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INTERNATIONAL ASSOCIATION *for* ENERGY ECONOMICS

IAEE Energy Forum

Fourth Quarter 2012 International Association for Energy Economics

President's Message

As my year as IAEE President is coming to an end this is my fourth and final "Message from the President". Not surprisingly this has been an exciting year. The conferences in Kyoto, Perth and Venice were great experiences, showing that IAEE is a thriving association and that energy economics is a field that indeed attracts talented young researchers and professionals in the energy industry. And at the moment of writing, the USAEE conference in Austin is yet to come. Another measure of the number of activities within IAEE is that I actually missed two conferences, the successful conferences in Moscow and Nabuja. The fact that these events were held means that it has been an IAEE conference in all five continents in 2012! No doubt IAEE has established itself as a truly global association.

Before turning to another subject I need to say a few words about the conference in Venice, held in the premises of the Ca' Foscari University in central Venice. The President of the university, my old friend Professor Carlo Carraro, opened the conference and could welcome a record high number of delegates, pushing the Stockholm conference down to the second place in this particular league. The organizing committee, lead by former IAEE President Carlo Andrea Bollini, had made an excellent job, which among many other things meant that the plenary and concurrent sessions competed successfully with all the attractions of the beautiful Venice. Congratulations to the Italian Affiliate, with its grand old man Edgardo Curcio, for organizing the 2012 European conference.

Between the sessions in Venice I had the opportunity to discuss with several delegates, among other things various matters related to the Association. One of these issues concerned the education in energy economics in universities and business schools. There was a common view that in spite of significant student interest, few courses in energy economics were offered that applied both to electives at the undergraduate and graduate levels and to specialized programs at the graduate and PhD levels.

Obviously a number of short conversations with conference delegates are not sufficient to conclude that the possibilities to study energy economics to a large extent are lacking. Thus I would be interested to learn about universities and business schools in various parts of the world where the situation is different. Please send an e-mail to the IAEE Headquarters at iaee@iaee.org and let us know about universities or business schools where courses or programs in energy economics are offered. Let us also know about the content of these courses or programs.

IAEE's mission is to foster research and qualified policy analysis of energy related problems and issues. Thus widespread access to high-quality education in energy economics is key concern for IAEE and the basis for its long term development. If the situation really is as bad as my conversations in Venice suggest it might be a good idea for IAEE to start offering a new service: Support to faculty members at universities and business schools who want to design and teach courses in energy economics. I will bring this idea to Council for discussion before it is time for David Newbery to take over the IAEE Presidency.

Lars Bergman

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Editor: David L. Williams

Careers, Energy Education and Scholarships Online Databases

IAEE is pleased to highlight our online careers database, with special focus on graduate positions. Please visit http://www.iaee.org/en/students/student_careers.asp for a listing of employment opportunities.

Employers are invited to use this database, at no cost, to advertise their graduate, senior graduate or seasoned professional positions to the IAEE membership and visitors to the IAEE website seeking employment assistance.

The IAEE is also pleased to highlight the Energy Economics Education database available at http://www.iaee.org/en/students/eee.aspx Members from academia are kindly invited to list, at no cost, graduate, postgraduate and research programs as well as their university and research centers in this online database. For students and interested individuals looking to enhance their knowledge within the field of energy and economics, this is a valuable database to reference.

Further, IAEE has also launched a Scholarship Database, open at no cost to different grants and scholarship providers in Energy Economics and related fields. This is available at http://www.iaee.org/en/students/ListScholarships.aspx

We look forward to your participation in these new initiatives.

Get Your IAEE Logo Merchandise!

Want to show you are a member of IAEE? IAEE has several merchandise items that carry our logo. You'll find polo shirts and button down no-iron shirts for both men and women featuring the IAEE logo. The logo is also available on a baseball style cap, bumper sticker, ties, computer mouse pad, window cling and key chain. Visit http://www.iaee.org/en/inside/merch.aspx and view our new online store!

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 of the *Forum* focuses on unconventional oil and we have five articles on various aspects of this, with quite a geographical spread. However, before that we're fortunate to have Christof Rühl and Joseph Giljum provide us with a summary of BP's latest *Statistical Review*. Though 2011 was a year of energy disruptions, they point out that the year showed the enormous flexibility of markets and that the inter-dependence of the world's energy system is its real strength.

Mamdouh Salameh says that the potential of unconventional oil resources is highly overrated. Apart from the limited size of production, unconventional oil is costlier to produce, more pollutant, a more voracious user of energy and is of poorer quality than conventional oil. Moreover, it's contribution to global oil supplies in the next 25 years will only make a dent in the future demand for energy.

Benjamin Cook and Charles Mason write that enhanced oil recovery is an important nonconventional oil production technique that consists of injecting CO_2 into mature oil formations. Explaining how this is done, they note that the technique can significantly increase oil production and may offer opportunities for carbon sequestration.

Jean Balouga writes that the settling of oil prices above $100/barrel has spurred an unconventional resource revolution, leading to a change in the energy landscape. This necessitates the application of new rules to new fuels. He looks at each of several types of unconventional oil.

Nadia Ouedraogo reports that Africa is a new frontier for unconventional oil exploration. Resources of bitumen or extra-heavy oil are reportedly present in many countries in Sub-Saharan Africa including the Republic of Congo, Madagascar, Nigeria, Angola, and elsewhere. However, she cautions that these African countries are vulnerable to careless exploitation of these resources.

Yuliya Pidlisna writes that the emergence of new oil reserves, due to the advance of technology, is important for energy security. The article focuses on Canadian unconventional oil resources, opportunities and challenges.

DLW

CONFERENCE OVERVIEW

The sustainability of global long term energy demand, supply, and energy diversity is in question in light of growing demand for energy in China, India, Brazil, and other emerging economies, increasing awareness of environmental issues, and the need to find new ways to address related concerns. Further uncertainties are raised by changing world events such as the global debt crisis, the Arab Spring, and the impact of Japan's tsunami and earthquake disasters on the development of nuclear energy. These and other issues challenge the transition toward a sustainable energy era where the current energy needs are met without compromising the energy needs of future generations, and they also create opportunities.

If there is a need to guide this transition, what type of roadmap should be developed to show a desired path to energy sustainability? To what extent will the roadmap be determined by drivers such as public and private investment, government and environmental policy, technological innovation, and research and development funding? Furthermore, what roles will be played in this transition by conventional and non-conventional fossil fuels; renewable energy resources such as wind, solar, geothermal, and biomass; distributed resources and storage; energy efficiency; electric vehicles; and the smart grid?

This conference is intended not only to address these questions but also to address possible challenges and opportunities for the transition to such a sustainable energy era. With its record of energy innovation and accessibility, Austin, Texas is an ideal setting for bringing together key players in the global energy and transportation industries, government, and academia to address questions and concerns raised in several plenary and concurrent sessions. Those interested in organizing sessions should propose a topic and possible speakers to Robert Borgstrom, Concurrent Session Chair (robertborgstrom2@gmail.com). The conference will also provide networking opportunities through workshops, public outreach and student recruitment.

HOSTED BY

Central Texas Association for Energy Economics

TOPICS TO BE ADDRESSED INCLUDE:

Conventional and Unconventional Gas and Oil Supplies

- Changing World Oil Supply/ Demand Balance
- Protection of Offshore Resources Versus Oil Supplies
- Exploration and Drilling Cost Concerns
- Future Utilization of Fossil Resources in Other High Value Added Products

Markets and Drivers of Renewable Energy

- Government's Promotional Role
- Integration of Solar and Wind Generation In Power Dispatch
- Mass Production for End-Use Distributed Renewable Resources
- Capital Markets – Financing Renewable Resources

Energy Efficiency – Defining and Meeting Realistic Goals

- Building Controls and Cost Allocation
- Energy Efficiency Rules for Government Sponsored Home Loans
- Tightening Standards
- The Minimal Energy Society – Danish Model
- New and Improved Automobile Efficiency Standards

Economic Analysis Methods and Assumptions

- Energy Data Sources
- EIA Reliability Amid Shale Gas Data Difficulties
- Private Surveys
- Smart Meter Consumption Data and Analysis

Role of Government in Transitioning to a Sustainable Energy Era

- Issues in Energy Regulation and Uncertainties
- Renewable Portfolio Standards (RPS)
- Goals and Standards Toward Energy Sustainability
- Incentive Mechanism to Enhance Energy Sustainability
- Financial Regulations and their Impacts on Energy Trading
- Market and Exchange Trading Efficiencies

Changing Geography of Energy Demand

- China
- India
- New Industrial Asia and South America
- North America and Europe
- Developing Countries

Climate Change Concerns

- Pros and Cons of Delaying a Decision
- Policies Compatible with Economic Slowdown
- Intergenerational Considerations
- Can Developing World Benefit from Additional Environmental Regulation?

Natural Gas – Bridge Fuel to More Natural Gas?

- Shale Gas Revolution and Water Issues
- LNG Trade
- Global Gas Contracts vs. Spot Market Trading
- Role of Gas in Meeting Renewable Portfolio Standard or CO_2 Emission Standards

Global Petroleum Security and Pricing

- OPEC Policies in a Changing World
- Oil Supply Crisis Due to Political Instabilities in Producing Countries
- Strategic Oil Storage Policies

Electricity

- EPA's New Standards and Coal Power Plant Trade-Offs
- Natural Gas and Wind Generation – Competition or Integration?
- Adequacy of Transmission Capacity to Accommodate Massive Renewable Resource Expansion
- Market Design and Efficiency
- Electricity Pricing, Fuel Pricing and Policy
- Wind and Solar Market Penetration Issues
- Role of Demand Response in Addressing Resource Adequacy and Reliability Issues

Energy Capital Investment & Allocation

- Wind
- Solar
- Nuclear
- End-Use Distributed Resources and Storage
- Infrastructure

Energy Infrastructure

- Capital Investment Requirements
- Costs of Capital
- Pipeline and Transmission Line Financing, Regulatory and Right-of-Way Issues

Energy Technology and Innovation

- Supply Expansion
- New Energy Technologies (Distributed Generation and Storage)
- Cost Reduction
- Demand and Efficiency
- Role of Smart Meters in Enhancing Smart Pricing and Value Added Services

Issues in Moving Beyond Petroleum in Transportation

- Short-Range vs. Long-Range Electric Cars
- Electric Vehicles in Mass Transportation
- Is Natural Gas Fuel of Choice to Replace Gasoline?
- Ethanol and Biodiesel

Energy and Wealth Distribution

- Can Energy Sustainability Be Consistent with Economic Growth?
- Can Developing World Benefit from Additional Environmental Regulation?
- Can New Energy Technologies Reduce the Gap between Industrialized and Developing Countries?

Energy and Water Issues

- Impact of Drought on Energy Generation
- Water Usage of Different Electric Generation Technologies
- Hydro Generation

Energy and Food

- Energy Consumption by Food Industry
- Food Waste Reduction and Energy Savings

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31ST USAEE/IAEE NORTH AMERICAN CONFERENCE

PLENARY SESSIONS & SPEAKERS

The 31th USAEE/IAEE North American Conference will attract noteworthy energy professionals that will address a wide variety of energy topics. Plenary sessions will include the following:

- Putting the "Sustainable" in Sustainable Energy Future
- Future Outlook for Oil & Gas Production
- Electricity Market Design
- Implications of North American Natural Gas Development
- The Future of Electric Markets: New Directions in Sustainable Energy Development
- North American Oil & Gas Infrastructure
- Unleashing the Potential of the Smart Grid
- Where Do We Go From Here? 2013 and Beyond

SPEAKERS INCLUDE:

Ross Baldick
Professor, University of Texas at Austin

Lars Bergman
President and Professor, Stockholm School of Economics

William Bumpers
Partner, Baker & Botts LLP

Ariel Cohen
Senior Research Fellow for Russian and Eurasian Studies and International Policy, Davis Institute for International Studies

H.B. "Tripp" Doggett
President & Chief Executive Officer, ERCOT

Roger Duncan
General Manager (Retired), Austin Energy

Cris Eugster
Executive VP and Chief Sustainability Officer, CPS Energy

Mark Finley
GM Global Energy Markets, BP

R. Dean Foreman
Chief Economist, Talisman Energy

Peter R. Hartley
Professor & Baker Institute Fellow, Rice University

Evan Hillebrand
Associate Professor of Geoeconomic Studies, Patterson School

William W. Hogan
Professor Kennedy School of Govt, Harvard University

John W. Jimison
Managing Director, Energy Future Coalition

Marianne S. Kah
Chief Economist, ConocoPhillips

Rebecca A. Klein
Principal, Klein Energy LLC

James D. Marston
VP of Energy Program, Director of Texas Regional Office, Environmental Defense Fund

Brewster McCracken
Executive Director, Pecan Street Inc.

Ariana McKnire
Natural Gas & NGL Advisor, Enbridge

Richard Morgan
Green Building Manager, Austin Energy

Todd Onderdonk
Senior Energy Advisor, Corporate Strategic Planning, ExxonMobil Corporation

Raymond Orbach
Director, Energy Institute, University of Texas at Austin

Hi-chun Park
Professor, Inha University

Karl R. Rabago
Vice President, Distributed Energy Services, Austin Energy

Benjamin Schlesinger
President, Benjamin Schlesinger & Assoc LLC

Fereidoon "Perry" Sioshansi
President, Menlo Energy Economics

Robert D. Stibolt
Managing Director, Galway Group LP

Samir Succar
Staff Scientist, Natural Resources Defense Council\

Douglas J. Suttles
Former COO, BP

Scott Tinker
Director, Bureau of Economic Geology, Jackson School of Geosciences, University of Texas at Austin

Nat Treadway
Managing Partner, Distributed Energy Financial Group LLC

Jaime Williams
President, CONCAMIN

Pat Wood III
Principal, Wood3 Resources

STUDENTS

Students may submit a paper for consideration in the USAEE 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 Best Student Paper Awards is July 6, 2012. Visit www.usaee.org/usaee2012/paperawards.html for full details.

TRAVEL DOCUMENTS

All international delegates to the 30th USAEE/IAEE North American Conference are urged to contact their respective consulate, embassy or travel agent regarding the necessity of obtaining a visa for entry into the U.S. If you need a letter of invitation to attend the conference, contact USAEE with an email request to usaee@usaee.org. The Conference strongly suggests that you allow plenty of time for processing these documents.

Since the Austin meeting falls on election day, U.S. members are urged to either vote early or by absentee ballot, depending on the election rules of their state.

VISIT OUR CONFERENCE WEBSITE AT: WWW.USAEE.ORG/USAEE2012/

Is IAEE In Tune with the Times?

Remarks by Einar Hope at the 12th IAEE European Conference, Venice, 10-12 September 2012.

