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IAEE Energy Forum

Third Quarter 2013 International Association for Energy Economics

President's Message

I am writing this having recently returned from the ELAEE conference in Montevideo but before setting off to Daegu in South Korea for the International Meeting in June. April in Montevideo was balmy by the sea-like and vast River Plate, and the city is clearly a very relaxed place, particularly on a sunny Sunday, but the conference was lively, entertaining and very informative. For that, special thanks to Marisa Leon, Vice President of ALADEE and real organizer of the 4th ELAEE, for her hard work and attention to detail that made the conference so successful. Thanks also to Gerardo Ravinovich, President of ALADEE (host to the Buenos Aires 2011 3rd ELAEE), for the steadfast support ALADEE has provided to developing and sustaining the Latin American Affiliate of IAEE. It is clear that ALADEE is hugely supportive of such ventures, and there was serious discussion of the possibility of annual meetings, rather than the present biennial meetings. This may yet happen, but meanwhile attention is concentrated on delivering the 2015 meeting in Medellin.

Attending these conferences reminds me what a huge amount of cooperative work goes into delivering a result that we all tend to take for granted, so high are our expectations. So it is particularly pleasing that in late May the Professional Convention Management Association awarded the IAEE's Executive Director the Global Executive of the Year Award. In announcing the award, Sherrif Karamat, CAE and Chief Operating Officer of the PCMA said "David is a proven leader in the industry, his winning of the award is justified by the energy and enthusiasm he brings and his will and desire to continuously move this industry forward especially in the global arena." I would add my praise to Dave, not only in tirelessly supporting the conference organisers, but in guiding the IAEE Council, its Executive Committee, and particularly the President, who arrives fairly fresh to the task each year. The award should assist Dave in his negotiations with conference venues and thus all of us. Hearty congratulations. (Also see Gürkan Kumbaroglu note on page 38).

At the Montevideo meeting, I was struck with the sense in which Southern Cone electricity markets are impacted by both world and local events. From the days of cheap hydro-electric power in Brazil and cheap natural gas in Argentina, times have changed considerably. Brazil needs some 6 GW of new capacity each year, which is to be met partly by distant and expensive run-of-river hydro but also by new thermal plant and other renewables. Wind power has been winning most of the auctions for new capacity and driving down prices, making it harder for new thermal plant to enter. Meanwhile, droughts now mean importing expensive gas, which if it comes in the form of LNG has been impacted by the Fukushima Daichi disaster. LNG prices have soared as Japan has closed nuclear power stations and switched to expensive LNG-supplied generation. Argentina has had to rely on combined cycle gas turbines running on imported LNG and distillate – both far more expensive than the highly subsidised electricity price.

The significance of hydro-power and gas was brought home to me dramatically by two recent site visits. The first was the fulfilment of a long-held wish to visit the Itaipu hydro scheme and the Iguazu falls (made famous by Robert De Niro in The Mission) immediately after the Montevideo conference. I am grateful for a personally guided tour of Itaipu arranged by the impressive entrepreneur and gas developer, Roberto Viana Batista. I knew Itaipu was big (and it is still the largest producer of hydro-electric power in the

(continued on page 2)

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CONTENTS

Editor: David L. Williams

(President's Message continued from page 1)

world, even though the Three Gorges scheme has a higher installed capacity), but was still unprepared for its scale. Its 20 massive turbines, each covered by a casing several times the diameter of the Heysham advanced gas-cooled nuclear reactor on which I stood on an earlier visit, are each powered by 700 tonnes of water per second, each half the volume of the entire Iguaçu falls system. Together these 20 turbines deliver 14,000 MW of baseload power, half to Brazil and half to the joint owner, Paraguay.

The second visit, arranged by National Grid, one of the sponsors of the Cambridge Energy Policy Research Group, was to the Isle of Grain LNG terminal in the Thames estuary and the nearby landing point of the 1,000 MW Britned electricity interconnector to the Netherlands. They, like Itaipu, are also hugely impressive pieces of infrastructure. Standing on the top of one of the vast LNG storage tanks one can see three neighbouring gas-fired power stations and three large old thermal power stations, one of which has converted to biomass, one of which runs on oil perhaps three days per year and will shortly close, and one hoped to become a CCS demo plant. It is not often one can look down on so many aspects of recent energy policy from a single land-based vantage point.

IAEE conferences will continue to track the rapidly changing world energy scene, as gas and low-carbon fuels continue to be important in every continent, and there is nothing like high LNG prices to stimulate the search for cheaper gas, both in Latin America and elsewhere.

David Newbery

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

This issue concludes our review of the energy efficiency topic with two articles. However, first; we look at the subject of energy independence and small nuclear reactors.

Ioannis Kessides discusses the potential prospects of small nuclear reactors (SMRs) noting that they could enhance component manufacturing productivity while reducing construction time, financing costs and investment risks; cap safety hazards because of their inherent safety features and reduced radioactive inventory; and more effectively address the energy needs of small developing countries.

Lina Escobar Rangel and François Lévêque review French nuclear power construction costs using the information issued in 2012 by the French government audit agency. They demonstrate that previous studies have overestimated the cost escalation in France and find positive learning effects whenever similar types of reactors are built.

Morgan Bazilian, Benjamin Sovacool, and Mackay Miller briefly explore the merits of energy independence as a policy concept, and dissect its shortcomings. They ground the concept in a wider framework of energy security and look at energy services as a means to broader social, environmental, and economic ends.

Kenichi Matsui recounts the history of nuclear power plant development, noting that from the beginning there were arguments for developing small modular reactors rather than the large, light water reactors which are dominant today. He explains the benefits of the small modular reactor and how its development is particular important for Japan.

Mamdouh Salameh argues that while the U.S. shale oil boom would probably have a positive impact on the U.S. economy, it would hardly make a dent in the global oil supply nor would it enable the United States to achieve oil independence.

Peter Grossman explains why U.S. energy policy always seems to fail. He posits that it is based on a narrative that for thirty-nine years has been mostly wrong and bears little resemblance to reality—either today or that of the past. Until the narrative changes he says we'll never see an effective energy policy in the U.S.

Haydn Furlonge examines the vast potential for the U.S., once a gas-importing country, to become a major natural gas supplier, and the ramifications of this. The bi-directional capability of its LNG import and gas storage infrastructure makes it an influential trading hub for the region. These supply/demand currents, coupled with a re-configured ownership structure of hydrocarbons and consequential geopolitical spin, make for a proverbial "perfect storm" in the Atlantic basin gas market.

Florens Flues, Andreas Löschel, Philipp Massier, Nikolas Wölfing note that the shale gas boom in the United States also awakens desires in Europe: Energy independence seems to knock at the European Union´s door. Yet, results from a survey of energy market experts at ZEW suggest that fracking in the European Union is only profitable when natural gas prices rise significantly and they question whether that will happen.

Sirid Sif Bundgaard, Kirsten Dyhr-Mikkelsen, Anders E. Larsen and Mikael Togeby report that following the new Energy Efficiency Directive, Member States throughout the European Union will implement Energy Efficiency Obligation schemes. They present lessons learned from Denmark regarding design and implementation challenges of these new Obligation schemes.

Yulia Pidlisna offers an overview of the Ukrainian electricity sector and provides results of research focused on the Ukrainian energy distribution companies called Oblenergos; in particular, on the difference between private and state owned operations.

DLW

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Program Announcement

Energy Economics of Phasing out Carbon and Uranium

13th European IAEE Conference
18-21 August 2013 in Düsseldorf, Germany

Hilton Düsseldorf Hotel, Georg-Glock Strasse 20, 40474 Düsseldorf

Dear Energy Colleague,

The ambitious renewable energy policy of the European Union and the German Government has stimulated an unanticipated increase of renewable electricity generation capacities. Likewise the renewable shares in the heating and the transportation sectors are on the rise. New global industries have been created which are flourishing in spite of still uncompetitive costs.

Following the Fukushima nuclear catastrophe, the German government has decided to speed up the phase out of nuclear power in this country. If renewable energies cannot close the generation gap, increased greenhouse gas emissions may be the consequence impacting the European Emission Markets.

The European 13th European IAEE Conference in Düsseldorf will offer the opportunity to discuss these developments and to analyze the policy and its economic, ecological and social implications from an energy economics perspective.

As delegate you will get insights into a unique energy policy experience, can compare it with the energy strategies in other countries across and outside Europe and will contribute with their own analyses to a better understanding of energy systems on the pathway towards sustainability.

Our IAEE affiliate, the *Gesellschaft für Energiewissenschaft und Energiepolitik (GEE) e.V.*, is honored to invite you to the Conference and would be proud if you will join us in August 2013 and contribute to this important energy meeting with your valuable input.

Our host city Düsseldorf in the "Rheinland" is a very interesting place of post-industrial transformation in Germany, perfectly easy to reach right in the center of Europe. You will be able to join offsite events that will give you the chance to experience the diversity of this region and the beauty of its nature.

We look forward to seeing you in Düsseldorf!

Preliminary Program

18 August 2013	18:00 -20:00	Welcome reception
19 August 2013		Student Breakfast, Opening ceremony, Plenary and Dual Plenary Session, Concurrent Sessions, Gala Dinner
20 August 2013		Plenary and Dual Plenary Session, two blocks of Concurrent Sessions, Offsite Event
21 August 2013	Until 13:00	Concurrent Sessions, Closing Session

Plenary sessions

The **(dual) plenary sessions** will be devoted to the following themes:

- European gas markets – towards new pricing arrangements
- Electricity market design
- Support mechanisms for low carbon technologies
- German energy transformation
- Long term planning of infrastructures
- Energy efficiency and consumer behavior

Confirmed speakers include among others:

- **David Newbery** (IAEE President)
- **Lore Smith Schell** (President USAEE)
- **Peter Hartley** (Rice University Houston)
- **Peter Cramton** (University of Maryland)
- **Carlo Andrea Bollino** (AIEE)
- **Christoph Schmidt** (RWI)
- **Hans-Peter Floren** (OMV)
- **Peter Boerre Eriksen** (energinet.dk)
- **Richard Scott** (E.ON)
- **Garrelt Duin** (Minister for economy and energy, Northrhine-Westfalia)

For further information visit http://iaee2013.gee.de

Registration Fees

Participants	Early Registration before May 31 (EUR)	Late Registration after June 1 (EUR)
GEE/IAEE Speakers and Chairs	500	550
Speakers/Chairs (Non-Members)	600	650
GEE/IAEE Members	650	700
Non-members	750	800
GEE/IAEE Full Time Students	250	300
Full Time Students (Non-Members)	300	350
Accompanying persons	200	250

IAEE Conference Student Program

As part of the IAEE Conference Student Program, the IAEE offers the IAEE Best Student Paper Award and IAEE Conference Student Scholarships. If you have any further questions regarding IAEE's Conference Student Program, please visit http://www.gee.de/iaee-european-conference-2013/iaee-konferenz-studierenden-programm/ or contact us via e-mail at: kontakt@gee.de

IAEE Best Student Paper Award
IAEE is pleased to offer an award for the best student papers on energy economics in 2013. The award will consist of a cash prize plus waiver of conference registration fees to attend the IAEE Conference.

OFID/IAEE Conference Student Scholarship
IAEE is offering a limited number of student scholarships to the 13th IAEE European Conference. IAEE scholarship funds will be used to cover the conference registration fees.

Venue

The venue of our conference is the Hilton Düsseldorf Hotel, close to Rhine river. It is easy to reach via DUS international airport, Düsseldorf central station and public transportation (station *Theodor-Heuss-Brücke* U78/U79). The historic center is famous for the "world's longest beer bar" and the boulevard *Königsallee*. Düsseldorf is placed in the "Rheinland", a region undergoing profound socio-economic changes, which are linked to a former transformation in the German energy sector... As Düsseldorf is an important international exhibition center in the heart of Europe, its infrastructure makes it the perfect host city for the 13th European IAEE Conference.

Committees

CHRISTOPH WEBER
(Chair)

MARTIN CZAKAINSKI
(Sponsorship Committee Chair)

GEORG ERDMANN
(Concurrent Session Chair)

CHRISTIAN VON HIRSCHHAUSEN
(Plenary Program Chair)

CLAUDIA ESSER SCHERBECK
(Local Arrangement Committee)

PHILIPP RIEGEBAUER
(Student Committee Chair)

37TH IAEE INTERNATIONAL CONFERENCE

JUNE 15–18, 2014 | NEW YORKER HOTEL | NEW YORK CITY, USA

ENERGY & THE ECONOMY

CONFERENCE OVERVIEW

The relationship between economic growth and energy becomes ever more important as economies around the world struggle to reinvigorate themselves and to develop energy resources in sensible, sustainable ways. Can economic growth be stimulated even with pressure to reduce if not forego certain forms of energy for environmental or safety reasons? Alternatively, can oil, gas and other energy development be a major force that stimulates economic growth? What policy framework would maximize the contribution of energy to growth while encouraging efficient substitution of sustainable for less sustainable sources?

The 37th IAEE International Conference, taking place in New York City in 2014, will focus on these and related issues. New York is the financial center of the United States, a place where multi-billion dollar bets are laid on future economic growth and on energy technologies, and therefore a place where analysis of subjects like these is constantly in demand. Some of the very best minds in energy economics in the world will assemble there for what promises to be one of the best IAEE Conferences ever. Economists from a number of countries will examine questions related to energy and the economy from a wide variety of perspectives. High level policy makers will talk about the challenges they face, while analysts will offer practical, evidence-based approaches to meeting such challenges. The agenda will be filled with top-notch speakers plus 3 days of concurrent sessions, places where the results of specific topical research will be presented and absorbed.

The conference also will offer networking opportunities through informal receptions, breaks between sessions, and student recruitment. These provide opportunities for attendees to renew acquaintances and to forge new ones. There will be special events for students, including paper, poster and case competitions. And as usual, an outside event will spice the conference agenda. If that weren't enough, New York City offers a myriad of cultural attractions from museums to musical, dramatic and athletic performances. Not to mention some of the best shopping in the entire world. It's a conference program and a venue not to be missed.

Topics to be addressed include:

The general topics below are indicative of the types of subject matter to be considered at the conference. A more detailed listing of topics and subtopics can be found at: www.usaee.org/usaee2014/topics.html

- Energy Demand and Economic Growth
- Energy Supply and Economic Growth
- Financial and Energy Markets
- Energy and the Environment
- Non-fossil Fuel Energy: Renewables & Nuclear
- International Energy Markets
- Energy Efficiency
- Energy Research and Development
- Political Economy of Energy
- Public Understanding of and Attitudes towards Energy
- Other topics of interest include new oil and gas projects, transportation fuels and vehicles, generation, transmission and distribution issues in electricity markets, etc.

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37[TH] IAEE INTERNATIONAL CONFERENCE CALL FOR ABSTRACTS

We are pleased to announce the Call for Abstracts for the 37[th] IAEE International Conference, *Energy and the Economy*, to be held June 15 through 18, 2014, at the New Yorker Hotel, New York City, USA.

CONCURRENT SESSIONS

There are two categories of concurrent sessions: 1) current academic-type energy economics research, and 2) practical case studies involving applied energy economics or commentary on current energy-related issues. This latter category aims to encourage participation not only from industry but also from the financial, analyst and media/commentator communities. In either instance, papers should be based on completed or near-completed work that has not been previously presented at or published by IAEE/USAEE or elsewhere. Presentations are intended to facilitate the sharing of both academic and professional experiences and lessons learned. It is unacceptable for a presentation to overtly advertise or promote proprietary products and/or services. Those who wish to distribute promotional literature and/or have exhibit space at the Conference are cordially invited to take advantage of sponsorship opportunities – please see www.usaee.org/usaee2014/sponsors.html.

The deadline for receipt of abstracts for both the Concurrent Sessions and the Student Poster Session is Friday, January 10, 2014.

Concurrent Session Abstract Format

Authors wishing to make concurrent session presentations must submit an abstract that briefly describes the research or case study to be presented.

The abstract must be no more than two pages in length and must include the following sections:

a. Overview of the topic including its background and potential significance
b. Methodology: how the matter was addressed, what techniques were used
c. Results: Key and ancillary findings
d. Conclusions: Lessons learned, implications, next steps
e. References (if any)

Please visit www.usaee.org/USAEE2014/PaperAbstractTemplate.doc to download an abstract template. All abstracts must conform to the format structure outlined in the template. Abstracts must be submitted online by visiting www.usaee.org/USAEE2014/submissions.aspx. Abstracts submitted by e-mail or in hard copy will not be processed.

Student Poster Session

The Student Poster Session is designed to enable students to present their current research or case studies directly to interested conference delegates in a specially designed open networking environment. Abstracts for the poster session must be submitted by the regular abstract deadline and must be relevant to the conference theme. The abstract format for the Poster Session is identical to that for papers; please visit www.usaee.org/USAEE2014/PaperAbstractTemplate.doc to download an abstract template. Such an abstract should clearly indicate that it is intended for the Student Poster Session – alternatively that the author has no preference between a poster or regular concurrent session presentation. Abstracts must be submitted online by visiting www.usaee.org/USAEE2014/submissions.aspx. Abstracts submitted by e-mail or in hard copy will not be processed. Poster presenters whose abstracts are accepted should submit a final version of the poster electronically (in pdf format) by April 14, 2014 for publication in the online conference proceedings. Posters for actual presentation at the conference must be brought directly to the conference venue on the day of presentation and must be in either ANSI E size (34in. x 44in.) or ISO A0 size (841mm x 1189mm) in portrait or landscape format.

Presenter attendance at the conference

At least one author of an accepted paper or poster must pay the registration fees and attend the conference to present the paper or poster. The corresponding author submitting the abstract must provide complete contact details—mailing address, phone, fax, e-mail, etc. Authors will be notified by February 27, 2014, of the status of their presentation or poster. Authors whose abstracts are accepted will have until April 14, 2014, to submit their final papers or posters for publication in the online conference proceedings. While multiple submissions by individuals or groups of authors are welcome, the abstract selection process will seek to ensure as broad participation as possible: each author may present only one paper or one poster in the conference. No author should submit more than one abstract as its single author. If multiple submissions are accepted, then a different author will be required to pay the registration fee and present each paper or poster. Otherwise, authors will be contacted and asked to drop one or more paper(s) or poster(s) for presentation.

STUDENTS

In addition to the opportunities at left, students may submit a paper for consideration in the IAEE Best Student Paper Award Competition (cash prizes plus waiver of conference registration fees). The paper submission has different requirements and a different deadline. The deadline for submitting a paper for the Student Paper Awards is February 13, 2014. Visit www.usaee.org/usaee2014/bestpapers.html for full details.

Students are especially encouraged to participate in the Student Poster Session. Posters and their presentations will be judged by an academic panel and a single cash prize of $1000 will be awarded to the student with the best poster and presentation. For more details including the judging criteria visit www.usaee.org/usaee2014/postersession.html

Students may also inquire about scholarships covering conference registration fees. Please visit www.usaee.org/usaee2014/scholarships.html for full details.

