IAEE INTERNATIONAL ASSOCIATION *for* ENERGY ECONOMICS

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Newsletter

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Second Quarter 2006

President's Message

Spring 2006 — Energy questions are more than ever at the forefront. Fundamental concerns about supply and demand, energy prices and their future evolution are the subject of heated discussion fired by geopolitical uncertainties, the possible effects of climate change, the reorganization of the energy industries and the challenge of meeting the increasing energy needs of developing countries.

It is such topics as these that form the backbone of the IAEE's action in the field of energy economics, as illustrated by the numerous articles published in ***The Energy Journal***, the ***IAEE Newsletter*** and the programs of the various conferences organized by the IAEE and its Affiliates. As an independent organization, the IAEE cannot substitute for public and private decision-makers, but it should, and regularly does, provide economic thought to help in making enlightened decisions, promote theoretical and practical analysis in the energy field and spread understanding of energy economics amongst the main players involved in the world of energy.

Indeed, the program for the next international conference, hosted by the German affiliate, GEE, to be held in Potsdam from 7 to 10 June promises to address these subjects squarely. Although the overall theme of the Conference, "Securing Energy in Insecure Times", was chosen two years ago, it resonates strongly with today's concerns. It should enable us to debate, during the plenary sessions, on gripping topics such as "Energy in an Insecure World", "Securing Oil and Gas Supplies", "The Role of Renewables in Energy Security, "Long-term Technology and Policy Choices". Other plenary sessions will include presentations and debates on "Energy Policy and Competition in Electricity and Gas Markets", "Sustainable Transportation" or "The Business Case for Carbon Management" will also be scheduled in further plenary sessions.

The call for papers for this Conference has already attracted a lot of interest and the organizers have received a record number of abstracts for presentations during the concurrent sessions. So their content will, I am sure, make for a particularly rich program. Due to the relevance and the quality of the proposed abstracts, it has been decided to extend the Conference by beginning half a day earlier, on the afternoon of Wednesday 7 June, in order to accommodate more sessions.

Details of the program can be found on the Conference website http://www.gee.de/2006-IAEE/index.php Georg Erdmann, the Conference Chairman, Ulf Hansen the Program Committee Chairman and Steffen Sacharowitz, their computer wizard, are busily preparing us a very exciting program and so I invite you to register as quickly as possible.

Our Association continues to develop. Shortly after its creation in 2005, the Spanish Affiliate (Asociación Española para la Economía Energética) held its first annual conference in Madrid in January. It was a pleasure for Arnie Baker, the IAEE past President, and me to deliver speeches at the opening session of this two-day event, the success of which promises a very bright future for the Affiliate.

Preparation for the 30th IAEE International Conference is also in full swing. It will be held in Wellington, New Zealand on 18-21 February 2007. Einar Hope, IAEE Vice-President for Conferences, and Dave Williams, IAEE Executive Director, went to Wellington in February to work with Geoff

(continued on page 3)

Editor's Notes

Roger Bentley writes that geology and 'P50' discovery data indicate that many countries are past resource-limited peak of conventional oil production, and that the global conventional oil peak is close. Analysts often rely on proved reserves data, but these are very misleading and poor analysis has resulted. The world contains large quantities of non-conventional oil

(continued on page 3)

Contents: President's Message p1 • Global Oil and Gas Depletion - A Letter to the Energy Modelling Community p6 • Oil Supply and Demand p15 • The Environmentalists Struggle with Energy Security Or: If Maslow Were in Energy Politics p20 • Evidence on Risk Preferences in E&P Operations: Examining the Decision to Evacuate p24 • Publications p35 • Calendar p35

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GEE.de
Gesellschaft für Energiewissenschaft und Energiepolititk e. V.

29th IAEE International Conference

SECURING ENERGY IN INSECURE TIMES

June 7-10, 2006   Kongresshotel am Templiner See
Am Luftschiffhafen 1, D-14471 Potsdam near Berlin, Germany

Conference Chair: PROF. DR. GEORG ERDMANN (georg.erdmann@tu-berlin.de)
Program Chair: PROF. DR. ULF HANSEN (ulf.hansen@uni-rostock.de)
Sponsorship Chair: DR. ANDREAS AUERBACH (andreas.auerbach@rwe.com)

The German IAEE affiliate, the *Gesellschaft für Energiewissenschaft und Energiepolitik* (*GEE*) *e.V*., invites you to the 29th IAEE International Conference and would be proud if you will join this important meeting.

Conference Programme

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7. June 2006, 14:00 – 20:00 h: Day on Progress in Energy Economics with concurrent sessions and an opening reception with wine tasting in the *Kongresshotel* Potsdam

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8. June 2006, 9:00 – 17:30 h: Day on global issues with plenary sessions on “The Global Energy Scene”, “Securing Oil and Gas Supplies” (dual plenary), “Kyoto: Making Money from Saving Karbon” (dual plenary) and further concurrent sessions.

18.00 – 22.30 h: Sunset dinner cruise on the lakes around Berlin/Potsdam

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9. June 2006, 9:00 – 17:30 h: Day on securing energy under competition and regulation with plenary sessions on “Regulation and Competition in Energy Markets”, “Sustainable Transportation” (dual plenary), “Renewable’s Role inSecuring Energy” (dual plenary) and further concurrent sessions

18:00 – 22.30 h Conference Dinner in the historic center of Berlin, “*Unter den Linden*”

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10. June 2006, 9:00 – 13:00 h: Day on long-term technology and policy choices: Plenary session and concurrent sessions

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Our host, the city, 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 exciting 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. A post conference tour offers visits to technical and cultural highlights in and around Leipzig and Dresden.

For details on the program, registration fees, the electronic registration, the post conference tour, and other cultural events, please visit www.gee.de/2006-IAEE/ Please arrange your travel and hotel room soon as airline and hotel capacity is heavily demanded during the soccer World Cup period.

For questions, please contact the local organizing committee at IAEE@tu-berlin.de

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

Bertram at the year-ahead meeting. They had fruitful preliminary discussions on the program and the call for papers.

Another important activity, with a view to the future, is developing the number of student members and ensuring their integration within the Association. The Affiliates are pursuing their efforts to open Student Chapters and it is very gratifying for me to announce the recent launch of Chapters in the United Kingdom and in Italy.

I am also happy to report that the IAEE's website continues to be widely used by our members as well as by the general public. In 2005 approximately 140,000 different visitors consulted our website and accessed, on average, 12 or more web pages per visit. The website is viewed most often in English, followed by German, Spanish and then French. The most popular page is, not surprisingly, the home page, followed by *The Energy Journal* and *The Energy Journal* search pages. Frequent use of the login page proves that the "members only" section housing *The Energy Journal* downloads and the Membership Directory are a sure draw. Approximately 7,000 individual articles of *The Energy Journal* were downloaded in 2005. The Membership Directory and Membership renewal/new application form come close behind in terms of access. The Conference page also gets its fair share of hits. Google sends, by far, the most new users to our website. I am particularly pleased to mention that for the first few months of 2006 our website statistics indicate an upswing in student activity. Education and Careers are the most popular pages visited within the student section of the website. May I take the opportunity here to mention that following the suggestion of student advisors to the Council, we have opened a student forum that should prove to be a very useful tool for contact with other students. The forum can be accessed at http://iaeestudents.forumsplace.com/

So, 2006 seems to have gotten off to a good start for the IAEE. Energy concerns are once more at the top of political and corporate agendas, as well as being a current preoccupation for the general public. I am sure that our conference in Potsdam will give us the opportunity to deepen our understanding of the current situation and take a step further in our analysis of present and future energy issues. I look forward to seeing as many of you as possible in June and hope that our conference will turn out to be as popular as the FIFA World Cup!

Jean Philippe Cueille

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

and oil substitutes, but all detailed current models show that these are unlikely to come on-stream fast enough to offset conventional'sdecline

Olivier Rech traces oil supply and demand from late 2003 to the present arguing that a new oil market paradigm has occurred. He notes that the strength in oil demand stemming from world economic growth has been augmented by an increasing need for mobility for passengers and freight. On the supply side, the rate of non-OPEC production growth has slowed considerably while OPEC's excess supply capacity had virtually disappeared. While new production capacity is expected to come onstream by 2008, the oil market is expected to remain extremely vulnerable at least until then.

History suggests that energy policy priorities can be stratified similarly to the way Maslow structured his famous pyramid of human needs. Christoph Frei claims that access to energy, supply security, energy costs, environmental issues and social acceptance are not subject to trade-off, but to a hierarchy that underlies the importance of satisfying lower order needs before addressing the higher order ones.

Christopher Jablonowski examines the decision to evacuate offshore oil and gas facilities for hurricanes to identify the variables that drive these decisions. While most analysis of risk preferences in E&P has focused on financial decisions (e.g., auctions, hedging), this article summarizes research on the role of risk preferences in an real operational setting with life and death payoffs.

DLW

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IAEE Mission Statement

In August IAEE Council approved the following Mission Statement to help guide the Association through its strategic planning process. IAEE encourages you to share this Mission Statement with your colleagues and friends:

"The International Association for Energy Economics is an independent, non-profit, global organisation for business, government, academic and other professionals concerned with energy and related issues in the international community. We advance the understanding and application of economics across all aspects of energy and foster communication amongst energy concerned professionals.

We facilitate:

- Worldwide information flow and exchange of ideas on energy issues
- High quality research
- Development and education of students and energy professionals

We accomplish this through:

- Providing leading edge publications and electronic media
- Organizing international and regional conferences
- Building networks of energy concerned professionals"

The Italian Affiliate in 2005

The Italian Association of Energy Economists-AIEE was founded in 1989 and has progressively developed its activities, increasing the number of its members.

AIEE has now 30 institutional members (associations, companies, institutions, etc.) and about 220 individual members (experts, professors, consultants, employees, etc).

AIEE recently founded the Student Section, for young graduates and students under 30 years old who are interested in energy issues, which actually lists 18 members.

During the last year the number of AIEE members, especially individual members, remained almost the same (with a turnover of about 30% per year).

This is a brief summary reporting the activities carried out by AIEE during the year 2005:

Conferences and Seminars

In 2005 AIEE organized together with other institutions and companies, 9 national conferences, 7 in Rome and 2 in Milan and cosponsored important conferences in Rome, Padova and other cities.

Among the national conferences organized by AIEE it is worth mentioning "Electricity demand in Italy: analysis and short-medium term forecast" organized together with CESI in Rome and "The Italian gas market: situation and perspectives" a conference organized in Milan together with an important bank.

AIEE participated also in some international events. In August 2005, in the IAEE Conference in Bergen, Norway, AIEE, represented by its President and Vice President, presented a proposal, that was accepted by the IAEE European Affiliate Leaders, to organize the 2007 IAEE European Conference "Energy Markets and Sustainability in a Larger Europe" in Florence, in June 2007.

Education

AIEE continued the cooperation with the University of Rome "La Sapienza" - Department of Engineering, organizing the Master in "Management of Energy and Environment". This post-graduate course, listing now 20 participants has obtained a great success during the last years and is now at its 5th edition.

AIEE was present through its experts and its support, also in post-graduate courses and masters organized by other universities in Italy and abroad (China). One of these courses organized by AIEE last year was about energy efficiency in electrical appliances and electricity consumption in the domestic sector.

Services for the AIEE members

AIEE made on request of some of its institutional members, some important studies of which the most relevant are:

- a study on the natural gas market in Italy;
- a study on energy final uses in the domestic sector;
- a study on the electricity in Italy with a forecast to 2020 and
- a study of green certificates on the Italian market.

In 2005, AIEE together with other European institutions started working together on a project, that will be completed in 2006, about the future of the European Union electric system (EUSUSTEL). AIEE's task is to make an analysis of the Italian system and of the electricity demand in the European Union.

The Monitoring Service on Energy and Commodities Prices, that started two years ago continued in 2005, and developed also other minor short-term forecast services on the evolution of the main energy sources. The service is very much appreciated by AIEE members and has a lot of subscribers.

Publications

In May 2005, AIEE published the 8th volume of its book collection: "***The electricity market: from monopoly to competition***" by GB Zorzoli that was very well received by the AIEE members.

The AIEE monthly Newsletter "Energy and Economy" is now sent both in paper copy and on-line and can be also downloaded from the AIEE website.

AIEE is also cooperating with various energy magazines and newspapers, publishing articles and comments on various energy issues.

The Energy Foundation

In June 2005, the meeting of the AIEE Board decided to create the Foundation of Energy Economists - Energy Foundation, starting with an initial capital of 50.000 euro and the donation of the Library belonging to the AIEE.

This new structure is a non-profit body whose mission is energy information, education and research together with other institutions and universities, for a more important future target, which is creating an energy culture.

AIEE organized the inauguration of The Foundation and the public presentation of its mission, during a special event, held in Rome with the participation of 200 special guests.

The Energy Foundation has already started operating and is involved in some important studies.

Edgardo Curcio

Edgardo Curcio, Chairman of AIEE, the Italian IAEE Affiliate.

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. These sessions include:

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	

Register for this informative conference by visiting our website at: http://www.usaee.org/usaee2006/

For questions please contact USAEE:
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.

Accommodations: The Ypsilanti Marriott at Eagle Crest is our conference venue. The setting is resort-like overlooking Ford Lake. This resort offers an 18-hole championship golf course. Rates are $139 for a Single/Double Room. Details about accommodations and transportation can be found on the conference website at http://www.usaee.org/USAEE2006/accommodations.html.

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/

Global Oil and Gas Depletion – A Letter to the Energy Modelling Community

*By Roger W. Bentley**

This letter requests the energy modelling community to move rapidly to understand depletion of the world's conventional oil and gas, so that significant effort can be put into analysis of the problems that arise.

There are two very different views about the seriousness of conventional oil and gas depletion. One view maintains that the resource-limited peak in the global production of conventional oil is near, and that the corresponding peak for conventional gas is within sight. The other view sees no near-term resource limits to either oil or gas supply, and fears that if society listens to the 'near-term peakers' damaging economic policies will result.

The fundamental reason for this divergence of view is the existence of two very different data sets. The *industry 'P50'* data on oil discovery indicate that the conventional oil peak is imminent, and the gas peak not too distant. But if *proved reserves* are used a very different picture emerges, namely one that supports a cohesive economic view which dismisses any near-term threat to hydrocarbon supply.

The following sections examine these two very different data sets.

1. Industry P50 Oil Discovery Data

1.1 Results from the P50 data

Industry data on the amount of oil discovered in individual fields are held by national and private oil companies; data companies such as IHS Energy (formerly Petroconsultants), Wood Mackenzie, Energyfiles and PFC Energy; and by petroleum or mineral institutes such as Germany's BGR or France's IFP. Such data are not held by organisations such as the IEA, the US' EIA, or IIASA.

In examining industry data on discovery, energy analysts generally need to use the 'P50' reserves values. 'P50' designates 50% probable, and is an industry estimate at a given date for the most likely size of a field's reserves. P50 estimates are often approximated quite well by 'proved plus probable' reserves.

Combining P50 discovery data with geological knowledge indicates that about two-thirds of the world's oil producing countries are now past their *resource-limited* peak of conventional oil production, and hence in terminal production decline. Some are small producers, but Chevron reports that production is in decline in 33 of the world's 48 largest oil producing countries. Large countries past peak include the U.S., Iran, Libya, Indonesia, UK and Norway. In addition, Russia is past its resource mid-point if not technically past peak. P50 discovery data show that many more countries will soon go past peak, including major producers such as China and Mexico.

Figure 1 shows that the world is living off its past exploration success, with the large finds from the 1940s to the 1970s being drawn down since about 1980, the historical turning point when global production began to exceed discovery.

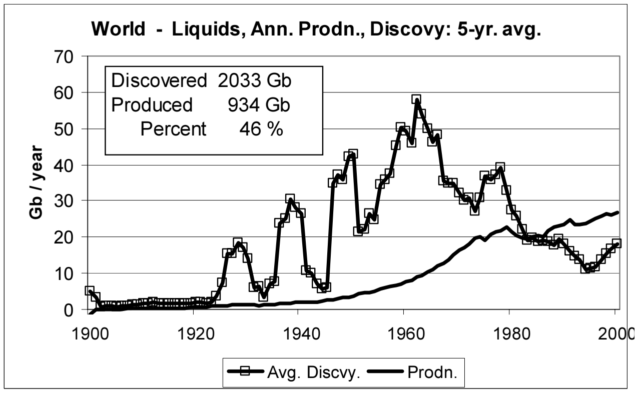

Figure 1
'P50' Discovery and Production of Petroleum Liquids (Oil plus NGLs) 1900-2000

Source: IHS Energy

Summarising, for some countries, we have:

	Peak of P50 discovery	Peak of production
U.S.	1930s	1971
Germany	1950s	1967
UK	1970s	1999
Norway	1970s	2001
World	1960s	~2005 - 2015

A list of discovery and production peak dates by country from the Campbell/Uppsala model is at www.peakoil.net. A full list of the 64 or so countries past peak can be purchased from Energyfiles.

