in percentage. Higher percentages denote greater potential offset against likely environmental degradation to the nation's energy supply security.

RESULT AND DISCUSSION

This section presents the results obtained from the calculation of three energy security indicators discussed above:

VULNERABILITY OF CASPIAN ECONOMIES TO OIL PRICE SHOCKS

From a macroeconomic viewpoint, the vulnerability of a net oil exporting country can be determined by the ratio of the value of net oil exports to GDP. The higher this ratio, the larger the fall in GDP that is required to offset a fall in oil prices. The impact of the oil price shock is calculated as the index of vulnerability multiplied by the percentage change in oil prices. Based on this, the vulnerability of the Caspian economies to oil price changes is calculated using historical data of GDP, oil consumption, exports and prices from 1980-2015[1] and the result is presented in figure 4.

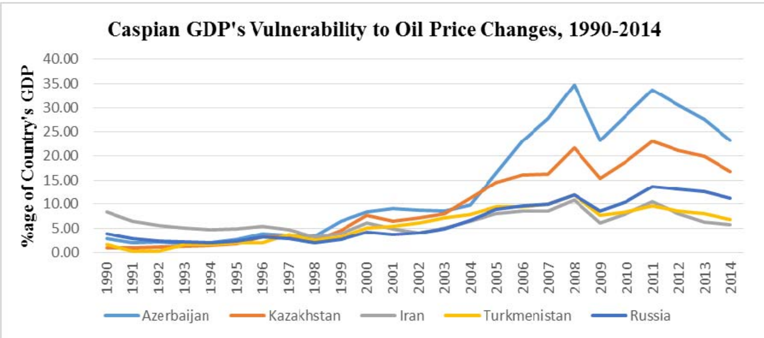

Figure 4: Caspian GDP's Vulnerability to Oil Price Changes, 1990-2014

Source: the study

The result reveals that the Caspian economy is much more vulnerable to oil price changes as the oil export share of GDP moves in the direction of variation in global oil market. During periods of high oil prices, notably 2008 and 2011, when the average annual price of oil was respectively $107 and $117 a barrel, oil export revenue share of GDP was significantly high in the region; while under plummeting oil price regimes (for instance 2009 and 2014 when average oil price dropped to $68 and $98 respectively (see figure 2), the contribution of oil exports to GDP was greatly submerged. Among the five member countries, however, the vulnerability impact is seen to be more pronounced in Azerbaijan and Kazakhstan owning to their highccontribution of oil export revenue to their GDP. Moreover, the downward trend or prices observed from 2011 to below $50 as of April 2016, suggests an increasing vulnerability of the Caspian Region's economy.

DIVERSIFICATION OF PRIMARY ENERGY SUPPLY (DPES)[2]

As earlier stated, DPES measures the degree of diversification within the Caspian economies' primary energy supply. The DPES values presented in Figure 5 are normalised on a scale of 0-100, with values closer to 100 reflecting an even distribution among the main energy sources in the economy. As evident in Figure 5, three economies, Russia, Iran and Kazakhstan had DPES value higher than 50, ranging from 58 (in Kazakhstan) to 70 (in Russia) between 1990-2014. These values signify that these economies are moderately diversifying their supply portfolios and owning to availability of sizeable energy supply sources, these economies are less prone to energy supply security risk.

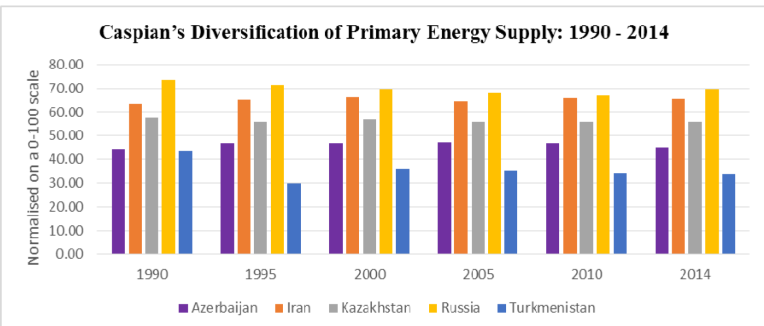

Figure 5: Caspian's Diversification of Primary Energy Supply (DPES) from 1990 - 2014

Source: the study

Nevertheless, the constancy of growth as well as intermittent DPES values obtained within the considered period suggests significant attention. As for the Azerbaijan and Turkmenistan economies, on the other hand, the DPES values below 50 suggest that they are primarily dependent on few sources of energy to meet their rising energy demand. These lower DPES values signal that the two economies have a higher level of energy supply security risk because they are highly prone to any changes occurring in the variable energy markets surrounding these sources.

In terms of average Caspian diversification efforts, a slightly decreasing DPES value from 53 to 52 was obtained within the considered period. This indicates that few economies in the region remain relatively low in terms of diversification, while those that exhibit high diversification tendencies like Russia and Iran also need great strides towards more diversification of their demand portfolios. Overall, this metric also reveals the potential for increasing energy supply risk within the Caspian as the economies are principally dependent on oil and gas proceeds. Moreover, high oil and gas export dependency is detrimental to the region's economic growth because of the unpredictability in the current and future prices of its main energy source in the global market, thus underlining the need for more diversity in the region's energy portfolio.

