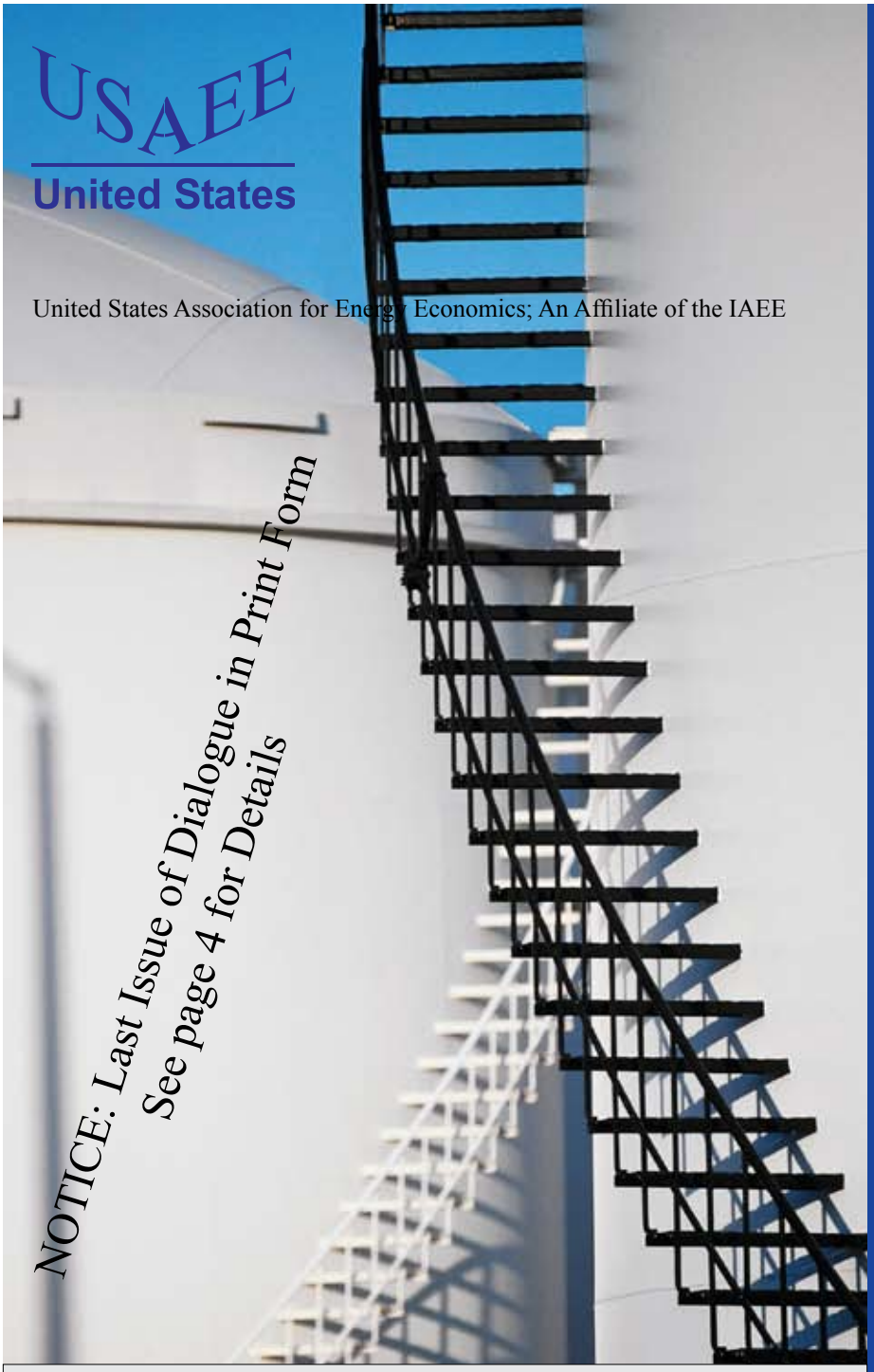
USAEE
United States

United States Association for Energy Economics; An Affiliate of the IAEE

Dialogue



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USAEE Mission Statement

The United States Association for Energy Economics is a non-profit organization of business, government, academic and other professionals that advances the understanding and application of economics across all facets of energy development and use, including theory, business, public policy and environmental considerations.

To this end, the United States Association for Energy Economics:

- Provides a forum for the exchange of ideas, advancements and professional experiences.
- Promotes the development and education of energy professionals.
- Fosters an improved understanding of energy economics and energy related issues by all interested parties.

Energy in a World of Changing Costs and Technologies

September 24-27, 2006 Ypsilanti Marriott at Eagle Crest Ann Arbor, Michigan - USA

26th USAEE/IAEE North American Conference

United States Association for Energy Economics International Association for Energy Economics

USAEE President: Shirley Neff Vice President for Conferences: Gürcan Gülen
General Conference Chair: David Nissen Program Co-Chairs: Lynne Kiesling & Tom O'Donnell
Concurrent Session Chair: Wumi Iledare

Conference Structure

This year we have chosen plenary session themes that we believe reflect the key policy challenges and uncertainties for North America in the global energy economy. We would like the concurrent sessions to expand on these themes, and are actively soliciting papers that address the suggested bullet points. Papers on other topic ideas are, of course, welcome, and anyone interested in organizing a session should propose the topic and possible speakers to:

Wumi Iledare, Concurrent Session Chair (p) 225-578-4552 (f) 225-578-4541 (e) wumi@lsu.edu

Transportation & Fuels	Electricity & Fuels
Transportation - Vehicle technologies • Evolution of technology • Hybrids, diesel, fuel cells • Company strategies and outlook • Fuel economy – market or regulation driven	**Electricity investment, reliability, and environmental effects** • Market design policy evolution in the USA • Capacity markets? – reliability, financing • Europe -- what do "national champions" mean for efficient competition? • Developing markets? -- lessons of liberalization and privatization
Future Trends in Transportation • Urban transportation policies • Developing and emerging market strategies • Unconventional supplies and advanced fuels	**Regulatory vs. market economics: which really maximizes electric utility consumer benefits?** • Market pricing allocates food, clothing & shelter – why not electricity? • Do technical factors in energy utility services defy competitive market economics? • Is unbundling "wires" from "energy" necessary? Is it sufficient? Is there a "natural monopoly" on the "wires?" • Two fundamentally different ways of setting prices, supply & demand – how do they compare from the electric ratepayer's perspective?
Oil market - security and reliability • OPEC capacity and price targeting • Strategic and commercial policy for reliability • Emerging roles of China and India • National Oil Company strategies • Impact of EITI and Local Content policies	**Crunch time for North American natural gas: 2007 - 2012** • North American markets • Arctic natural gas • LNG infrastructure • Evolution of global gas markets
Energy, Economic Development & Energy Poverty • Transition from traditional biomass to modern energy services: policies, technologies • Urban versus rural energy poverty alleviation • Centralized, large-scale projects versus decentralized, micro-scale, locally-owned projects • Investment needs: development aid, project financing, micro financing, cooperatives • Energy sector governance and building local capacity: transparency, institutions, public education and participation	
Science and Technology Policy • Basic research and commercialization strategies for vehicle technologies, electricity generation, and carbon sequestration • S&T policy to realize "learning by doing" and diffusion externalities	

**** CALL FOR PAPERS ****

Abstract Submission Deadline: April 28, 2006

(Please include a short CV when submitting your abstract)

Abstracts for papers should be between one to two paragraphs (***no longer than one page***), 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. Authors will be notified by June 2, 2006, of their paper status. Authors whose abstracts are accepted will have until August 4, 2006, to return their papers for publication in the conference proceedings. While multiple submissions by individuals or groups of authors are welcome, the abstract selection process will seek to ensure as broad participation as possible: each speaker is to present only one paper in the conference. No author should submit more than one abstract as its single author. If multiple submissions are accepted, then a different co-author will be required to pay the reduced registration fee and present each paper. Otherwise, authors will be contacted and asked to drop one or more paper(s) for presentation. 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

Students: Submit your paper for consideration of the USAEE Student Paper Awards (cash prizes plus waiver of conference registration fees). Students may also inquire about our scholarships for conference attendance. Visit http://www.usaee.org/USAEE2006/paperawards.html for full details.

Travel Documents: All international delegates to the 26th USAEE/IAEE North American Conference are urged to contact their consulate, embassy or travel agent regarding the necessity of obtaining a visa for entry into the U.S. If you need a letter of invitation to attend the conference, contact USAEE with an email request to usaee@usaee.org The Conference strongly suggests that you allow plenty of time for processing these documents.

Visit our conference website at: http://www.usaee.org/usaee2006/

President's Message

While preparing to write this note, I reread the first letters of my two predecessors, Mine Yucel and Marianne Kah. They both noted the elevated profile of the energy sector, highlighting the swirl around rising oil and gas prices, uncertainty as to price elasticity of supply and demand, the debate about peak oil, Congressional investigations and, most fundamentally, whether the U.S. body politic will allow/do what needs to be done to ensure an adequate, affordable supply of energy.

So where are we today? The Moscow meeting of the G-8 Finance Ministers on February 11th laid out a blueprint for energy security as a focus of the Heads of State meeting in July. There is a conference on peak oil somewhere just about every week. The long awaited energy bill did little more than punt the oil demand issue to a discussion of geopolitics. Fortunately, serious snow and cold weather did not hit the Northeast, at least, until mid February or I might be lamenting an even more volatile political environment than my predecessors especially given the recent earnings reports from the oil and gas industry.

Of course, the politicians and pundits who normally do not think about energy any longer than it takes to fill their vehicle tanks become loquacious experts when prices rise. Every newspaper, blog and talk show in recent weeks has been full of energy policy remedies – little of it well informed, often incoherent. I have to reemphasize Marianne's challenge of a year ago for the members of this organization to engage in the debate. To be clear, I am not suggesting the USAEE take policy positions, we do not do that as an organization, rather that the members of the USAEE make their voices heard backed up with solid analysis rather than rhetoric and ideology. Toward that end, one of the new initiatives this year is a revamping of the USAEE website to provide greater opportunity for information sharing and member networking. A new "members only" section of the website is being created which will provide a space for posting links to your published writings. There will be different categories for ease of access plus space for commentary. We tried to set up a blog a few years ago before such things were the rage, but with relatively little interest. With this expanded feature we hope to facilitate professional interaction among the membership, as well as stimulate debate on important issues. Postings will be monitored (not censored) to ensure a professional and civil tone. We hope that a robust discussion and debate within the organization will spill out more visibly to affect the broader policy debate.

Beyond the well publicized issues in global oil and gas markets, a number of developments this past year have changed the contours of many areas of the domestic energy sector. First, while passage of the Energy Policy Act of 2005 (EPACT 2005) was not an event of moment for most, it did provide closure after years of uncertainty for the utility sector. Importantly, the Act clarified the parameters of federal authority, including the framework for a mandatory electric reliability organization, the undoing of the Public Utility Holding Company Act (PUHCA) of 1935 and the regulatory authority governing future mergers. The repeal of PUHCA opens the way to significant consolidation in the sector, possibly even acquisition of U.S. utilities by foreign companies. Further market restructuring and realignment in the sector will be a prime area of interest for energy economists.

EPACT 2005 also included incentives for investments in new nuclear power generation. Only a few years ago, the conventional wisdom was that there would be no consideration of a next generation of nuclear power plants until there was a long term solution for the storage of high level waste. A re-evaluation of nuclear

(continued on page 4)

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Dialogue

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Editor: Wumi Iledare

Submissions

Articles, notices, news of chapter events and relevent energy news can be sent to the editor.

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President's Message *(continued from page 3)*

power by some in the environmental community as an option to stem the growth of greenhouse gas emissions was clearly the tipping point that led to a change in the attitude of the Congress. Further moving the debate, over the protestations of the Bush Administration, the Senate passed a resolution stating that climate change is at least in part caused by human activity and must be addressed by a mandatory policy that reduces greenhouse gas emissions while growing the American economy and engaging the developing world. It appears a serious debate in the U.S. has at last begun with respect to the economics and attendant policy framework to mitigate the growth of greenhouse emissions. This is not to say a carbon control regime is imminent, but the focus has moved to solutions rather than debate over whether the problem exists. Clearly a growth area for energy economists young and old…

One of the most controversial provisions of EPACT 2005 involved the change in fuel requirements – specifically, the elimination of the mandate refiners include an "oxygenate", primarily MTBE or ethanol, in reformulated gasoline in exchange for a national renewable fuels standard (RFS). The RFS goes into effect with this summer's driving season, but the long term framework for the program is still being developed. This particular change was the result of a political "deal" not serious evaluation of the market implications. Given the complexity of the fuel specifications in the U.S. and the strains on U.S. refining capacity compounded by the lack of harmonization with other supplier markets, I think this provision especially calls for serious, objective analysis before the final framework is set. (I wrote a short paper on how the initial oxygenate requirement came to be enacted that you may find of interest. http://www.pirinc.org/download/congressionalactiontomandateMTBE.pdf)

I have listed just a few key issues in play in the policy arena. There are also serious debates concerning policies affecting deployment of new technologies. Where and how are renewable technologies competitive, are they being characterized correctly in current modeling exercises. What about efficiency and demand response? Then, of course, there's the question of demand in the transport sector. This leads me to the upcoming 26th Annual North American Conference of the USAEE/IAEE, Energy in a Changing World of Costs and Technologies scheduled for September 24-27 near Ann Arbor, Michigan. Many of the issues I have described here will be more fully analyzed, dissected and debated at the conference.

An excellent agenda is being prepared by General Conference Chair, David Nissen (Columbia University) and Co-Chairs Tom O'Donnell (University of Michigan) and Lynne Kiesling (IFREE). Omowumi Iledare (LSU Center for Energy Studies) has generously agreed to serve again as Concurrent Session Chair. There will be a particular focus on transportation starting with a session on the technology strategies of several of the major auto manufacturers chaired by Vijay Vaitheeswaran, Energy and Environment Correspondent for the *Economist*.

Another area we are addressing at the plenary level for the first time is energy poverty. The lack of attention within the USAEE/IAEE organization to this critical problem was raised at the Washington, DC conference two years ago. This will be a follow on to some excellent sessions at the IAEE Conference in Taipei last year. Gurcan Gulen (CEE-BEG, University of Texas), Vice President for Conferences, who has been doing extensive work in West Africa on this issue is taking the lead. Wes Foell has agreed to organize several concurrent sessions to expand on the plenary. Energy poverty and economic development will be a continuing focus at the IAEE conference in Wellington, NZ next year, as well.

For a number of years, the USAEE has had a best student paper award as well as a student scholarship program to enable students to attend our conferences without paying the fee. The USAEE Council has decided to expand the student paper award to encourage more active student participation at the conferences. This will be a competitive, merit based program with up to ten student awards, including a "Best" paper award, may be given this year. The awards would come with a small stipend of $500; the recipient of the Best Paper award will continue to receive $1000. Councilmember Jim Smith (Southern Methodist University) has agreed to chair the student paper award committee. Details on the award program may be found at www.usaee.org/USAEE2006/paperawards.html. The Council has voted to fund the award program from reserves; however, the student scholarship program has to be funded out of contributions. We continue to urge members to contribute what they can to the scholarship program.

Finally, as a professional organization we try to restrain costs while providing services of value to our members. In that vein, we will be expanding use of the website to keep you informed on the conference planning. Please check out this new section on the website - www.usaee.org/USAEE2006/. Greater use of the website in general will help us cut back significantly on printing and mailing costs thereby helping hold down membership dues and conference fees. Therefore, this will be the last printed version of the *Dialogue* sent to the few members still receiving it in the mail. In the future, an electronic version will be emailed, and of course, it will remain available on the website.

On behalf of myself and the rest of the USAEE Council, I hope you will be happy with the changes we are making and encourage your feedback and participation online and at the upcoming conferences.

Shirley Neff

Dialogue Moves to all Electronic Format

In a move to streamline production and save costs, beginning with the summer issue of ***Dialogue***, the Association's newsletter will only be available in electronic format. No hard copies of ***Dialogue*** will be printed. All members, whose email address we have on file, will continue to receive the publication electronically. We urge that you keep USAEE Headquarters (usaee@usaee.org) posted on your email address changes and/or provide us with your email address if we do not now have it on file.

USAEE News
Editor's Corner

President Bush, in his State of the Union speech, proposed a 75 percent reduction target, in the long run, for the amount of oil imported from the Middle East. He premised this optimism on advances in new coal technology, alternative energy innovations, and diversification of oil import sources away from Middle East countries and efficient energy use and conservation. This proposal has rekindled the energy-independence debate of the late 1970s and the oil security-dialogue of the late 1980s and 1990s. There are oil analysts who would suggest that this goal, as noble as it may seem, could be detrimental to the U.S. economy. Do you have an opinion? The *USAEE Dialogue* welcomes members to engage in this debate with solid analysis.

In this issue of the *USAEE Dialogue* are four major articles on energy economics. The first article by Iraj Isaac Rahmim suggests that Gas-to-Liquid (GTL) technology is one component in the strategy to meet the increasing demand for liquid petroleum products.

Next, Richard Munson writes that in the next several years, much of the U.S. aging electrical, mechanical, and thermal infrastructure will need to be replaced. He suggests that restructuring the electricity industry based on the principles of technology modernization, market efficiency, and consumer choice will bring about immense benefits for both the economy and the environment.

Julian Silk's article on real-time pricing (RTP) characterizes RTL as a pricing mechanism that varies with demand and supply conditions; as opposed to time-of-use (TOU) pricing that automatically varies with time of day, regardless of the market. The author argues that at the current absolute levels of the differences between peak prices and average prices, the costs needed to implement RTP will be in addition to the costs consumers pay for conventionally supplied electricity.

The article by Fereidoon (Perry) Sioshansi, President of Menlo Energy Economics, is based on several news reports from the October 2005 and Feb 2006 issues of *EEnergy Informer*. Perry suggests that higher energy prices and a belief that being bigger is better are among the primary reasons for the latest rise in utility mergers and acquisitions (M&As) after a period of relative lull.

Finally, this edition of the *USAEE Dialogue* contains three short articles on global oil and gas economics. Robert W. Gilmer, Carrie Ann Fossum and Iram Siddik review the primary reasons for the concentration of so much energy activity on the Texas and Louisiana Gulf Coast and evaluate the extent of this concentration in both production and processing of oil and natural gas. Dr. A.F. Alhajji proffers a number of reasons for the apparent lack of success in forecasting global oil market conditions over the years. The third short article by Gray Peckham and Arthur Smith presents a perspective on the potential impact of bird flu, should it break out, on the global oil demand picture and the oil and gas industry.

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 (Center for Energy Studies, 1107 Energy, Coast, and Environment Building, Louisiana State University, Baton Rouge, LA 70803). Please note that this will be the last printed version of the *USAEE Dialogue*. In the future, an electronic version will be emailed to all members and of course it will be made available on the USAEE website.