Mr. Chairman, Ladies and Gentlemen,

I have decided to take advantage of, or maybe rather to misuse, my privilege as the outgoing, past president of the IAEE not to speak on a specific energy economic topic on this occasion, but rather to share with you some reflections, from a certain perspective soon to be explained, on some major developments in the 35-year history of the Association. I hope that my reflections over the past will complement well with the interesting closing remarks made by my co-panelist, Reinhard Haas, about the Venice IAEE European Conference and the issues and challenges that the Association presently is facing, as he sees them.

The IAEE came off to a modest start in 1977 in the USA, when a handful of delegates came together to establish a professional association and discuss energy matters. This association has from then on developed to become a thriving, international association with more than 4000 members around the world, organizing an annual international conference and four regional conferences, publishing three journals and offering a number of other products and services to its members. We are now at the closing of the largest European IAEE-Conference ever to be held, with more than 500 participants and some 300 papers presented and discussed. I think that is quite impressive and a remarkable achievement and development of the IAEE over its 35-year lifespan.

In a different setting and a different organization I was associated with, the presidents were expected to phrase a motto or a slogan to indicate the focus or intention of the program for their presidential year. For my year I decided to choose a motto that would translate into English as something like: For the organization to be in tune with the times, which I thought was appropriate for the particular organization at that particular phase of its development.

If I had been required or expected to come up with a motto for my year as the IAEE president two years ago, I think I would have chosen the same phrase, i.e., for the IAEE to be in tune with the times. With this I would mean that the IAEE should be a modern, up-to-date, professional association, picking up and reflecting on the major issues and developments on the international energy scene, from an economic perspective. Maybe it should also be trying to be ahead of the times, in the sense of looking into the crystal ball once in a while and thus becoming aware of issues and developments looming on the horizon. On that basis it should furnish its members and the world at large with relevant information, analyses, knowledge and insights, presented openly at conference, seminars and in publications, so as to prepare them to be able adequately to handle issues and developments by taking advantage of this information and knowledge as part of their decision-making process and general understanding of the energy world.

I think that all this boils down to one word or requirement, i.e., for the IAEE to be considered relevant to its members and the world at large under changing circumstances and surroundings. But then, of course, the term relevance can be conceived differently by the five broad membership groups of the association, i.e., members from industry, government, consulting, the academic and research community, and the students. The challenge is to be considered relevant to each individual group and also to the groups taken together. I think that, in particular, we should put our ears to the ground and listen to what our students and young professionals consider to be an association in tune with the times.

With all this I would now like to ask the question whether or not the IAEE as an association has been in tune with the times over its 35-year history, and is considered to be in tune with the times as of now. For that purpose I will distinguish between three broadly demarcated periods or epochs in the IAEE history.

The first period begins from the very start of the association in 1977 and may be termed the Petroleum Period. The establishment of the association was to a large extent initiated by the oil crisis in 1973. The crises and its aftermath dominated the activities and focus of the association to the extent that it might, alternatively, have been named the International Association for Petroleum Economics then. This is reflected in the conferences held at that time as well as in its publication, The Energy Journal. The IAEE was also to a large extent a U.S. association with a U.S. perspective on the developments on the international petroleum scene, but gradually, of course, other players engaged themselves on the scene with analyses and debate.

The second epoch starts in the early 1990s and may be termed the Liberalization of Electricity and Gas Markets Period. This was to a large extent a European development, initiated by countries like the UK and Norway. It was quickly reflected in the program of the European IAEE-conferences and gradually became a dominant feature of those conferences. Market design, design of regulatory models and mechanisms for the infrastructural parts of the electricity and gas systems, privatization, market integration, and a number of other concepts and issues characterized this period to an extent that perhaps they dwarfed some other important issues and problems on the international energy scene then. This has been, by the way, my special area of research interest, and also of policy advocacy, for a period even longer than the IAEE lifespan.

Then comes the third epoch in which we still are very much into. This can be characterized with one word, i.e., sustainability, and may thus be termed the Sustainability Period. Several of our last, and also upcoming conferences, have sustainability in their main theme, in various combinations with energy, the environment, climate change and similar concepts; take, for example, the Energy Challenge and Environmental Sustainability theme of this conference.

Here I would like to point to one recent development or initiative taken by the IAEE as a concrete example, I think, that the Association is reasonably well in tune with the times. This is the launching of its new journal, Economics of Energy & Environmental Policy, or EEEP for short. The ambition of this journal is exactly to fill in the interface between energy and environmental economic issues with research based analyses and insights - with an explicit policy orientation and published in a form to make them accessible to a diversified readership. EEEP will complement our long-standing journal of high international ranking and reputation, The Energy Journal, and together with our newsletter, the Energy Forum, I think that we now have established a well-balanced portfolio of publications to make the IAEE interesting and relevant to our members and the world at large.

There are, of course, considerable overlaps of issues and developments between the three periods and new developments may spur a revival of interest in "old" issues. Take, for example, the unconventional oil and gas revolution and its many impacts on the oil and gas sectors, reviving and redefining the Petroleum Period.

What will the next epoch look like compared to the three ones outlined briefly above? I have not looked into the crystal ball, but personally I think that we should look more closely into the whole set of issues around energy and economic development. We are touching upon them at our conferences and there are some sessions at this conference, but I think that more attention should be devoted to them, both in their own right and also if we aim at being a truly international or global association.

But then maybe we have reached a point where we are faced with such a myriad of complex energy and environmental issues that it is not possible, or even right, to try to single our areas or epochs of concentration of our activities, but rather to face them and attack them with a diversity of approaches in order to try to understand and disentangle them. Hopefully, we will thus be coming up with knowledge and insights that are considered relevant and useful by our members and the world at large in various contexts. I think that the plenary sessions and the 300 or so papers being presented at this conference are a good illustration of this myriad of issues and diversity of analytical approaches.

So do we have an association that has been reasonably well in tune with the times in the past and as of now? Personally, I would definitely give a positive answer to the question. There are, of course, improvements to be made and challenges ahead. For example, I think that we have to engage ourselves more in multidisciplinary research to better understand the complex energy and environmental issues of the day and thus be considered more relevant. Here the IAEE as an association could be taking initiatives to facilitating dialog between disciplines and professions, and bringing together professionals from various disciplines in seminars and conferences with an explicit multidisciplinary orientation and purpose to stimulate such research and cooperation across disciplines.

However, multidisciplinary research is more easily said than done. A fundamental requirement is a willingness for us as economists to contribute to such research and understanding without compromising with our scientific, professional and ethical standards in the process.

There are also improvements to be made with regard to policy analysis, in the sense of policy analysis to be faced squarely in its own right and not only as an afterthought of an otherwise interesting theoretical or empirical research based exercise. I think that we also should engage ourselves more in research based policy advice and advocacy as individuals to be considered relevant, but objective though, while the IAEE as a professional association as such should, of course, stay completely independent in relation to interest groups and stakeholders in such a process.

So my conclusion is that, by and large, I am quite much happy and pleased with the performance of the association and its achievements so far, as an association in tune with the times.

This is not meant as a farewell address, because I will be following keenly, and with great interest, the activities and progress of the IAEE in the time to come. But since I no longer will have a formal position within the association, I would like to thank all the people whom I have had the pleasure of working together with over the years for a very pleasant and stimulating cooperation. In particular, I would like to thank the IAEE Head Quarters and our never-resting Executive Director, David Williams, for his devotion and excellent services to the Association. Lastly, I would like to extend a special word of thanks to the organizers of the Venice 2012 IAEE European Conference for a most successful conference in magnificent surroundings.

Broaden Your Professional Horizons

Join the

International Association for Energy Economics

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

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

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

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

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

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

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

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

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

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_____**Yes**, I wish to become a member of the International Association for Energy Economics. My check for $80.00 (U.S. members $100 - includes USAEE membership) is enclosed to cover regular individual membership for twelve months from the end of the month in which my payment is received. I understand that I will receive all of the above publications and announcements to all IAEE sponsored meetings.

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Join online at http://www.iaee.org/en/membership/

4/12Forum

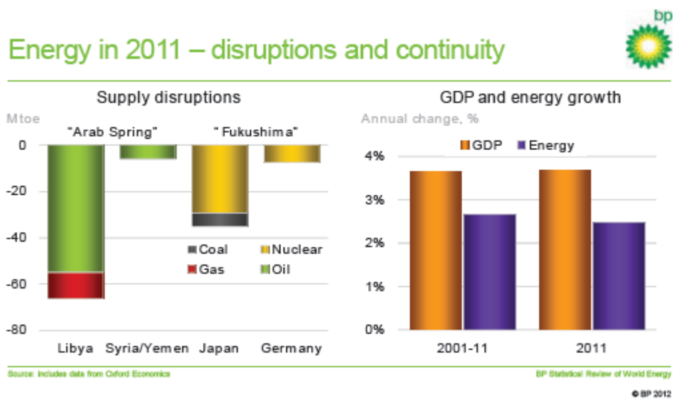
Energy in 2011 – Disruption and Continuity

By Christof Rühl and Joseph Giljum*

A Year of Disruptions

2011 was a year of political upheaval and natural disasters that translated into huge and unpredictable disruptions to the global energy system. While individual fuel markets each have a unique tale to tell, the main theme of this review is about fuel substitution and changes in trade patterns in response to the disruptions of 2011, how global energy markets coped, and what lessons can be drawn from the adjustment. The following is a summary of the findings of the 2012 Statistical Review of World Energy, a rigorous and objective review of last year's energy data. This paper addresses the major theme of last year – disruption and continuity – and how the global energy system coped by examining individual fuel markets.

Political unrest and violence caused outages in oil and gas production in parts of the Arab world. The cessation of Libyan oil exports alone removed 1.2 Mb/d of crude for the year. Adding in outages of natural gas and losses in other countries shows a total decline in excess of 72 mtoe compared to 2010 production – equivalent to more than 11% of the European Union's oil consumption.



The shut-down of nuclear reactors at Fukushima and earthquake-related damage to Japanese coal-fired power stations, plus the subsequent closure of additional reactors in Japan and Europe led to losses of 43 mtoe for the year – equivalent to almost a third of Asia's, or 7% of global nuclear power consumption in 2010.

And yet - nothing in the aggregate data indicates anything out of the ordinary. In fact, both GDP and energy consumption growth last year landed right at their long term average with GDP at 3.7% growing slightly faster than primary energy consumption at 2.5%. Furthermore, other major long term trends, such as the shift of the world's center of gravity toward the non-OECD economies, continued unabated as well. So how did the energy system cope?

Price changes give a first indication that major adjustments took place underneath the smooth aggregate surface. 2011 saw big price increases: average annual Brent prices increased by 40% to reach $111 per barrel, the highest annual nominal oil price ever; for a higher price in inflation adjusted terms one has to go all the way back to 1864. A simple average of international coal prices increased by 24%, with the biggest increase in Europe. While U.S. gas prices continued their decline following the shale gas revolution, oil indexed gas prices outside the U.S. increased, pulled up by the rising price of crude while spot prices followed suit.

With disruptions one plausible cause for rising energy prices, the other usual suspect is economic growth.

Energy and the Economy

To be upfront, there is not much in the economic data to indicate abnormal pressure on energy demand or prices. As has become customary, non-OECD economies outpaced the OECD, contributing almost three quarters of global growth. Adding in primary energy growth confirms that for once, given the upheavals of the last few years, there was no extraordinary impact from the economy on energy demand. An interesting deviation from trend emerges only if one distinguishes OECD from non-OECD energy growth.

Non-OECD energy consumption growth of 5.3% stayed firmly on trend last year, with China growing at 8.8% – that is, adding more than total annual UK energy consumption – similar to last year. OECD energy consumption, in contrast, fell by 0.8%, despite average GDP growth. While OECD GDP finally returned to pre-crisis levels, energy consumption remains 3.3% below its 2007 peak; it has declined in three out of the last four years. Why last year?

There are broadly three reasons: first, the impact of high oil prices everywhere, and of high coal and gas prices outside the U.S. Energy prices in the OECD are least sheltered by subsidies, and so the price impact is most direct. The second reason for the decline was the impact of Fukushima: energy consumption in Japan, the world's third largest economy, declined by 5%; and switching off

* Christof Rühl is Chief Economist and Vice President at BP plc. Joseph Giljum is an Economist with the firm. The Statistical Review data and a more detailed analysis can be found at www.bp.com/statisticalreview

nuclear power had knock-on effects on another large economy, Germany. Finally, Europe experienced an exceptional swing to warmer weather compared to 2010, the key reason behind a 3.1% decline in EU energy consumption.

The energy dislocations in the OECD give another indication of how markets coped with the disruptions that characterized 2011. Fuel substitution, supply and demand responses and trading patterns all played their role. In a nutshell, three major adjustments took place: an increase in oil supplies, most notably from Saudi Arabia, together with flexibility in trading and in the global refining system, allowed heavier Saudi crudes to replace lighter Libyan oil in Europe; a diversion of natural gas from Europe to Asia allowed the substitution of lost nuclear energy in Japan without harming the energy needs of other economies in this fast growing region; and finally, the release of coal from the Americas, facilitated by the availability of unconventional gas in the U.S., helped to replace gas in Europe.

To trace these developments in more detail, it's best to look at them fuel by fuel.

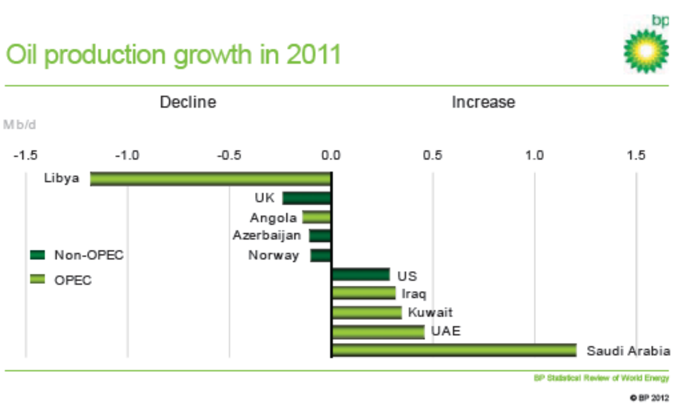
Fuel by Fuel

Crude Oil

Like energy markets at large, oil markets experienced significant turbulence in 2011. Oil prices rose substantially in 2011. Prices began the year slightly above $90 and rose sharply following the loss of Libyan supplies in February. They peaked just below $127 in mid-April and moderated thereafter as the economy weakened, OECD nations released 35 Mbbls of oil from strategic storage in July and August, and other OPEC producers began to increase output.