CARBON FREE ENERGY PORTFOLIO (CFEP)

This study also analyses Caspian's vulnerability in terms of non-carbon energies in the region's overall energy portfolio; which includes hydro, nuclear and renewable energies. Although a high carbon-free percentage reveals a greater potential for curbing potential environmental degradation, the share of this vital indicator amidst Caspian economies is seen to be very low, less than 4% throughout the considered period. Figure 6 reveals great variation in the CFEP values in the selected years. In 1990, Russia's CFEP share was 3.0%, this improved to 3.7% (the highest) in 1995 and thereafter declined over the years reaching a low figure of 2.9% in 2014.

As for Azerbaijan, its CFEP value rose from 0.7% in 1990 to reach 3.3% in 2010 and eventually dropped to about 1.9% in 2014, while this same metric in Kazakhstan rose from 1% in 1990 to 2% in 2000 and stood below 1% in 2014. In the case of Iran and Turkmenistan, CFEP values stood at approximately 1% and 0.2% respectively in 2014. The low yet fluctuating historical CFEP trend highlights the absence of any concerted effort amidst the Caspian states to develop carbon free energy sources. Moreover, the clearly low proportion of non-carbon based fuel in the Caspian economies' energy portfolio highlights the need for these economies to seriously pursue options to curb energy stimulated GHGs emissions and facilitate future CFEP growth in the region. The index, however, discloses the region's high vulnerability to possible environmental degradation associated with huge fossil energy production and export.

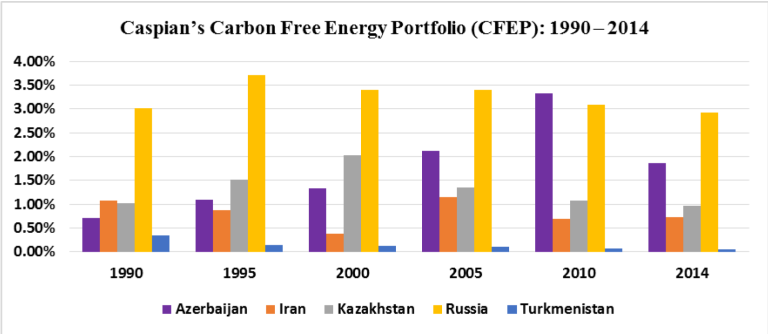

Figure 6: Caspian's Carbon Free Energy Portfolio (CFEP): 1990 – 2014

Source: the study

CONCLUSION

This study reveals that the Caspian as an important net oil exporting region is highly vulnerable to oil shocks and that the recent downward trend in the global oil price is further exacerbating the situation, thus placing a crucial burden on economic growth and competitiveness of member economies. Based on the findings of this study, energy supply cum foreign earning sources diversification is very essential for meaningful economic and energy security amongst the member economies. In addition, huge investment in renewable energy technologies (wind, solar, hydro and biomass) is required to reduce Caspian's heavy dependence and high vulnerability to oil price changes as the prices of renewable solutions are independent of the global oil price.

To further strengthen the region's energy security efforts, it is vital to encourage research and development (R&D) initiatives as this will promote technological improvement in the region. Finally, regional cooperation among member states is also recommended to facilitate investment, project funding, capacity building and technology transfer. The general conclusion of this research is that the Caspian economy faces a serious problem of adjusting to the present and potential future low oil price shocks. Nevertheless, few policy measures are available to member states. This paper hence calls for thorough research (on country basis) into the gravity of the implication these would have on the different sectors of the economy; this will perhaps offer invaluable insights for relevant policy formulation to curb this situation at sectoral levels instead of a broad approach.

Footnotes

[1] Historical data for this indicator was acquired from World Bank and BP Statistics, 2015.

[2] Historical data from 1990 is acquired from the International Energy Agency (IEA) database, and therefore includes major primary energy supply sources in the region, both renewable and non-renewable.

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Calendar

07-07 February 2017, V INTERNATIONAL ACADEMIC SYMPOSIUM: Challenges for the Energy Sector at Barcelona (Spain). Contact: Email: chairenergysustainability@ub.edu, URL: http://www.ieb.ub.edu/es/catedra-de-sostenibilidad-energetica/v-international-academic-symposium-challenges-for-the-energy-secto

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13-16 March 2017, Financial Modelling for Energy Industry - Johannesburg at Johannesburg, South Africa. Contact: Phone: +6563250351, Email: vincs@infocusinternational.com, URL: http://www.infocusinternational.com/financialmodelling/index.html

15-17 March 2017, Argus Latin America LNG Summit at Rio de Janeiro, Brazil. Contact: Phone: 713.360.7566, Email: bel.cevallos@argusmedia.com, URL: https://go.evvnt.com/70295-0

20-22 March 2017, Master Class LNG Industry at Barcelona, Spain. Contact: Phone: +31 (0) 88 1166837, Email: bakker@energydelta.nl, URL: https://www.energydelta.org/mainmenu/executive-education/specific-programmes/master-class-lng-industry-lng-training-course

20-22 March 2017, Managing and Negotiating Engineering, Procurement and Construction (EPC) Contracts for Energy Industry at Kuala Lumpur, Malaysia. Contact: Phone: +6563250351, Email: vincs@infocusinternational.com, URL: http://www.infocusinternational.com/epcenergy/index.html

21-22 March 2017, European Smart Grid Cyber Security 2017 at Holiday Inn Kensington Forum, London. Contact: Phone: +44 (0)20 7827 6156, Email: tchung@smi-online.co.uk, URL: http://www.smartgirdcybersecurity.co.uk/iaee

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