Wumi Iledare

Conference Proceedings on CD Rom
25th North American Conference
Denver, CO, USA • September 18-21, 2005

This CD-Rom publication includes articles on the following topics:

Natural Gas Industry
Economics of Electric and Gas Utilities
International Energy Economics
Energy Industry Finance
Market for Motor Vehicle Fuels
How Credible are Proven Oil Reserves?
High Oil Prices: A Non-OPEC Capacity Game
Restoring the Nuclear Option in the U.S.
Energy Data and Modeling Demand Estimation
Economics of New Energy Technologies
Energy and the Environment
Oil Industry: E&P, Transportation, Refining, etc.
Are High Oil Prices Here to Stay?
The Hydrogen Futures Simulation Model
Natural Gas Market Volatility
Deregulation and Restructuring in Power Markets

Single Volume $130.00 - members $180.00 - non-members

Payment must be made in U.S. dollars with checks drawn on U.S. banks. Complete the form below and mail together with your check to Order Department, USAEE, 28790 Chagrin Blvd., Suite 350 Cleveland, OH 44122, USA.

Name _____

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Please send me ____ copies @ $130.00 each (member rate) $180.00 each (nonmember rate).
Total enclosed $_____ Check must be in U.S. dollars and drawn on a U.S. bank, payable to IAEE.

NEW EXPANDED USAEE STUDENT PAPER AWARD GUIDELINES

USAEE is pleased to offer a new awards program for student papers on energy economics. The awards will consist of a cash prize of $500 plus a waiver of conference registration fees (a value of $355) for the 26th USAEE/IAEE North American Conference, September 24-27, 2006. Up to 10 awards may be given. In order to receive the award and the cash prize, the student must attend the conference and present the paper. One paper will be selected at the conference as the *Best* paper and will receive a total cash award of $1000 (in addition to the waiver of the conference fees). To be eligible for consideration for the USAEE Student Paper Award competition, follow the guidelines below:

- Student must be a member of USAEE or IAEE in good standing.
- Electronically submit COMPLETED paper by **June 30, 2006** to USAEE Headquarters. The submitted paper (25-35 pages) should be double-spaced on an 8.5 by 11 inch page format.
- Paper MUST be original work by the student.
- Submit a letter stating that you are a full-time student or have completed your degree within the past 6 months and are not employed full-time.
- Submit a letter from your faculty member, preferably your faculty supervisor, confirming the work is your own and recommending the paper for consideration.

Complete applications should be submitted to the USAEE Headquarters office no later than June 30, 2006 for consideration. Please submit all above materials electronically to usaee@usaee.org

Four of the recipients of the USAEE Student Paper Award will be invited to participate in a special session the first day of the conference. The judges for the session will decide which paper receives the *Best* Student Paper Award based on the presentation and the written paper. An award ceremony will recognize all of the students' work later in the conference. Please note that all travel (ground/air, etc.) and hotel accommodations, meal costs in addition to conference-provided meals, etc., will be the responsibility of the award recipients.

For further questions regarding USAEE's Student Paper Award, please do not hesitate to contact David Williams at 216-464-2785 or via e-mail at: usaee@usaee.org

* *

26th USAEE/IAEE NORTH AMERICAN CONFERENCE STUDENT SCHOLARSHIPS AVAILABLE

USAEE is offering a limited number of student scholarships to the 26th USAEE/IAEE North American Conference. Any student applying to receive scholarship funds should:

1. Submit a letter stating that you are a full-time student and are not employed full-time. The letter should briefly describe your energy interests and tell what you hope to accomplish by attending the conference. The letter should also provide the name and contact information for your main faculty supervisor or your department chair, and should include a copy of your student identification card.

2. Submit a recommendation 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.

USAEE scholarship funds will be used only to cover conference registration fees for the 26th USAEE/IAEE North American Conference. All travel (air/ground, etc.) and hotel accommodations, meal costs in addition to conference-provided meals, etc. will be the responsibility of each individual recipient of scholarship funds.

Completed applications should be submitted electronically to USAEE Headquarters office no later than August 31, 2006. Email to usaee@usaee.org

Students who do not wish to apply for scholarship funds may also attend the conference at the reduced student registration fee. Please respond to item #1 above to qualify for this special reduced registration rate. Please note that USAEE reserves the right to verify student status in accepting reduced registration fees.

If you have any further questions regarding USAEE's scholarship program, please do not hesitate to contact David Williams, USAEE Executive Director at 216-464-2785 or via e-mail at: usaee@usaee.org

The Effect of GTL Commercialization on Fuels and Specialty Products Markets

By Iraj Isaac Rahmim*

Interest in commercial gas-to-liquids (GTL) technology, limited for over 70 years to countries with political rather than economic drivers, has heightened in the past decade with now-monthly announcements of technical advances and commercial agreements, studies and demonstrations and front-end engineering and design (FEED) awards, and even a groundbreaking or two.[1] Companies with commercial GTL histories, such as Sasol and Shell, as well as others including BP, Syntroleum, ExxonMobil, Rentech, and ChevronTexaco, have made advances in hardware design, catalysts, and operating conditions in an attempt to improve GTL economics. Certain governments, such as those of Qatar and California, have taken leading positions in developing and implementing GTL as a component of long-term strategies.

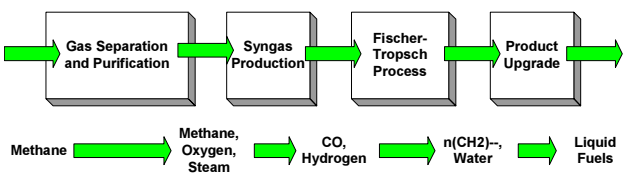
Key GTL products fall into the categories of fuels (primarily diesel but also LPG), specialty streams (lube basestocks and waxes), and petrochemicals (naphtha for steam cracking). This article will examine these markets and the potential impact of GTL developments on the global and regional markets for natural gas and some of these products.

GTL basics

GTL technology involves the multistep, indirect conversion of methane to higher molecular weight hydrocarbons ranging from LPG to paraffin waxes, often controlled to peak in the diesel range (Fig. 1).

The first step after feed preparation and purification involves steam reforming and/or partial oxidation of methane to carbon monoxide and hydrogen. The key reactions include:

Figure 1. General GTL Process.



$$CH_4 + H_2O \Leftrightarrow CO + 3\ H_2$$
$$CH_4 + ½\ O_2 \Rightarrow CO + 2\ H_2$$

The synthesis gas is then converted to hydrocarbons in the Fischer-Tropsch (F-T) section with cobalt (with natural gas as feed) or iron-based (with heavy feeds such as coal) catalysts:

$$CO + 2\ H_2 \Rightarrow \text{--}CH_2\text{--} + H_2O$$

The liquid products are separated in the final upgrading section, which often also involves mild hydrocracking to convert higher molecular weight waxes and lubes to LPG, naphtha, and diesel.

In modern variations, GTL unit designs and operations are modulated to achieve desired product distribution and a range of product slates. Certain operations (low temperature and/or no hydrocracking) result in primarily wax, lubes, and diesel products, whereas other conditions (higher temperature and/or mild hydrocracking) increase diesel, straight-chain paraffinic naphtha, and LPG at the expense of lubes and waxes.[2,3] Wax and lube production typically ranges from zero to 30%, diesel from 50% to 80%, and the lighter products to as much as 25% of the final liquid products. The products are of generally high quality with near zero sulfur and high cetane for the diesel (Table 1).

Table 1. Sample Product Slate for World-Scale (50,000 B/D) GTL Unit

	No Hydrocracking (MBD)	With Hydrocracking (MBD)	Comments
LPG	1	2	• Similar to other plant (LNG, refinery) LPG • Can be co-processed and marketed with them
Naphtha	9	13	• Straight chain paraffinic • Near zero sulfur • Preferred use: steam cracker feed
Diesel	25	35	• High cetane • Near zero sulfur • Low density • Low aromatics
Lubes	15	<1	• High grade • Low volatility • Low pour point • Low viscosity • Low sulfur
Wax	5	<1	• High quality

For more detail on the GTL chemistry and processes, see reference 4.

The earliest commercial adoption of GTL was for use in the German World War II effort, with the second use in South Africa starting in the 1950s. These combined gasification with GTL to take advantage of coal resources.

Three commercial units currently operate in South Africa (Table 2). Shell Bintulu (Malaysia) was built in 1993 and recently upgraded and expanded to approximately 14,000 b/d liquid product capacity. One plant (Oryx in Qatar) is under construction, another (Escravos in Nigeria) is at an advanced stage of bidding, and a large number of other facilities are at the study, planning, and design stages.

Given the low value of stranded gas and the premium expected for clean GTL diesel and heavier products, which will be discussed, a key determinant to the profitability of new GTL facilities is the capital cost. Historical capital costs of in excess of $50,000/bbl (total installed costs) have dropped due to technical advances to $25,000-30,000/bbl with $20,000/bbl in sight and even smaller numbers considered.[5] (Shell's stated goal is to reduce the cost to $12,000/bbl.) There have been reductions

* Iraj Isaac Rahmim (iir@e-metaventure.com) is president of E-MetaVenture Inc., a consulting and training firm working in the areas of natural gas and oil processing technology and economics. A past-president of IAEE-Houston chapter, he holds BS and MS degrees from the University of California and a PhD from Columbia University, all in chemical engineering.

in reactor size, improved catalysts, advances in temperature control using fluidization and hardware design, and optimized operating conditions.[6 7]

Table 2. Commercial-Scale GTL Plants

Company	Location	Size (BPD)	Comments
Sasol I	Sasolburg, South Africa	5,600	1955; Sasol technology Feed: coal
Sasol II/III	Secunda, South Africa	124,000	1955/1980; Light olefins and gasoline; Sasol technology Feed: coal
Petro SA (formerly Mossgas)	Mossel Bay, South Africa	22,500	1991; Gasoline and diesel; Sasol technology Feed: offshore natural gas
Shell MDS	Bintulu, Malaysia	14,000 (12,500 pre-1997)	1993; Waxes, chemicals, diesel; recently revamped; Shell SMDS technology Feed: natural gas
Bidding/Construction			
Sasol ChevronTexaco	Escravos, Nigeria	34,000	Construction to begin; FW; $1,200 MM Feed: natural gas
Sasol Chevron QP	Ras Laffan, Qatar ("Oryx GTL")	33,700	2006 completion; Technip-Coflexip; $850 MM; studying increase to 100 MBD by 2009 Feed: natural gas

Synergies are also considered, including integration with power generation[8] or hydrogen manufacture,[9] while some GTL is driven by supply of coal, low value petcoke, bitumen, and Orimulsion.[9 10] There are also less well-known but promising technologies in the pipeline.[11 12 13]

Several factors have resulted in the interest in GTL and its variations over the past 2 decades. These include:

- Need to develop and exploit additional energy resources.
- Existence of large reserves of stranded natural gas and the attempt to monetize them.
- Desire for strategic diversification on the side of both producers and consumers.
- Environmental drivers ranging from a movement to reduce flaring to auto-emission regulations.

A number of consuming and producing countries have come to consider GTL as one component in a strategy of diversification and growth. On the producing side, Qatar can serve as an example. With current proven reserves of about 15 billion bbl of crude and production of 700,000-750,000 b/d, Qatari oil is depleting with a possible production decline to 500,000 b/d by 2012 and the commensurate loss in revenues.[14] As such, monetization of the giant North field is of great strategic importance to Qatar with four key components of LNG, pipeline gas, petrochemicals, and GTL all currently being pursued.

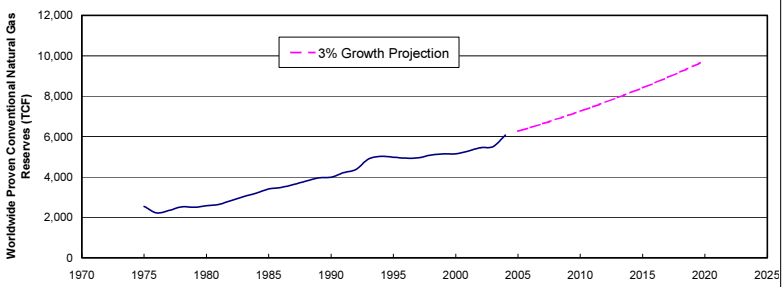
Consuming countries also have an interest in diversification and enlargement of supply. Given the many political and social uncertainties in the Persian Gulf region (which could potentially translate to commercial and regulatory uncertainty), it is noted that about 65% of the world's crude, but only 36% of its natural gas reserves, are located in the Middle East. About 30% of the world's natural gas is located in the Russian Federation, with the rest in Asia Pacific, Europe, the Americas, and Africa.

At the same time, the projected rapid economic growth in the Asia-Pacific region, particularly the much talked-about need of China for energy during the first half of the 21st century, along with the decline in a number of existing oil fields, requires rapid entry of new energy resources including natural gas into the market.

Economics and markets

Worldwide proven natural gas reserves stand at about 6,100 tcf[16] with approximately 3,000 tcf considered stranded. Much of GTL economics is dictated by significant new stranded natural gas finds. Of these new finds, some are very large, such as Qatar's North field (900 tcf proven reserves) and Iran's South Pars field (500 tcf). However, a segment of the natural gas of interest, particularly gas produced with crude oil, has been known of for decades but not exploited. For example, Nigeria flared 620 bcf of natural gas in 2000.[16] Overall, reserves are expected to grow as, aside from one 5-year period during the past 50 years, discovered natural gas has far outpaced volumes brought on stream (Fig. 2).[15 17]

Figure 2. Worldwide Proven Reserves of Conventional Natural Gas



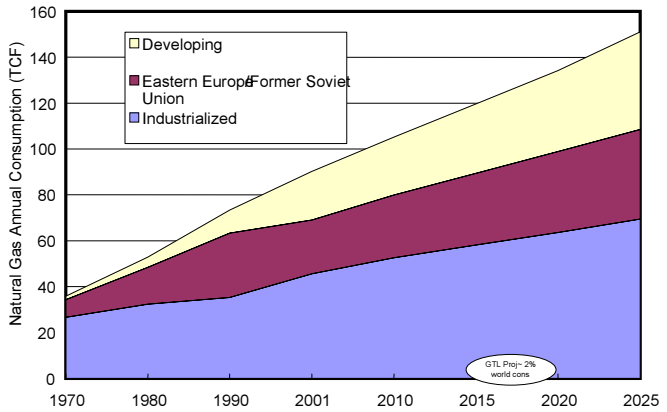
Unconventional sources are also of interest. Some, especially coalbed methane and gas from tight formations, and to a lesser extent basin-center aquifer gas, have been or are in production in countries such as the US, UK, and Australia. Another unconventional source, methane hydrates, found in colder regions such as Canadian, US, and Siberian permafrost, are of great interest due to their very large estimated amounts. The current consensus estimate of gas in place as hydrate, 600,000 tcf, is around 100 times larger than proven conventional reserves of natural gas.

Worldwide consumption of natural gas stood at 89.4 tcf/year in 2002,[18] equivalent to about 45 million bbl of crude. Much stranded gas is reinjected, used as plant fuel, or, if associated with oil, flared if produced or kept in the reservoir, which limits crude production. For example, certain oil and gas reservoirs in Siberia are produced at a low rate due to the absence of an outlet for the natural gas.

Compared to the total consumption of natural gas, existing LNG and GTL facilities are small. Globally, GTL units use 130 bcf/year and LNG units 7.2 tcf/year, which together represent 0.12% of proven gas reserves and about 8% of global annual gas consumption (Fig. 3).

Although there are nearly 50 GTL facilities under various

Figure 3. Worldwide Consumption of Natural Gas



states of consideration with potential gas capacity of 4-5 tcf/year, observers believe that, at most, only half of this capacity (about 2.2 tcf/year) is likely to come on line in the next 10-15 years. This is approximately 2% of projected total gas consumption between 2015 and 2020.

In key regions, numbers differ, but our analysis suggests that unless there is surprising growth in the number and capacities of GTL facilities, it is unlikely that GTL will increase demand for stranded natural gas enough to increase the value of the gas in the field. In large fields, particularly, it is feasible to operate multiple GTL plants alongside LNG or other gas monetization units.

Slow growth

It is interesting to note that growth in GTL capacity has been slower than optimists of the mid-1990s projected. Causes include:

- Recession of the late 1990s and low crude prices.
- LNG as a fierce competitor for capital.
- Slow pace of negotiations due to technical and economic unknowns, issues of regulatory stability, and evolving financial structures.

Furthermore, gas that is not stranded (in or with access to markets) is of significantly higher value—$5/MMbtu for Japanese imports in 2002, for example—and as such will not be suitable as GTL feedstock. A number of studies show that for GTL to be viable, the gas cannot be valued above 50¢/MMbtu, which is in the stranded gas range and similar to values assumed for LNG.[19]

Given the availability and likely low value of stranded gas, a key factor will be availability of and competition for capital. A number of studies have compared the full GTL and LNG trains and found that, for modern units with $20,000-30,000/bbl cost, GTL is competitive with LNG.[2]

One key factor driving GTL and LNG is the global attempt to reduce flaring of natural gas in associated fields. As a recent World Bank study shows,[16] the total worldwide flared gas in 2000 was estimated at 3.8 tcf with a particularly high ratio of flared gas to oil produced for a number of African countries (Table 3). Indeed, a key factor in the Nigerian decision to pursue GTL has been the attempt to reduce flaring.

Table 3. Gas Flared in 2000

Region	Flared NG (BCF)
Africa	1306
Asia-Oceania	388
Europe	106
FSU	671
Latim America	353
Middle East	565
N. America	424

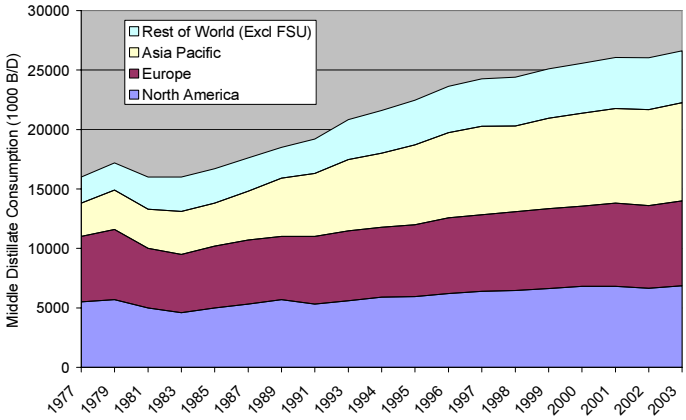
Source: World Bank (16)

Diesel from GTL

The most intriguing and important GTL product, one that has been studied extensively and one that warrants focus here, is diesel-range material.

Automotive diesel market: The global middle-distillates market, at about 27 million b/d, is a significant portion of the worldwide fuels market with a history of about 3%/year average growth during the past decade (Fig. 4). Of this, about 14 million b/d is automotive diesel. Europe has the largest diesel market, with demand of 3.4 million b/d; followed by Asia-Pacific, 3 million b/d; and North American, 2.8 million b/d.

Figure 4. Global Consumption of Middle Distillates



These numbers are expected to continue to grow, largely driven by increased diesel-powered auto sales. For example, Schmidt's Automotive Industry Data (AID) estimates that the sale of such vehicles in Europe will grow from approximately 6 million units in 2002 to over 8 million by 2008, constituting over 60% of sales in countries such as France and Austria.[2] The increase in Europe is mediated by a combination of emission mandates, jurisdictional tariff strategies, improved auto designs, and increased availability of low-emission fuels.

