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Newsletter

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Third Quarter 2005

President's Message

First, let me say that we are deeply saddened by the events of July 7, 2005 - the senseless injuries and loss of lives to the good people of London. Our thoughts and prayers are with them and their families and with all of our UK members. London seems to be taking things in stride and moving ahead, as we all must, though healing takes time and is never easy.

In a much more pleasant vein, those of you who were with us in Taipei know that our 28th Annual International Conference there was exceptional. It resulted from superb leadership, planning and execution by Vincent Siew (General Conference Chair), Ching-Chi Lin (CAEE President), Ching-Tsai Kuo (Sponsorship Committee Chair), Huey-Ching Yeh (Program Committee Chair), Yunn-Ming Wang (CAEE President 2003-04) and Jeffrey Bor (Conference Executive Director). It was supported by a lot of hard work by CAEE and IAEE members and staff, including excellent support by Dave Williams, Karen Cheng, Tristan Liao, 35 very dedicated, hardworking and personable student volunteers, and many others, too numerous to mention.

I want to express my sincere thanks to all of you and to all of our IAEE and CAEE members who were able to participate and benefit from the high quality program, the excellent cuisine, and the outstanding cultural events.

I was quite honored to be a part of a small delegation that met with President Chen to discuss energy and environmental policy. And I was further honored to participate in Joanna Lei's ICQ widely broadcasted television interview on energy and environmental policy with Dr. Yuan-Tseh Lee, Taiwan's Nobel Laureate in Chemistry and President of Academia Sinica.

Those of you who were there know that energy security and the environment are taken quite seriously in Taiwan. The country imports some 97 percent of its energy, its economy is driven by international trade, and as an island nation of 23 million people its environment is critical to its survival. These issues, plus distributional equity, were discussed in detail during Taiwan's National Energy Conference (June 20-21)—their first such conference since 1998. The Conference involved experts from Taiwan's government, national laboratories, industry and universities, as well as members of their environmental community. I had the privilege, as IAEE President, to deliver the keynote plenary talk and to set the stage for policy deliberations.

Through all of these events it's clear that Taiwan places a very high value on the IAEE and CAEE, and it recognizes their vital role in helping inform the energy and environmental policy decision-making process. This is a role which, with your help, I hope we can grow in coming years, deepening it in countries in which we have active members, and extending it to important energy consuming and producing countries where we currently do not.

Council and I were able to spend some quality time together in Taipei discussing this, considering the IAEE's future directions and building a framework for longer term strategic thinking to help make our association stronger, more inclusive, and more valuable to informed energy-economic decision-making. We are very close to agreement on our first Mission Statement, and we plan to continue our strategic discussions in informal working sessions in Bergen and Denver, and through electronic meetings as well. As we continue to make progress, we will share our results with you and will seek your thoughts and input to the process.

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Editor's Notes

Russia will need over 150mt/yr of new export infrastructure within a decade. The country has three outlets for crude: the Baltic Sea, the Black Sea and the Druzhba pipeline. The port of Primorsk on the Baltic Sea will soon displace Novorossiysk in terms of throughput; but, it reinforces export dependence on Europe as well as on tanker shipments. Transneft, the Russian state-owned pipeline system, would like to extend its network to an arctic export terminal and is pointing toward the port of Indiga on the Barents Sea. A pipeline connection to Indiga would be less costly than

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Certainly our current energy environment has no shortage of complexities and public policy challenges, as the events of July 7th made all too clear. Oil prices have now touched $60 a barrel, though they are still below the $95 real dollar peak in 1980. Natural gas prices at Henry Hub are staying over $7.00/mmbu as we enter the summer. Iran has new conservative leadership with expressed interest in nuclear technology, while the EU and U.S. have proliferation concerns. Iraqi insurgency continues. Questions about the stability of Nigerian oil production remain.There are significant uncertainties over Russian and Venezuelan treatment of foreign oil and natural gas investment. The effects of high oil prices on economic growth, and that of economic growth on oil demand, seem increasingly problematic.

The Chinese are interested in purchasing UNOCAL and in pursuing other foreign oil investments, while many countries have a strong interest in investing in China. France and the Netherlands rejected the proposed EU constitution, while the EU pursues electricity restructuring and other integration policies. And nuclear power is emerging in some countries as a means of avoiding fossil fuel imports and helping reduce carbon emissions, while it remains off the table as an option in others.

Just to name a few things to ponder, as we begin to head off for summer vacations with family and friends.

Following summer vacation, I hope to see many of you in August and September at our upcoming affiliate conferences. The IAEE European Affiliate Conference is in Bergen, Norway (August 28-30), and is focusing on "European Energy Markets in Transition". For those of you interested in this area, I would highly recommend our just released *Energy Journal* Special Issue, "European Electricity Liberalisation," edited by David Newbery.

