United States Association for Energy Economics

USAEE **Dialogue**

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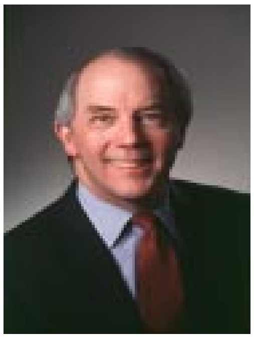
PRESIDENT'S MESSAGE



The magnificent dome of St. Paul's is sometimes visible from the fifth floor research department here in London. I'm nine months into a temporary assignment in the UK, embarking on my year as President of the USAEE, and looking forward to getting back to the States. It has been an extraordinary time to be living here in an island nation that sees itself as a 'bridge' between Europe and America.

Last year, Arnie Baker spoke eloquently about the mission of the USAEE: to advance the understanding and application of economics across all facets of energy development and use, to provide a forum for the exchange of ideas; and to foster an improved understanding of energy economics and energy-related issues by all. My frequent trips onto the Continent have offered a fresh perspective on America and on US policies — including energy policy - that was more difficult to have from my usual vantage points in Washington, Houston, and New York. In many respects, American energy policy has become increasingly unpopular in the capitals of Europe. The exchange of ideas and learning has been hindered by an intellectual divide opening up between market analysts and economists on opposite sides of the Atlantic.

Many Europeans blame the United States for fostering unilateralism in its policy choices. Several of the issues that are causing friction have little to do with energy (the debate over genetically modified foods, for example, or US steel import quotas). But a number of concerns directly or indirectly seem to involve oil, energy or the environment: the rejection of the Kyoto treaty on global climate change, sanctions on Iraq, the Law of the Seas convention, low gasoline taxes and 'cheap' energy, and US Mid-East policy in general. Signs declaring "No blood for oil!" are prominent in many of the street demonstrations in London. Is the quest for oil and natural gas the main driver of US international energy policy? What is the role of energy in foreign policy?

In my view, the growing rift on many of these subjects could be closed or at least bridged through more effective analyses and dissemination of research by our members. The US, as one of the world's most powerful advocates of global trade and open markets, has a difficult job. Mistakes get made, and decisions are often influenced by a rough-and-tumble political process that sometimes ignores economic criteria. Nevertheless, I believe that US companies are often accused of 'exploitation' when in fact their actions, governed properly, promote the creation of wealth and alleviation of poverty.

The word 'profits' is frequently used disparagingly, and is not well understood as a straightforward tool for efficiently allocating society's scarce resources and for motivating action. Norman Duncan's article in the November 2002 USAEE Newsletter pointed out that 'wealth' (could we read 'oil'?) is too often seen as a fixed entity to be seized and distributed. Americans generally view wealth as created by innovation and entrepreneurial energy, and are predisposed to maximize personal choice while minimizing the involvement of the state. It's not the oil that matters, but what you do with it.

Perhaps the divide would be narrower if more of us said "but have you considered this?" instead of giving a flat "yes" or "no" to the issues that we face. It is in that spirit of colloquy and bridge-building that I am looking forward to hearing more about these and many other topics at the upcoming IAEE International Conference in Prague (June 4-7) and the USAEE North American Conference in Mexico City (October 19-21).

This will be the first time that the North American Conference has been held in Mexico. Mexico and Canada each generate a significant portion of the world's GDP and both

(continued on page 2)

Editor's Corner

The Winter edition of USAEE *Dialogue* includes three articles. Dr Ferdinand Bank discusses another perspective on economic theory and the world oil market. Dr. Mamdouh G. Salameh's paper evaluates various strategies that are being espoused to reduce U.S. oil import dependency. The paper by Dr. Mark Kaiser and Professor Allan Pulsipher describes and identifies the decision variables underlying the use of explosive/non-explosive methods to remove offshore structures in the U.S. Gulf of Mexico OCS.

The issue also presents précis of a study on U.S. vulnerability to oil supply shocks published in the February 3, 2003, edition of *Oil and Gas Journal* by James Williams and Dr. A. F. Alhajji; a report on Houston energy deregulation and restructuring conference by Stephen Chriss and Marilyn Radler of the USAEE Houston chapter; and a spotlight by Lori Cameron on The Energy Council, a legislative organization founded in 1975.

Please send new articles, notices, news of chapter events, and relevant energy news to the editor via e-mail (wumi@lsu.edu.), by fax (225-578-4541) or by regular mail

(continued on page 2)

President's Message *(continued from page 1)*

countries are major producers, consumers and exporters of energy. Mexico has ambitious plans to restructure its economy and energy sector. Our conference will provide attendees with the opportunity to join industry leaders and prominent researchers - and to share their vision of the important issues underlying the integration of the energy markets. Program Chairman Pablo Mulás has done a superb job of organizing the conference- ably assisted by José M. Gonzalez, André Plourde and many others including Michele Foss, Joe Dukert and Shirley Neff.

It looks like 2003 could be one of the most volatile on record for the energy industry, and I am delighted that Marianne Kah, Rafael Quijano, and Michael Telson have agreed to be on the USAEE President's Advisory Committee. I'm sure that their collective skills on technical and strategy questions will be of enormous benefit to me and the organization. What Arnie Baker said last year is still true: energy issues are front and center on the public policy agenda. Education and communication are critical. The USAEE remains strong and vibrant, and our new council will endeavor to keep it that way. Please let me or Dave Williams (our long-serving and indispensable Executive Director) know how we can serve you.

Adam Sieminski

Editor's Corner *(continued from page 1)*

(Center for Energy Studies, 1107 ECE Building, Louisiana State University, Baton Rouge, LA 70803). If you have comments, suggestions and/or questions, I can be reached by phone at (225) 578-4552.

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USAEE

Dialogue Disclaimer

USAEE is a 501(c)(6) corporation and neither takes any position on any political issue nor endorses any candidates, parties, or public policy proposals. USAEE officers, staff, and members may not represent that any policy position is supported by the USAEE nor claim to represent the USAEE in advocating any political objective. However, issues involving energy policy inherently involve questions of energy economics. Economic analysis of energy topics provides critical input to energy policy decisions. USAEE encourages its members to consider and explore the policy implications of their work as a means of maximizing the value of their work. USAEE is therefore pleased to offer its members a neutral and wholly non-partisan forum in its conferences and web-sites for its members to analyze such policy implications and to engage in dialogue about them, including advocacy by members of certain policies or positions, provided that such members do so with full respect of USAEE's need to maintain its own strict political neutrality. Any policy endorsed or advocated in any USAEE conference, document, publication, or web-site posting should therefore be understood to be the position of its individual author or authors, and not that of the USAEE nor its members as a group. Authors are requested to include in an speech or writing advocating a policy position a statement that it represents the author's own views and not necessarily those of the USAEE or any other members. Any member who willfully violates the USAEE's political neutrality may be censured or removed from membership.

Nominations for 2003 USAEE Awards Requested

The USAEE is now receiving recommendations for the Senior Fellow Award and Adelman-Frankel Award recipients. Below please find a brief description of the awards and their parameters.

Adelman-Frankel Award

This award is given to an individual or organization for a unique and innovative contribution to the field of energy economics. The award may be given to someone residing outside of the U.S. Presentation is made at the annual North American Conference of the USAEE/IAEE. A plaque is given.

Senior Fellow Award

The Fellow Award is given to individuals who have exemplified distinguished service in the field of energy economics and the USAEE. Up to three recipients may receive the Fellow Award in any given year. The awards are given to the recipients at the annual North American Conference of the USAEE/IAEE. A small desk clock is given as well as life membership in the USAEE.

The USAEE Council welcomes recommendations from its membership for consideration in bestowing these awards. Please submit a 50-250 word recommendation of the person(s)/organization(s) you feel would be appropriate for receiving these awards to:

Dr. Michelle Michot Foss
Executive Director, IELE
University of Houston
100 Law Center
Houston, TX 77204-6060

Recommendations may also be faxed to Dr. Foss' attention at 713-743-4881 or emailed to mmfoss@uh.edu

*** USAEE WEBSITE UPDATED ***

If you have not been to usaee.org lately you are in for a surprise. Our new site has been rebuilt from the ground up, including a streamlined design, cleaner navigation and an easier search for information. We encourage you to visit usaee.org when looking for association happenings, news, conference and chapter information.

Some of the information you will find on our site includes:

√ Online Energy Discussion Forum
√ Overview/Objections of USAEE
√ Council and Chapter Presidents Listing & Contacts
√ Chapter News and Conference Information
√ Full Issues of USAEE's Dialogue
√ USAEE North American Conference Information
√ Links to IAEE's Energy Web Links and Member Database
√ USAEE/IAEE Membership Database

We're sure you will find our new site full of up-to-date information. Please feel free to drop USAEE Headquarters an email at usaee@usaee.org if you have any suggestions on how we can improve and expand our website.

INTEGRATING THE ENERGY MARKETS IN NORTH AMERICA:
Issues & Problems, Terms & Conditions

October 19-21, 2003 Camino Real Hotel México City, México

23rd IAEE North American Conference

Supported by

United States Association for Energy Economics
Asociación Mexicana para la Economía Energética
International Association for Energy Economics
Canadian Association for Energy Economics

Honorary Chair: Francisco Barnes, Undersecretary for Energy Policy, Mexico
General Chairs: Adam Sieminski, José Gonzalez Santaló, André Plourde

Program Chair: Pablo Mulás
Arrangements Chair: David Williams

Conference Objective

To explore the forces driving and opposing the creation of regional North American energy markets

Plenary Session Themes

Gas & Power Sector in North America
Oil & Natural Gas in Mexico
Energy Trade & Transport
Energy Security & Reliabity
Environment & Energy
Role of State Owned Utilities

Possible Concurrent Session Topics

Concurrent sessions will be developed from the papers selected for the program. The following is a non-exclusive list of possible topics: Resource estimates; Development challenges – deepwater, oil sands, GTL; Distribution networks - LNG, refineries, tankers, terminals, pipelines; Harmonization of fuel specs, MTBE, biofuels; Relationship with OPEC; Direction of the transportation sector; Integration of gas and electricity markets; Markets issues – regulatory reform, transparency, pricing, demand side options; Power sources – fossil, nuclear, renewable, distributed technologies; Sustainability and environmental issues; Access to capital, project finance, foreign investment; Impact of economic and demographic trends on continental energy markets; Infrastructure security; Energy R&D and technology transfer.

All topic ideas are welcome and anyone interested in organizing a session should propose the topic, motivations, and possible speakers to: Pablo Mulás – (p) 52/55/5483-4027 (f) 52/55/5483-4028 (e) pmulas@correo.uam.mx

**** CALL FOR PAPERS ****

Abstract Submission Deadline: June 13, 2003
(Please include a short CV when submitting your abstract)

Abstracts for papers should be between 200-750 words, giving a concise overview of the topic to be covered. At least one author from an accepted paper must pay the registration fees and attend the conference to present the paper. The lead author submitting the abstract must provide complete contact details- mailing address, phone, fax, e-mail etc. Please specify if you will be presenting your paper in Spanish or English. Authors will be notified by July 7 of their paper status. Authors whose abstracts are accepted will have until August 18 to return their papers for publication in the conference proceedings. Abstracts should be submitted to:

David Williams, Executive Director, USAEE/IAEE
28790 Chagrin Blvd., Suite 350, Cleveland, OH 44122 USA
Phone: 216-464-2785 / Fax: 216-464-2768 / E-mail: usaee@usaee.org

USAEE Best Student Paper Award ($1,000 cash prize plus waiver of conference registration fees). If interested, please contact USAEE Headquarters for detailed applications / guidelines. Student Participants: Please inquire also about scholarships for conference attendance.

Interested in touring Mexico? Visit www.mexico-travel.com or www.mexicocity.com.mx

!!! MARK YOUR CALENDARS — PLAN TO ATTEND !!!

New Challenges for Energy Decision Makers

24th IAEE International Conference – June 4-7, 2003
Prague, Czech Republic – Dorint Don Giovanni Hotel
Hosted by the Czech Association for Energy Economics

If you're concerned about the future of the energy industry and profession, this is one meeting you surely don't want to miss. The 24th IAEE International Conference will detail current developments within the energy industry so that you come away with a better sense of energy supply, demand, security and policy. Some of the major conference themes and topics are as follows:

Prospects for Global Energy Markets
Sustainable Development in Energy Context
Ethics in Energy Companies
Law and Energy Economics
Europe and the U.S.: Rethinking Energy Security
Energy Market Design: Experiences and Issues
Renewable Energy: Enhancing Long Term Security
Oil & Gas: Frontier Issues
Efficiency and Regulation of Electricity and Gas Distribution Companies

Volatile fuel prices, market restructuring, globalization, privatization and regulatory reform are having significant impacts on energy markets throughout the world. Most major energy industries are restructuring through mergers, acquisitions, unbundling and rebundling of energy and other services. This conference will provide a forum for discussion of the constantly changing structure of the energy industries.