The automotive diesel market in the US is noticeably smaller, with diesel-powered light vehicles representing less than 4% of the total US auto market.[20] As a result, the diesel market in the US is primarily driven by the commercial sector and is thus tied to overall economic growth. The growth in US diesel demand has averaged about 5%/year during the past decade.[21] Regional and regulatory efforts are likely to increase diesel usage in the US during the next decade. These include activities and studies by the California Energy Commission, California Air Resources Board, and US Department of Energy.[22] A number of fleets (light as well as heavy) have tested or shifted to clean die-

sel (including GTL and biodiesel blends) in various parts of the US with potential impact on long-term attitudes and trends.[23]

Growth in Asia-Pacific has been rapid yet uncertain and is expected to remain so. During the first half of the 1990s this growth stood at about 7%/year but slowed to under 3%/year in the recession years that followed. In a number of countries diesel-powered automobiles form a large fraction of the vehicles (for example, Japan at 20%). With the rapid developments in China, it is likely that growth will remain above 3%/year.

Globally, one observer suggests an increase in the proportion of diesel automobiles (including biodiesel and GTL) to 40% over the next few years from the current average of 30% relative to gasoline-powered cars, followed by partial replacement with hybrid technologies over the following decade.[23] Based on overall economic growth and regional trends, observers anticipate demand for middle distillates (incorporating automotive diesel) to continue growing at 3%/year,[21] from 27 million b/d currently to 44 million b/d by 2020. Of the 2020 demand level, 22.5 million b/d is projected to be automotive diesel.

GTL diesel supply: The projected numbers for GTL liquid product barrels are subject to great uncertainty. All GTL projects existing or under various stages of consideration represent total liquid product capacity of perhaps 1.8-2 million b/d.[1] Some examples: Iran has had four studies. Nigeria has a number of agreements, some in advanced stages. Several studies point to GTL as a significant option for monetizing stranded gas in northern Australia. And Qatar alone is considering a liquid product capacity of 750,000-900,000 b/d by 2012-15, nearly 70% of which is likely premium diesel stock suitable for use as automotive diesel-blend material.

However, only a fraction of these potential capacities will likely come on stream in the foreseeable future. A study for the California Energy Commission estimates total worldwide GTL diesel capacity at about 75,000 b/d in 2010, 388,000 b/d in 2015, and 800,000 b/d by 2020.[7] Sasol Chevron suggests 600,000 b/d of GTL diesel capacity by 2016-19.[24]

A quick example: Let us assume total GTL liquids of 750,000 b/d by 2020. At 70% diesel yield, this produces approximately 525,000 b/d of diesel fuel. This is expected to be less than 3% of the total worldwide automotive diesel market (Fig. 4). We thus expect a relatively small chance of oversupply caused by the introduction of GTL.

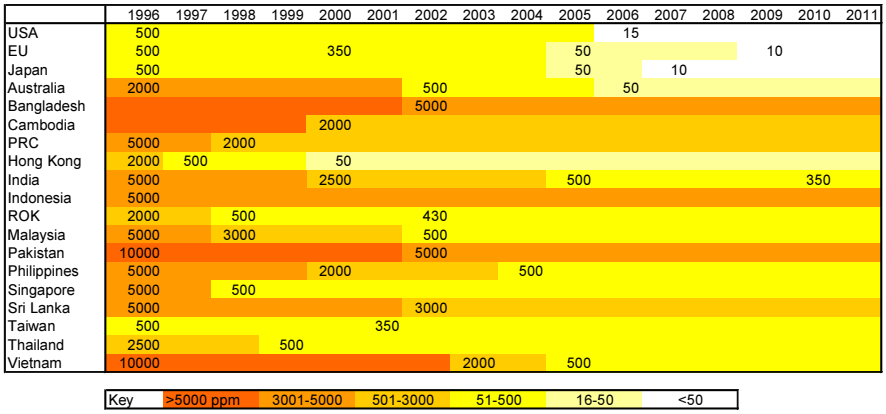
From a local point of view, however, GTL products could form a significant portion of a region's diesel consumption. For example, Shell estimates that one large-scale GTL plant would fully satisfy the city of London, while 10 such plants would produce enough pure GTL diesels for the entire US Petroleum Administration for Defense District V.[23]

It is possible, therefore, to develop a critical mass of available GTL diesel blendstock for a small market. As an example, GTL diesel from Shell Bintulu has been offered throughout Thailand in the past 2 years as a 30% blend in the premium grade Pura. Shell also has been very aggressively working with a number of governments in Asia, particularly China and Japan, to boost demand for blends of GTL and conventional diesel.

Regulatory environment: Emission standards for heavy and light-duty diesel vehicles have tightened or are expected to tighten considerably in a number of regions. These standards have produced emission or content limits on sulfur, particulates, aromatics, polynuclear aromatics (PNAs, impacting particulates), and nitrogen oxides.

In the European industrial countries as well as Japan and the US, sulfur-content limits have evolved toward the 10-50 ppm range (Fig. 5). At the same time, a number of other countries, including many in the developing world, have introduced new and more restrictive mandates of 200-1,000 ppm.

Figure 5. Evolution of Diesel Specifications (parts per million)



Source: Pytte (22)

Aside from sulfur, PNAs are regulated in Europe at 11 wt % with restrictions on particulates, aromatics, and NO_x upcoming or under study in a number of jurisdictions.

GTL diesel is virtually sulfur-free and primarily paraffinic (very low aromatics, less than 5% PNA content). Therefore has come to be considered a potentially important blending element in satisfying environmental and auto emissions requirements in various regions.

A number of studies have demonstrated emissions improvements resulting from use of GTL diesel (neat or in blends) not only compared to conventional high-sulfur diesel, but also low-sulfur, low-aromatics refinery diesel. For example, one study suggests 40-50% reduction in the emission of hydrocarbons, 9% in NO_x, and 30% in particulates when compared to low-sulfur refinery diesel.[25] Another study estimates significant emissions benefits for light-duty and heavy-duty vehicles with current engine technology and 100% GTL diesel[23] as well as with new engine technologies (Euro-4 and Euro-5) and using 15-30% GTL diesel blends.

Though tailpipe emissions with diesel GTL are significantly lower than with conventional refinery diesels, these benefits can be less pronounced from a well-to-wheel (WTW), greenhouse gas point of view. For example, a US study shows that the WTW CO_2 emissions of refinery diesel was actually

slightly lower than that of diesel from natural gas and F-T (460 g/mile of CO_2 vs. 480 g/mile)[23] with the great benefit of GTL, in such case, being that the lion's portion of the CO_2 is produced far from population centers (not as auto emissions but as plant emissions) and can therefore be relatively easily sequestered and dealt with.

In addition to content and emission specifications, a number of jurisdictions have structures mandating or encouraging the incorporation of "alternative" fuels. These include the European Commission legislative proposals with mandatory targets for biofuels, natural gas, and hydrogen[26] and the US Energy Policy Act of 1992 (applied to domestically produced GTL fuels in 2000).[23]

Quality, pricing issues: GTL diesel, in addition to having low sulfur and reducing emissions, is highly paraffinic, resulting in cetane numbers of 70-80. Further, it typically has lower density than refinery diesel (0.77-0.80 kg/l. vs. 0.83-0.85 kg/l.), resulting in a "density premium."

Diesel containing GTL blendstock is currently sold commercially in Thailand, Greece, Germany, and South Africa. Though contemplated also in pure form, for a number of reasons it is found to be more practical as blendstock.

These include:

- The lower density (and associated lower T90) results in a perceived lower fuel efficiency (miles per gallon) when compared to standard diesel.
- Pure GTL diesel would require separate infrastructure and some modifications of the automobile. This would take away a key benefit of GTL: that its fuel is compatible for use with current fuels and as an excellent transition fuel as regulations and markets develop for other, more radical alternatives.
- GTL diesel has relatively poor cold-start properties. This is less of a problem in warmer climates but nevertheless must be accommodated.
- In jurisdictions with very tight sulfur-content specifications (10-50 ppm, for example), the volume of GTL diesel required for diluting the sulfur in conventional diesel needs to be very high.

As a result, GTL diesel is most likely to be used in:

- Blending to bring off-specification diesel into compliance in jurisdictions with relatively lax specifications or where the base blend is close to specifications. For example, most of the 24,000 b/d of Qatar's Oryx GTL diesel is likely to be used as blendstock in Europe to bring conventional refinery diesel to specifications.
- Blending to bring certain refinery intermediate streams such as the FCC light cycle oil into diesel specification to avoid the alternative use of the FCC light cycle oil as fuel oil product blendstock.

A number of studies, during the 1980s and 1990s and in the context of refinery hydroprocessing requirements, suggested a 5-10¢/gal premium for low sulfur diesel when compared with standard diesel. Such numbers have since been found reasonable for GTL diesel as well in light of the low sulfur, low density, and high cetane of GTL diesel. Commercially, for example, Shell's Pura brand diesel is sold at a premium relative to standard brands in Thailand.

However, as applied to sulfur, competition exists. Over the past 2 decades, the ability of refiners to reduce sulfur in products has improved dramatically, thanks in large part to construction of hydrotreaters and hydrocrackers in a very large number of refineries, but also to improvements in FCCs and other units. At the same time, biofuels, such as methyl esters and ethanol, though a small proportion at this time, are expected to grow in light of significant tax benefits in the US as well as mandates in a number of regions. Therefore, it is possible that the sulfur premium for GTL diesel might erode in years to come, although this possibility is mitigated by the anticipated increase in demand for both high and low sulfur diesel.

Some observers suggest that GTL diesel's premium will be primarily due to its high cetane and low aromatics. If so, the GTL diesel will be more attractive in Europe than in the US or Asia due to the former's being more restrictive cetane and aromatics specifications.

Other markets

While diesel-range material is the largest and most important, other markets exists for GTL products, including lubes, waxes, and naphtha.

Lubes market: Increased demand for high quality lubes (Group III/IV) and a projected increase in global demand for all lubes from 720,000 b/d in 2002 to 820-850,000 b/d in 2010)[2 27] have stimulated efforts to bring new lubes hydroprocessing capacity on stream. Worldwide hydroprocessed base-stock capacity is projected to grow well beyond the demand of about 250,000 b/d.[28] This and other factors have put downward price pressure on premium stocks, which may well continue into the next decade.

The heavy paraffins produced by GTL have virtually no sulfur and low viscosity, pour point, and volatility and make excellent lube base stocks when compared with products from conventional solvent processing. However, due to the small size of the lubes (and premium stocks) market, even one world-scale GTL unit (50,000-100,000 b/d total liquids with as much as 15,000-30,000 b/d of lubes) can provide a significant fraction of the worldwide demand for premium base stocks (on the order of 6-12%). Unmitigated, a handful of such units could exert additional downward pressure on the price of premium base stocks. (The ExxonMobil project announced last year in Qatar is expected to deliver about 30,000 b/d of lube stocks into the market.) For example, an assumed worldwide GTL capacity of 750,000 b/d by 2020 could, in the worst case, result in a glut of over 200,000 b/d additional premium lube base stocks. ExxonMobil estimates that the introduction of high-quality base stocks from GTL could not only exert price pressure on very high viscosity index (VHVI) base stocks, polyalphaolefins, and lubes in Groups III and IV but also eventually on the conventional lubes of Groups I and II.

Because of this, the majority of the GTL plants under construction or planning include a product-cracking step in order to reduce the volume of lubes produced via conversion to the diesel and lighter range.

Wax market: Most of the paraffin wax in the world is cur-

rently supplied by refineries in the form of slack wax, which is subsequently refined by removing oil, aromatics, and sulfur into a range of products such as scale waxes, refined paraffin waxes, and microcrystalline waxes. The total global wax market is about 70,000 b/d, of which half is for food-grade waxes. The US market is 25-30% of the worldwide market.[29]

Growth in the market has been steady over the past 25 years, and models suggest this steady growth in demand should continue for the next 15 years (Table 4).

Table 4. The Global Wax Market

Wax consumption in BPD	North America	Europe	Asia Pacific	Rest of World	Total	Food Grade Wax
1990	19,168	12,645	20,673	2,810	55,296	
1995	21,075	13,448	24,688	4,115	63,325	
2000	23,082	15,053	27,096	3,512	68,744	
2005	24,336	16,057	29,856	3,763	74,013	
2010 (proj.)	25,591	17,061	32,616	4,014	79,081	39,540
2020 (proj.)	27,899	18,064	39,841	4,516	90,321	45,160

Two existing GTL plants, the Shell Bintulu and Sasol Secunda facilities, provide about 17% of worldwide petroleum waxes. These include food-grade derivatives and are of high quality.

At the same time, industry insiders think that the number of refineries willing to produce wax will be reduced as the manufacture of waxes is operationally difficult. For example, Chevron reduced its presence in the wax market in 2001. Regardless, as with the case of lubricants, the wax market is very easily overwhelmed due to its small size. For example, one typical GTL plant with total liquid product of 50,000-100,000 b/d could potentially produce as much as 5,000-10,000 b/d of high-grade wax, 6-11% of the total global wax market in 2015. As a result, most GTL plants are likely to opt to hydrocrack their wax-range products into diesel and naphtha.

GTL naphtha**:** GTL naphtha is highly paraffinic (primarily straight chains, low octane) and low in aromatics, making neither good gasoline blendstock nor a suitable refinery catalytic reformer feed. Rather, it is an excellent feed for steam crackers to produce ethylene and other olefins. In fact, due to its paraffinicity and purity, GTL naphtha yields more ethylene than does refinery naphtha. There are indications that the Asia-Pacific is likely the strongest future market for GTL naphthas due to the rapid growth of the petrochemicals sector in that region.

Drivers and effects

The potential growth in GTL is, in large part, driven by the need to monetize large reserves of stranded natural gas along with the increasing demand for liquid products with tighter specifications. GTL technology is one component in the strategy by various parties to meet these demands.

We find that, given the commercial state of the technology and its anticipated growth during the next 10-15 years, GTL is unlikely to cause significant disturbance to the diesel market but, if unchecked, might increase the inventories of slack wax and high-quality lube blendstock so as to bring downward pressure on their prices.

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Let Electricity Innovation Thrive

By Richard Munson*

Most discussions about electricity policy, unfortunately, focus on subsidizing preferred fuels rather than on creating an economic climate for innovative technologies to thrive in the marketplace. Many utilities, for instance, want to continue support for their mix of coal-fired power plants and nuclear reactors. Some environmental groups, desiring to take advantage of the nation's coal yet reduce the pollution associated with its burning, propose substantial taxpayer benefits for coal gasification; others argue for government to support biomass and solar technologies.

Such shortsighted approaches fail to appreciate that the United States is on the verge of a tremendous explosion in energy innovation. Entrepreneurs advancing an array of modern technologies could increase the electric system's efficiency, cut the generation of pollutants and greenhouse gases, expand consumer choices, enhance productivity and economic development, and spawn a multi-billion-dollar export industry. The technological revolution, however, needs to be matched by a policy revolution. Congress in 1978 opened monopoly markets slightly in the direction of modern technologies, and the Federal Energy Regulatory Commission and several state regulators have sought to further encourage electricity entrepreneurs. Yet scores of laws and regulations still protect old-line monopolies and lock out the most promising innovations.

A Superior Form of Energy

Electricity is clean at the point of use, capable of performing many tasks, and easily controlled. Such attributes have increased its share of total energy use over the past three decades from 25 percent to nearly 40 percent. Yet unlike water and natural gas, electricity is not a substance, but a physical effect occurring throughout the wires that conduct it. This power does not exist naturally in quantities that can be manipulated for our benefit. It also cannot be easily stored. Its delivery, in fact, requires the ultimate just-in-time enterprise that balances supply and demand at every instant.

This wonderful, drudgery-reducing form of energy has changed our lives. Electric lights lengthened our days. Electric elevators and streetcars altered our cityscapes. And electric processes continue to accelerate an industrial revolution with precision machinery.

Electricity may be wonderful and a necessary part of modern life, but its generation does have downsides. Power plants spew two-thirds of the nation's sulfur dioxide emissions, one-third of the nitrogen oxides that cause smog, one-third of the carbon dioxide (a greenhouse gas), and one-third of mercury emissions. Electricity generators, moreover, are the largest consumers of the region's water. Hydroelectric dams disrupt instream flows, and thermal facilities – those that rely on nuclear power or the burning of coal or gas – entrain millions of fish and heat the region's rivers and lakes. Some utilities use almost 2 billion gallons daily to cool a large power plant.

The U.S. power system, although remarkable, is rickety and old. The average generating plant was built in 1964 using 1959 technology, and more than one-fifth of U.S. power plants are more than 50 years old. Today's high-voltage transmission lines were designed before planners ever imagined that enormous amounts of electricity would be sold across state lines, and, consequently, the wires often are overloaded and subject to blackouts. One outcome of this overloading has been an increase in line losses from 5 percent in the early 1980s to 10 percent today, placing a little-recognized $12-billion annual "tax" on consumers that didn't exist 20 years ago.

Another problem is that the average efficiency of generators has not increased in the past 50 years. While the efficiency of computers and electronics has soared, power plant efficiency has been stuck at approximately 33 percent. That means for every unit of fuel, two-third of it is wasted, sent up the smokestacks or down the water pipes as waste heat.

The system's waste is substantial and has serious consequences. U.S. generators throw away more energy than Japan consumes. High energy prices are driving manufacturers and their U.S. jobs to locate in other countries. Unreliable supplies are shocking the nation's computer-dependent industries.

A Changing Industry

Electricity is a huge business. The traditional generators and deliverers of power – electric utilities – hold assets exceeding $600 billion and have annual sales above $260 billion. They are this nation's largest industry – roughly twice the size of telecommunications and almost 30 percent larger than the U.S.-based manufacturers of automobiles and trucks.

This huge business, however, is changing. For almost 80 years, it was based on the model of a monopoly, overseen by a state agency, controlling all power business within its service territory. The Public Utility Regulatory Policies Act of 1968 provided the first crack in that monopoly structure, and now the bulk of new power generation is provided by independent generators.

Most policy discussions about electricity over the past several decades have taken two forms. First, some have argued that power should be provided by private or investor-owned companies, while others favor public or government-owned enterprises. That public-private battle certainly continues as each side labels the other either a robber baron or a socialist.

The second debate could be described as fuel bickering. Some favor nuclear power, others embrace solar and wind, while others support coal and its gasification. The battle amongst the various fuels has led to enormous taxpayer expenditures, a good portion of which has been wasted.

The policy focus, instead, should be on innovation and efficiency. The issue is no longer whether the nation's and region's interests are better served by profit-seeking monopolies or by government-owned monopolies. Today's debate must be about what balance of competition and regulation will deliver more consumer choices, cost savings, environmental sustainability,

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and reliable electrical service.

Technological Innovations

Technological advances are transforming the electricity industry. Compared with the decades-old, efficiency-stagnant generators protected by tradition-bound utility monopolies, an array of modern equipment offers opportunities for new and innovative players to enter the electricity market. Such technologies, if not blocked by outmoded policy, could vastly increase productivity, expand consumer options, and reduce pollution.