P50 discovery data coupled with geological knowledge can be used to predict the future of global conventional oil production. Such calculations are included in the models discussed in Section 4.

1.2 Getting access to the aggregate P50 data

In the past, those who doubt the near-term conventional oil peak have complained - with at least some justification - that as they could not get to see the industry data, they could not judge the data's correctness, nor that of the conclusions drawn.

'Proved plus probable' reserves data for *individual fields* are available from numerous industry and government sources, and these numbers are often the same, or at least similar, to the industry P50 estimates. But the difficulty is of realistically assembling and assessing these often disparate field data to give credible country, regional, and world totals. Such totals are necessary if conclusions on overall discovery rate are to be drawn.

Full datasets by field from most data companies are indeed expensive. IHS Energy's suite of world data plus analysis has an annual licence fee in excess of $1 million. Fortunately much cheaper *aggregate* industry P50 data on oil discovery are available, and useful amounts of the P50 data, in various adjusted forms, are now also available in the public domain.

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*Roger W. Bentley, is CTO of Whitfield Solar Ltd. Previously he was a Senior Research Fellow in the Department of Cybernetics, University of Reading, UK. This is a condensed version, sans footnotes, of a much longer paper. The full version is available from the author at r.w.bentley@reading.ac.uk

Public-domain aggregate P50 data are available from:

- Data companies, in the form of publicity material. This information is generally sparse, but can be extremely valuable.
- USGS assessments. The year-2000 assessment, for example, gives end-1995 P50 reserves by country from the IHS Energy dataset.
- A wide variety of publications by Jean Laherrère, see, e.g., www.oilcrisis.com/laherrere.
- The Campbell/Uppsala model, available on the ASPO website: www.peakoil.net. The P50 reserves data here apply to 'regular' oil (see Note 3), are based on a variety of sources, and are usually adjusted for perceived over or under-reporting in the industry databases.
- Various books by Colin Campbell, and the monthly 'country analyses' in the *ASPO Newsletters*. These reflect the same data as in the Campbell/Uppsala model. .

2. Proved Reserves

2.1 The poor quality of proved reserves data

Proved reserves data are quite unsuitable for calculating future oil production as they exhibit serious errors of under-reporting, over-reporting, and non-reporting. These data problems have not been adequately recognised by much of the energy modelling community, leading to serious errors of analysis.

(a) Under-reporting

It has been known for a very long time that the proved reserves data for a field, a company or a region are usually very conservative numbers. Proved reserves generally report only the oil that is *just about to be brought to market*, rather than *the total amount of oil that has been discovered*. (The latter quantity is tallied by the P50 numbers.)

Confusion, however, between the two data sets is still widespread and has fuelled nearly every aspect of the oil depletion debate. The IEA, IIASA and IFP have all published tables listing proved reserves alongside P50 reserves without any comment on the datasets' intrinsic difference; while both the EU's *Energy Security Green Paper* and the UK's *Energy White Paper* clearly imply that proved reserves are meaningful estimates of total remaining oil.

BP's widely respected annual *Statistical Review of World Energy* makes the same mistake. It defines proved reserves as " … those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions". This is hopelessly wide of the mark, as proved reserves usually report quantities of oil *well below* what can be recovered with reasonable certainty under existing conditions.

Some examples will illustrate this point.

For the past 20 years the UK's proved reserves have hovered consistently around 4 to 5 Gb, see Table 1. By stark contrast, the UK's P50 reserves stood at 20 Gb in 1980 and have been falling steadily since. Today they stand at about 10 Gb, still twice the proved reserves number.

Norway is another example. In its early history the Norwegian Petroleum Directorate (NPD) calculated the country's reserves simply by totalling oil company submissions of SEC-defined proved reserves. But later the NPD realised that, with little in the way of new finds or improved recovery, the country had produced far more oil than the proved reserves could account for. The NPD switched in 1995 to reporting *all* categories of reserves, including P50 data and on up to higher estimates.

But the best example of the consistently conservative nature of proved reserves is the U.S.. Here the reserves numbers have changed hardly at all for decades, staying broadly in the ~30 to 40 Gb range, with a slight peak after Prudhoe's reserves were included. Once again the reason is because proved reserves do not report the *total* oil discovered, but simply that portion judged close to production under SEC rules. On a rolling basis, as the existing reserves are produced, the companies put in the investment and infrastructure needed, and gain the permissions, to bring the next tranches of discovered oil close to market, and hence within the SEC definition. As a consequence, the U.S. R/P ratio has also stayed virtually constant over the period, at around 10 years.

IHS Energy treats their U.S. data very differently from that of other countries. The company generates P50 reserves for other countries by totalling its P50 field discovery data and subtracting cumulative production. But for the U.S. they work backwards, adding cumulative production to *published proved* reserves, to generate what in effect are 'proved discovery' data. For nearly all other countries the backdated cumulative P50 discovery in such a plot shows a steep rise resulting from large early finds. In the U.S. the 'proved discovery' curve simply stays just ahead of production - by the R/P ratio of about 10 years - for virtually the whole of the more than 100 years' of data. Laherrère points out, however, that U.S. 'proved and probable' data are available up to 1988 in the USDoE/EIA-0534 1990 report; where for more recent discoveries, which by volume are mostly offshore, the fairly mild MMS three-fold growth factor can be applied.

In summary *proved reserves* for a field, a company or a region are usually significantly under-reported when compared to the actual quantity of oil that has been found. Table 1 compares P50 reserves data from two industry sources with proved reserves. As can be seen, the UK, Norway, FSU and China are all 'normal' countries, i.e., countries where P50 reserves are larger than the proved reserves.

(b) Over-reporting

A second serious problem with the proved reserves data is the opposite of the above. For the main Middle East OPEC countries their P50 reserves data held by industry are considerably *smaller* than their proved reserves. This anomaly was due to the 'quota wars' increases of the late 1980s, where allowable production under OPEC's quota was driven in part by the size of a country's reported proved reserves. As Table 1 shows, the changes adopted by the countries were dramatic, doubling proved reserves overnight in a number of countries and trebling them in the case of Abu Dhabi. In total the increases added 300 Gb to global proved reserves.

A number of analysts, apparently unaware of the reason for the OPEC increases in proved reserves, interpreted these as representing genuine additions to the global oil supply, either from discoveries or revisions.

Table 1
Proved Reserves from BP's *Stastical Review* and 'P50' Reserves

Year	UK	Norway	USA	FSU	China	UAE	Iran	Iraq	K'wt.	S.Arabia	Venez.
PROVED RESERVES											
1960			38.4	31.5			35.0	27.0	65.0	53.0	18.5
1965			39.4								
1966			39.8								
1967			40.0								
1968			39.3								
1969			37.8								
1970			46.7								
1971			45.4								
1972			43.1								
1973			41.8								
1974			40.6	83.4	25.0						
1975	16.0	7.0	38.9	80.4	20.0	32.2	64.5	34.3	71.2	151.8	17.7
1976	16.8	5.7	37.3	“	“	31.2	63.0	34.0	70.6	113.2	15.3
1977	19.0	6.0	35.5	75.0	“	32.4	62.0	34.5	70.1	153.1	18.2
1978	16.0	5.9	33.7	71.0	“	31.3	59.0	32.1	69.4	168.9	18.0
1979	15.4	5.8	32.7	67.0	“	29.4	58.0	31.0	68.5	166.5	17.9
1980	14.8	5.5	31.9	63.0	20.5	30.4	57.5	30.0	67.9	168.0	18.0
1981	14.8	7.6	36.5	“	19.9	32.2	57.0	29.7	67.7	167.9	20.3
1982	13.9	6.8	35.1	“	19.5	32.4	55.3	41.0	67.2	165.3	21.5
1983	13.2	7.7	34.5	“	19.1	31.8	51.0	43.0	66.7	168.9	24.9
1984	13.6	8.3	34.5	“	“	31.9	48.5	44.5	92.7	171.7	25.8
1985	13.0	10.9	35.9	61.0	18.4	32.4	47.9	44.1	“	171.5	25.6
1986	5.3	10.5	35.1	59.0	“	32.4	48.8	47.1	94.5	169.2	25.0
1987	5.2	14.8	35.4	“	“	96.2	92.9	100.0	“	169.6	56.3
1988	4.3	10.4	34.7	58.5	23.6	“	“	“	“	172.6	58.1
1989	3.8	11.6	33.6	58.4	24.0	98.1	“	“	97.1	257.6	58.5
1990	3.8	7.6	33.8	57.0	“	“	“	“	97.0	260.0	59.0
1991	4.0	7.6	33.7	“	“	“	“	“	96.5	260.3	59.1
1992	4.1	8.8	32.1	“	“	“	“	“	“	“	62.6
1993	4.6	9.3	31.2	“	“	“	“	“	“	261.2	63.3
1994	4.5	9.4	30.1	“	“	“	89.3	“	“	“	64.5
1995	4.3	8.4	29.9	“	“	“	88.2	“	“	“	“
1996	4.5	11.2	30.2	65.5	“	97.8	93.0	112.0	“	261.5	64.9
1997	5.0	10.4	29.8	65.4	“	“	“	112.5	“	“	71.7
1998	5.2	10.9	30.5	“	“	“	89.7	“	“	“	72.6
1999	5.2	10.8	28.9	“	“	“	“	“	“	263.5	“
2000	5.0	9.4	29.7	65.3	“	“	“	“	“	261.7	76.9
2001	4.9	9.4	30.4	65.4	“	“	“	“	“	261.8	77.7
2002	4.7	10.3	“	60†	18.3	“	“	“	“	“	77.8
2003	4.5	10.1	29.4	71.2	17.1	“	133.5	115.0	99.0	262.7	77.2
2004	4.5	9.7	“	72.3	“	“	132.5	“	“	“	“
'P50' RESERVES											
USGS	9.7	13.5	-	151.6	24.5	57.2	71.3	77.6	54.3	214.9	29.6
C/U	9.3	13.9	~45	113.0	24.3	49.5	59.9	62.2	63.0	146.7	34.6

Notes: Heavy line indicates step-change in reserves. Ditto mark (“) indicates value identical to previous year. UAE = Abu Dhabi. Dubai, Ras-al-Khaimah, Sharjah. Neutral Zone split between Kuwait and Saudi Arabia. Proved reserves are at year-end. Older US data: US 1950 R/P = 13 yrs; 1960 R/P = 12 yrs. Venezuela proved reserves includes some Orinoco oil. Note Saudi Arabia anomaly in 1976. †= Russian Federation (changed from Former Soviet Union, FSU). **P50 data:** USGS: IHS Energy end-1995 'ultimately recoverable reserves' (URR) from USGS year-2000 Assessment. As noted earlier, IHS Energy data do not hold P50 data for the US. C/U: End-2004 ~'P50' reserves as given in the Campbell/University of Uppsala model (see www.peakoil.net).

Table 1 includes the P50 data for the OPEC countries where these reserves are smaller than their proved reserves.

(c) Non-reporting

The third problem with proved reserves, and now the most serious, is non-reporting. Each year in recent years proved reserves for the majority of countries have not changed, with these static data sometimes running for a decade or more, see Table 1.

Overall, the key idea to retain about proved reserves is that for the majority of countries in the world, and especially the large producers, the data have no bearing at all on true reserves.

2.2 Determining the date of peak from proved reserves data

Not surprisingly, the date at which a country goes over its production peak cannot be determined simply from its proved reserves data; additional analysis is needed as set out in Section 3.1.

As Table 1 shows, none of the U.S. 1971, UK 1999 or Norway 2001 peaks can be deduced simply from the proved reserves data. This is because leading up to the peak, and likewise following, the proved reserves stay at roughly the same level. For the UK and Norway the data fluctuate primarily from the whims of reserves reporting.

Despite these data making clear that proved reserves give no direct information about peak, it was said by one of the 'running into oil' protagonists that there could be no credence to oil peaking fears until there had been several years' fall in world proved reserves. This view is not sensible. The date at which data-driven analysis of global peaking could be undertaken was when sufficient regions were past peak (primarily U.S. states) for the mechanisms of peaking to become clear. Analyses of this sort were carried out by Hubbert in the 1940s. Confidence about the predicted date of global peak became fairly solid in the 1970s once global P50 discovery was in decline and its trend clear. The date at which rational planning for global decline should probably have started was in the 1980s, once the P50 reserves began to fall. [21] Waiting until *proved* reserves start to decline is to wait until the peak is long past.

2.3 Misleading conclusions from using proved reserves data

Does it matter that proved reserves have been reported conservatively?

It has mattered a great deal, and is the prime reason that the oil depletion debate is taking place at all. What looks at first blush like a staid and respectable policy on reserves reporting has had a number of serious side-effects.

Most of these have resulted from the mistaken belief that proved reserves are a reasonable measure of the oil remaining at a given date. For example in the 1970s many believed that the world would 'run out of oil' in about thirty years, as it had thirty years' of proved reserves left. Today, with forty years' of proved reserves remaining, the impression is widely held that oil forecasting is, therefore, unreliable. The real explanation, that the 1970s proved reserves data simply took no account of the known probable oil, nor of the yet-to-find, is still largely unrecognised.

From the same reasons it has become accepted that it is difficult to measure the amount of oil in a reservoir. In fact the oil-in-place in structures is usually known quite accurately, especially if quoted statistically across a range of related fields; while the predicted recovery factor of a specific method today is also usually broadly correct. For large fields today the assessed quantity of recoverable oil is an output of detailed finite-element modelling.

As another example, the observation that reserves are frequently replaced without significant new discoveries is widely explained by the likes of the IEA or the UK's DTI as being due to advances in technology, including directional drilling and 3-D seismic. The IEA's use of a graph showing an apparent three-fold increase in the amount of oil in the North Sea between that deriving from 1986 'proven technology' and from 1999 'new technology' is one such example.[22] Examination of individual fields, however, shows that most of apparent technology-driven growth is explained by conservative original reporting, either of proved reserves, or 'production engineering' estimates of proved plus probable reserves.

Another misleading outcome of conservative reserves reporting is that some analysts explain the very long run of almost constant U.S. proved reserves by proposing that investment is the primary determinant of reserves. This view maintains that it is investment that turns "resources into reserves", and that the size of the underlying resource is of no concern, being both "unknown and unknowable".

As set out above, this explanation has an element of truth, as under SEC rules it is investment, or at least the intention to commercialise, that brings already-discovered oil into the proved reserves category. Where the analysis falls down utterly is in failing to recognise that the real size of the U.S. reserves has long been known, and that their long-term reduction is also well documented. To get at these real reserves the proved reserves have to be 'grown', as Hubbert and others have shown (Section 3.1). It is hard to imagine that anyone who has looked at Hubbert's graph of U.S. Lower-48 'grown' discovery per foot drilled, where this declines inexorably since the 1930s, could think that the U.S. reserves of conventional oil are primarily a function of investment.

However, this 'resources into reserves' view is deeply embedded, and has recently had an extraordinary exemplar. The IEA has just published a report with effectively this title, that concludes, "Hydrocarbon resources around the world are abundant, and will easily fuel the world through its transition to a sustainable energy future. What is badly needed, however, is capital investment ..."

The fundamental reason for the IEA's ignoring of the peaking arguments is almost certainly due to the evolution of an 'economic view' of oil supply, as explained next.

2.4 An 'Economic view' of oil supply

The broad set of misunderstandings described above, driven largely by thinking proved reserves to be a useful measure of remaining oil, fed into a cohesive 'economic view' on oil supply.

- Price, investment and technology are the main drivers of supply, not resources.

- Past forecasts failed because they assumed the resource base to be fixed.
- Should supply difficulties approach, they will be signalled by rising price and falling proved reserves.
- Any supply difficulties are most efficiently corrected by the market - short-run increases in price will limit demand and bring on adequate new supplies.

Those who hold this view see it has having been solidly corroborated by history:

- The 1970s price shocks turned out to be simply political, and were not driven by resource shortage as was widely believed at the time.
- OPEC did not remain in the driving seat, and the oil price did not continue to escalate as many had forecast. Instead the higher prices brought in competing sources of oil, and the price fell.
- Despite recurrent predictions of shortage, proved reserves have consistently been replaced.

History, in fact, tells a very different story:

- The 1970s shocks were driven fundamentally by the U.S. peak, but no authoritative body at the time thought that the world peak was close; it was well documented that this would not occur before about the year 2000 (see Section 3.4, below).
- With the world still on the up-side of the Hubbert curve, excess production was indeed likely that would limit OPEC's power for a time. Importantly this new oil (Alaska, North Sea, new Mexican fields, and so on) had been found *before* the oil shocks, not after.
- As already discussed, proved reserves replacement gives almost no information about real reserves, nor about future supply.