At this time, confirmed speakers include the following:

Arnold B. Baker, Sandia National Laboratories
Lars Bergmann, Stockholm School of Economics
John Brodman, U.S. Department of Energy
Mary-Ellen Boyle, Clark University
Jean-Philippe Cueille, IFP
Robert Ebel, Center for Strategic & Int'l Studies
Medhi Farsi, University of Lugano
Massimo Filippini, University of Lugano
Michael Grubb, Imperial College, London
Tooraj Jamasb, University of Cambridge
Hoesung Lee, Council on Energy & Environment, Korea
Ray Leonard, YUKUS Oil Corporation
Charles McPherson, World Bank Group
Poul Erik Morthorst, RISO National Laboratory
Shirley Neff, Goldwyn International Strategies
Willy Olsen, Statoil
Miroslav Pise, EON
Yoshihiro Sakamoto, Institute of Energy Economics, Japan
Rick Sellers, International Energy Agency
Matthew R. Simmons, Simmons & Company Int'l
Nils von Hinten-Reed, CapAnalysis (Europe)
David Barton, Amnesty International
Fatih Birol, International Energy Agency
Alfred John Boulos, Boulos International
J. Christensen, RISO National Lab., Denmark
Robert Eagan, Sandia National Laboratories
Marie Fagan, Int'l Human Resources Devel. Corp.
Jean-Pierre Favennec, IFP-ENSPM
Herman Franssen, Petroleum Economics Ltd.
Einar Hope, Norwegian Sch. of Econ. & Bus. Admin.
Andrei Konoplyanik, Energy Charter Secretariat
Sang-Gon Lee, Korea Energy Economics Institute
Johannes Maters, European Commission, DG TREN
John Mogford, BP, Plc.
Mohan Munasinghe, Munasinghe Inst for Development
David Newbery, University of Cambridge
Anthony Owen, University of NSW, Australia
Robert Rios-Herran, Legal Advisor
Jiri Schwarz, Liberal Institute, Czech Republic
Adam Sieminski, Deutsche Bank AG
Vito Stagliano, Calpine
Frank Wolak, Stanford University

Keynote luncheon presentations will be given by Michael Fehn, Chairman, E.ON Czech Holding and Jeremy Leggett, Chief Executive, Solar Century.

We are very pleased to announce that over 260 abstracts have been received for presentation consideration. To the best of our knowledge this is the strongest response for abstracts in IAEE's history. Given this fact, we have extended the conference an extra half day on Saturday, 7 June. We are very pleased with this program extension which will allow for more speakers to present their papers. We have 35 concurrent sessions lined-up along with 5 separate poster sessions planned to address timely topics that effect all of us specializing in the field of energy economics.

Prague is a beautiful destination to meet and very affordable. Single nights at the Dorint Don Giovanni Hotel are EURO 151. Contact Denisa Havlik at the Dorint Hotel (denisa.havlik@dorinthotels.cz) or fax +420-2-6703-6704 to make reservations. Conference registration fees are $570.00 for IAEE members and $670.00 for non-members.

For further information on this conference, please fill out the form below and return to IAEE Headquarters.

New Challenges for Energy Decision Makers

24th IAEE International Conference

Please send further information on the subject checked below regarding the June 4-7, 2003 IAEE Conference.

_____ Registration Information _____ Sponsorship Information ____ Accommodation Information

NAME: ______________________________

TITLE: ______________________________

COMPANY: ______________________________

ADDRESS: ______________________________

CITY,STATE,ZIP: ______________________________

COUNTRY: ____________ Email: ____________ Phone: ____________

IAEE Conference Headquarters, 28790 Chagrin Blvd., Suite 350, Cleveland, OH 44122 USA

Phone: 216-464-5365 • Fax: 216-464-2785 • Email: iaee@iaee.org

Visit the conference on-line at: *http://www.iaee.org/en/conferences*

Report from Houston: Conference on Energy Deregulation and Restructuring

By Stephen W. Chriss and Marilyn Radler

Restructuring is a long and painful process during which there will be winners and losers. Strong market oversight is needed but, at the end, the process will yield significant benefits for the society overall. This was the conclusion from "Energy Markets at Crossroads: Has Deregulation Failed?"—a mini-conference hosted by the Houston chapter of IAEE on December 12, 2002, to address the current status and future of energy deregulation and restructuring. Interest was high, despite bad weather, with over one hundred representatives from the industry, academe, regulatory and government agencies and departments, and media participating in the half-day conference dedicated to discussion and presentations by distinguished speakers.

After a luncheon in the Grill Room of the Houston Club in downtown Houston, Dr. Iraj Isaac Rahmim, conference co-chair and Chapter president, and Dr. Gürcan Gülen, conference co-chair, opened the session.

Dr. Gülen set the tone by describing the serious credibility problem for energy companies caused by the negative impact of the 2001 California crisis and the trading scandals following the collapse of Enron on the energy sector. He described the country as roughly divided in half in terms of supporting FERC's Standard Market Design (SMD) proposal and so, despite the general lack of confidence in the industry, this "regulatory uncertainty," he stated, is the key reason for the absence of financing.

The purpose of the conference was not merely to focus on the California crisis but also to look at how other states, such as Texas, are handling the transition to competitive energy markets, and perhaps more uniquely, to review and learn from the record of other deregulated network industries.

Dr. Clifford Winston, Senior Fellow in Economic Studies at the Brookings Institution, was the keynote speaker and provided the review of other deregulated industries. Winston used the deregulation of airlines, railroads, and trucking in the United States to illustrate the results of introducing competition in these network industries. He started by stating that he has no second thoughts about deregulation, that he firmly believes it has been successful in these network industries, and that although he is not an expert on the energy industry, there is no fundamental reason for deregulation to fail in the electricity industry.

After reminding the audience that deregulation was the result of inefficiencies in old systems, Winston said innovations are key to deregulation. These innovations are in marketing, where knowing the customer is essential. Also, they are in the ability to properly respond to external shocks, which includes predicting demand. Efficiency enhancing innovations are the result of new entrants and increased operating freedoms provided by the competitive environment. He then discussed several examples of innovation in trucking, railroads, and airlines since these industries were deregulated. He further outlined the remaining role of government in an industry that undergoes deregulation as that of proper enforcement of laws, harmonizing other policies with deregulation, and resisting calls for re-regulation.

He concluded that deregulation has not failed. Experiments such as California's transition are necessary steps in the long and painful process of establishing competitive markets and that it is vital not to forget the initial economic motivation for deregulation and to find the least-cost solutions to the problem.

Dr. Michelle Michot Foss, Executive Director of the Institute for Energy, Law & Enterprise at the University of Houston Law Center, moderated a panel of four presenters consisting of Jeffrey Leitzinger, John Stauffacher, John Olson and Parviz Adib.

Dr. Jeffrey Leitzinger, President of Econ One Research, Inc. spoke on the lessons learned from natural gas deregulation, a restructuring process which involved a fair amount of trial and error. Market forces improved the allocation of resources, *i.e.*, the national pipeline grid, Leitzinger said, and that they balance supply and demand better than regulators do, which is the most important reason why deregulation happened.

The threat of stranded costs is a powerful force for change and, except for stranded costs absorbed by the industry, consumer savings are hard to find in gas deregulation. Rates declined because producers and pipelines absorbed the stranded costs of gas, Leitzinger said. A good way to see this is to examine the average residential price of gas in 1994 dollars: in 1984 and 1994, average price of gas was $8.73 and $6.41 per million cubic feet (MMcf), respectively. What happened? The average wellhead price declined $1.96/MMcf, the transmission margin declined $0.60/mcf, and the distribution margin increased $0.24/MMcf.

Mr. John Stauffacher, former vice president for Regulatory Affairs at Dynegy, spoke on the current situation in electricity markets, which are still in transition toward deregulation with one foot firmly planted in the past and much uncertainty because of a lack of clear direction.

Stauffacher said that the good old days and stranded costs were part of a political price that had to be paid. He warned that a "credit Armageddon" might loom as the credit rating agencies' credibility is suffering in the wake of Enron's fall and the electric industry is paying the price. He believes that major problems lie ahead, as $90 billion of projects face refinancing by 2006. "Who will the buyers be for all the non-completed power projects and those others left by the bankrupt companies?" he asked. Although he did not provide an answer, he

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* Stephen W. Chriss and Marilyn Radler are, respectively, the 2002-03 Secretary and Vice President of the Houston Chapter.

believed that most of these projects will be completed.

Stauffacher also mentioned two efforts by the industry to respond to the current crisis of confidence: the EPSA Code of Ethics and the Committee of Chief Risk Officers on governance and trading practices.

Mr. John Olson of Sanders Morris Harris spoke on liquidity in gas markets. Liquidity is gone, he said: in September 1998, the average trading volume of gas at Henry Hub was 4,210 million cubic feet per day (MMcfd). In September of 2002, that average volume had shrunk to 700 MMcfd.

Olson warned that the workforce in energy marketing is dwindling as well. The number of people employed in sales and trading in December 2002 is in the range of 1,500-2,000, down from 4,000-5,000 a year earlier. Although banks are making a stronger presence in trading now, they will quickly exit the energy trading business, he predicted.

Despite depressed capital spending today, Mr. Olson said that money will flow back into exploration and production, as wellhead revenues remain strong this decade. An integrated natural gas business model is currently the most attractive play, he said.

Finally, Dr. Parviz Adib, Director of Market Oversight Division at the Public Utility Commission of Texas, provided his views on the role of market oversight in competitive electricity markets. Adib believes that restructuring will eventually work, but as Winston and others also expressed, it will take time and it will be painful. In the case of electricity, he said, we cannot simply ignore what happened in California, market manipulation investigations by FERC, and questionable trading practices such as wash trades. Adib sees strong market oversight as the first step to help restore confidence in the energy industry. Key ingredients for successful market oversight are co-operation and communication between regulators and market participants, prevention of market design flaws, and deterrence of unethical behavior.

Overall, the following common theme seems to have emerged from the conference: restructuring is a long and painful process during which there will be winners and losers. Strong market oversight is needed, but at the end, the restructuring process will yield significant benefits for society overall.

Slide copies and related papers can be found on the USAEE Houston Chapter web link: http://www.usaee.org/energy/houston121602.asp

USAEE

Call For Papers

6th USAEE/IAEE

Allied Social science Associations Meeting

San Diego, CA - January 3-5, 2004

The IAEE annually puts together an academic session at the ASSA meetings in early January. This year's session will be structured by Professor Fred Joutz of The George Washington University.

The theme for the session will be "*The Value of and Role for Government/Strategic Inventories in Petroleum Markets*." If you are interested in presenting a paper, please send an abstract of 200-400 words to Fred Joutz at bmark@gwu.edu by May 23, 2003. If you are willing to be a paper discussant, email your interest by that date as well.

Preliminary decisions on papers to be presented and discussants will be made by July 1, 2003. The program including abstracts will be posted at www.iaee.org by September 1, 2003. Papers and comments will be published with those for the North American meeting of the USAEE/IAEE that follows the January meeting. Please send abstracts in electronic format that is easily converted into program information. (e.g. WORD, WP, or text file).

For complete ASSA meeting highlights and pre-registration information please visit: http://www.vanderbilt.edu/AEA/index.htm.

USAEE Student Scholarship Fund: A Call for Support

USAEE is proud to continue its student scholarship fund. Funds are used to cover the cost of registration fees for students attending the annual conference of the USAEE/IAEE. Students must submit a written application and letter from their student advisor requesting that funds be granted. At the Vancouver Conference, eight students qualified to have their conference registration fees waived in an effort to share our conference experience, the field of energy economics and networking opportunities with other students. Further, inviting student participation at our conferences is one of the best mechanisms for recruiting new members to the USAEE.

The 2002 student scholarship fund has been generously provided by the support of the following organizations/individuals:

ConocoPhillips
Exxon Mobil Corporation
Andre Plourde

Recognizing the need for interested and qualified graduates, many funding organizations view the program as supporting education as well as recruitment. The USAEE has started its campaign for scholarship funds for the 2003 North American meeting in Mexico City, Mexico, October 19-21. Contributions have ranged from $50 to $2500. If you would like to receive information on how your or your company can become a supporter of this program, please contact Dave Williams, USAEE Executive Director at (p) 216-464-2785, (f) 216-464-2768, or usaee@usaee.org

!!!!! MARK YOUR CALENDARS – PLAN TO ATTEND !!!!!

Integrating the Energy Markets in North America: Issues & Problems, Terms & Conditions

23rd IAEE North American Conference
Supported by the USAEE/AMEE/CAEE
October 19 – 21, 2003
Mexico City – Camino Real Hotel

If you're concerned about the future of the energy industry and profession, this is one meeting you surely don't want to miss. The 23rd IAEE North American Conference will detail current developments within the energy industry so that you come away with a better sense of energy supply, demand, security and policy. Some of the major conference themes and topics are as follows:

North American Energy Security and Reliability
Continental Trade and Transportation: Forward or Reverse?
Gas and Power – Convergence or Divergence?
Environment and Energy in North America
Oil and Gas in Mexico
Role of State Owned Utilities in North America

Volatile fuel prices, market restructuring, globalization, privatization and regulatory reform are having significant impacts on energy markets throughout the world. Most major energy industries are restructuring through mergers, acquisitions, unbundling and rebundling of energy and other services. This conference will provide a forum for discussion of the constantly changing structure of the energy industries.