The main factor driving prices up last year was the sustained loss of supplies caused by upheavals in the Arab world, primarily in Libya, and the slow pace of other OPEC members in filling the void. Libyan output last year fell by 1.2 Mb/d or 71% – the largest decline in a country's oil production since the aftermath of the Soviet collapse 20 years ago.

However, these losses are not visible in the annual data: global oil production increased last year by 1.1 Mb/d. Moreover, virtually all of that increase was from OPEC countries – a group that includes Libya. The reason is a massive increase in oil production among OPEC members in the Arabian Peninsula and Iraq, who collectively increased output by 2.5 Mb/d, in the event meeting not only the loss of Libyan supply but also the growth in global oil demand. Saudi Arabia alone increased output by 1.2 Mb/d, with production reaching a record 11.2 Mb/d. Outside OPEC, production was essentially flat, with growth in the U.S., Canada, Russia and Colombia offsetting continued declines in mature provinces such as the North Sea, extended outages in a number of countries such as Azerbaijan, and flat biofuels output due to weather related disruptions in Brazil.



Consumption growth, meanwhile, was weak. Global oil demand rose by just 0.7% or 600 Kb/d in 2011, a little over half the ten year average – despite global GDP staying at trend. Non-OECD consumption grew by 1.2 Mb/d or 2.8%. China once again saw the world's largest increase, at 500 Kb/d, accounting for 42% of the net increment, with significant gains also seen in Russia (160 Kb/d), India (140 Kb/d) and Saudi Arabia (110 Kb/d). Consumption declined in North Africa and growth was below average in the Middle-East – yet another glimpse of the political upheaval in these regions, but also reflecting subsidy cuts in Iran. OECD demand continued its long term decline and fell by 600 Kb/d, reaching its lowest level since 1995, with the U.S. (350 Kb/d) and Germany (80 Kb/d) accounting for the largest contractions.

The consumption data confirm another important development. Demand responses to high prices are still disproportionally concentrated in OECD economies, where subsidies of oil products are absent. However, emerging economies are becoming more price sensitive because subsidization in this segment has decreased. Only about 20% of the world's oil consumption was in countries with subsidies last year, down from nearly 40% in 2008, the last year of record high oil prices. Because subsidies are expensive and because of the realization that energy efficiency matters in international competition, the cycle of rising oil prices resulting in rising subsidies appears to have been broken: we estimate that non-OECD countries passed roughly 70% of last year's oil price increase on to consumers, up from about 25% in 2008.

These global developments in production and consumption explain nicely the trajectory of prices in 2011. As 2011 began, oil consumption was outpacing production and that gap widened significantly after the loss of Libyan supplies in February. Even with the large increase in output from Saudi Arabia and other Gulf states described earlier, overall OPEC output did not surpass pre-disruption levels – and global production did not exceed consumption – until late in 2011. This timing left inventories well below average despite the SPR release and in this way supported crude prices throughout the second half of 2011.

Refining

The global refining environment continues to be characterized by excess capacity and slow throughput growth. Net global refining capacity grew by 1.4 Mb/d in 2011, led by growth of 730 Kb/d in Asia Pacific, mainly in China. In contrast, global crude runs grew by just 380 Kb/d, slightly below liquids consumption growth because of new NGL supplies. Therefore, global unused capacity increased by 1 Mb/d and is now more than 5 Mb/d higher than it was in 2005 while refinery utilisation fell to 81.2%, the second lowest since 1994. There is too much refining capacity – but not everyone is suffering to the same extent. Flexible sites with world class operations can be successful and in 2011, some had the opportunity to prove it.

The disruption of Libyan supplies meant that Europe lost around 800 Kb/d of good quality crude oil. Other African exporters made good about half of these losses by re-optimizing trade. The Former Soviet Union is Europe's largest crude oil supplier by far but its oil production grew only marginally last year. That created an opportunity for Middle East exporters to regain market share and, led by Saudi Arabia, they increased medium and heavy sour crude exports to Europe by more than 250 Kb/d. With flexible sites and excess capacity in Europe, the lost Libyan barrels were, therefore, easily replaced.

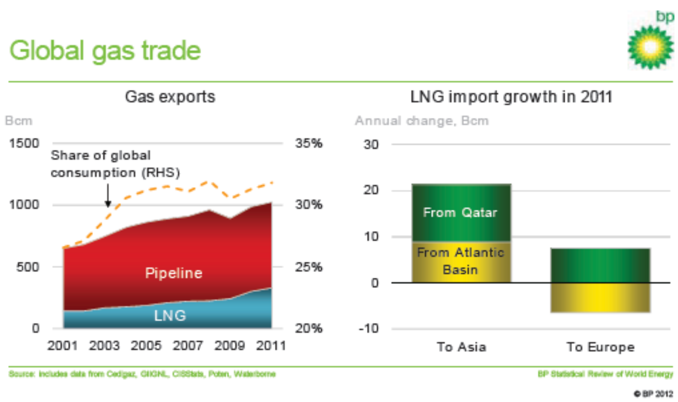
Natural Gas

Natural gas has produced some of the biggest changes in energy markets over the last few years: there is the rapid increase in trade, especially of LNG, that connects hitherto segmented regions in an increasingly flexible manner and the development of unconventional resources in the U.S. Both of these developments shaped 2011; and as it happens played a key role in the response to last year's disruptions.

Overall, natural gas production and consumption growth moderated, compared to last year's exceptional increases. Global production was up 3.1% (98 Bcm) with growth originating from the Middle East (11.4%, 54 Bcm), North America (5.5%, 45 Bcm) and the Former Soviet Union (4.6%, 34 Bcm). Consumption rose by 2.2% (70 Bcm) led by Asia Pacific (5.9%, 33 Bcm), North America (3.2%, 28 Bcm) and the Middle East (6.9%, 26 Bcm). European consumption, in contrast, suffered an unprecedented 7.8% (42 Bcm) decline.

There is no global price for natural gas. Regional price changes, therefore, provide a first glimpse of the underlying forces of demand and supply. Annual average spot prices for LNG in Asia rose by 82% to $14/Mmbtu in 2011, driven by a combination of higher oil prices pushing up oil-indexed contract prices, and strong additional demand for LNG from Japan, to displace losses in nuclear power. At the other end of the spectrum, U.S. prices slipped by 8% to an average of $4/Mmbtu in 2011. European spot and contract prices hovered between the U.S. and Asian extremes, with UK spot prices averaging $9/Mmbtu in 2011, up 37% on the previous year.

International trade continued to outpace consumption, rising by 4% (39 Bcm). LNG grew by more than 10%. 32% of all natural gas is now traded across international borders; and 32% of all traded gas is LNG, meaning that LNG accounts for 10% of all natural gas consumed globally. Trading patterns in 2011 show a large shift of LNG toward Asia, driven by the continued need to fuel rapid demand growth, especially from China, as well as the necessity to replace nuclear power in Japan. Asian net LNG imports increased by 34% (27.6 Bcm), compared to just 3% (2.1 Bcm) in Europe and Asia's share of LNG deliveries rose to 63% of the global total, whereas Europe's market share fell to 27%. By coincidence also last year, Qatar finalized the final phase of expansion of its LNG export capacity. Thus Japanese demand could tap into a combination of short-term deals for new Qatari supply and spot



purchases from various suppliers, especially Atlantic Basin producers such as Nigeria and Equatorial Guinea.

With Asia absorbing most of the growth in LNG supplies, there was little left for Europe. European markets also had to deal with the loss of Libyan supplies (7 Bcm) and large production declines in the North Sea (23 Bcm). The situation was mitigated, however, by increased pipeline imports from Russia, falling demand, and substitution by additional coal consumption. Gas consumption was sharply lower across most European markets due to the combination of weak economic growth, an exceptionally mild winter compared to 2010, and substitution by coal in power generation. In fact, the European Union's gas demand dropped by 10% which was the largest on record.

So while Asian markets were looking for supplies to meet surging demand, and Europe coped with declining production, the North American gas market faced a very different challenge. The continued momentum in the growth of unconventional gas supplies saw U.S. gas production increase by a record 47 Bcm, accounting for 48% of the growth of world gas production in 2011, and taking U.S. gas production to a new all-time high, above the previous peak in 1973. Demand could not keep up (2.4%, 17 Bcm), despite a reduction of net imports and gas prices low enough versus coal to encourage substantial substitution in power generation, leading to significant gains in inventories and downward pressure on prices.

Overall, the growth of LNG and the production of unconventional supplies continue to transform the world of natural gas. In 2011, they combined to give gas markets the flexibility to accommodate additional Japanese LNG demand, without disruption in other parts of the system. To see how, one needs to look at coal.

Coal

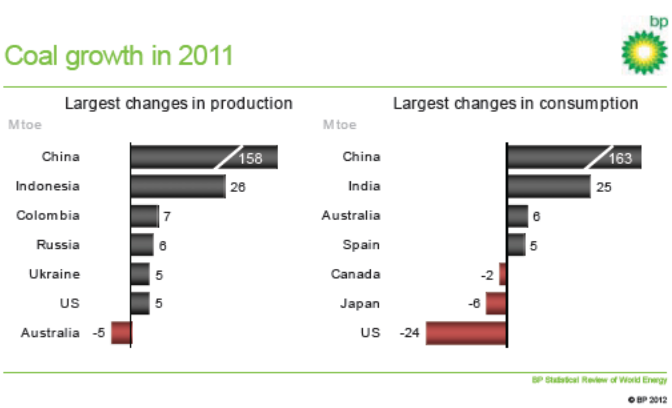
Coal was the fastest growing fossil fuel last year, in production as well as consumption. The coal story is a one of production and trade patterns able to adjust to market conditions. In this way, coal was buttressing global supply security.

Coal production increased by 6.1% (229 mtoe) globally, easily exceeding the ten year average (4.9%). Growth last year, as in many previous years, came from China (8.8%, 158 mtoe) which provided the largest volumetric increment, raising its share in global production to 50%. It did not come from India, where a prolonged monsoon caused production growth of 2.3% (5 mtoe) to lag consumption growth by an even wider margin than usual. EU production also grew by 2.6% (4.2 mtoe), the first increase since 1995.

Only a small share of coal is traded, but this share is growing – in size and reach. In 2011, and outside China, coal exporters, benefiting from growing import needs in Asia and Europe, have been the largest contributors to production growth with Indonesia recording the largest production increment (18.1%, 30.6 mtoe) by far. The world's biggest exporter, Australia, was an exception; it recorded a production decline (2.2%, 5.3 mtoe) because of floods.

Strong demand was driven by the non-OECD, in particular by China at 9.7% (163 mtoe) and India at 9.2% (25 mtoe) who together accounted for 98% of net consumption growth. Over the last decade, the OECD share in global coal demand has declined from 47% to 29%. Last year, OECD consumption declined by 1.1% (12 mtoe), five times the average rate. Yet this was not your typical coal-equals-emerging-markets year.

The OECD decline in 2011 was particularly pronounced in the US (-4.6%, 24 mtoe) where shale gas eroded coal's role in power generation; and in Japan (-4.8%, 6 mtoe), where coal-fired electricity production had to be reduced after the earthquake. These declines were partially offset by growth in the EU (3.6%, 9.8 mtoe), where coal was winning against gas in power generation because of lower prices, and also because of regulatory incentives: carbon prices remained extremely weak and explicit quotas protected coal from competition in Spain.



Steam coal prices in Asia remained at a premium, with Chinese import demand driving up prices throughout the region - including in Japan, the world's second largest coal importer. European import prices rose more rapidly (31.4% y-o-y, compared to 26.1% in China), albeit from a lower level – and just enough to attract additional imports from across the Atlantic. A clear pattern emerges: Asian suppliers and Russia provided the bulk of additional coal for Asia; American suppliers and Russia did the same for Europe – in the course of events also replacing European Union imports from Indian Ocean suppliers that had been redirected to Asia.

In this way, markets balanced. European markets compensated for LNG bypassing the old continent for Asia in part by picking up abundant U.S. and Colombian coal supplies. Higher Asian prices directed previous exports from Indian Ocean suppliers back into Asia, while attracting new supplies from Russia and Indonesia. And coal from the U.S. was available at a price advantage against gas because at home, it had been backed out by natural gas.

This, then, completes the puzzle of how markets coped with the large scale disruptions dominating the headlines in 2011. Production increases, demand changes and even the weather all helped. In essence, however, this is a story of fuel substitution and shifts in trade flows, triggered by price adjustments.

Non-Fossil Fuels

Nuclear was of course at the heart of one of the major disruptions in 2011. Global nuclear generation fell by 4.3% (119 TWh), the largest decline on record, bringing it back roughly to the level of 2001. Nuclear's share of global energy (4.9%) was at the lowest level since 1986. But beyond the closure of Japanese and German nuclear plants, the global impact on energy markets of the Fukushima incident has actually been relatively mild as nuclear output grew in 22 countries in 2011.

Renewable power generation grew 18%, the ninth successive year of double-digit growth. This was the largest ever volume increment (29.3 mtoe), contributing 10% of the overall increase in world energy consumption. The U.S. (16.4%), China (48.4%) and Germany (22.9%), together accounted for more than half (56%) of renewable power growth in 2011. Overall, renewable energy, including biofuels, accounted for 2% of primary energy consumption in 2011, of which 1.6% was from fuels for power generation.

Conclusion

There are a few takeaways to be had from this year of disruptions, with seemingly normal growth and in line with long-term structural changes. These evolve around the flexibility of markets – the ability to increase production, to substitute across fuels, and to change trading patterns has been crucial to the ease with which the system has adapted. For this to work, prices must be allowed their role as signals to guide the reallocation of energy flows.

There is a second, related, conclusion here. It has become fashionable to advocate energy independence as a path to security. However, an objective look at the data shows that it is precisely the interdependence of the world's energy system that is its real strength. Just imagine if Japan would have been truly self-sufficient, and not integrated into the global energy system at all – the adjustments we have seen would have been impossible.