However, such is the academic standing of this 'economic view', and its degree of apparent support by history, that it has held almost complete sway within the world's oil companies, at oil conferences, and in the corridors of power now for about the last twenty years. Moreover, this view removed the need for any quantitative analysis of depletion, so over most of this period there have been extraordinarily few analysts - certainly fewer than ten in total worldwide, across all of industry, academia, government and independents - who were quantitatively examining the production limits set by the size of world's recoverable resources of conventional hydrocarbon.

Also as a result of the dominance of this 'economic view', any modelling over this period that was resources-based and which did not explicitly include the effects of price and technology was dismissed out-of-hand by the economists. In return, the many studies by the economists where the resource base was treated as effectively infinite - only the demand needed modelling - were dismissed by the geologists. For about twenty years there has been almost complete lack of dialogue between these two groups in the matter of global hydrocarbon supply.

3. Other Aspects of Modelling Hydrocarbon Supply

This section discusses some of the other aspects of oil and gas depletion that call for better comprehension. Here we look at reserves growth, use of the Hubbert curve, and the reliability of past oil forecasts.

3.1 Reserves growth

Reserves growth is a complex topic, and needs careful analysis. As used here, and generally, reserves growth refers to the increase over time in the reported original volume of recoverable oil in a specific field or group of fields.

(i) 'Reporting' reserves growth

Odell reported an average of nine-fold growth in field size over total field life for Western Canadian fields. In the U.S. six-fold field growth was used for on-shore fields, and three-fold for offshore. Such very large growth factors were to be expected because of the conservative nature of proved reserves reporting. In particular, reserves growth was the norm under SEC rules for large fields as increasing portions of the original field were brought closer to market; for example, by being drilled-up with additional production wells. (But see the earlier note of Laherrère's analysis showing that continued scope for U.S. field growth is now considerably less).

If the proved reserves for *a group* of fields is being quoted then other factors enter also. In the case of the UK, for example, much of the small size of the proved reserves is almost certainly due to exclusion of discovered fields that had not yet received government production sanction. As time moved on, such newer fields received sanction and were added to the proved reserves data, which, therefore, stayed roughly constant as the reserves of the older fields declined through production.

For the U.S., analysts like Hubbert recognised the need to 'grow' the proved reserves of fields if a realistic estimate was to be obtained of the amount of oil the fields would yield over their lifetime. The method uses the historical sequences of proved reserves and production data to generate 'proved' discovery by year. These annual numbers are then increased by the amounts that past experience has shown likely for fields of different ages, thus generating realistic 'grown' discovery data. Hubbert used such data in a number of powerful analyses, including the very telling statistic on U.S. discovery per foot drilled mentioned above. The latter showed that the U.S. lower-48 'grown' discovery had peaked in the 1930s and fallen dramatically ever since.

(ii) 'Real' reserves growth

The above all refers to what might be called 'reporting' reserves growth. Of great interest also is technical or 'real' reserves growth, where a field yields more oil over time due to better knowledge of its reservoir, or the introduction of a technology that increases its recovery factor, such as waterflood or tertiary recovery. A higher oil price can, of course, contribute directly to such real reserves growth, by bringing in a procedure that was already known but previously uneconomic for the field in question.

A key question is: How much real reserves growth do we expect in the industry P50 data?

Some analysts such as Campbell have expected little. After all, the P50 figure is supposed to be the best estimate for each field's ultimately recoverable reserves ('URR'), i.e., the amount of oil that will have been extracted when the field is finally shut-in. In the IHS Energy database these field URRs include the reasonable application of current and expected technology to the field. But globally the *theoretical scope* for recovery improvement is very large indeed, as averaged across all fields the world currently recovers only something like 50% by volume (about 35% vs. number of fields) of its total conventional oil-in-place.

In answering the question of how much real reserves growth to expect in P50 data it must be recognised that much of industry P50 data, including those held by IHS Energy, are 'backdated'. This simply means that when the size of a field is revised the new information replaces the old. Since the database holds this information against the year that the field was discovered, the change appears as an increase to the world's discovery at that date. To see how the size of a specific field has changed one, therefore, needs to access past database records for the field in question. Systematic studies of this type have been carried out for the North Sea and a few other regions, but not, I think, many.

In general, therefore, real reserves growth in the industry data needs to be assessed by other means; for example by looking at plots of field production vs. cumulative production to see if step-changes appeared in the extrapolated URRs; or by considering the impact of specific changes in recovery technology. The oil company studies that I know of suggest fairly modest numbers for real reserves growth once secondary recovery is in place. But this is an area which merits more detailed research.

3.2 The USGS' perspective on reserves growth

In its year-2000 Assessment the USGS included data on reserves growth that have proved controversial, especially since bodies such as the IEA and the 'WETO' study group base their forecasts on the USGS estimates of global 'ultimate' that incorporate these reserves growth factors.

The primary aim of the periodic USGS global oil and gas assessments is to estimate the total amounts of oil "available for discovery" in specific basins over a realistic time period, and to sum these to country and regional totals. However, the USGS does at the same time generate estimates of 'ultimates' for countries, by adding the yet-to-find estimates to IHS Energy P50 reserves data and cumulative production. For past assessments the USGS explicitly discounted the need to 'grow' the global P50 reserves data, stating that in most parts of the world they judged the P50 numbers to be pretty good estimates of the 'ultimate reserves' of existing fields. This approach changed in the USGS year-2000 assessment, with quite large reserves growth factors, based on U.S. field-growth experience (for proved reserves) being applied to countries outside the U.S. (with 'proved plus probable' reserves). This process added 690 Gb in total to the mean globally assessed 'ultimate'. The USGS did note, however, that they were unsure how to model reserves growth outside the U.S., and that they took this approach as much to raise awareness of the issue as to be certain that it would give the correct results.

So the question is: How realistic is it to use USGS year-2000 'grown' data when assessing world peak?

The USGS was reportedly much encouraged in the wisdom of including large reserves growth factors when a study by IHS Energy found that its backdated global P50 discovery data, after taking out the discovery of new fields, had shown very large increases - in total some 464 Gb over the period 1995 to 2003. This has been taken by the USGS and others as proof of on-going very significant real reserves growth around the world, i.e., of large knowledge- and technology-driven increases in recovery factors across the globe.

However, it was recognised that as the growth applied to global *aggregate* data, any one of a number other reasons, such as including new classes of oil, switching to different data sets, or missing early fields could also have generated these increases. IHS Energy, therefore, examined their data more closely; looking, for example, at U.S. data (which are proved, and hence expected to grow); at FSU data for which new data sources had become available; and at the Middle East numbers where these were known to be very uncertain. As a result, the company stated that about only 175 Gb of the 464 Gb "seems a reasonable ball-park estimate ... that can properly be attributed to the ['real'] resource growth mechanism in pre-1995 discoveries during the period 1995-2003." Nevertheless, the company noted that when added to the new field and pool discoveries of 144 Gb over the same period this represented a 133% replacement of global liquids production. However, IHS Energy cautions that "It is impossible to quantify with accuracy the true contribution of the 'resource growth' phenomenon. Note also that other datasets, for example Wood Mackenzie, carry a total world P50 discovered quite a bit lower than IHS Energy's, the difference being possibly a more conservative assessment of oil accessibility, and perhaps treatment of some Middle East reserves.

So the question remains as to how much 'real' (technology-driven) reserves growth will occur in the industry datasets in future, and crucially, how much of this 'extra oil' will get developed in time to have any effect on the global date of peak.

To support its case on reserves growth, the USGS looked at reserves growth in UK and Norwegian fields. Here changes over time in the public-domain 'proved and probable' reserves data were examined, and the increases identified. However, even these data need to be examined carefully.

Firstly, of course, the growth that the USGS should be considering is that which has occurred in the IHS Energy database over time (as these are the P50 reserves data used in the year-2000 assessment), not in the 'proved plus probable' reserves data published by the North Sea countries. For example, using IHS Energy data the UK large fields have shown an average increase in size of 50% over the long term; with smaller fields showing a corresponding increase of 25%. Similar growth factors turn up for fields in other *non* North-American countries although the data are rather sparse. Increases of this sort of magnitude are significant and need proper handling in the modelling, but are far smaller than the many-fold growth factors encountered when the U.S. *proven*, and Canadian *developed* data are examined. As mentioned above, it was reserves growth factors based on the U.S. growth factor that were applied to the world data in the USGS year-2000 assessment.

Secondly the USGS analysis of North Sea field growth also needs to be careful not to be confused by the early Norwegian data that reflected only SEC-reported reserves. Thirdly it has long been known that for large fields early public-domain 'proved plus probable' reserves are usually on the conservative side, as for example with Prudhoe Bay in the U.S. and Forties in the UK. Such early conservatism usually reflects engineering pragmatism on the size of infrastructure to build early in a field's life; and also perhaps a wish to avoid being over-optimistic to the market on an asset should problems arise later.

More recently, the USGS has done a very useful study of field growth in the IHS Energy data. This identifies significant growth, though even here caution is needed on the apparent growth in Middle East fields.

3.3 Analysis Using the Hubbert Curve

In the energy modelling literature there has been considerable misunderstanding of the 'Hubbert' curve, which is the derivative of the logistic curve. Here we look at this curve from three points of view: how well it matches discovery and production; use of the curve to predict the date of peak; and criticism of the curve.

(a) Using the Hubbert curve to match Production

The curve is misunderstood despite Hubbert's very clear original papers, coverage in a wide range of energy textbooks in the 1970s and 80s, and the excellent present-day explanations by Deffeyes, Campbell and others. The key idea to understand is that the curve is a mathematically-tractable approximation for estimating the date of a region's production peak which is both useful and robust. It was never intended as a precise forecast of production long into decline.

Hubbert studied peaking for many U.S. states. Today, there are many more examples to look at. Well over a hundred sizeable regions of the world are now far enough into decline for the shape of their long-term production curves to become clear. Such regions include most of the U.S. states, many of the 65 or so countries past peak, and many individual oil provinces including separate on-shore and off-shore regions. By far the majority of these areas show production curves where production goes up rather like the left-hand side of a bell curve and down roughly exponentially.

Where a region has clear phases of discovery, production generally follows the above production profile for each discovery phase. For example, the U.S. production curve follows a close approximation of this curve for most of its Lower-48 production, with a similar but smaller curve added for Alaskan production - the latter not surprising since Prudhoe Bay, the largest single U.S. field by far, was found very late compared to the bulk of Lower-48 finds. U.S. production will now show the addition of a third, yet smaller, curve due to production from the recent off-shore deepwater finds.

Chilean production is another good example. This has a two-humped 'camel' profile, but examination of the underlying data shows that this simply reflects the addition of production curves for its on-shore and subsequent off-shore regions. Indonesian production likewise reflects separate on-shore and off-shore discovery phases, though here the timing and relative magnitudes of these phases has resulted in a declining plateau-like production curve. Germany is now exhibiting the addition of its relatively small off-shore production curve to its primary on-shore curve. (In the UK, however, the 'camel' profile has different causes: there was a small second phase of discovery but the primary cause of the profile was safety work across all fields resulting from the Piper-Alpha disaster, combined probably with a delay in start-up of some mid-sized fields awaiting change to the petroleum revenue tax.)

Note that a 'Germany-like' production profile is to be expected mathematically as a result of a region's larger fields generally getting into production before its smaller ones.

(b) Use of the Hubbert curve to predict the date of peak

So how did Hubbert use the Hubbert curve?

Hubbert sought to determine the date of the U.S. peak. In his early work he drew by hand curves having a 'Germany'-shape that covered total areas equalling estimates of the U.S. conventional oil ultimately obtained from industry sources. Such curves then directly gave estimates for the date of peak.

However, estimates for the size of the U.S. ultimate then began to rise, and so later Hubbert sought instead a prediction method that depended solely on U.S. historical production data. Using data from those regions already past peak, Hubbert found - after trying many curves - that the logistic curve fitted cumulative production in these regions pretty well. It also had the advantage of being one of the simpler curves able to capture the zero-peak-zero production of a finite resource.

Hubbert used a linearisation approach to fit this logistic curve to the U.S. historical cumulative production data. This generated an estimate for the date of peak without the need to assume an ultimate. The method can in theory be applied using just three data points, i.e., right at the beginning of a region's production, but Hubbert found in practice that about a third of the full production cycle had to elapse before the data yielded consistent estimates for the date of peak. It is this 'later-Hubbert' method that was recently applied by Deffeyes to world production to give an estimated date of peak as 2005.

The Hubbert curve can also be used to predict peak in other ways. One is to make an estimate for ultimate, and combine this with the symmetry of the Hubbert curve to predict that peak will occur when production reaches 50% of the ultimate. This method was used by the 1995 Petroconsultants' study and is currently used in the Campbell/Uppsala model.

So the question for these models is: Does production peak at 50% of ultimate? This has been looked at by a number of authors. The usual answer is that a region's peak occurs at less than 50% of ultimate; though the spread is fairly wide, from as low as 10% of ultimate (usually for regions with rather few fields) up to 60%, the latter tending to be cases where policy some other factor, such as accident as in the case of the UK, constrained production before the peak occurred. Of course, where higher estimates of 'ultimate' are used, for example the USGS mean estimates, then peak occurs at correspondingly lower percentages. Overall, 'mid-point peaking' is a reasonable first-cut approximation to apply to many regions, bearing in mind that it has a tendency to predict peak later than actually occurs.

Note that the Petroconsultants 1995 and Campbell/Uppsala calculations use 'mid-point peaking', but do not assume a Hubbert profile for production. Instead they use a production growth function that depends on the region being modelled up till peak is reached, and then exponential decline post peak, where this decline is calculated from the quantity of oil remaining, itself a function of ultimate. Note also that many of the current models make no use at all of the Hubbert curve, including those of Energyfiles, Miller of BP, the BGR and PFC Energy, though all, of course, owe a debt to Hubbert for the general concept of peaking and how this might be calculated.

If the Hubbert curve is a good approximation - but not an exact one - to production, how well does it model discovery?

(c) Using the Hubbert curve to match Discovery

Hubbert postulated that discovery also follows a logistic curve. This is true for U.S. 'proved discovery', as this is just production advanced 10 years by the proved reserves R/P ratio. But the logistic curve is a poor approximation for back-dated 'real' discovery data, as any industry dataset will show, simply because in practice the large fields tend to get found first. It is this tendency that gives discovery its characteristic 'creaming curve' shape, with a steep rise followed by exponential flattening.

However, both Ivanhoe (for the world discovery data) and Laherrère (for many regions and countries) do model discovery by a logistic curve, in the latter case using multiple curves where there have been distinct phases of discovery such as Alaska in the U.S.. They then predict production as a delayed 'mirror' of discovery. This approach is in fact very effective, provided the logistic curve is aligned to capture the bulk of the discovery shape. Laherrère's many graphs of this type are essential reading.

(d) Criticism of the Hubbert curve

Despite all the foregoing being well documented, a number of analysts criticise use of the Hubbert curve, citing as primary evidence the fact that U.S. production far on the downside of peak departs from the curve. These authors emphasise that the *percentage* (not absolute) error increases the further down the production curve one goes. Given what has been said above this criticism betrays a lack of understanding of both the background and purpose of the curve, and almost certainly indicates that the critics have examined few regional depletion curves - if any - in detail. The mass of evidence indicates that Hubbert's insights and analysis are by-and-large completely valid, and have given society a powerful set of quantitative tools with which to forecast the date of peak.

3.4 Past Forecasts

Past forecasts of oil production need examination because most who doubt the imminence of the conventional oil peak, point to the apparent failure of past forecasts to conclude that oil forecasting is impossible. So the question is: Did these forecasts really 'cry wolf'? Like reserves growth, this is an area where careful analysis is needed.

Given the importance of oil, it is not surprising that for many years there were fears that it might run out, with forecasts from the 19th century up to the Second World War being concerned about the adequacy of supplies. Most, perhaps all, of these forecasts were based on just oil in specific regions, and so it is not surprising that they predicted declines in output.

However, in terms of *world endowment*, though Ghawar had been identified before the war it was not drilled until 1948, and it was some further years before its full size was recognised. Without Ghawar no sensible estimate of the world total was possible, and it was only with the widespread use of digital seismic from the 1960s that a true picture of the world endowment could emerge. Not surprisingly the industry estimate used by Hubbert in the 1950's for global endowment of conventional oil 1350 Gb was, therefore, on the low side, as only by the early 1970s did realistic estimates became available of the global conventional oil endowment, at around 2000 Gb.

Once this ~2000 Gb figure was known, realistic estimates for the date of the global peak also became possible. Many such estimates from recognised sources were generated in the 1970s and '80s and in many of the energy textbooks from that period. Hubbert's forecast at the time used Nehring's estimate of 2000 Gb for the global conventional oil 'ultimate'. All these forecasts predicted that world oil production would continue upwards for some 30 years, and peak around the year 2000.