At this time, confirmed and/or invited speakers include the following:

Francisco Barnes, Undersecretary for Energy Policy & Technology
Luis Giusti, Center for Strategic and International Studies
Adrian Lajous, Petrometrica
Joseph Dukert, Energy Consultant
Mario Molina, Nobel Prize Winner, MIT
Javier Estrada Estrada, Consultant
Jean-Thomas Bernard, Universite Laval
Andre Plourde, University of Alberta
Ernesto Martens, Secretary of Energy
Bradley Patterson, Duke Energy International Mexico
Shirley Neff, Goldwyn International Strategies
Guy Caruso, Energy Information Administration (tentative)
Michelle Michot Foss, University of Houston
Rafael Fernandez de la Garza, PEMEX
Roberto Osequeda Villasenor, PEMEX Corporativo
Daniel Resendiz Nunez, Comisión Federal de Electricidad
Juan Eibenschutz Hartman, Comision Nacional de Seguridad Nuclear y Salvaguardias

There are 28 planned concurrent sessions. The abstract cut-off date is June 13, 2003 (please visit http://www.usaee.org/energy/) for to view our Call for Papers announcement. Given the location of the meeting in Mexico City, we anticipate a good draw to our concurrent sessions.

Mexico City is a city filled with history and a great place to begin or end a pre/post vacation. Single nights at the beautiful Camino Real Hotel are $110.00 per night. Contact the Camino Real Hotel at 5255-5263-8889, to make your reservations. Conference registration fees are US$570.00 for USAEE/IAEE/AMEE/CAEE members and US$ 670.00 for non-members.

For further information on this conference, please fill out the form below and return to USAEE/IAEE Conference Headquarters.

Integrating the Energy Markets in North America: Issues & Problems, Terms & Conditions

23rd IAEE North American Conference

Please send further information on the subject checked below regarding the October 19-21, 2003 IAEE North American Conference.

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NAME: ______________________________
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USAEE Conference Headquarters
28790 Chagrin Blvd., Suite 350 • Cleveland, OH 44122 USA
Phone: 216-464-2785 • Fax: 216-464-2768 • Email: usaee@usaee.org

Visit the conference on-line at: http://www.usaee.org/energy/

Focus on the Energy Council

The Energy Council is a legislative organization founded in 1975. The original five member states (Louisiana, Arkansas, Oklahoma, Texas and New Mexico) were located within the same region, and the group was initially known as the Southwest Regional Energy Council.

The organization was formed to provide a forum for producing-states legislators interested in energy policy. It allows legislative policymakers to maintain a dialogue and learn more about energy issues of importance to their states, citizens, environment and revenue base. Today the member states number ten, including Mississippi and Alabama to the East and Colorado, Wyoming, and Alaska to the West.

In recognition of the international nature of energy markets, the Council has welcomed four international affiliates over the last decade—the nation of Venezuela, as well as Canadian Provinces of Alberta, Newfoundland and Labrador, and Nova Scotia.

Two years ago, the Energy Council's Executive Committee (comprised of two senators and two representatives from each state) completed an 18-month project drafting a National Energy Strategy proposal. The essence of the proposal may be summarized as conservation, access (in the broadest sense of the word), and technology. These guiding principles were the basis of presentations made to congressional and Administration offices in the spring of 2001.

In 2002 the Energy Council's goal of promoting dialogue on energy issues led to the Northeastern Energy Forum, held in August in St. John's, Newfoundland. Focusing on issues of importance to policymakers in energy-consuming states, the Council invited legislative peers from 10 Northeastern states. Key amoung the issues discussed were transmission concerns.

The Forum was held in Newfoundland to showcase the emergence of energy supplies destined for Northeastern United States markets. Participating Energy Council legislators gained a better understanding of energy consumer issues and an appreciation of developing Maritime energy resources.

The Energy Council's most recent initiative is a policy statement urging Congress and the Federal Energy Regulatory Commission to accommodate interstate compact commissions to govern the siting of energy transmission projects.

One of the strengths of the Energy Council is its ability to draw on both the private sector and academia for comments and input on policy questions. To this end the Council has an affiliate organization, the Center for Legislative Energy and Environmental Research (CLEER).

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U.S. Vulnerability to Oil Supply Shocks: Petroleum Security Measures Warn of Trouble!

James Williams, president of WTRG Economics and Dr. A. F. Alhajji, an economics professor at Ohio Northern University, Ada have just concluded a research study on energy security in the U.S. and Europe. The authors have identified and evaluated fourteen measures of energy security, which they plan to publish in a series of articles in various specialized magazines and journals in the U.S. and Europe. A summary of their research results with respect to petroleum supply security in the U.S. appeared in an article entitled "Parallels With Earlier Energy Crises Underscore US Vulnerability to Oil Supply Shocks Today" in the February 3, 2003 edition of *Oil and Gas Journal*.

Defining energy crisis as "a situation in which the nation suffers from a disruption of energy supplies (in the U.S. case, oil) accompanied by rapidly increasing energy prices that threaten economic and national security," five principal measures of petroleum security from the U.S. perspective. These measures, which they analyzed in their paper include domestic production capacity, dependence on imports, the degree of import concentration, petroleum inventory relative to imports, and the ability to second source petroleum imports in the event of an interruption from one or more suppliers.

Williams and Alhajji compared the factors that accounted for the shortages of 1973 and 1979 to those underlying the current state of the global oil market economy, and reported that relative to the time of the oil embargo in 1973, domestic production is about half what it was then, dependence on imports is 50 % higher, the number of days that stocks can replace imports is 5 % lower, and a larger percentage of imports is concentrated in a few suppliers.

They concluded that the signals that existed prior to the energy crises of 1973 and 1979 suggest that the potential for an oil supply shocks in the U.S. has never been higher than today.

Another Perspective on Economic Theory and the World Oil Market

*By Ferdinand E. Banks**

> "The world can have the energy it needs for the rest of the 20th century,… But herein lies the real problem. With a false sense of security, many will not look over the horizon to the early part of the 21st century. … It is only by looking beyond the early 2000's that we can see how fast the change will come."
>
> *J. Kiely (1980)*

Earl Cook (1975) makes the following important observations: the (long run) recovery prospects for oil in the United States are such that they "may unbridle the technological optimist, and allow estimates that put extreme demands on the technological cavalry to come riding over the hill in the nick of time to rescue the nation from scarcity."

Many economists expect technology to come riding to the rescue in case the television audience paints itself into an energy corner, and they also have an unreasonable faith in the ability of the price system to get them the oil they want. Why the latter? The answer is that they fail to understand its more subtle ramifications where exhaustible resources are concerned.

One of the absolutely largest producing oil wells in history, the Cerro Azul Number 4, near Tampico, Mexico, featured an initial production rate of 260,000 barrels per day. Eventually it produced 60 million barrels, and then suddenly its only output was salt water. No price system of any sort can be constructed that is capable of forming the (*scarcity*) prices required to efficiently allocate resources in the presence of geological uncertainty of this nature, to include a price system that is supplemented by a full range of futures and options markets.

There are many points of this nature that need to be repeatedly brought to the attention of persons with a serious interest in the oil market, and a few of them are found below. There is also a short algebra comment in the appendix that may interest many readers. I would like to emphasize that the main thrust of this paper is pedagogical, since students of economics need to be thoroughly familiar with some elementary geological concepts that are crucial for understanding the oil market. At the same time, they should learn to ignore the interpretations and extensions of the exhaustible resource hypothesis of Harold Hotelling (1931), as well as question why it is given so much valuable time in lectures and space in books and articles.

Beliefs and Disbeliefs

About 20 years ago several world-class econometricians and energy economists used a very complex econometric model to predict that after the US gas price was 'freed', production would reach an (at that time) astronomical 34 Trillion cubic feet/year (= 34 Tcf/y). Equally ambitious examples of econometric overkill were once a common feature of energy publications and conferences, but now most alert researchers have learned that it is a good career move to leave their more abstract econometric investigations in their offices when confronting knowledgeable audiences. Of course, in unguarded moments a few of these researchers can still be detected claiming that healthy price rises will provide unlimited access to resources that no longer exist.

At the same time that the above (natural gas research) effort was taking place, the United States Geological Service (USGS) provided an estimate of the amount of gas that might ultimately be found in the US that was so extreme that the same organization soon felt compelled to reduce it by three-fourths. The USGS recently published an unexpectedly cheerful estimate of oil that is as yet undiscovered, but which – they say – will eventually be moved into the 'discovered' bracket. It seems to me that these two estimates – and perhaps others – may have a political dimension. Given the circumstances in which they appeared, it would not have been tactful to arrive at the opposite conclusion.

Several years ago I attended a lecture by the chief economist of a leading oil company, in the course of which he pieced together a vision of the future world oil supply that, to my way of thinking, was completely detached from reality. Now I hear that the chief economist of another enterprise has issued a report in which he and his staff envisage the oil price declining after 2010 (or so). This is not impossible; however, it should never be forgotten that oil firms are spending billions of dollars to locate and make possible the exploitation of (in an historical sense) fairly modest deposits, and if it were generally believed that the oil price might be steadily rising after 2010, obtaining access to these deposits could cost many more billions in the form of royalties and merger/buy-out costs.[1]

A further comment might be useful here. Oil extraction and exploration in deep-sea and frontier environments are accompanied by huge unrecoverable costs. The profitability of any project of this nature is thus vitally dependent on the expected value of future oil prices relative to the various investment costs that might be incurred (which in certain situations are (*ex-ante*) highly uncertain). Even though the (*ceteris paribus*) growth in oil demand is comparatively easy to predict, long-term oil prices are difficult to estimate due to the uncertainty associated with long-term supply.

Because of such uncertainties, the investments being referred to above are conventionally undertaken only when expected returns are substantially higher than 'required' returns – i.e. returns that are associated with the opportunity cost of capital. Put somewhat more technically, a discounted cash flow analysis of the project must result in monetary outcomes that exceed the present value of investment expenditures by a large amount. Thus, when we see the size of the investments that are actually being undertaken in deep-sea and frontier environments, it is difficult to avoid the conclusion that the managers of large oil producing corporations do not generally

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[1] See footnotes at end of text.

adhere to the pessimistic depiction of low future oil prices that their (paid and unpaid) publicists disseminate..

Of course, occasionally the meaning in the messages that we encounter might be considerably more difficult to decipher. Until recently, the Caspian area has been identified by the popular press as a minor Kuwait, while the tar sands of Alberta have been proclaimed by any number of observers to be the location of an oil bonanza superior in volume to that found in Saudi Arabia. As it happens though, in a recent edition of the *Newsletter of the International Association for Energy Economics*, Mamdouh Salameh (2002) suggests that the Caspian is a vastly overrated oil province – at least on the basis of information that is available at the present time.

I can go farther than that. A simple examination of the ratios of estimated undiscovered reserves to identified reserves will show that this ratio is much greater for the Caspian area than for any other part of the world – so much greater that it is impossible to disregard a warning by the Baker Institute (of the University of Houston) that the Caspian Basin is not going to be an "ace in the hole for international energy security." Something else that should be kept in mind is that the macroeconomic growth that could take place in Russia in the not too distant future would *(ceteris paribus*) require changes in the rosy supply picture that is entertained by many potential importers of Caspian and Russian oil. This is not to deny, however, that if world oil production should peak in ten or so years, any amount of oil that can be exported from that part of the world will be extremely valuable.

Similarly, many of the spectacular claims that have been promulgated about the Alberta tar sands are designed to attract investment dollars to that region. The unvarnished truth is that neither the tar sands of Alberta, nor the tar sands of anywhere else have lived up to their grandiose publicity, nor will they do so unless the world oil price increases by a considerable amount.

From Myth Toward Reality

A few years ago I had the distasteful experience of being assured that as a result of such things as horizontal drilling and seismic imaging, oil exploration and production were on their way into a new golden age. I chose to disregard a large part of these tidings because I had heard them about a decade earlier. Horizontal drilling could help to reduce drilling costs but, again, it will not find oil that does not exist. By the same token, one of seismic imaging's most important uses has turned out to be confirming the absence of oil in areas where optimists once convinced audiences that giant oil fields could be located and profitably exploited.

The cardinal reality of oil is to be found in the present amount of its consumption – almost 76 million barrels per day (= 76 Mb/d) – and a predicted need to increase oil production by at least a million barrels every year over the forseeable future.[2] We are talking here about a great deal of oil, and in these circumstances it could be a momentous indiscretion to accept or to even contemplate theories claiming that new projects in exotic locales can compensate for the stagnation in production increases that could take place in certain oil rich countries if very many billions of dollars in physical investment do not find their way to these countries, and perhaps fairly soon, or if these states decided to exhibit the same interest in their own long range economic development as they have graciously shown in contributing to inexpensive motoring in other parts of the world.