Consider what's happening with the recycling of energy at several steel mills along Lake Michigan's southern shore. At U.S. Steel's Gary Works, for instance, an entrepreneur is producing 161 megawatt of power – enough to supply a small city – from the gas that used to be flared from the giant blast furnaces. Similar processes are working at Ispat Inland's steel-making operation in East Chicago, Illinois; sixteen heat recovery boilers capture and utilize the waste heat from that steel company's metallurgical coke-making facility, and a desulfurization process and fabric-filter system make Ispat the steel industry's environmental standard. The potential for such recycled heat exceeds a substantial 45,000 megawatts of electricity – the equivalent of 60 large coal-fired power plants – and could reduce carbon dioxide pollution by 320 million tons. Recycled energy is every bit as environmentally friendly as heat and power from renewable energy sources, yet few people – even environmental advocates – pay it any mind.

Another hot item is the cogenerator. This ingenious machine, a primitive version of which Edison employed at his Fleet Street power plant, produces both heat and electricity and can mean huge savings for consumers that might otherwise vent most of their energy to the great outdoors. A cogenerator captures the usually wasted heat to warm buildings, power chillers, dry paints and materials, and run an array of industrial processes. The benefit of cogeneration – sometimes called combined heat and power – is efficiency. The hybrid machines more than double the deployment of useful energy. A power plant producing only electricity is approximately 32 percent efficient, while a cogenerator using the same amount of fuel – but utilizing both electricity and heat – can be 80 percent efficient. Despite the economic downturn, some 31,000 megawatts of cogeneration capacity were added in the United States between 1998 and 2002, and the identified potential exceeds 200,000 megawatts.

Less noticed but equally productive are back-pressure steam turbines that capture the energy when industries or institutions reduce pressures in their steam pipes. Many universities, hospitals, and industrial buildings, particularly in colder climates, employ district heating systems that distribute hot water or steam through pipes to buildings throughout their complexes. Few of these institutions, however, capture the pressure reduction when valves cut the high-pressure steam coming from the generator to the low-pressure steam that can be handled by individual buildings. Lumber, pulp & paper, food, refining, and chemical firms also could employ similar back-pressure steam turbines to extract the energy released when they reduce steam pressure in order to run different industrial processes or when they release pressurized flue gas. Similarly-designed expansion turbines take advantage of the pressure drop when natural gas in high-pressure pipelines is decompressed for local networks. These simple, micro turbines are relatively inexpensive, the "fuel" is recycled and free, and their U.S. potential exceeds 6,500 megawatts or the output of 13 large coal-fired power plants.

Huge energy savings can result from the widespread adoption of seemingly simple technologies that increase energy efficiency. Compared to the basic incandescent bulb, for instance, compact fluorescent lamps consume one-quarter the energy and last seven times longer. Modern compressors and heat exchanges can reduce dramatically the operating costs of refrigerators. Architects can make better use of natural lighting and ventilation, and the federal government's Energy Star program highlights electronic devices that cut the standby consumption of computers and other equipment. Numerous energy management firms install sophisticated monitors and controls that trim costs and pollution, and scores of companies are devising more efficient and cleaner ways to produce paper, aluminum, steel, and chemicals.

Such efficient technologies already have reduced the nation's energy intensity. From 1973 to 2000, this measure of energy used per unit of economic activity fell 42 percent in the United States. In essence, the nation produced more with less power. The government's national laboratories maintain the energy-savings potential remains great – almost 50 percent for lighting and space heating and cooling, and about 33 percent for refrigeration, water heating, and iron and steel production. Advancing the efficiency resource has meant less need for electricity generation and transmission and their accompanying economic and environmental costs. New efficiency standards for appliances could further reduce electricity demand over the next 20 years by 25,000 megawatts, the equivalent of 50 coal-fired power plants, yet one of the Bush administration's first acts was to roll back air-conditioner efficiency standards.

Another modern technology is the combined-cycle gas turbine, made possible by advances in jet airplane engines that resulted from cash-strapped airlines demanding lower fuel costs and the military demanding better efficiency. These innovative turbines capture waste heat from the combustion turbine and use it to power a steam turbine. Put another way, the heat from burning natural gas or some other fuel is cycled twice through turbines in order to generate more electricity. (Unlike cogenerators, however, the remaining heat is vented and not captured.) Combined-cycle units, although they now generate only 3 percent of U.S. electricity, account for 88 percent of planned power plants. Because their relatively low emissions don't spark lengthy environmental reviews, a power-only, natural-gas-fired unit can be sited and licensed in less than 18 months. Combined-cycle units, while still substantial in size, can be mass produced to meet near-term demands for power.

Improvements in truck turbo-chargers and hybrid electric vehicles have spurred a slew of micro turbines, which provide electricity and heat or cool air to small buildings and commercial businesses. These innovations feature a shaft that spins at up to 100,000 rpm and drives a high-speed generator. Because

micro turbines use recuperators to transfer heat energy from the exhaust steam back into the incoming air stream, they are far more efficient than other small combustion turbines. The recuperators also lower the exhaust temperature to the point where nitrogen-oxide pollution is not formed. Mass production should soon lower costs to only $250 per kilowatt, making them attractive to the residential market.

Wind turbines are another increasingly-sophisticated technology, and, although starting from a relatively small base, they represent the world's fastest growing energy source, expanding some 30 percent annually. Progress in the United States, while substantial, has depended upon a federal tax credit equaling 1.8 cents per kilowatt-hour. Wind turbine performance has improved dramatically as a result of better rotor blades and controls. Larger turbines also are lowering costs, which average, depending upon wind speed, about $0.04 to $0.06 per kilowatt-hour. Wind technologies can be deployed in centralized wind farms or on a smaller scale, as evidenced by the retail chain Target marketing a one-kilowatt Bergey wind machine for home use.

Among the more promising, but not yet widely commercialized, developments are hydrogen fuel cells that produce an electric current and heat from chemical reactions rather than from combustion. They work by combining hydrogen with oxygen from the air, and their waste product is simply water. Although similar to a battery, fuel cells are recharged by the addition of hydrogen. Despite relatively high costs (more than $3,000 per kilowatt-hour), fuel cells are attractive in niche applications because they emit negligible pollution, have very high electric efficiency, employ few moving parts, require low maintenance, and are quiet. Of the several types of fuel cells, perhaps the most attractive is the proton-exchange membrane (PEM), which uses a special polymer "filter" that looks like an ordinary sheet of plastic wrap. Daimler-Chrysler and Toyota already are using PEM units in cars, while General Motors and Dow Chemical are installing a large-scale proton exchange membrane fuel cell (up to 35 megawatts) at the giant chlorine-production plant in Freeport, Texas.

Hydrogen also can store and carry energy directly. One advocate says, "Hydrogen as a widely used energy carrier is essential and inevitable," yet other researchers argue that using electricity directly remains more efficient than making hydrogen to store and transport power. The transition to a hydrogen economy, although promising, will take time and demand substantial costs. According to the National Academy of Sciences, it will require "a comprehensive, long-range program of innovative, high-risk/high-payoff basic research" in catalysis, nanomaterials, membranes, and separation. That report makes a specific plea for expanded research into distributed hydrogen production and storage systems.

Another innovation is the photovoltaic cell, a solid-state device that converts sunlight into electricity. PV costs have fallen fourfold in the last 15 years and further reductions seem likely because of advances in the manufacture of silicon wafers. Firms are developing more efficient solar cells as well as modules that can be integrated into a building's structure. At current prices, approximately $0.25 per kilowatt-hour, photovoltaic can compete in niche markets, often in rural areas where it is more costly to extend transmission and distribution lines, yet they remain about three times the cost of conventional electricity.

New technologies also are improving the production and processing of biomass, which includes wood, forestry and farm wastes, municipal garbage, and crops grown for energy use. These sources can be burned as well as converted into gaseous and liquid fuels. Biomass-powered electricity generation doubled in the U.S. from 1987 to 1999. Sweden, which has established willow tree plantations, intends to obtain 40 percent of its energy from biomass by 2020.

Advocates of centralized power point to new nuclear designs, such as the pebble-bed modular reactor (PMBR) that would employ tennis-ball-sized "pebbles" filled with uranium oxide granules. Compared to reactors from the 1970s, the smaller PMBRs are promoted as safer, quicker to construct, and less expensive. Although PMBR would emit no air pollution, it still would produce long-term radioactive wastes, and most investors (as well as the general public) remain skeptical of nuclear technologies after past accidents and cost overruns.

To continue burning the nation's substantial supply of coal, other engineers advance processes that convert coal into a gas. When subjected to heat and pressure, coal breaks down into a relatively clean-burning "syngas" of hydrogen and carbon monoxide, which can then be piped to turbines and burned. The combined-cycle process uses the waste heat to create steam and additional electricity. Without using the scrubbers that usually clean pollutants, four coal-gasification pilots – including a 250-megawatt station in West Terra Haute, Indiana – are releasing significantly less sulfur, nitrogen oxides, and mercury than conventional coal-powered generators. The technology, however, remains expensive, and risk-sensitive power companies have been reluctant to invest, although the climate may change if stricter air pollution regulations are enforced.

Innovations also are occurring in the transmission and distribution of power. The traditional power industry's knee-jerk reaction to the 2003 blackout was "expand the grid." Specific problem areas certainly need to be upgraded; yet holistic planning and modern technologies could minimize substantially the grid's vulnerability.

A growing number of engineers argue that the 2003 blackout should provoke a dramatically new approach to delivering electricity. They draw a comparison to computers and their evolution from centralized mainframes of the 1960s that were tied in a hub-and-spoke arrangement to today's decentralized web in which distributed computers are networked. These engineers foresee a radical new power network – one that's adaptive, self-healing, and compatible with distributed, on-site energy sources. It would have sophisticated sensors to anticipate crises, electronic circuits to redirect wayward currents, and a computerized "brain" to power down dishwashers and other noncritical electricity loads when the system is nearing its capacity. Such automatic adjustments would be unnoticeable – slightly dimming overhead lights or raising the summer temperature by a degree or two – but throughout a skyscraper or at

a factory they would result in substantial energy savings.

Microgrids link small generators within an industrial park or housing complex, and sophisticated software based on neural networks (a type of self-organizing system in which a computer teaches itself to optimize power transfers) can increase power quality and reduce the risk of overloads. The biggest barriers to such advancements are regulatory rather than technical. Although microgrids would save money and enhance reliability, state laws declare that only utility monopolies can string wires across streets or among customers. Microgrid advocates suggest that revised interconnection requirements would spark enormous benefits, as they did in the telephone industry in 1968 when the Carterphone legal decision enabled customers to connect to non-AT&T equipment and enjoy a world beyond the monopoly's black rotary telephones.

The University of California at Irvine, working with Southern California Edison and Southern California Gas Company, has created a "premium-power park" that deploys distributed generators and micro grids to supply the super reliable power needed by many of today's innovative industries. In the jargon of utility engineers, today's grid provides "three-nines" reliability, or power delivered 99.9 percent of the time. This sounds good, but that 0.1 percent means hours of disruptions, surges, and sags throughout a year, and those hours translate into millions of dollars in lost revenue for many businesses. The goal of electrical engineers, such as those in Irvine, is to achieve nine-nine reliability or uninterrupted power 99.9999999 percent of the time. Noting the modern economy's need for steady electricity, such premium-power parks could be launched in urban centers throughout the country.

Improved information, in fact, can provide enormous benefits. When consumers better understand their energy usage and the varying cost of power over time, they make more efficient and cost-saving decisions. The slight adjustment of a thermostat during a heat wave when power demand is at its peak, for instance, can save money for both the consumer and generator of electricity. New York's Niagara Mohawk offers the sophisticated meters that provide many of its largest customers with real-time power prices, enabling them to purchase less-expensive power at night and on weekends when the utility's generators are not stressed and have extra capacity. Rather than consumers paying the same rate whenever they use electricity throughout the month – the common practice that insulates buyers and sellers from the frequent and often substantial changes in power prices – a study by McKinsey Co. calculates that the availability of real-time pricing across the country would save some $15 billion each year.

The appearance of so many innovative technologies is surprising since utilities spend so little on research. Compared to the pharmaceutical industry's 12 percent of revenue, power companies devote less than 3/10 of 1 percent on R&D, less, according to one researcher, than the research commitments of the dog food industry. The federal government also has cut its energy research and development by more than a third over the past decade, despite the rise of oil imports and the increasing costs of blackouts. New electric technologies, therefore, result largely from developments within several separate industries. Airplane manufacturers, for instance, introduced the advanced turbines that power companies now utilize, while computer makers enabled the power industry to obtain more sophisticated electricity distribution.

Some analysts argue that today's cornucopia of electric technologies reflect the entrepreneurial climate created by the Public Utilities Regulatory Policy Act of 1978 and the Energy Policy Act of 1992. Others suggest that the development of modern equipment, particularly the cogenerator, forced policymakers to reform the regulated and centralized utility paradigm. No doubt today's opportunities result from some combination of policy and technology, and future benefits will depend upon innovations in both fields.

Policy Barriers

The fact that more efficient technologies are available or just on the horizon does not mean they all will be adopted, or that continued technology development will be a priority of a restructured electricity industry. Whether power innovations are boosted depends a great deal on how policy barriers are removed and open markets are advanced.

To obtain additional savings across the country, what's needed is a policy revolution to accompany the emerging technological revolution. Rather than provide subsidies to politically-favored technologies, energy laws and regulations must overcome regulatory inertia and become innovation-friendly. Current rules designed to support the status quo – centralized, steam-powered generators controlled by regulated monopolies – include restrictive interconnection standards, counter-productive environmental permits, and outmoded equipment depreciation schedules.

Bringing innovation to the power industry requires a paradigm shift in thinking. More than four generations of Americans have come to accept the notion that electricity is best produced by monopolies at centralized generators. Most take for granted the traditional system in which distant power plants throw away much of their heat, while more fuel is burned elsewhere to produce that same thermal energy. Few appreciate that improved small-engine and turbine technologies have made it more efficient and economical to build dispersed power plants that provide both heat and power to consumers. Although utilities have been protected from market discipline for almost 100 years, few challenge the wildly-inaccurate assumption that the United States already has achieved maximum efficiency.

Crafting the rules for an innovation-based electricity market is an uncertain and complex process. California's "restructuring" experience certainly demonstrates that costly consequences of haphazard planning, yet other states have introduced rules that are increasing consumer options and limiting any producer's market power. In essence, they represent experiments at integrating competition and regulation. These ground rules will be tested and revised, but the reforms demonstrate an ongoing effort to restructure an inefficient system based on centralized power plants and regulated monopolies.

Innovation-friendly markets will require the elimination of numerous regulatory, financial, and environmental obstacles to

innovation. Consider the following barriers:

Dominant power companies limit competition by blocking competitors from connecting to the grid, or by imposing obsolete and prohibitively-expensive interconnection standards and metering requirements that have no relation to safety.

States ban the stringing of independent wires across any public street, forcing distributed generators to negotiate with their competitors in order to send power to their customers. Developers can build telephone lines, steam tunnels, and internet extensions to their neighboring buildings, but stringing their own electric wires across a street, rather than relying on the utility monopoly, would send them directly to jail.

The balkanization of state electricity regulation fails to appreciate the interstate nature of electricity sales and discourages efficiency and reliability.

Utility lobbyists have won state regulatory approval to recover most of their investments in power plants and transmission lines that would not survive in a competitive market. These so-called stranded costs are being recovered through either a fee on future electricity sales or a charge to those individuals or businesses exiting the utility's system, thereby discouraging energy entrepreneurs.

Fifteen, mostly southern, states prohibit independent sales of electricity to third parties. An entrepreneur, as a result, can install a cogenerator at a chemical plant but cannot sell the resulting electricity to that facility; instead, he must market his power to the local utility.

Most states allow only the local utility monopoly to supply backup electricity to an independent generator down for maintenance, and regulators have endorsed high backup rates that assume all distributed generators will fail at the same time during periods of peak demand. Since the need for backup power at any given moment is only about 2 percent of total contracted power, these arrangements impose exorbitant rates on competitors. Unlike insurance premiums of only $2 for $1,000 of coverage, utility monopolies essentially get to charge $1,000 per year for a $1,000 life-insurance policy.

Many consumers can cost-effectively generate some of their own electricity, but monopolists penalize customers who purchase less than all of their power from them.

Regulated electricity rates average monthly costs and don't send accurate pricing signals to consumers. Regulators, by allowing utilities to pass all fuel costs to the customers, also provide no incentive for power companies to improve efficiency or install distributed generators.

Market power abuses can occur when one or two companies own most of the transmission as well as generation facilities in a particular region.

Depreciation schedules for electricity-generating equipment are, on average, three times longer than those for similar-sized manufacturing equipment. They made sense when a utility monopoly wanted to operate its facilities, whatever the efficiency, for 30 or more years. However, they discourage the introduction of innovative technologies that spur efficiency and productivity.

Because regulated monopolies obtain a profit on any investment, they have an incentive to build large, expensive, and site-constructed power plants. Such regulation also offers little incentive for utilities to retire those rate-based generators, even when new technologies are more economical, efficient, and environmentally sound.

The Clean Air Act of 1970 exempted existing electric generating plants from stringent air-pollution rules. More than 30 years later, these "grandfathered" coal-fired facilities keep polluting while emission reductions must be borne by the small subset of new generators. Federal regulations, moreover, fail to recognize that efficient power plants, which emit 20 times less pollution, will curtail the need to generate electricity at dirtier facilities.

State rules fail to recognize the location value of generators, even when distributed placements reduce transmission and distribution costs dramatically.

The U.S. currently measures air emissions based on fuel inputs, usually stated as pounds of pollutants per unit of fuel. Unfortunately, this input-based approach fails to reward power plants that operate more efficiently. In contrast, output-based regulations would calculate emissions based on the amount of electricity generated, thereby rewarding those innovative generators that supply more electricity but less pollutants.

Although federal regulations clearly require that all generators enjoy ready access to the electricity grid, most transmission/generation owners give priority to their own customers, which they refer to as their "native load."

Several other countries have systematically eliminated such policy barriers. Portugal, for instance, embraces distributed generation as a means to increase reliability and to avoid the high costs of transmission wires, line losses, and pollution. Denmark, Netherlands, and Finland advance cogeneration and, as a consequence, use half the U.S. average of fuel per kilowatt-hour while they maintain robust industrial economies. Similar policy innovations are needed for the United States to obtain the benefits of technological advances.

Conclusion

Electricity – which provides flexibility, convenience, and controllability – holds enormous promise. This precious energy source altered our landscape and lives, and electrotechnologies have revolutionized the flow of information, the processing of steel, and the construction of machines. Modern electricity-powered applications offer even greater precision and reliability; higher quality, portability, and modularity; enhanced speed and control; expanded productivity and consumer options; and "smarter" and miniaturized designs. Yet innovation in electricity generation and delivery hold enormous promise only if they are not blocked from the marketplace.

Just the environmental benefits alone are enormous since power plants spew almost half of all North American industrial air pollutants, and forty-six of the top fifty emitters are electricity generators. In contrast, new gas turbines emit 500 times less nitrogen oxide per kilowatt-hour than today's older power plants, and modern refrigerators use only 10 percent of the electricity consumed by a unit built in 1975.