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!! Congratulations !!

2012 USAEE/IAEE Best Working Paper Award

USAEE and IAEE are pleased to announce the winner of the 2012 USAEE/IAEE Best Working Paper Award. Congratulations go to:

Matthew Brigida

for his paper entitled:

"The Switching Relation between Natural Gas and Oil Prices"

Matthew Brigida is an Associate Professor of Finance at the Clarion University of Pennsylvania

Approximately 50 papers were received into the Working Paper Series in 2012. Papers were judged based on their contribution to the literature, scholarship, and originality. The review committee consisted of Kevin Forbes (chair), The Catholic University of America; Ricardo B. Raineri, The World Bank; and Kenneth Medlock, Rice University. The committee noted that the paper addresses a well-known issue using a very clever empirical technique. Specifically, the paper examines the cointegrating relationship between natural gas and crude oil prices. In contrast to earlier research, the pricing regime is endogenous to the model. The research is expected to contribute to an improved understanding of energy markets and better forecasts of relative prices.

The committee also noted that the overall quality of the papers was excellent and would like to thank all of the authors for their submissions.

For more details regarding the USAEE/IAEE Best Working Paper Series please click here.

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Small Modular Reactors in an Uncertain Nuclear Power Future

By Ioannis N. Kessides*

The future of nuclear power remains clouded in uncertainty and controversy. The Fukushima Daiichi disaster in March, 2011 has heightened public apprehension about nuclear safety, as after the disasters at Three Mile Island and Chernobyl. Consequently, public opposition to nuclear power has intensified in Europe and in a number of developing countries. Great debate also exists over the cost-effectiveness of nuclear energy, and about current and future technical advances that could address economic and safety concerns.

Nevertheless, several developing countries (larger and smaller, middle and lower-income) are actively considering nuclear power in their national energy mix. This interest in nuclear power is driven primarily by energy security concerns—the level and volatility of fossil fuel prices, and the availability and reliability of other sources of supply. While many developing countries are also making major commitments to renewable energy, all large-scale (grid-connected) renewable investments require considerable subsidies given the current state of technology, implying a long-term financial burden. Although there have been significant cost reductions driven by technological change, wind, solar and other renewable generating technologies are still more expensive (per unit of electricity delivered) relative to conventional fossil fuels. An overly rapid uptake of renewables in developing countries could have significant implications for their competitiveness.

Recent research indicates that there is no obvious "silver bullet" for addressing the challenges of energy security and the need for massive increases in electricity supply in developing countries, while also curbing global emissions of greenhouse gases leading to climate change. A number of energy sources and technological options exist. However, there are highly divergent views on the environmental, social, and economic tradeoffs associated with all of these options. In the face of significant economic and technological uncertainties, prudence calls for energy supply diversification. A broad portfolio of low-carbon technologies and energy sources (larger and smaller-scale) needs to be investigated and developed, in addition to major improvements in energy efficiency. Over the longer term, in particular as technology advances, nuclear power may need to play an important role in managing the costs of transition to a low-carbon economy with scalable and affordable electricity supplied to meet the projected large absolute increase in electricity demand in developing countries.

For nuclear power to play a major role in meeting the future global energy mix and security, the hazards of another Fukushima and the construction delays and costs escalation that have plagued the industry in recent years have to be substantially reduced. The technical complexity, management challenges, and inherent risks of failure posed by the construction of new nuclear plants have been amplified considerably (perhaps non-linearly) as their size increased to the gigawatt scale and beyond. And so have the financing challenges. One potential solution might be to downsize nuclear plants from the gigawatt scale to smaller and less-complex units. New generations of nuclear reactors are now in various stages of planning and development promising enhanced safety, improved economics, and simpler designs.

Small modular reactors (SMRs) are scalable nuclear power plant designs that promise to reduce investment risks through incremental capacity expansion, become more standardized and lead to cost reductions through accelerated learning effects. They can also address concerns about catastrophic events since they offer passive safety features and contain substantially smaller radioactive inventory. Thus, SMRs could provide an attractive and affordable nuclear power option for many developing countries with small electricity markets, insufficient grid capacity, and limited financial resources. They may also be particularly suitable for non-electrical applications such as desalination, process heat for industrial uses and district heating, and hydrogen production. Moreover, multi-module power plants with SMRs may allow for more flexible generation profiles.

Small Modular Reactors

In recent years, small modular reactors (SMRs)—350 MWe or less, compared to a typical nuclear power plant of 1000 MWe—have been attracting the attention of government officials, regulators and energy leaders around the world. These designs incorporate innovative approaches to achieve simplicity, improved operational performance, and enhanced safety. They offer a number of distinct advantages:

* Ioannis Kessides is the Lead Economist in the Development Research Group of The World Bank. The findings, interpretations, and conclusions are the author's own and should not be attributed to the World Bank, its Executive Board of Directors, or any of its member states.
See footnotes at end of text.

- small size and modular construction—this would allow these reactors to be manufactured completely in a factory and delivered and installed module by module, improving component manufacturing productivity through learning effects while reducing construction time, financing costs, and investment risks;
- substantially simpler designs (fewer systems)—this leads to a lower frequency of accident initiators and events that could cause core damage in comparison to the complex current generation plants;
- a diverse set of useful applications—low-carbon electricity generation in remote locations with little or no access to the grid, industrial process heat, desalination or water purification, and cogeneration applications (e.g., in the petrochemical industry);
- an expanded set of potential siting options—their small size makes them suitable for small electric grids or for locations that cannot accommodate large-scale plants;
- capping safety and proliferation hazards—compared to large-scale reactors, SMRs have a larger surface-to-volume ratio (easier decay heat removal), lower core power density (more effective use of passive safety features), smaller core inventory relative to traditional large-scale reactors, and multi-year refueling so that new fuel loading is needed very infrequently.

Small modular reactors have compact designs—e.g., the containment vessels of 25 Westinghouse SMRs (225 MWe each) could fit into a single AP-1000 containment vessel—and could be manufactured in factories or other central facilities and then transported (along with the necessary containment walls, turbines for generating electricity, control systems, and so on) to the site of a future plant by truck or rail. Building reactors in a factory could substantially decrease construction times and lead to savings on both construction and financing costs. Thus the small size and modularity of SMRs could make them more affordable to small utilities and developing countries by decreasing capital costs (i.e., requiring less lumpy capital investments) and construction times (Aness, 2011).

Design Status of SMRs

Small modular reactors can be classified according to the reactor technology and coolant: They include (IAEA, 2011):

- Pressurized water reactors (PWRs). Designs based on light water reactor technologies are similar to most of today's large pressurized water reactors and as such they have the lowest technological risk. Several are considered to be very close to commercial deployment. Still these designs incorporate innovative technologies and novel components to achieve simplicity, improved operational performance, and enhanced safety. They are typically less than 300 MWe and could be used to replace older fossil-fired power stations of similar size.
- Gas cooled reactors [mostly high-temperature gas-cooled reactors (HTGRs)]. These designs provide broad flexibility in application and in the utilization of the fuel. One of the key advantages of HTGRs is the high outlet coolant temperatures compared to conventional reactors. Core outlet temperatures can range from around 650 °C to 1000 °C for very advanced reactors—these high operating temperatures allow for greater thermal efficiencies. The HTGR can be used with either steam cycle or gas turbine generating equipment, and as a source of high temperature process heat (Schropshire and Herring, 2004).
- Sodium-cooled fast reactors (SFRs). The SFR design features a fast-spectrum, sodium-cooled reactor and a closed fuel cycle. It is designed for efficient management of high-level wastes—in particular the management of plutonium and other actinides. The reactor's key safety features include a long thermal response time, increased margin to coolant boiling, a primary system that operates near atmospheric pressure, and an intermediate sodium system between the radioactive sodium in the primary system and the water and steam in the power plant.
- Lead and Lead-bismuth cooled fast reactors (LFRs). The LFR design features a fast-spectrum lead or lead/bismuth eutectic liquid-metal-cooled reactor and a closed fuel cycle. Since it operates in the fast-neutron spectrum, it has excellent materials management capabilities. The LFR can also be used as a burner to consume actinides from spent LWR fuel and as a burner/breeder with thorium matrices. An important feature of this design is the enhanced safety that results from the choice of molten lead as a relatively inert coolant. It does not react with water or air exothermically and, therefore, the reactor needs no intermediate heat transport system. In terms of sustainability, lead is abundant and hence available, even in case of deployment of a large number of reactors. More importantly, as with other fast systems, fuel sustainability is greatly enhanced by the conversion capabilities of the LFR fuel cycle.

More than two dozen SMR concepts have been developed or analyzed worldwide during the past decade (IAEA, 2006).[1] Several of these concepts have progressed to advanced design and licensing stages, and are near commercial as evidenced by established partnerships with the industry and on-going interactions with national regulatory authorities. All in all, these SMRs have a reasonable chance of being deployed, as a prototype or under a pilot plan, by 2020. In addition to the steadily progressing SMRs, there are some reactor concepts that are at very early stages of design. There is no detailed technical data available for these designs, some of which have been substantially slowed down or even stopped following the Fukushima accident.

Capping Safety and Proliferation Hazards

There are currently only 435 nuclear power plant units operating worldwide, and 68 plants are under construction (WNA, 2013). For nuclear power to make a significant contribution to the future global energy mix, and if SMRs are to comprise the bulk of expanded nuclear deployment, then the number of deployed SMRs could be in the thousands or even tens of thousands. Indeed, most SMR concepts envision widespread deployment of a large number of small nuclear plants sited in diverse environments and frequently in close proximity to users. These considerations place very stringent requirements on SMR reliability and safety performance—arguably even more exacting relative to traditional large-scale nuclear plants. The hazard created per SMR deployed must be maintained exceedingly small in order for the cumulative hazard of the global SMR fleet to remain acceptably small. Two cumulative hazards that scale with the number of deployed plants are safety and nuclear weapons proliferation. These have been specifically addressed in the designs for SMR plants and their supporting fuel cycle architecture.

In general, due to their significantly reduced size and simpler design, SMRs require smaller operator participation for both normal steady-state operations and responding to transients and postulated accidents. Most SMRs employ passive or inherent safety features that place reliance on natural laws of physics. Thus, they add an additional layer of "defense in depth"[2] to back up traditional engineered safety systems and operator action. This increases the level of reliability for achieving a safe response to accident initiators and reduces the safety hazard per deployed SMR. Moreover, because they have a smaller power rating but the same fuel burnup limit as larger reactors, the SMR radioactive source term is smaller than in large reactors—in fact, their radionuclide inventory is orders of magnitude less. So on top of reduced hazard of core damage, the potential radiological consequences of any accidents are much smaller than those of existing large-scale plants, due to the smaller source terms. Finally, the physical layout and reduced size of an SMR plant (the smallest SMRs will occupy less than one acre with perhaps three acres of land needed to support plant activities) also contribute to making management of an emergency simpler (ANS, 2010).

The effectiveness of passive safety features can be illustrated by comparing outcomes from probabilistic risk analysis (PRA). In 1991, a Level-2 PRA was developed for the EBR-II fast neutron spectrum experimental breeder reactor—a 21 MWe plant—to compare its operational risk to that of commercial LWR's for which PRA's were available. EBR-II employs an extensive array of passive and inherent safety measures to back up traditional active safety systems. This PRA exercise showed that for EBR-II the risk of simply violating a fuel pin technical specification (with no core damage) is less than the risk of significant core disruption for the LWRs of the time. The point of the PRA comparisons is that application of passive and inherent safety measures as incorporated in SMRs can help to overcome the increase in numbers of SMRs needed to deliver the same societal energy provided by a smaller number of large-sized LWRs. Similarly, preliminary Level-1 PRA results for the NuScale reactor indicate a total single-module mean core damage frequency of 2.8x10-8/reactor-year, well below that of existing nuclear plants. And for the direct cycle boiling water reactor VK-300, the probability of severe core damage has been estimated to be less than 2.0x10-8/reactor-year (Hill et al, 1998; Kuznetsov and Gabaraev, 2007; Modarres, 2010).

As to the proliferation hazard, a tension has always existed between the expanded deployment of nuclear technology to provide abundant low-C energy and the risk of the technology being diverted instead to the development of nuclear weapons. The proliferation hazard of nuclear energy mainly arises from the fuel cycle facilities—both at the front end of the fuel cycle, during which natural uranium is enriched to make reactor-grade fuel, and at the back end of the cycle to extract fissile material from spent fuel (Richter, 2008). In the past, for energy security reasons, countries that relied heavily on nuclear energy often emplaced indigenous fuel cycle infrastructure facilities along with their nuclear power plants. Under indigenous fuel cycle infrastructure deployment, the proliferation hazard scales with the number of countries embracing nuclear energy for a significant share of their energy supply.

Most SMRs have been designed for multi-year refueling so that new fuel loading would be needed very infrequently. With long intervals available to secure fuel delivery, the risk of supply disruption is reduced. Moreover, the proliferation hazard of expanded SMR deployment could be substantially reduced through the adoption of hub-and-spoke configurations that restrict all sensitive activities (such as isotope separation of uranium or reprocessing of spent fuel) to large, international/regional energy parks that would export fuel, hydrogen, and even small (40–50 MWe) sealed reactors to client states (Feiveson, 2001). These reactors would be assembled and fueled at the central nuclear park, sealed (so that individual fuel assemblies could not be removed) and delivered as a unit to the power plant cites of client countries. At the end of their core life (say 15–20 years) the reactors would be returned to the central park unopened. Thus, during the 15–20 years of operation there would be no refueling and consequently the client countries would need no fuel fabrication facilities and management capabilities. To the extent that such modular reactors would operate almost autonomously, the hub-and-spoke architecture could reduce substantially the rationale and opportunities for countries to develop nuclear research laboratories and train technical specialists and scientists whose know-how could later be diverted to weapons activities. It should be noted that providing attractive alternatives to the buildup of indigenous facilities is a good idea. However, trying to restrict knowledge diffusion is arguably futile and non-sustainable.[3]

The Economics of SMRs

In a deregulated global electricity marketplace, economics will be a key consideration in future decisions to build new nuclear plants. Thus assessing the forward-looking cost elements of nuclear power and the uncertainties underlying those cost estimates is key to evaluating its potential role in balancing the electricity supply and demand over the next several decades and mitigating the threat of climate change. Even if countries decide that the challenge of decarbonizing electricity generation requires more state control, economics will continue to be important, although the perceived costs of risk might then be somewhat lower.

One of the fundamental problems underlying the debate on the potential role of SMRs in meeting the future global energy needs relates to the continuing lack of consensus on what will be their costs under an expanded future deployment. Capital costs estimates for SMRs are very preliminary given that these systems are in the early stages of their development and there is lack of data regarding their construction cost (Rosner and Goldberg, 2011). Thus, it is very difficult to perform a credible comparative assessment of SMR competitiveness. This issue is only likely to be resolved with accumulating information about the full costs of SMR build. Still, it can be plausibly argued that because of economies of scale SMRs will suffer a significant economic disadvantage compared to large reactors in terms of their overnight costs per unit of installed capacity. Specific capital costs (i.e., capital costs per unit of installed capacity) are expected to decrease with size because of fixed set-up costs (e.g., siting activities or earth works for connecting to the transmission grid), more efficient utilization of primary inputs (e.g., raw materials), and the higher performance of larger components (e.g., pumps, heat exchangers, steam generators, etc.).

SMRs offer a number of advantages that can potentially offset the overnight cost penalty that they suffer relative to large reactors. Indeed, several characteristics of their proposed designs can serve to overcome some of the key barriers that have inhibited the growth of nuclear power. These characteristics include (Carelli et al, 2010; Kuznetsov, 2010):

- Reduced construction duration.
- Investment scalability and flexibility.
- Better power plant capacity and grid matching.
- Factory fabrication and mass production economies.
- Learning effects and co-siting economies.
- Design simplification.

Summary

One promising direction for nuclear development might be to downsize reactors from the gigawatt scale to less-complex smaller units (with substantially smaller radioactive inventory) that are more affordable. SMRs are scalable nuclear reactor designs that could: (i) enhance component manufacturing productivity while reducing construction time, financing costs, and investment risks; (ii) cap safety hazards because of their passive or inherent safety features and reduced radioactive inventory; (iii) more effectively address the energy needs of small developing countries because of the lower capital requirements and suitability for small electric grids.

Footnotes

[1] These include the: mPower Reactor; Holtec Inherently Safe Modular Underground Reactor (HI-SMUR) 140; NuScale Power Reactor; The Westinghouse SMR; KLT-40S; RITM-200; VBER-300; VK-300; ABV reactor variants; CAREM-25; SMART; GT-MHR (Gas-Turbine Modular Helium Reactor); ANTARES (AREVA's New Technology Advanced Reactor Energy System); Pebble Bed Modular Reactor; HTR; HTTR; Hyperion Power Module (HPM); Power Reactor Inherently Safe Module (PRISM); EM2 (Energy Multiplier Module); 4S (Super-Safe, Small and Simple Reactor); BREST-300; SVBR-100.

[2] An approach to designing and operating nuclear facilities that prevents and mitigates accidents that release radiation or hazardous materials. The key is creating multiple independent and redundant layers of defense to compensate for potential human and mechanical failures so that no single layer, no matter how robust, is exclusively relied upon. Defense-in-depth includes the use of access controls, physical barriers, redundant and diverse key safety functions, and emergency response measures (http://www.nrc.gov/reading-rm/basic-ref/glossary/defense-in-depth.html).

[3] Although international energy parks and the hub-and-spoke nuclear architecture are technically feasible, they could prove politically difficult to implement. Countries might reasonably view these arrangements as threatening their sovereignty and encroaching upon their so energy independence. Moreover, the hub-and-spoke system would normally require the spoke countries to accept restrictions on their nuclear activities that might not be similarly imposed on the larger countries hosting the international or regional nuclear parks. Inevitably, such restriction will be viewed as being discriminatory, unless all countries (including the advanced industrial countries) were willing to accept a high degree of international control over their nuclear energy programs.

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Revisiting the Nuclear Power Construction Costs Escalation Curse

By Lina Escobar Rangel and François Lévêque*

Introduction

Nuclear power competitiveness depends on its capital costs, inasmuch as they represent, on average, 80% of the levelized cost of electricity. However, from the first wave of nuclear reactors constructed back in the late 60's and 70's, to the on-going construction of Generation III+ reactors in Finland and France, nuclear power seems to be doomed to a cost escalation curse.

If this cost increasing trend goes on, nuclear power will become more expensive while competing technologies will become cheaper. Therefore, determining how to escape this curse is vital for nuclear power to remain a competitive energy source. In this sense, we revisited the French nuclear experience due to the recent publication of the actual construction costs of the nuclear fleet. With this new information, we have identified cost's main drivers and we found some important lessons to take into account to ease the cost escalation phenomenon.