But even if they continue to be so benevolent, it might not make a difference. The amount of oil discovered over the past ten years seems to be only 25-30% of that being produced, and the amount of reserves that are discovered every decade is not only falling, but falling by a large amount. Furthermore, even if it turns out that technology is 'overwhelming natural depletion' and reducing costs all along the line, which may be true, without an increase in the amount of oil discovered, preferably in the form of larger deposits, the rise in global production that has brought so many benefits to world motorists and jet setters will have to come to an end. This is considered in some detail in my textbook and the survey mentioned above (2001), and can be explained as an *economic* as compared to a *geological* phenomenon.

However, let me make it clear that a close look at the numbers does not substantiate the exasperated point-of-view put forth by the oil optimists when they encounter opposition to their various ruminations. Since l981, US oil output has fallen from 8.6 Mb/d to 5.8 Mb/d, even though firms now drill deeper (to an average of 6,105 feet, as compared to 4,512 feet 20 years ago). In addition, the cost of the average production well is now about $769,000 as compared to $855,000 (in real terms) in l981, and the success ratio has reached 80% as compared to the earlier 70%. The profitability of some international operations is also impressive, and where the major oil companies are concerned, there is no sign that it will decline. But even so, in the light of the observed fall in production, it might be best for all concerned if any festivals that have been planned to celebrate oil plenitude are not launched in the near future.

Thus, regardless of any technological prodigies that are ostensibly being performed on deposits in that country, aggregate production continues to decline, while imports of crude increase. Given the quantities that are involved, this is not a particularly attractive prospect for anyone, anywhere in the world, that is on the buying side of the oil market, however there is precious little that they can do about it. The US oil sector is on the falling portion of its depletion curve, and a durable reversal of this situation is almost unthinkable – and by that I mean almost unthinkable if every square inch of onshore and offshore US territory, to include Alaska, was thrown open to exploration and production, regardless of the environmental costs.

The Most Important Observation

An observation by the International Energy Agency (IEA) in their latest survey deserves some mention here. They have finally come to the conclusion that world oil production *could* peak around the end of the present decade – even though the global reserve-production ratio (R/q) is around 40. Since I have always believed that for non-geologists like myself, the critical R/q ratio [= e.g. $(R/q)^* = q^*$] as compared to the simple (R/q), is supremely important, this could mean that the IEA has finally stopped trying to draw conclusions from the simple figure (of about 40).

When the R/q ratio for a well or a field or a reservoir falls below its critical value, this ratio will determine production in the sense that production should adjust in such a way as to keep the R/q ratio constant. If this were not done, it would be tantamount to overworking the deposit, and as a result of accelerated (physical) depreciation, the amount of oil that could be ultimately obtained would be reduced. Let's be even more explicit about this. According to Craft and Hawkins (1959), "…many reservoirs are clearly rate sensitive, and there is a maximum efficient rate above which there will be a significant reduction in the practical ultimate oil recovery." There is also the matter of wasting a part of the useful life of the associated production equipment and/or infrastructure. What happened in the US a few years ago was that the R/q ratio fell below 10 – which is often taken as the bottom limit of the critical value – and surprisingly continued downward until it was approaching 9 nine. At that point the inevitable happened in the form of one of the largest declines in US oil output in modern times. (But please notice that output in the US has been falling since l970-71; this sharp decline was merely an accentuation of the downward trend.)

Although production is falling in the US, just as it is falling or soon will fall in several other important producing regions, it is rising in other districts (e.g., the Caspian and Angola). As summarized by Bentley (2002), evidence seems to be accumulating that the upshot of these declines and rises is a global peak that could come before the end of the present decade. The argument here is straightforward. Oil discovery peaked in 1964, and (on average) declined until the first oil price shock, after which there was a brief surge in discoveries that was soon followed by a continuation of the downward movement. Assuming that the ultimate supply of oil is about 2000 Gb, some observers suggest that the global oil supply could peak as early as 2005. Needless to say, this is very, very unlikely. In fact, for political reasons it is impossible – although the less said about those reasons the better. The same is true of the estimate by Deffeyes (2001) that the peak could arrive sometime between 2003 and 2008, (geologist and statistician J.H. Laherrère believes that Deffeyes work correctly captures the discovery/ production behavior of most basins and regions).

Let's look at it this way: if the ultimate supply of conventional oil is 2000 Gb, which seems to be the consensus figure, then the peak should arrive around 2010. Interestingly enough, although the World Energy Outlook of the IEA for 2000 predicted a peak "beyond 2020" (based on a USGS estimate of 3345 Gb for the ultimate supply of oil), their most recent publication alludes to the possibility of a much earlier peak – which suggests that their confidence in USGS estimates has decreased.

Can this peak be delayed? I have heard arguments based on the work of Deffeyes (2001) that this is impossible, but I disagree. The production curve has a bell-like appearance, which means that after the peak, production does not collapse. Thus, in order to delay the peak, some output must be shifted backward from the period after the peak toward (and past) the imminent peak. This will postpone the peak, though it could entail a sizable increase in the aggregate unit cost for this non-peak period. Should it be desired to further delay the peak, the same procedure can be resorted to again; however, this will result in an even larger aggregate unit cost. Eventually, this increase in the cost will be judged unacceptable (unless there is an emergency), and so the peak will be experienced, followed by a decline. Regrettably, the longer the peak is delayed, the steeper will be the decline. Please notice the primacy of economics in this argument. Geology plays a supporting role.

But there is a geological componen that all readers should make an effort to comprehend. The production of conventional oil involves reservoir fluids flowing under pressure out of the reservoir rock into a production well (or borehole). Initial production tends to be constant for a period ranging from several days to several years. Then, as the pressure declines as a result of production, and/or the oil having to move longer distances through the reservoir rocks to reach a given well, the output will tend to decline – *ceteris paribus*. One of the things that will reduce the pressure further is a too rapid depletion (given such factors as the relative size of the field, and the permeability and porosity of the reservoir rock), since this will permit increasing quantities of gas and water to move into the reservoir rock near the well, and thus displace the oil

Now we see why the R/q ratio is so important: when operating below the critical R/q ratio, we are reducing the amount of oil that can ultimately be obtained. Something else that should be recognized is that petroleum engineering is a serious profession, and not every economist has the background or time to understand the more elusive details of oil production. Thus, for economists, levels and changes in the R/q ratio are proxies for a great deal of important geological information. The production profile for a typical oil field – where a field is a group of deposits in the same general area – exhibits rising production, a plateau, and then falling production. Obtaining this profile begins with drilling a number of production wells. Initially the flow from new wells exceeds the depletion of those already drilled, and so we start out with a rising production pattern. Then, new drilling takes place at a pace that is designed to keep output more or less constant, and finally drilling slows because as the amount of oil remaining in the field declines, the cost of extra wells can be extremely high compared to the additional amount of oil obtained. The downturn in drilling accounts for the declining portion of the profile.

Something that has not been done above is to distinguish between *natural drive*, and more sophisticated production mechanisms (such as pumping water or reinjecting gas into the reservoir in order to maintain pressure). This matter is too technical to discuss here, but it should be emphasized again that the total amount that can be taken from a deposit may depend on the pattern/sequence at which production has and will take place. (If, e.g., 10 Mb is to be removed from a deposit in the next 5 years, taking 2 million barrels a year could have a very different effect on ultimate recovery from taking 3 Mb/y during the first 2 years, and 4/3 Mb/y over the final 3 years of that period.)

Before continuing, a few statistics might be in order. The conventional oil already produced is (about) 850 billion barrels (= 850 Gb). The consensus figure for proved reserves available now is also 850 Gb. The (estimated) amount that will still be found is 300-500 Gb, and thus *ultimate* reserves are 2000-2200 Gb. Optimists, however, say that ultimate reserves are 3000 Gb, and pessimists say 1900. If we look at the forecasts of the IEA for world demand, we see crude oil demand in 2010 at 85 Mb/d – although given the present condition of the world economy, it could turn out to be slightly lower. Theories also exist suggesting that if about one-half of the ultimate global oil supply has been consumed (= 1000 Gb), then *global* oil supply will replicate the production pattern of a typical reservoir or oil producing region and peak. Unfortunately, I consider this an unproved hypothesis.

Oil – a Few Basic Truths

The title of this section is the title of an APPEC conference that was recently held in Singapore. One of the speakers was Dr Leo P. Drollas who is the deputy director and chief economist of the Centre for Global Energy Studies in London. Dr. Drollas began his presentation by quoting Disraeli: "Something unpleasant is coming when men are anxious to tell the truth."

Unpleasant is the exact word that I would use, because I really don't know what kind of economics is being practised in this old world of ours when it is possible to come to Drollas' conclusion that OPEC has been placed in the "invidious" position of having to shut in some of their low-cost production in order to accomodate the growing output of the higher-cost producers. They have not been placed in this position (by external forces or circumstances). Instead, they have placed themselves, and rightly so. Twenty or thirty years ago Professors Morris Adelman, Peter Odell, and others envisioned OPEC countries flooding the world with cheap oil, which would have meant depriving these countries of the only resource they possess for diversifying/developing their economies. I studied and taught development economics at one time, before giving it up as a pretentious waste of time; but for genuinely ambitious OPEC countries, the more sophisticated development literature contains some important lessons. Even the Shah of Iran understood that oil was "too precious to be burned up in the air" (in order to e.g. keep our Volvos rolling toward the skiing and partying at Courchevel or St. Anton). Instead, as much as possible should be saved to be used as an input in the production of petrochemicals, or to furnish energy for various other industrial activities.

A Final Comment

There are two points that need to be stressed before concluding this short paper. The first is that something might appear odd about the claim that by the end of the next 8 years, at least another 8 Mb/d of oil must be produced. If the present consumption is 76Mb/d, and the present rate of growth of consumption is between l and l.5 percent/year, then it does not appear easy to justify a production of at least 84 Mb/d by 2010, not to mention the larger numbers that we often encounter.

In reality, however, it is a simple matter. As pointed out by Husseini (2002), the total increase in production must make up for both the increases in oil consumption and the natural decline – i.e. natural depletion – in existing oil wells in mature basins. Accordingly, the necessary rate of production increase could be substantially above the 1-1.5 percent that apply to consumption..

I also want to mention again that even the brilliant microeconomics textbooks that we teach from contain an illusory depiction of natural resource extraction based on the work of Harold Hotelling. A unique attribute of Hotelling's work entails identifying the rate of interest as the key variable for determining intertemporal natural resource production, although with oil and gas the key variable is reservoir pressure. An important exception is the textbook of Besanko and Braeutigam (2002), and the reason it might be an exception is because Braeutigam is a graduate in petroleum engineering who probably has no sympathy for esoteric foolishness when dealing with the most important commodity in the world.

Footnotes

[1] A good example here might be negotiations between oil companies and governments for access to oil located near the West Coast of Africa.

[2] See the first paragraph of the conclusion for the need to distinguish between annual additions to consumption and annual additions to production.

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Appendix

"…..never underestimate the power of oil."

-The Economist (April 13, 2002)

As noted in the previous discussion, in a producing well, in order to maintain pressure, the flow should be limited so that yearly production should not exceed – or rarely exceeds – l percent of remaining reserves. This immediately identifies l as the reciprocal of the critical reserve production ratio, or $q^* = 1/l$. With present reserves and production at R_0 and q_0 we have $q_0 \$ lR_0$. Similarly, for the next period we can write $q_1 \$ lR_1 = l(1 - l)R_0$. If we continue in this vein then we should soon see that for any period 't', we can write $q_t \$ lR_t = l(1 - l)^t R_0$. Observe that what we are doing here is putting a 'ceiling' on the allowable production in a given period. Although the above expressions consist of inequalities, at the peak, at time t, if we assume that production is expanding by g percent per year, then we can write $q_t = q_0(1 + g)^t = l(1-l)^t R_0$.

This expression can be solved for t. First we can write it as:

(continued on page 18)

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United States Energy Security in the 21st Century: Is Rising Oil Import Dependency a Threat?

*By Mamdouh G. Salameh**

Introduction

The United States has been for ages diversifying its fuel mix and its energy import sources. First coal replaced wood, only to be itself replaced, to a large measure, by oil and then by natural gas. Natural gas and nuclear energy have been replacing coal and oil for electricity generation for years. In the coming years fuel-cell vehicles will make their appearance on the market side by side with the internal combustion (IC) vehicles while solar energy will contribute significantly to electricity generation along with natural gas and nuclear energy. The US is already investing heavily in the research into solar photovoltaic, fuel-cell motor technology and other technologies for alternative and renewable energy sources.