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A Curmudgeon's View of Real-Time Pricing

By Julian Silk*

Introduction

Economists have been almost unanimous in their praise of real-time pricing (RTP) as a device to improve consumer welfare. Borenstein (2005) is only one of the latest in this chorus. He states "Finally, it is worth pointing out that RTP is being adopted in a number of places in the U.S. and elsewhere. The programs are relatively young – the oldest began in the early 1990s – but there are already a number of examples of programs with which both the utilities and the customers are quite happy, and that have documented both peak-demand reductions and reduced need for peaking capacity", Borenstein, op. cit., 116.

Borenstein states that "For a very thorough description of voluntary dynamic price programs in the U.S., see Barbose, Goldman and Neenan (2004)", Borenstein, ibid. But Barbose, Goldman and Neenan (2004) (hereafter BGN) are much less cheerful about the prospects for real-time pricing. "Experience to date suggests that customers are highly unlikely to gravitate in large numbers towards voluntary RTP programs on their own accord", op. cit, 37. Moreover, "Our review of experience with voluntary RTP programs suggests that few customers can be expected to enroll in the absence of explicit efforts to build customer awareness and acceptance", op. cit., 39.

There is thus a profound difference between what should work theoretically and actual practice. Economists have a contribution to make in narrowing this difference. The object here is to try to describe the standard intuition of economists, and to go step by step from this intuition to practice. Basically, we are going to set up an ideal RTP mechanism and see what would go wrong with it. To some extent, this will be an attempt to explain BGN's results, by expanding their box, op. cit., 8, on costs (equipment costs, short-term losses of amenity, and training and transactions costs). To a greater extent, this will be an effort to summarize the results in Moezzi, Goldman, Sezgen, Bharvirkar and Hopper (2004), hereafter Moezzi et. al. Our hope is that by mapping out these differences, by introducing factors that economists will need to deal with, they will be put into a form in which they can be modeled empirically.

Where the Economists Are

We start with the assumptions of the economists about real-time pricing. As with Borenstein, we take RTP to be pricing that varies with demand and supply conditions, as opposed to time-of-use (TOU) pricing that automatically varies with time of day, regardless of the market. The assumed RTP-electricity customer searches for savings on the spot price of electricity. The customer is assumed to be risk-neutral and to have stable arbitrary preference rankings or technology.

We thus assume that our consumers have a device that searches in continuous time for lowest electricity price amongst all suppliers for each relevant time span. Should the price of a new supplier for the next time span be lower than the price of a supplier who is currently supplying the customer, the device switches from the current supplier to the new lowest-price supplier. The device purchases the required amount of electricity for the required time, makes the contracts for it, and arranges for the delivery of the electricity.

Our device thus embodies the standard economic assumption that consumers have complete knowledge of their own behavior and of all prices in the market. Suppose we consider purchases over a year, beginning on January 1st. In its strongest form, our device must have complete knowledge of all spot prices as well as all fixed contracts to be offered during the year, and be able to compare them all. Otherwise, if our device searches anew each day, purchasing on the spot market each day must be an efficient strategy for consumers.

Two other assumptions delineate the extent of the market. The first is that the customer is not in the market for (or does not possess) technology that uniformly lowers electricity demand at all times. This is to differentiate the markets for demand-side management (hereafter DSM) from the RTP market. Moezzi et. al., 16, state, "In response to probing questions about whether their energy-efficiency investments were linked to real-time prices, most customers indicated that they were not".

The second is what might be called a "fixed-actor" assumption. Electricity consumers (regardless of whether they are final consumers or produce some other product) stay on the demand side of the market. No electricity price will move them to become electricity suppliers for the same time period.

We can illustrate this assumption with the market for tomatoes, where it holds without question. Suppose a tomato consumer shops at a summer roadside vegetable stand. No such consumer can see a price for tomatoes, immediately grow tomatoes from scratch, and open up a stand across the road to compete the same day.

It turns out that these standard assumptions (which seem almost to be definitions) are quite confining in the case of electricity.

Separability

Moezzi et al, 5, state, "Reasons customers gave for why they weren't price-responsive include implicit value placed on reliability, pricing structures, lack of flexibility in adjusting production inputs, just-in-time practices, perceived barriers to onsite generation, and insufficient time". We will try to characterize these features in terms of economic theory.

One possible way of characterizing the difficulties with pricing structures, lack of production flexibility and just-in-time practices (as well as insufficient time) is with the notion of separability. (By separability, we will mean a constant elasticity of substitution with respect to electricity.) Goods producers whose cost function is not separable in electricity prices, or final goods consumers whose utility function is not separable in electricity would be more probable to be RTP consumers.

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Nadiri, 447-448 in Arrow and Intriligator, eds., (1982) defines separability for production and cost functions (roughly that cost of production goes up every time electricity prices go up and vice versa, regardless of scale or production mix).

The very thorough study of Charles River Associates (2005) on time-of-use and critical-peak pricing seems to support this segregation. The maximum percentage impact of the prices of the variable critical-peak prices they studied (which may be the most comparable to real-time pricing) was about a 16% drop. This was observed for residential customers as peak prices went from $0.13 to $0.90, or –16%/592% ≈ -0.027 (Figure 1-3, 8, op. cit.). (Industrial and commercial customers had a smaller percentage drop, but their base usage was higher in general, so their aggregate effect was greater.) Much of the drop was due to changes in air-conditioning, and the customers who had "enabling technology" (smart thermostats, supplied for free) had more of a drop than those without (9, op. cit.).

It may be possible to go further than this. Barton and Böhm, 424 in Arrow and Intriligator, op. cit., discuss Pigou's Law, in which own-price elasticities are virtually proportional to wealth (or income) elasticities. This law applies to a subset of cases that satisfy separability. A panel data study of electricity customers, separated by quintile, calculating individual income elasticities and own-price elasticities, might show these tend towards a constant proportionality factor across customers, so a type of this law might hold for electricity customers with separability.

Of course this will hold for daily income elasticity and daily price elasticity, as for most consumers, daily income percentage changes will be close to zero, so zero times something will equal zero. The more interesting case is whether there might be a relation between daily price elasticity and, say, annual income elasticity.

The relevant distinction to support a relationship may be between capacity utilization of existing devices and purchases of new devices. If electricity bills go up from $20 a month to $100 a month, a customer may raise the thermostat in summer from 70° F to 80° F and be uncomfortable. That appears to be the case in the California results. But if electricity bills continue to go up to $150 a month, it is much less probable that the customer will raise the thermostat in summer to 90° F, unplug the refrigerator, throw away the television, etc. It is also unlikely that the customer will get rechargeable batteries and wake up randomly in the wee hours of the morning to charge them.

What is likely is that the meaningful response to high prices will not be reduction in utilization, but purchase of more efficient equipment (such as glass with higher R ratings or refrigerators with higher SEER ratings), additional vacations, etc., as more income becomes available. That the characteristics of the reduction in electricity usage will depend on equipment type, which will be fully utilized, and that the reduction for separable customers will depend on income growth seems to be a reasonable testable hypothesis.

Generation and Error-Free Analysis – Fixed Cost

Electricity is not as simple to purchase as tomatoes. In purchasing electricity, the consumer is purchasing both generation and transmission. It will be simplest to begin with the problems involved in purchasing electricity generation. We start by assuming electricity transmission has a price of zero, can be purchased effortlessly and that electricity transmission functions flawlessly for each purchase. These assumptions will be removed later.

The simplest problem to note with our device is that we need access to all relevant electricity generation prices. If our device is a computer program, we need access to all relevant generation prices, and knowledge of how to obtain these prices and reprogram production equipment or consumption to cope with these prices. We must also know our own quantity of electricity used. At a minimum, this requires a sacrifice of computer or information technology from production (or consumption) to doing this program. Otherwise we require the electricity supplier or some agent to provide this knowledge for us.

This search mechanism (even for electricity generation) thus adds (at least) a fixed cost to ongoing purchases, even if it never errs.

The search mechanism would also not be simple. Electricity prices vary more than is recognized. Suppose we consider PJM, the independent system operator (ISO) for Pennsylvania, New Jersey and Maryland, which is probably the industry standard. On Sunday, January 2nd, 2005 at 3AM, PJM's price for electricity generation was $3.54 per MWh. This compared to a price of $13.88 per MWh at 2AM that same day, and a price of $13.88 per MWh at 4AM that same day. (See http://www.pjm.com/markets/energy-market/real-time.html and 20050102.zip). The day ahead prices for that day listed for Saturday, January 1st, 2005, were $20.03 per MWh for 2AM, $17.25 per MWh at 3AM and $16.33 at 4AM. (See http://www.pjm.com/markets/energy-markets/day-ahead.html and 20050101-zip.zip). Incidentally, the electricity used for the RTO for that Sunday was 23718 MW for 2AM, 23294 MW for 3AM and 23214 for 4AM.

Thus, even for PJM, electricity generation prices are unpredictable and extremely volatile. (As this is written, PJM prices do not usually have this wide and rapid a variation, but are still varying from about $30 per MWh to $80 per MWh per day.) A producing firm with non-separable electricity prices in its cost function would thus have to handle random processing time. Firms without this property that tried to be RTP customers (without further modification) would be paying overtime labor costs (and administration) as well as rescheduling deliveries under the best of circumstances.

For end-use consumers to have the properties of non-separability necessary to take advantage of RTP would probably require large capital investments, for metering, controllers, energy storage (batteries or some other method), computer hardware and software, insulation, etc.

Generation and Errors – Another Fixed Cost

But even if we have no problems with transmission, any reasonable programmed search mechanism can err. Certain features have to be installed to cope with this possibility.

First, all relevant prices must be stored. This means either the storage of all generation prices, or a statistically sufficient

list of prices to satisfy the likelihood of effectively obtaining the lowest price. This adds another fixed cost (in terms of computer and information technology resources).

We also want to compare prices. Hourly prices can be compared between PJM, the New York ISO (NYISO) and the New England ISO (NEPOOL) with relative ease, for each entire ISO, and for individual facilities, for the current day and the past.

But this does not hold for other ISOs. At the site http://www.midwestmarket.org/page/Real-Time+Info, clicking on "Market Reports" enables one to get system ISO data (by clicking on "Day-Ahead Reports" or "Real-Time Reports") and individual facility data (by clicking on "Historical LMPs"). But the current data (available by clicking on "LMP Contour Map & Data") does not have a current ISO system price.

The situation for the Texas ISO, ERCOT, appears to be much worse. There appears to be no individual facility historical data available at all. Balancing Services Market Clearing Prices, by zones, are available at http://mospublic.ercot.com/ercot/jsp/balancing_services_mcp.jsp. Other prices are available (but again, only by zone) at http://www.ercot.com/mktinfo/prices/index.html. There also appears to be no system ISO pricing information of any sort available. This lack makes it very difficult to compare generation prices.

Note should be made of software tools available from Cambridge Energy Solutions which claim to be able to overcome these problems. (See http://www.ces-us.com/download/CES%20Bio.pdf). The tools are by individual ISO. But with the mergers and acquisitions going on in electricity markets, the Cambridge Energy Solutions tools can't be a one-time only purchase. So again, at least one fixed cost has to be added to ongoing operations.

Transmission and Loop Flow – A Random Cost

All the problems that exist for electricity generation are much worse for electricity transmission. For example, as argued by U.S. Energy Information Administration (December 2004), data on electricity transmission are not organized and readily available.

The worst problem that is encountered with electricity transmission is the phenomenon of loop flow. The classic case of loop flow is discussed by Stahlkopf, 264, in Einhorn and Siddiqi, eds., (1996), in which transmission that is contracted to go across a border from Ontario Hydro to New York flows through lines in Ohio and Kentucky before reaching New York. Such flow covers more than one ISO region and will be difficult to analyze.

The simplest discussion of transmission is Hogan, 143-182 in Einhorn and Siddiqi, op. cit. The Kennedy School of Government maintains the web site http://www.ksg.harvard.edu/hepg/, which discusses various modeling approaches to transmission (see http://www.ksg.harvard.edu/hepg/transmission_flowgate.htm). The approach of Hu, Ralph, Ralph, Bardsley and Ferris (2004) shown on this site is especially interesting. But none of these transmission models has been empirically tested against data (or each other), or used for forecasting, so there are no records available for potential users of the models.

There is a commercial model that copes with transmission pricing, as well as the features mentioned above for generation: UPLAN (see http://www.energyonline.com/products/uplane.asp). But again, because of the changing nature of the markets, the modeling will not be a one-time only purchase, but will be a fixed, ongoing cost. The transmission costs themselves will be random costs, beyond the control of the consumer, depending on system congestion.

In practice, the real need for organized exchanges for large-scale electricity markets is to enforce spot (and futures) purchases. The standardized exchanges minimize transaction costs by guaranteeing prices and terms of delivery. Idiosyncratic consumer purchases that our assumed device would enable would have all the problems of generation and transmission that current electricity consumers encounter, but would impose additional reporting and legal costs on the ISO markets as well, barring some sort of standardized licensing procedure for entry and exit.

Mechanism Breakdowns – Another Random Cost

The devices to implement RTP themselves are not perfect. If they break down in the middle of the night, the consumer who owns them will be in a vulnerable position if they pay to have them fixed to recoup any remaining savings. It is not just the workers of the firm who have to be compensated, but repair personnel, who can charge monopoly rents for coming out in the middle of the night.

This problem is largely because of the small number of RTP users, and may disappear if this number increases. It may also disappear if globalization and technological advance continue; it is possible to imagine workers in India maneuvering a robot onsite in the U.S. to fix meters, etc., for a standard fee. A subscription service for this would thus change a random cost into another fixed cost.

Technological Limits with RTP: Waiting, Security and Environmental Risk

Nothing in the description so far of our assumed search device need necessarily be unique to electricity. A similar search device might search for least-cost telephone service, register switches, etc. In this case, having purchased the device or service, we are stuck (at least temporarily) with the level of telephone services the device provides.

VoIP telephone service has recently become widespread (e.g., http://en.wikipedia.org/wiki/VoIP). If we had purchased our search device for standard telephone service, we would now want a new device to perform continuous-time searches for least-cost VoIP services. The existence of merchant VoIP providers would seem to be the next step in VoIP's evolution, waiting only on regulatory lag to provide a legal framework.

It is difficult to imagine a comparable development in the electricity sector to the development of VoIP in telephony that would offer promise of drastic technological change for RTP use. High-temperature superconductivity (e.g., at liquid nitrogen temperatures) might be one such case. Kirchoff's Law, which generates the current loop flow transmission problems with congestion, would still probably operate for transmission

with superconductivity, albeit on a much lesser scale. But incremental ongoing technological changes in electricity use would still make efficient RTP purchases an ongoing relationship instead of a one-time purchase.

The security aspect of RTP use has also not received sufficient stress. With all the devices required to implement RTP, you are putting a lot of stress on information technology. This makes RTP users more vulnerable to computer viruses or other information technology attacks than would be non-RTP users. Even if there aren't attacks or viruses, the high volume of communications required makes monitoring by eavesdroppers easier, since they have more opportunities to listen in. Thus, RTP users either upgrade their information security – another fixed cost – or impose a greater risk on their operations.

RTP users will also have to deal with environmental costs. Widespread RTP use would bring environmental benefits, by removing the need for additional construction of generating and transmission facilities. But it isn't environmentally cost-free.

If the promised savings of RTP use depend on additional use of coal-burning facilities (or transmission from coal-burning facilities), they depend on an environmental regime which is subject to change. There have been two recent stories in the Washington Post about coal-burning plants in Virginia which illustrate these possibilities. The first is on mandated installation of scrubbers (Michael Shear, "Dominion to Cut Power Plant Emissions - $500 Million Committed to Reduce Pollution From Coal-Fired Generators", Wednesday, November 23, 2005, B03). The second is on the possible closure of the old Potomac River Generating Station (Peter Behr, "Powerless – Lights Out? The Region's Fraying Electric Supply", Sunday, December 11, 2005, B05). Environmental limits (or cost increases) on incumbent coal-burning facilities can make RTP's promised benefits disappear; so RTP customers have to watch environmental restrictions closely.

Imperfectly Competitive Supplier Markets

The search device specified above is imaginary, but a proxy for the device is Google's price service, Froogle. Froogle doesn't cover electricity prices, but the results from Froogle may offer insight into what would happen if electricity suppliers were organized into one uniform market.

In http://news.zdnet.com/2100-9588_22-5566812.html, Paul Festa writes "A lot of early studies predicted that all firms would be forced to price their goods at cost and prices would be driven down", said Michael Baye, a professor of economics at Indiana University's Kelley School of Business. "That hasn't happened. There is still considerable price dispersion online."

This statement is based on Baye, Morgan and Scholten (2004a), Baye, Morgan and Scholten (2004b), and Baye and Morgan (2004). Festa states "Specifically, merchants are using what Baye calls 'hit-and-run' pricing strategies, varying their prices in order to keep the competition from being able to consistently undercut them."

Upon reflection, these results are extremely plausible. There is an incentive for suppliers who are competitive with others but who do not dominate on price to price under break-even average total cost on occasion to keep consumers and competitors guessing.

If any suppliers withdraw supply, the effectiveness of this policy increases. This has occurred recently. Joskow, 10, (2006) notes, "Concerns about market power in the U.S. were reinforced by the events in California in 2000-2001 (Borenstein, Bushnell and Wolak (2002), Joskow and Kahn (2002)), where market power and the exploitation of market design imperfections contributed to the explosion in wholesale prices beginning in June 2000."

The additional market power effect may be temporary. Baye, Gatti, Kattuman and Morgan (2004), 4, note "A monopoly seller faces an elasticity of demand of about –2.5, while in the most competitive markets we analyzed (15 sellers), the elasticity of demand for a representative firm's product is about –6.0." Joskow, op. cit., states "despite all the concerns about market power, the wholesale markets of the Northeast appear to be very competitive".

What remains is the result that any search procedures (or devices) could not be "cached" or standardized, but would have to be de novo searches each time for imperfectly competitive markets. Festa quotes Baye (from Baye and Morgan (2001)) on this result: "This is the information paradox," Baye said. "The only way a price comparison site is going to attract consumers is by providing valuable information. But if in doing so they created this world where all merchants charged the same price, who would bother going to a price comparison site?"

These (random) costs might be characterized as "information casino" costs, the price you pay to play. That (some) suppliers might take losses to remain considered by searches is immediately clear. But demanders may pay more than their bare minimum as well, in order to be plausible candidates for purchases from individual suppliers, either as spot purchases through the exchanges or "over-the-counter", or in purchasing with fixed long-term contracts.

To eliminate such information casino costs would require rapid and complete entry and exit on the part of suppliers (and possibly demanders as well). Joskow, op. cit., argues convincingly that entry into either electricity generation or transmission in the U.S. is now highly problematic.

Risk-Aversion, Backup On-Site Generation and a Problem with Success

Risk aversion adds some explicit costs to RTP. For suppliers, even if RTP would be cost-effective for risk-neutral consumers, risk-averse consumers will not enter into RTP. So the suppliers have to lower their margins to make sales to such customers, or they have to provide some form of insurance. To calculate this insurance can be difficult if consumers have utility functions of the hyperbolic absolute risk aversion (HARA) class that are not special cases (Ingersoll, 39, (1987)).