Also at that time, however, there were many who misunderstood the conservative nature of proved reserves, and who wrote that global oil would *run out* in 30 years. Others looked at the exponential rate of growth in production that had been occurring, about 7% p.a., and pointed out (correctly) that such growth could not be sustained for very long more-or-less regardless of the size of the resource.

However, even the 'recognised source' predictions have come under fire. Odell, Davies, John Mitchell and more recently by Vaclav Smil have all claimed that BP's prediction of a 1985 peak in *Oil crisis .... again?* was a classic failure of 'fixed-volume' oil forecasting. Others have likewise pointed to failure of Hubbert's prediction of a 1996 world peak, based on a 2000 Gb ultimate, as giving similar cause for scepticism.

Like so much of the oil peaking debate, these criticisms show as much as anything a lack of careful analysis. In the case of the BP prediction, this was for the non-communist world and taking out NGLs (as can be seen by matching the early part of the prediction to historical production). The forecast then used a *resource* figure that still looks realistic today, but assumed that global production would grow during the 1980s, rather than fall as was the case, due to the effects of price on demand. The same explanation applies to the Hubbert 'unconstrained' forecast of a 1996 peak. That is, both these forecasts were 'geological' forecasts, using sensible resource numbers but not correctly including the impact - perhaps then still not clearly known - of price on demand. What these forecasts do not do is demonstrate the failure of 'fixed resource' modelling.

4. Predicting Global Oil and Gas Production

4.1 The models

Forecast of global oil production have been carried out by a wide variety of methods, each having advantages and disadvantages. The models can be categorised into three broad groups based on how the authors see future oil production:

- Group 1 calculations indicate that global oil production will reach a resource-limited maximum sometime between the years 1996 and 2020, and thereafter decline. Some of these calculations relate to conventional oil only, others to both conventional and non-conventional oil.
- Group 2 forecasts terminate in 2020 or 2030, and find that the resource base is sufficient for global oil production to meet anticipated demand to these dates. These 'business-as-usual' forecasts give no indication if a resource-limited peak is subsequently expected.
- Group 3 analyses dismiss the possibility of a hydrocarbon resource-limited peak occurring in the near or medium term, and hence see no need to quantitatively assess future oil production.

Most Group 1 models assess the oil resource base by adding industry P50 discovery data to an estimate of yet-to-find. They then use one of the following to calculate future production:

- 'mid-point' peaking (e.g., Hubbert, Petroconsultants '95, or Campbell/Uppsala);
- (partly) field-by-field modelling plus assumed production profiles (Energyfiles, Miller, PFC).

Alternative powerful techniques used by Group 1 modellers include techniques already mentioned earlier, such as the linearised production plot based on the logistic curve (later-Hubbert, Deffeyes), or modelling production as an approximate delayed 'mirror' of discovery (Ivanhoe, Laherrère).

Group 2 forecasts either assume that large quantities of non-conventional oil will come smoothly on-stream as conventional declines (Shell; maybe Exxon); or else place reliance on the USGS year-2000 assessment without paying attention also to the potential discovery rate, nor to reserves growth factors outside the U.S. (IEA, U.S. DoE, 'WETO' study). The 'WETO' model for example assumes a conventional oil 'ultimate' of 4500 Gb, based on aggressive assumptions on reserves growth (in effect adding rapid reserves growth to already-grown USGS numbers). Such an ultimate must be compared to the global discovered conventional oil to-date (incl. NGLs) in the range of only 2000 - 2200 Gb, and the discovery rate of new-field oil of about 10 Gb annually on a generally declining trend. Thus the 'WETO' study and other authors who propose conventional oil ultimates much above ~2400 Gb (incl. NGLs) must explain in detail the discovery data, and the technical arguments behind the anticipated recovery factors, that support their estimates. (The reality is probably that the 'WETO' authors, for example, have simply not compared their forecast production curves with the actual production curves of the numerous countries past peak.)

Group 3 analyses include those by Paul Stevens, Peter Davies, M. Adelman, Michael Lynch, Peter McCabe and Leonardo Maugeri. These analyses rule out the need to examine the oil resource base for a variety of reasons:

- Some assume that higher prices will bring on sufficient new conventional oil to prevent difficulties in supply;
- Others assume high prices will gently reduce demand, thus bringing supply/demand back into balance without serious economic disruption;
- Still others consider conventional and non-conventional oil to be economically indistinguishable, and that the non-conventional resource (including shales, and perhaps hydrates) is so large that limits to conventional oil production will have no economic significance.

In broader terms, many of the Group 3 analysts express what might be called the 'standard economic view' of oil depletion. The arguments are rational enough, and many are based on well-established economic theory. But as shown throughout this 'letter' quite a number of the assumptions behind these views do not stand up to scrutiny. There is, however, more work to be done to fully clarify the situation, and some of these issues that need better analysis will be discussed in a later article

4.2 Is the peak right now, or should we expect a mini-glut of oil?

Is the resource-limited peak in the global production of conventional oil right now, as, for example, Deffeyes predicts, or should we expect a 'mini-glut' of oil over the next few years? If the peak is, indeed, not yet past, this puts the world still on the up-side of the Hubbert curve, still with potential excess capacity.

Based on the resource data in most current models (BGR, Energyfiles, PFC Energy, Campbell/Uppsala, BP's Miller) the answer is that a mini-glut is expected. In these models increased production from a number of regions including deep offshore U.S. and Africa, from Kazakhstan and Russia, and from new tar sand plants more than offsets the declines in production elsewhere. This is also the current view of CERA, which is very bullish on near-term supply.

The situation, however, is not so clear cut.

On the up-side, in addition to the already discovered fields listed above, the current high oil price will certainly bring on more marginal fields, as well as in-fill drilling and work-overs in the mainstream fields as happened with the last oil shocks. Moreover, demand will also be dampened or even reduced. This spells 'mini-glut'. The affect on price will then be controlled by how well OPEC can manage supply, since the new sources oil will all need to produce to the maximum to see returns on investment.

On the down-side, however, Skrebowski who has the same data as CERA sees a lower level of supply, asking whether the oil that undoubtedly exists can in fact come on-steam as fast as expected. Current information from rig analysts and the like bear out this more pessimistic view.

But the biggest reason to think that peak may be sooner than most current models predict is that they may all be using over-estimated Middle East reserves. This is a serious potential problem, as Simmons and Zagar have highlighted.[37] Moreover as the data indicating the approaching peak become ever clearer, it may well be that producers will switch, as they did during the 1970s shocks, to a 'conservation' strategy - slower, high-priced, low-investment production - rather than the current high-investment high-production strategy that maximises up-front volumes.

Oil Supply and Demand

By Olivier Rech[*]

The year 2004 saw a change in the oil market paradigm that was confirmed in 2005. Despite a calmer geopolitical context, prices continued to rise vigorously. Driven by world demand, they remain high as a result of the saturation of production and refining capacity. The market is still seeking its new equilibrium.

Before reviewing the situation for 2005, let's take a brief look at the exceptional nature of the previous year, which justified thinking that a change in the oil market paradigm had occurred.

2004: The Paradigm Starts to Change

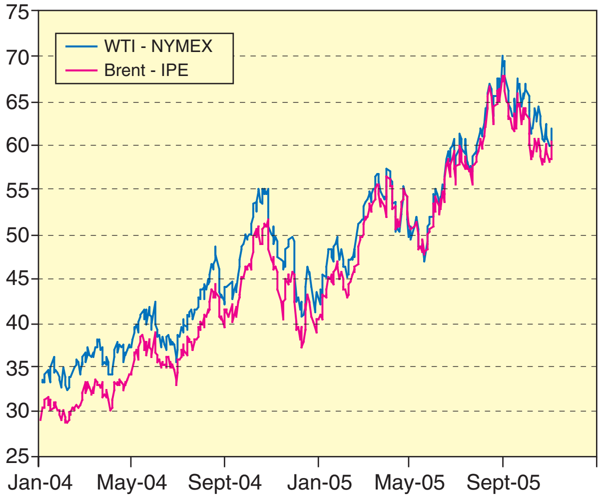
Although at one time overproduction had been forecast for the end of 2003, it did not materialize for several reasons. The failure by Iraq to make a comeback on the international oil scene coincided with economic factors that worked to sustain world consumption and with several judicious decisions by OPEC to adjust its quotas. Instead of slackening as expected, the market tightened starting early in 2004 until, in some ways, it recalled the decade of the 1970s. Surplus production capacity dropped sharply, affecting all of the players along the oil supply chain that have been delivering security of supply along with relative price stability for the last twenty years.

The world economy grew, stimulated by particularly low interest rates. As a result, oil consumption increased at a rate of nearly 2.6 Mb/day, more than twice the average for the last twenty years. All continents contributed to this acceleration in the wake of the Chinese market (up 0.86 Mb/day), where temporary demand for petroleum products as a replacement energy during electricity shortages amplified the structural effects of exponential economic growth. The American market consolidated its leading world position with an increase of 0.7 Mb/day, generated mostly by motor fuels, despite a level of per-capita consumption that is already especially high.

Facing this sharp upturn in the rate of demand, OPEC progressively mobilized virtually all of its capacity. According to estimates, the surplus capacity available in October 2004 fell below 1 Mb/day. The crude price then broke a symbolic record, exceeding the $50 threshold for a few days. It became critical to rely on OPEC production due to the low short-term price elasticity of non-OPEC production, not yet benefitting from these favorable business conditions. With a contribution of 0.7 Mb/day (total: nearly 1.1 Mb/day), Russia continued to represent the bulk of the increase in non-OPEC production. The other non-OPEC producers registered limited growth of about 0.4 Mb/day, in sharp contrast to the requirements and vitality of the world market.

The price hike — over which OPEC had entirely lost control due to the lack of available capacity — was aggravated by a similar situation in the refining industry, where utilization rates were reaching historic highs all over the world. The pressure exerted on capacity was also aggravated by the fact that the quality of the last barrels of crude to be put on the market did not match the needs of refiners. Very high sulfur heavy crudes were offered by OPEC as a last resort, but they did not provide a satisfactory short-term response to demand for very low sulfur motor fuels.

Figure 1
Crude Price Variations in 2004 and 2005 ($/b)



Source: PLATTS.

As demand pursued its frenetic upward course, stocks continued to deteriorate despite the mobilization of all production and refining capacity. In 2004, OECD stocks coverage of petroleum and refinery product consumption was at its lowest since full market deregulation in 1986. Due to the combined effects of low stocks and saturated production capacity, the (Brent) crude price rose $30 early in the year to reach over $50 during the last quarter.

2005: A Market in Search of Equilibrium

Although the symbolic price threshold of $40 then $50 were exceeded, the current situation does not have many points in common with the 1970s. The first and second oil shocks involved a sudden cut-off of the oil supply in a time of geopolitical turmoil and uncertainty. Prices are rising today because of industrial bottlenecks emerging for reasons related to demand and investment.

World Oil Demand is Resilient

World demand was revised upwards significantly several times in 2004, but a series of estimates made for 2005 indicated some slackening. World market growth, initially projected to be 1.8 Mb/day, will apparently not exceed 1.2 Mb/day. Slowing considerably compared to 2004, an exceptional year, the growth rate is expected to return to the same level as the average for the last two decades. Non-OECD countries, which account for 40% of world consumption, are

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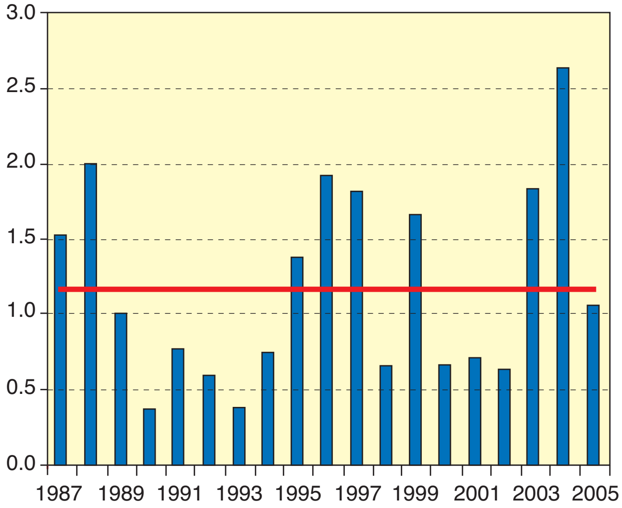
responsible for 75% of its growth (about 0.9 Mb/day). For the OECD zone, growth was more modest (0.3 Mb/day) and located mostly in North America.

Figure 2
Growth of World Oil Demand (in Mb/day)



Source: IEA.

In 2005, there were no particular events to generate major negative impacts on the market. This helped world oil demand return to normal, a trend consistent with the macroeconomic situation. In all likelihood, world economic growth should top 4%. Emerging countries are expected to grow by over 6% versus 2.5% for all of the industrial countries. Despite great disparities, especially among the so-called emerging countries, overall economic performance provides a satisfactory explanation for the trend in oil demand.

In a context of high international prices, the world oil market continued to grow steadily. This leads one to question whether demand is capable of responding to price signals. To put it schematically, the representative level of motor fuel taxation in OECD countries helped cushion the impact when the crude barrel price doubled (from $30 to $60); the price at the pump went up about 25 to 30%. The situation of consumers in emerging countries is less uniform; domestic price regimes vary considerably, depending on whether the country is a net exporter or importer. According to estimates, 25 to 30% of non-OECD oil consumption is covered by policies that subsidize the price paid by end users. In absolute terms, therefore, these prices are lower than international market prices. Furthermore, on a market like this, there is no parallel between retail price fluctuations and prices.

In fact, the resilience of world oil demand to high crude prices can be attributed to the fact that there are no replacement products available in the short term to replace petroleum products, especially in the transport sector. Another reason is that international price variations are not transmitted properly to domestic markets due to heavy, unproportional taxation in the more developed countries and to different degrees of subsidization in many emerging countries, including some producing countries. Motor fuel demand is responsible for nearly all growth in oil demand. We will come back to this later.

Non-OPEC Production: Striking Contrasts

For the first time, non-OPEC production is expected to average over 50 Mb/day. Yet performance remains low, with an increase of no more than 0.2 Mb/day. Only two years in the last decade (1998 and 1999) posted lower growth figures, but the economic situation at that time was completely different, with the price per barrel below $20. It's true that heavy infrastructure damage by hurricanes Rita and Katrina in the Gulf of Mexico played a part in reducing overall production volume by about 0.25 Mb/day (annual average). Nevertheless, this does not change the basic diagnosis: the rate at which non-OPEC production is growing has slowed substantially.

Since 2001, the bulk of production growth has occurred in the countries of the Former Soviet Union (FSU). 2005 is no exception: production is about to set a new record at over 11.60 Mb/day, or an increase of nearly 0.4 Mb/day, with Russia accounting for about 60%. In countries outside OPEC and the FSU, production was down by about 0.2 Mb/day. Even if the south of the United States had not been hit by a series of exceptionally violent hurricanes, the countries outside OPEC and the FSU would not have shown growth of more than 0.05 Mb/day, at best.

This stagnation arises from a situation presenting striking contrasts and distinct trends. First of all, this slowdown seems to confirm the decline of the North Sea, often announced only to be contradicted. For the third straight year, production has dropped by almost 0.3 Mb/day. The cumulative decrease since 2002 has already reached nearly 1 Mb/day, for current production of about 5.7 Mb/day. The United Kingdom is the country most affected by this trend. Norwegian production has condensate fields to compensate for the decline in oil production. Secondly, significant uptrends were observed in Latin America and Africa, driven by two leading offshore producers: Brazil (+0.2 Mb/day) and Angola (+0.26 Mb/day). Finally, a number of announcements were made in 2005 concerning projects to recover oil from the tar sands of Canada, but there has been no effect on production thus far.

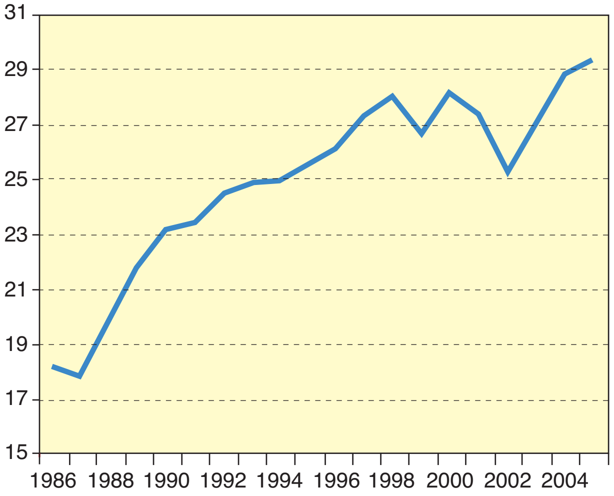
As regards the market equilibrium, 2005 brought confirmation of the situation that appeared in 2004. Although impressive offshore successes are compensating for the decline of mature regions, net growth is no longer sufficient to cover the increase in world demand, even at the moderate average rate noted for the last two decades and the past year.