The Construction Cost Escalation Curse in Nuclear Power

The continuous cost revisions and delays in the construction of the latest generation of reactors revives the fear of the cost escalation that has characterized nuclear power and raises concerns about the economic viability of this energy source. For instance, the construction of the first EPR in France revealed that even when this reactor was initially thought as no more costly than its predecessor (the N4 reactor) this would not be the case. At the beginning of 2005, the costs of this project were €3.3 billion. However, this figure was revised in 2011, when EDF announced that the costs had reached €6 billion. This situation worsened with the latest EDF press release in 2012; it was acknowledged that the cost for the Flamanville 3 reactor had risen to €8.5 billion.

For the Westinghouse latest design (AP1000) the situation is very similar. The first cost estimations done both by the MIT and Chicago University on 2003, partially based on the applications submitted to the Nuclear Regulatory Commission were around USD 2400/kW. Nevertheless, these costs were later revised in the MIT (2009) report, which suggest an important increase given that the range of overnight costs was USD2010 3.650/kW to USD2010 5.100/kW. Similarly, Chicago University (2010) forecasts for the AP1000 came up with an average cost of USD2010 4.210/kW.

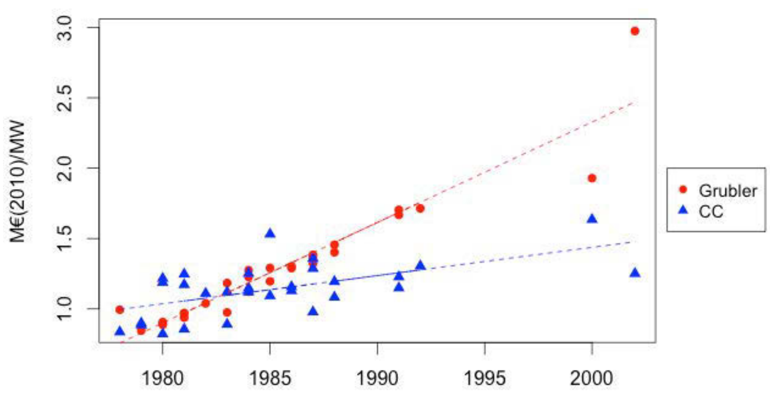

Figure 1: Grubler's and Cour de Comptes Costs for the French Nuclear Fleet by Pair of Reactors

This phenomenon has been widely studied in the U.S. given that the cost escalation there was severe. If we compare the costs of the last nuclear power plant in USD2010/MW with those of the first one, we find that they were 7 times greater.

For the French case, the cost assessment done by Grubler (2011) pointed out that the units installed in 1974 were 3.5 times less costly, in constant euros, than the post 1990 installed reactors. This finding led to the thinking that cost escalation is inherent in nuclear power, given that even under the best conditions, as prevailing in France (i.e., centralized decision making, high degree of standardization and regulatory stability), the construction costs have also risen significantly.

The so called negative learning by doing found by Grubler for the French case was shocking, because even with higher cost escalation and a more diverse nuclear fleet, the econometric studies done for the U.S. case had found positive learning effects[1] at the firm level. However, we revisited the French experience due to the availability of the new information contained in *Cour des Comptes*[2] report and we found positive learning effects when building the same type of reactors.

It is important to mention that the centralized nature of the French nuclear power program not only allowed a fast deployment of this technology but also shielded its costs against private eyes and public scrutiny. For this reason, the

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previous cost assessment was done using cost estimates rather than the actual costs. As we can see in Figure 1, the cost escalation with the *Cour des Comptes* was less severe than what was thought. By using the actual costs we found an average cost increase rate equal to 4.6% per year, while by using Grubler's estimates we computed an increase of 5.8% per year.

Lessons from the French Experience

We used the actual expenditures for the construction of the 58 commercial reactors currently operating in France[3], to identify the main drivers of the increase in costs. We have used a principal component linear regression model in which the costs are determined by an index of the cost of labor, capacity, experience and safety indicators.

We found that the increase in labor costs was an important driver of the escalation. Although we are using the construction costs expressed in constant euros, it is important to recognize that during the period in which the reactors were constructed, the cost of labor in France increased much more rapidly than the inflation index that was used to homogenize the cost data.

In regard to capacity, we found that by increasing the size 1%, we might expect a cost increase of 1.31%. Nevertheless, this result does not reject economies of scale, because the construction of bigger reactors not only entailed a capacity augmentation but also a technological change. This result does not come as a surprise, given that it is well documented that for the U.S. experience the scale-up meant more complex reactors and longer lead-times that resulted in more expensive units per MW installed.

Our results also indicate that as the number of reactors built, at the same *palier*[4] and of the same type, increased, construction costs decreased. To our knowledge, this is the first time that is possible to confirm the existence of learning effects in the French nuclear power program by using public data. This result allows us to conclude that constructing similar types of reactors is one of the main elements that prevented a severe cost escalation in France.

Our last result says that those reactors with better safety performance were more expensive. Then achieving higher safety levels also helped to explain the cost escalation in the French nuclear fleet.

Discussion

After analyzing the construction costs of the *Cour de Comptes* report, we found that the escalation was about a factor of 1.5 between the first and the last unit, thus the cost increase was less severe than it was originally believed, and by no means comparable with the U.S. case.

On the basis of the analysis using the *Cour des Comptes* data, there is every reason to believe that the construction cost escalation in France is mainly due to the increase in the labor costs but also the scaling-up strategy. The increase in the reactor size induced greater complexity and lead-times, which in turn meant an augmentation in costs per MW.

For this reason, capacity could be one of the starting points in rethinking nuclear power strategy. In this sense, several authors such as Kessides (2012) and Rosner and Goldberg (2011b) have outlined the advantages of installing small modular reactors. They argue that since these reactors have shorter construction schedules, they have lower market risk, thus a lower cost of capital.

Our analysis also revealed that although overall experience did not translate into lower costs, some gains were achieved due to the construction of same types of reactors. These learning effects suggest that standardization is a successful strategy to overcome delays and uncertainties during the construction process and thus reduce the cost of the following reactors of the same series.

In this context, it would be interesting to study the construction costs of the nuclear fleet in Russia and China. Both countries have highly centralized and state-oriented energy sectors, both have experience in nuclear power and have envisioned the construction of an important number of reactors in the near future.

In Russia, there is only one supplier, the state-owned vendor ROSATOM, who has constructed more than 35 reactors, is now constructing 10 reactors and has plans to install 17 more. In the Chinese nuclear power program four different vendors coming from Russia, France, Canada and China have supplied the installed reactors and at the present time China is building 28 new reactors. If the construction costs become public one day the comparison between these two nuclear programs can shed some light in the gains of diversity versus the learning effects through standardization in nuclear power.

The results regarding the safety indicators show that the most expensive reactors have achieved better safety performance. This result might indicate that reducing the risk of a serious accident has also played its role in the French cost escalation, either because the regulatory safety standards have increased or because EDF internalized safety concerns in the conception of new designs. In any case, this finding supports what has been often argued by nuclear industry, that is that the newest designs although more expensive, have also embodied better safety features.

Footnotes

[1] See Cantor and Hewlett (1988) and McCabe (1996)

[2] *Cour de Comptes* is the French governement audit agency.

[3] In the *Cour des Comptes* report the costs are reported by pair of reactors.

[4] In the French nuclear fleet, the reactors are classified in three groups called Palier. This category collects all the reactors with the same capacity. In the first Palier, we find 34 units all of them with 900 MW. The second Palier groups 20 reactors with 1300 MW and in the last Palier there are only 4 units with 1450 MW each one.

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Linking Energy Independence to Energy Security

By Morgan Bazilian, Benjamin Sovacool, and Mackay Miller*

Introduction

Dramatic changes in oil and gas production in the United States have resurrected public interest in "energy independence" (see e.g., Houser and Mohan, 2012).[1] This interest came up very rapidly (as Figure 1 depicts) – the rhetoric only 5-7 years ago was dramatically different (see e.g., CFR, 2006). This attraction likely stems in part from a connotation that "independence" equals resiliency and stability of energy services without risk of volatility. However, both domestic energy issues and geopolitics are considerably more interrelated than this argument allows. In addition, the vocabulary used is often imprecise. We briefly explore aspects of the concept, and argue that although politically seductive, energy independence can distract from sound decision-making in the energy sector.

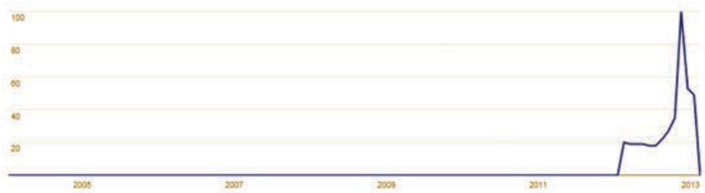

Figure 1: Google trends "interest over time" 2004 to present for the term "U.S. energy independence". A clear spike occurs beginning in early 2012.

In reality, the global energy system is deeply interconnected. Not only is this true for oil markets, as an example, but when focusing on independence (or domestic supply/demand balances), it matters what the situation is in other countries and how it evolves. The case against relying on energy independence as a policy prescription tends to look at the end goals of energy policy, and describes resiliency and stability of energy services not as ends themselves, but rather as means of economic growth, innovation, and social well-being. History suggests that energy independence has persistent public and political appeal, and so the practical challenge is to rigorously ground the exuberance it can generate. To that end, we contextualize energy independence through the more robust concept of "energy security" and broader end goals of energy policy.

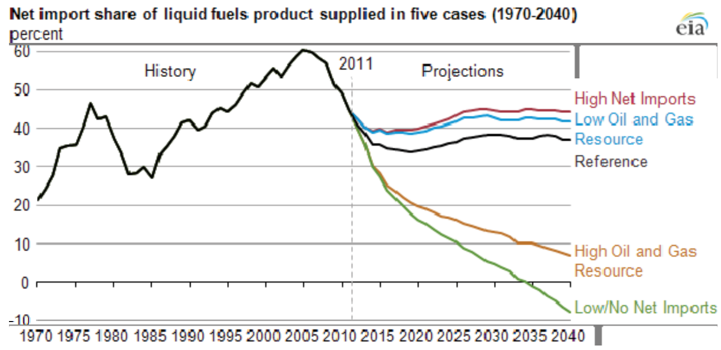

Figure 2: Net Import Shares in Various Scenarios (EIA, 2013a)

Of Independence

Some degree of enthusiasm is, though, warranted – increasing domestic supply and decreasing imports has numerous possible social and economic benefits. The past five years have witnessed a sea change in the proven reserves and the production of oil, natural gas, and natural gas liquids in the United States. Largely as a consequence, there has been a marked shift in the import/export balance of these commodities. In the United States, energy independence is commonly defined in terms of the degree of reliance on imports from outside North America,[2] and falling imports have made independence appear attainable. Often the thrust of the energy independence goal is pinned on removing our interests from the Middle East.[3] However, as O'Sullivan (2013) notes, "Interests other than energy, such as terrorism, nuclear proliferation, the security of Israel and the well-being of more than more than 300 million Arabs, will continue to be high on the U.S. agenda".[4]

Two significant reports underscore the popular conception of the term. The International Energy Agency (IEA) in its 2012 World Energy Outlook (IEA, 2012) noted that: "The United States will overtake Saudi Arabia as the world's leading oil producer by about 2017 and will become a net oil exporter by 2030."[5] In addition, the Citi Group published an influential report in 2012 (Morse et al., 2012) with the provocative title, "Energy 2020: North America, the new Middle East?" On first pass both appear to focus only on increases in supply, but in fact both acknowledge a significant portion of the balance is due to assumed decreases in demand. That subtlety is often missing from popular discourse, and belies the need for well-designed demand-side policy.

Levi (2012a) argues that the notion of independence ignores realities of global markets in oil (the United States does not set that price), promotes complacency in both domestic energy policy as well as foreign policy, and at the

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extreme, gives fuel to, "energy isolationism", which would likely harm the global economy[6]. These three concerns vary considerably in how likely they are to influence U.S. energy policy. One need only conceive of a major energy exporting country, such as Saudi Arabia, to be reminded that such a title does not remove them from having wider energy challenges. As an example, the Kingdom's recent significant efforts on energy efficiency and investment in solar energy are evidence of their desire to take into consideration broader requirements for their energy and economic systems.[7]

The potentially misleading nature of the concept of energy independence can be illustrated by the difficulty in quantifying its central metric: import dependence. The EIA recently elaborated on this difficulty, with a focus on the differences that emerge by accounting for refinery flows in the United States (EIA, 2013b). Figure 2 illustrates the uncertain future with five very different possible scenarios of net import shares in liquid fuels product.

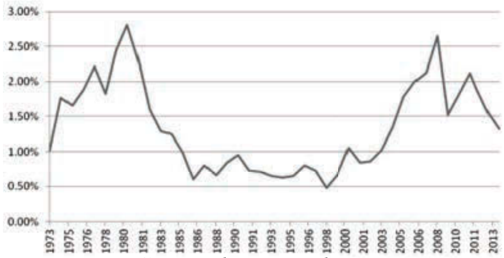

Figure 3: U.S. spending on oil imports as a fraction of U.S. GDP. (Levi, 2012b)

But import dependence (net oil imports) alone does not capture the right metrics for decision making when considered from a macroeconomic perspective. Calculating oil import expenditures as a fraction of U.S. GDP gets closer to the real concerns of the economy as Levi (2012b) points out. Figure 3 illustrates that by this measure, U.S. oil imports as economic cost are still as high as they have been since 1982.

It is clear that an over reliance solely on import dependence does not account for the economic impacts of energy supply, nor many other factors, and thus is only one of many elements that need be considered for robust decision making. We argue that a far larger set of considerations should drive energy policy, and that the concepts and methodologies from the "energy security" literature provide firmer grounding for policymaking. We briefly touch upon the related literature to that end. Still, we must recognize that energy security is an often misused concept itself, and that it has no generally agreed upon set of metrics.

Towards Security

In its formal derivations, energy security requires a rigorous aggregation of dozens of variables that impact energy flows in the real world (see e.g., Bazilian et al., 2006). The complexity of the issues embodied within energy security are broad and vary depending on the context and perspective from which it is evaluated, and thus, no common definition exists. One assessment, for example, noted at least 45 separate definitions of energy security presented in the academic and policy literature over the past decade (Sovacool, 2011a). The bulk of the global energy security literature focuses on the geo-political aspects of energy security policy from an industrialized country perspective. As it is conceived of in those countries, an energy security policy generally comprises measures taken to reduce the risks of supply disruptions below a certain tolerable level. Insecurity in energy supply originates in the risks related to the scarcity and uneven geographical distribution of primary fuels and to the operational reliability of energy systems that ensure services are efficiently delivered to end users (see e.g., Bazilian and Roques, 2008).

Elkind (2010) argued that energy security is composed of four elements: *availability, reliability, affordability*, and *sustainability*.[8] Availability refers to the ability of consumers and users to secure energy that they need. It requires an extensive commercial market, buyers and sellers trading goods, parties that agree on terms, as well as sufficient physical resources, investments, technology, and legal and regulatory frameworks to back them up. Reliability refers to the extent that energy services are protected from disruption, predicated on a number of interrelated criteria including:

- Diversification of sources of supply (various fuels and technologies)
- Diversification of supply chains
- Resilience or the ability to handle shocks and recover from failures
- Reducing energy demand to ease the burden on infrastructure
- Redundancy in case failures occur
- Distributing timely information to markets.

Affordability involves low or equitable prices relative to income and stable prices. Sustainability refers to minimizing the social, environmental, and economic damage that can result from long-lived energy infrastructure. Utilizing this framework, Table 1 illustrates the complexity of energy security, showing that each of these four elements can be correlated with different components and threats.

Elkind's broad definition of energy security, mapped against components and threats, provides a nuanced framework for energy policy.

Elements	**Components**	**Threats**
Availability	Physical endowment of producers	Exhaustion of reserves that can be extracted cost effectively
	Ability of producers, transit countries, and consumers to agree on terms of trade	Limits on development opportunities such as resource-nationalist policies and state-to-state contracts
	Technological solutions for production, transportation, conversion, storage, and distribution	Problems in siting infrastructure including NIMBY syndrome
	Capital investment	Financial, legal, regulatory, or policy environments that inhibit investment
	Viable legal and regulatory structures	
	Compliance with environmental and other regulatory requirements	
Reliability	Robust, diversified energy value chain	Failure of energy systems due to severe weather and natural disasters
	Adequate reserve capacity	Failure due to poor maintenance or underinvestment
	Protection from terrorist attacks and political disruptions	Attack or threat of attack by military forces and terrorist organizations
	Adequate information about global energy markets	Political interventions such as embargoes and sanctions
Affordability	Minimal price volatility	Exhaustion of reserves that can be extracted cost effectively
	Equitable prices	Energy prices that require lower income households to expend large shares of their income
	Transparent pricing	Excessive subsidies that distort prices
	Realistic expectations about future prices	Failure to institute sound pricing policies
	Prices that reflect full costs	Failure to incorporate environmental and social costs to energy production and use
Sustainability	Low emissions of greenhouse gases	Adoption and promotion of carbon intensive energy infrastructure
	Minimal contribution to local, regional, and global forms of environmental pollution	Impacts of indoor and outdoor air pollution associated with energy use
	Protection of energy systems from climate change	Impacts of a changing climate such as rises in sea level, storm surges, and severe weather events

Table 1: Elements, Components, and Threats to Energy Security (Elkind, 2010)

Measuring Progress

Elkind's conceptualization of energy security implies that the security of supplies of oil (Toman, 2009), natural gas (Luciani, 2004), coal (Kessels et al., 2008), and uranium (Keppler, 2007) are but one focal point of concern for energy policy makers throughout the world. Supply side security needs are tightly coupled with the other pillars of energy policy and security, namely environmental considerations, governance and regulation, affordability, and industrial competitiveness.

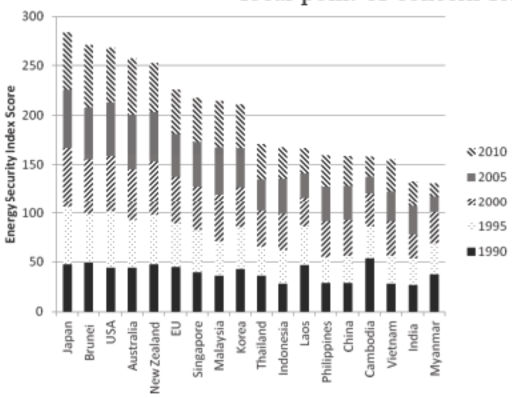

Figure 4: Average Energy Security Performance for Eighteen Countries

As proof of the multidimensional complexity of energy security, our work has matched the various dimensions of energy security to particular metrics, enabling energy security to be measured according to an energy security "index" or "scorecard" (Sovacool et al., 2011b; Sovacool, 2013). The metrics involved, when applied over time to major energy consumers such as the European Union and United States, as well as the developing economies of Asia, imply that Japan (perhaps oddly), Brunei, and the United States are the most energy secure, whereas Vietnam, India, and Myanmar are less secure. These results are presented in Figure 4.