These costs need not be stationary, but may respond to news. Well-informed consumers are aware of the events surrounding the TOU pricing experiment with Puget Sound Energy (PSE), which was concluded in 2002 (see http://www.eere.energy.gov/femp/program/utility/utilityman_elec_wa.cfm). The problems with this experiment, which can be put most charitably as transferring risk from PSE investors to PSE consumers,

would tend to increase the costs of risk-aversion over what they might otherwise be.

To the extent that RTP is not just a synonym for peak load reduction, the natural response is to purchase some sort of backup on-site generation. Moezzi et. al., 15, note: "In Duke Power's voluntary RTP program, for example, seven of the 12 top responders in the program used on-site generation (Schwarz et. al. (2002))." Once consumers have installed backup on-site generation, they can "cherry-pick", using RTP when offered prices are low, and using the backup on-site generation when prices are high.

The environmental restrictions on combined heat and power (CHP) are the most obvious limit for backup on-site generation. But besides the environmental CHP limits, there are the learning and operating costs to deal with the generators. To the extent that consumers are risk-averse or the technologies are complicated (fuel cells have been mentioned as a possible candidate), these costs are worsened.

Two other problems occur with backup on-site generation which are more subtle. The first is a system problem that would occur even if there were no environmental problems. Suppose all backup on-site generation for RTP customers for a particular ISO were in the form of photovoltaic (PV) cells, and that this amount of generation was equal to 10% of the total generating capacity of the ISO. Suppose the peak output of the PV cells occurs at 5PM (when load is at 90% of peak), and that the sun sets at 6PM (when load is at 95% of peak), and the peak load on the system is at 7PM. Instead of going from 90% of peak to 95% of peak, if all the RTP customers switch to the PV cells at 5PM, we will go from 80% of peak to 95% of peak in one hour. If there are gradient or voltage constraints on the transmission system, at best we will have system problems.

These problems worsen if the backup on-site generation is sufficient not just to remove load, but for the RTP customers to provide sales to some of the other customers. Such problems might be removed with advanced grid control equipment, such as Flexible AC Transmission System or FACTS (see Hingorami, 239-257 in Einhorn and Siddiqi, op. cit.); however, "Technologies such as large-scale FACTS generally require the support of a wide-area measurement system (WAMS), which currently exists only as a prototype. Without a WAMS, a FACTS or any major control system technology cannot be adjusted to deliver its full value and, in extreme cases, may interact adversely with other equipment" (U.S. Department of Energy (May 2002)).

The second problem goes back to our "fixed-actor" assumption. It's a problem with success. Suppose some purchaser has acquired a complete RTP system from some electricity supplier, has practiced DSM, and has purchased backup on-site generation. Suppose the amount generated not only satisfies the customer's needs, but exceeds them. Instead of selling the excess back to the grid, what (besides risk-aversion) prevents this RTP customer from undercutting the electricity supplier to supply some other non-RTP customer? It's as if tomatoes were so hard to sell that the roadside vendor had to sell them together with magic tomato plants (that grew a few tomatoes 2 hours later) to sell them any large number of tomatoes at all. Certainly profit margins will be reduced, and a system like this can only go so far in the absence of binding long-term contracts. Moezzi et. al., 7, op.cit., state that RTP program participants had commitments of up to 5 years.

Conclusion and Policies

DSM is designed to lower electricity use. People believe that electricity suppliers are better off financially by increasing the amount of electricity sold. They will thus wonder why electricity suppliers would want consumers to use DSM if it works as promised. Something similar may be going on with RTP.

Economists tend to assume that RTP would be used instead of conventional electricity pricing. For the current absolute levels of the differences between peak prices and average prices, it is argued here that the costs needed to implement RTP will be in addition to the costs consumers pay for conventionally supplied electricity. An attempt is made to characterize consumers on the basis of separability, to draw out a few implications of this distinction, and to outline the costs involved. Additional economic research can help make these costs concrete.

If the peak-average price differences continue to widen, eventually RTP usage will become widespread under laissez-faire. Because of the benefits RTP offers to the environment, insurance companies may become involved in subsidizing RTP and promoting it. The more the costs are recognized and accurate figures are provided for them, the better a laissez-faire approach to RTP can work.

Otherwise, specific government interventions will probaby be required to address the cost differences outlined here for RTP to become popular in the next decade. An example of such a policy on a national scale might be a Federal subsidy for electricity suppliers who hedge sufficiently in weather and fuel derivatives to offer lower annual electricity costs for consumers in 2008 than their 2007 annual electricity costs with conventional pricing. States might also have a role to play, by providing for partial rate-basing of the devices needed to implement RTP. States might also impose mandatory purchase fees for carbon rights on conventional pricing customers, or revise the payments to RTP to include payments for altering the albedo (e.g., with reforestation) for customers. Economic analysis of RTP costs can put accurate price tags on such interventions, and thus lower the cumulative social cost of electricity in the coming years.

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Consolidation of Utility Companies Shows No Sign of Abating

By Fereidoon P. Sioshansi*

After a period of relative lull, utility mergers and acquisitions (M&As) appear to be on the rise again. At least five major M&As were announced in 2005 (see table), all mutually consenting except for the hostile takeover of Endesa by much smaller Gas Natural, which is pending final regulatory and government approval at the time of this writing. Higher energy prices and a belief that being bigger is better are among the primary reasons. Bloomberg reports $440 billion worth of energy industry (not just electric or gas utility) mergers in 2005, 38% higher than 2004. Analysts say 2006 may match or possibly exceed that level.

M&As are back in vogue

Major mergers & acquisitions of 2005 ranked by value of the deal, $ billion

Acquisition	Company (Country)	Announced	DealValue in Billions
Gas Natural SDG (Spain)	Endesa (Spain)	Sept. 5	28.3
Suez (France)	Electrabel (Belgium)	Aug. 9	14.3
FPL Group (U.S.)	Constellation Energy (U.S.)	Dec. 19	11.3
Duke Energy (U.S.)	Cinergy (U.S.)	May 9	8.8
NRG Energy (U.S.)	Texas Genco Holdings (U.S.)	Oct. 2	8.3

Source: Compiled from varying sources

The motivations for the M&As vary from no good reason at all to highly sensible strategic fits, operational synergies, and/or economies of sca. But even in cases where there are good reasons to merge, regulatory complications and actual difficulties of combining different cultures, operations and systems typically tend to be far more daunting than originally anticipated – wiping out many of the projected costs savings.

More to follow?

Snapshot of FPL and Constellation

	FPL	Constellation Energy
Revenue as of 3Q 2005	**$8.68 billion**	$11.97 billion
Net income as of 3Q 2005	**$679.0 million**	$427.9 million
Customers	**4.2 million**	1.83 million
Regions	**24 U.S. states**	22 U.S. states: 3 Canadian provinces
Generating capacity	30,000 MW	12,500 MW

Source: The companies and The Wall Street Journal 15 Dec 05, 2004 data

An interesting case in point, announced in mid-December 2005, was the $11.3 billion acquisition of Constellation Energy Group Inc. by FPL Group Inc., parent of Florida Power & Light Company, the largest utility in Florida. Each company owns and operates 3 nuclear plants, making the combination among the biggest nuclear operators in the US.

The combination would become the third largest investor-owned utility in the US if measured in terms of revenues. The top ranked utility would be created by Duke Energy's $8.8 billion acquisition of Cinergy Corp. followed by Exelon Corp's $16 billion acquisition of Public Service Enterprise Group – all pending lengthy regulatory approvals. Exelon currently ranks as the biggest operator of nuclear power plants, followed by Entergy Corp.

FPL/Constellation combination does make a lot of sense – most analysts agree. Not only does it get FLP out of its home base geographically, but Constellation's extensive experience in the retail business in states where competition for customers is allowed should prove valuable. Over 75% of Constellation's earning come from its successful unregulated businesses. The reverse applies to FPL. The combined company would have a nice mix of regulated and unregulated assets, in different time zones with an impressive footprint that covers many states. The combination would own 25 GW of merchant plus 17 GW of regulated plants – it should do well no matter how things evolve in the murky US electricity market.

More notable is the profile of the CEO's of the two companies. Constellation is run by Mayo Shattuck, previously with Deutsche Bank Alex Brown. CEO of FPL and the combined company is Lewis Hay, who came from food service industry background. This, one can surmise, is the type of large utilities that will emerge in the coming years, run by professionals with financial and business background. Engineers who used to run utility companies in the past will be delegated to maintain the boilers.

The recent surge of M&A activity is not limited to the US; of course, Europe has had its share of acquisitions and consolidations for some time, leaving the top ranks of the utility companies to a handful of super-giants. The European Commission (EC) had originally wanted to introduce competition to all electricity and gas customers by 2005, but was persuaded by its two biggest members, Germany and France, to delay the initiative to July 2007.That temporary reprieve, however, has created a strong impetus to merge, expand and otherwise gain an advantageous position before it is too late. The pressure to make a pre-emptive move and the fact that many of the big players are literally sitting on hoards of cash has resulted in moves that sometimes defy logic and would often result in less, not more competition – which is what the EC is driving for.

Among persistent regional and country-wide price disparities, and different government policies that ranges from indifferent to supportive of strong so-called national champions, existing big players are determined to get bigger and/or move outside their national markets. Last month, Gas Natural SA, Spain's virtual gas distribution monopoly launched a $27.5 billion bid to take over electric utility Endesa SA, which is twice its size. While the logic of the move makes perfect sense for gutsy Gas Natural, it promises to create a giant utility reducing any prospects for competition in Spain. The combined company plus Iberdrola SA, the other big Spanish electric utility, would

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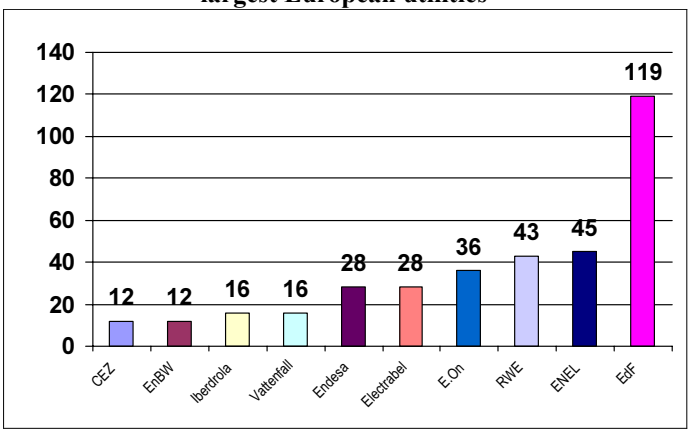
control 75% of the electricity and gas market in the country. The Spanish regulator, Comision Nacional de Energia (CNE), one can only surmise, has been in a difficult bind if it were to conclude that the merger would enhance competition.

The big generators keep getting bigger

Installed capacity owned by some of the largest European utilities



Source: R. Haas, Technical University of Vienna

Following the announcement, EU's Energy Commissioner Andris Pieblished by the EC in May 2005 pointed out that Europe was turning into country-dominated markets controlled by one or two big players. While companies such as E.On and Vattenfall have made significant investments outside their home markets, the EC report concluded that market penetration of electricity companies outside their home markets was less than 20%.

Highly concentrated

Market share of the largest and top 3 generators in selected European countries

Country	Largest (%)	3 largest (%)
Austria	45	75
Belgium	85	95
Czech Republic	65	75
Germany	34	71
France	85	95
Hungary	46	65
Italy	55	75

Source: R. Haas, Technical University of Vienna

Professor Reinhard Haas of Technical University of Vienna, who has been following the consolidation of major power generators in Europe, points out that in several European countries a significant segment of the market is controlled by relatively few companies, with significant ramifications for competition at the wholesale level. Lack of sufficient transmission capacity into or out of certain key markets makes matters worse.

There are signs that EC regulators are beginning to put limits on anti-competitive mergers. In September 2005, for example, the European Court upheld an earlier decision by Neelie Kroes, the EU's Competition Commissioner, who had blocked the Energias de Portugal (EdP) proposal to acquire Gas de Portugal.

Another cause for concern is persistent price disparities among countries and regions. Prices in Eastern Europe, for example, are half of those in Italy, which is import dependent but poorly served by limited transmission capacity. Frustrated by lack of progress, the EC did something very American. In July, it filed suit against Greece, Estonia, Ireland, Spain and Luxembourg for failing to implement one of the many EU deregulation legislation by the deadline.

A 2005 survey of global energy companies by Platt's shows a continuing trend towards consolidation among the world's biggest energy companies – be it in the oil or utility sector. Size, it seems, gives clout for those who want to remain relevant on a global scale. The accompanying table, compiled from Platt's most recent survey, shows the current ranking of the world's largest electric utilities, diversified utilities and independent power producers (IPPs). The rankings are based on assets, valued as of the end of 2004 – hence do not reflect more recent developments in utility valuations, nor the recent mergers announced. The rankings are limited to listed companies.

If you inspire to be big, size does matter

Top 20 listed global energy companies, by 2004 assets

Rank	Company	Country	Assets*, $b	Revenues, $b	Co. Type
1	EON	Germany	$154	$61	EU
2	TEPCO	Japan	$123	$47	EU
3	RWE	Germany	$114	52	DU
4	ENEL	Italy	$93	49	EU
5	Suez	France	$85	55	DU
6	KEPCO	Korea	$71	23	EU
7	Endesa	Spain	$65 (sought by Gas Natural)	24	EU
8	Kansai	Japan	$61	24	EU
9	Duke	USA	$55 (acquiring Cinergy Corp)	23	EU
10	Chubu	Japan	$51	20	EU
11	Electrobras	Brazil	$50	7	EU
12	National Grid	UK	$47	16	DU
13	Dominion	USA	$45	14	DU
14	Exelon	USA	$43 (acquiring PSE&G)	15	EU
15	Southern Co	USA	$37	12	EU
16	Tohoku	Japan	$37	15	EU
17	Kyushu	Japan	$36	13	EU
18	AEP	USA	$35	14	EU
19	PG&E	USA	$35	11	DU
20	SCE	USA	$33	10	EU

* Assets are as of Dec 2004. Several companies are in the process of getting merged; Electricite de France was not partially privatized until late in 2005 and is not included in table
Legend: EU = electric utility; DU = diversified utility; IPP = independent power producer
Source: Platt's ranking of top 250 global energy companies, Dec 05 issue of Insight

The ranking are likely to change pending a number of mergers and acquisitions already announced plus more to come in 2006.

A Review of the Extent of Concentration of Energy Production and Processing on the U.S. Gulf Coast

By Robert W. Gilmer, Carrie Ann Fossum and Iram Siddik*

One of the results of Hurricanes Katrina and Rita was a sudden and widespread public recognition that energy facilities are heavily concentrated on the Texas and Louisiana Gulf Coast. As these storms limited the production, processing and movement of U.S. energy products, the unfolding events in Texas and Louisiana became a compelling pocketbook issue throughout the United States. This article reviews the reasons for the concentration of so much energy activity on the Texas and Louisiana Gulf Coast and documents the extent of this concentration in both production and processing of oil and natural gas.

Why the Gulf of Mexico?

A question asked again and again by television reporters as the recent hurricanes crossed the Gulf of Mexico and approached land was how so much energy infrastructure came to be located on the Gulf Coast. Table 1 shows that the size of the Gulf Coast population and economy probably plays a relatively small role. Texas and Louisiana combined account for 9.2 percent of the nation's population and 8.3 percent of its personal income. The Gulf Coast portions of these two states represent less than half the state totals, and the Houston–Texas City region alone makes up about half the Gulf Coast population and income.[1]

Table 1
Texas, Louisiana, and the Gulf Coast as a Share of U.S. Population and Income (percent)

	Population	Personal Income
Texas	7.6	7.0
Louisiana	1.6	1.3
Gulf Coast	4.0	3.6
South Louisiana	1.1	1.0
Port Arthur/ Lake Charles	0.3	0.3
Houston/Texas City	1.9	2.0
South Texas	0.7	0.4

NOTE: Totals may not add due to rounding error. Data are for 2003.
SOURCES: Bureau of Economic Analysis; authors' calculations.

Much more important than population is the concentration of oil and natural gas reserves in the region. Table 2 shows that 22.4 percent of the nation's oil reserves and 35.4 percent of its natural gas reserves are on the Gulf Coast or in adjacent state and federal waters. For both oil and gas, the federal offshore is home to by far the most reserves. In terms of production from these reserves, the Gulf's share is significantly higher for both products: 30.6 percent of U.S. oil and 38.7 percent of natural gas. Once again, the waters of the Gulf of Mexico dominate, providing 26.4 percent of U.S. oil production and 21.3 percent of natural gas.

Table 2
Gulf Coast and Offshore Areas as a Share of U.S. Reserves, Production and Drilling Activity (Percent)

	Reserves		Production		
	Oil	Natural Gas	Oil	Natural Gas	Drilling
United States	100.0	100.0	100.0	100.0	100.0
Gulf Coast	22.4	3.4	30.6	38.7	28.8
South Louisiana	1.4	1.8	2.0	4.2	2.3
Houston+Port Arthur	0.9	1.7	1.5	3.7	5.5
South Texas	0.4	5.5	0.7	9.5	8.2
Offshore Texas	1.1	3.5	3.5	N.A.	0.9
Offshore Louisiana	18.6	22.9	22.9	N.A.	11.9
Total Offshore	19.7	26.4	26.4	21.3	12.8

NOTE: Drilling data are for the 12-month period from November 2004 to October 2005. Offshore data are for both Federal and state waters.
Houston and Port Arthur are Texas Railroad Commission District 3; South Texas is District 2 plus Disrict 4.
Reserves and production data are for 2004.
SOURCES: Reserves and production are from the Energy Information Administration or from Texas and Louisiana State governments; drilling data are from Baker Hughes; authors' calculations.

Oil and gas exploration activity in the region accounted for 28.8 percent of the rigs active in the U.S. during the 12 months ending in October 2005. Although the Gulf of Mexico has fallen out of favor in this drilling cycle as a target for exploration, it was still the most active Gulf Coast region, with 12.8 percent of active rigs.[2] South Texas was the most active land area, with 8.2 percent of working U.S. rigs.

History also plays a role in the concentration of energy facilities along the Gulf Coast. The first true gushers in the U.S. were the salt dome discoveries of the Texas Gulf Coast, beginning with Spindletop in 1900 and followed quickly by Sour Lake, Batson, North Dayton, Humble and many others. Several large refineries on the Gulf Coast, especially in Beaumont, Port Arthur and Houston, date to these huge discoveries in the industry's early days. The ties in skills and inputs between refineries, gas processors and petrochemical plants created numerous agglomerative cost economies as the region developed.

Energy processors are also drawn to the region by water transportation, an inexpensive way to move massive amounts of gas and liquid product by ship or barge. These large volumes may be inputs, such as crude to be refined, or products, such as gasoline or fuel oil. The growing U.S. dependence on imported oil in recent years has simply heightened the importance of port facilities like the Louisiana Offshore Oil Port and the Houston Ship Channel.

Finally, for regions of the U.S. less familiar with gas processing, refining or petrochemical production, the plants are simply perceived as big, noisy, dirty and dangerous. They are natural targets for local not-in-my-backyard movements, often met with sympathy by regulators. In Texas and Louisiana, long familiarity has bred a comfort level and acceptance of the negatives generated by these plants that is not found elsewhere, as well as a better understanding of the positive economic impacts that accompany these facilities.