OPEC

In the face of steep, rapid growth in market demand and the low short-term response capability of non-OPEC producers, OPEC was obliged to make several important decisions during the second half of 2004. It raised quotas by 3.5 Mb/day to 27 Mb/day at the beginning of 2005. The price per barrel stayed above $50, prompting the organization to fix the official production ceiling at its highest level ever: 28 Mb/day. OPEC did this in two steps. The first increase took place on March 15 at its 135th meeting in

Ispahan, and the second on June 15 at the 136th meeting in Vienna. OPEC's obvious determination to keep the market equilibrium and price trend under control rapidly came up against the ultimate barrier of production capacity, which relegated quota issues to the sidelines. Official production (excluding Iraq) came to 27.45 Mb/day. In recent months, OPEC members showed a level of quota compliance that, in the not-so-distant-past, would have constituted an impressive show of discipline, since the organization does not always present a united front. The fact that there was 100% compliance during the first ten months of year is misleading and gives cause for concern in two respects.

Figure 3
Total OPEC Prodution
(including Iraq, in Mb/day)

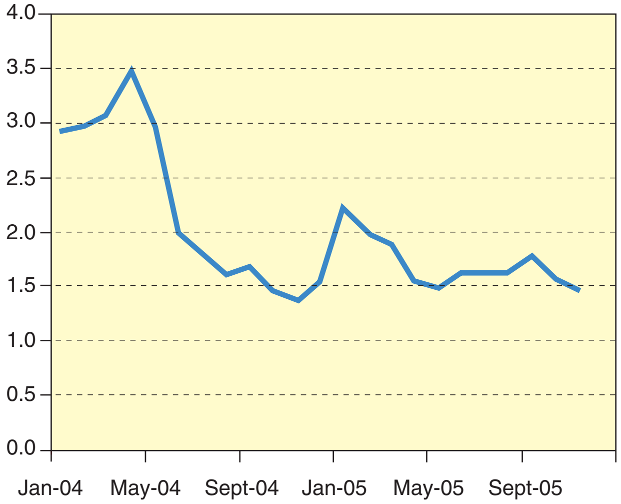


Source: IEA.

First of all, not all OPEC members could contribute to the production increase. Specifically, Venezuela, Indonesia and Iran could not implement OPEC policy or fully honor their assigned quota despite a very favorable business environment. Venezuelan production fell by an average of 0.07 Mb/day over 2004, apparently a consequence of the internal dispute at PDVSA at the end of 2002. The decrease in Indonesian output was on the same order of magnitude (0.02 Mb/day) but, although production did slow to some extent, it is following a decline curve that started about ten years ago. Iranian production merely stagnated, which limits the potential for crude exports, already under pressure from fast-growing domestic demand. Iraq, although still excluded from quota allocations, could not maintain the same level of production as in 2004 (1.86 Mb/day); output dropped by about 0.15 Mb/day. The second problem is that since the 1970s and until recently, OPEC production capacity (including Saudi capacity) had never been completely saturated, except under exceptional circumstances in 1990 and 1991 during the Gulf War. Suddenly, in the last fifteen months, it has found itself at full saturation. It is thought that surplus production capacity held by OPEC members, excluding Iraq, fell under 2 Mb/day at mid-year 2004 and stayed below this figure throughout 2005.

Under these conditions, there was no way that price-moderating signals emitted by OPEC could have the intended effect. At its 137th meeting on September 20, after heavy infrastructure damage had occurred in the Gulf of Mexico, the organization decided to pool residual production capacity, officially estimated to be 2 Mb/day, and make it available to the market for the last quarter of 2005. By doing so, it lent credence to market analysis whereby the tension is lasting and structural, justifying emergency measures. The relative slackening of prices in October (they fell by about $8) can be attributed much more to the fact that a part of the strategic reserves held by the members of the International Energy Agency was immediately mobilized and to the strong decrease — or what looked like a strong decrease — in domestic oil demand in the United States, than to the measures taken by OPEC on the supply side.

Figure 4
Surplus OPEC Capacity (not Including Iraq, in Mb/day)



Source: IEA.

Refining Capacity Still Saturated

The virtual disappearance of OPEC's surplus crude production capacity is not the only reason for the strong price increases that have occurred since early 2004. After two difficult decades and painful rationalization, the world refining industry is also seeing saturated capacity in the face of vigorous demand. In 2005, tensions not only failed to ease but became more acute. The estimated utilization rate is approaching 95% for distillation capacity and 100% for cracking and conversion capacity for the Atlantic Basin and Asia. Units are operating at close to their maximum load.

Tensions between refinery product supply and demand peaked after hurricanes Katrina and Rita swept the Gulf of Mexico in late August and late September. In the following days, lost refining capacity, mostly in Louisiana and Texas, totaled 4 Mb/day due to property damage and the interruption of the electric power supply. The situation gradually returned to normal: impaired capacity, which totaled 1.6 Mb/day in mid-October, will apparently remain in the neighborhood of 0.8 Mb/day until the beginning of 2006. This number is equivalent to 5% of total U.S. refining capacity.

The aggravation of tensions is illustrated by variations in OECD stocks, measured in the number of days of consumption covered. Although this indicator showed a slight improvement over 2003 and 2004, it hit a level (52 days, on average) that ranks among the lowest in the last 15 years. But the high level of prices cannot be explained by low stocks alone. First and foremost, these prices integrate present and future problems related to the evolution of production capacity.

The Outlook

It seems certain that price escalation, which began in 2003, was confirmed in 2004 and intensified in 2005, is not just a passing phenomenon but represents a break with the past, marking a shift in the market equilibrium. Forward barrel price quotes for deliveries in a few years' time have exceeded $50. This shows that, in the short run, spring forces cannot act as effectively as, up until recently, it was commonly thought they could.

Figure 5
Forward Price Quotations for WTI Crude Deliveries in 2010-2011 (NYMEX, $/b)

Source: NYMEX.

Structural Adjustments in the Face of Price Hikes

In the first place, the strength of oil demand reflects world economic growth (between 3 and 4%), reinforced by integrating major players like China and India in international trade. But the effect of the rise in per-capita income is amplified by the development of mobility requirements. A given income (expressed in constant money terms) will generate oil consumption in transport that has been estimated to be 50% higher than in the early 1970s. The need for mobility, for passengers and freight alike, is growing independently of the rise in income. Emerging countries outside the OECD, which already generate three-quarters of growth on the world oil market, account for most of the mobility requirements that will have to be satisfied in the future. Even if petroleum-based fuels have lost market share for stationary uses in industry and the residential/service sectors, demand for motor fuels should keep the oil market growing at least at the same pace as in the last two decades, i.e., 1 to 1.5 Mb/day (annual average).

International prices have been high for two years, but oil demand has not shown any significant reaction. There are several reasons for this: the lack of energy and technological replacement solutions in the short term and the exposure of most of the world population to a mode of development based on mobility, not to mention price and energy policies that are dictated by considerations other than economic or environmental considerations and which subsidize the price paid by the end user. With respect to the latter point, 2005 may mark a turning point and give rise to structural adjustments with a number of consequences. The cost of subsidization systems in some of the largest oil-consuming countries outside the OECD (e.g., India, Indonesia, Thailand and Egypt) has been multiplied by a factor of between two to five, depending on the instance. Countries that have retained this type of system must now choose between overloading the public budget or implementing a policy based on real prices whose postponement only makes it more painful for the population and more fraught with risk for the government when it is eventually implemented. In point of fact, in recent months, most net importing countries seem to be opting for the second alternative, implementing this type of policy at a rate that they deem feasible. This has led to some very large price increases, especially for motor fuels, sometimes of more than 50% compared to 2004. Some increases have already had a fast, visible impact in bringing down domestic consumption (e.g., in Thailand). The Chinese market is a special case that is more complex. For the least prosperous and largest component of the population, the regulation of retail prices — which are imposed on the local refining industry in China like in India — offers real protection, which is what subsidization programs are supposed to do. But vigorous development in the most dynamic provinces is generating industrial requirements and purchasing power such that price ceilings inhibit consumption; there are fewer deliveries on the domestic market, because they are not profitable. It is expected that the next prices increases will accelerate the growth of Chinese oil demand.

The structural adjustments made by emerging net importing countries, which are irreversible, could modify the rate of growth in demand. This would confirm one conclusion of empirical studies that oil price-demand elasticity, low in the short term, is much greater over the long term. Net exporting countries, with the notable exception of the United Arab Emirates and Nigeria, have maintained a policy of low, stable prices that shield consumers from international market variations. One consequence is that domestic demand rises in the short term at an artificial rate, to the detriment of export volumes. Furthermore, looking at a longer time frame, the cost of subsidies jeopardizes the financing needed to invest in production capacity.

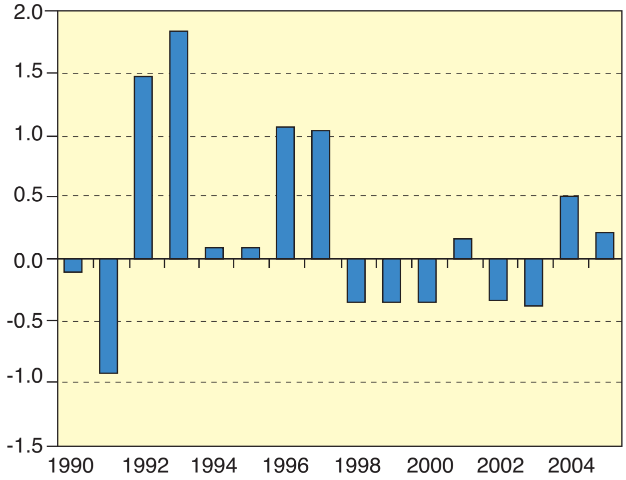
Contributions to the Development of Production Capacity

By 2008, new production capacity or major extensions will come onstream in the West African offshore sector (Angola, Nigeria and the Congo) and the Caspian Sea (Kazakhstan). These are substantial contributions: 500 kb/day for Kizomba B and C, 295 kb/day for Dalia, Rosa and Lirio, 800 kb/day for Azeri-Chirag-Gunashli, 450 kb/day for Tengiz and 370 kb/day for Kashagan. However, these large-scale developments, scheduled to come onstream in the near future, do not change the diagnosis: non-OPEC production has slowed considerably, which is why the tie between the barrel price, E&P investments and how they translate into terms of production growth, is weaker than it used to be. That Canada's tar sands have bright prospects has been confirmed, but the advantage of the abundance of the resources in place is offset by constraints that must be taken into account: the cost of the gas supply, the burden on water resources and the low availability of qualified labor. Finally, refinery products (diesel fuel for the most part) from gas-to-liquids facilities in Qatar and Nigeria should reach the market by 2009 (200 kb/day). The use of non-conventional resources is increasing but more slowly than world demand.

This being so, the only solution is for OPEC countries to boost production capacity. Projects currently under development are expected to translate into net growth of crude production capacity on the order of 2.5 Mb/day within the next three years. However, this estimate needs to be confirmed, because it contrasts sharply with the small scale of capacity variations in recent years, outside Saudi Arabia and Iraq. The steady rise in condensate production, which is not included in the quota system, is still making a non-negligible annual contribution of about 0.3 to 0.4 Mb/day. Beyond its announcements and intentions, OPEC is facing some very tough questions: What policy should it implement and what should the target price be? At its 135th meeting on March 15 in Ispahan, the organization suspended the target price range of $22-28 that it had established in March 2000, which offers an initial indication. Now that the reference price range has become obsolete, the low price-demand elasticity on the world oil market and the non-OPEC supply situation militate, for the time being, in favor of a much higher target price that should be defended, if need be. In the longer term, the development of production capacity in the upstream sector, in conventional refining and in heavy crude prerefining projects cannot be disassociated from the financing capacity of the State-owned companies. Since 2003, producing states have seen an unprecedented improvement in their macroeconomic situation, owing to crude price hikes and record production figures. This should shed new light on the recurring question regarding the necessity of opening up oil and gas acreage to international investors.

Considering the persistence of great tensions between production capacity and demand, growing uncertainty on many fronts, and the fact that short- and long-term issues are inextricably linked, we conclude that the oil market is and will remain extremely vulnerable. The recent mobilization of strategic reserves to cope with upset conditions on the market of a major importing country, the United States, and not an exporting country, is symptomatic. Major consuming countries, developed and emerging alike, must make their contribution to the search for sustainable balance on the oil market.

Figure 6
Variations in OPEC Capacity Outside Saudi Arabia and Iraq (in Mb/day)



Source: IEA - IFP.

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

The Environmentalists Struggle with Energy Security Or: If Maslow Were in Energy Politics

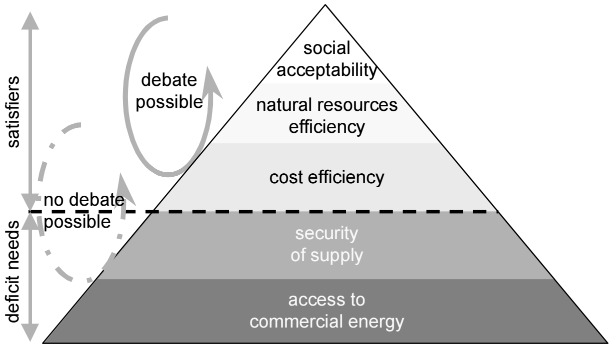
By Christoph W. Frei*

Abstract

History suggests that energy policy priorities can be stratified similarly to the way Maslow structured his famous pyramid of human needs. The essay below claims that access to energy, supply security, energy costs, environmental issues and social acceptance are not subject to trade-off, but to a hierarchy that underlies the importance of satisfying lower order needs before addressing the higher order ones. The following essay demonstrates the hierarchy with an "energy policy needs pyramid" based on historical evidence. The pyramid is used to analyse the viability of current items of the energy policy agenda. Conclusions indicate that the public understanding of the critical aspects regarding energy security is the foundation on which a robust and balanced energy policy can be built; that progress with respect to the mitigation of greenhouse gas emissions may be hampered by supply insecurity; that environmentalists should opt for a large international Energy Forum to control energy prices and facilitate the necessary investments, invest in R&D that would focus on simple energy solutions and systems rather than on sophisticated high-tech, promote trade rather than local production of biofuels and make the fight against energy poverty their first priority in order to achieve their overall goals.

"A person who is lacking food, safety, love and esteem would most probably hunger for food more strongly than for anything else," stated the American psychologist Abraham Maslow in 1943 while formulating a theory to explain the motivational structure of a healthy person. He distinguished different groups of needs and defined the hierarchy now known as Maslow's Pyramid. Could there be a model similar to Maslow's Pyramid stratifying different groups of needs and explaining the motivations that determine a country's decisions regarding energy policy dilemmas? Countries have been struggling for decades with setting priorities and continue to do so when confronted with dilemmas in the supply of energy to their people and economy. Is supply security the top priority? What determines the trade-off between evils: nuclear waste versus greenhouse gas emissions versus high costs of renewables? The mixture of spices is very much a creative approach – no recognized concept exists that helps getting priorities right. Surely, a country that lacks access to commercial energy, a secure energy supply, societal and international recognition for complying with environmental standards, would prioritize access to commercial energy before everything else.

The "Energy Policy Needs Pyramid"



Historical observation of national energy policies shows that once access to commercial energy is obtained, the first priority is supply security, followed by cost efficiency. At the end of the 1970s, industrialized countries began to consider natural resources efficiency (keyword: internalization of external costs) and then (in industrialized countries since the late 1980s) by social acceptability. The last three aspects – cost, natural resource efficiency and social acceptability – explicitly reflect the pillars of sustainable development that aimed at balancing, rather than stratifying, the efforts made on each of the relevant aspects. But, to what extent does political viability leave room for trade-offs or for balancing needs?

In Maslow's Pyramid, the hierarchy illustrates that only once the lower order needs of physical and emotional well-being are satisfied do we concern ourselves with the higher order needs of influence and personal development. Conversely, if the aspects that satisfy our lower order needs disappear, we are no longer concerned about the maintenance of our higher order needs. Can we observe similar patterns in historically observed energy policy priorities?