!! Congratulations !!
2011 USAEE/IAEE Best Working Paper Award

USAEE and IAEE are pleased to announce the winner of the 2011 USAEE/IAEE Best Working Paper Award.
Congratulations go to:

Colin Vance & Manuel Frondel

for their paper entitled:

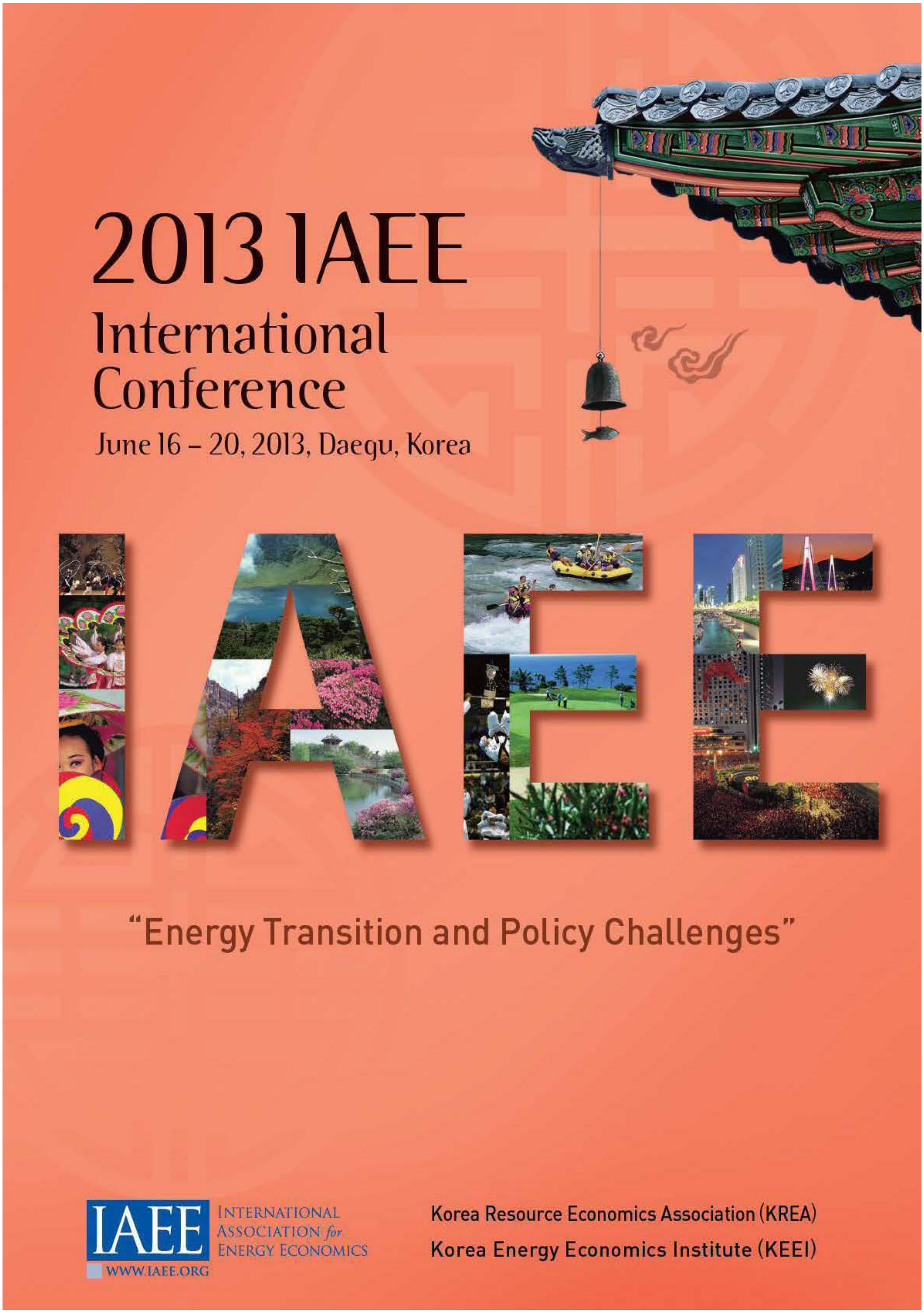
Re-Identifying the Rebound: What About Asymmetry

Both Vance and Frondel are affiliated with the Rheinisch-Westfalisches Institute (RWI) in Germany.

Over 30 papers were received into the Working Paper Series in 2011. Papers were judged based on their contribution to the literature, scholarship, and originality. The review committee consisted of Kevin Forbes (chair), Catholic University of America, Edmar de Almeida, Federal University of Rio de Janeiro and Kenneth Medlock, Rice University. The committee noted that Vance and Frondel's paper asks an important and timely question and addresses it with a judicious blend of theory and empirical analysis.

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 Working Paper Series please click here.


2013 IAEE
International
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First Announcement and Call for Papers
The 36th Annual IAEE International Conference

"Energy Transition and Policy Challenges"

June **16~20**, 2013,
EXCO and Hotel Inter-Burgo,
Daegu, Republic of Korea

We are pleased to announce that the 36th IAEE International Conference will be held at Daegu Exhibition and Convention Center (EXCO) and Hotel Inter-Burgo in Daegu, Korea on June 16~20, 2013. We welcome you to Korea and Daegu. Our theme is Energy Transition and Policy Challenges, and topics in plenary and concurrent sessions will include:

- Energy Challenges and Global & Regional Cooperation
- North-East Asia
- Unconventional Oil and Gas : Technology and Perspectives
- Energy Security and Energy Poverty
- Renewable Energy and Smart Energy Systems
- Climate Change and Policy Challenges
- Role of Government and Government Corporations in Energy Sector

Call for Papers

Abstracts in PDF format, maximum 2 pages in length, covering Overview, Methods, Expected results and References should be submitted via conference website or e-mail to the Program Committee. (program@iaee2013daegu.org) Please visit our website at www.iaee2013daegu.org for further information. **The deadline for abstract submission is January 11, 2013.**
Authors who are interested in organizing special sessions are encouraged to propose their topics and possible speakers.

Location (Korea & Daegu)

Korea's history dates back more than five millennium and a visit to this beautiful land is like a visit through time. As a member of OECD, the driving engine of Korea comes from both economic development and vibrant participation in international society by hosting 2013 World Energy Congress(WEC) and the PyeongChang Olympic Winter Games.

Daegu Metropolitan City, where the 2013 IAEE International Conference held, has been a center of the southern part of Korea. With a population of 2.50 million people, Daegu is a time-honored city that inherited the glorious cultures of the old Silla and Gaya Dynasties, as well as Confucian culture.

Daegu functions as a central management point for such hinterland industrial cities as Gumi Electronics Complex, Daejeon Daedeok Science, POSCO Complex, Ulsan Chemical and Heavy Industries Complex, and Tongyeong Natural Gas Station and the Energy Belt of Daegu & Gyeongsang area.

Thanks to the convenient transportation system, it has been renowned as a center for shopping since ancient times. Participants can enjoy both old markets and modern department stores once it has been developed as a leader of Korea's textile, fashion and design industries. In addition, it takes 1 and 40 minutes by high express train(KTX) and 50 minutes by flight from Seoul and Incheon respectively.

The world-class exhibition and convention center, EXCO, which is known as the "green convention center" offers an ideal place for the international IAEE conference.

On behalf of the organizing committee, I would like to invite you to Korea and Daegu and the 36th IAEE International Conference.

General Conference Chair
Hoesung Lee
Professor, Korea University Green Graduate School
Vice Chair, IPCC

www.**iaee2013daegu.**org

For general inquiries about the 36th IAEE International Conference, please send e-mail to :
general@iaee2013daegu.org

12th IAEE European Conference, Venice, 9–12 September 2012

Energy Challenge and Environmental Sustainability

The 12th IAEE European Conference was held in beautiful surroundings at the San Giobbe Campus of the Ca'Foscari University in Venice. The conference venue had excellent facilities for the practical arrangement of plenary and concurrent sessions, with luncheons and coffee-breaks served in the open courtyard under the splendid Italian sun.

This was the largest IAEE European Conference ever to be held, both in terms of number of participants and sessions organised and papers presented. More than 500 participants attended the conference, some 300 papers were presented in 80 concurrent sessions, and a number of topics were discussed in 8 plenary and dual plenary sessions during three full conference days, under the general conference theme: "Energy challenge and environmental sustainability".

Was it the attraction of Venice that stimulated the large turnout of participants and papers at the conference this year or was it a reflection of a continued increase in the interest and engagement in research and analysis of energy and environmental issues on the European scene? Maybe it was a combination of both aspects, but it is in any case remarkable and comforting to see that the IAEE European conference now draws such an attention among researchers, energy professionals and students, and also to witness the breadth and depths with which energy and environmental issues were presented and discussed at the conference. There was still a concentration on energy economic topics, but issues in the interface between energy and environmental economics and policy analysis were also very much in focus.

The social events added extra value and attraction to the conference. The gala dinner on Monday night took place at the Torcello Island in the garden of the Locanda Cipriani Restaurant, in such beautiful surroundings and excellent food that we did not take notice of the mosquitos! Likewise, the conference dinner on Tuesday night was held under the open sky in the courtyard of the magnificent Ca'Foscari Palace.

Half an hour after the conference ended at 4 p.m. on Wednesday, after three days of warm and sunny weather, it started to rain!

A heartfelt word of thanks goes to the Conference organisers, under the general chairmanship of Professor Carlo Andrea Bollino, ably assisted by the Programme Committee Chair, Professor Carlo Carraro, and Edgardo Curcio, Ugo Farinelli and their efficient team of the Local Organising Committee, for organising a most successful conference. Everything went so smoothly and right on time, with hardly any cancellations or programme changes – a great organizational achievement.

Next year the IAEE European conference will be held in Düsseldorf, Germany, also a most attractive venue. The General Conference Chair, Professor Georg Erdmann and his team, will have a lot to live up to after the Venice success, but I have no doubt that they will face the challenge with the typical German organising talent, dedication and thoroughness.

Einar Hope

The Potential of Unconventional Oil Resources: Between Expediency & Reality

By Mamdouh G. Salameh*

Introduction

A large share of the world's remaining oil resources is classified as unconventional. These resources such as Canada's tar sands oil, Venezuela's extra-heavy oil and shale oil, known collectively as synfuels, have been promoted as a major source of energy that could offset the decline in conventional oil production and reduce dependence on Middle East oil. Others by contrast see unconventional oil as an expensive and extremely pollutant oil resource whose production consumes voracious amounts of energy.

The inclusion of unconventional oil resources in Venezuela's and Canada's proven oil reserves has raised the proven oil reserves of Venezuela to 296.6 billion barrels (bb) and Canada's to 175.2 bb and vaulted these two countries to first and third places respectively in the world's reserves rankings.[1]

Unconventional oil resources have only recently been considered to be part of the world's oil reserves as higher oil prices and new technology enable them to be profitably extracted and upgraded to usable products.

Previously the term 'crude' has been restricted to conventional oil resources which are capable of flowing up a well-pipe, either under pressure existing in the reservoir, or with the mechanical assistance of bottom-hole pumps or gas lift. Excluded from this definition is oil extracted from shale or from the highly-viscous, semi-solid deposits found in Canada's bituminous tar sands and Venezuela's extra-heavy oil.

Even OPEC has been persistently adamant in rejecting Venezuela's demand to have its unconventional extra-heavy oil reserves added to its conventional heavy and medium reserves and reflected in its OPEC production quota.

Unconventional oil resources are generally costly to produce, though considerable progress has been made in addressing technical challenges and lowering costs.

In the medium- to long-term, almost all of the world's unconventional oil supply will come in the form of tar sands oil, extra-heavy oil and shale oil. Unconventional oil production (excluding biofuels) is projected to rise from 1.55 million barrels a day (mbd) in 2011 to 3.05 mbd by 2020.[2]

The only significant unconventional oil production today comes from the Canadian tar sands oil and so far most of the bitumen has been extracted from huge mines. But mining is expensive, and new projects need an oil price of $80/barrel to make a 10% return on investment.[3] The process also requires huge volumes of water. Worse, mining is only possible for deposits less than 75 meters deep – and that is just 20% of the total resources.

The rest has to be produced using in-situ techniques like steam-assisted gravity drainage (SAGD), where steam is injected into a horizontal well to melt the bitumen which then flows down into a lower well to be pumped out. This is cheaper and uses much less water than mining, but far more energy – usually in the form of natural gas – because of the need to raise steam. An industry-sponsored report in 2005 found that if tar sands oil production rose to 5 mbd by 2030, it would devour 60% of western Canada's entire gas supply, which it said would be 'unthinkable'.

So with huge reserves and new technologies, can unconventional oil offset the decline in conventional oil production and the depletion of its reserves? Surprisingly, promoters of the newest technologies are sceptical. They stress the massive investments that will be required to reach the industry estimates of 3.75 mbd by 2030 and doubt production can be raised significantly further. They reckon that unconventional oil resources are not going to solve the world's oil supply problems.

Conventional and Unconventional Oil Resources are not the Same

There are major differences between conventional and unconventional oil resources in terms of API, recovery rate, environmental and productivity factors as well as the energy input needed to produce them (see Table 1).

Unconventional oil has an API ranging from 7%-8%. This compares with 22% or less for conventional heavy oil, 22%-31% for medium oil and 31%-45% for light or sweet oil. This means that on the basis of API, 3 barrels of unconventional oil equate with one barrel of conventional heavy oil, or 4 barrels with

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See footnotes at end of text.

Factors	Conventional Oil	Unconventional Oil
API	22%-45%	7%-8%
Recovery Factor (RF)	34%	5%-10%
Productivity rate	100 barrels	5-10 barrels
GHG emissions	64 kg / barrel	75 kg / barrel
Reservoir pressure	existent	non-existent
Diluents	not needed	essential
Flow rate	free flowing	viscous / semi-solid
Production costs	$1-$10/barrel	$40-$60/barrel
Classification	Crude	Non-crude

Table 1
Major Differences between Conventional & Unconventional Oil Resources
Sources: IHS Energy Database / Alberta Government Data / IEA, World Energy Outlook 2011.

a barrel of conventional medium oil or 5 barrels with a barrel of conventional sweet or light oil (see Table 2).

So when Canada, for instance, says it has proven reserves of 175 bb of crude bitumen, this should not be taken to mean the same as 175 bb of Iraqi or Saudi reserves but should only equate to 58 bb of conventional heavy oil or 43 of medium oil or 35 bb of light oil.

There is another major difference. The recovery factor (RF) for unconventional oil ranges from 5%-10% whilst conventional oil reserves have a global average RF of 34%. Therefore, it is ludicrous and illogical to treat unconventional oil reserves equally as conventional oil reserves. Not all reserves are equal.[4]

And when it comes to productivity, unconventional oil lags hugely behind conventional oil. The real problem is the slow extraction rate. The productivity rate of conventional oil is estimated at 10-20 times more than that of unconventional oil. It is estimated that only 5-10 b/d of unconventional oil can be extracted from a mine compared to 50-100 b/d from a conventional oil well of similar reserve size.

Unconventional oil		Conventional oil
3 barrel	=	1 barrel of heavy oil
4 barrel	=	1 barrel of medium oil
5 barrel	=	1 barrel of light oil

Table 2
API Equivalence
Source: Author's calculations.