Processing Energy

Energy-processing facilities on the Gulf Coast fall primar-

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ily into three groups: refineries, gas processors and petrochemical producers. The refinery is the most familiar of these, taking a barrel of crude oil and turning it into gasoline, heating oil, jet fuel, diesel and other oil products. Table 3 shows that about 17.1 million barrels per day of crude oil are refined in the U.S., 39.8 percent of it on the Gulf Coast. The share refined by the Texas and Louisiana Gulf Coast is slightly larger than the share refined in the East Coast, West Coast and Great Lakes regions combined.

Table 3
Refining Capacity on the Gulf Coast as a Share of U.S. Gas Processing

	Barrels (thousands)	Capacity (percent)
United States	17,125	100.0
West Coast	2,643	15.4
East Coast	1,717	10.0
Great Lakes	2,322	13.6
Gulf Coast	6,818	39.8
South Louisiana	2,123	12.4
Port Arthur–Lake Charles	1,716	10.0
Houston–Texas City	2,293	13.4
South Texas	686	4.0
Other U.S.	3,625	21.2

NOTE: Data refer to early 2005.
SOURCES: Energy Information Administration; authors' calculations.

On the Texas and Louisiana coastline, we see refinery capacity more or less uniformly divided between South Louisiana, Port Arthur–Lake Charles and Houston–Texas City. South Texas has only 4 percent of U.S. refining, concentrated in Corpus Christi.

Natural gas used by consumers is primarily methane. When natural gas is produced from an oil or gas well, it may contain water vapor, hydrogen sulfide, carbon dioxide, helium, nitrogen or various natural gas liquids. The gas stream must be processed to remove impurities, but also to remove the heavier hydrocarbon liquids—ethane, butane, propane, isobutanes and natural gasoline—which have a higher value than the methane gas stream. The liquids will then be used for the manufacture of plastics or home heating fuel or as refinery feedstock.

Table 4
Natural Gas Processing on the Gulf Coast as a Share of U.S. Gas Processing (Percent)

	Capacity	Gas throughput	Liquid products
United States	100.0	100.0	100.0
Gulf Coast	34.5	31.1	22.8
South Louisiana	21.5	18.1	11.1
Port Arthur/ Lake Charles	5.4	4.5	3.4
Houston/Texas City	2.7	2.5	3.2
South Texas	5.0	6.1	5.1

NOTE: Parts may not sum to total due to rounding error. Data are annual data for 2004.
SOURCES: Oil and Gas Journal; authors' calculations.

Table 4 shows the concentration of natural gas-processing capacity and 2004 throughput of natural gas streams. The Gulf Coast accounts for 34.5 percent of U.S. capacity and 31.1 percent of throughput, figures that are slightly lower than the 38.7 percent share the Gulf Coast holds in natural gas production. The region accounts for only 22.8 percent of the U.S. production of liquids because the Gulf Coast gas stream is less rich in liquids than it is in other parts of the country.

South Louisiana is the dominant Gulf Coast location for these gas-processing facilities, accepting the gas streams as they come ashore from pipelines in the Gulf of Mexico. The Houston–Texas City share of U.S. gas processing is the smallest at only 2.5 percent, despite the fact that the Mont Belvieu market center, located outside Houston, is the NYMEX settlement point for gas liquids and a major storage center.

Petrochemical plants use the natural gas liquids or oil-based naphtha to produce plastic or synthetic rubber. Ethane and propane would be the large bellwether products for the industry, among thousands of plastic, rubber and polymer products that evolve as you go further downstream. Table 5 shows that the Gulf Coast dominates U.S ethylene production, turning out 90.9 percent of the 28.3 million tons of ethylene produced each year. The Houston–Texas City region accounts for about half of the Gulf Coast ethylene production, while South Louisiana and Port Arthur/Lake Charles each account for 19 percent of U.S. output.

Table 5
Gulf Coast Ethylene Capacity as a Share of U.S. Capacity

	Million tons per year	Percent
United States	28.32	100.0
Gulf Coast	25.73	90.9
South Louisiana	5.37	19.0
Port Arthur/ Lake Charles	5.39	19.0
Houston/Texas City	12.52	44.2
South Texas	2.45	8.7
Other	2.59	9.1

SOURCES: Oil and Gas Journal; authors' calculations. NOTE: Data is for 2004.

Table 6 is yet another way to see the concentration of a number of chemical products on the Gulf Coast. As Hurricanes Katrina and Rita crossed the Gulf of Mexico, the uncertainty of their paths and their power caused widespread precautionary shutdowns of petrochemical facilities. This table shows the percentage of capacity shut down at the peak period by each storm, expressed as a percentage of North American capacity. It is again clear from this table the extent to which the Texas and Louisiana coasts dominate the U.S. petrochemical industry.

Table 6
Chemical Plants Affected By Hurricanes (Percent Capacity Shut Down at Peak By Each Storm)

	Katrina	Rita
Ethylene	15.8	58.5
Propylene	18.5	30.7
Benzene	19.6	68.5
Polyethylene	3.7	63
Styrene	29.3	85.3
Butadiene	9.1	95.8

NOTE: Data are for 2004, expressed as a percentage of North American capacity.

Notes

1. Table 1 divides the Texas and Louisiana Gulf Coast into four regions based on county definitions. Each region is anchored by one or more metropolitan areas. Seven counties of the Houston–Sugar Land–Baytown metropolitan area make up 92.2 percent of the population of the Houston–Texas City region. New Orleans is 64.5 percent of South Louisiana. Beaumont–Port Arthur and Lake Charles are 62.9 percent of the Port Arthur–Lake Charles region. Corpus Christi, Brownsville–Harlingen and McAllen–Edinburg are 68.8 percent of South Texas. Tables 3 through 5 are also based on these definitions. Table 2, as explained in the note, is based on state energy regulator definitions of Railroad Commission Districts (for Texas), South Louisiana and offshore state waters.

2. The average number of working rigs in the Gulf of Mexico was 136 in 2000 and 148 in 2001. Drilling in the Gulf never bounced back from a cyclical low of 109 in 2002; the rig count averaged only 93 in 2004 and 88 year-to-date in 2005.

Do You Want to Start Your Own USAEE Chapter?

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Electricity Innovation *(continued from page 17)*

Timing is critical if the United States is to capture economic and environmental benefits. In the next several years, much of the nation's aging electrical, mechanical, and thermal infrastructure will need to be replaced, offering a unique opportunity to substitute efficient generators for outmoded power plants and old industrial boilers.

Maintaining the status quo is no longer an option, in part because the current monopoly-based structure has forced Americans to spend far more than needed on outmoded and polluting energy services. Yet achieving the benefits of innovation requires the elimination of numerous regulatory, financial, and legal barriers. Restructuring the electricity industry based on the principles of technology modernization, market efficiency, and consumer choice will bring about immense benefits for both the economy and the environment.

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 faculty advisor requesting that funds be granted. At the Denver Conference, forty-two 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.

2005's student scholarship fund has been generously provided by the support of the following organizations/individuals:

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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 2006 North American meeting in Ann Arbor, MI, September 24-27. Contributions have ranged from $100 to $2500. If you would like to receive information on how you 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

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Forecasting Oil Supply and Demand: What Went Wrong in 2004 and 2005?

By A. F. Alhajji, PhD*

At the end of 2003 and the beginning of 2004, several agencies announced their 2004 forecasts of oil prices, world oil demand, world oil supply, and the details of supply and demand by region and by country. As time passed, they also provided estimates for 2005. None of these forecasts were correct. OPEC and the IEA predicted at the end of 2003 that world demand for oil would reach 79.6 mb/d in 2004. In 2004, the actual demand was higher by at least 2.4 mb/d. The EIA's estimate of world demand in 2004 seems closer to reality than the OPEC and IEA estimates. It estimated world demand to be 80 mb/d in 2004. However, it turns out that its estimates are more erroneous than others on a close look at the demand structure. The EIA underestimated the demand growth of China and assigned that growth to other regions. The IEA estimated China's demand in 2004 to be 5.70 mb/d. OPEC's estimate for China was 5.75 mb/d, and the EIA's estimate was 5.50 mb/d. The actual Chinese demand was around 6.40 mb/d.

Price estimates were also off the mark. The EIA predicted that, in the base case, oil prices would reach $24.25 at the end of 2004 and $32/b in the case of high economic growth. Oil prices averaged $43.48/b in December 2004, about 80% above the price in the base case. The Deutsche bank predicted an average price of $25.40/b for WTI in 2004. The actual average was 63 percent higher than predicted: $41.44/b.

As prices increased, most experts and analysts predicted that high oil prices would curb demand, encourage additional supply, and consequently lower prices. Others went further and predicted lower economic growth and higher rates of inflation and unemployment. None of that occurred.

Why did high oil prices not affect economic growth? Why did the forecasts for 2004 and 2005 fail? The main reason is the prevailing conventional wisdom inherited from the 1970s that higher oil prices decrease economic growth, reduce the demand for oil, and stimulate additional oil supplies. Does this conventional wisdom apply today? What were the conditions that prevailed during the formation of the conventional wisdom? Do these conditions still exist today?

The differences between the conditions that prevailed in the 1970s and those that have prevailed between 2003 and early 2005 remain elusive to most analysts. For example, the period mentioned is the only period in the history of OECD countries when oil prices, economic growth, military expenditures, and government expenditures have all increased and interest rates, inflation, and dollar value have all decreased. During the first and second energy crises, interest rates increased and government expenditures decreased.

The impact of dollar devaluation on the oil industry, especially since the literature in this area is still in its infancy, is yet to be fully understood by energy experts and analysts. With dollar pricing of oil; dollar devaluation increases world oil demand and limits the effect of high oil prices to the US. Oil prices reached records only in dollar terms, but not in euro and yen. The demand for oil in the rest of the world continued to grow as prices in dollars continued to increase. Even in the US, increasing oil prices have not slowed down economic growth. The effect of expansionary monetary and fiscal polices was so great that their impact on the economy was much larger than any negative impact from high oil prices.

Further, the impact of dollar devaluation on oil supplies seems to be missed by analysts as well. Dollar devaluation usually limits supply, especially in the North Sea where companies pay their workers in euros while they sell their oil in dollars. Dollar devaluation reduces the purchasing power of OPEC oil exports, leaving less money for investment in capacity expansion.

This is not the first time that forecasters and analysts have overlooked the impact of exchange rates on the oil industry. They ignored the impact of the devaluation of Russian currency on the Russian oil industry. Not until the recent boom in Russia's production that started in 1999 did analysts realize the impact of its currency devaluation.

The impact of the IT industry on the demand for oil has been omitted by forecasters. Forecasters overlooked the fact that, as almost everything has become computerized, energy consumption in manufacturing these items has increased. Unlike traditional industries, IT manufacturing is energy intensive.

Forecasters also failed to realize the impact of the migration of IT technology on emerging economies such as China and India. Since IT manufacturing is energy intensive, migration shifted much of the growth in oil demand from the West to the East. Therefore, China's economic growth is not solely responsible for the sharp increase in China's demand for oil. This "transferred demand" is also responsible for the increase. In other words, the increase in China's demand for oil can be divided into two parts, one that is related to accelerated economic growth and the other one is related to the migration of IT manufacturing from the US, Europe, and Japan as companies from these countries moved to China. If these companies did not move, the demand for oil in these countries would have increased and the gap in the growth in oil demand between China and these countries would have been much less than the actual difference in 2004.

The impact of growth in energy intensive industries have also been previously overlooked by energy experts. They did not detect the impact of the growth in the petrochemical industries in the 1970s and the migration of these industries to developing nations in the 1980s. This migration shed some doubts on the causes of the decline in the demand for oil by OECD countries in the early 1980s.

(Continued on page 31)

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What if? Possible Effects of Bird Flu on Global Crude Oil Demand

By Gray Peckham*

Royal Dutch/Shell popularized the strategic initiative of "scenario planning" with the objective – not of making accurate predictions about the future, but -- of preparing for the unexpected "curve ball." (See "The Art of the Long View" by Peter Schwarz)

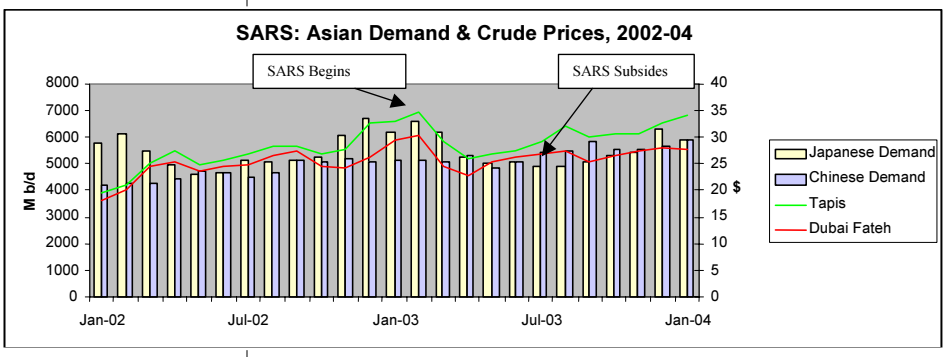
Toward a "scenario planning" goal, Herold prepared the following analysis of the avian influenza subject. Our objective is not to be alarmist in any way, but rather to investigate the issue and its potential ramifications on the global petroleum markets.

Avian influenza, strain H5N1, has infected dozens of people, primarily in non-OECD Asia. At present, "bird flu" can only be transmitted from fowl to humans via close contact, but mortality rates of approximately 50% have caused widespread concern. The great fear is that the H5N1 virus will mutate into a form transmittable from human to human, using international air travel to spread rapidly, causing a pandemic. There is a growing consensus among epidemiologists, including leaders at the Center for Disease Control and World Health Organization, that the virus will eventually acquire the ability to be transmitted from human to human. Opinions differ, however, on the scale that the outbreak would take, ranging from isolated to catastrophic. What is clear is that bird flu, should it break out, has the potential to change the global demand picture more rapidly than any of the price induced "demand erosion" scenarios being considered currently, with serious implications for the industry.

Localized bird-flu scenario

Without global pandemics during the modern air travel era for comparison, the search for a historical precedent ultimately comes to Severe Acute Respiratory Syndrome (SARS), which infected over 6,000 people, mostly in Asia, in early 2003. The SARS epidemic is a useful indicator as to the possible effects on oil demand of a "localized" bird flu outbreak, which envisions human-to-human transmission with relatively small numbers of people affected, but with high psychological effects. If H5N1 were to spread from human to human, epidemiologists expect that the outbreak would begin in Southeast Asia or Southern China, offering a general geographic correlation to SARS.

Jet fuel was hit hardest by SARS, as regional air travel was cut back significantly. The effect of SARS on Asian oil demand and on Asian benchmark Dubai Fateh and Tapis spot crude prices can be seen in the chart, below. The SARS outbreak began in March 2003, with an immediate corresponding drop in Chinese oil demand of 83,000 b/d from the previous month. At the time, more than 40% of flights into Hong Kong were cancelled. Lufthansa, for example, reported an 85% decline in passengers on its Asian flights. Crude prices followed demand downward rapidly. April was the deadliest month of the outbreak, but also the peak of infections. Crude prices hit their low for the year in that month. In May, ten Asian governments agreed on travel screening and restrictions, further cutting back on air travel. China Aviation Oil, which supplies the majority of that country's jet fuel, recorded a 46% y-y decline in jet fuel sales in May. Chinese oil demand responded by dipping under 5MM b/d for the first time in 9 months (significantly, Chinese demand has never again gone below the 5MM b/d threshold). The effect on Japanese crude demand is harder to judge, as decreases during the timeframe could also be part of a regular seasonal trend. By June however, the crisis was beginning to subside, and both crude demand and prices recovered quickly. Thus, the SARS effect was dramatic but relatively short-lived. In the wake of SARS, Petroleum Intelligence Weekly reported that Chinese product demand had dipped by as much as 10% during the crisis. General economic malaise during the period was blamed on the disease, with tourism and retail also taking hard hits. Estimates from the IEA, EIA and other industry groups are that SARS cut global oil demand by 70,000 to 90,000 b/d during the first half of 2003.



Using SARS as a guideline, a similar 90,000 b/d reduction in demand caused by a localized bird flu outbreak would bring the current (November '05) global crude surplus from 1.09 MM b/d to 1.18 MM b/d in rapid fashion. The market normally absorbs much larger supply increases without significant downward price movements (October global production was up 200,000 b/d over the previous month, according to Oil Market Intelligence). However, it is impossible to predict the market reaction, particularly the futures market, to such a sudden downward demand revision with the potential for a wider outbreak weighing heavily on the world's collective psyche.

Global pandemic scenario

Experts fear that in the worst-case scenario, a true global bird flu pandemic could kill millions, comparable to the "Spanish Influenza" of 1918-19, which killed an estimated 40 - 60 million people around the world. No measurable precedent for oil demand destruction exists for such an unthinkable situation. Due to the deadly nature of H5N1, several governments have held summits to discuss potential responses to a widespread outbreak. Travel bans and restrictions of movement feature

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prominently in plans to prevent a pandemic. Taking the United States as a test case, the effects of a bird flu pandemic on oil demand become strikingly clear. Like in SARS, jet fuel would bear the immediate brunt of a bird flu outbreak, as travel bans, especially on international flights, would go into immediate effect, with the possibility of domestic restrictions as well. The United States accounts for approximately 50% of the world's jet fuel demand, or 1.65 MM b/d (3Q 2005 average). Using the 40% flight cancellation metric in Hong Kong during SARS as a conservative precedent, the same decrease in U.S. airline flights would take 660,000 b/d of demand out of the market.

In addition to air travel, one of the keys strategies to prevent rapid spreading of H5N1 will be for the government to discourage large gatherings and unnecessary domestic travel. This would take its toll on oil demand for transportation purposes, which according to the EIA amounts to more than 50% of the U.S.'s daily consumption of more than 20.8 MM b/d (3Q 2005 average), or approximately 10MM b/d. Assuming even a modest decrease of 10% in auto travel would take a further 1 MM b/d of demand out of the market. Combined losses from air and auto travel would remove at least 1.66 MM b/d of demand from the market. Demand decreases of a similar magnitude (1.137 MM b/d) occurred in September 2001, as air travel was shut down for several days and economic disruptions made their way through the economy after the terror attacks on New York, the Pentagon, and Pennsylvania. Throughout the rest of the product chain, home heating oil demand and natural gas demand for residential use would likely stay high in a bird flu pandemic, creating a small floor for demand, as people hunker down in their homes. Industrial and other commercial oil and natural gas demand would suffer from depressed economic activity, with levels ultimately depending on the duration and severity of the outbreak.

Global crude balances stood at a surplus of approximately 1.3 MM b/d in November. In the scenario described above, demand reductions in the U.S. market alone would more than double the current supply balance, turning the current tight crude balance to a supply glut, with corresponding ramifications for pricing. Extrapolating those same percentages around the globe could cause a sever oversupply situation, necessitating immediate moves by OPEC and other producing nations to cut production. Realistically, however, assuming a 40% reduction in air travel and a 10% reduction in auto transportation might be too conservative in such a grave situation. The chaos observed in the wake of Hurricane Katrina could be a better indicator of the kinds of social disruption, and by extension, crude demand disruption, caused by a true pandemic. Beyond hoping that bird flu does not acquire the ability to move from human to human, the situation bears watching by the industry as it has the potential to become the unforeseen bump in the road that changes pricing forecasts, project economics, and leaves budgets in tatters.