While narrower than the Energy Security Index – the Oil Vulnerability Index (OVI) developed by Gupta (2008) – is another example of a tool to compare national progress. It, too, reveals that energy security needs may be more complex than they otherwise appear. A side-by-side comparison of OVI and oil import dependence illustrates quantitatively the imprecision of the latter. Table 2, for example, shows the raw oil import dependence of various countries compared with an oil vulnerability index. Note that some of the most vulnerable countries according to the OVI are not necessarily those that have high levels of oil dependence.

We must recall that energy security too is but one of many facets of the increasingly complex and dynamic global energy system.

	Oil Import Dependency (%)	Oil Vulnerability Index	Divergence
Ireland	100%	0.49	-0.51
Belgium	99%	0.6	-0.39
Greece	98%	0.89	-0.09
Sweden	99%	0.37	-0.62
Switzerland	99%	0.49	-0.5
Portugal	98%	0.83	-0.15
Spain	98%	0.7	-0.28
Japan	97%	0.51	-0.46
Finland	96%	0.56	-0.4
France	96%	0.45	-0.51
Germany	95%	0.44	-0.51
Turkey	94%	0.82	-0.12
Italy	93%	0.55	-0.38
Austria	91%	0.46	-0.45
Netherlands	91%	0.55	-0.36
United States	58%	0.37	-0.21
Australia	37%	0.24	-0.13
		Average Divergence	*-0.36*

Table 2: Comparison of Oil Import Dependence and Oil Vulnerability Index of 17 OECD countries. (Source: International Energy Agency and Gupta, 2008)

Conclusions

In sum, the simplifications that come with the energy independence frame can promote sub-optimal policy choices because they fail to acknowledge the complexity of energy security and wider considerations.

As an example, in the U.S. shale gas context, the abundant and rapid increase in supplies have spurred debates regarding for the attractiveness of achieving maximum energy self-sufficiency, and lead to policy prescriptions such as a suggested moratorium on further exports. The tradeoffs of these policies are illuminated in the context of the energy security index: increasing production promises a corresponding reduction in remaining years of production, and limiting exports could prop up prices for key trading partners. These first-order interdependencies illustrate some of the complexities of energy policy formulation. They reveal both the long-lasting nature of energy policy decisions (today's choices may limit the options available to future generations) and the cascading negative economic impacts of energy isolationism. At the second order, there are other unintended consequences, such as:

- Policy and regulatory dashes in support of oil and gas competing for policy support for energy efficiency and newer, more environmentally benign generation technologies.
- Exhausting or polluting increasingly scarce water resources, especially since hydrofracturing is more water intensive than conventional gas production.

The litany of energy security tradeoffs is emblematic on how improving some of the dimensions of energy security inherently conflict with other meaningful dimensions. The future will likely bring more globally interdependent markets and systems. As a result, the pillars of robust U.S. energy policy could include an embrace of global partners, a wise optimization of the bounty of oil and gas in North America toward sustainable patterns of consumption and use, and close consideration of the possible synergies between fossil fuels and renewable energy resources.

Footnotes

[1] For media coverage early in 2012, see e.g., Krauss and Lipton, 2012.

[2] The oil and gas networks of Canada, the United States, and Mexico are tightly integrated.

[3] For media coverage on this, see e.g., Blas, 2013.

[4] See also Cordesman, 2013.

[5] See also commentary by the Executive Director: https://acs.nrel.gov/maria-van-der-hoeven/,DanaInfo=www.huffingtonpost.com+obstacles-in-the-path-to_b_2638047.html

[6] One might add here the confusing nature of the popular discussion on this topic, which, as an example, often conflates natural gas and oil markets – despite their considerable dissimilarities in aspects such as their geographic scope and price setting.

[7] Or consider Norway's productivity concerns (see e.g., Milne, 2013).

[8] On the environmental challenges of independence see, e.g., Destler, 2013.

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A Thought on Small Modular Reactors

By Kenichi Matsui*

Prominent nuclear physicist Dr. Alvin Weinberg expressed reservations about the safety of the large light water reactor in 1964 just after its commercial success and the signing of GE to construct the 515 MW BWR nuclear power plant at Oyster Creek in New Jersey. He warned that "The Oyster Creek reactor is just getting under way. It is still possible, I suppose, that some flaw will develop in boiling water reactors after they have operated for a long time."[1] His warning turned out to be true in Fukushima. Pursuance of the up scaling of the light water reactor has required more safety measures which in turn increases costs and demands operators to carry out more severe monitoring and maintenance to ensure safety.

Looking back at the history of nuclear power plant development, there were arguments from the very beginning of the development that commercial reactors should not be large, light water reactors which are dominant today, but should be small reactors including small fast breeder reactors and molten salt reactors. In fact, the first nuclear reactor which generated electricity was a fast breeder reactor, EBR I (Experimental Breeder Reactor Number One) at the Idaho site of Argonne National Laboratory. This reactor came into operation in December 1951 and supplied electricity to the reactor control system as well as the building and a machine shop. This reactor proved the breeding concept and the possibility of an almost unlimited supply of energy and the use of plutonium as generation fuel. Dr. Weinberg believed that "the commercial success of nuclear power would have to await the development of the breeder."[2] This reactor had been operated for around 10 years until replaced by a little larger version, EBR II,in 1962. However, further development of this reactor for commercialization was interrupted by a change in the research policy of the laboratory which favored development of a large fast breeder reactor coping with large light water reactors. While this project to develop a large fast breeder reactor failed, research on EBR II has continued appropriating a small portion of the budget allocated for various projects and items. And in 1984, Argonne National Laboratory started the project to develop an IFR (Integral Fast Reactor) system based on the research on EBR combined with spent fuel pyroprocessing technology. IFR is a complete system composed of a safer, more fool-proof reactor and a new process that allows the recycling of its spent fuel and creates a waste product with a much reduced radiological lifetime. After around 10 years of research, this project was suddenly terminated in September 1994 by President Clinton. He terminated "all advanced reactor development" because "it is unnecessary".

Thus development of the small reactor was interrupted politically. It has also been intentionally ignored by the established nuclear community in order to protect their interests in the large light water reactor. Recently, however, escalating costs, long construction times and growing safety concerns about large light water reactors turned the spotlight on the small modular reactors (SMR) raising their merits of passive safety philosophy, simple structure, easy construction (like prefabricated homes), easy maintenance, operational flexibility, reduced construction time, reduced upfront capital costs and debt loads, lowering the burden of high radioactive waste disposal and proliferation-resistance features, etc.

Recognizing the possible great contribution of SMR for the United States in many aspects, including giving a key competitive edge in the global clean energy race, creating new jobs and business, the Obama administration has committed to speed up their commercialization.

A small version of the current light water reactor will be commercialized around 2020 and will be followed by innovative, small fast reactors. They will dramatically solve the problem of the final treatment of radioactive waste specifically the high radioactive fission materials.

The long history of human beings and energy use tells us that cutting edge science theory and the technology based on that theory has led the development of civilization. The civilization of the 20th century was spurred by technology based on Newtonian physics and that of 21st century will be led by technology based on the theory of Relativity and Quantum Mechanics represented by information technology and nuclear technology. Science and technology has its own dynamism. Countries ignoring or contradicting this dynamism will ultimately pay dearly. Science and technology have two sides; a very large benefit and a very large destructive power. Human beings have coexisted with the development of science and technology whatever the dangers they pose. Human beings are not so wise and have made many mistakes. But human beings are not stupid either. They know where the stupidity should be stopped. I don't make any ethical judgment about the development of science. But in the past, the difficulty caused by technology has been overcome with more advanced technology and it will be repeated in the future. I believe

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there is no other way to live.

Now, I think development of SMR has specific meaning for Japan as a country with almost no fossil fuel resources and as the only country bombed by the atomic bomb. Japan should lead a peaceful use of nuclear energy in the international non-proliferation framework through development and introduction of SMRs not only in Japan but also in the world.

After the Fukushima nuclear power plant accident, safety is the most critical factor for the future of the nuclear power plant. Also, the final treatment of radioactive waste and non-proliferation questions should be addressed. Simple extension of the current nuclear power plant system based on large light water reactors will not be accepted socially and the introduction of SMRs to the current system could be an answer.

In the past, Japan had a good chance to introduce the SMR. In the late 1980's to the beginning of 1990's, several Japanese nuclear researchers and executives of the nuclear industry visited the Argonne Laboratory to learn about the IFR program. Impressed by the project, Japan signed agreements for a joint program on IFR technology with the USDOE. Altogether, these agreements represented an over $100 million contribution from Japan. However these contracts were terminated when the IFR program was terminated by President Clinton. Dr. Charles Till, leader of the IFR program, said in his book "The few years we collaborated with the Japanese utilities were among the highlights of my career. Given the situation with nuclear energy in the U.S. I truly believed that the IFR with pyroprocessing might be first commercialized in Japan"[3]

Japan missed the chance, however, due to the commitment to construct the French type purex processing plant. This plant still doesn't work well after 20 years from its introduction. I think Japan has the technical base to commercialize SMRs including the IFR system. I wish that Japan would reconsider the introduction of SMR including the IFR system and take due action.

If Japan will not move and U.S. will not move fast enough, other countries including Russia, China and Korea will lead the development of these technologies. In the middle of the Shale Gas Revolution, the Nuclear Revolution is creeping. However, with a little encouragement the Nuclear Revolution and the Second Era of Nuclear Energy can come much faster than generally perceived.

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We look forward to your participation in these new initiatives.

Scenes from the 4th ELAEE Montevideo Conference April 8-9, 2013





4° ELAEE
April 8, 9 - 2013 | Montevideo Uruguay
Radisson Montevideo Victoria Plaza Hotel










CONFERENCE REPORT

The 4th Latin American Conference for Energy Economics (4ELAEE) was held in the Radisson Hotel of Montevideo on 8-9 April 2013. The theme of the conference was *Energy Trends in Latin America: Towards Regional Integration and Sustainability*, and to look at ways of influencing LATAM policy for a better allocation of our region´s energetic resources.

On the evening of Sunday 7, the ALADEE members met to discuss an agenda that included the approval of the next ELAEE site, Medellín 2015, and the election of the ALADEE President for the next two years. Gerardo Rabinovich, ALADEE President hosted this meeting that was also attended by ALADEE vice president (and now President-elect) Marisa León, IAEE President David Newbery and IAEE President-elect Omowumi Iledare. After this meeting ALADEE and IAEE members joined the 4ELAEE group for a cocktail in the beautiful Solis Theatre of Montevideo.

The first day of the 4ELAEE programme included plenary and dual sessions about *Financing Energy Projects in Latin America, Natural Gas, Electric Markets Integration, Policy and Regulation for Renewable Energy, Oil in LATAM* and *Energy Trends and Development in Latin America.* Guest speakers were executives from energy companies, energy specialists from universities and research institutions, and government officials such as Roberto Kreimerman, Minister of Industry, Energy and Minery (MIEM) of Uruguay and Ramón Mendez, Energy Director of MIEM.

In the evening, all participants were invited to a Gala Dinner where a typical Uruguayan barbecue was served, in a delightful atmosphere.

The following day focused on the social issues of energy policies and activities, in a demand perspective, such as the following sessions: *The Right of Energy Access, Social Policies and its Challenges* and *Transportation and Energy Demand.* During the two days, the conference hosted 25 concurrent sessions with more than 150 papers presented, with an extraordinary academic value of most of them.

The Conference served as a forum for representatives from all sides of the energy sector to interact and build bridges. The different sessions provided the framework of wider discussions on how energy integration has been fostered to date and what can be done to direct regional energy policies in the future. Indeed, the two days were buzzing with lively discussion and debate – not only during the interactive sessions, but also around the different social events.

The ALADEE is particularly grateful for the companies and institutions that supported the 4ELAEE and also wishes to thank all contributors and participants of this event for making it an informative as well as enjoyable two days!

(Details of the conference and proceedings are provided in the ALADEE website www.aladee.org)

Impact of U.S. Shale Oil Revolution on the Global Oil Market, the Price of Oil & Peak Oil

By Mamdouh G. Salameh*

Introduction

Much has been written about the United States shale oil revolution. Some sources like the International Energy Agency (IEA) went as far as to predict that the United States will overtake Saudi Arabia and Russia to become the world's biggest oil producer by 2020 and energy self-sufficient by 2030.[1] Others called it a game changer with a new emerging balance of power in the global oil market. Yet others were in such a state of euphoria about the success of American shale oil production to say that it may deny OPEC the power to set global oil prices and that the world oil industry won't be the same in the wake of shale. Some also claimed that the idea of peak oil had gone in flames. The above claims aside, given recent increases in U.S. shale oil and gas production, it is now clear that these resources might play some role in non-OPEC supply prospects.

However, it begs the questions: what is the potential contribution of shale oil to future global oil supply? Will the high development costs, and environmental impacts and challenges affect this potential? And will it be possible to replicate the U.S. success story globally?

U.S. shale oil production is projected to increase from about 1 million barrels a day (mbd) in 2012 to 2 mbd in 2020 possibly reaching 3 mbd by 2025.[2] However, this increase would hardly offset the normal annual depletion rate of 3%-5% in U.S. conventional oil production, estimated at 1.2 mbd–2.0 mbd during the same period.[3]

With regard to the economics of U.S. shale oil development, the drilling and completion costs for a horizontal shale oil well currently range from $4 to $6 million. This relatively high cost arises from the steep first year decline rate of 70% - 90% for the wells. Nevertheless, a break-even oil price of $72-$80/barrel suggests that most shale oil plays are profitable at current oil price levels.[4]

This article will argue that U.S. shale oil production would hardly make a dent in the global oil supplies as it would largely offset the decline in U.S. conventional oil production. It will also argue that the U.S. would never be able to overtake Saudi Arabia or Russia in oil production and would continue to be dependent on oil imports for the foreseeable future. The article will conclude that the U.S. shale oil boom would not be easy to replicate in the rest of the world nor would it invalidate the peak oil concept.

Shale Oil Reserves

Although no serious attempts have been made yet to analyze the size of the U.S. shale resources, it seems that even if the in-place volumes are large, reserves will not be as high due to very low recovery factors, presently in the range of 1% to 10% with few exceptions. It is one thing having huge resources of shale oil in-place and quite another turning them into a sizeable production capacity.[5]

According to the U.S. Energy Information Administration's (EIA's) 2012 Energy Outlook, the unproved technically-recoverable shale and tight oil resources in the U.S. were estimated in 2010 at 33 billion barrels (bb), with recoverable shale gas resources about 480 trillion cubic feet (tcf). For the latter, it is worth mentioning that this level is almost half that reported (827 tcf) a year earlier. It is a further indication of the large uncertainties still associated with recoverable resource estimates.[6]

U.S. Shale Oil Potential

U.S. shale oil production is projected to increase from about 1 mbd in 2012 to 2 mbd in 2020 before it plateaus at 3 mbd by 2025 and then starts its downward trend.

Total U.S. oil production is projected to increase from 6.41 mbd in 2012 to a projected 7.50 mbd in 2019 (see Table 1). After 2020 production begins declining gradually to 6.1 mbd by 2035 through to 2040 as producers develop sweet spots first and then move to less productive or less profitable drilling areas.[7]

Oil imports are projected to decline from 65% of consumption in 2012 to 60% by 2019 before they resume their rise reaching 68% by 2035. This means that there is neither a chance for the United States ever to become self-sufficient in oil nor to overtake either Saudi Arabia or Russia in oil production.

Assessing the producible reserves of a shale/tight oil formation is a compli-

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See footnotes at end of text.

cated process. Each shale formation is different and the properties within an individual field (porosity, permeability, etc.) can sometimes vary from well to well. Furthermore, the rapid output increase and decline of shale/tight oil-producing wells further complicates matters and makes shale/tight oil operations a "drilling-intensive" activity thus significantly adding to the costs of production.[8]

	2012	2013	2014	2015	2016	2019	2020	2025	2030	2035
Production	6.41	6.64	6.88	7.04	7.21	7.50	7.40	6.93	6.49	6.10
Consumption	18.46	18.48	18.50	18.52	18.54	18.60	18.62	19.50	19.11	18.86
Net Imports	12.05	11.84	11.62	11.48	11.33	11.10	11.22	12.57	12.62	12.76
As a % of Consumption	65%	64%	63%	62%	61%	60%	60%	64%	66%	68%

Table 1
U.S. Current & Projected Crude Oil Production, Consumption & Imports, 2012-2035
Sources: OPEC World Oil Outlook 2112 / BP Statistical Review of World Energy, June 2012 / EIA Early Overview of Annual Energy Outlook 2013 (AEO2013) / Author's Estimates.

Can the U.S. Overtake Saudi Arabia & Russia as Top Oil Producer?

	2015	**(mbd) 2020**	**2035**
United States	10.00	11.10	9.20
Saudi Arabia	10.90	10.60	12.30
Russia	10.00	10.00	9.00

Table 2
IEA Projections of U.S., Saudi Arabia & Russia's Oil Production 2015-2035
Source: IEA's Annual Energy Outlook 2012.

Reports about the U.S. shale oil boom being a game changer have proliferated after the November 2012's prediction by the IEA that the United States will overtake Saudi Arabia and Russia to become the world's biggest oil producer by 2020 and energy self-sufficient by 2030. While such rosy forecasts play well to the IEA's audience, which is largely American, they are not borne out by the realities of the global oil market.

The IEA said it saw U.S. oil production rising to 11.10 mbd by 2020 and overtaking Saudi Arabia and Russia at 10.60 mbd and 10.00 mbd respectively (see Table 2).

Allowing for the slow shale oil production and the steep depletion in U.S. conventional oil production ranging from 3%-5% per annum, the projected U.S. production by 2020 would amount to no more than 7.40 mbd, far less than the IEA projection of 11.10 mbd and far below the projected production of Saudi Arabia and Russia. Moreover, that level of shale oil production is probably only sustainable for a couple of years because of the early peak and steep first year decline in shale production rates in new wells.

Another claim that does not stand up to scrutiny is that the success of American shale oil production has the potential to deny OPEC the power to set global oil prices and could also shift the balance of power in global energy markets.[9] That is not going to happen since the world is projected to become increasingly dependent after 2020 on OPEC whose share of world oil production will rise to 48% from 42% now.