It seems obvious that the question of supply security only matters to people who already have access to commercial energy. Regarding the next higher level, the U.S. experience shows that supply security prevails over cost-efficiency, environmental and social issues. This is illustrated by the fact that concerns about decreasing supply security traditionally have won out over environmental issues, such as climate change and Alaskan wilderness preservation. Similarly, biofuels, which could be imported at half the cost from Brazil, are heavily subsidized if domestically produced. Such domestic production is not only more expensive, but also less environmentally sound than the Brazilian: sugar cane, the standard Brazilian crop, is still the most energy efficient feedstock for producing bioethanol and far better than the crops used in the U.S. As another example, the increased questioning of elec-

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*Christoph W. Frei is Director, Energy Industry & Strategy, World Economic Forum. This paper is based on concepts that have been published under: Christoph W. Frei, The Kyoto protocol—a victim of supply security? Energy Policy, Vol. 32, Issue 11, July 2004, pp. 1253-1256, Elsevier, ISSN: 0301-4215 and Christoph W. Frei, Bottomline Decisions, Concerns about reliable supply will always trump the call for cleaner energy, Newsweek International, Sept. 6-13 issue, 2004, p. 83 (http://msnbc.msn.com/id/5852177/site/newsweek/) See footnotes at end of article.

tricity market liberalization (the promise of cost efficiency in energy supply) that followed the 2003 summer of blackouts again indicated that supply security took precedence over the low cost energy issue. A similar conclusion can be derived from the observation that China has set up for its automotive industry stringent and cost-intensive constraints regarding the per mileage consumption (as of 2005). The driver behind this is energy security (more than environmental) concerns in the context of a rapidly growing mobility market and a just as rapidly growing foreign energy (oil) dependency. Again, supply security ranks over (here: mobility) costs. A number of economists promote internalization of external costs (i.e., the idea that the polluter pays for his pollution), adopting the viewpoint that this would be economically efficient, while other economists promote market liberalization for precisely the same reason. Reality shows that only the latter is on most national policy agendas. This suggests that low cost issues prevail over economically justifiable environmental concerns. Likewise, President Putin illustrated this point with his statement (10/03) that the domestic fight against poverty was more urgent than the ratification of the Kyoto Protocol (while at the same time liberalizing the electricity industry). It is further interesting to analyze the attitude of Germany during the natural gas crisis between Ukraine and Russia, January 01-04, 2006. Ukraine's right to national self-determination is an important (socio-political) issue for the Europeans, but it ranks substantially below their own energy (-security) interests. When Gazprom stopped delivery to Ukraine and the Ukrainians siphoned natural gas bound for Europe, Moscow was betting that the Europeans – and particularly the Germans – would rapidly drop support for the Ukrainians. Mrs. Merkel kept a very low profile and made it clear that Germany's first interest is energy security. Finally, the nuclear waste problem or the esthetics of wind farms are debated much more in industrialized countries where the lower order needs are satisfied. Social acceptance and environmental issues are often closely related which indicates that the hierarchy among the top two issues is not very strong.

Besides confirming the historically grown "energy policy needs hierarchy", the previous set of examples suggests that balancing priorities may be politically feasible only to a limited extent and only among the higher order needs.

This simple model can describe the motivational structure determining a nation's policy that is concerned with supplying energy to its economy and people. The pyramid is based on observations and is, therefore, of a purely descriptive nature and it would be wrong to interpret it as a normative hierarchy. In other words, the statement that, for example, supply security issues would prevail over ecological concerns is based purely on observation – by no means does the pyramid morally justify this hierarchy. Further, by drawing a simple picture, we did not consider the nexus with other policy domains – constraints from security policy, finance policy, health policy, etc., which can have an important impact on energy policy, both on a national and international level. As an example, decisions related to "security of demand" in oil and gas exporting countries are driven by budget policy and are not necessarily part of the nation's policy that is concerned with supplying energy to its economy and people – but they clearly affect energy geopolitics and thereby the supply security of other countries.

That said, the pyramid reflects a certain reality. By learning from it we might avoid chasing illusions, desirable as they might be. Like a pianist, dreaming of Rachmaninov's third piano concerto – choosing to play one of his preludes instead, being realistic about the limits of his technique and finger ability, does not keep him from dreaming and slowly getting closer to his dream but prevents him from being frustrated from having spent his talent and time on a failed attempt that aimed a level too high.

So let us now extrapolate and behave as if the pyramid was to determine future energy policy priorities.

Using the Pyramid as a Crystal Ball

First of all, the pyramid tells us that understanding the supply security issue is crucial. We intentionally use the narrow term of supply security rather than the wider term of energy security. The former reflects a traditional focus on supply of crude oil and natural gas while the latter is broader and includes issues such as electricity blackouts, inadequacy of refining capacity, etc. We argue that after the 1973/79 oil shocks the former is anchored in people's minds as a powerful fear factor and that energy security is often reduced to supply security. We should bear in mind that security perception is based not only on facts but is, to a certain extent, a social phenomenon. This means that unless there is a clear public understanding and agreement on appropriate level of energy security, lobbies that may be questioned by higher order needs will use the "fear-tactic". In other words, they will insist that the existing level of supply security is inadequate, thereby sharpening the focus on pure supply/demand issues. This is simple and has demonstrated populist impact. Thus, the public understanding of the critical aspects regarding energy security is the foundation on which a robust and balanced energy policy can be built.

Mitigation of greenhouse gas emissions – hampered by supply insecurity? As long as supply security is a dominant issue for the international energy policy scene, the attempt to reach international agreements regarding higher order needs is seriously questioned. The Kyoto Protocol has until the late nineties been associated with an environmental agenda with a correspondingly low priority on the political agenda. This perception clearly has changed, not only in countries with clear exposure to flooding (such as, e.g., the Netherlands) and not only after the hurricanes Katrina and Rita in 2005. The issue is now much more associated with economic and even with (national) security agendas, which brings it to a "competitive" priority level with energy security. The recent priorities of the G8 agenda underline this point: While G8 leaders in 2005 and under Prime Minister Blair's leadership focused on climate change, they will, in 2006 and under President Putin's leadership address energy security. Clearly, an "environmental" issue can make it to the commanding heights, but only once it is perceived to be a security issue. However, we also observe that energy security pushed climate change off the 2006 G8 agenda. Does this mean that the fear-tactic is being practiced again?

"Poor people desperately want energy, electricity particularly," commented Barbara Stocking, Executive Director, Oxfam GB (01/02). Today, around 1.6 billion people, or one-quarter of the world's population do not have access to electricity. This energy divide has many faces. The standard of living improves with access to commercial energy; electricity makes it possible to cool medical drugs or to pump water. According to the World Energy Investment Outlook published in 2003 by the International Energy Agency the cost of providing electricity access by 2030 to the then estimated 1.4 billion people without access is estimated at US$ 665 billion (compared to US$ 9,841 billion needed for overall electricity investments on a worldwide level over the same time period). According to the same source, total CO_2 emissions would increase by as little as 1.4%-1.6%. – Would you ask your co-citizen who has not enough to secure a meal and a bed to spend his time and money for fire brigade contributions? No doubt, there may be a fire and there is a common interest in having a fire brigade. Is your conclusion that society should pay for such a service while the worse-off should be exempted from any payment? What about the case where the potential fire is called climate change and co-citizens are co-nations, some of which with a majority of the people still without access to commercial energy? As long as countries have not secured a certain level of electricity supply at a reasonable cost they will not commit (intrinsically motivated) to an environmental agenda (although they may do it based on external pressure). Conversely, if coal is locally available and cheap, that is what will be used – full stop. Indira Gandhi captured this situation eloquently, referring to poverty as the ultimate pollutant (Stockholm, 1972). The pyramid would suggest that fighting energy poverty should rank top on the world's energy agenda before international agreements on higher order energy needs can be achieved. Should this make the fight against energy poverty an environmentalist's first priority?

Is OPEC good for the environment? We all know the rationale that OPEC helps preserving scarce resources by maintaining high prices – here we follow another track to find a similar conclusion. We could observe that OPEC has, during the Gulf crisis in 1990/91, during the Venezuela strike in 2002/03 and even in the beginning of the war in Iraq in 2003, contributed to maintain supply and demand balanced at a surprisingly stable price – OPEC has thereby acted as an important contributor to energy-geopolitical supply security. Even though this role seems to go beyond OPEC's capabilities since late 2003, when Chinese growth combined with continued instabilities in Iraq, Venezuela and Nigeria have driven oil prices close to historical heights, we can make the following observation. The cartel has managed to moderate the price spikes for some time (at the cost of increasing the average price). Such stability in turn made it possible for individual countries to continue to address higher order needs. The pyramid would suggest that this makes OPEC a facilitator of potential environmental policy measures in the countries that benefit from the improved supply security (at least as long as long-term investments are ensured even though the lack of clear price signals may keep markets from an appropriate anticipation). If we carry the same rationale a bit further we find that a shift to a cartel free, gas prevailed energy picture may question today's level of environmental policy. Should an environmentalist rather opt for a large international Energy Forum to control energy prices and facilitate the necessary investments? Clearly, this Forum would need to be more inclusive than the International Energy Agency (IEA) or the Organization of the Petroleum Exporting Countries (OPEC).

Should we learn to love expensive energy? This scenario certainly increases efforts towards energy efficiency and savings and is, as such, every environmentalist's hope. If we follow the logic that there is some elasticity between energy and capital, the scenario also encourages capital-intensive – high-tech? – solutions. Following the logic of the pyramid, social acceptance then loses its weight in the policy agenda, helping controversial technologies such as nuclear power or carbon sequestration to find their way (back) in the energy mix. As a further consequence, the high capital cost of advanced technologies would be likely to increase the divide between energy-poor and energy-rich countries, making the task of bridging the energy divide even more challenging. Should the quoted environmentalist in such a situation invest in R&D that would focus on simple energy solutions and systems rather than on sophisticated high-tech? The former can be locally produced and implemented also in energy-poor countries, based on locally available (or achievable, as, e.g., demonstrated by the Barefoot Solar Engineers electrifying rural villages in India) qualifications.

Does the pyramid advocate for the hydrogen economy? The hydrogen economy is a popular vision for the energy future. However, we are still decades away from the realization of this dream in which hydrogen as a secondary energy carrier used to fuel mobility would complement electricity for stationary uses. It typically takes 30-50 years before a technical breakthrough has economic viability. The development and maturing of the appropriate technology, the construction (and financing) of the needed fuel distribution infrastructure, and the required car park replacement time (of about 20 years) determine the time horizon for the introduction of such new technology. Last but not least, the question of the origin of the hydrogen itself needs a sustainable answer. Producing hydrogen from fossil energy would certainly solve neither the climate change problem nor the resource issues. This said, if hydrogen (or another secondary energy carrier) can be produced, stored and transported in large quantities from worldwide well-distributed resources (be it coal, nuclear, or renewable energy) the energy-geopolitical risk exposure could be significantly reduced compared to today. Today's known oil and natural gas reserves are geographically very much concentrated to a few (to a large extent considered "unstable") regions. OPEC controls 40% of production, 60% of exports and 80% of reserves. Non-OPEC oil supplies are expected to plateau by 2010 while the cartel's ample reserves will allow its production to gain a world market share of over 50% by 2030, according to IEA's 2002 World Energy Outlook. The concentration of oil reserves in a small number of countries leaves increasingly less room for origin diversification. This, combined with elements such as geopolitical turmoil in the Middle East or unpredictable state interventions in the energy business as observed in Russia or Venezuela, increases concerns with respect to energy security. Even if expensive, the potential of increasing supply security could, as we are told by our pyramid, be an accelerating advocate for this vision – unless there are better alternatives.

What about the biofuel economy? Biofuels in many ways represent the same advantages as hydrogen. They have the potential to be climate and environmentally friendly as long as produced with best practices (i.e., sustained plantation without initial deforestation, energy efficient production based on sugar cane, etc.). With no or few changes in infrastructure and engine technology, bioethanol or biodiesel can directly substitute for parts of the fossil fuel demand: Bioethanol can be mixed up to 25 percent with conventional gasoline and used by existing engines; biodiesel can substitute diesel up to 30 percent; slightly modified flex-fuel vehicles can take 100 percent bioethanol. Geopolitically, these fuels could come from countries that are not traditional oil exporters (e.g., Brazil, Ukraine, Indonesia, India) and could thereby potentially contribute to the diversification effort. Production costs in some of these countries are several times lower than in industrialized nations and reach the competitive levels of international oil prices. This all sounds great, but why are they not more widely used and traded then? Clearly, competition with food agriculture and sustainable production schemes are potentially problematic. However, these cannot be the true obstacles, as they can be addressed, for example by a labeling approach similar as used with bio-food, wood (Forest Stewardship Council), fish (Marine Stewardship Council), etc. The true obstacles that have prevented the wide introduction and trade of biofuels are agricultural trade barriers, quota systems, state-controlled import monopolies and fuel legislation. As specific examples, the 2005 energy bill in the U.S. fosters biofuel and continues to highly subsidise the domestic production while the EU simply limits the bioethanol share in gasoline to 5%. The agricultural lobby in the countries are strong and they manage to make out of it an existential question – in other words, a question that is in competition with the very bottom of our pyramid! Would it help to overcome this deadlock if the environmentalist would take unconventional stands and promote trade rather than local production of biofuels?

Like many theories, Maslow's hasn't endured the test of time – it failed to explain the existence of poets. Poets would probably not exist if their first preoccupation was lower order needs such as the health of their bank balances. Yet, poets are a minority. They are just as much of a minority as countries that give equal priority to environmental concerns and supply security issues. We may challenge our priorities and values – and thereby the pyramids – with new visions; and then, perhaps, there will be more poets. We may however decide to focus on projects that are aligned with how today's world functions and, therefore, are feasible in the short-term; and then, hopefully, we will secure our energy future more sustainable.

Footnotes

[1] Maslow, Abraham Harold, A Theory of Human Motivation, 1943, Psychological Review, 50, 370-396.

[2] Here we use a definition whereby commercial energy includes, besides electricity, energy products such as candles or lamp-kerosene. Consequently, where other energy products are available to substitute electricity there is no access-void and substitution becomes an efficiency issue. Only for purposes where electricity cannot be substituted (e.g., in a hospital) it becomes an access issue (that may be solved by diesel generators if diesel is commercially available). Based on this definition it follows that supply security cannot be understood as a measure that is independent of a given energy-system: if the given system heavily relies on grid-distributed electricity (from diverse sources), supply security does as well. If the system relies on lamp-kerosene and decentral diesel generators, it is the availability of these energy products that determine the level of supply security.

[3] See e.g. The Future of Energy Policy, Timothy E. Wirth, C. Boyden Gray, John D. Podesta, Foreign Affairs, July/August 2003, Vol 82, Nr 4, p. 134: "Reducing this exposure [i.e., U.S. dependence on foreign oil] […] must be a primary goal of national energy policy."

[4] One could argue that Italy is an exception to the above-outlined rule – a country where the factual abandon of nuclear energy in 1987 without an appropriate replacement has lead to a situation where the security of today's electricity supply is questioned as the 2003 blackout has confirmed. Still, the decision of stopping nuclear energy may have been taken by the deciders (the people) without the full awareness and understanding of the problem of supply security and its consequences. It will be interesting to observe what Italians will do in reaction to the recent blackout.

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Evidence on Risk Preferences in E&P Operations: Examining the Decision to Evacuate

By Christopher J. Jablonowski*

Introduction

Decisions to evacuate offshore oil and gas facilities in the path of hurricanes occur frequently in the Gulf of Mexico and are costly. There has been little empirical research on the variables that drive these decisions and the role of risk preferences in this decision-making context. This article summarizes some preliminary research on this high stakes decision. Econometric models provide support for the conclusion that location attributes, specifically water depth, increase the propensity to evacuate. There is also support for the conclusion that oil company experience increases the propensity to evacuate, that is, experience leads to caution. Initial results of a utility-based model suggest a high degree of risk aversion.

Offshore Drilling Operations Overview

In the Gulf of Mexico, oil companies lease oil and gas exploration and production rights from the U.S. government. Once a lease is acquired, the oil company drills exploration wells based on seismic data and geophysical and geological analysis. If economic quantities of hydrocarbons are discovered, the lease is developed with additional production wells. Exploration and development drilling operations occur either on mobile offshore drilling units (MODUs) or directly on the production platform with a modular rig (platform rig) that is installed on the platform. Oil companies engage the services of a drilling contractor who owns the drilling rig and employs and manages the drilling crew. Other subcontractors are typically coordinated by the oil company, and come to the drilling location as needed to perform specialty services. The number of people on board the rig on any day varies between drilling rig types, drilling contractors, oil companies, and is a function of current operations on the rig. Based on interviews with practitioners, an average of 55 persons on board is assumed for this analysis. While evacuation decisions are made for both production facilities and drilling units, it is the *drilling operations* that are the focus of this study.