Our USAEE/IAEE North American Conference is in Denver, Colorado (September 18-20), and is focusing on "Fueling the Future: Prices, Productivity, Policies and Prophesies." Both conferences have excellent programs and are in wonderful locations for a bit of follow on touring.

I continue to welcome your feedback on how the IAEE can do a better job and can better service you, our members. Please send your suggestions to me electronically in care of Dave Williams (iaee@iaee.org).

With very best wishes for a safe, relaxing and enjoyable summer.

Arnie Baker

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

Murmansk. But overall, Indiga would be the more expensive option because of severe ice conditions. Paul de Zardain discusses the pros and cons of the two ports.

Ali Hussain details nine reasons why, given the rise in prices, oil demand remains high and production has not increased significantly to meet the demand. He suggests that for the reasons given, oil prices will remain volatile for some time to come.

James Dorian, Herman Franssen, and Dale Simbeck note that environmental and security concerns are stimulating global interest in hydrogen power, renewable energy and advanced transportation technologies, but no significant movement away from oil and a carbon-based world economy is expected soon. Over the longer-term, however, a transition from fossil fuels to a non-carbon based economy will likely occur. They identify key challenges in energy and the choices which will have to be made on how to facilitate an eventual revolutionary-like transition to a non-carbon based global economy.

Matthew Siniawski notes that the field of tribology has been involved in increasing energy efficiency for thousands of years. In the future, tribology can play a prominent role in decreasing overall energy losses. He comments that some areas where tribology can currently increase energy efficiency are the transportation sector, energy production technologies, implementing life cycle analyses and the promotion of recycling. In addition, tribology can also increase the promotion of cleaner, more efficient modes of transportation and energy production.

DLW

Council Approves New Logo

At its Taipei meeting, Council approved a new IAEE logo. For a good example of it, see the masthead on the cover page of this Newsletter and also page 22. There are other variations on this new style and you will be seeing them all as the Association's publications are moved to the new format.

ANNOUNCEMENT
8th Annual USAEE/IAEE/ASSA Meeting
Boston, Mass., USA January 6 - 8, 2006
Current Issues in Energy Economics and Energy Modeling

Presiding: Fred Joutz, George Washington University

Youngho Chang, National University of Singapore – *Modeling Pricing Behavior with Vesting Contracts in a Deregulated Electricity Market*

Young Yoo and Bill Meroney, Federal Energy Regulatory Commission – *A Regression Model of Gas/Electricity Price Relationship and Its Application for Detecting Potentially Anomalous Electricity Prices*

Margaret Taylor and Greg Nemet, University of California, Berkeley –*The Interaction Between Policy and Innovation In Renewable Energy Technologies*

Graham A. Davis, Colorado School of Mines – *The Resource Curse: Assessing the Empirical Evidence*

Abstracts are posted at http://www.iaee.org/documents/2005/assa-abstracts.pdf

We still need some discussants. If you are interested in being a discussant contact Carol Dahl – cdahl@mines.edu right away as program will be finalized very soon. Date, time, and location will be posted in September.

The meeting is part of the Allied Social Science Association meetings (ASSA)

For program information and pre- registration forms on the larger meeting (usually available in September) go to http://www.vanderbilt.edu/AEA/anmt.htm.

!!!!! PLAN TO ATTEND !!!!!

Fueling the Future: Prices, Productivity, Policies, and Prophecies

25th Annual North American Conference of the USAEE/IAEE

September 18 – 21, 2005

Denver, CO – Omni Interlocken Resort

We are pleased to announce the 25th Annual North American Conference of the USAEE/IAEE, ***Fueling the Future: Prices, Productivity, Policies, and Prophecies***, scheduled for September 18-21, 2005, in Denver, CO at the Omni Interlocken Resort.

Plenary sessions will be interspersed with concurrent sessions designed to focus attention on major sub-themes. Ample time has been reserved for more in-depth discussion of the papers and their implications. Some of the key themes and sessions for the conference are as follows:

Fossil Fuels Reliance
National Energy Policy for the 21st Century
Future Fuels and Use: Hope for Tomorrow
Experience in Electricity Market Restructuring: The Bad, The Ugly and the Not So Bad
Energy Policy Gone Awry
Non-Conventional Energies: Probable to Proven
Decoding the Future: An Overview of Shell's New Global Scenarios
Renewable Energy: Back to the Future?