Anywhere in the world, of course, it takes energy to produce energy. But tar sands oil and extra-heavy oil are especially voracious consumers of energy, consuming about 1000 cubic feet of natural gas to convert a barrel of bitumen into light crude oil that refiners want. In 2011 Canada produced 1.3 mbd of tar sands oil consuming in the process an estimated 1.3 billion cubic feet (bcf) of natural gas a day, equivalent to 8% of Canada's entire daily production.[5]

And to add to their woes, the extraction and upgrading of one barrel of unconventional oil releases 75 kg (165 lb) of GHG emissions.[6] This is 15% higher, on average, than emissions from conventional oil production.

In conventional oil production, reservoir pressure from gas and water associated with the oil is generally sufficient to cause the oil to flow to a production well. If natural reservoir pressure becomes depleted, then oil flow may be enhanced by injecting gas or water into the reservoir to push the residual oil to the production well. Tar sands oil and extra-heavy oil commonly require the addition of diluents (gas condensate, natural gas liquids, or light crude) to enable the oil to be transported by pipeline. In recent projects in the Venezuelan Orinoco heavy oil belt, 1 barrel of diluents was required for every 3 or 4 barrels of extra-heavy oil produced while tar sand oil needs a one-third blend of condensates or a half blend of synthetic light oil to move it through a pipeline. The cost of producing a barrel of tar sands oil is currently estimated at $50-$60 compared to that of conventional oil which can range from $1 per barrel in Iraq to $3/barrel in Saudi Arabia and over $10 in the United States and Canada.

So in summary, critical issues for the development of tar sands oil and extra-heavy oil include large and growing capital costs, lengthy time to produce, constraints on natural gas and water supplies, the need for large volumes of diluents and environmental degradation.

Unconventional Oil Reserves

Recoverable unconventional oil resources are estimated at 603 bb: 173 bb of tar sands oil reserves in Canada, an estimated 270 bb of extra-heavy oil and bitumen reserves in Venezuela and 160 bb of oil shale worldwide (see Table 3).

Production

As a result of the development of tar sands reserves, tar sands oil is now the source of almost half of Canada's oil production (see Table 4).

Canada	Venezuela	Worldwide	Total
Tar sand oil	Extra-heavy oil	Shale oil	
173	270	160	603

Table 3
Unconventional Oil Reserves (bb)
Sources: BP Statistical Review of World Energy, June 2012 / U.S. Department of Energy.

Because growth of tar sand oil production has exceeded declines in conventional crude oil production, Canada has become the largest supplier of oil and refined products to the United States ahead of Saudi Arabia, Mexico and Venezuela.7 Venezuela's extra-heavy oil production capacity is estimated currently at 310,000 b/d (see Table 5).

Can Unconventional Oil Resources Bridge the Energy Gap?

Production of unconventional oil currently amounts to 1.55 mbd and is projected to rise to 3.05 mbd by 2020 and 3.75 mbd by 2030. In 2011, unconventional oil contributed 2% to global oil demand and this is projected to rise to only 3% by 2030 (see Table 6). This level of production will not even offset the depletion of conventional oil production estimated at 3.5 to 3.9 mbd.

	2007	2008	2009	2010	2011	2015	2020	2025	2030
Tar Sands oil	1.20	1.17	1.20	1.40	1.30	1.43	1.72	2.00	2.15
Conventional	2.11	2.05	2.02	1.97	1.85	1.64	1.28	0.90	0.69
Total	3.31	3.22	3.22	3.37	3.15	3.07	3.00	2.90	2.84

Table 4
Canada's Tar Sands Oil Production (mbd)

Sources: BP Statistical Review of World Energy, June 2012 / IEA, World Energy Outlook 2011 / Alberta Government Data.

	2007	2008	2009	2010	2011	2015	2020	2025	2030
Oil production	2.61	2.56	2.50	2.36	2.10	2.64	3.14	3.24	3.50
Of which:									
Extra-heavy oil	0.41	0.40	0.35	0.31	0.32	0.50	0.55	0.60	0.75

Table 5
Venezuela's Current & Projected Crude Oil Production (mbd)

Sources: BP Statistical Review of World Energy, June 2012 / US Energy Information Administration (EIA): Country Analysis Brief/Platts, www.platts.com.

Environmental Issues

Tar sands development is the single largest contributor to the increase in climate change in Canada. In 2011 tar sands oil production emitted an estimated 80 million tons of CO_2.[8]

Like all mining, tar sands operations have an effect on the environment. Tar sands projects affect the land: when the bitumen is initially mined and with large deposits of toxic chemicals; the water is polluted during the separation process and through the drainage of rivers; and the air is also polluted due to the release of carbon dioxide and other emissions, causing deforestation. Current tar sands oil production techniques require 2-5 barrels of "makeup" water per barrel of product.[9] Immense amounts of water are currently being discarded into settlement ponds in which it may take 200 years for the smallest particles to settle down to the bottom. Some of these impoundment ponds are many miles in area and will pose an environmental problem or hazard for many centuries. Approximately two tons of oil sands are needed to produce a barrel of oil (roughly 1/8 of a ton).[10]

	2009	2010	2011	2015	2020	2025	2030
Demand	84.10	86.40	88.03	90.40	107.00	112.35	117.40
Supply	79.95	81.32	83.58	81.20	81.10	80.50	80.00
Of which Unconventional	1.55	1.55	1.55	1.93	3.05	3.40	3.75
As a % of global demand	2	2	2	2	3	3	3

Table 6
Current & Projected Contribution of Unconventional Oil to Global Oil Demand, 2009-2030 (mbd)

Sources: U.S. Department of Energy's International Energy Outlook, 2011 / IEA, World Energy Outlook 2011 / BP Statistical Review of World Energy, June 2012 / OPEC World Oil Outlook 2011 / Author's projections / U.S. Joint Operating Environment - 2010.

Still, there are some major benefits to be derived from unconventional energy resources.

Lessons from the United States

While shale gas has revolutionized gas production and reserves in the United States, it is the development of shale oil which will have the greatest impact on U.S. oil production and oil imports in coming years.

The U.S. accounted for the entire net increase in oil output over the past three years – excluding OPEC and the Former Soviet states – as its large shale reserves begin to reshape the global energy market.

The U.S. increased daily production of crude oil and other liquid hydrocarbons by 1.1 mbd during 2008-2011, while other non-OPEC countries lost a net 200,000 barrels a day (b/d) during the same period.[11]

While the U.S. remains the world's largest oil importer, the surge in its oil production means that the proportion of its oil demand met by imports is projected to start a downward trend from 58% in 2011 to much lower proportions in coming years (see Table 7).

Advances in the techniques of horizontal drilling and hydraulic fracturing, first applied to shale gas reserves, are now making it possible to produce oil from the huge U.S. shale reserves that were not previously commercially viable. Thanks to U.S. shale and Canadian tar sands, North America may become self-sufficient in oil by 2025.[12]

	2008	2009	2010	2011	2015	2020	2025	% change 2008-2025
Crude oil production	6.73	7.27	7.56	7.84	8.00	8.60	8.82	+ 31%
Consumption	19.50	18.77	19.18	18.84	18.65	19.58	20.56	+ 6%
Net imports	12.77	11.45	11.62	11.00	10.65	10.98	11.74	- 8%
As a % of Consumption	65	61	61	58	57	56	57	

Table 7
2008-2025 U.S. Current & Projected Crude Oil Production, Consumption & Imports

Sources: BP Statistical Review of World Energy, June 2012 / Financial Times, June 14, 2012, p. 8 / Author's projections.

Conclusions

The potential of unconventional oil resources is highly overrated. Apart from the limited size of production, unconventional oil is costlier to produce, more pollutant, a more voracious user of energy and is of poorer quality than conventional oil. It is one thing having huge reserves of unconventional oil resources and quite another turning them into a sizeable production capacity.

Still, there are some major benefits to be derived from unconventional energy resources. Tar sand production is already helping to partially offset the decline in Canada's conventional oil production while shale oil production in the U.S. could, eventually, help it reduce its dependence on oil imports.

In spite of this, the contribution of unconventional oil production to global oil supplies in the next 25 years will only make a dent in the future demand for energy despite the multi-billion dollar investment in unconventional oil resources.

Any benefits that are derived from the production of unconventional oil must be balanced against the adverse impact on the environment in terms of deforestation, degradation of land and water resources and the vociferous consumption of natural gas.

Footnotes

[1] BP Statistical Review of World Energy, June 2012, p. 6.

[2] Mamdouh G Salameh, **The Changing Oil Fundamentals: Impact on Energy Security & the Global Oil Market** (a paper given at the 17th ECSSR Annual Energy Conference, 1-2 November, 2011, Abu Dhabi, UAE), p. 10.

[3] David Strahan, **Non-conventional oil: Can it Fill the Gap?** Petroleum Review, February 2010, p16.

[4] Mamdouh G Salameh, **Saudi Proven Crude Oil Reserves: The Myth & the Reality Revisited** (a paper given at the 10th IAEE European Energy Conference, Vienna, 7-10, September 2009),p. 8.

[5] BP Statistical Review of World Energy, June 2012, p. 22.

[6] **Canada's Oil Sands – Opportunities & Challenges to 2015: an Update**, National Energy Board, June 2006, p. 38.

[7] **Canadian Energy Review 2007**, National Energy Board of Canada, May 2007.

[8] **Climate Change**, Greenpeace Canada.

[9] **FAQ – Oil Sands**, Government of Alberta Environment Ministry. http//:environment.gov.ab.ca/inf/fags/fag5-oil sands. asp.

[10] **The Facts about Alberta Tar Sands**, Climateandcapitalism.com.

[11] Financial Times, June 14, 2012, p. 8.

[12] According to Mr Ryan Lance, Chief executive of ConocoPhillips, the third largest US oil company by production as reported by the Financial Times on June 14, 2012, p. 8

Enhanced Oil Recovery: Going Beyond Conventional Extraction

By Benjamin R. Cook and Charles F. Mason*

In 1978, amid growing concerns over exposure to foreign oil producers – particularly OPEC – the U.S. Congress instructed the Office of Technology Assessment to assess the state of U.S. oilfield production. The resulting report indicated that hundreds of billions of barrels of known oil in the United States remained unproduced because it was not economically attainable by conventional methods. The report evaluated the potential for a range of enhanced oil recovery (EOR) techniques to recover significant amounts of this 'stranded' oil; a specific focus was on the use of Carbon Dioxide (CO_2), and its potential for recovering a significant fraction of this oil.

Increased production from existing fields by adopting unconventional techniques such as EOR is comparable to resource growth associated with successful exploration. Indeed, in mature oil provinces, better knowledge of known fields can facilitate more rapid reserve expansion than exploration for new fields. The potential for EOR to increase expected production from existing oil fields has been realized in a number of mature oil fields, particularly those located in the Permian Basin of West Texas, Wyoming and Saskatchewan. Estimates have suggested that recovery rates for existing reserves could be approximately doubled, while the application of EOR on a broad scale could raise domestic recoverable oil reserves in the United States by over 80 billion barrels (Advance Resources International, 2006). Similarly, roughly half of the known oil reservoirs in Alberta may be amenable to CO_2 injection for enhanced oil recovery, which could translate in an additional 165 billion barrels of oil recovered (Babadagli, 2006; Shaw and Bachu, 2003).

At sufficiently high pressures, CO_2 mixes with oil (*i.e.*, it is *miscible*). This causes the oil to swell, which lowers the oil's viscosity significantly, thereby allowing it to flow more easily to the wellbore. In addition, injecting CO_2 reduces the interfacial forces that cause oil to stick to the surrounding reservoir rock. It also increases reservoir pressure, again facilitating production.

There are several important challenges that must be overcome if EOR is to reach its full potential in any particular field-reservoir. First, starting a CO_2–EOR operation entails substantial initial capital costs: wells must be made ready to accept CO_2, which is corrosive; injection, separation and recycling[1] capital must be put in place; and pipeline infrastructure must be available. In addition, there must be a ready supply of CO_2. It is useful to compare these challenges against those associated with petroleum exploration. Exploration can be quite risky: there is the concern of drilling a dry hole, but beyond that there is the concern that a successful venture may locate insufficient resources to allow profitable production, as may be the case with the Niobrara Shale formation. There is the additional concern of delivering the resource to market, as with the Bakken play; this is less likely to be a concern with EOR, as it is generally undertaken in mature fields which are more likely to be connected into existing pipelines.

The potential for EOR to generate a significant increase in production is illustrated in Figure 1, which shows the monthly production levels over a 20 year period at the Lost Soldier field near Bairoil, Wyoming. By 1989 the field had gone into decline, with production levels falling sharply; CO_2 injections into the field commenced in May of 1989.[2] **Shortly thereafter production levels increased dramatically as a result of the CO_2 injection; through 2011, the field has produced an estimated 44.5 million barrels of incremental oil.**[3]

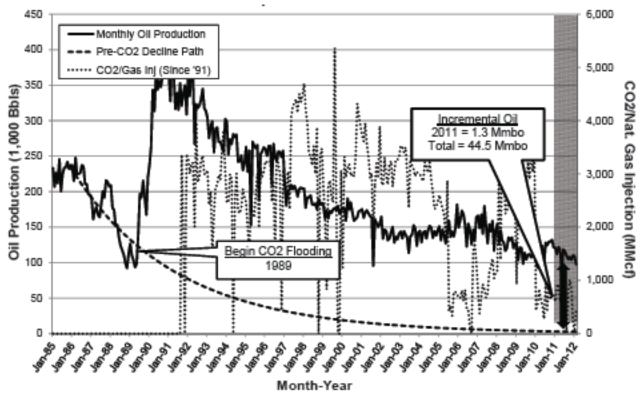

Figure 1
Lost Soldier CO_2 Units (Bairoil, WY)
Monthly Oil & Pre-CO_2 Decline Path

While CO_2-EOR projects are becoming increasingly popular in the U.S. (Anonymous, 2012; Schenewerk, 2012), not all fields are suitable for this unconventional production technique. The experience of Rancher Energy Corp. with the Wall Creek unit in the Big Muddy field in the Powder River Basin illustrates the point. Over its history, the Wall Creek unit had over 150 wells drilled, but when oil prices stagnated in the 1990s these wells were permanently abandoned. Using EOR to resurrect the field would require significant investments in new drilling and well workover; ultimately, the cost was projected to be

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See foornotes at end of text.

$200 million. When Rancher announced its plan in 2008, the spot price of oil was over $90/barrel; but after the spot price collapsed several months later, Rancher was unable to service its debt and declared bankruptcy.