Weather and Evacuation Criteria

When severe weather such as a hurricane threatens drilling operations, both the drilling contractor and the oil company make decisions regarding the immediate progress of the well, and whether or not to evacuate the drilling rig. Securing the well and rig equipment reduces the probability of drilling mud or oil spills and equipment damage. Evacuating the drilling rig of personnel eliminates the possibility of loss of life. In most oil company ethical and operating guidelines, it is stated that protection of workers is paramount. That is, the burden is clearly put on decision-makers to avert personal injuries and deaths. In addition to compelling ethical arguments, there exists a potential for direct economic consequences. Most drilling rigs are rated to withstand ~100 knot winds in a worst-case configuration (maximum variable load in the derrick). If winds exceed the rating, it is possible for the rig to be severely damaged or lost entirely. In fact, an average of one percent of the Gulf of Mexico drilling fleet is lost per year due to hurricanes.[1] Any personnel remaining on board during a hurricane would be subject to this catastrophic risk and the oil company would likely incur a large financial loss if all or part of the crew were lost due to a non evacuation.[2]

During the hurricane season, which typically spans June through October, decision-makers pay increased attention to weather developments. Drilling rig managers are normally equipped with sufficient technology to track hurricanes and to gather public forecast information at their drilling locations. Some oil companies also retain private forecasters to develop additional storm development scenarios or customized forecasts. Prudent operators are always aware of the time required to safely secure the well and equipment and to evacuate the rig, which may take days. This time requirement, or safe evacuation time (SET), is a function of the type of drilling rig, its location, features and progress of the well, and perhaps attributes of the decision-makers. The fact that the SET is positive forces an evacuation decision to be made before hurricane conditions would be present at the drilling location. The SET is continually updated based on drilling progress.

When the rig is operating under a hurricane threat, weather becomes a critical component of the daily management routine. Current position coordinates, wind speed and pressure at the eye of the hurricane are available from the National Hurricane Center (NHC) every six hours. This raw data is valuable to decision-makers, as it allows them to plot the track and speed of the storm, and thus to estimate the distance of the hurricane (in time) to the drilling rig. The NHC also generates 12, 24, 36, 48, and 72 hour forecasts. Decision-makers evaluate the raw data and the forecasts along with the SET to inform their optimization of drilling operations and their evacuation decisions. The drilling contractor and the oil company managers work together to optimize rig operations under the weather constraint, and to structure operations to minimize the SET (e.g., maintaining a minimum of drill pipe in the derrick, partial evacuation of non-essential personnel). Longer duration operations are unlikely to be initiated. It is common for managers to meet several times per day to discuss the progress of the storm, drilling operations, and evacuation contingencies. It is a very complex and dynamic process.

Econometric Model of the Decision to Evacuate

The decision to evacuate for a particular hurricane is appropriately modeled as a discrete choice. Either the crew is

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See footnotes at end of text.

released from the rig, or it stays on location and rides out the hurricane. In summary, an unobservable latent variable is defined, $Y_{it}*$, as the propensity to evacuate as follows:

$$Y_{it}* = X_{it}\beta + u_{it} \qquad (1)$$

where, X_{it} = Vector of independent variables, β = Vector of parameters to be estimated, and u_{it} = Random error term, $\sim N(0,\sigma^2)$. The subscript i represents the individual rig, and the subscript t represents the time index for the storm. The first observation is made when the hurricane (or tropical storm) enters the observation area,[3] and the last observation is made once the storm has made landfall (the typical end of life for most hurricanes) or once a particular rig has made a decision to evacuate. Y_{it}^* is not observed, but Y_{it} is according to the rule:

$$Y_{it} = 1 \text{ if } Y_{it}* > 0 \text{ (evacuate), 0 otherwise (not evacuate). } (2)$$

Development of a qualitative response model such as probit or logit is straightforward, and a probit model is employed here.

The ideal specification of Equations. (1) and (2) would include observations every six hours (the frequency of new forecast and actual hurricane information) for each rig over the life of the hurricane, or until a decision to evacuate was made, at which point observations for that particular rig would cease. Such a specification would allow a model of decision-makers' response to subtle changes in the forecasts and changes in raw hurricane position and strength. One would be modeling both the discrete decision to evacuate and the timing of that decision. There is a fundamental hurdle to such an analysis because the observations of the *decision* to evacuate (or not) are not precise. The evacuation observations are taken from drilling records that contain simple depth versus days plots that are loosely annotated with drilling information and other pieces of information regarding the overall progress of the well. Because of this, there is imprecise accounting of the timing of the decision to evacuate, although the start and overall duration of the evacuation is discernable. Given the quality of the data currently available on evacuations, a relaxed specification is proposed that models the discrete choice to evacuate, but does not incorporate the exact timing of the decision (deletion of time indexing).[4] As a result, it is not possible to obtain any information on which weather or forecast variables ultimately elicit the evacuation decision. For example, it will not be possible to comment on whether decision-makers are responding to 24 or 48-hour forecasts.

Independent Variables and the Data Set

Having described the decision-making process and base model, it is now appropriate to discuss the independent variables that belong in a model of evacuation decision-making.

Location and Well Attributes. It is reasonable to suspect that features of the well being drilled influence the decision to evacuate. Decision-makers on floating deepwater rigs are forced to make their evacuation decision earlier and under higher uncertainty than their counterparts on jackup or platform rigs due to a higher SET. A water depth variable, **WD400**, can be defined to represent this dichotomy. A binary variable is defined that takes on a value of one when the water depth exceeds 400 feet (a proxy for the floating rig threshold). Based on this definition, the sign expectation for this coefficient is positive. Similarly, other well attributes such as well depth in feet, **DEPTH**, and whether or not a well is being drilled over a production platform may also affect the lead time required to secure the well. The deeper a well, the longer it takes to condition the drilling mud and hole, trip drill pipe, set cement plugs, and temporarily abandon the well. Therefore, the sign expectation on the DEPTH coefficient is positive. When a well is being drilled over an existing production platform, operational complexity increases. Securing the joint work site for a hurricane may require more time and precautions, and, therefore, more lead time. Development wells are typically drilled over existing production platforms while exploration wells are drilled in open water. A binary variable, **EVD**, is constructed that takes on a value of one for exploration wells and zero for development wells. Based on these hypotheses, the expectation for the sign of this coefficient is negative. Another interpretation for EVD is independent of the time required to evacuate. Since a production well is typically drilled over a platform, there is the opportunity for rig/platform interaction during a storm. Damage that may otherwise be uneventful when the rig or platform is isolated may be catastrophic when the structures are so close together, or even connected. For example, if the drilling rig's derrick were to collapse, it may fall on the production platform, increasing the damage and risk to the crew. A decision-maker may be more likely to evacuate in such circumstances.

Evacuation Costs. When evacuation costs are high, the likelihood of evacuation is decreased, *ceteris paribus*. For each storm and rig type, one can estimate the evacuation cost, **COST** = rig rate*evacuation duration.[6] This value varies between rig types and over the years as rig rates change. The expectation for the sign of this coefficient is negative.

Decision-Maker Attributes. It is possible that evacuation criteria vary among oil companies. Some decision-makers may be more conservative than others and hence more likely to evacuate under identical circumstances. But what attributes lead to different evacuation criteria? One attribute that may affect the decision to evacuate is the decision-maker's offshore experience. More experienced operators who have made many such decisions may be more (less) likely to evacuate based on the accumulation of their experience making such decisions and living with the related outcomes. A variable **OPCUM** is defined that represents the cumulative number of wells drilled by the particular oil company as of the year prior to the evacuation decision. There is no hypothesis regarding the sign of this coefficient. That is, it is not clear whether experience should lead to caution, or confidence. A second hypothesis is to expect larger, well known companies that possess valuable brand names and accumulated goodwill to value evacuations differently. Such companies have more to lose in the case of a human catastrophe, and these losses would negatively impact the value of the brand name and goodwill. To model this hypothesis, a variable **RET** is defined that takes on a value of 1 if the oil company possesses retail gasoline sales, and zero otherwise. The expectation is that the sign of the coefficient will be positive.[7]

Six storms were evaluated in this preliminary study. Correlation coefficients and basic descriptive statistics are available from the author. The sample is defined by storms where both evacuations and non-evacuations were observed. The sample used in this analysis includes the following named storms (year/#observations): Alicia (1983/13), Barry (1983/12), Chantal (1989/16), Elena (1985/13), Flo (1988/14), and Juan (1985/17).

Estimation of the Probit Model

A probit model for Equations. (1) and (2) is specified and estimated employing five of the six explanatory variables defined above and fixed effects for the individual storms. The COST variable is omitted due its high correlation (ρ = 0.93) with WD400. This specification appears appropriate for this specific sample given that two of the storms (Alicia and Barry) exhibit more balanced proportions of evacuations and non-evacuations than the other storms which exhibited a high proportion of evacuations which may be a result of the particular storm histories. Also, the results from a fixed effect model are significantly more robust than pooled estimates (not reported here). Since the error terms are i.i.d., the discrete nature of the dependent variable does not introduce any unusual estimation issues.[8] Results are presented in Table I.

Table I. Probit Model of Evacuation with Fixed Storm Effects

Variable	Coefficient Estimates (t-stats)	
ALICIA	-0.0533	(-.076)
BARRY	-0.2666	(-.381)
CHANTAL	1.5172	(2.145)
ELENA	1.1850	(1.526)
FLO	1.1050	(1.435)
JUAN	1.6382	(2.123)
RET	-0.2526	(-.550)
OPCUM	0.5148	(1.662)
DEPTH	-0.1613	(-.536)
WD400	0.5736	(1.397)
EVD	-0.5471	(-1.080)
LR (p-value)	21.7572	(0.016)
Log Likelihood	-38.7471	
LR Index	0.2192	
# Observations (Pos)	85 (62)	

The coefficient for WD400 is weakly significant and its sign is as expected. When in deep water, decision-makers are more likely to evacuate, likely due to the increased time to secure the well and rig, and the need to make an evacuation decision under greater uncertainty. Decision-makers on shallow water locations can defer their decision (relatively), and will, on average, evacuate less often. Recall that the expectation for the sign of the COST coefficient is negative, i.e., the higher the cost of evacuating the less likely to evacuate. Given that WD400 and COST are highly correlated (positively), one can conclude that COST does not appear to play a significant role in the decision to evacuate. This result is likely a manifestation of the scale of the costs and losses. Whatever the decision-making process is, the fact that the expected loss is orders of magnitude larger than the evacuation costs tends to mask the influence of slight variations in the cost.[9] The results suggest that whether or not the oil company has retail gasoline sales (valuable brand name)is not a significant factor in decision-making. Recall that if RET is construed as a proxy for risk preferences (see footnote 9), this result on RET could be due to a balancing of opposing forces on the decision-maker. OPCUM is significant at the 10 percent level, implying that experience leads to caution. Such a result may be due to bad experiences in the past that led to human and financial losses, and perhaps corporate policies that subsequently err on the cautious side. Although not statistically significant, the sign on EVD is negative as anticipated, providing some support for the idea that exploration wells are less likely to evacuate than development wells.

The differential evacuation rates between storms is observable in the scale and significance of the fixed effects. Alicia formed over the drilling area and quickly strengthened and evacuations may not have been possible in some cases. Barry was a weak storm that skirted the bottom of the Drilling Area, convincing some decision-makers to continue drilling operations. Chantal, Juan, and Flo display similar storm histories to each other, so it is no surprise they yield similar fixed effects and significance. Elena was a strong storm that veered just East of the Drilling Area. This type of storm path is generally identified by high evacuation rates (for Elena evacuation rate was 87 percent).

Risk Aversion, Utility, and the Decision to Evacuate

A test for the existence of risk aversion is possible via a richer specification of the model of the decision to evacuate that incorporates a utility function. A structural model of decision-making in a utility framework is developed along the lines of Cicchetti and Dubin (1994). A general form of utility function is defined, $U(W; s, e)$, where s represents attributes of the decision-maker, and e is a random component of utility. If one assumes additively separable errors, the utility function can be written as $U(W; s) + e$. Under the assumption of utility maximization, the decision-maker would evacuate when:

$$U(W-C;s)+e_1>(p)U(W-L;s)+(1-p)U(W;s)+e_2$$

where, W = Measure of wealth, C = Evacuation cost, p = Probability of a hit, and L = Expected loss given a hit. Finally, if one assumes that the e_i are independent and extreme value distributed (McFadden, 1974; Maddala, 1983), the probability of observing an evacuation is:

$$\Pr(evacuation) = 1/(1+e^{-\theta}), \qquad (3)$$

where

$$\theta = U(W-C;s) - [(p)U(W-L;s) + (1-p)U(W;s)].$$

There is no theoretical foundation to inform the specification of a utility function for offshore oil and gas decision-makers. Therefore, a flexible form from the family of hyperbolic absolute risk aversion functions (HARA) of the following form is specified:

$$U(W;s) = a_1(W+a_2)^k + e. \qquad (4)$$

A detailed discussion of the mathematical properties of this family of utility functions is available in Merton (1971). Given this utility function, utilities for each state are as follows:

Evacuate: $a_1(W\text{-}C+a_2)^k + e_1$ (5)
Do Not Evacuate: $(p)a_1(W\text{-}L+a_2)^k + (1\text{-}p)a_1(W+a_2)^k + e_2$.(6)

The exponent k is intended to capture differences in risk aversion across decision-makers and physical locations, and is a function of the variables previously defined in the discrete choice evacuation model. There are several ways to specify k here. Based on the results of the probit, k is specified as follows:

$$k = b_2 WD400 + b_3 OPCUM + c_1 ALICIA + c_2 BARRY + c_3 CHANTAL + c_4 ELENA + c_5 FLO + c_6 JUAN. \qquad (7)$$

This specification leads to the following likelihood function:

$$L = \Pi_i [1/(1+e^{-\theta_i})]^{y_i} [1-(1/(1+e^{-\theta_i}))]^{1-y_i} \qquad (8)$$

where y_i = observation of decision to evacuate (1) or not (0).[10]

Continuous wealth measures are not readily available for every decision-maker in the data set. Therefore, a proxy of annual drilling cost is used, based on the number of wells drilled by the oil company in the year of the observation and the average daily operating cost for the drilling rig. This approach defines the decision as one of *annual* utility maximization. This proxy should be sufficient to anchor the analysis on the appropriate part of the utility function. Note that rescaling of the wealth and cost figures in the context of numerical optimization must be proportional. The expected loss given a hit is computed assuming 55 people on board, and a value of statistical life of $2.275 million.[11] The historic climatological probability of a hit is taken from Considine *et al*. (2002). Parameters to be estimated are the a_i and b_i. The model of Equation (8) is estimated and the results presented in Table II.

Table II. Coefficient Estimates, Pooled Sample with Fixed Effects (k = b$_2$WD400 + b$_3$OPCUM + c$_1$ALICIA + c$_2$BARRY + c$_3$CHANTAL + c$_4$ELENA + c$_5$FLO + c$_6$JUAN)

Variable	Coefficient Estimates (t-stats)	
ALICIA	-0.306	(-1.0375)
BARRY	-0.225	(-.9614)
CHANTAL	0.062	(1.0423)
ELENA	0.017	(.3049)
FLO	0.006	(.0966)
JUAN	0.057	(1.1459)
A1	6476.678	(.4069)
A2	221.468	(.3469)
WD400	0.082	(1.7678)
OPCUM	0.092	(1.1321)
Log Likelihood	-37.965	
# Observations (Pos)	85 (62)	

Results are reported using the names of the explanatory variables, versus the b_i's, for clarity. As in the probit model, inclusion of fixed effects by storm significantly improves the overall fit of the model relative to pooled specifications. The general structure of the results (signs and relative magnitudes) for the fixed effects coefficients is similar to those of the basic discrete choice model, although here their individual statistical significance is diminished. WD400 is significant at the 10 percent level, and OPCUM is now only marginally significant. But we are more interested here in the predicted values of the variable *k*. Predicted values of *k* can be interpreted as an indicator of the degree of risk aversion. As *k* decreases (increases), the level of risk aversion increases (decreases). The closer to one, the closer to risk neutrality. For these 85 observations, 74 percent of the observations yield positive *k* values, with those observations yielding an average value of *k* of 0.13 with a maximum of 0.28 and a minimum of 0.01. While not all of the observations conform to the mathematical restriction on *k*, those that do indicate a high degree of risk aversion. Additional data would be valuable to further substantiate these initial findings.

Conclusion

These results provide support for the conclusion that both location attributes (water depth), and decision-maker experience increase the propensity to evacuate. The results on utility and risk preferences using a fixed effect model suggest a high degree of risk aversion in this setting. Issues that deserve additional study if additional data can be collected are the sensitivity to different specifications of the utility function, sensitivity to estimates of cost, and refining the proxy for wealth.

Footnotes

[1] Based on an analysis of the "Accident History of the Mobile Offshore Drilling Rig Fleet," Offshore Data Services, Houston, TX.

[2] Even when the oil company or drilling contractor carry general liability insurance, deductibles are often quite large (tens of millions of dollars), and a non-evacuation could be construed by the insurer as a lack of reasonable care, and refuse to pay for any losses.

[3] Based on interviews with decision-makers and historical track and speed information, the observation area is defined to begin west of 75 degrees longitude (about the eastern tip of Cuba) and north of 15 degrees latitude (about the southern tip of Mexico). This definition is intended to consistently capture the moment when decision-makers begin to pay attention to a storm's path insofar as it relates to management of their day-to-day operations and the potential decision to evacuate.