	2012	**2014**	**2015**	**2016**	**2020**	**2025**	**2030**	**203**
World Oil Demand	88.70	90.70	91.80	92.90	96.90	100.90	104.20	107.39
World Oil Supply	84.40	84.63	85.37	85.17	87.91	89.62	90.05	90.06
Non-OPEC	46.60	47.70	47.90	47.90	48.68	48.92	49.16	49.31
OPEC	36.80	35.80	36.20	36.00	37.23	37.70	37.89	38.00
U.S. Shale oil	1.00	1.13	1.27	1.27	2.00	3.00	3.00	2.75
Demand / Supply Deficit *	-4.30	-6.07	-6.43	-7.73	-8.99	-11.28	-14.15	-17.33
Shale oil as % of Global Supply	1%	1%	1%	1%	2%	3%	3%	3%

Table 3
World Oil Demand & Supply, 2012-2035
Source: OPEC: World Oil Outlook 2012 / IEA, World Energy Outlook 2012 / BP Statistical Review of World Energy, June 2012 / EIA, Energy Outlook 2012 / Author's projections.
* The demand/supply deficit is accounted for by stock changes, consumption of non-petroleum additives and substitute fuels. Otherwise it will be reflected in higher oil prices.

U.S. Shale Oil Contribution to Global Oil Supplies

In 2012 U.S. shale oil production contributed 1% to global oil supplies and this is projected to rise to 2% by 2019 possibly reaching 3% by 2025 (see Table 3). Such a level of production will hardly make a dent in global oil supplies.

Total non-OPEC supply increases by 1.3 mbd over the 2012-2016 period. The key sources of supply driving this growth are rising shale oil production from the U.S., Canadian oil sands and crude oil from the Caspian and Brazil.

Impact on the U.S. Economy

So far the only estimate of the broader impacts of the combined shale oil and gas production on the U.S. economy has been made by Citigroup, according to which "the cumulative impact of new production and reduced consumption could increase real U.S.

GDP by 2% to 3.3%, or by $370 bn to $624 bn and add as many as 3.6 million new jobs by 2020".[10] In addition, the shale oil & gas revolution may substantially help reduce the U.S. account deficit which, "currently is running a negative 3% of GDP, by anywhere from 1.2% of GDP to 2.4% of GDP".[11]

A surprise bonus of the shale gas boom in the U.S. is a coal boom overseas according to IEA sources. U.S. Coal, displaced at home by shale gas, is finding its way overseas particularly to the European Union, India and China.

Meanwhile, manufacturers in the U.S. have announced more than $90 bn worth of investments to take advantage of cheap natural gas which appears to be driving the country's industrial renaissance.[12]

Can OPEC Disrupt U.S. Shale Oil Production Surge?

According to OPEC Secretary General Abdullah Al-Badry, OPEC does not see increased U.S. oil output as a threat to its interests but is skeptical about industry estimates that U.S. shale production could amount to 3 mbd within 20 years as well as forecasts of U.S. energy independence.[13]

Fears that OPEC will boost output to push down oil prices are misplaced. OPEC's ability to push prices lower to disrupt new emerging sources of supply is constrained by members' higher fiscal needs, a result of the social turmoil unleashed by the Arab Spring.[14]

Saudi Arabia and other major OPEC producers need oil prices on average at $95/barrel to sustain the extra spending. On the other hand, U.S. shale developments need prices of $72-$80/barrel to break even.

Even if U.S. benchmark West Texas Intermediate (WTI) oil drops 30% from the current price of $86/barrel, U.S. shale oil producers would continue producing. Saudi Arabia can't afford a decline of that magnitude after the government pledged an unprecedented $630 bn on social welfare and building projects. The Kingdom couldn't meet these commitments if prices fell 25% from the current $111/barrel.

The Problems Looming over U.S. Shale Oil

Among the major obstacles to unlocking the huge potential of the shale oil plays in the U.S. is the lack of an adequate infrastructure to transport and refine oil and the rules governing overall U.S. domestic oil movements. Oil can't move freely throughout the United States or be exported from the country.[15]

Theoretically, the possibility of exporting U.S. crude oil could address these questions, but U.S. laws ban oil exports for the sake of national security except for modest volumes which must be authorized by federal authorities. There is also the difficulty of what to do in the future with the excess natural gas associated with shale/tight oil production. This has already led to the collapse of gas prices in early 2012 and could in the future complicate the overall economics of shale/tight oil production and even the feasibility of fully deploying its potential.[16]

Another looming problem would be the inevitable rising costs of services, rigs, labour and pipelines, caused by inflationary pressure from the frenetic activity throughout the shale/tight oil and gas sector.[17]

The Environmental Impact of Shale Oil Production

Shale oil and gas are extracted by pumping water, sand and chemicals into the ground at high pressure to crack rocks open, a process known as hydraulic fracturing, or "fracking."

However, hydraulic fracturing is increasingly perceived as contributing to water and land contamination, causing natural gas infiltration into fresh water aquifers, and even triggering earthquakes. Moreover, the intensive use of water will increasingly impose additional costs and could threaten the viability of projects for shale oil and gas. A shale oil well requires between 4 and 5 million gallons of water.[18] This may exacerbate water shortages in states where water availability is already a problem.

Therefore, the oil industry needs to develop technological solutions to minimize water use, minimize and report chemical use, and carefully monitor production sites. However, if such a collective effort by industry does not materialize, the government may respond with more onerous regulation in the near future that could impact U.S. shale oil production

U.S. Oil Independence

Since the first oil crisis in 1973, the notion of U.S. oil independence has been of great importance in U.S. political debate. Yet oil self-sufficiency may be important only in cases of major wars, when the disruption of sizeable foreign oil supplies could endanger the military effort or the country's self-defence. In all other cases, one must never forget that the oil market is global and fungible, and a country can't be insulated from what is happening in the rest of the world even if it is self-sufficient in oil.

Oil independence is not really the issue confronting the U.S. economy. The real issue is the price needed to get the oil out of the ground.[19] American oil independence is not going to change the reality of triple-digit oil prices. On the contrary, oil prices may have to climb much higher, possibly to $200/barrel for the IEA's forecast about U.S. shale oil production to come true.

U.S. Shale Oil Production Versus the Oil Price

With U.S. shale oil production surging and profitability for U.S. domestic oil producers high and also with no change in sight to U.S. rules preventing crude oil exports, it is projected that WTI prices could fall to $50/barrel over the next 24 months to force a slowdown in supply growth or a change in crude oil export rules.

The U.S. crude oil market could come to resemble the natural gas market where a huge shale gas production has led to a collapse of the gas prices in the U.S.

This is exactly the situation with shale oil production now. U.S. shale oil producers have no reason to stop pumping. So the bottom line is: large production, low breakeven costs, low financing costs, and tight capacity across the entire petroleum infrastructure. The ingredients are there for a price collapse.

The real issue facing the U.S. economy isn't the availability of oil but the price needed to get it out of the ground. That Brent oil is hovering near $111 /barrel is a clear signal of U.S. growing dependence on the very unconventional sources of supply being championed in the IEA report.

Getting oil out of the ground has never been more expensive. Just look at the pullback in capital spending among oil sands operators in Canada. And costs are only going up from here. Forecasts of exponential growth in U.S. shale oil ignore some very real challenges with it – such as wells that deplete at a rate of more than 40%, even in rich fields like Eagle Ford in Texas and the Bakken in North Dakota.

The real reason that once-marginal sources of supply such as shale oil have been catapulted to prominence is soaring global oil prices. Without higher prices, no one would be chasing shale oil.

However, the higher the price of oil, the less of it our economies can afford to burn. If global economic growth is already grinding to a halt when oil prices are around $111/barrel, what do you think would happen to economic growth – and hence global oil demand – if prices reached the even higher levels needed to make the IEA's supply dreams come true.

Just like the forecasts the IEA made a decade ago about the much anticipated increase in deep-water production from the Gulf of Mexico, the agency's hopes for another game changer are unlikely to pan out.

Has U.S. Shale Oil Production Made Peak Oil Redundant?

Claims that the idea of peak oil had gone in flames as a result of surging U.S. shale oil production, are not borne out by the realities in the global oil market.

Conventional oil production peaked in 2006. Also nine of the top oil producers in the world have already peaked: USA peaked in 1971, Canada 1973, Iran 1974, Indonesia 1977, Russia in 1987, UK 1999, Norway 2001, Mexico 2002 and Saudi Arabia 2005. Moreover, three of the world's largest oilfields have already peaked: Kuwait's Burgan, Mexico's Cantarell and Saudi Arabia's Ghawar.[20]

The world is currently consuming just over 32 bb a year, yet on average finding just over 6.80 bb a year. Over the period 1992-2011, only 23 percent of the global oil production has been replaced by new discoveries or by enhanced oil recovery (EOR).

Should we worry about peak oil? Our world is completely dependent on oil. The most critical factor determining the performance of the world economy is access to inexpensive oil.

With more than fifty oil-producing countries now in decline, focus on the oil-rich Middle East has sharpened dramatically but as this region nears its own oil peak probably this year, any relief it can provide is limited and temporary. Therefore, the pressure on the oil price will continue unabated in coming years.

However, the fact that the oil price has been hovering near $110-$111/barrel for the last three years despite the worst global recession the world has ever witnessed, and the rush for the development of expensive unconventional oil resources are a proof that the peak oil theory is valid and alive.

Can the U.S. Shale Success be Replicated Elsewhere?

The U.S. shale success can't be easily replicated in other areas of the world – at least in a short period of time – due not only to the huge resource base of shale oil existing in the U.S., but also to some unique features of the U.S. oil industry and market.[21]

In the U.S. individuals and companies may own property rights on mineral resources, while in most parts of the world these rights belong to states only. This fact gives a huge incentive to land owners to lease their property rights and to the oil industry to lease or buy them.

Another major feature is the presence of thousands of independent oil companies that historically played the role of pioneering new frontiers. Yet another feature is the presence of several financial institutions, funds, capital ventures, and equity firms that are eager to fund independent companies.

A final unique feature is the broad availability and flexible market of drilling rigs and other essential tools of exploration and production. For instance, the U.S. and Canada have about 65% of all drilling rigs existing in the world.[22]

These features which don't exist in other parts of the world make the U.S. a sort of unique play for experimentation and innovation.

Conclusions

While U.S. shale oil production will probably have a positive impact on domestic oil production and the level of oil imports, it will hardly make a dent in the global oil supply.

Total U.S. oil production oil will peak at 7.50 mbd in 2019 before it starts to decline reaching 6.10 mbd by 2035. This means that there is neither a chance for the United States ever to become self-sufficient in oil nor to overtake either Saudi Arabia or Russia in oil production. Moreover, the U.S. will never be in a position to deny OPEC the power to set global oil prices.

However, the biggest obstacles to an expansion of U.S. shale oil production would be a backlash against its adverse impact on the environment, lack of oil transport and refining infrastructure and rising costs of production. Without higher prices exceeding $100/barrel, no one would be chasing shale oil.

The U.S. shale oil boom would not be easy to replicate in the rest of the world nor will it invalidate the concept of peak oil.

Footnotes

[1] The International Energy Agency's (IEA's) Annual Energy Outlook 2012.

[2] OPEC's World Oil Outlook 2012, pp.121-122.

[3] This is calculated on the basis of 3%-5% annual depletion rate of U.S. conventional oil production between 2012 & 2020 and estimated at 1.2 mbd-2.0 mbd. A1 mbd increase in shale oil production during the same period will partially offset the decline in conventional oil but leave a deficit of 200,000 b/d -1 mbd.

[4] OPEC's World Oil Outlook 2012, p.122.

[5] Ibid., p. 121.

[6] Ibid., pp. 121-122.

[7] EIA's Annual Energy Outlook 2013 Early Overview (AEO2013), released on 5 December, 2012, p.8.

[8] Leonardo Maugeri, Oil: The Next Revolution (a paper published by Belfer Centre for Science & International Affairs at Harvard Kennedy School, June 2012), p. 45.

[9] Bloomberg report accessed through http://www.crainscleveland.com/article/20121211/BLOGS03/121219978

[10] Leonardo Maugeri, Oil: The Next Revolution, p. 45 & p. 63.

[11] Ed Morse, Move Over OPEC – Here We Come, Wall Street Journal, March 20, 2012.

[12] ED Crooks, Financial Times, December 14, 2012.

[13] That is what OPEC Secretary General, Mr Abdullah Al-Badry told a press conference held during the OPEC oil Ministers conference in December, 2012 and reported by Associated Press (AP) on 13 December, 2012.

[14] Javier Blas, OPEC Unlikely to Disrupt U.S. Shale Boom, Financial Times, December 12, 2012.

[15] Leonardo Maugeri, Oil: The Next Revolution, p. 55.

[16] Ibid., p.57.

[17] Ibid., p.58.

[18] Ibid., pp. 59-60.

[19] Jeff Rubin, When Shale Oil Won't Save You at the Pumps, the Globe & Mail, Toronto, Canada, November 22, 2012.

[20] Mamdouh G Salameh, The Changing Oil Fundamentals: Impact on the Global Oil Market & Energy Security (A paper given at the ECSSR 17th Annual Conference, November 1-2, 2011, Abu Dhabi, UAE), p.7.

[21] Leonardo Maugeri, Oil: The Next Revolution, p. 45.

[22] Ibid., p. 46.

The Energy Independence Solution

By Peter Z. Grossman*

Why does U.S. energy policy always seem to fail?

Because it is based on a story—a story that is 39-years-old and was mostly wrong even when it was first told, and bears little resemblance to reality today. Nevertheless, it is the story that most policymakers from both political parties seem to believe. I call this the "U.S. energy narrative" and it has been an impediment to effective policy for almost four decades.

The story goes something like this:

America is in the midst of an energy crisis and has been for several decades. At the heart of this crisis is the fact that the U.S. is dependent—in fact, "dangerously dependent"—on world oil markets.

Dependency is dangerous because the market is controlled by the nations of the OPEC oil cartel, many of whom wish us ill. This is troubling because they can cut off our oil supply, that is, use oil as a weapon to coerce us into changing our national policies; this is a threat to national sovereignty. Arab OPEC members used this weapon in 1973, and the weapon remains a threat. Any day an adversary or group of adversaries will unsheathe it.

In the event that OPEC nations should choose to "attack" us, Americans will sit in their cars waiting for gas and at home in the cold and the dark. Polls repeatedly have shown that Americans retain this fear, even though wide-scale protracted shortages of oil and gasoline have not occurred since the 1970s and even then the causes were misunderstood.

Yet dependency, by definition, has a solution: independence. According to the story, the only solution to this threat to our way of life is to become energy self-sufficient. Every president since Richard Nixon has embraced this panacea; the only disagreement is on the means not the ends.

For some, the means would be extensive drilling in such places as the Arctic Natural Wildlife Reserve or the Outer Continental Shelf. But to others any fossil-fuel panacea is inherently problematic. If we depended on our own conventional resources (recent expansion of natural gas production notwithstanding) we would find ourselves paying higher and higher prices until the "tap ran dry."

But we can't rely on world resources either. Not only is there the threat of the weapon, but also economic development in countries such as China and India, has led to rising world demand for oil and gas resources. In fact, demand will soon be out-stripping supply world-wide. The demand-supply gap will only get worse in the years ahead, and shortages will be ubiquitous.

The solution, according to this scenario, is for government programs to develop a new technology (or set of technologies) that provides super-abundant quantities of domestically-produced energy, at low prices. It is just a matter of harnessing U.S. know-how, making development a national priority, and funding it sufficiently—as we did to put a man on the moon. President Obama referenced the Apollo program with respect to energy as recently as his 2011 State-of-the-Union address.

In 1973 when this narrative became the common wisdom, it seemed to fit the facts. The Arab OPEC nations had imposed an embargo against the U.S. and the Netherlands for supporting Israel in the war that had begun on October 6. There were shortages of oil products, especially gasoline and diesel fuel, in the U.S., and given declining U.S. oil and gas production, greater dependence and vulnerability seemed inevitable. Neo-Malthusian analyses such as the "Limits to Growth" models suggested dire consequences ahead even if OPEC was willing in the short term to sell us more oil.

But in almost every respect the narrative was wrong.

Our gas lines were due to U.S. policies (price controls and later allocation controls). The demand-supply gap, first noted in the 1970s, was, and is, nonsensical; if the rate of demand growth exceeds the rate of supply growth (or even if supply stops growing or shrinks) there will be increases in prices.

Neither the U.S. nor the world is about to run out of any energy resources any time soon, though there could be temporary supply problems and fluctuating prices, resulting at times in short-term economic downturns that have had few long-term effects.

The government has never produced an important innovation that would move us toward the independence panacea. Economist and Obama administration advisor, Lawrence Summers, noted that the government is a "crappy" venture capitalist and cannot conjure up a commercial product with an Apollo program.

Moreover, the portrait of OPEC has been extremely simplistic. It is true that at times the organization has wielded market power. But exporters have been far

(continued on page 35)

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Portent of a Perfect Storm - *U.S. Energy Independence*

By Haydn I. Furlonge*

Regional Supply Outlook

According to the World Energy Outlook, 2011 (International Energy Agency), U.S. gas demand will increase by about 5 trillion cubic feet (tcf) per annum by 2035. Current imports amount to about 3.5 tcf per annum (Annual Energy Outlook, 2013, EIA, U.S. DOE). Cumulative imports plus incremental consumption amount to less than 200 tcf through to 2035. Numerically, all of this can be easily met by newly found shale gas reserves, currently estimated to be 482 tcf.

Hence, the question is not whether there are ample reserves for export, but how much and how soon. Actually, the U.S. already has more planned projects (10 out of 38) over the period 2013 to 2018, and planned capacity (113.8 mtpa versus 336.1 mtpa) than any other country in the world (LNG Journal, Oct. 2012). Whilst only a fraction of these planned projects will be built, the scale of this trend is impressive when one considers that current global capacity is 287.5 mtpa. In other words, U.S. gas and LNG producers are gearing up to compete for market space.

Assuming half of the planned U.S. liquefaction capacity is built (and this is optimistic by U.S. EIA estimation), about 60 tcf of gas will be consumed by the U.S. to 2035. The point here is that even if the U.S. were to cease imports of gas (see expected trend in Figure 1) in lieu of domestic supply (200 tcf), and generously export LNG (60 tcf), this is just over half of the new 482 tcf of indigenous commercial reserves. Bear in mind that the U.S. also has 202 tcf of conventional gas reserves. The implication for the regional gas market is that a "tidal wave" from the West can be expected.