This experience highlights the importance of conducting a thoughtful analysis of the economic viability for a candidate oil field for EOR. In particular, it is paramount that the feasible range of production and oil price outcomes be considered to identify the likely profitability of the project.[4] In general, suitable reserves have oil gravities between 22º – 48º API, proven waterflood performance, and depths in excess of 2,000 feet. Moreover, given the large capital outlays and associated risks of implementing EOR, an internal rate of return at or above 20% is in order to ensure economic viability.[5] In retrospect, it seems that Rancher was overly optimistic about the profitability of the Muddy Creek venture.[6]

One final point seems germane. In the event that the country of origin has in place a carbon policy that either implicitly or explicitly places a price on carbon, CO_2-based EOR projects have the potential to generate an additional revenue stream. To the extent the injected CO_2 is obtained from an anthropogenic source, as in the examples we discussed above, the adoption of EOR facilitates carbon sequestration (Leach et al, 2011).

While the value associated with this revenue stream is likely to be small in comparison to oil revenues, it can nevertheless be substantial. For example, in the Lost Soldier field case discussed above, the average monthly purchase was slightly larger than 1 million cubic feet CO_2, which translates into about 33 thousand cubic feet (Mcf) per day. If we assume a carbon price of $20/ton, which is roughly on par with the recent European history, this would correspond to a price of $1.16 per Mcf, suggesting potential carbon sequestration revenues on the order of $38.28 per day. To compare this value to the revenues associated with oil production, we note that the gross utilization ratio of injected CO_2 to oil produced was on the order of 11 thousand feet per barrel.[7]

Footnotes

[1] Because the CO_2 mixes with the oil in the reservoir, the output stream also contains a mixture of oil and CO_2. Thus, before the oil can be delivered to market the CO_2 must be separated from the oil. In principle, the CO_2 could then be vented, but at historic prices and recycling costs it has generally been economic to re-inject the CO_2. The fraction of injected CO_2 that reflects recycled gas varies over the life of the project, but is commonly on the order of 55%.

[2] The source of the CO_2 is the Exxon natural gas / helium plan, in southwest Wyoming. The gas processed at this plant contains relatively large levels of CO_2, which must be removed before the gas can be marketed; this gas is captured and delivered via pipeline to the Bairoil field.

[3] In 2011 alone CO_2-EOR projects in Wyoming produced an estimated 6.6 million barrels of incremental oil, which represents 12.1% of oil production in the state (Cook, 2012).

[4] See van 't Veld & Phillips (2010) for discussion.

[5] See Cook (2011) for a Monte Carlo analysis that suggests these criteria.

[6] One could argue that Rancher was simply unlucky, inasmuch as it was hard to envision the dramatic drop in crude prices that sealed its fate. That point noted, Rancher bet a very large amount of money on the venture, paying $74 million for that field as well as two others, and that it may have underestimated the expense associated with shoring up the existing well infrastructure and overestimated the likely productivity of EOR in the field (Mullen, 2011).

[7] Of course, the oil produced from EOR will ultimately generate CO_2 emissions, e.g., from burned gasoline. Aycaguer et al. (2001) find that this indirect effect is roughly of the same order of magnitude as the sequestered CO_2.

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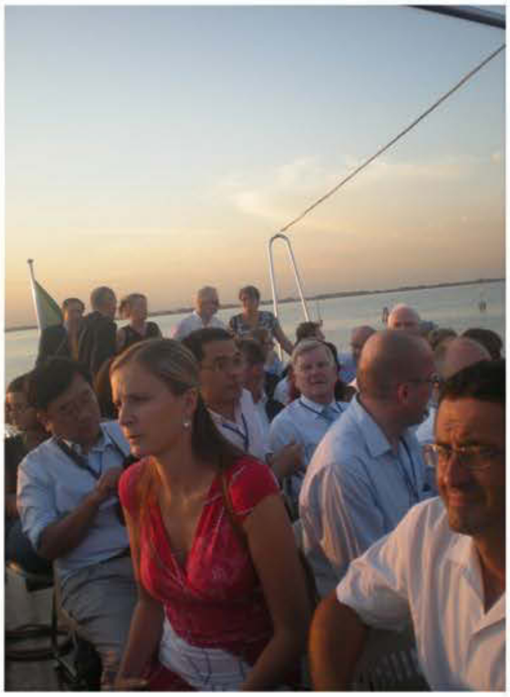





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Unconventional Oils: The 21st Century Rescuer?

By Jean Balouga*

Introduction

Fossil fuels (coal, oil, and natural gas) account for roughly 85 percent of global energy consumption. Renewables and nuclear energy make up the rest. And while the growth in solar and wind has been enormous, the base is small, and intermittency and infrastructure challenges remain a significant hurdle to widespread adoption. In the wake of the Macondo oil spill in 2010, the Fukushima nuclear incident in 2011, and the shale gas "revolution," the energy landscape is changing. Higher prices and technology applications at scale are driving the unconventional resource revolution as there are enormous unconventional oil and gas resources the world over. This phenomenon has the potential for creating a new energy reality, one in which the U.S. once again becomes a global leader in oil and gas production. This, coupled with efficiency improvements and alternative supplements, can substantially reduce U.S. oil imports, achieving a significant reduction in her balance of payments. It can also simultaneously create an engine for economic growth, a platform for technology and innovation, job creation, new tax and royalty revenues, and the revitalization of domestic industries.

The realignment of world oil prices upward, settling above $100 per barrel over the past year, is spurring a transformation of oil technology and markets. The oil industry is posting substantial profits, reinvesting significant capital, and gaining new capacities to identify, probe, recover, and process oils that were once unknown, inaccessible, unmanageable, or uneconomical. As such, oil corporations and national oil companies are developing a wide array of new oils worldwide.

Blurred Definition

Though they have been recognized as new sources of petroleum, according to the U.S. Energy Department, unconventional oils have yet to be strictly defined. In reality, new oils are emerging along a continuum from conventional crudes to transitional oils to unconventional oils, with their classification varying according to the ease of extraction and processing. While no two crudes and oil processes are identical, petroleum products—at least for the time being—are expected to remain relatively unchanged in appearance and use despite burgeoning changes in oil quality. That gasoline, diesel, and jet fuel will likely remain unchanged at the pump will obscure the fact that oils are transforming upstream, with unintended societal consequences—from increased climate forcing and groundwater contamination to forest destruction and impacts on indigenous cultures.

Many new breeds of petroleum fuels are nothing like conventional oil. Unconventional oils tend to be heavy, complex, carbon-laden, and locked up deep in the earth, tightly trapped between or bound to sand, tar, and rock. Unconventional oils are nature's own carbon-capture and storage device, so when they are tapped, we risk breaking open this natural carbon-fixing system. Generally speaking, the heavier the oil, the larger the expected carbon footprint. From extraction through final use, these new oils will require a greater amount of energy to produce than conventional oil. And as output ramps up to meet increasing global demand for high-value petroleum products, unconventional oils will likely deliver a higher volume of heavier hydrocarbons, require more intensive processing and additives, and yield more byproducts that contain large amounts of carbon. This is a key moment to determine the future energy balance between oil and low-carbon alternative fuels. This paradigm shift in petroleum sources, if left to the marketplace alone, will likely have profound local and global impacts. Understanding the trade-offs associated with unconventional oils will be instrumental to managing them prudently. Only with sound policy guidance can we arrive at a de-carbonized fuel system to drive our transportation sector and fuel the global economy.

This heterogeneous bundle of resources not only represents a departure from conventional oil, new oils differ widely from one another as well. The spectrum of new oils runs the gamut: some of tomorrow's liquid hydrocarbons are akin to today's oil, others will evolve but remain more oil-like, and still others will be synthesized from coal or natural gas. Transitional oils, for example, tend to have conventional make-ups but are difficult to extract. These include tight oils, which is oil trapped in shale that can be accessed by hydraulic fracturing or "fracking", a procedure by which rock formations are fractured by injecting fluids to force them open, allowing oil (and gas) to flow out. Ultra-deep oils, that are buried as remotely as 10 miles below the water's surface, are also considered transitional. More coal-like oils include semisolid extra-heavy oils such as bitumen in tar and oil sands, kerogen in oil

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shale, and liquid oils derived from coal itself.

Tight and Transitional Oils

Conventional oils are also being found in difficult-to-reach places. Ultra-deep oil in the Gulf of Mexico, for example, can be trapped many miles below the ocean floor. Oils have been discovered under 4 miles of water, salt, sand, and rock as well. Deep pre-salt fields—generally high-quality oil located in deep-sea areas under thick layers of salt and requiring large-scale investment to extract—are offshore of Brazil and West Africa. They are the first of their kind being drilled around the globe. In North America, tight shale oils are being fracked in the northern Bakken (spanning North Dakota, Montana, Saskatchewan, and Manitoba); in Eagle Ford, Barnett, and the Permian basin in Texas and New Mexico; in the Cardium play in Alberta; in the Miocene Monterey and Antelope deposits in California; in Mowry-Niobrara in Wyoming and Colorado; in Oklahoma's Penn Shale; in Montana's Exshaw Shale; and in Utica Shale in Colorado, Wyoming, and New Mexico. Additional transitional tight shales are being probed for oil (and gas) in New York, Maine, Mississippi, Utah, and Alaska's North Slope and Cook Inlet.

There is an even-greater potential for new tight oils on a global scale in China, Australia, the Middle East (especially Israel), Central Asia (Amu Darya Basin and the Afghan-Tajik Basin), Russia, Eastern Europe, Argentina, and Uruguay.

Transitional oils are oils with conventional compositions that are extracted by unconventional means. As conventional oils become less accessible, new, more technical, energy-intensive methods are being developed for their recovery, from ultra-deep wells drilled miles below the sea to fracturing shale rock in order to tap oil trapped in low-permeability siltstones, sandstones, and carbonates deep in the earth. But no two source rocks are alike. Therefore, no two shale oils are exactly alike. The lighter and sweeter the oil, the less involved the processing and the higher the yield of high-value petroleum products, including gasoline, diesel, and jet fuel. But the more extensive the recovery method, the more energy is required for extraction, which means that these oils tend to result in higher carbon emissions and other societal impacts.

New oil conditions in the Arctic are unlike any other and will require drilling in some of the coldest waters, far from civilization, amid areas of high environmental sensitivity and unpredictable weather. Still, the Arctic Circle nations, including Russia, the United States, Canada, Norway, and Denmark—with one-sixth of the world's landmass and spanning 24 time zones—may constitute the geographically largest unexplored prospective area for petroleum remaining on earth. The United States Geological Survey has assessed the area north of the Arctic Circle and concluded that about 13 percent of the world's undiscovered oil and 30 percent of the world's undiscovered gas may be found there.

In the latter part of the twentieth century, as conventional oils became more heterogeneous, their geography became increasingly more diversified. **Heavy oils** in California, Venezuela, China, Indonesia, the Middle East, and along the Alberta-Saskatchewan border initiated the oil transition.

Unconventional Oils

Lacking a clear definition, unconventional oils are typically identified by their characteristics. The heavier the oil is—for example, oil sand (bitumen) and oil shale (kerogen)—the more carbon laden, higher in sulfur, and filled with toxic impurities. Unconventional oils are typically much heavier and sourer than even the lowest-quality conventional oil. An array of unconventional solid, liquid, and gaseous hydrocarbons can be processed into petroleum products. But these extra-heavy, impure oils require very large energy inputs to upgrade and preprocess into synthetic crude oil that is then processed by a refinery. Some new oils are effectively solid and must be removed through mining or heated in place *(in situ*) until they flow. These new oils tend to be less valuable than conventional crude, which is readily transformed into the most marketable petroleum products by today's standards.

Oil Sands (bitumen)

They are a combination of quartz sand, clay, water, trace minerals, and a small (10–18 percent) share of bitumen, and their sulfur content can be in excess of 7 percent. Bitumen is made up of organic components ranging from methane—the simplest organic molecule—to large polymeric molecules having molecular weights in excess of 15,000. This extremely complex hydrocarbon mixture can be synthetically processed into oil. However, it cannot be transported to market by pipeline without adding diluting agents—such as gas-processing condensates including the diluent pentanes plus—to meet pipeline density and viscosity limitations. A large portion of Alberta's bitumen production is currently upgraded to synthetic crude oil and other products before shipment to refineries.

Extra-Heavy Oils

The bitumen contained in oil sands is the most prevalent extra-heavy oil. The estimated world's total quantity of extra-heavy oil in place is 5,756 billion barrels (WEC, 2007:121). The province of Alberta, Canada—including the Athabasca Wabiskaw-McMurray, Cold Lake Clearwater, and Peace River Bluesky-Gething regions—has the globe's largest deposits of bitumen. Outside of Canada, 21 other countries have bitumen resources, including Kazakhstan, Russia, Venezuela, and Africa, including the Republic of Congo, Madagascar, and Nigeria. In the United States, oil sands are deposited in at least a dozen states, including (in relative order) Alaska, Utah, Alabama, California, Texas, Wyoming, Colorado, and Oklahoma. However, the U.S. and other nations' oil sand reserves are currently considered to be far smaller in volume than Canada's reserves and may also be less easily recovered due to different physical and chemical compositions. Extra-heavy oil (non-bitumen) is recorded in 166 deposits worldwide, the largest in eastern Venezuela's Orinoco Oil Belt. The deposits are found in 22 countries, with thirteen of the deposits located offshore.

Oil Shale (kerogen)

This is "immature oil" that has not been in the ground long enough to form oil. It is mostly composed of clay, silt, and salts, with a small (12 percent) share of insoluble organic matter (kerogen) and even smaller (3 percent) share of soluble bitumen. The organic kerogen, once extracted and separated from the oil shale, can be processed into oil and gas. Like oil sands, oil shale has a similarly high sulfur content—up to 7 percent. Kerogen has the potential to be one of the largest unconventional hydrocarbon resources in the world. Conservatively, it is estimated at 2.8 trillion barrels (WEC, 2007:94). In North America, the richest and thickest oil shale deposits are in the Green River Formation, which covers portions of Colorado, Utah, and Wyoming. Prudhoe Bay, Alaska, and additional basins in Colorado (Piceance), Utah and Colorado (Uinta), and Wyoming (Washakie) are also known locations of oil shale. A block of U.S. states bordered by Michigan, Missouri, Alabama, West Virginia, and Pennsylvania contains a grouping of large oil shale plays, that is, promising areas targeted for exploration. Internationally, Brazil, Israel, Jordan, Sumatra, Australia, China, Estonia, France, South Africa, Spain, Sweden, and Scotland all have notable oil shale deposits. (There is an estimated 1.7 billion barrels of oil shale in Nigeria (WEC, 2007:114)).