[4] In the current specification, time related (weather related) information is removed from the model. But previous research indicates there is consistent evacuation behavior across decision-makers for the primary categories of storm types (paths and intensities). Based on the relative similarity of the forecasts for each drilling location for those storms where evacuation rates do differ, the reasons for differences in the choice to evacuate are likely to reside in the decision-maker attributes, not weather or forecast information. Therefore, it appears that dropping weather related information from the model of the evacuation decision does not result in a significant loss of information with regard to the ultimate decision to evacuate or not.

[5] Because the evacuation decision is made earlier with less information, the probability window of a hit is larger and decision-makers are more likely to evacuate, ceteris paribus. Of course, this affect can work in the opposite direction if the earlier information indicates that a hurricane is not threatening, then waiting for later information that indicates a threat may actually increase the likelihood of evacuations (that is, jackup rigs would be more likely to evacuate). But previous research on hurricane forecast accuracy with respect to offshore operations indicated that the Pr(hit|forecasted miss) was only about 2 percent, so the opposite interpretation is not generally operative (see Considine et al. 2002).

[6] Decision-makers know their rig rate and develop an E(evacuation duration). To compute the COST here, the actual evacuation durations are used.

[7] Another plausible hypothesis posits that due to their larger accumulated wealth, large companies (RET=1) tend to be more risk neutral than smaller companies, and one could expect fewer evacuations, ceteris paribus. Under this hypothesis in the basic probit specification, the expectation of the sign of this variable coefficient is negative. A utility based model is estimated below that more fully investigates this issue.

[8] If the i.i.d. assumption is relaxed in this framework, the probit model is ill suited to the task. A random effects model is feasible, albeit quite complex (Greene, 2000; Baltagi, 2002).

[9] This issue is investigated via a valuation of hurricane forecasts in Considine et al. (2002).

[10] Maximization of Eqn. (8) is non-trivial given the complexity of the specification. The primary problem in this case is the nature of the utility function itself. Recall Eqn. (4): $U(W; s) = a1(W+a2)k + e$. Given that the goal is to estimate parameters comprising k and a2, no restrictions are placed on any parameters during the iterations. It is therefore possible for $-1<k<1$ and $(W+a2)<0$, causing a degeneration of the iterations. Techniques exist to overcome such obstacles, and involve ignoring degenerate observations during each iteration, rescaling of explanatory variables, and adjusting starting values.

[11] See Viscusi (2000) and Moore and Viscusi (1988) for additional context on value of life estimates.

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9th IAEE European Energy Conference
"Energy Markets and Sustainability in a Larger Europe"
Florence, June 10-12, 2007

The 9th IAEE European Energy Conference "Energy Markets and Sustainability in a Larger Europe" will be organized in Florence, on June 10-12, 2007 by the A.I.E.E - Italian Association of Energy Economists and the Energy Foundation.

The conference will debate a whole range of up-to-date energy issues in one of the most beautiful and artistic cities in the world, offering the participants a unique opportunity to see its cultural heritage and to visit exceptional museums and galleries.

The general programme of the Conference

MONDAY 11 June

08:00-09:00 Registration
09.30-10:30 Opening session
10:30-10:45 Coffee break

Plenary session 1

10:45-11.45 Sustainability:
Implications of different scenarios for energy supply and demand; Technology outlook response
11.45-12:45 Security of supply:
Availability of oil; The role of natural gas in Europe
12:45-14.00 Lunch
14:00-15:45 **Concurrent sessions 1**
15:45-16:00 Coffee break
16:00-17:45 **Concurrent sessions 2**
19:30- Gala dinner

TUESDAY 12 June

Plenary session 2

08:30-9.30 A wider EU energy market:
From Eastern Europe to the Mediterranean; Evolution in market regulation
9.30-10:30 Implementing renewables.
Drivers and opportunities for EU industries.
10:30-10.45 **Coffee break**
10:45-12:30 **Concurrent sessions 3**
12:30-14:00 Lunch
14:00-15:45 **Concurrent sessions 4**
15:45-16:00 Coffee break
16:00-17:45 **Concurrent sessions 5**
17:45-18:15 Closing session

The "call for papers": the topics of the papers to be presented in the concurrent sessions

Four of the concurrent sessions should be devoted to the four themes covered in the plenary sessions, both to present additional papers on these subjects and to discuss the presentations in the plenaries.

The following is an indicative list of other themes that will be accommodated in the concurrent sessions:

1) Transmission and transportation infrastructures in a liberalised environment
2) Experience curves cost development vs. value
3) Policy measures to accelerate development of RES
4) Integration of intermittent RES into energy markets
5) Market instruments to improve energy efficiency
6) Improving social acceptance of energy infrastructures
7) Liberalisation and regulation of the European energy markets
8) Supply and security in oil and gas European market
9) Regulatory regimes in the larger Europe
10) Geopolitics of energy
11) Understanding energy demand
12) Energy, environment and emission trading

A special Website will soon be set up for the Conference that will provide precise information regarding the format and modality for submitting the abstracts.

For the moment, the information about the conference venue, organization and social events can be found on the AIEE website www.aiee. It will soon be able to also provide information regarding the conference registration fees and student scholarship funds.
Arrangements will also be made for special rates with hotels of various categories near the conference venue.
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- 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.

First Conference of the Spanish Association for Energy Economics (AEEE)

The Spanish Association for Energy Economics, the Spanish chapter of the IAEE, held its first conference in Madrid on January 16 and 17.

The conference featured a large number of speakers and attendees, included, among other presentations, speeches by Arnold Baker and Jean Philippe Cueille, chairmen of the IAEE, as well as by María Teresa Costa Campí, President of Spain´s National Energy Commission.

Speakers touched on several timely issues in the Spanish energy industry, such as the current and future outlooks for energy use and CO_2 emissions, security of energy supply, problems in development of the electricity network, the location of polluting facilities, support for renewable energies, the evolution of oil prices, and combining energy activities with environmental protection.

The main conclusions underlined the need to encourage research and development in new technologies and instruments for modeling, along with regulation, as fundamental tools for resolving current energy problems.

During the conference, a new phase for the association was announced, in which it aims to become a national forum for academics, companies and institutions interested in Energy Economics. The association appointed a new board, comprised of José Luis Díaz Fernández as president, and Xavier Vives and Ignacio Pérez Arriaga as vice presidents.

José Luis Díaz Fernández is a professor at Madrid´s Polytechnic University, and vice president of the Repsol YPF Foundation in Spain. Xavier Vives is a professor at IESE Business School and research professor at ICREA-UPF as well as professor of European Studies at INSEAD. Ignacio Pérez Arriaga is a professor at the Pontificia Comillas University in Madrid and director of the BP Chair in Sustainable Development.

More information about the Spanish chapter of IAEE and its first conference is available at http://webs.uvigo.es/aeee and http://www.aeee.es.

Teresa Costa, President of Spain's National Energy Commission, chats with José Luis Diaz Fernández, President of the Spanish Affiliate and Ignacio Pérez Arriaga, an Affiliate Vice President.

Services for Student Members on the IAEE Website

Careers & Energy Education Database

IAEE is pleased to announce a comprehensive careers database, with special focus on graduate positions (http://www.iaee.org/en/students/student_careers.asp after log-in).

Employers are invited to use this database, at no cost, to advertise their graduate positions to student members of IAEE, as well as other positions. The student community at IAEE is large and rapidly growing. It is also diverse geographically and in terms of subjects of specialization.

IAEE is also pleased to provide the Energy Education Database. Members from academia are kindly invited to advertise, at no cost, graduate, postgraduate and research programmes as well as their universities and research centres on the following website: http://www.iaee.org/en/students/education.aspx

We look forward to your participation in these new initiatives.

ENERGY ECONOMIST
MIDDLE EAST LOCATION

A major oil and gas company requires an energy economist to join its Corporate Planning Organization as a key advisor on economic matters affecting the company and to support executive management decisions.

The Corporate Planning organization addresses the full range of business activities including exploration, production, refining, gas processing, power generation and interacts regularly with operating, engineering, marketing and financial organizations as necessary.

The candidate will have a Ph.D. in economics and at least ten years experience in business, consulting or related endeavors: a technical background in petroleum industry processes would be a plus. The job will involve the application of economic principles with a focus on pricing, capital budgeting, economic evaluation, regulation and taxation. In addition the person will participate on a variety of strategic task forces. Effective written and oral communication of complex issues to company management will be essential.

Interested parties should forward their resumes to IAEE. Interviews can be arranged at the upcoming IAEE conference in Berlin June 6 – 10.

Competitive salary offered commensurate with experience. Please send resume and letter of interest to iaee@iaee.org

!! Many Thanks !!
Contributors to the IAEE Student Scholarship Fund

IAEE gratefully acknowledge the following contributors for their generous support of our student scholarship fund. The student scholarship fund is set-up to cover the cost of conference registration fees for promising students who study energy and economics and want to participate in IAEE conferences. This scholarship fund actively encourages corporate and individual support. For information on contributing to this fund, please contact to David Williams by phone/email: (p) 216-464-2785; (e) iaee@iaee.org.

The following individuals have contributed to the IAEE Student Scholarship fund from May 1, 2005 – April 30, 2006.

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Publications

Annual Oil Market Forecast and Review 2006, Julian Lee (2006). Price: £650. Contact: Marketing Department, Centre for Global Energy Studies, 17 Knightsbridge, London, SW1X 7LY, United Kingdom. Phone: 44-20-7309-3610. Fax: 44-20-7235-4338. Email: marketing@cges.co.uk URL: www.cges.co.uk

Call For Papers: Special Issue of Energy Economics on "Modeling Industrial Energy Consumption", Dr. Joseph Roop, Dr. Gale Boyd, and Dr. Lorna Greening, Editors (2006). Contact: Dr. Lorna Greening, Energy and the Environment, 625 Paige Loop, Los Alamos, NM 87544, USA. Email: LGDoone@aol.com URL: http://ees.elsevier.com/eneeco/

Refining & Petrochemical Survey Middle East & North Africa 2006. Price: Euro 620. Contact: APRC, 7 avenue Ingres, 75016 Paris, France. Phone: 33-1-45-24-33-10. Fax: 33-1-45-20-16-85. Email: aprc@arab-oil-gas.com URL: http://www.arab-oil-gas.com

2**006 Catalog of Publications & Data for International Business – Country & Political Risk Methodologies** (2006). Price: $299.00. Contact: The PRS Group, Inc., 6320 Fly Road, East Syracuse, NY 13057-9358, USA. Phone: 1-315-431-0511. Fax: 1-315-431-0200. Email: custserv@prsgroup.com URL: www.prsonline.com

Calendar

14-17 May 2006, Energy and Arab Cooperation at Amman, Jordan. Contact: Information Department, OAPEC, PO Box 20501, Safat, 13066, Kuwait. Phone: 00965-4844500. Fax: 00965-4815747 Email: oapec@qualitynet.net URL: www.oapecorg.org

15-16 May 2006, Coaltrans Brazil at Le Meridien Copacabana, Rio de Janeiro. Contact: Jianjia Chan, Coaltrans. Phone: +44 (0) 20 7779 8895. Fax: +44 (0) 20 7779 8946 Email: jchan@euromoneyplc.com URL: http://www.coaltrans.com/default.asp?Page=11&eventid=ECK129&site=coaltrans

16-18 May 2006, OGU 2006; 10th Uzbekistan International Oil & Gas Exhibition & Conference at Tashkent, Uzbekistan. Contact: Julia Romanenko, Project Director, ITE Group Plc, 105 Salusbury Road, London, NW6 6RG, United Kingdom. Phone: +44 207 596 5233. Fax: +44 207 596 5106 Email: julia.romanenko@ite-exhibitions.com URL: www.ite-exhibitions.com/og&#160

16-17 May 2006, 15th Annual Latin American Energy Conference at La Jolla, CA. USA. Contact: Ana Lima, Associate Director, Energy Program, Institute of the Americas, 10111 North Torrey Pines Road, La Jolla, CA, 92037, USA. Phone: 858-453-5560 x125. Fax: 858-453-2165 Email: alima@ucsd.edu URL: www.iamericas.org

16-17 May 2006, Intermountain CHP Summit: Increasing Clean & Efficient Energy in the West at Golden, CO. Contact: Patti Case, Director, Intermountain CHP Center, 2260 Baseline Road, Suite 212, Boulder, CO, 80302, USA. Phone: 801-278-1927 URL: www.intermountainchp.org/events/2006summit

17-19 May 2006, Distribution Europe 2006 at Barcelona Spain. Contact: Elisabeth Brusse, Synergy, The Netherlands. Phone: +31 346590901. Fax: +31 346590601 Email: elisabeth@synergy-events.com URL: www.distibution-europe.com

29-30 May 2006, 2nd Annual Project Finance in the Middle East at Dubai, UAE. Contact: Raj Krishan Sood, Marketing Coordinator, Fleming Gulf FZ LLC, PO Box 500604, Dubai, UAE. Phone: 971-4-3616112. Fax: 971-4-3661048 Email: nabil.alam@fleminggulf.ae URL: http://fleminggulf.com/buxus/generate_page.php?page_id=225

May 31, 2006 - June 1, 2006, Energy Trading Central and Eastern Europe 2006 at Warsaw, Poland. Contact: Sandra Langedijk, Synergy. Phone: +31 346 590901. Fax: +31 346 590601 Email: sandra@synergy-events.com URL: www.energytradingcee.com

5-9 June 2006, World Gas Conference at Amsterdam. Contact: R. Aptroot, Coordination Committee Secretary, IGU, Post Box 19, Groningen, 9700 MA, The Netherlands. Phone: +31505213047. Fax: +31505211977 Email: r.aptroot@gasunie.nl URL: www.wgc2006.nl

(continued on page 36)

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

12-15 June 2006, Energex'2006 at Stavanger, Norway. Contact: John Olav G Tande, Organising Committee, SINTEF, Energiforskning AS, Trondheim, NO-7465, Norway. Phone: 47 73 59 72 00. Fax: 47 73 59 72 50 Email: john.o.tande@sintef.no URL: www.energex2006.com

20-22 June 2006, RPGC 2006; 4th Russian Petroleum and Gas Congress Alongside Neftegaz Exhibition at Moscow, Russia. Contact: Alla Sfakianiakis, Sales Executive, ITE Group Plc, 105 Salusbury Road, London, NW6 6RG, United Kingdom. Phone: +44 207 596 5179. Fax: +44 207 596 5106 Email: alla.sfakianakis@ite-exhibitions.com URL: www.ite-exhibitions.com/og

21-22 June 2006, 3rd Renewable Energy Finance Forum - Wall St at Waldorf Astoria Hotel. Contact: Jianjia Chan, Euromoney Energy Events. Phone: +44 (0) 20 7779 8895. Fax: +44 (0) 20 7779 8946 Email: jchan@euromoneyplc.com URL: http://www.euromoneyenergy.com/default.asp?Page=11&eventid=ECK134&site=energy

21-23 June 2006, Using Real Options to Value & Manage Natural Resource Projects at Golden, CO. Contact: Conference Coordinator, Colorado School of Mines, USA. Phone: 303-273-3321 Email: space@mines.edu URL: www.mines.edu/outreach/cont_ed

22-24 June 2006, InterSolar 2006 at Freiburg im Breisgau, Germany. Contact: Conference Secretariat, Solar Promotion GmbH, PO Box 100 170, Pforzheim, D-75101, Germany. Phone: 49-7231-585980. Fax: 49-7231-58598-28 Email: info@intersolar.de URL: www.intersolar.de

13-18 August 2006, Less is More, En Route to Zero Energy Buildings at Pacific Grove, California. Contact: Rebecca Lunetta, Conference Manager, ACEEE 2006 Summer Study Office, PO Box 7588, Newark, DE, 19714-7588, USA. Phone: 302-292-3966. Fax: 302-292-3965 Email: rlunetta@comcast.net URL: http://aceee.org/conf/06ss/06ssindex.htm

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

15-20 October 2006, 15th Pacific Basin Nuclear Conference at Sydney, Australia. Contact: Conference Coordinator, 15PBNC Conference Managers, GPO Box 128, Sydney, NSW, 2001, Australia. Phone: 61-2-9265-0700. Fax: 61-2-9267-5443 Email: pbnc2006@tourhosts.com.au URL: www.pbnc2006.com

25-26 October 2006, Emart Energy 2006 at Berlin, Germany. Contact: Sandra Langedijk, The Netherlands. Phone: +31 346 590901. Fax: +31 346 590601 Email: sandra@synergy-events.com URL: www.emart-energy.com

November 30, 2006 - December 1, 2006, Asia 2006 Intl Symposium Water Resources and Renewable Energy Development in Asia at Bangkok, Thailand. Contact: Mrs. Maria Flintan, Asia 2006, Aqua-Media International, Westmead House, 123 Westmead Road, Sutton, Surrey, SM1 4JH, United Kingdom. Fax: 44-20-8643-8200 Email: bkk2006@hydropower-dams.com URL: www.hydropower-dams.com

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