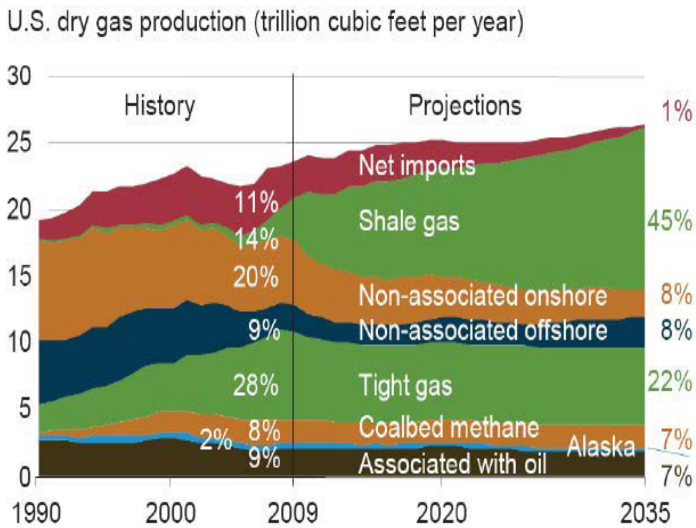

Figure 1: Projected U.S. Net Imports and Shale Gas Production (Source: U.S. DOE)

From the East, about 20 million tonnes of LNG is due to come onstream between 2012 and 2015. A restart of the Kenai plant, Angola's first Train and incremental production in Algeria will more than meet incremental demand. In the medium-term, East Africa's new 400 tcf of gas reserves will make an impact sooner or later. Australia's quest to become the world's largest LNG player could see 40 million tones being added. Pacific supply will no longer be restricted to Pacific deliveries. The commissioning of the Panama Canal expansion works will open a flood gate, as LNG carriers will be able to move freely from East to West.

All things considered, this spells the brewing of a "perfect storm" right in the middle of the Atlantic basin region. The implications for an increasingly globally connected gas business are several.

Regional Gas Pricing

According to the NERA Report (Dec. 2012) commissioned by the U.S. DOE, there is expected to be a slight to moderate impact of increased U.S. export of gas owing to shale production on U.S. gas prices (between U.S.$ 0.22 and 1.11 per Mcf). Such an increase above the current U.S. gas price range of U.S.$ 3.00 to 4.00 per Mcf is not intolerable for U.S. consumers considering past trends. Given where gas prices are in the region today (in the U.S.$ 10 to 18 per Mcf range), the price perturbation within the U.S. is negligible compared to the potential impact of U.S. export volumes on regional pricing. The scale of increased U.S. LNG re-export and liquefaction supply capability will serve to help settle unprecedented gas prices in South American and European markets which have been troubled by the freeze on nuclear power and oil price linkages.

Further, the relevance of the Henry Hub gas price marker has all but momentarily disappeared given that the demand pull from Europe and the Far East means that the UK's National Balancing Point (NBP) and crude oil prices have respectively influenced Atlantic prices. However, as import/re-export and liquefaction infrastructure is boosted, the U.S. could once again become a genuine natural gas hub and price indicator for the Atlantic.

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Increased U.S. Petrochemical Production

"For the first time in over a decade, U.S. natural gas prices are affordable and relatively stable, attracting new industry investments and growth and putting us on the threshold of an American manufacturing resurgence," according to the Chairman and CEO of Dow Chemicals (Source: ICIS news, 19 April 2012). This phenomenon is very good for the U.S. economy, but it has a ripple effect beyond its borders. Traditionally, U.S. manufacturers have relied on investments in and product from facilities in other countries such as Mexico, South America and Trinidad.

The competitive advantage of these countries has now taken a blow, as incremental U.S. demand may now be soaked up by its own indigenous production. As shown in Figure 2, ammonia imports are expected to decline over the next several decades, and U.S. methanol production is already on the rise (Figure 3). The decision by Methanex to relocate its methanol plant from Chile to Louisiana is a sure sign of which way things are moving. This changes the petrochemical supply chain in a fundamental way, and is cause for concern for countries that have grown accustomed to foreign direct investment in their export-based economies.

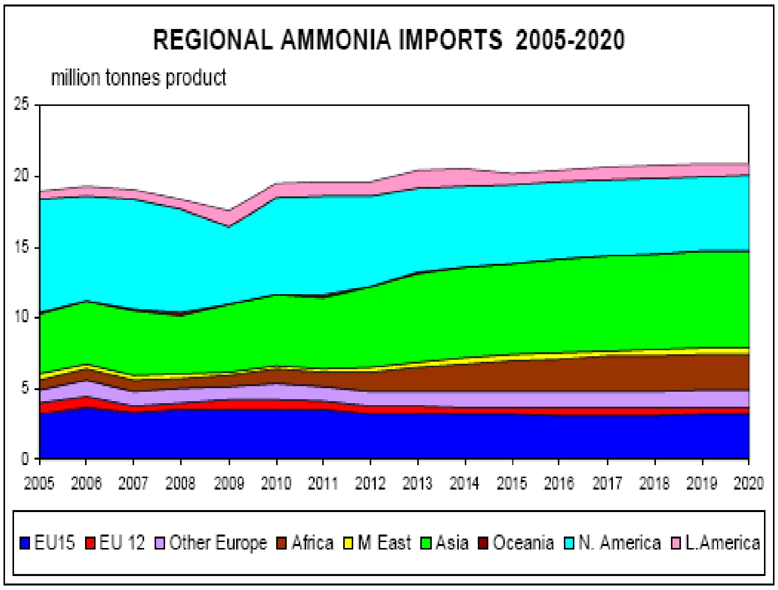

Figure 2: Projected U.S. Ammonia Import
Source: Fertecon

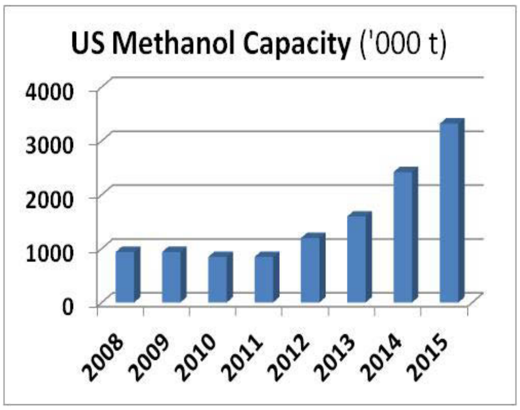

Figure 3: Projected U.S. Methanol Capacity
Source: Chemical Marketing Associates Inc.

NGL Market

U.S. shale gas and oil production will cause natural gas liquids (NGLs) production to increase by 50% in five years time from about 2.4 million barrels per day to 3.6 mbpd. Most of this incremental supply will emanate from Eagle Ford covering south Texas, Marcellus in Pennsylvania and other liquids-rich shale plays. Cheaper natural gas for heating and incremental demand from petrochemical expansion will unfortunately not be able to absorb new propane and ethane supply respectively.

As such, a glut of NGLs is expected, driving down U.S. prices. Inevitably, excess volumes will seek the export market, thereby resulting in the U.S. becoming a net exporter of NGLs. This may not find a ready market in Latin America and Europe, which already have a high penetration rate for NGLs and is sufficiently supplied. This can only lead to increased competition for existing NGL exporters in the region.

New Ownership Matrix

Another impact of the opportunities arising from U.S. shale business activity at the company level, has to do with new investments, divestments and acquisitions. With other opportunities beckoning elsewhere and financial re-structuring imperatives, some companies are even taking the early occasion to sell their interests and move on. The recent GdF-Suez and now Repsol moves to restructure their business are noteworthy given their level of involvement in the region's gas arena. This makes room for new players, not the least of which are Chinese firms who have demonstrated keenness to take strategic interests in Western gas assets. On the product off-take segment of the gas chain, Indian companies are taking strong interests to secure U.S. LNG volumes to feed relatively new import facilities.

At the country level, diminished U.S. reliance on energy imports, and its potential to become a significant energy exporter has major implications not only on market dynamics but energy geopolitics. Countries such as Nigeria, Algeria, Trinidad and Tobago, and those in the Middle East would no longer find the U.S. a haven for LNG, which alters the influence of these countries in political terms to some extent. In fact, the U.S. will be their outright competitor. Even for new provinces in Africa that are only just trying to enter the energy export market, having a competitor with already well established gas infrastructure (pipeline, tank and underground storage, and export terminals) only makes their circumstances that more difficult.

With divestments along with significant investment to be made in U.S. shale resources and in new provinces in Africa, the ownership matrix of hydrocarbon reserves is currently being transposed. If one were to juxtapose Australia's efforts to commercialize its conventional gas reserves as well as to develop its coalbed methane and shale gas reserves, with access via the Panama Canal, then it is not far-fetched to envisage a shifting of the axis of the energy world from the Middle East to latitudes of the West and Far East.

Concluding Remarks

U.S. Energy Independence is a subject of great interest for the energy market of the Atlantic region. Industry players are flocking close to the shores of the U.S. in anticipation of some dramatic changes in the supply side of the equation. Even a moderate policy position on U.S. exports will be welcomed by U.S. manufacturers and upstream players. Reaction by the rest of the region and indeed a more connected global gas market has far greater implications for consumers and governments around the world than one might conceive.

The Energy Independence Solution (continued from page 32)

more dependent on selling oil to us than we have been in buying it from them. Though fears of the oil weapon abound, in fact the embargo was a total fiasco from the standpoint of the exporters. Notice how often it's been used since 1973.

The narrative is counterproductive since it posits a world that doesn't exist and never has, and offers a solution—independence—that is next to impossible to achieve; it would be extremely costly and foolish to try.

Nevertheless, it is kept alive because it provides a bold-sounding, yet straightforward answer to a complex social-technological issue that affects the daily lives of everyone. But there are no easy answers, no cure-alls, for America's energy issues. It's not even clear what anyone means by "energy independence" much less what it would actually take to get there. As the late Nobel prize-winning social scientist, Elinor Ostrom observed, "[We need to] call attention to perverse and extensive uses of policy panaceas…We should stop striving for simple answers to solve complex problems."

Energy independence is a simplistic concept, but a logical goal given the energy narrative. Until the narrative changes, we will never see effective energy policy in the United States.

Perspectives on the Future of Unconventional Gas in Europe – Insights from the ZEW Energy Market Barometer

By Florens Flues, Andreas Löschel, Philipp Massier and Nikolas Wölfing*

The "shale gas boom" in the United States (U.S.) has triggered discussions about the extraction of unconventional gas[1] resources in the European Union (EU). Advocates of extraction believe that import dependencies would decrease, even energy independence seems possible. Furthermore, natural gas prices are believed to decline substantially.

Looking at market fundamentals, however, these beliefs are likely exaggerated. Comparing the U.S. and Europe there are significant differences in estimates of technically recoverable resources of unconventional gas.[2,3] The European Commission's Joint Research Centre (EU JRC) provides mean estimates of 39.9 trillion cubic meters (tcm) for the U.S., yet only 11.7 tcm for Europe.[4] Thus, fewer resources in Europe make the quest for energy independence harder.

Moreover, it remains questionable whether the extraction of unconventional gas resources in Europe will be economically feasible. The EU JRC, in line with other studies, estimates extraction costs of 5-12 US.-dollar per million British thermal units ($/MMBtu).[5] In that respect, extraction seems fairly profitable given current market prices of about 10 $/MMBtu for front year futures.[6,7] Yet, these cost estimates, based on aggregating individual cost factors bottom-up, typically focus on engineering costs and ignore various kinds of (transaction) costs. For example, the costs for acquiring the land access from local land owners and obtaining the drilling rights from the public authorities are often not explicitly accounted for. Compared to the U.S., plot sizes of farm land are often significantly smaller in Europe such that firms would have to negotiate with multiple land-owners and state authorities before even building the first drilling rig. Furthermore, as local communities are often hostile to unconventional gas extraction, this may lead to civil protest and long mediation processes adding more transaction costs to the bill.

Given the uncertainty about technically recoverable resources and extractions costs we suggest an alternative way of revealing the profitability of shale gas extraction in the EU. We asked energy market experts from the ZEW Energy Market Barometer[8,9] from which price level onwards they would expect a significant increase in the extraction of unconventional gas resources in the EU. Experts have different notions about the size and relevance of specific cost factors. By asking about the Break-even price level for unconventional gas we aimed for experts to provide their best estimate for the overall cost of significant unconventional gas extraction in the EU.[10] The distribution of estimates by the experts gives us information about the range, as well as median estimates of overall extraction costs.

In addition to the expected Break-even price of unconventional gas extraction in the EU, we also asked for the expected market price of natural gas, the future development of total extraction volumes, and the expected regulatory actions regarding unconventional gas extraction. This allows us to draw a more detailed picture of the perspectives on and for the European gas market in light of recent developments in the shale gas industry. In the following we present and discuss the findings of our survey.

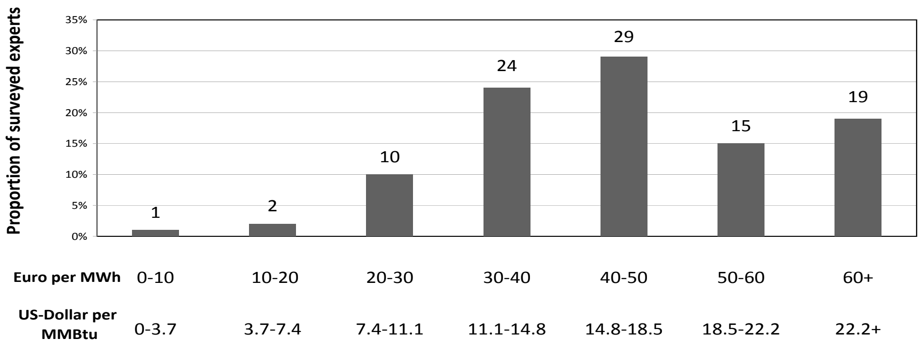

Figure 1: Break-even Price of Unconventional Gas in the EU

Median Break-even Price between 40 and 50 €/MWh (14.8-18.5 $/MMBtu)

The median estimate for the Break-even price of unconventional gas in the EU is between 40 Euro per megawatt hour (€/MWh) (~ 14.8 $/MMBtu) and 50 €/MWh (~18.5 $/MMBtu). 19 percent of the respondents even expect that a wholesale price of natural gas above 60 €/MWh (~22.2 $/MMBtu) is necessary to substantially increase the extraction of unconventional gas in the EU (see figure 1).

These Break-even price expectation are substantially above current wholesale market prices in the UK, Netherlands and Germany, which are about 27 €/MWh ($10 $/MMBtu).[11] Thus, European natural gas prices would need to increase sig-

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See footnotes at end of text.

nificantly for unconventional gas extraction to become profitable. Will they? 66 percent of the experts think that the price for natural gas will increase in the next five years. In addition, 50 percent of the experts predict a constant supply of unconventional gas for the next five years. Hence, it seems unlikely that the expected price increase is sufficient to foster a broad extraction of unconventional gas in the EU in the coming years. However, 76 percent reckon with an increase of extraction volumes of unconventional gas in the next ten years.

Increase in Overall Gas Supply and Stable Import Dependency

What impact will an increase of unconventional gas extraction in the long term have on the overall supply of natural gas in the EU? Half of the respondents predict a decrease in conventional gas supply in the next ten years. An equal amount anticipates that the overall extraction volume of conventional and unconventional gas in the EU increases. Hence, the experts expect that the decrease of conventional gas extraction in the EU is overcompensated by the increase in unconventional gas extraction in the next ten years. Contrary to this, 36 percent expect a constant overall extraction volume of conventional and unconventional gas.

Regarding the demand side the majority of respondents expect an increase in demand for natural gas in the EU in five years (71 percent) as well as in ten years (64 percent). The crucial question regarding energy independency is whether this demand will be served by domestic or foreign supply? About half of the respondents think that the security of supply will not change in response to the extraction of unconventional gas deposits. This indicates that the demand structure will also not change significantly. Demand will likely be served by sources inside as well as outside the EU as today.

After all, Russia, Azerbaijan, Turkmenistan, and Qatar explored recently conventional gas fields with high capacity and low extraction costs. Also the capacities for the transportation of gas from Eastern Europe and the Middle East are already increasing and will do so further with the construction and operation of new pipelines as well as liquefied natural gas (LNG) ports.

Expectations about the Legal Framework

Although the development of unconventional gas in Europe is currently not very dynamic, questions regarding the legal framework are broadly discussed. Furthermore, the International Energy Agency (IEA) recently published a report stating that a regulatory framework is necessary to take the special risks of fracking technologies into account.[12] According to the IEA report a regulatory framework would increase extraction costs only slightly. Yet, no regulation at all could increase resistance to fracking technologies and thus hinder their diffusion. Accordingly, we asked our experts, which additional regulation they would expect in Germany and the EU.

Ninety two percent of the experts presume that there will be mandatory environmental impact assessments (EnvIA) in Germany. Also 82 percent expect further regulation regarding water legislation and 61 percent with respect to mining legislation. Moreover, 72 percent of the respondents expect additional standards in public participation processes. Thus, the majority foresees more regulation in these areas in Germany. On a European level there is more uncertainty about regulatory developments. Nevertheless, 58 percent of the experts expect mandatory EnvIAs. Forty nine percent expect additional water legislation.

How do these expected developments in the regulatory framework affect extraction costs? Respondents who foresee one or more changes of the regulatory framework on the

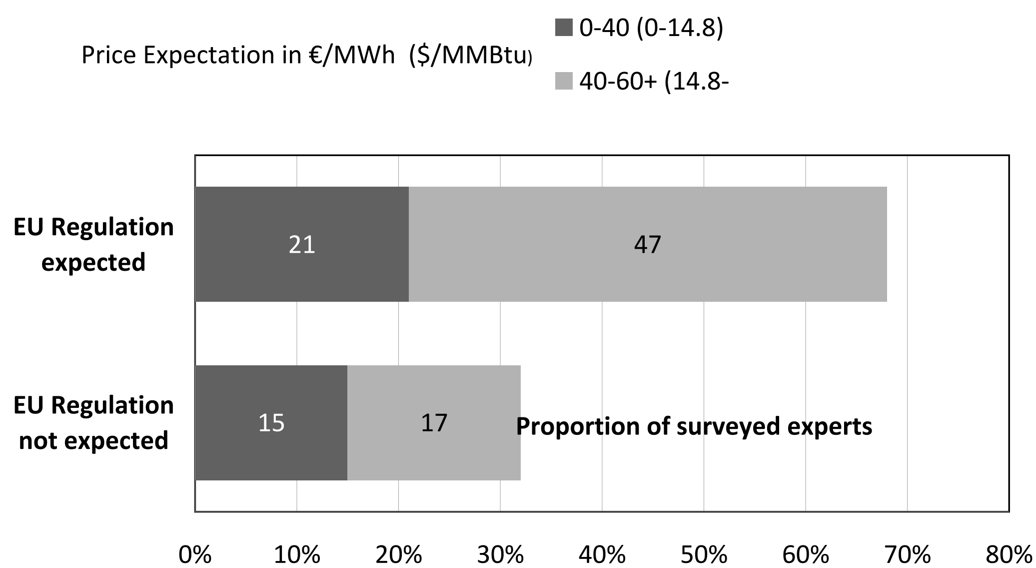

Figure 2: Price Expectation Given Expected Regulation

EU level also predict a higher Break-even price of unconventional gas (see figure 2). However, a simple linear regression model explains just about five percent of the variation in Break-even prices by expected regulation. Thus, the skepticism on the large scale profitability of unconventional gas in Europe is apparently not driven as much by the legislative framework as one might expect.