Confirmed and/or invited speakers include:

Douglas J. Arent, National Renewable Energy Laboratory
Joseph Desmond, California Energy Commission
Thomas Drennen, Sandia National Laboratories
John Edwards, University of Colorado at Boulder
Jean-Pierre Favennec, IFP-ENSPM
Mark Finley, BP America
S. David Freeman, Renewable Resources Group
Janet Gellici, American Coal Council
Michael "Mickey" Glantz, Nat'l. Center for Atmospheric Research
Daniel M. Kammen, University of California Berkeley
Robert Alfred Lamarre, Lamarre Geological Enterprises, LLC
Doug Larson, Western Interstate Energy Council
Amory Lovins, Rocky Mountain Institute
Michael C. Moore, University of Calgary
Shirley J. Neff, President-Elect, USAEE
Amy Jaffe, Rice University
Jim Mulva, CEO, ConocoPhillips, Inc.
Fereidoon Sioshansi, Menlo Energy Economics
Andrew Slaughter, Shell Exploration & Production Co.
Philip Herald Stark, IHS Energy Group
James L. Sweeney, Stanford University
Wim Thomas, Shell International plc
Taff Tschamler, KEMA, Inc.
Hermann-Josef Wagner, University of Bochum
Thomas J. Woods, Platts Research & Consulting
Jay Zarnikau, Frontier Associates, LLC

There are 30 planned concurrent sessions. Given the location of the meeting in Denver, CO, we anticipate a good draw to our concurrent sessions with over 140 confirmed speakers.

Denver/Boulder, CO are inspiring cities and a great place to begin or end a vacation. Single nights at the elegant Omni Interlocken Resort are $135.00 per night. Contact the Omni Interlocken Resort at 303-438-6600 or 1-800-THE-OMNI to make your reservations. Conference registration fees are US $600.00 for USAEE/IAEE members and US $700.00 for non-members.

Our current program announcement can be found by visiting http://www.iaee.org/en/conferences Please take advantage of the pre-registration discounts and make both your conference and hotel reservations as soon as possible. September in Colorado is a celebration! Further information on Denver, CO may be obtained at: http://www.denver.org Further information on Boulder, CO may be obtained at http://www.bouldercoloradousa.com

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

Fueling the Future: Prices, Productivity, Policies, and Prophecies

25th USAEE/IAEE North American Conference

Please send further information on the subject checked below regarding the September 18-21, 2005 USAEE/IAEE North American Conference.

_____ Registration Information _____ Sponsorship Information ____ Exhibit Information ____ Accommodation Information

NAME: ______________________________
TITLE: ______________________________
COMPANY: ______________________________
ADDRESS: ______________________________
CITY,STATE,ZIP: ______________________________
COUNTRY: ____________________ Phone/Email: ____________________

USAEE Conference Headquarters
28790 Chagrin Blvd., Suite 350
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The Barents Sea: Strategic Options for Oil Exports in Russia's Northwest

*By Paul de Zardain**

Abstract

Transneft, Russia's state-owned pipeline system, wants to extend its network to the port of Indiga in Nenets Autonomous Okrug. The Arctic export terminal would go online in 2009 with a 400km connection to Kharyaga. Indiga port would serve the growing crude output from Timan-Pechora in Russia's Northwest. Transneft has overlooked the high costs of marine transportation in the Arctic, as well as environmental factors. For 6-9 months of the year, the southern coast of the Barents Sea is locked in ice of up to 80cm. Diesel-powered icebreakers are limited by size and endurance, making nuclear-powered vessels the only alternative. The Murmansk Shipping Company currently has 4 atomic icebreakers in operation. No further construction has been budgeted by the Russian Federation for 2005. Limits to dead weight tonnage are also problematic because the piloting icebreakers are only 30m wide. Tankers of even 150,000 deadweight tons (dwt) would face difficulties serving Indiga for more than 3 months a year. The cost structure will thwart plans to increase energy cooperation with the U.S., a political objective in Moscow. How do ice conditions at Indiga impact export costs? How does the Barents Sea compare to the Baltic Sea? What are some of the environmental hazards?

Introduction

The five-year oil boom in Russia is coming to an end. Production in 2005 is projected to rise by 3.8% to 9.6 million barrels per day. This figure is less than half the growth rate of the past five years. Russia has been largely responsible for non-OPEC production growth since 1999 and has been matching barrels with Saudi Arabia. The country holds an estimated 10% of world oil reserves and one third of global natural gas deposits.