Production Method	**Product**	**Operating Cost**	**Supply Cost**
Cold (Wabasca, Seal)	Bitumen	6-9	14-18
Cold heavy oil with sand (Cold Lake)	Bitumen	8-10	16-19
Cyclic steam (Cold Lake)	Bitumen	10-14	20-24
SAGD	Bitumen	10-14	18-22
Mining/extraction	Bitumen	9-12	18-20
Integrated/mining extraction, upgrading	Syncrude	18-22	36-40

Costs in Canadian dollars (assumed at 2005 US $0.85), at plant gate.

TABLE: Estimates of Operating and Supply Costs by Production Method

Source: WEC, 2007, p.124

At the core, geologic and chemical factors determine the geography of new oils. Global oil - that beyond confirmed assets currently owned by companies or contained in countries (proven reserves) - is being remapped. Looking ahead, it is increasingly likely that international oil companies will be involved in developing the "frontier" oils -shale, tight, deep offshore, Arctic - due to their expertise and experience. Innovative, asset-rich, profit-driven, and technologically capable international oil companies may be a significant factor in identifying North America's large unconventional oil reserves. This will not diminish the longer-term dominant role of state-run national oil companies, which own some 75 percent of the world's proven conventional oil reserves and still reap the benefits of their comparatively low production costs. Still, these national companies have historically lagged on commercial reserve replacement given tensions to use national capital budgets to fulfill important social and economic goals. International oil companies will have to take on more risk, developing new oils in new geographies and under new conditions. But the prospects for profit are driving these difficult plays.

Further Challenges

In addition to the uncertainty of not yet having an economical and environmentally viable commercial scale technology, the following challenges should be considered:

Impacts on water, air, and wildlife: Developing oil shale and providing power for oil shale operations and other activities will require large amounts of water and could have significant impacts on the quality and quantity of surface and groundwater resources. In addition, construction and mining activities during development can temporarily degrade air quality in local areas. There can also be long-term regional increases in air pollutants from oil shale processing and the generation of additional electricity to power oil shale development operations. Oil shale operations will also require the clearing of large surface areas of topsoil and vegetation which can affect wildlife habitat, and the withdrawal of large quantities of surface water which could also negatively impact aquatic life.

Socioeconomic impacts: Oil shale development can bring an influx of workers, who along with their families can put additional stress on local infrastructure such as roads, housing, municipal water systems, and schools. Development from expansion of extractive industries, such as oil shale or oil and gas, has typically followed a "boom and bust" cycle, making planning for growth difficult for local governments. Moreover, traditional rural uses would be displaced by industrial uses and areas that rely on tourism and natural resources would be negatively impacted.

That said, as with all energy sources, there continue to be operational risks and consequences. The practice of fracking is not without controversy. Environmental concerns about water contamination, water use at scale, recycling and proper disposal, land use, property values, noise, haze, methane, and greenhouse gas emissions, seismicity, concerns around wastewater disposal, congestion and other local issues will have to be responsibly addressed. But technology, well integrity, operational "best practices," and community engagement, coupled with proper regulation and enforcement, should make realization of the benefits of this resource achievable.

Not surprisingly, many of the concerns related to shale gas development are also associated with accessing unconventional oil. As is the case with unconventional gas, industry has committed to step up its game with respect to responsible management of both "above" and "below ground" issues, greater transparency, education and community engagement. Smarter, safer, cleaner is now an operational necessity.

As development continues at scale, new issues will undoubtedly arise—including the build-out of new supporting infrastructure, the role of exports, the timing and sequencing of development initiatives, the right mix of federal and state regulation, etc. However, the prospect of sizable new production opportunities in the United States and North America necessitates a reassessment of America's decades old tool kit and a serious policy rethink when it comes to mapping out the coming decades as she progresses toward a more sustainable energy future. This serious policy rethink applies to oil-exporting African countries as well.

Conclusion

Most analysts agree that for a variety of reasons (growing global demand, concentration of resources, limited access and governance challenges, infrastructure needs, balance of payments outflows, changing geopolitical alliances, and security considerations) America's current energy system - like most energy systems- is simply unsustainable. A transformation is already underway. But it will take decades to complete. While there are potential opportunities for commercial development of large unconventional oil and gas resources, such as oil shale, in the United States, these opportunities must be balanced with other potential technological, environmental and socioeconomic challenges.

Recommendations

There is the need for the formation of a powerful Advisory Committee that would provide an independent forum to research and clarify aspects of unconventional oil supply that are a source of confusion and debate. There is also the need to create an environment that fosters innovation and results in production growth, and access to acreage with sufficient oil resources combined with long-term stable fiscal regimes and fiscal measures that provide industry the certainty and time needed to develop unconventional resources in an economically viable, socially acceptable, and environmentally responsible manner.

The current governance structure established for conventional crude oil, its processing specifications, and its byproducts will need to be revisited with the new oils in mind. Therefore, new rules will likely be required to deal with new fuels. This includes managing their (direct and indirect) impacts and determining the mix of unconventional oils in the future mix of petroleum products; and then there must be synergy among countries exploiting unconventional oils on energy technology and policy, programs, and approaches to advance a secure and environmentally responsible world energy system.

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IAEE/Affiliate Master Calendar of Events

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

Date	Event, Event Title and Language	Location	Supporting Organizations(s)	Contact
2012				
November 4-7	31st USAEE/IAEE North American Conference *Transition to a Sustainable Energy Era: Opportunities and Challenges*	Austin, Texas	USAEE/CTAEE/IAEE	USAEE Headquarters *usaee@usaee.org*
2013				
January 17-18	8th Conference of the Spanish Association *For Energy Economics*	Valencia, Spain	AEEE	Gonzalo Saenz de Miera *aeee@aeee.es*
April 8-9	6th NAEE/IAEE International Conference *Energy Resource Management in a Federal System: Challenges, Constraints & Strategies*	Lagos, Nigeria	NAEE/IAEE	Adeola Adenikinju *adeolaadenikinju@yahoo.com*
April 22-23	4th ELAEE Conference *Energy Policy in Latin America: Regional Integration and the Promotion of Renewables*	Montevideo, Uruguay	LAAEE/IAEE	Marisa Leon *melon@adme.com.uy*
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*
2014				
June 15-18	37th IAEE International Conference *Energy to Survive 2020*	Prague, Czech Republic	CZAEE/IAEE	Jan Myslivec *janmyslivec@yahoo.com*
September 19-21	4th IAEE Asian Conference *Economic Growth and Energy Security: Competition and Cooperation*	Beijing, China	CAS/IAEE	Ying Fan *yfan@casipm.ac.cn*
2015				
May 24-27	38th IAEE International Conference *Energy Security, Technology and Sustainability Challenges Across the Globe*	Antalya, Turkey	TRAEE/IAEE	Gurkan Kumbaroglu *gurkank@boun.edu.tr*

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GESELLSCHAFT *für* ENERGIEWISSENSCHAFT *und* ENERGIEPOLITIK E.V.
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First Program Announcement and Call for Papers

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!

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)

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

Call for Papers, Deadline: 15 March 2013

Concurrent sessions will be organized from accepted abstracts. Please submit abstracts of one to two pages in length, comprising (1) overview, (2) methods, (3) results, and (4) conclusions. Please also attach a short CV. The lead author submitting the abstract must provide complete contact details: mailing address, phone, fax, e-mail etc. At least one author of an accepted paper must pay the registration fee and attend the conference.

Authors will be notified by May 2013 of their paper status. While multiple submissions by individual or groups of authors are welcome, the abstract selection process will seek to ensure as broad participation as possible: each speaker is to deliver only one presentation in the conference. If multiple submissions are accepted, then a different co-author will be required to pay the reduced registration fee and present the paper.

All information and abstract submission soon at http://iaee2013.gee.de

Registration Fees

Participants	Early Registration EURO	Late Registration EURO
Speakers/Chairs	500	550
GEE/IAEE-Members	660	720
Non-members	750	800
Full Time Students	250	275
Accompanying persons	200	200

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 do not hesitate to contact
David Williams, IAEE Executive Director, at 216-464-2785 or via e-mail at: iaee@iaee.org

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.

Sub-Saharan Africa:Unconventional Oil Resources

By Nadia Ouedraogo*

Resources of bitumen or extra-heavy oil are reportedly present in many countries in Sub-Saharan Africa: Republic of Congo, Madagascar, Nigeria, Angola, and elsewhere.

Some of these countries are now in early development planning phases of the exploitation of these resources with the help of European companies and their technological know-how, including BP, ENI, and Total.

Madagascar

The unconventional oil deposit in Madagascar is located on the Western coast of the island in *Melaky* region. Tar sands resources are found in the *Bemolanga* field, and extra heavy oil resources are being explored at the *Tsimiroro* field. Both fields are approximately 70km² in area. The bitumen content ranges from about 3.5 to approximately 11.0 weight percent, with the effective mineable area at an average of 5.5 weight percent bitumen in the ore (this bitumen content is approximately half of that found in the Canadian tar sands).

The *Bemolanga* block is a 5,463 km² in area and holds a best estimate of over 16.5 billion barrels in place with around 10 billion barrels recoverable. Madagascar Oil, a Houston-based independent company and currently the largest onshore oil operator in the country, estimates that at full production the site could produce 180,000 barrels per day over 30 years. The depth of the *Bemolanga* field is on average 15 metres below the surface; that is close enough to the surface for opencast mining operations (Madagascar Oil, 2009). Given the resource is likely to be mined, exploration and operational costs would probably be lower than in Canada. At an oil price above $80 per barrel, Total, the operator, has stated that *Bemolanga* could produce 200 kb/d, with mining technology (IEA, World Energy Outlook, 2010).

The *Bemolanga* field could also be more energy - and carbon - intensive than equivalent projects in Alberta. Because the material's bitumen content is lower it would be harder to separate. However, it is thought that a higher proportion of the oil in *Bemolanga* could be recovered than in Alberta, so this would reduce the comparative energy intensity.

Tsimiroro is the most advanced project in Madagascar and holds a best estimate of almost 1 billion barrels (Madagascar Oil, 2009). An independent estimate of the *Tsimiroro* field, however, stated it at 3.5 billion barrels in place, with 900 million barrels recoverable. The depth of the field is between 40 and 300 metres below the surface. This means the oil will need to be extracted through in situ steam-based production techniques as in the Canadian tar sands, requiring significant water and energy resources. It could produce 90,000 barrels a day for 30-40 years and breaks even at just under $50 a barrel.

The *Tsimiroro* field is 100% owned by Madagascar Oil, while the *Bemolanga* (tar sands) field is 60% owned by Total and 40% by Madagascar Oil.

Total expects to start producing heavy oil at *Bemolanga* by 2019, while Madagascar Oil is aiming at production by 2015 on the *Tsimiroro* field[1]. Overall, under the terms of the production sharing contracts, Madagascar is set to receive just 4% of the oil revenue derived from the projects after a proposed thirty-year commercial exploitation.

Higher oil prices make the projects viable and the government is impatient to get production going. An extremely generous tax regime to entice Madagascar Oil and its French partner, Total, has been designed. Operators are being offered 99% of the revenue for the first 10 years while they recoup their costs, with just 1% for the government[2].

Republic of Congo

The bitumen resource in the Republic of Congo is estimated, by the Italian Company ENI, at least 500 million barrels risked, with the potential for discovering up to 2.5 billion barrels (unrisked)[3]. The huge 1,790 km² tar sands concession covers two areas, *Tchikatanga* and *Tchikatanga-Makola*, in the south of the country near the oil capital of Pointe-Noire. The huge area stretches from the border with the Angolan exclave of Cabinda to the *Conakouati-Douli* national park bordering Gabon. The resources are deep, in the 100-200 metre range, and so will require in situ technology to develop.

In 2008, ENI and the Republic of Congo Energy Ministry signed draft agreements to invest in tar sands in the country[4].

Nigeria

Bitumen was first discovered in Nigeria in 1900 and there have been several exploration efforts over the past fifty years. Nigeria's bitumen belt is located in

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See footnoates at end of text.

the southwest of the country, stretching along 120 km of coastline, straddling the states of *Ondo, Ogun*, and *Edo* and the resource is potentially much larger than in Madagascar or Congo. Nigeria's bitumen is estimated at 27 billion barrels of oil equivalent, although proven reserves are only 1.1 billion barrels[5].

In 2002, Conoco Energy Nigeria carried out a pre-feasibility and scoping study of the bitumen belt and between 2001 and 2008, 40 core holes were drilled. In 2007, the country's new Mining Act created an "enabling environment," including corporate-friendly fiscal and favourable tax regimes to attract foreign direct investment.

Exploitation of Nigeria's tar sands deposits appears to be at a standstill since 2009. However, given the historical level of investment in conventional oil by multinational oil companies in Nigeria, it seems likely that the unconventional resource will be next for exploitation (EU commission, 2010).

Research has also shown that the southeastern region of Nigeria possesses a low-sulphur oil shale deposit. The reserve has been estimated to be of the order of 5.76 billion tonnes with a recoverable hydrocarbon reserve of 1.7 billion barrels.

Democratic Republic of Congo (DRC)

Tar sands in this country are present in several regions including the *Lake Tanganyika Graben* in the east as well as in the western Congo bordering the *Cabinda* province of Angola.

It has 300 million barrels in place of tar sands with a proven reserve value of 30 million barrels. For bituminous, the concession areas total approximately 400 km² in the *Bas Congo* western coastal basin.

In 2009, ENI announced an agreement with the DRC government to carry out feasibility studies for the development of non-conventional hydrocarbons, in the eastern areas of the country.

Ethiopia

Ethiopia has 3.89 billion tonnes of oil shale located in *Tigray* province, which borders Eritrea. However, there is currently a lack of interest in exploring the shale oil, possibly due to a previous dispute over the area which led to conflict between Ethiopia and Eritrea. This conflict continues.

In addition to the region of *Tigray*, there is a smaller deposit of 100-120 million tonnes at the Delbi Moyen coal development, southwest of Addis Ababa, although Ethiopia has plans to utilise this for manufacturing urea fertiliser (World Energy Council, 2007).

Angola

Angola has two natural bitumen deposits located in Bengo province which surrounds the capital, *Luanda*. They contain 4.65 billion barrels of oil in place and 465 million barrels of reserves of tar sands oil. There are currently no plans to develop these deposits, but they will become a more attractive resource once Angola's traditional oil resources start to dwindle (World Energy Council, 2007).

Environmental and Social Issues of Unconventional Oil Development in Africa

Given the particularly carbon-intensive techniques associated with developing unconventional resources, the opportunity for environmental damage is high.

Tar sands production has a very high carbon footprint, on average producing one barrel emits between 17-23% more greenhouse gases (GHGs), depending on the techniques used for production, than a barrel of conventional oil[6].