In 2001 the United States imported 58% of its oil needs, almost half of which came from the Middle East and the rest from Canada, Mexico, Venezuela and West Africa (Angola and Nigeria). Although the US has been for a long time diversifying its oil import sources, the fact remains that these countries have limited productive and export capacities and can't, therefore, satisfy the US growing oil needs in the long-term. The Middle East with its immense oil and gas reserves and its huge potential for expanding production capacity, can;; hence the US growing dependence on oil supplies from the region.

At present, energy in the United States comes mainly from fossil fuels (oil, natural gas and coal). Indeed, in 2001 oil accounted for 40% of total US primary energy needs with natural gas accounting for 25% and coal for 25%. Nuclear power provided 8% of energy needs and hydro-electricity only 2%.[1] Table 1 shows that the United States will continue for the foreseeable future to be a major consumer of fossil fuels with natural gas being the fastest growing fuel followed by oil and coal. The United States' heavy reliance on fossil fuels is projected to continue well into the twenty-first century.

Table 1
United States Fossil Fuel Consumption, 1990-2020

Fuel	1990	2000	2005	2010	2015	2020	Average Annual % change 1990-2020
Oil (mbd)	17.0	19.8	21.2	22.7	24.3	25.8	1.7
Natural gas (tcf)	19.1	23.1	25.2	28.0	31.6	34.7	2.7
Coal (mtoe)	482	565	629	657	671	690	1.5

Sources: US Energy Information Administration (EIA), International Energy Outlook 2001 / BP Statistical Review of World Energy, June 2002.

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Oil Dependency Versus Vulnerability

In the aftermath of the first oil crisis in 1973, the United States and other major oil consuming countries have encouraged exploration for oil in areas outside the Middle East. Thus since then, exploration and development operations have accelerated all over the world including the North Sea, West Africa, Latin America and lately the Caspian Basin.

But despite the increasing supplies from the North Sea, Latin America, West Africa and the Caspian Basin, the Arab Gulf region remains the main source for global oil supplies. This situation is underpinned by four facts. First, the Gulf region holds 65% of the global oil reserves and 35% of the world's total natural gas reserves.[2] Secondly, the Gulf region has at present 75%, or 4 mbd, of the global spare oil production capacity.[3] This is important in the event of supply disruption unless the disruptions were to occur in the Gulf region itself. Thirdly, costs of oil production in the Gulf region are the cheapest in the world, ranging from \$1/b-\$2/b. Finally, oilfields in the Gulf are located close to global markets and also to transport routes.

Dependence on oil imports by the United States and other major consuming countries has been on the rise over the last two decades and this trend is set to continue for the foreseeable future (see Table 2).

Table 2
Imports from the Gulf as % of Net Oil Imports, 1983-2001

Year	US	W.Europe	Japan
1983	9%	41%	60%
1987	16%	43%	60%
1990	25%	48%	65%
1993	21%	50%	68%
1998	20%	50%	76%
2000	25%	57%	79%
2001	26%	57%	81%

Source: EIA / BP Statistical Review of World Energy, June 2002 / Japan's Ministry of International Trade & Industry (MITI).

Today, one promising oil province that remains unexplored is the Spratly Islands in the South China Sea, where exploration has been delayed by conflicting claims to the islands by six different countries. Potential reserves in the disputed territories are estimated in multi-billion barrels of oil and gas. Although the South China Sea is an attractive prospect, there is little likelihood that it is another North Sea.[4] But even if the South China Sea oil reserves are proven, they could hardly quench China's thirst for oil, let alone enhance US energy security. By 2010, China will need to import 6.35 mbd, or 76% of its needs, and would have by then overtaken Japan to become the world's second largest oil importer after the United States.[5]

Another promising oil province is the Caspian Sea. Fanciful estimates claiming that Caspian oil reserves could rival those of other sources have gone as far as to ascribe potential recoverable oil reserves of 200 bb to the area. However, according to the BP 2002 Statistical Review of World Energy, the Caspian Sea's proven reserves are at present estimated at 16.8 bb, or 1.5% of the world's total proven reserves. Apart from the limited size of the reserves, the area's oil is very costly to find, develop, produce and transport to world markets. Caspian

Sea oil production of 2-3 mbd by 2010 can be achieved only when oil prices exceed the $17/b-$18/b range. Oil prices will be the key factor in the expansion of Caspian Sea oil.[6]

In 2001, total oil exports from the Caspian Sea amounted to only 645,000 b/d. These exports are projected to rise to 2.34 mbd in 2010 reaching 3.6 mbd by 2020. In contrast, exports from the Gulf region are projected to reach 41.8 mbd by 2020.[7] With long-term production potential that would contribute roughly 3% to future global oil supply; thus, the Caspian will never be a strategic alternative to the Arab Gulf. Moreover, the projected exports of Caspian Sea oil will only make a modest dent in the United States energy security.

The United States already imports 1.4 mbd from West Africa (Nigeria & Angola). However, both countries have a very limited potential to increase production and export capacities. At best, they may be able to increase exports to the US by 400,000 b/d to 1.8 mbd by 2010.

In order to meet the growing US and global demand for oil, production capacity has to be expanded in major Gulf producers. However, two major factors will determine the scope and the magnitude of this necessary capacity. The first factor is the price of oil. It is estimated that adding a new 5-mbd capacity by the big five producers in the Gulf by 2005 will necessitate an estimated investment of $31.2 billion.[8] Without a relatively high oil price ranging from $25 to $28 a barrel, the Gulf producers would neither have the incentive nor the capital to expand capacity.

The other factor is geopolitics in the Gulf region. US sanctions policy has slowed down the development of the huge oil reserves in Iraq, Iran and Libya. This has meant less diversification of production capacity and less total capacity. Lifting the sanctions against these three countries would be the logical way to de-escalate the political tensions in the Middle East, build up the Gulf producers' production capacity and enhance global oil supplies. By any standards, Arab Gulf producers will remain central to world oil security and the region will continue to be a primary focus of the United States energy policy.

Thus, a clear distinction should be made between dependency on oil imports and vulnerability. Oil dependency does not necessarily mean that the US is vulnerable to oil supply disruptions. If the US oil imports come from many producers and one of them suddenly stopped exporting oil, this would have little impact on the US, even at a high rate of US dependency, unless that producer is Saudi Arabia or Russia. The United States, for instance, imported 58% of its oil needs in 2001, but it did so from 60 different countries, no one of which accounted for more than 16% of the total. Concentration on a few suppliers, not dependency, would lead to vulnerability.[9]

The use of oil as a political weapon has become a relic of the past. Moreover, globalisation has made the oil markets much more transparent than before. Therefore, it matters not where a barrel of oil is traded as long as it ends up supplying the global energy needs. As long as the United States continues to be engaged in the global oil market, it will feel the impact of oil supply disruptions wherever they occur. Interdependence, rather than independence, is the cornerstone of contemporary oil security.

An important favourable development shaping the issue of energy security has been the proliferation of oil-producing countries. Between 1978 and 1996, 22 new non-OPEC countries began producing oil, an increase of more than 40%. This is due, in part, to the break-up of the former Soviet Union, but it also includes new producing countries in Africa and Asia. With these changes over the last 15 years, the issue of energy security has become less clear-cut. Even though net importing countries are and will remain dependent on oil from the Arab Gulf, the magnitude of the threat seems smaller. Concern over energy security will never go away, but each new supplier contributes to the perception of a diminishing threat.[10]

Oil Import Dependency Reduction Strategies

The lack of sufficient domestic oil resources and the absence of new oil discoveries mean that the United States' dependence on oil imports can only deepen. This dependency has raised concerns regarding the nation's energy security. Various strategies have been devised to reduce US dependence on imported oil. A close examination of these strategies might indicate their prospects of success in the future.

The Use of Technology to Enhance Domestic Oil Production: A major ingredient of the Bush Administration's energy policy is the use of technological advances to expand domestic oil production in both onshore and offshore areas within the United States. One such area is ANWR. With recoverable reserves estimated at 10 bb, ANWR's initial production is projected to reach 600,000 barrels a day (b/d) peaking at just over 1.0 mbd by 2010.[11]

However, the American Council for an Energy-efficient Economy estimates that gradually raising the fuel efficiency of light trucks and cars in the US from the current 21.2 miles per gallon (mpg) to 35 mpg, would save 1.5 mbd in 2010 and 4.5 mbd by 2020 - up to seven times the 600,000 b/d ANWR could initially produce. Moreover, these could be permanent energy savings that would not require invading an environmentally preserved area.[12] The Natural Resources Defence Council, an environmental organization in the U.S., estimates that increasing the fuel-efficiency standards for new cars to 39 mpg over the next decade would save 51 bb of oil over the next 50 years, many times more than even the most optimistic predictions for the ANWR.[13]

But in spite of the potential to increase domestic production by relying on technological advances, three limiting factors do exist. The first factor is the volatility of the oil price. Despite a substantial cost reduction, it is still cheaper to produce oil outside rather than inside the United States. Thus, high oil prices will make it cost-effective to explore for oil in areas like ANWR and low oil prices are likely to discourage production. The second factor is that advances in technology have not yet managed to arrest the ongoing decline in US oil production. Finally, most of these untapped oil resources are located in environmentally sensitive areas. Opposition by the environmental lobby could still scupper oil exploration in these areas.

Acceleration of Renewable Energy Research: The United States is already investing heavily in the research into solar photovoltaic, fuel-cell motor technology and other technologies for alternative and renewable energy sources. Solar photovoltaic and hydrogen powered fuel cells are destined to become major energy sources during the 21st century but only if their enabling technologies improve significantly enough to ensure affordability and convenience of use.

In 2001, renewable energy sources contributed 1% to the

Table 3
Global Primary Energy Consumption, 2001-2050
(mtoe)

	2001		2025		2050	
	World	USA	World	USA	World	USA
Primary Energy	9128	2237	16194	3419	18697	4403
Oil	3511	896	5135	1267	5338	1663
Natural Gas	2164	555	5119	1043	6927	1663
Coal	2255	556	3526	719	2748	552
Nuclear	601	183	1061	300	955	375
Hydro	505	44	314	20	299	18
Renewable	92	3	1039	70	2430	132
Renewable: % of total	1.0%	0.1%	6%	2%	13%	3%

Sources: Shell International, Scenarios to 2050 / BP Statistical Review of World Energy, June 2002 / Author's Projections.

global primary energy demand. However, by 2025 they are projected to contribute 6%, rising to 13% by 2050. For the United States, the contribution of renewable energy to its primary energy needs is projected to reach 2% by 2025 rising to 3% by 2050 (see Table 3).

The photovoltaic cell is, at present, the object of a great deal of research and investment but progress must yet be made in bringing down costs before this method becomes economical. Looking into the future, however, some significant advances in the storage of electricity must be made before solar generation comes into its own.

Hydrogen-powered fuel cells will, in the future, supply an increasing percentage of commercial and residential electricity. But it is in transport that fuel-cell motor technology will eventually leave its mark on future energy needs. Fuel-cell motor technology will eventually have a great impact on the global consumption of gasoline and diesel. But it will take 15-20 years before fuel-cell cars dominate the highways and certainly not before they are able to compete with today's cars in terms of range, convenience and affordability.

Conservation: If the economy of the United States operates as efficiently as those of Europe and Japan, American energy consumption and greenhouse emissions would fall dramatically - even below the emission levels envisioned in the Kyoto Treaty.

The US consumes more energy than the size of its economy can afford or its share of the world population would warrant. The US accounts for 22% of the global GDP but uses 25% of the world's energy and in doing so, accounts for 25% of global emissions of carbon dioxide. By contrast, the European Union accounts for 20% of the global GDP but only consumes 16% of the world's energy. The numbers for Japan are similar. What these figures boil down to is that for every dollar's worth of goods and services the US produces, it consumes 40% more energy than other industrialized nations.[14]

The fact is that if, from an energy policy perspective, the US economy operated as efficiently as those of Europe or Japan, American energy consumption would fall by about 30%. In that case US carbon emissions might be expected to fall to the European rate per dollar of GDP; that would mean a 35% drop. This means that the US would meet the Kyoto emission targets - to be 7% below its 1990 carbon dioxide emissions by 2012. In fact, emissions in 1999 would have been about 22% below the quantities outlined in the Kyoto Protocol.

However, conservation alone is not the answer to the United States' energy difficulties. But conservation and energy efficiency combined can easily help reduce energy consumption by an estimated 30% and carbon emissions by 35%. Therefore, conservation should be integrated into a comprehensive and long-term energy strategy.

Nuclear Power: Nuclear energy provides the second largest source of energy for US electricity generation. In 2000 coal provided 57% of electricity generation, while nuclear energy provided 20%, followed by natural gas 16%. The rest was provided by hydro-power, oil and renewable sources.