Forecasting Oil *(continued from page 29)*

Experts failed to see that the timing of the increase in oil prices relative to the business cycle is very important in understanding the impact of high oil prices on the economy. The conventional wisdom of the 1970s regarding the impact of high oil prices applies only when oil prices hit the business cycle near its peak. This is the only period in history when rising energy prices hit the business cycle near its bottom. In all other cases high oil prices hit the business cycle near its peak. Forecasters and analysts failed to realize that oil prices, the demand for oil, and economic growth had no other way to go but up after OECD economies hit rock-bottom after the recession of 2001 and the terrorist attacks of September 11. Current forecasting models do not consider the timing of the increase in energy prices relative to the age of the business cycle. However, the literature in this area is still very weak, which creates an additional set of challenges for energy forecasters.

Experts failed to predict OPEC behavior. Forecasting models still use outdated assumptions. They predict world demand and non-OPEC supply based on behavioral variables and assumes that OPEC will supply the difference between world demand and non-OPEC supply. Recent data prove that OPEC's production has not been able to fill this gap. Future plans for expanding capacity are nowhere near the expectations of the IEA, the EIA, and others. The current situation in the oil market illustrates the need for modeling OPEC behavior based on behavioral variables. The recent reduction of predicted OPEC production by more than 5 mb/d in 2025 by the EIA 2005 is a welcome step in that direction. However, the reduction was not based on behavioral variables. Rather, it was based on strong conviction that the old prediction was not correct.

Conclusion

The reasons that all 2003 forecasts for 2004 demand, supply, and prices were unsuccessful are many. Experts failed to see the impact of dollar devaluation and IT technology on the oil industry. They also failed to understand the relationship between oil prices and business cycle. High oil prices will affect the economy only if high oil prices hit the business cycle near its peak. There are several other factors that experts overlooked when forecasting demand, supply, and prices. These factors include declining interest rates, unprecedented increase in government expenditures, and gradual increase in oil prices between 2002 and early 2005. Incorporating the above-mentioned factors improves forecasting methods, but it will not eliminate the difficulties and challenges. In fact, it might add to the challenges, since the increased number of variables could easily affect the reliability of already questionable models. Evaluating the conventional forecasting method and its results creates more challenges, especially if it involves comparisons among various forecasts by various forecasting groups. The groups do not use the same definitions, units, and geographic locations.

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Conference Programme

7. June 2006, 17:30 – 19:00 h: Opening reception in the *Kongresshotel* Potsdam
8. June 2006, 9:00 – 17:30 h: Day on global issues with plenary sessions on "Energy in an Insecure World", "Securing Oil and Gas" (dual plenary) and "Kyoto and Beyond" (dual plenary). 18.00 – 22.30 h: Sunset dinner cruise on the lakes around Berlin/Potsdam
9. June 2006, 9:00 – 17:30 h: Day on securing energy under competition and regulation with plenary sessions on "Long term Contracts, Vertical Integration, and Competition in Electricity and Gas Markets", "Sustainable Transportation" (dual plenary) and "Renewable's Role in Securing Energy" (dual plenary). 18:00 – 22.30 h: Conference Dinner in the historic center of Berlin, "*Unter den Linden*"
10. June 2006, 9:00 – 13:00 h: Day on long-term technology and policy choices

Our host, the city of Potsdam, belongs to the most outstanding historical and cultural places in Germany. We have arranged offsite events that will give you the chance to enjoy the beauty of the city with its many castles, lakes and gardens. You will combine your stay with a visit of Berlin, which is an exiting city under tremendous transformation. If you are not interested in the historic and cultural highlights, you may take pleasure in the atmosphere of the soccer world cup in Germany.

For more details on the program, including themes and speakers of the plenary and the concurrent sessions, registration fees, the electronic registration, post conference tours, and other cultural events, please visit www.gee.de/2006-IAEE/.

The cut-off date for early bird registration is April 30, 2006. If you have any questions, please do not hesitate to contact the local organizing committee at IAEE@tu-berlin.de

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WWW.IAEE.ORG
INTERNATIONAL ASSOCIATION for ENERGY ECONOMICS

30th IAEE INTERNATIONAL CONFERENCE

Hosted by:
Oceania Affiliate of the IAEE and the School of Economics and Finance, Victoria University of Wellington, New Zealand

From Restructuring to Sustainability: Energy Policies for the 21st Century

18-21 February 2007
at Pipitea Campus, Victoria University, Wellington, New Zealand

Conference Themes and Topics

Taking Stock:
Two Decades of Deregulation and Restructuring in Energy Markets
- Country case studies on restructuring experience
- New market experiments in Africa and Latin America
- Comparative studies of reform outcomes
- Is a systemic approach to institutional design feasible?
- Obstacles to uptake of demand-side and decentralised-energy opportunities in restructured markets
- Investment coordination and infrastructure adequacy
- Electricity and gas market design issues

Looking Forward: Energy, Poverty, and Sustainable Development
- Energy poverty: evidence and policy issues
- Economics of decentralised and renewable energy technologies
- Electricity access for the poor in Africa, Asia, Latin America
- Making the power sector sustainable in developing economies
- Cross-border energy trade and the poor
- Consequences of rapid growth in China and India
- Energy and development in small islands in the Pacific and elsewhere

New Market Drivers:
Emerging Global Markets for Carbon and LNG
- Cross-border energy trade and arbitrage in LNG and carbon
- Growth and structure of the global LNG market
- New transportation technologies for LNG and bulk CNG
- Price relativities between oil and LNG
- New market instruments for trading GHG abatement opportunities
- Recent developments in the global institutional backdrop for GHG abatement efforts
- Climate-change policy responses in New Zealand, Australia, and elsewhere

Old Habits Die Hard: The Future of Oil and Coal
- Geopolitics, oil prices, and energy security
- Is a nuclear comeback likely?
- The economics of emerging technologies for carbon capture and storage
- Alternative liquid fuels to replace oil
- New transport fuels and technologies

Keynote Plenary Session Themes

- **The World Energy and Environmental Outlook at the Commencement of Kyoto I**
- **Energy Market Design: Lessons and Issues from Around the World**
- **Network Expansion, Infrastructure Adequacy and Crisis Management in Decentralised Electricity and Gas Markets**
- **Energy, Poverty and Sustainable Development**
- **The Global Market for LNG: Technologies, Arbitrage Opportunities, and Consequences for National and Regional Energy Markets**
- **The Future of Decentralised Energy Systems**
- **European, New Zealand and Australian Energy and Environmental Perspectives**

CALL FOR PAPERS

Abstract Submission Deadline: 23 October 2006 (Include a short CV when submitting your abstract)

We are pleased to announce the Call for Papers for the 30th IAEE Annual International Conference entitled 'From Restructuring to Sustainability: Energy Policies for the 21st Century', scheduled for 18-21 February 2007 at Victoria University of Wellington, New Zealand. Please mark your calendar for this important conference. There will be at least six major plenary sessions, and at least 24 concurrent sessions.

Papers, and proposals to organise concurrent sessions comprising 4-5 papers each, are invited under the topic headings listed above (NB all invited concurrent session speakers are required to pay speaker registration fees). In addition, abstract submissions on any other topics of likely interest to IAEE members are welcome, and additional sessions may be organised.

General Organising Committee

Geoff Bertram: General Conference Chairman, School of Economics and Finance, Victoria University of Wellington; **John Small:** Deputy Conference Chair, Covec, Auckland, NZ; **David Smol:** Deputy Secretary, Ministry for Economic Development, Wellington NZ; **Ian Dempster:** Gas Industry Company, Wellington, NZ; **Sue Freear:** School of Economics and Finance, Victoria University of Wellington; **Stephen Gale:** Castalia, Wellington, NZ; **Bill Heaps:** Stratagen, Wellington, NZ; **Pattrick Smellie:** Contact Energy, NZ; **Frank Scrimgeour:** University of Waikato, NZ; **Jonathan Lermit**; **Dan Twaddle**.

IAEE BEST STUDENT PAPER AWARD: US $1,000 cash prize plus waiver of conference registration fees. If interested, please contact IAEE headquarters for detailed applications/guidelines.

STUDENT PARTICIPANTS: Please inquire about scholarships for conference attendance to **iaee@iaee.org**

All abstracts are to be submitted online on the conference website **www.vuw.ac.nz/iaee07**

At least one author from an accepted paper must pay the registration fee 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. Authors will be notified by November 10, 2006, of their paper status. Authors whose abstracts are accepted will have until 29 January 2007, to return their papers for publication in the conference proceedings. While multiple submissions by individuals or groups of authors are welcome, the abstract selection process will seek to ensure as broad participation as possible. No author should submit more than one abstract as its single author. If multiple submissions are accepted, then a different co-author will be required to pay the reduced registration fee and present each paper. Otherwise, authors will be contacted and asked to drop one or more paper(s) for presentation.

Broaden Your Professional Horizons

Join the

International Association for Energy Economics

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

The IAEE currently meets the professional needs of over 3100 energy economists in many areas: private industry, non-profit and trade organizations, consulting, government and academe. Below is a listing of the publications and services the Association offers its membership.

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

Alternative Transportation Fuels	Hydrocarbons Issues
Conservation of Energy	International Energy Issues
Electricity and Coal	Markets for Crude Oil
Energy & Economic Development	Natural Gas Topics
Energy Management	Nuclear Power Issues
Energy Policy Issues	Renewable Energy Issues
Environmental Issues & Concerns	Forecasting Techniques

- **Newsletter:** The *IAEE Newsletter,* published four times a year, contains articles dealing with applied energy economics throughout the world. The Newsletter also contains announcements of coming events, such as conferences and workshops; gives detail of IAEE international affiliate activities; and provides special reports and information of international interest.
- **Directory:** The Annual Membership Directory lists members around the world, their affiliation, areas of specialization, address and telephone/fax numbers. A most valuable networking resource.
- **Conferences:** IAEE Conferences attract delegates who represent some of the most influential government, corporate and academic energy decision-making institutions. Conference programs address critical issues of vital concern and importance to governments and industry and provide a forum where policy issues can be presented, considered and discussed at both formal sessions and informal social functions. Major conferences held each year include the North American Conference and the International Conference. IAEE members attend a reduced rates.
- **Proceedings**: IAEE Conferences generate valuable proceedings which are available to members at reduced rates.

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

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Welcome !! The following individuals joined USAEE from 10/1/05 to 1/31/06

Aleksander Abram
Chicago Board of Trade

David M. Anderson
Pacific Northwest National Lab

Edward Arnold
Jacobs Consultancy

Monica Berry
Sullivan & Worcester LLP

Robert Camfield
Christensen Associates Energy Csltg

Sharon Chandler
Georgia Institute of Technology

Sukanya Chandrasekar
Columbia University

Jeffrey Clark
Duke University

Gabe Collins
CARE

Mark Cronshaw
Colorado School of Mines

Kelly S. Eustis

Eric Everett
Amerada Hess Corp

Olga Filippova

R. Dean Foreman
Exxon Mobil Corporation

Nat Gregory
Univ of Chicago Business School

Jason Gross
Duke University West Campus

Patrick G. Hager
Portland General Electric

Katherine Hill

Andrew Hirsch
Fuelcor LLC

Alexander Kasuya

Vanessa Lamort de Gail
Columbia University SIPA

Ines Margari Lime de Azevedo
CMU Engineering and Pub Policy

Lu Liu

Richard G. Lubinski
Think Energy Management LLC

Lynne M. Mackey
LS Power Development

Joseph C. Mandarino
Balch & Bingham LLP

Jose J. Marroquin
Accenture

Simin Mozayeni
State University of New York

Richard Munson
Northeast-Midwest Institute

Geri Nicholson
Sage Energy Consulting LLC

Daniel J. Nikolich
AGL Resources

Edward L. O'Brien III
Schlumberger

Brian P. O'Donnell

D. Andrew Owens
Entergy Corporation

Morgan H. Parkes
Barnard College – Columbia Univ

John Parsons
Massachusettes Inst of Tech

Dmitri Perekhodtsev
LECG

Scott Roberts

Tim Ryherd
Alaska Dept of Natl Resources

Aaron Shaw

Jean Shelton
Itron Inc

Eriks Smidchens
CA AIPG

Jennifer S. Szaro
Florida Solar Energy Center

John P. Thomasen
Virchow Krause and Co

Robert S. Wegeng

New York City Chapter for USAEE

The USAEE has newly reconstituted the chapter in the New York City area – the Energy Forum, Inc. The Energy Forum has been in existence for a number of years affiliated with the City University of NY then New York University, but has just been reestablished as an independent organization. Longstanding IAEE members, Ed Morse, Cheryl Trench, David Knapp, David Nissen, Dermot Gately, Larry Goldstein and Shirley Neff are all involved in the leadership of the new organization.

The Energy Forum organizes four or five programs per academic semester as well as special programs and conferences as the opportunity arises. The website, www.NYEnergyForum.org, has information on Energy Forum and other events of interest to the energy community in the greater New York City area. Members of the IAEE visiting New York may wish to check the website for upcoming events and/or sign up to be on the email distribution list.

Recommendations for 2006 USAEE Awards Requested

The USAEE is now receiving recommendations for the Senior Fellow Award and Adelman-Frankel Award recipients. To view past award recipients please visit http://www.usaee.org/about/awards.asp Below please find a brief description of these awards.

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. A brief presentation is made at the annual North American Conference of the USAEE/IAEE. A plaque and $500.00 stipend is given to the recipient.

Senior Fellow Award

The Senior Fellow Award is given to individuals who have exemplified distinguished service in the field of energy economics and/or the USAEE. Up to three recipients may receive the Senior 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 Awards Committee welcomes recommendations from its membership for consideration in bestowing these awards. Please submit a 250-500 word recommendation of the person(s)/organization(s) you feel would be appropriate for receiving these awards to:

Mine Yucel
Vice President & Senior Economist
Federal Reserve Bank of Dallas
2200 N Pearl Street
Dallas, TX 75201

Recommendations may also be faxed to Ms. Yucel's attention at 214-922-5194 or emailed to mine.k.yucel@dal.frb.org

Calendar

14-15 March 2006, Coal Properties & Investment at Ft. Lauderdale, Florida. Contact: Ronald Berg, Conference Manager, Platts, 24 Hartwell Avenue, Lexington, MA, 02421, USA. Phone: 781-860-6118 Email: registration@platts.com URL: www.events.platts.com

4-5 April 2006, Wall Street Green Trading Summit at New York City. Contact: Peter Fusaro, Partner, Hedge Connection, 2565 Broadway PMB #385, New York, NY, 10025, USA. Phone: 941-383-9768. Fax: 212-222-0550 Email: info@hedgeconnection.com URL: www.hedgeconnection.com

4-6 April 2006, Wireless Utilities 2006 at Chicago, Illinois, USA. Contact: Natalie Belgrave, Marketing Manager, marcus evans. Phone: 246-417-5389. Fax: 888-844-4901 Email: utilities@marcusevansbb.com URL: http://www.marcusevansbb.com/wireless2006

10-11 April 2006, Global Offshore Drilling at Houston, Texas, USA. Contact: Natalie Belgrave, Marketing Manager, Marcus Evans. Phone: 246-417-5389. Fax: 888-844-4901 Email: utilities@marcusevansbb.com URL: http://www.marcusevansbb.com/offshoredrilling

10-12 April 2006, Power-Gen Renewable Energy at Las Vegas, NV. Contact: Jan Simpson, Conference Manager, Power Gen, 1421 S Sheridan Rd, Tulsa, OK, 74112, USA. Phone: 918-831-9736. Fax: 918-831-9875 Email: pgreconference@penwell.com URL: www.power-gengreen.com

23-26 April 2006, 23rd Intl Energy Conference and 27th Intl Area Conference at Boulder, CO. Contact: Dr. Dorothea H. El Mallakh, Director, ICEED, 850 Willowbrook Road, Boulder, CO, 80302, USA. Phone: 303-442-4014. Fax: 303-442-5042 Email: iceed@colorado.edu URL: www.iceed.org

24-25 April 2006, Ziff Energy North American Gas Strategies Conference at Houston, Texas. Contact: Carla D'Annibale, Conference Supervisor, Ziff Energy Group, 1117 Macleod Trail SE, Calgary, Alberta, T2G 2M8, Canada. Phone: (403) 234-4279. Fax: (403) 237-8489 Email: carla.dannibale@ziffenergy.com URL: www.ziffenergyconferences.com

2-4 May 2006, Electric Power 2006 at Atlanta, GA. Contact: Conference Coordinator, TradeFair Group Events, 11000 Richmond Ste 500, Houston, TX, 77042, USA. Phone: 832-242-1969. Fax: 832-242-1971 Email: christyw@tradefairgroup.com URL: www.electricpowerexpo.com

8-19 May 2006, New Era in Oil, Gas & Power Value Creation at The University of Texas at Austin. Contact: Center for Energy Economics, Bureau of Economic Geology, The University of Texas at Austin, TX, USA. Phone: 281-313-9763. Fax: 281-340-3482 Email: energyecon@beg.utexas.edu URL: www.beg.utexas.edu/energyecon

7-10 June 2006, Securing Energy in Insecure Times, IAEE's 29th International Conference at Potsdam, Germany. Contact: David Williams, Executive Director, IAEE, 28790 Chagrin Blvd Ste 350, Cleveland, OH, 44122, USA. Phone: 216-464-5365. Fax: 216-464-2737 Email: iaee@iaee.org URL: www.gee.de/2006-IAEE

24-27 September 2006, Energy in a World of Changing Costs and Technologies, 26th USAEE/IAEE North American Conference at Ann Arbor, MI. Contact: David Williams, Executive Director, USAEE, 28790 Chagrin Blvd. Ste. 350, Cleveland, OH, 44122, USA. Phone: 216-464-2785. Fax: 216-464-2768 Email: usaee@usaee.org URL: www.usaee.org

CALL FOR PAPERS

9th IAEE/USAEE Session at the
Allied Social Science Association Meeting
Chicago, IL, USA – January 7 - 9, 2007

The IAEE/USAEE annually puts together an academic session at the ASSA meetings in early January. Our 2007 session chair will be Carol Dahl of the Colorado School of Mines.

The theme for the session will be:

Current Issues in
Energy Economics and Modeling

If you are interested in presenting please send an abstract of 200-400 words to Carol Dahl at (cdahl@mines.edu) by May 15, 2006. At least one member of each paper must be a member of the IAEE for the paper to be included in our session. The session along with discussion remarks will be published in the Papers and Proceedings of the next North American Meeting of the USAEE/IAEE. Preliminary decisions on papers presented and discussants will be made by July 1. The program including abstracts will be posted at iaee@iaee.org by September 1, 2006. Please send abstracts in electronic format that is easily converted into program information. Suggestions or volunteers for paper discussants are most welcome.

For complete ASSA meeting highlights and pre-registration information please visit:

http://www.vanderbilt.edu/AEA/index.htm

USAEE Dialogue
United States Association for
Energy Economics
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