Conclusion

Our survey does not support hopes for decreasing import dependency of fossil fuels or lower natural gas prices in Europe. The respondents predict clearly higher extraction costs for unconventional natural gas resources compared to today's wholesale prices. At most, the extraction of unconventional gas will increase to a significant level in ten years. Yet, this extraction will merely balance the decrease in the conventional gas supply and the increase in demand. Higher import shares and absolute levels of imports remain a likely scenario. Thus, there is no indication for energy independency, but with a diverse portfolio of gas suppliers, the EU should be able to ensure a secure supply. Regarding the regulatory and legislative framework in the EU many experts anticipate further developments regarding environmental impact assessments and water legislation.

Footnotes

[1] We refer with unconventional gas to shale gas, tight gas, and coal bed methane.

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[5] Pearson, Ivan, et al., ibid.

[6] European Energy Exchange (EEX), "Natural gas", retrieved from the World Wide Web on 26 Feb. 2013: http://www.eex.com/en/

[7] ICE Futures Europe (ICE), "Daily Volumes for ICE UK Natural Gas Futures (Monthly)" (futures up to six years ahead), retrieved from the World Wide Web on 27 Feb. 2013: www.theice.com

[8] The Centre for European Economic Research (ZEW) hosts a panel of energy markets experts, who are surveyed biannually for the ZEW Energy Market Barometer [ZEW Energiemarktbarometer]. The ZEW Energy Market Barometer is an industry-specific indicator of economic sentiment regarding energy supply, energy trade, and energy service industries in Germany. It comprises the expectations of about 200 experts concerning short- and long-term developments in the national and international energy markets. The majority of the panelists work for the energy supply industry or in energy trading. Furthermore, experts stem from academia and energy consultancies. A small part of the participants work for energy related associations, administrations or institutions. Given that the ZEW Energy Market Barometer addresses German energy market experts, results may relate particularly to the German situation. The panel was established in 2003.

[9] The complete series of the Energy Market Barometer can be retrieved from: http://www.zew.de/de/publikationen/energiemarktbarometer.php. This article is based on the latest Energy Market Barometer from January/February 2013, which is only available in German.

[10] We equalize Break-Even prices with overall costs based on the assumption of perfect competition and zero long-run profits. This assumption can be justified looking at the US shale gas industry, which is very competitive.

[11] EEX, ibid. ICE, ibid.

[12] IEA, „Golden rules for a golden age of gas", (2012), Paris, France.

Dave Williams Honored

In my role as the Vice President for Conferences, I have been working closely with our Executive Director, David Williams, in the planning of IAEE meetings. It has always been a very pleasant and enriching experience to work with him. His dedication, professionalism and his outstanding positive energy have always impressed me. His commitment and passion to the advancement of IAEE meetings has been overwhelming. His hard work is acknowledged by the whole Professional Conference Management Association(PCMA) now. It is no surprise to me that the PCMA has honored David Williams with its "Global Executive of the Year" award. This well-deserved award makes him a proven leader in the industry worldwide. Dave, we are proud of you !

Gürkan Kumbaroglu

Energy Efficiency Obligation Schemes in the EU - Lessons Learned from Denmark

By Sirid Sif Bundgaard, Kirsten Dyhr-Mikkelsen, Anders E. Larsen and Mikael Togeby*

Introduction

Improved energy efficiency is a valuable means for the European Union (EU) to improve security of supply and reduce greenhouse gas emissions in a cost-effective way thus mitigating climate change. Further, a more energy efficient economy would boost innovative technological solutions, increase competitiveness of the industry and create high quality jobs.

The 'Europe 2020' strategy adopted by the EU in 2010, confirmed the '20/20/20' targets. One of these targets is to save 20% of the Union's primary energy consumption by 2020 compared to projections made in 2007. In other words, to reduce primary energy consumption from 1,842 Mtoe to 1,474 Mtoe in 2020, i.e., a reduction of 368 Mtoe compared to projections. Recent studies have shown that the EU is not on track in reaching the 20% energy efficiency target. To ensure that the target is in fact achieved a new Energy Efficiency Directive (EED) has been adopted [1].

The Energy Efficiency Directive

The new EED is to replace the current Energy Service Directive (2006/32) and the Cogeneration Directive (2004/8). The EED introduces legally binding measures for each Member State to increase energy efficiency. Measures include the legal obligation to establish an energy efficiency obligation (EEO) or alternative policy measures in all Member States. The goal is to drive forward energy efficiency improvements in the household, business, industry and transport sectors. The EED also specifies a savings target for the EEO.

Energy Efficiency Obligation

EEOs and the related tradable white certificates have been used for years in Denmark, France, Italy and United Kingdom. From 2013, an EEO will be in place in Poland. The existing EEOs illustrate the diversity of possible designs. For example,. among the four countires the Danish EEO is the strongest in relation to energy efficiency in industry. This is in contrast to France, Italy and UK where households and the public sector dominate.

Recent analyses have generally found EEOs to be economically attractive [2,3,4], but they may not be the best solution for all Member States. A Swedish report [5] concludes that it would not be cost effective to introduce an EEO in Sweden. The report finds that an EEO will have an unfortunate overlap with the EU Emissions Trading System (EU ETS) and stresses that Sweden has no other policy objectives, such as the desire for smaller energy imports, which could support the introduction of an EEO. In order to accommodate such situations the EED allows Member States to choose an alternative approach to an EEO, however, with the same savings target. Member States are, however, subject to EU approval of such an alternative scheme.

How best to design EEOs, white certificates or other market mechanisms for energy efficiency depends on national characteristics, e.g., the savings potential, other measures being in use and the tradition and experience with energy efficiency. The requirements in the EED pose several design and implementation challenges for Member States such as:

- Ensuring that savings are as cost-effective as possible
- Minimising administrative cost
- How to realise the potential for savings in buildings
- How to effectively ensure third party access and competition, and
- Setting up a system for control, verification, documentation and sanctions.

The following presents some of the lessons learned from Denmark with regards to those challenges. In the EED it is up to each Member State to determine which energy distributors or retail energy sales companies should be obliged to achieve the savings target laid down in the EED. While the obligation must be assigned on the basis of objective and non-discriminatory criteria, the EED suggests that small energy distributors, small retail energy sales companies and small energy sectors be excluded from the EEO to avoid the disproportionate administrative burdens for the regulatory authority and obligated parties.

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The Danish EEO

Energy distribution companies have been involved in energy savings at the end-user level since the early 1990s. Traditionally, their savings effort was limited to advising their own customers. This work was formalised with the first EEO operating from 2006 onwards. The EEO was based on a voluntary agreement within a legislative framework with the distributors of electricity, natural gas, and district heating. The private heating oil companies committed to the obligation voluntarily. With the introduction of the EEO the savings effort was significantly restructured and the energy distribution companies were able to realise energy savings across the country and within all forms of energy. The change meant increased competition in providing competent advice to attract industrial customers [4].

From 2011 onwards first-year savings are weighted with a simple priority factor (with values 0.5, 1 or 1.5), which to some extent reflects the lifetime of savings, gross energy consumption associated with the realised savings cost, and expected CO_2 impact of savings – especially in regards to whether the savings are realised inside or outside the EU ETS area. Negotiation for the upcoming period (2013-2020) of the Danish EEO is still on going. The design parameters of the current Danish EEO can be seen in Table 1.

Design parameter	Denmark
Policy Objectives	To decrease total primary energy consumption by 7,6 % in 2020 compared to 2010.
Legal Authority	Voluntary agreements by obligated parties and the Danish Energy Agency within a legislative framework.
Fuel Coverage	Electricity, natural gas, district heating, and heating oil. The transport is not included.
Sector and Facility Coverage	Residential, public & private business and industry end-users.
Energy Saving Target	2.95 PJ/year for 2006-2009 (0.7% of total final consumption); 6.1 PJ/year for 2010-2012 (1.2% of total final consumption) 10.7 PJ/year for 2013-2014 and 12.2 PJ/year for 2015-2020. The target is in first year savings.
Sub-targets and Portfolio Requirements	None.
Obligated Parties	Distributors of electricity, natural gas, district heating (regulated monopolies), and heating oil.
Measurement, Verification, and Reporting	Distributors verify and report savings; can be calculated or deemed savings. Yearly random sample control.
Compliance Regime	Energy savings must be well documented and they must be verifiable by an independent party if chosen for control
Penalty	None
Performance Incentives	Yearly benchmark of savings and costs for obligated parties
Eligible Energy Savings	Distributors must engage third parties to achieve energy savings outside own distribution area or energy type except for transport
Eligible Energy Efficiency Measures	Many types, including energy audits, subsidies for efficient appliances, equipment and retrofitting; also small scale renewables
Trading of Energy Savings	Energy savings, when realised, may only be traded among obligated energy distributors
Funding	Cost recovery through tariffs

Table 1
Design Parameters of the Danish Energy Efficiency Obligation Scheme [5,6,7].

Goal Achievement

The EED stipulates that the EEO must set a cumulative end-use energy savings target by the end of 2020 "*at least equivalent to 1.5% of the annual energy sales to final customers of all energy distributors or all retail energy sales companies by volume, averaged over the most recent three-year period prior to 1 January 2013*" and permitted exemptions may not reduce this target by more than 25%. Energy used in the transport sector and industrial activities covered by the EU ETS may be partially or fully excluded from the target. The calculation of energy savings should take into account the lifetime of the savings and it is possible to count savings obtained in a given year as if instead obtained in any of the two previous or three following years. Further, savings in transformation, transmission and distribution may be included in the reported savings.

While the cumulative end-use savings target of 1.5% of annual energy sales by 2020 can seem challenging, the experiences from the scheme already operating are encouraging. So far no sector or a group of companies that have been subject to an EEO have failed to fulfil the national savings target. On the contrary, there is a tendency toward overachieving [2,3,9]. In Denmark the target has been raised several times, and the obligated parties are still over achieving. The obligation in 2006-2009 was 2-3 times higher than the savings realised under the previous system. From 2010 the obligation was doubled, and is planned to double again in 2015 (see Figure 1).

The most recent evaluation of the Danish EEO showed that in 2011 the energy companies had realised 140% of the savings required by the scheme [9]. With the increase in EEO target this would more than comply with the requirement under the EED. In light of this, the EU target appears not overly ambitious but reachable and realistic.

Energy Savings in the Production Industry

In many countries the industrial sector represents a challenge for policy makers. Many countries have been hesitating to use taxes or CO_2 quotas to motivate industry to higher energy efficiency for fear of hampering the competitiveness of the industry. Experience from the Danish suggests that EEO or similar measures may be of special relevance in such cases.

In principle, industrial projects are allowed in the Italian and French systems; however, certain requirements on monitoring and documentation prevent these savings from being realised in any significant volume. This is not the case in Denmark. As a result of the increased obligation from 2010 onwards in the Danish scheme, there have been significantly more savings realised in industry (see Figure 2).

The instruments used are: Advice given directly by the obligated parties, advice given by consultants as a third party involved, and subsidies given per saved kWh. Savings in industry are considered attractive as they often provide significant savings in other projects and thus reduce administration costs. Furthermore, the 2012 evaluation shows that energy savings in industry under the EEO scheme are profitable, have a high net effect and can be considered a cost-effective measure [9]. The experience from Denmark is that when left to the discretion of the obligated parties the most cost-effective and dominating sector to realise savings is industry. For Member States that are considering establishing an EEO, it is thus worth considering a design that allows and encourages savings in industry.

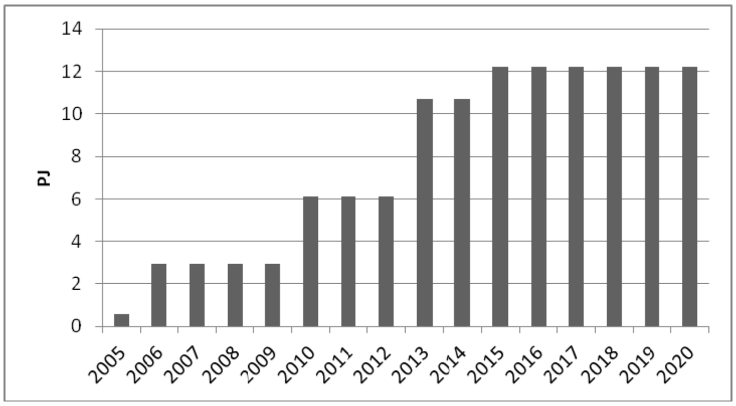

Figure 1
Development in the Danish energy efficiency obligation target. The value for 2005 (0,6 PJ) shows savings from the previous system and is estimated based on reporting from utilities [9].

There are, however, cases where subsidies have been given to projects that are highly profitable even without the subsidy and in a few cases the subsidy is greater than the investment [10]. While not actually against the rules in the Danish EEO design, it is difficult to argue that subsidies exceeding the investment are appropriate. Restriction of subsidies in regards to payback time and the proportion of investment in energy savings, might improve the societal value for the cost of the EEO [9,10].

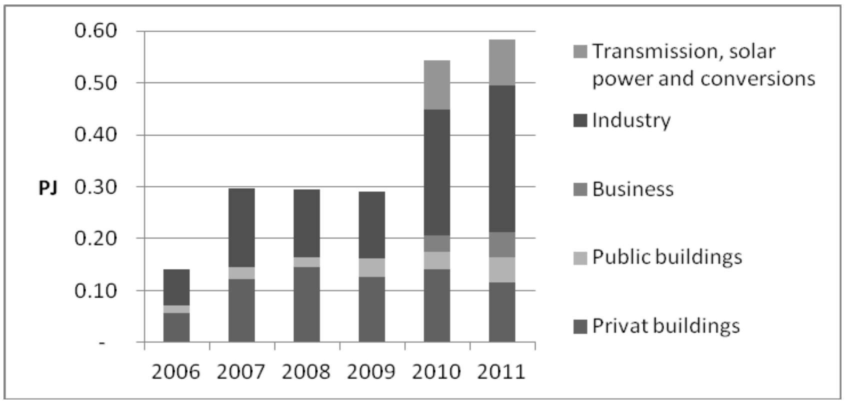

Figure 2: Reported savings in the Danish EEO 2006-2011 distributed on sectors [9]

Another issue is the question whether the EEO provides a reasonable net effect for highly profitable projects in industry, or whether these projects would have been carried out regardless. The Danish EEO takes this into account by requiring that the obligated company – or a third party – must be involved in the energy savings project *before* it is initiated. Recent studies show, however, that the current design might not be enough to ensure early involvement and consequently an acceptable contributing factor of the cost under the EEO [9,10].

Energy Savings in Public and Private Buildings

As opposed to the EEO in the United Kingdom, the Danish EEO does not have a strong focus on fuel poverty nor private buildings. On the contrary the Danish EEO has as objective to realise the set target at minimum costs, regardless of sector and energy form. While the amount of savings realised in private and public buildings has been stable, both the 2008 and 2012 independent evaluation of the Danish EEO showed a very low net effect in these sectors. The 2012 evaluation showed that only 20% of the savings in private buildings could be contributed to the measures used in the EEO as opposed to 45% in industry [9]. Thus, the subsidies or advice provided through the EEO are negligible for realising the savings compared to other determining features. One explanation for this result is that energy renovations of existing buildings are costly, both from a user perspective and a socio-economic perspective.

One of the challenges in relation to socio-economically viable energy savings in buildings is that it is expensive to improve energy efficiency in an existing, medium efficient building which means that the investment cost alone will be high [11,12]; each building has a limited energy consumption, which means that the instrument costs of, for example, obligatory energy audits at the time of sale/purchase quickly becomes too high, and that Denmark already has a very high level of taxation on energy used for heating in buildings. This gives a strong incentive to realise energy savings even without the EEO, making the savings not already realised less attractive from an economic perspective [13].

The cost of energy saving is much lower, if implemented, when the buildings are to be renovated anyway. Therefore, focus must ensure that buildings become more energy efficient when the renovation decision is already taking place, thus advocating *energy efficient renovation* rather than *energy renovation*. But how can the general measures designed hit this particular time?

The experience from the Danish scheme is that an EEO may not be the best instrument to realise the energy savings potential in existing buildings. If the renovation is already decided, one may argue that it implicitly is difficult to achieve a high contribution factor. However, the dilemma is that the energy saving potential in existing buildings cannot be ignored if climate change and energy security objectives are to be achieved. Thus it is important to supplement the EEO with other instruments such as building standards. It can be argued that measures aimed at market transformation, i.e., impact on the entire value chain, can be effective. If suppliers and craftsmen are trained and motivated to save energy, then this knowledge would be present when buildings are being renovated [13]. Also the measures in the EED covering energy saving in public buildings – that 3% of total floor area owned and occupied by central government bodies should be renovated every year to meet minimum energy performance requirements – will address the challenge of realising energy savings in existing buildings.

Involvement of Third Parties

In the EEO design outlined in the EED, Member States may permit the obligated parties to include certified energy savings achieved by energy service providers or other third parties in their reported energy savings. The challenge for the Member States that permit this is to ensure a clear and transparent approval process open to all market participants, while minimising the costs of certification.

The Danish EEO encourages the use of third party involvement by requiring the obligated companies to include a third party in order to realise savings outside their own distribution area or energy form. As such the use of third parties is widespread. In the Danish EEO, the third party does not have to be a part of the contract chain, but may receive a payment directly from the end-user. The recent evaluation found the EEO adequate in this area and that there is a general satisfaction with the system amongst the stakeholders. This is especially true for the small stakeholders such as builders and plumbers.

Control Measures

According to the EED the energy savings achieved by each obligated party, or each sub-category of obligated party, shall be published once a year. The EED emphasises that a measurement, control and verification system must be put into place to ensure that at least a statistically significant proportion and representative sample of the energy efficiency improvement measures put in place by the obligated parties is verified. Furthermore, this verification must be conducted independently of the obligated parties.

The Danish EEO fulfils the EED requirements within the area of control, verification and documentation. Independent random sampling tests are conducted each year and independent evaluations of the EEO are carried out routinely. With regards to penalties applicable in case of non-compliance the Danish design is insufficient [10]. The only consequence of deliberate or involuntary faults or omissions discovered in the annual random sampling control is that the overall energy sector must provide extra savings the following year equivalent of the savings that were deemed faulty. As the risk of being caught is small, this system gives incentives for over reporting of savings.

The obligated parties in Denmark have monopoly status and the cost incurred as a result of their EEO activity is financed over the energy bill. Only the total costs are reported by the obligated parties and in essence the Danish Energy Agency (DEA) and the Danish Energy Regulatory Authority (DERA) do not know what the money is spent on. Nor is the energy consumer informed of how much they contribute to energy savings financed over the energy bill. The system is designed in this way in order to minimise administration cost.