The EIA estimates that US demand for electricity will rise by 45% over the next 20 years. With US electricity demand rising so fast, the EIA is projecting that the country will need to build 1,300 new generating plants in the next 20 years - almost one plant every two weeks. However, another study entitled: "Scenarios for a Clean Energy Future" published in 2000 by the US Department of Energy argued that efficiency measures alone could obviate the need for building 610 of the 1,300 plants needed.[15]

Though not strictly renewable, nuclear power is one of the cleanest energy sources. Nuclear power produces no atmospheric pollution. Waste volumes are comparatively smaller than fossil fuels: fossil fuel systems generate hundreds of thousands of metric tons of gaseous and solid wastes, but nuclear systems produce less than 1,000 metric tons of waste.[16] Spent nuclear fuel can be reprocessed to generate new fuel and reduce waste. Nevertheless, the public perception of nuclear power is still negative. Hanging over it is the question of radioactive waste and how to dispose of it safely.

Nuclear power must, however, expand before 2020 to help supply the increasing world demand for electricity. Modular, fail safe, economically competitive nuclear power plants with zero emissions can be built to replace coal-fired power plants.[17]

North American Regional Energy Policy: The pursuance of a North American regional energy policy involving Canada and Mexico has always been considered a cornerstone in ensuring US energy security and reducing dependence on oil imports from the Arab Gulf region. Indeed, both countries have been major suppliers of oil to the US for the last several years. In 2001, Mexico exported 1.42 mbd of oil to the United States with Canada exporting another 1.79 mbd.

The energy interdependence between the three North American states is even stronger in natural gas than in oil. Canada has been supplying the bulk of US natural gas imports and is expected to continue to do so for the foreseeable future. In 2001, Canada supplied 18% of US gas needs.[18]

Within five years, oil flowing south from Alberta's oil sands is expected to surpass the current output of 1 mbd from Alaska'a North Slope. By 2010, 2 mbd could be pumped from Alberta into a North American pipeline network that will feed a market in the US that now consumes about 20 mbd. And also by 2010, 75% of Canadian oil sand production will go down to the United States. Canada - for many years the largest foreign supplier of natural gas and electricity to the United States – is becoming important in oil as well.[19]

The technology for extracting oil from tar sands exists but extraction costs are high, currently around \$9-\$10/b. However, the real problem is the slow oil extraction rate. And despite a \$22 bn-investment in Canada's tar sand oil production, only 790,000 b/d of sand oil were produced in Canada in 2000.[20] Tar sand oil is three times as labour-to-energy intensive and ten times as capital-to-energy intensive as conventional crude oil.

The energy trade between the US and Mexico has substantially expanded in the last several years. In 2001, the US supplied Mexico with 13% of its gas needs and 18% of its petroleum products and imported in return 7% of its crude oil needs. Mexico's domestic consumption of natural gas is rapidly increasing and its domestic production is not keeping pace with the demand. For the foreseeable future the country is likely to remain a net gas importer.

Mexico needs to invest billions of dollars to upgrade and modernize its oil and gas infrastructure. The State-run Petroleos Mexicanos (Pemex) has neither the capital nor the technology to extract the amount of gas Mexico desperately needs. According to Pemex, Mexican oil output will decline by 33% within the next five years unless investments of \$33 bn are made in oil and gas exploration. Therefore, there is no substitute to opening the door to private and foreign investments. The United States has been urging Mexico to allow more investment by American oil companies into its oil sector to ensure that Mexico remains a reliable and significant oil exporter. But the Mexican constitution prohibits foreign or private ownership in the energy sector. This means that the constitution must be amended to allow foreign participation in energy production.

Mexico's future as an oil exporter depends on the success of the ongoing remedial work on its offshore Gulf of Mexico Cantarell fields, which contain the country's largest known oil reserves and which traditionally have provided some 75% of total national oil production. In 1996, well productivity plummeted, in some cases to one-fourth of previous levels, signalling a dramatic decline in reservoir pressure. Pemex quickly drew up an enhanced oil recovery plan designed to increase reservoir pressure with massive injections of nitrogen in order to increase and maintain reservoir pressure in the Cantarell fields. The plan's cost has been estimated at more than \$10 bn over 15 years. However, Pemex is forbidden access by the Mexican constitution to private Mexican or foreign equity financing and it must therefore meet its capital requirements entirely with loans or internal cash flow. As it generally needs to offer future production as collateral for loans, Pemex is forced to concentrate on known reserves, such as those in Cantarell, and is believed to be prone to exaggerating the production potential of these reserves.[21]

In summary, turning to regional sources of oil to reduce the US vulnerability to oil crises can't guarantee US energy security. Mexico and Canada have limited oil production and export capacities and can't, therefore, satisfy US growing oil needs in the long-term. The combined oil export capacity of both countries could at best be increased by 1mbd from the current 3 mbd to 4 mbd by 2010. However, some experts have considerable doubts about Mexico's ability to maintain its oil exports even at current levels because of stagnating production and accelerating domestic consumption. Others argue that Mexico could cease to be a net oil exporter by the end of this decade. Oil consumption in Mexico has been growing by almost 3% per annum for the last ten years.

Summary and Conclusions

Four major themes will dominate the United States energy security in the 21st century. One is the need to diversify the fuel mix (i.e., oil, natural gas, coal, nuclear power, hydro-electricity and other renewable resources). Another is the need to diversify the geographic origin of the energy. A third is conservation and energy efficiency. And the final theme is devising new ways of managing dependence on oil imports rather than aiming at achieving "energy independence".

Fossil fuels, particularly crude oil and natural gas, will continue to dominate the United States energy needs well into the 21st century. And while recent technological advances have made it possible to economically produce oil from conventional and unconventional sources, they have not yet arrested the ongoing decline in US oil production. Technology cannot make up for declining resources. And despite the huge investment into renewable energy sources like fuel-cell motor technology and solar photovoltaic, their contribution to US primary energy needs will still be measured in single percentage points even by 2050.

Pursuing a regional energy policy will not guarantee energy security. Mexico and Canada have limited oil production and export capacities and cannot, therefore, satisfy US growing oil needs in the long-term. And despite increasing supplies from the North Sea, Latin America, West Africa and the projected contribution of the Caspian Basin to global energy security, the Arab Gulf region will continue to occupy the driver's seat in the global oil market both at present and for the foreseeable future.

The United States should, therefore, realize that oil security does not mean achieving a state of self-sufficiency. Nor does dependency on oil imports necessarily mean vulnerability to supply disruptions. US energy security could be better served by devising ways of managing dependence rather than engaging in meaningless debate over energy independence. This means that the United States should take a fresh look at its sanctions policy against major oil producers like Iraq, Iran and Libya. Such a policy is detrimental to US energy security in the sense that it hampers the diversification and expansion of the global oil production capacity and also increases the risk of oil supply disruptions.

Footnotes

[1] BP Statistical Review of World Energy, June 2002, p. 38.

[2] BP Statistical Review, June 2002, p. 4 & 20.

[3] Mamdouh G. Salameh, *Anatomy of An Impending Third Oil Crisis* (A Paper presented at the 24th IAEE Conference, Houston, USA, 25-27 April, 2001), pp. 3-4.

[4] Mamdouh G. Salameh, *China, Oil & the Risk of Regional Conflict,* Survival, Vol. 37, No.4, Winter 1995-96, p. 134 & 143.

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[6] Fadhil J. Chalabi, *Gulf Oil vs. the Oil of the Caspian Sea* (a paper published by the Emirates Center Strategic Studies & Research (ECSSR) Abu Dhabi, UAE, 2000), p. 155 & 167.

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[9] Gawdat Bahgat, *United States Energy Security*, p. 14.

[10] Sarah A. Emerson, *The Relevance of Caspian Oil for the World Market* (a paper published by ECSSR, Abu Dhabi,UAE, 2000), pp. 183-184.

[11] EIA, *Country Profile: The United States of America.*

[12] International Herald Tribune, *Cheney's Choice,* 8 May 2001, p. 10.

[13] *Alaska: Oil's Ground Zero*, p. 43.

[14] Norbet Walter, *America Needs to Pay Urgent Attention to Energy Efficiency,* International Herald Tribune, 14 June 2001, p. 8.

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[16] Richard Rhodes, *Bright New Dawn Ahead for Nuclear Power Plants*, International Herald Tribune, 8 May, 2001, p. 11.

[17] John D. Edwards, *Transition from Fossil Fuels to Renewable, Non-polluting Energy Sources,* p. 4.

[18] BP Statistical Review of World Energy, June 2002, p. 28

[19] New York Times, 23 January 2001, p. C1.

[20] Petroleum Review, June 2001, p. 14.

[21] Petroleum Review, November 1999, pp. 12-13.

Another Perspective.... *(continued from page 12)*

$$\left(\frac{1+g}{1-\lambda}\right)^{\tau} = \lambda\frac{R_0}{q_0} = \frac{1}{\theta *}\left(\frac{R_0}{q_0}\right)$$

Solving for t we get:

$$t = \frac{\ln\left(\frac{1}{\theta *}\left(\frac{R_0}{q_0}\right)\right)}{\ln\left(\frac{1+g}{1-\lambda}\right)}$$

Often in the literature we set the critical reserve-production ratio (q*) set equal to 10; however, many petroleum engineers and geologists will point out that there could be many fields in a producing region that are in the earlier stages of development, and as a result this ratio should be taken as 12-15. (Flower (1978) is probably the best reference for this discussion).

This is neither the time nor place for more algebra, but if it is possible to accept the concept of the cost of oil being a function of the amount extracted to date as well as current production, then a volume effect can be introduced into the analysis. Readers who are interested in the details can examine my recent paper on oil (2002) or my book on natural gas (1987).

New Members of USAEE

The following individuals recently joined the USAEE in the period November, 2002 to January, 2003 Welcome!!

Michael Brandl
University of Texas at Austin

Jeff Clopton

Kenneth Costello
National Regulatory Research Inst.

Donald Craig
Licensed Real Estate Broker

Tarek A Elshayeb
University of Texas at Austin

Eric Epstein
EFMR Monitoring Group

Luis Galito
PricewaterhouseCoopers LLP

Edgard Habib
ChevronTexaco Corporation

Syed F. Hashim
Idaho State University

Hironori Kawamura
MIT

Lynne Kiesling
Northwestern University

Shankar Kumar
University of North Dakota

Vello Kuuskraa
Advanced Resources International

Frank Leiber

Shunsuke Managi
University of Rhode Island

Johnnae A Nardone

Scott Reeves
Advanced Resources International

Jacques Roeth
GE Power Systems

Richard Running
Engineer

Mervyn Sambles
Fluor Corporation

Matthew A Samsel
FPL Energy

Michael Schulte
PricewaterhouseCoopers Consulting

Ed Segner

EOG Resources Inc.

Al Vikmanis
Petroleum Finance Company

David Wells
Shell Trading

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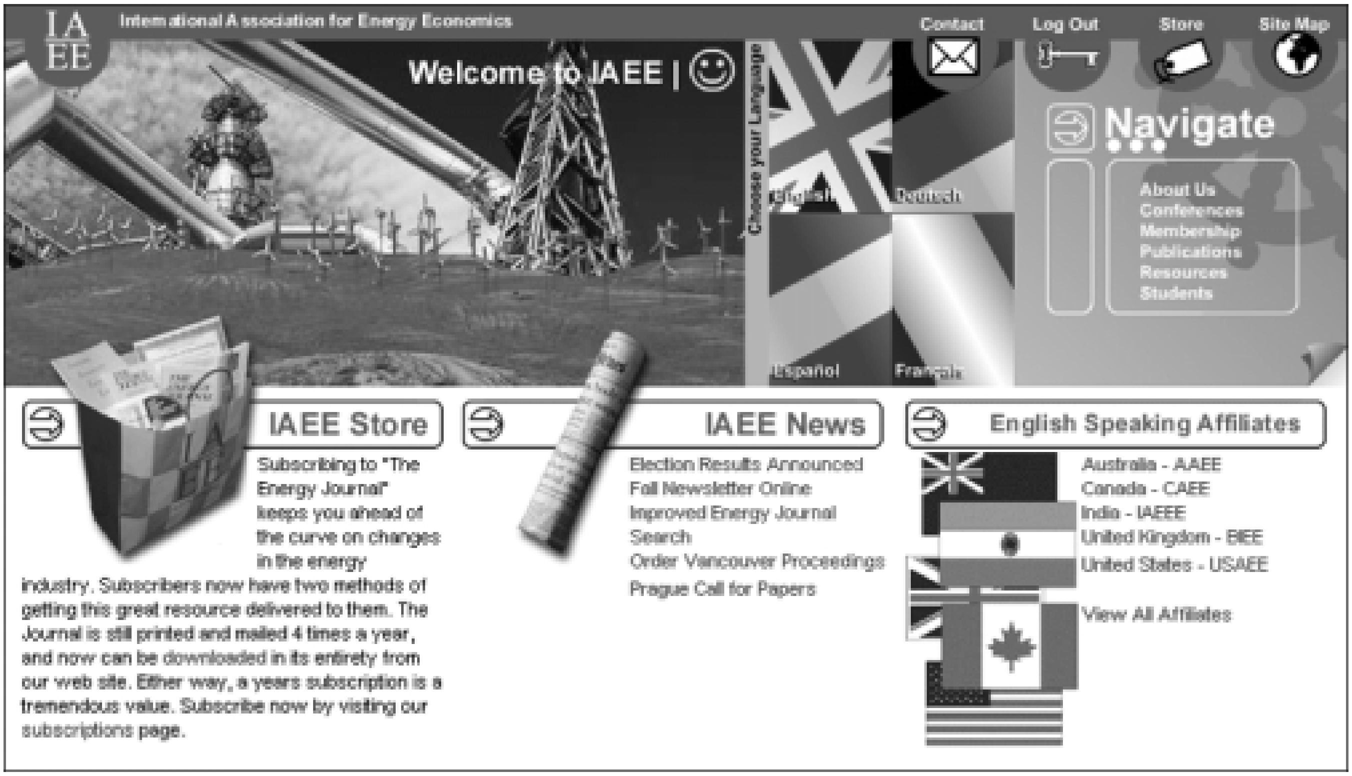

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A Binary Choice Model for the Removal of Offshore Structures in the Gulf of Mexico

*By Mark J. Kaiser and Allan G. Pulsipher**

Abstract. The decision to use explosive versus non-explosive severance techniques to decommission an offshore structure will depend on the outcome of a risk-based comparative assessment involving cost, safety, technical, environmental, operational and managerial considerations. The purpose of this paper is to describe the factors involved in the decision to use explosive/non-explosive severance methods, to quantify the probability that a structure will be removed with explosive technology, and to develop a predictive model of the decision to use explosive methods. An empirical analysis of oil and gas structures removed in the Gulf of Mexico between 1986-2001 provide the historic data required to compute the probability of an explosive removal and to estimate binary choice models for severance selection. Binomial logit and probit models of severance selection are constructed to establish the relationship between a set of attributes describing a structure and the probability that a particular severance technique will be employed. The limitations of quantitative modeling are summarized.