It is the fastest growing source of emissions in Canada, challenging the country's Kyoto commitments. Thus, tar sands production poses unquantifiable environmental and social risks to local environments and communities. The expansion of unconventional oil in Africa will likely include countries with weak governance frameworks that are particularly vulnerable to the social and environmental damage associated with careless fossil fuel extraction. In addition, projects are unfortunately located on vulnerable areas such as forests or near residential areas.

In Nigeria the Ikale region in Ondo state is likely to be one of the most affected areas if tar sands production goes ahead, with displacement of local populations and impacts on the area's fragile eco-systems possible. Given the history of violence stemming from the social and political conflict generated by oil production in the Delta, tar sands development in Nigeria will be particularly sensitive in both social and environmental terms.

Congo has important forest resources (about two thirds of the country is forested) providing livelihoods for local communities and assisting climate protection. However, ENI's tar sands zone development covers between 50 to 70 percent of Congolese rainforest and other environmentally sensitive areas and would thus threaten nearby communities and local ecosystems[7].

The tar sands concession in Congo includes savannah, tropical rainforest and wetlands that are home to endangered bird species. It borders a national park described by the government as the "most ecologically diverse habitat in Congo"[8] and encroaches on the UNESCO-recognised *Dimonika* biosphere. There is concern about the lack of information and lack of understanding about the project on the part of local communities and also, given the limited transparency in the country, that the government may not have an accurate understanding of its potential environmental and social impacts.

Melaky in Madagascar is home to the Tsingy de Bemaraha Nature Reserve, listed as a UNESCO World Heritage Site in 1990 due to its unique geography, preserved mangrove forests and wild bird and lemur populations. Around half of the reserve is designated as a "strict" or "integral" reserve, meaning no development or tourism is allowed.

Environmental regulations are unlikely to be onerous in an island famed for its biodiversity. However, it is vital that any tar sands development starts from the set up of environmental regulation policy. Indeed, the first bitumen development projects in Madagascar are likely to use more energy than the world's only other existing oil sands projects, in Alberta, Canada. The *Tsimiroro* project will use an in-situ method, which involves injecting vast amounts of steam into the ground to heat up the oil and allow it to surface. According to industry estimates, to extract five barrels of oil at *Tsimiroro* will burn up one barrel of oil.

Conclusion

One new frontier for tar sands development is Africa, a region especially vulnerable to environmental impacts. Tar sands production in Canada has resulted in some damage to local communities and the environment. If this occurs in a country with a well-developed legislative framework and established democratic institutions, the consequences of such investments could be devastating for poor communities with weaker political and environmental governance frameworks.

Footnotes

[1] "Madagascar replaces top oil, mines official", Reuters, 8 September 2011. http://af.reuters.com/article/commoditiesNews

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Canadian Oil Sands: Current Projects and Plans, and Long-term Prospects

By Yuliya Pidlisna*

Introduction

Oil sands reserves are found in several locations around the world, including Venezuela, USA, and the Russian Federation. The largest oil sands operations are in the province of Alberta, Canada (Ordorica-Garcia, 2009). However, British Columbia, Saskatchewan and Manitoba also have producing or potential oil sands operations. In Eastern Canada, the potential for tight oil resources exits in Anticosti Island in Quebec and Western Newfoundland. The largest four projects are those of Syncrude, Suncor, Shell/Albian's Athabasca oil sands project and Imperial's Cold Lake. Canadian oil sands are a strategic future resources for Canada, North American and the global market

Referring to the IEA and the BP Statistical Review, in 2011 Canada ranked as the 6th largest oil producer after such countries as Russia, United States, Saudi Arabia, Iran and China. When taking into consideration proved oil reserves Canada is ranked third in the world after Venezuela and Saudi Arabia with 28.2 thousand million tones or 175.2 thousand million barrels or about 10.6% of total world reserves (see Figure 1). The oil sands account for more that 97% of proven oil reserves in Canada. Recently, the number of Canadian oil sands projects under active development has increased from 11.5 thousand million barrels in 2001 to 25.9 thousand million barrels in 2010 (see Figure 2). The Kearl oil sand project accounts for 4.6 billion barrels of the recoverable reserves of bitumen resources. It is Canadian largest and one of the highest quality oil sands deposits. The project life is over 40 years with a production capacity up to 345,000 bpd.

So what do unconventional oil reserves in Canada consists of, and what role will they play in the future as more easily accessible and lighter crude oil resources are depleted?

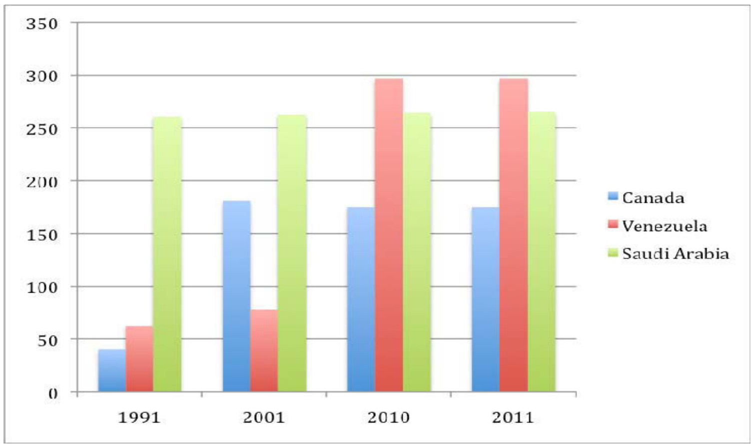

Figure 1. Proved Reserves in billion barrels
Source: BP Statistical Review, 2012

Unconventional Oil in Canada

Unconventional oil reserves in Canada consist of high deposits of oil sands. Shale's tight sands and tight carbonates are unconventional sources of oil, as the reservoir rock must be stimulated or fractured to enable the oil to flow. Extracting requires large amounts of energy in the form of steam, hot water, hydrogen, power, process heat, and diesel fuel. Most of the resources consist of an extra-heavy crude oil known as bitumen.

Technological advancements in drilling (long-reach horizontal well bores) and completion techniques (multi-stage hydraulic fracturing) are increasing the outlook for the supply of crude oil in North America.

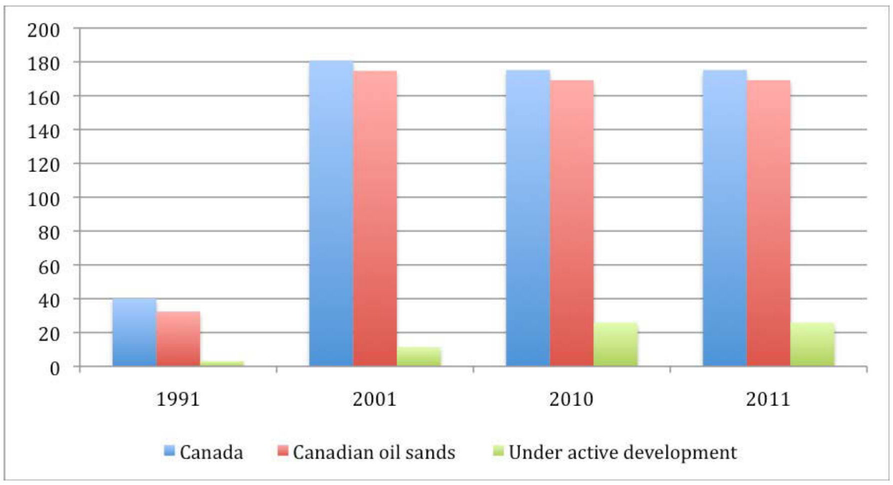

Figure 2. Proved Canadian Oil Reserves in billion barrels
Source: BP Statistical Review, 2012

In Canada there are two primary methods of extracting bitumen: open cast mining and situ thermal extraction. In situ extraction, steam injection is the most commonly used method with intense use of natural gas to run steam generators. CSS (cyclic steam stimulation) comprises a three-stage process used where the overburden is more than

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300m. The SAGD (steam assisted gravity drainage) is a newer method comprising drilling two wells parallel with the formation (Soderbergh et al. 2007).

Unconventional Resources and Opportunities in Canada

Most of Canada's recoverable reserves (175.2 billion barrels) are unconventional sources, the remaining 6 billion barrels are conventional oil (BP Statistical Review, 2012).
According to Statistics Canada, in 2009 mined oil sands equaled 465,926 thousands tones of oil. Canadian Energy Research Institute reports that daily production from Alberta's oil sands is exceeding the country's conventional oil production (see Figure 3).

In the IEA's World Energy Outlook (2004) conventional oil is expected to peak around 2015, and non-conventional oil will account for a third of the world's needs in 2030. Results of a study undertaken by Green et al. (2006) suggest that the transition from conventional to unconventional oil will begin before 2023. According to research done by Mohr & Evans (2010), Canadian natural bitumen will reach peak production in 2040. Other authors suggest that the unconventional oil peak will be reached in 2078.

According to Natural Resources Canada, North America is now the fastest growing oil-producing region outside of OPEC. Additionally, output is expected to jump by 11% over the 2010 to 2016 period due to increased output from Canada's oil sands. Canadian oil production is expected to breach the 4 mb/d marker in late 2012, and new in situ and mining bitumen projects are forecast to raise Canada's oil output by 280 kb/d to 4.1 mb/d in 2013.

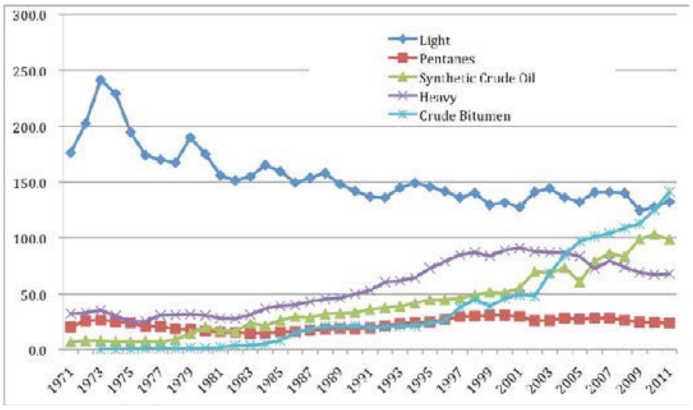

Figure 3. Canadian Crude Oil & Equivalent Production by type (1971-2011) in thousands cubic meters per day

Challenges of Oil Sands Production-- Environmental Issues

The strong growth and expansion of oil sands projects in Canada raises a number of environmental issues and challenges. Most attention is giver to issues addressing GHG emissions, but other matters such as surface disturbance and water conservation are also presenting serious problems to the environment. According to Soderbergh et al. (2007), GHG emissions of large amounts of carbon dioxide (CO_2) and some methane (CH_4) gas and nitrous oxide (N_2O) are the most complicated future environmental issues.

Extracting and upgrading bitumen to SCO yields substantial level of CO_2 emissions. The CO_2 emissions from hydrogen and power production total 40% of overall CO_2 production in Canada (Ordorica-Garcia, 2009). Therefore, Carbon Capture and Storage (CCS) technology is recognized as an essential element in Canada's overall CO_2 mitigation plans.

Extracting bitumen and other heavy crude oil requires more energy than the production of more accessible lighter crude oil. According to Canadian Natural Resources Agency, in 2009 GHG emission from oil sands contributed to 6.5% of Canada's total GHG emission and 0.1% of global emissions.

Regulations

Under Canada's Constitution, each province owns the onshore hydrocarbon resources within its provincial boundaries and is responsible for regulating resource development. Therefore, provincial regulatory environment defines each aspect of tight oil development (e.g., pre-drilling and drilling activities, hydraulic fracturing and production, resource management, abandonment and reclamation). Canadian regulation of the oil and gas sector is designed to protect water resources during oil and gas development. Specific regulations vary between provinces, but in most cases steel casing and cement are used to isolate and protect groundwater zones from deeper oil, natural gas and water zones.

According to the British Columbia Oil and Gas Commission (BCOGC), the Saskatchewan Ministry of Energy Resources, and the Alberta Energy Resources Conservation Board (ERCB), there has never been a confirmed case of groundwater contamination resulting from hydraulic fracturing in British Columbia, Saskatchewan or Alberta, the three provinces where most oil and gas drilling activity in Canada occurs. Hydraulic fracturing is a proven technology already used safely in a large proportion of the roughly 11,000 oil and gas wells drilled each year in Canada; this technique is essential to the effective operation of the oil and gas sector; and it is routinely done without negative safety consequences or significant adverse environmental impacts.

Market for Canadian Crude Oil

Canadian crude oil traditionally supplies markets in the U.S. midwest and Canada. With increasing heavy oil refining capacity in the region, the demand for Canadian crude oil in the U.S. midwest will grow. Due to expected growing supplies of Canadian bitumen there will be a quest for new markets for larger volumes. One of these projects is TransCanada Keystone XL pipeline project.

If the project receives presidential approval in 2013, it can start construction of 1,897 km pipeline. Construction has already started on TransCanada's Gulf Coast pipeline project. Both the Keystone and Gulf Coast pipelines will eventually be connected to move crude oil from the Athabasca oil sands region to refineries on the gulf coast of Texas.

Additionally new ways of supplying the ever-growing demand for crude oil in Asian markets must be found. One example of future projects is the Northern Gateway Pipeline Project from Edmonton, Alberta to port in Kitimat. Crude oil will be shipped via pipeline to the Pacific coast and then loaded on tankers for delivery to the U.S. west coast and Asian markets.

Oil Sands Projects

The development of oil sands projects requires twenty to thirty years of advance planning for production, upgrading, transportation, and marketing. Additionally, upgrading bitumen to be acceptable to conventional refineries requires natural gas and hydrogen. The capital investment required is huge and thus only the largest of companies can participate. Still, so far only the more favorable sites are being developed, given that the bitumen in oil sands is variable, thus the future would appear bright.

Conclusion

Canadian oil sands will remain a central topic for both the Canadian and world's economy. Canada is affected by future unconventional resources development both as producer and consumer of oil products.

Development of Canadian oil sands depends on multiple factors such as national government and public policy making regimens, U.S. legislation, capacity levels, technological advances, the marginal cost of production, greenhouse gas emissions regulations, etc. Future production of Canadian oil sands is focusing on in situ production and new technologies advancing in that area. One of the challenging matters is the question of the availability the large supply of energy, such as natural gas, needed for the continuous development of in situ projects. The option of constructing nuclear power in order for Canada to meet its commitments to the Kyoto Agreement is will be considered in the future as a constant energy provider is needed for situ production. Another important issue that is supposed to be addressed is whether SAGD techniques can be used to yield high production from lower quality reservoirs. And finally there it the question of how many oil sands deposits enable situ production.

The future will see higher rates of development of unconventional oil, and a transition from conventional to unconventional resources. Canadian unconventional oil resources are going to play a major role in the future of world energy resources.

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