Within the Danish system there is probably a certain amount of self-discipline and potential shaming effect if caught. It can, however, be argued that the system does not sufficiently encourage cost-minimisation [10] and that credibility currently rests on the generally low corruption level in the country; that the obligated party have experience in providing energy savings for end-users and, therefore, have highly skilled employees; and that the obligated parties supports and agrees with the target. If these circumstances are not in place the credibility of a cost recovery system with a minimum of control might not be appropriate.

Concluding Remarks

The Danish EEO can give inspiration as to how to design an EEO that meets the requirements and target of the EED, encourages cost-effective savings in industry, effectively includes third parties and implements a solid verification and measurement system. With regards to cost recovery, fault in reporting and penalties, Member States should carefully consider whether the obligated parties and the society structure provides credibility for a similar design. Lastly, the Danish EEO highlights the necessity of supplementary instruments to realise the potential savings in existing buildings if public and private buildings are not the only target are of the EEO.

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Energy Efficiency of State and Privatized TSOs in Ukraine

By Yulia Pidlisna*

Introduction

The Ukrainian energy system and the efficiency of its distribution companies, called Oblenergos, in particular, have often been discussed in the context of improving energy efficiency. The underlying goal of this research is to find an effective national regulatory framework and also to determine the difference in operating efficiency of state and privately owed TSOs.

The installed capacity of the Ukrainian power industry is dominated by nuclear generation (47%), closely followed by thermal plants (44%). The main renewable source of power is hydropower generation (6%). Other renewable sources such as wind, solar, geothermal, and small-scale hydropower are very modest and account for less than 1% of total power generation. The Ukrainian power system from generation, transmission to distribution is plagued by major structural problems. These include outdated production facilities and the need of major investment in order to restore the production capacity.

Historical Perspective

Ukraine gained its independence in early 1990s and since then the energy sector has been under continuous reformation. During the mid-1990s, Ukraine was the first among the Former Soviet Union countries to liberalize the electricity sector. In 1995, a national government body in charge of regulatory and other activities in the electricity industry was established and named NERC – National Electricity Regulation Commission. Subsequently, in 1997, the Ukrainian wholesale energy market was established.

The energy sector in Ukraine is represented by the United Energy System of Ukraine that sustains the production, transmission, distribution, and supply of power to residential and industrial sectors. As previously indicated power production consists mainly of nuclear, hydro, and thermal power plants. Recently, several solar and wind energy projects have been developed. In 2011, total power generation was estimated to be 193,9 TWh.

Liberalization Period

During the liberalization, the power sector was restructured with the unbundling of generation and distribution in order to increase competitiveness. However, a large share of the sector is still state-owned and new initiatives for full liberalization are being discussed. According to a recent statement by IEA Executive Director Maria van der Hoeven, Ukraine's ongoing efforts to liberalize its electricity markets are in line with the Energy Community Treaty and will require increased investment to achieve energy efficiency (see reference: IAE Ukraine 2012 Energy Policy Review).

The wholesale power market in Ukraine is a single-buyer model with Energorynok being the only buyer. Energorynok purchases electricity at wholesale market prices and sells it to Oblenergos and independent suppliers at a mixed rate. Oblenergos are regional monopolies responsible for distribution and supply to residential and industrial consumers at NERC-regulated tariff rates.

Regulation Framework

According to Jamasb and Pollitt (2001), a number of countries are instituting incentive regulation in order to promote improvement in operations of utility power transmission and distribution companies. There are several benchmarking methods used. Following an analysis of benchmarking methods for distribution utilities, Irastorza (2003) lists several risks regulators should be aware of. Developing a reference for regulators for comparing one utility's costs and other characteristics to other utilities in order to improve utility's efficiency showed several problems. For example, for regional monopolies, costs and qualities are different for legitimate reasons, such as variations in customer base, population density, terrain, and consumption patterns.

Davies, Wright and Waddams Price (2005) stress the importance of privatization and regulation issues for developing countries. However, besides the fact that there are extensive research studies done on the topic of privatization reforms, there is no single measure of reform effectiveness. The main goal of privatization in developing countries is to increase investment thereby improving quality and reducing network losses. There are other issues to address, such as the control over monopoly power and large regulator's profits after privatization. Newbery and Pollitt (1997) highlight the conditions for effective regulation: setting adequate tariff levels and being independent from political pressures with clear objectives

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and procedures for dispute resolution and licensing issues. Hooper and Medvedev (2008) sum up the discussion stating that for transitional economies, energy efficiency improvements can be reached by a combination of higher prices and regulatory and policy reforms.

TSOs Regression Analysis Model

The Ukrainian electricity industry is a mixed system of public and private ownership. This paper's focus is on the difference between public and private distribution company operations. According to Irastorza (2003), in order to compare utility performance, different methods can be used. Most often studies are based on average methods, frontier methods (DEA, COLS, SFA) but also a method of ordinary least squares (OLS). Regulators use this regression analysis to estimate the differences in productivity among utilities companies. This method is used to distinguish between efficient and inefficient companies along a regression line of average efficiency. The risks associated with this method reflect the sensitivity of results to functional specification. Choices of variables or residuals may measure not only inefficiencies but also factors unexplained by a model.

In studies conducted by Jamasb and Pollitt (2001), distribution efficiency is analyzed with a variety of variables. The outputs of distribution utilities are measured by energy delivered through network lines to the consumer nodes, and losses are measured in transmission (Edvardsen and Førsund, 2003).

In this research the output variable, operating costs (OPEX in thousand UAH), are used as a dependent variable. Ukraine is known for high energy losses in the network. On average energy losses in the Ukrainian network are 2 - 2.4 times higher compared to the average rates in developed countries (see reference: The Ukrainian electricity system). These losses are included in the model.

The model also includes capital and labor costs for power line and transformer operation. Peak load is included in the model as are geographical factors that can influence utility performance.

In sum, the independent variables included in the model are:

AREA – Served area (square meters)
CONNECT – Number of connection points (units)
LOSSES – Energy losses in network (%)
MAXLOAD – Maximum load in a period (MWh)
LABCOST – Labor costs per person (UAH)

There are also two dummy variables included in the model. These variables represent the unique characteristics of each distribution company including its ownership type.

DUMMY HILL – dummy variable, which is equal to 0 if the area is flat, and equal to 1 if the area is with hills.

DUMMY PRIVATE – dummy variable, which is equal to 0 if the ownership is state, and equal to 1 if the ownership is private.

Data is taken from NERC on 25 national utility companies for the 2002 – 2006 time period. The research data consists of 125 data points. The descriptive statistics for the dataset are provided in Table 1.

	Average	Median	Standard Deviation	Minimum	Maximum
OPEX	105,817.4	84,027.0	76,172.9	21,169.0	503,225.0
AREA	23,640.2	24,600.0	6,637.2	8,100.0	33,625.0
CONNECT	769,419.8	627,842.0	380,332.4	324,442.0	2,014,882.2
LOSSES	19.1	17.9	8.2	0.1	35.2
MAXLOAD	936.5	562.0	895.2	253.0	4,301.0
LABCOST	980.4	949.4	191.8	611.9	1,993.0

Table 1: Summary Statistics. Number of Units - 125

The regression analysis results are presented in Table 2. As we see from the table, adjusted R squared is equal to 87%. It is a valid model because the dependent factor of operational expenditures is explained by 87% of the independent variables, such as area served, number of connection points, losses in the network, maximum load, and labor costs. The Durbin Watson statistics is not close to 2, which indicates there is autocorrelation between residuals. The dummy variable of ownership has an insignificant impact, but there are indications that operational expenditures tend to decrease in the case of private ownership.

Conclusion

Regulatory mechanisms should be designed to fit the ownership structure to which they are applied. Since liberalization and the change of ownership structure, different regulatory frameworks have been used in Ukraine for analyzing the operations of distribution companies. The quality of data and the choice of model framework are critical in the analysis of regulation and efficiency of distribution company operations under different types of ownerships.

Data used for the research in this paper is analyzed using the ordinary least square method (OLS). The results suggest that OLS can be used for benchmarking by the regulatory body to compare utility performance. Regulators can use this regression analysis in order to distinguish between efficient and inefficient companies operations. Results of this study suggest that privately owned distribution companies have a lower rate of operational expenditures. However, further analysis is needed to define the most effective regulatory framework for efficiency of distribution companies in Ukraine.

Method: Panel Least Squares
Cross-sections included: 25
Total panel (balanced) observations: 125

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-3.882	1.123482155	-3.455289956	0%
CONNECT	0.570	0.082789093	6.882431345	0%
MAXLOAD	0.266	0.054269075	4.903586632	0%
AREA	0.506	0.086493774	5.852085206	0%
LABCOST	0.412	0.112710069	3.653884006	0%
LOSSES	-0.831	0.283340352	-2.934045378	0%
DUMMY_HILL	0.243	0.05958182	4.070984159	0%
DUMMY_PRIVATE	-0.079	0.046183707	-1.714842038	9%

R-squared	0.881218872	Mean dependent var	11.58370616
Adjusted R-squared	0.874112309	S.D. dependent var	0.5778013
S.E. of regression	0.205007688	Akaike info criterion	-0.269678328
Sum squared resid	4.917293819	Schwarz criterion	-0.088666249
Log likelihood	24.85489553	F-statistic	124.0007087
Durbin-Watson stat	0.954305361	Prob(F-statistic)	4.64E-51

Table 2: Regression Analysis by Method of Least Squares

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June 16-20	36th IAEE International Conference *Energy Transition and Policy Challenges*	Daegu, Korea	KRAE/IAEE	Hoesung Lee hoesung@unitel.co.kr
July 28-31	32nd USAEE/IAEE North American Conference *Industry Meets Government: Impact on Energy Use & Development*	Anchorage, Alaska	USAEE/IAEE	USAEE Headquarters usaee@usaee.org
August 18-21	13th IAEE European Conference *Energy Economics of Phasing Out Carbon and Uranium*	Dusseldorf, Germany	GEE/IAEE	Georg Erdmann georg.erdmann@tu-berlin.de
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To whom it may concern

2nd International PhD-Day of the AAEE Student Chapter

14th edition of Young Energy Economists and Engineers Seminar

On the 21st & 22nd March 2013 the second edition of the international PhD-Day of the AAEE Student Chapter took place at the Vienna University of Technology. We managed to bring the 14th Young Energy Economists and Engineers Seminar (YEEES) to Vienna at the same time, a semi-annual European event with same aim and format. The event was a great success with 22 presentations and in total 31 participants from ten countries (AT, DE, IT, IR, ES, UK, US, NL, DK, IE) as well as 12 senior discussants. Due to the support of three Austrian energy utility companies (Energie AG, Kelag and Verbund) we were able to offer a nice surrounding programme for our guests including a conference dinner and a visit of one of Vienna's famous wine taverns. We had very interesting discussion topics such as energy efficiency, electricity markets, the integration of renewable energy sources and support schemes. Many transnational contacts were established which will probably lead to future co-operations. The combination of the two events led to a further link and fruitful exchange between the IAEE- and YEEES-community.

Done in Vienna, 17 May 2013

Raphael Bointner
AAEE Student Representative

Marcus Hummel
AAEE Student Representative

Calendar

8-9 July 2013, Contract Drafting and Risk Management Training for Oil & Gas at The Marcliffe Hotel and Spa. Contact: Kim, Vigilia, IQPC, North Deeside Road, Pitfodels, Aberdeen, AB15 9YA, United Kingdom. Phone: 020 7368 9510 Email: kim.vigilia@iqpc.co.uk URL: http://atnd.it/ZIMEIS

16-17 July 2013, The 7th Annual Mining the Pilbara Conference 2013 at Matt Dann Cultural Centre, Hamilton Rd, South Hedland, Western Australia, 6722, Australia. Contact: John, Wilson, Informa, Level 2, 120 Sussex Street, Sydney, NSW, 2000, Australia. Phone: +61 2 9080 4037 Email: info@informa.com.au URL: http://atnd.it/ZXul2U

28-31 July 2013, 32nd USAEE/IAEE North American Conference - "Industry Meets Government: Impact on Energy Use & Development" at Anchorage, Alaska. Contact: David Williams, Executive Director, USAEE, 28790 Chagrin Blvd., Suite 350, Cleveland, Ohio, 44122, USA. Phone: 216-464-2785. Fax: 216-464-2768 Email: usaee@usaee.org URL: www.usaee.org

July 29, 2013 - August 2, 2013, Cologne International Energy Summer (CIES) at Cologne, Germany. Contact: Felix Höffler, Prof. Dr., Institute of Energy Economics at the University of Cologne (EWI), Vogelsanger Str. 321, Cologne, NRW, 50827, Germany Email: energy-summer@ewi.uni-koeln.de URL: http://www.ewi.uni-koeln.de/en/research/workshops/

18-21 August 2013, 13th European IAEE Conference at Dusseldorf, Germany. Contact: George Erdmann, Conference Chairman, GEE, Einsteinufer 25 TA8, Berlin, D-10587, Germany URL: http://www.gee.de/iaee-european-conference-2013/

26-28 August 2013, Offshore Wind Power Substations at Swissotel, Hillmannplatz 20, Bremen, 28195, Germany. Contact: Isabell, Prior, IQPC De, Friedrichstrasse 94, 10117 Berlin, Bremen, Bremen, 10117, Germany. Phone: +49 (0) 30 20 91 30 Email: info@iqpc.de URL: http://atnd.it/12At2XU

26-28 August 2013, Advances in Wind Turbine Towers at Swissôtel, Hillmannplatz 20, Bremen, 28195, Germany. Contact: Isabell Prior, IQPC De, Friedrichstrasse 94, Berlin, 10117, Germany. Phone: +49 3020913274 Email: info@iqpc.com URL: http://atnd.it/10yaXd1

26-27 August 2013, Nuclear New Build 2013 at Prague Hotel, Pobrezni 311/1, Prague, 186 00, Czech Republic. Contact: Torben, Haagh, IQPC De, Friedrichstrasse 94, 10117 Berlin, Berlin, Berlin, 10117, Germany. Phone: 490 30 20 9130 Email: info@iqpc.de URL: http://atnd.it/12uJFUV

4-6 September 2013, BioEnergy Exhibition & Conference: A Boost For Entire Industry at Jyvaskyla, Finland. Contact: Dan Asplund, Conference Chairman, Benet Ltd, Piippukatu 11, Jyvaskyla, 40100, Finland. Phone: 358-40-718-2026 Email: bioenergy@benet.fi URL: www.benet.fi

10-12 September 2013, South East Asia Australia Offshore Conference - Seaaoc 2013 at Darwin Convention Centre, Stokes Hill Road, Darwin, NT, 0800, Australia. Contact: John, Wilson, Informa, Level 2, 120 Sussex Street, Sydney, NSW, 2000, Australia. Phone: 61 2 9080 4037 Email: info@informa.com.au URL: http://atnd.it/16mtrRO

16-27 September 2013, Executive Master of Finance & Control for the Energy Industry (first session) at Moskou. Contact: Thiska Portena, Account manager, Energy Delta Institute, Netherlands Email: portena@energydelta.nl URL: http://www.energydelta.org/mainmenu/executive-education/executive-master-programmes/executive-master-of-finance-control-for-the-

16-18 September 2013, 3rd Annual Global Refining Technology Forum at Doha, Qatar. Contact: +971 4609 1570, Mr., Fleming Gulf, Qatar. Phone: +91 962344 0356 Email: ajay.nimbalkar@fleminggulf.com URL: http://www.fleminggulf.com/conferenceview/3rd-Annual-Global-Refining-Technology-Forum/388

17-18 September 2013, Operational Readiness in Mining at Duxton Hotel, No.1 St Georges Terrace, Perth, Western Australia, 6000, Australia. Contact: Maria Marambio, IQPC, Level 6, 25 Bligh Street, Sydney, NSW, 2000, Australia

September 23, 2013 - September 23, 2015, The Oil and Gas MBA at Maple House, 149 Tottenham Court Road, London, W1T 7NF, United Kingdom. Contact: Sharise Wilkinson, Informa, Gubelstrasse 11, Zug, CH-6300, Switzerland. Phone: 020 7017 5000 Email: headoffice@informa.com URL: http://atnd.it/ZPDpqX

September 30, 2013 - October 2, 2013, Master Class LNG Industry at Barcelona. Contact: Thiska Portena, Account manager, Energy Delta Institute, Netherlands Email: portena@energydelta.nl URL: http://www.energydelta.org/mainmenu/executive-education/specific-programmes/master-class-lng-industry-lng-training-course

8-10 October 2013, 2013 Arctic Energy Summit: Richness, Resilience, and Responsibility - The Arctic as a Lasting Frontier at Akureyri, Iceland. Contact: Conference Secretariat URL: www.institutenorth.org/arcticenergysummit

8-10 October 2013, Energiemarkten at To be determined. Contact: Janet Smid, Course Manager, Energy Delta Institute, Netherlands Email: smid@energydelta.nl URL: http://www.energydelta.org/mainmenu/executive-education/introduction-programmes/energiemarkten-2

13-17 October 2013, 22nd World Energy Congress Daegu 2013 at Daegu, Korea. Contact: Conference Coordinator, Conference Connection Pte Ltd, 135 Middle Road, 05-01 Bylands Building, Singapore, 188975, Singapore Email: Info@cconnection.org URL: http://www.wec2013-cc.com/

14-15 October 2013, Master Class Gas Pricing Strategies at Dusseldorf. Contact: Thiska Portena, Energy Delta Institute, Netherlands Email: portena@energydelta.nl URL: http://www.energydelta.org/mainmenu/executive-education/specific-programmes/master-class-gas-pricing-strategies

1-25 October 2013, International Gas Value Chain Course at Amsterdam. Contact: Janet Smid, Account manager, Energy Delta Institute, Netherlands Email: smid@energydelta.nl URL: http://www.energydelta.org/mainmenu/executive-education/introduction-programmes/international-gas-value-chain

29-30 October 2013, Gas Transport and Shipping Course at Groningen. Contact: Thiska Portena, Account manager, Energy Delta Institute, Netherlands Email: portena@energydelta.nl URL: http://www.energydelta.org/mainmenu/executive-education/specific-programmes/gas-transport-shipping-course

30-31 October 2013, Australian Gas Turbines Conference at Hilton Hotel, 190 Elizabeth St, Brisbane, 4000, Australia. Contact: John, Wilson, Informa, Level 2, 120 Sussex Street, Sydney, NSW, 2000, Australia. Phone: +61 2 9080 4037 Email: info@informa.com.au URL: http://atnd.it/ZXrjvk

30-31 October 2013, Australian Gas Turbines Conference at Pullman Melbourne Albert Park, 65 Queens Road, Melbourne, Victoria, 3004, Australia. Contact: John, Wilson, Informa, Level 2, 120 Sussex Street, Sydney, NSW, 2000, Australia. Phone: +61 2 9080 4037 Email: info@informa.com.au URL: http://atnd.it/ZXrjv

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