Introduction

There are currently around 4000 or so structures in the federally regulated offshore waters of the Gulf of Mexico (GOM) associated with oil and gas production. The structures vary widely according to function and configuration type and since 1947, when offshore production in the Gulf first began, roughly 6,000 structures have been installed and 2,000 structures have been removed in the federal offshore waters. Most structures removed to date have been simple structures such as caissons and well protectors in shallow waters, and roughly speaking, for every major structure decommissioned two non-major structures have been removed. The number and type of structures removed can vary considerably from year-to-year. Over the past decade, the number of structures removed has ranged from a low of 75 to a high of 179, and this range continues to serve as a good indicator on the bounds of future decommissioning activity. Table 1 presents oil and gas structures in the GOM by configuration type, water depth, and number of slots available (tables are shown at end of paper.)

The decommissioning of offshore structures is a severing intensive operation. Cutting is often required throughout the structure above and below the waterline and mud line. More significant cutting operations are required on elements that are driven into the seafloor, such as multi-string conductors, piling, skirt piling, and stubs which need to be cut at a minimum of 15 feet below the mud line, pulled, and removed from the seabed. Cutting piles and conductors is probably the most critical and important part of a decommissioning project since if the piles and conductors are not cut properly, a potentially dangerous condition could arise during the operation.

A variety of technology exists to perform severance operations and the most common cutting methods include abrasive water jet, diamond wire, diver torch, explosive charges, mechanical methods and sand cutters. For severing operations that occur above the waterline, the cutting technique selected is usually dictated by the potential for an explosion. Cold cut methods are used when the potential for an explosion exists; otherwise hot cuts are employed. Cutting in the air zone is conventional[1] since it involves methods which are regularly used for dismantling onshore industrial facilities. Below the waterline cutting is more specialized. In water depths that do not exceed 150 feet or so, divers perform cuts on simple elements such as braces and pipeline, and for shallow water structures such as caissons, diver torch is sometimes the preferred severance method. In water depths exceeding 150 feet, remotely operated vehicles (ROV's) deployed with abrasive, diamond wire and explosive charges are used for severance operations. Cutting operations required on conductors, piling, and stubs normally employ abrasive water jet, explosive charges and mechanical methods. Mechanical methods and explosive charges are primarily used for conductors, while abrasive cutters and explosive charges are mainly used for piling.

The decision to use explosive and/or non explosive methods often depends on the outcome of a risk-based comparative assessment, which involves cost, safety, technical, environmental, operational and managerial considerations. To perform a risk-based cost assessment for GOM decommissioning projects after the operation has occurred (post-job) is clearly an imposing (some would say impossible) task, and so we must rely on various proxy variables to estimate the probability that a particular severance technique will be applied. It is desirable from a methodological point of view to build a predictive model of the decision to use explosive methods to gain insight into the removal patterns that are expected to occur in the GOM in the future. The scope of this paper is motivated by the desire to predict the removal techniques expected to be deployed in the future. Since economic and technical considerations on a structure-by-structure basis are essentially unobservable, we will rely on a simplified decision model to gain insight on the processes involved in severance selection.

The purpose of this paper is to describe severance operations within the context of decommissioning and to identify the factors involved in the decision to use explosive/ non-explosive methods, to quantify the probability that a structure will be removed with explosives, and to establish a relationship between a set of attributes describing a structure and the probability that a particular severance technique will be used. A more complete version of this article is available from the authors.

Severance Selection Modeling Framework

A large number of factors are potentially involved in selecting the severance technique for a specific job with cost, safety, risk of failure, and technical feasibility the primary factors that are considered when alternative options are available. Many different severance operations are required during

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[1] Conventional but not hazard-free. All decommissioning operations are potentially hazardous to human life.

decommissioning, and depending upon the job, more than one alternative may be available at each stage of the operation. In general, cutting techniques are expected to be reliable, flexible, adaptable, safe, cost effective and environmentally sensitive. If a cutting technique fails with respect to one or more of these factors, or if an operator has more than one "bad experience" with a particular method, then chances are that the technology will not gain in popularity or acceptance among GOM contractors.

Variables that drive the cost and risk associated with a specific severance technique are numerous and involve factors such as the location and nature of the site, sensitivity of the marine habitat, structural characteristics, the amount of preplanning involved, salvage/reuse decisions of the operator, human safety, marine equipment availability, operator experience and preference, contractor experience and preference, the number of jobs the contractor is scheduled to perform and the schedule of the operation, market conditions, etc. Some of these variables are observable, but the degree of correlation between the observable variables and severance decision factors is expected to be weak, and so the extent to which cutting methods can be accurately predicted based on these factors is uncertain.

The choice of which severance technique should be used to cut the piles and conductors of a structure depends primarily on factors which are unobservable or uncertain, and so it is clear that for a given structure we can only seek the probability that explosive methods will be applied. It is necessary to proxy the unobservable variables with factors that are accessible and are "reasonably" reflective of the offshore environment. Configuration type, water depth, and the structure age upon removal are available within the MMS master database, while the characteristics of the piles and conductors associated with each structure; e.g., number, size, application of grout, number of casing strings, etc. are not recorded. It would be preferable to perform the analysis at the lowest possible level of aggregation – which in this case is described through the characteristics of the structure – and then to "work up" through various aggregation strategies. Unfortunately, due to deficiencies in the historical database it was not possible to explore the impact of aggregation schemes on the probability measures.

Caissons are the most likely to be removed using non explosive methods, and well protectors and fixed platforms, if removed with non explosive technology, is more commonly performed in shallow water (Table 2). As water depth increases the chance of using explosives increase across all configuration types. Note that the percentage values depicted in Table 2 need to be interpreted relative to the size of the set, since a category may only contain a handful of data, and in such circumstances, one cannot assign much confidence to the percentage values as being "representative" of conditions in the region. This is particularly a problem for well protectors in the 61-200m water depth category where only six structures have thus far been removed from the GOM. Refined partitions of the water depth data (using 3m, 10m, and 25m increments) showed no discernable "trends," indicating that the application of water depth as a relevant factor is questionable.

The percentage of structures removed using explosive techniques is depicted in Table 3 according to age upon removal, configuration type, and water depth. The use of non explosive methods is most common across all configuration types within the 0-10 year category when the structure has the greatest chance for re-use, and as the age and water depth of structures increase, roughly speaking, the probability of an explosive removal also increases.

Binomial Logit and Probit Models of Severance Selection

A binary-choice severance selection model assumes that the operator is faced with a choice between two alternatives (explosive versus non explosive severance) and that the choice of which cutting method to select depends on characteristics that are identifiable. The requirements of the binary-choice model are thus quite strong, since as we have described previously, many important characteristics of the severance decision are not observable, and hence, not possible to incorporate within a model. It is nonetheless useful to explore the use of an econometric model since it quantifies the probability of an explosive cut and provides additional insight into the decision making process.

The purpose of a qualitative choice model is to determine the probability that a structure with a given set of attributes will realize a specific removal method. We will try to establish a relationship between a set of attributes describing a structure and the probability that the operator will make a given choice.

A binomial logit and probit model is constructed to model the probability that a structure will be explosively severed. Define the dummy variable

$$D = \begin{cases} 1, \text{ structure is removed with explosives} \\ 0, \text{ otherwise.} \end{cases}$$

If we collect a sample of structures that have been removed from the GOM, it is clear that the outcome D is a random variable that will only be known after the sample is drawn.

There are many relevant variables that impact the selection of the severance method, and some of the observable characteristics include the configuration type, x; age upon removal, y; and water depth of the structure, z. The general model is thus written

$D=f(x, y, z)$,

where,

$$x = \begin{cases} 1, \text{ if the structure is a caisson} \\ 2, \text{ if the structure is a well protector} \\ 3, \text{ if the structure is a fixed platform,} \end{cases}$$

y = Age of the structure upon removal,

z= Water depth of the structure.

The logit model is based on the use of a cumulative logistic probability function which is specified as

$$F(l) = P(L \leq l) = \frac{1}{1 + e^{-l}},$$

while the probit model is associated with the cumulative normal probability function which is written as

$$F(t) = P(Z \leq t) = \int_{-\infty}^{t} \frac{1}{\sqrt{2\pi}} e^{-.5u^2} du .$$

If the probability of an explosive removal is related to the variables in a linear fashion, such as

$$\mathrm{E}(D) = \beta_0 + \beta_1 x + \beta_2 y + \beta_3 z + \varepsilon,$$

then the probability that the observed value D takes the value 1 in the logit model is given by

$$P(L \le \beta_0 + \beta_1 x + \beta_2 y + \beta_3 z) =$$
$$F(\beta_0 + \beta_1 x + \beta_2 y + \beta_3 z) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x + \beta_2 y + \beta_3 z)}}$$

while the probit model expresses the probability as

$$P(Z \le \beta_0 + \beta_1 x + \beta_2 y + \beta_3 z) =$$
$$F(\beta_0 + \beta_1 x + \beta_2 y + \beta_3 z)$$

By construction, the value of the probability in the logit and probit models will lie in the interval (0, 1) and represent the conditional probability that an event occurs given the values x, y, and z.

The binomial logit and probit models are limited by several conditions:

- Ability to capture the relevant factors involved in decision making,
- Ability to adequately model the identified factors, and
- Ability to extract sufficient data to support the modeling effort.

Each of these issues plays a role in the construction and development of the qualitative choice model.

Estimated Model Results.

The expected signs for the coefficients of the regression model are straightforward, since as the complexity, age, and water depth of a structure increases, so does the probability that explosives will be used (recall Tables 2 and 3). Hence, the coefficients of the regression models are expected to be positive.

The sample set is the universe of structures removed in the Gulf of Mexico between 1986-2002 and consists of over 1,500 individual observations. The coefficients of the logit and probit model are then estimated using maximum likelihood, an iterative estimation technique useful for nonlinear equations.

The results of the estimation are shown in Table 4. The estimated coefficients have the expected signs and two coefficients are significantly different from zero. The water depth does *not* appear to be a relevant factor which is supported from earlier statistical analysis. The logit and probit model results are similar since they are both based on cumulative distribution functions. The value of R^2 cannot be relied on as a measure of the overall fit of the model with a dummy dependent variable, but one alternative is to compute R_p^2, the percentage of the observations that the estimated equation correctly explains. To use this approach, compute

$$R_p^2 = \frac{\text{number of observations "predicted" correctly}}{\text{total number of observations}}$$

R_p^2 is not used universally, but it is a convenient and easily interpreted measure. The R_p^2 indicates that the equation correctly "predicted" over 60% of the sample based on nothing but three variables.

Summary and Conclusions

The MMS tracks the number of structures removed, the manner of severance and the structure classification, and this data provides the basis for the model construction. The characteristics of the structure, including the number and size of the tubular members, the application of grout, and the manner of removal of each tubular element do not form part of the MMS data set, and thus also cannot be incorporated within the decision model. It is unlikely, but not certain, that the inclusion of more refined data at a lower level of aggregation will provide more useful information in the model, and so in principle, the limitations of the MMS database are not effectual.

The large number of factors potentially involved in the selection of a severance method provides the first indication that the decisions involved in severance are complicated and difficult to model. The proliferation of factors is the first clue that simple models can not provide a complete reflection of the decision framework, and in fact, it is unlikely that *any* model of the decision process can incorporate all the relevant factors. Most certainly a simple model will not yield satisfactory results, but the modeling process itself is useful and provides some additional information on severance selection.

By and large, the decommissioning activities in the GOM are driven by economics and technological requirements and governed by federal regulation. Decisions about when and how a structure is decommissioned involve complicated issues of environmental protection, safety, cost, and strategic opportunity, and the factors that influence the timing of removal as well as the manner in which a structure is removed are complicated and depend as much on the technical requirements and cost as on the preferences established by the operator and/or project management team overseeing the decommissioning project.

Relevant company and site specific information (e.g., equipment available at the time of the removal, the amount of pre-planning involved in the removal, the contractors preference and the operational scheduling, the terms of the contract, the quality of the structure blueprints, etc.) play an important role in the choice of removal method, but because these factors are unobservable, they cannot be statistically analyzed. It is thus clear that a significant portion of the decision making framework *cannot* be incorporated within the model.

Acknowledgement

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Table 1
Gulf of Mexico Active and Removed Structures by Configuration Type, Water Depth and Number of Slots (1947-2001)

Configuration Type	Water Depth (feet)	Number of slots	Active	Removed
Caisson				
	0-80		1076	921
	80-200		117	112
	200+		5	1
Well Protector				
	0-80			
		0-6	271	193
		7-12	8	8
		12+	2	2
	80-200			
		0-6	97	74
		7-12	16	12
		12+	3	2
	200+			
		0-6	26	3
		7-12	2	2
		12+	1	3
Non-Major Fixed				
	0-80			
		0-6	291	85
		7-12	5	0
		12+	0	0
	80-200			
		0-6	155	23
		7-12	7	0
		12+	2	1
	200+			
		0-6	57	6
		7-12	9	0
		12+	3	0
Major Fixed				
	0-80			
		0-6	511	272
		7-12	132	58
		12+	85	13
	80-200			
		0-6	304	168
		7-12	228	80
		12+	178	33
	200+			
		0-6	95	33
		7-12	109	28
		12+	212	24
TOTAL			4,007	2,159

Table 2
Number of Structures Removed (R), Structures Removed by Explosive Technique (R_E), and the Percentage of Explosive Removals (p_E) as a Function of Water Depth and Configuration Type for the Gulf of Mexico (1986-2001)

Water Depth Range (m)	Caisson			Well Protector			Fixed			All		
	R	R_E	p_E	R	R_E	p_E	R	R_E	p_E	R	R_E	p_E
0-60	749	381	51	193	119	62	595	387	65	1537	887	58
61-200				6	5	83	81	61	75	87	66	76
200^+										2	1	50
Total	749	381	51	199	124	62	676	448	66	1626	954	59

Table 3
Percentage of Explosive Removals by Configuration Type and Age Upon Removal in the Gulf of Mexico (1986-2001)

Age Upon Removal (Year)	Caisson		Well Protector		Fixed	
	0-60m	61-200m	0-60m	61-200m	0-60m	61-200m
0-10	39		52	100	55	76
11-30	55		64	67	71	76
30^+	72		77	100	73	100

Table 4
Probit and Logit Model Results

Factor	Probit		Logit	
	Coefficient	(Z-Statistic)	Coefficient	(Z-Statistic)
Constant	0.1372	(1.02)	0.0815	(0.97)
Configuration type	0.0563	(3.21)	0.1121	(3.26)
Age upon removal	0.0051	(5.42)	0.0167	(5.49)
Water depth	0.0005	(0.10)	0.00001	(0.11)
R_p	0.65		0.63	

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- Submit a brief letter from a faculty member, preferably your main faculty supervisor, indicating your research interests, the nature of your academic program, and your academic progress. The faculty member should state whether he or she recommends that you be awarded the scholarship funds.

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18-18 March 2003, National Energy Modeling System/Annual Energy Outlook (NEMS) Conference at Washington, DC. Contact: Peggy Wells, Conference Coordinator, Energy Information Administration, EI-84, 1000 Independence Ave SW, Washington, DC, 20585, USA. Fax: 202-586-3045 Email: peggy.wells@eia.doe.gov URL: www.eia.doe.gov/oiaf/aeo/conf/

24-26 March 2003, 7th Annual Distributed Generation & On-site Power at Warwick Hotel, Houston Texas, USA. Contact: Ken Dee, President, Global Energy Solutions, 21 Tynan Ave., East Taunton, MA, 02718, USA. Phone: 508-823-5797. Fax: 508-823-5197 Email: gesi@attbi.com URL: www.dist-gen.com

25-26 March 2003, Best Practice Sand Control at The Hyatt Regency. Contact: Customer Services. Phone: 1 973 256 0205 Email: enquiry@iqpc-oil.com URL: www.iqpc-oil.com

25-26 March 2003, 2nd Annual Energy Security: Safeguarding Our Nation's Power at Arlington, VA. Contact: Conference Coordinator, Strategic Research Institute, 236 W 27th St, 8th Flr, New York, NY, 10001, USA. Phone: 646-336-7030. Fax: 646-336-5891 Email: info@srinstitute.com URL: www.srinstitute.com

25-26 March 2003, 2nd Annual Energy Security: Safeguarding Our Nation's Power at Sheraton Crystal City, Arlington, VA. Contact: Dave Reichlin, Strategic Research Institute URL: www.srinstitute.com/cr241

26-28 March 2003, Aspen Clean Energy Roundtable X at Aspen, CO. Contact: Conference Coordinator, Montreux Energy LLC, 700 17th St, Ste 1950, Denver, CO, 80202, USA. Phone: 303-534-0193. Fax: 303-534-0195 URL: www.montreuxenergy.com

26-27 March 2003, Fuel Cell Investor at Cherry Hill, NJ. Contact: Conference Coordinator, Strategic Research Institute, 236 West 27th St, 8th Flr, New York, NY, 10001, USA. Phone: 888-666-8514. Fax: 646-336-5891 Email: info@srinstitute.com URL: www.srinstitute.com

26-27 March 2003, US and International Sanctions in Oil & Gas at The Hyatt Regency, Houston, TX. Contact: Customer Services. Phone: 1 973 256 0205 Email: enquiry@iqpc-oil.com URL: www.iqpc-oil.com/NA-1955/ediary

March 31, 2003 - April 1, 2003, Fuel Cells 2003: Fuel Cells and the Hydrogen Infrastructure The Third Annual BCC Conference at Stamford, CT. Contact: Sharon Faust, Conference Coordinator, Business Communications Company, Inc., USA. Phone: 203-853-4266 ext 304 Email: conference@bccresearch.com URL: www.buscom.com/fuel_cells2003/registration.html

2-3 April 2003, GLOBALCON at Hynes Convention Center, Boston MA. Contact: Jared Pursell, Exhibit Manager, Association of Energy Engineers, POB 1026, Lilburn, GA, 30048, USA. Phone: 770-279-4392. Fax: 770-381-9865 Email: jared@aeecenter.org URL: http://www.aeecenter.org

7-8 April 2003, The Second Annual Green Trading Summit: Emissions, Renewables & Negawatts at New York. Contact: Peter Fusaro, Global Change Associates, 211 W 56th St #23M, New York, NY, 10019, USA. Phone: 212-333-4979. Fax: 212-399-3471 Email: info@greentradingsummit.com URL: www.greentradingsummit.com

9-11 April 2003, 12th Annual MEMS Professional Program at Golden, CO. Contact: Melody Francisco, Conference Division, USA Email: mfrancis@mines.edu

27-30 April 2003, The 30th Intl Energy Conference and The 24th Intl Area Conference, IRCEED at Boulder, CO. Contact: Dr.Dorothea El Mallakh, Director ICEED, IRCEED, 850 Willowbrook Rd, Boulder, CO, 80302, USA. Phone: 303-442-4014. Fax: 303-442-5042 Email: iceed@stripe.colorado.edu URL: www.iceed.org

29-30 April 2003, Produced Water Management - Preventing and Managing Water Production for Enhanced Oil Recovery at Houston TX. Contact: Customer Services, Oil & Gas IQ, 150 Clove Road, Little Falls, NJ, 07424-0401, USA. Phone: +(1)973 256 0211. Fax: +(1)973 256 0205 Email: enquire@iqpc-oil.com URL: www.iqpc-oil.com/NA-1964/ediary

12-13 May 2003, Distributed Generation at San Francisco, CA. Contact: Conference Coordinator, The Center for Business Intelligence, Registration Department, 500 W Cummings Park, Ste 5100, Woburn, MA, 01801, USA. Phone: 781-939-2438. Fax: 781-939-2490 Email: cbireg@cbinet.com URL: www.cbinet.com

15-16 May 2003, Flow Assurance: A Holistic Approach at The Hyatt Regency Hotel, Houston TX. Contact: Customer Services, Oil & Gas IQ (A division of IQPC), 150 Clove Road, PO Box 401, Little Falls, New Jersey, 07424-0401, USA. Phone: (1) 973 256 0211. Fax: (1) 973 256 0205 Email: enquire@iqpc-oil.com URL: www.iqpc-oil.com/NA-1997/ediary

20-22 May 2003, 78th Annual Intl School of Hydrocarbon Measurement at Oklahoma City, OK. Contact: Leon Crowley, ISHM Arrangements Chairman, 1700 Asp Avenue, Norman, OK, 73072, USA. Phone: 405-325-1217. Fax: 405-325-7698 Email: lcrowley@ou.edu URL: www.ISHM.info

27-30 May 2003, Extreme Events & Energy, Agricultural and Natural Resource Management at Boston, MA. Contact: Conference Coordinator, Global Warming Intl Center, PO Box 5275, Woodridge, IL, 60517, USA. Fax: 630-910-1561 URL: www.globalwarming.net

28-30 May 2003, Using Real Options to Value & Manage Natural Resource Projects at Colorado School of Mines. Contact: Graham Davis, Colorado School of Mines, Golden, CO, 80401, USA. Phone: 303-273-3321. Fax: 303-273-3314 Email: gdavis@mines.edu URL: www.mines.edu/outreach/cont_ed

4-7 June 2003, 26th Annual IAEE International Conference - New Challenges for Energy Decision Makers at Prague, Czech Republic. Contact: Jan Myslivec, General Chair, Czech Association for Energy Economics, Odboru 4, 120 00 Prague 2, Czech Republic. Fax: 420-2-2492-2072 Email: jan.myslivec@wo.cz URL: www.iaee2003Prague.cz

9-13 June 2003, Export & International Project Finance in the Energy Sectors at New York. Contact: Jeff Kaminski, Euromoney Training - Americas, 225 Park Avenue South, New York, NY, 10003, United States. Phone: 212-843-5225. Fax: 212-361-3499 Email: jkaminski@euromoneyny.com URL: http://www.euromoneytraining.com/databasedriven/coursedetail.asp?busareaid=3&CourseID=160

11-15 July 2003, Western Economic Association International's 78th Annual Conference at Denver, CO. Contact: Event Organizer, WEA International, USA. Phone: 714-898-3222. Fax: 714-891-6715 Email: julie@weainternational.org URL: www.weainternational.org

6-8 August 2003, COAL-GEN at Columbus, OH. Contact: Conference Coordinator, USA URL: www.coal-gen.com

17-20 August 2003, Energy 2003, Real World - Real Solutions at Lake Buena Vista, FL (Orlando). Contact: Joann Stirling, Conference Coordinator, Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL, 32922, USA. Phone: 321-638-1014. Fax: 321-638-1010 Email: joann@fsec.ucf.edu URL: www.energy2003.ee.doe.gov

8-10 October 2003, Hydrogen Infrastructure Investment Roundtable II at Denver, CO. Contact: Conference Coordinator, Montreux Energy LLC, 700 17th St, Ste 1950, Denver, CO, 80202, USA. Phone: 303-534-0193. Fax: 303-534-0195 URL: www.montreuxenergy.com

19-21 October 2003, Integrating the Energy Markets in North America: Issues & Problems, Terms & Conditions at Camino Real Hotel, Mexico City, Mexico. Contact: David Williams, Executive Director, USAEE/IAEE, 28790 Chagrin Blvd., Ste. 350, Cleveland, Ohio, 44122, USA. Phone: 216-464-2785. Fax: 216-464-2768 Email: usaee@usaee.org URL: http://www.usaee.org/energy/

17-21 November 2003, Export & International Project Finance in the Energy Sectors at New York. Contact: Jeff Kaminski, Euromoney Training - Americas, 225 Park Avenue South, New York, NY, 10003, United States. Phone: 212-843-5225. Fax: 212-361-3499 Email: jkaminski@euromoneyny.com URL: http://www.euromoneytraining.com/databasedriven/coursedetail.asp?busareaid=3&CourseID=160

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