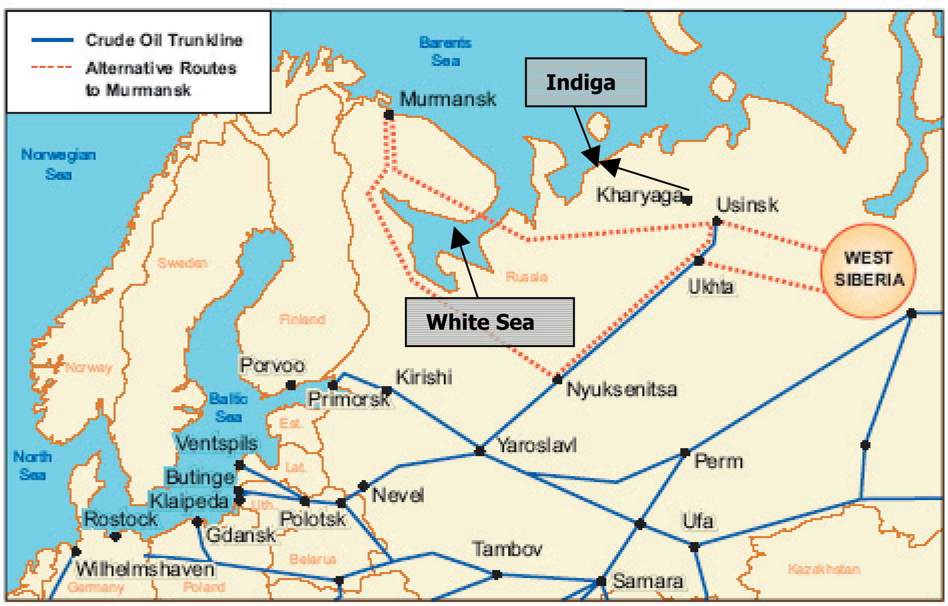
Field investment has dipped in part because of the unfavorable business climate. The opposite was true five years ago when low ruble costs and improved political stability made Russia attractive. In 2004, the high-profile expropriation of Yukos and tax raids against industry contributed to $7.8 billion in capital outflows. According to the Ministry of Energy, drilling activity declined by 2.8%, with Yukos-owned wells suffering a 37% drop. Russia's largest oil producer, Lukoil, also reduced drilling by 6.2%.

Under President Vladimir Putin, energy policy has been characterized by a state clawback of oil and gas resources. Changes in subsoil licensing have effectively curtailed the ability of foreign firms to acquire new acreage. In February, the Ministry of Natural Resources announced that only companies registered in Russia with a 51% domestic-owned structure could participate in auctions for strategic fields. Risk management has been reprioritized and the new model for oil companies is conservative.

West Siberia, the source of Russia's *brownfield renaissance*, is projected to reach a second peak in 2010. The rape-and-pillage methods practiced by Yukos damaged field structures in West Siberia. Meanwhile, East Siberia is still an unknown in terms of commerciality. The Timan-Pechora basin in Russia's Northwest will increasingly be the object of exploration and production. From an output of 349,000 barrels per day in 2003, a high scenario that assumes new discoveries, output in Timan-Pechora is expected to grow to 565,000 barrels per day by 2010.

Pipeline politics is the main culprit behind Russia's slowdown. Transneft has chosen to respond to bottlenecks with stop-gap solutions and arbitrary tariff-setting. Logistical constraints have blunted crude oil deliveries via Russian Railways (RZD), one of the alternatives to Transneft. To maintain state control over oil flows, the government has scrapped plans for a pipeline route to Murmansk. The Indiga project, where ice conditions and shallow waters make large-scale exports unprofitable, is an example of this flawed economic strategy.

Murmansk-Indiga Barents Sea Region



The map shows dotted lines to the proposed export terminal in Murmansk. The arrow points to the Kharyaga-Indiga connection favored by Transneft.
Source: Cambridge Energy Research Associates. The use of this graphic was authorized in advance by CERA. No other use or redistribution is permitted.

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*Paul de Zardain works as an energy analyst at TNK BP in Moscow as part of the Alfa Fellowship Program. He may be reached at pdezard1@jhu.edu

The Barents Sea

Why is the Russian Federation interested in an export option in the Barents Sea? One reason is the environment of high oil prices and another is the chronic bottlenecks in domestic pipelines. A third reason is that a Barents Sea outlet would launch energy cooperation with the United States. By opening a new export route, Moscow is looking to diversify export markets.

Despite ice conditions in the Arctic, the western end of the Barents Sea has no geographic limits on oceangoing tankers. Murmansk is bathed by warm sea currents and remains ice-free year-round. The synergy with regional mining companies can help lower construction costs. In comparison, the Danish Straits already limit tanker size to 150,000dwt, putting a natural cap on capacity at Russia's Primorsk terminal. The Black Sea export route is subject to similar constraints. The downside for Murmansk is vulnerability to oil prices, as well as environmental risk.

Year-round navigation in the Barents Sea began in the 1970s with nuclear-powered icebreakers like the *Lenin*. In the 1980s, total shipments of raw materials in the region amounted to 4mt, including 2.5mt of nickel and iron ore. Traffic slowed after the collapse of the Soviet Union. There is only one year-round tanker route in this part of Russia: Dudinka-Murmansk. The Norilsk Mining Company, with its main industrial complex in Dudinka, uses nuclear-powered icebreakers to pilot 20,000dwt tankers.

Oil production growth in Timan-Pechora is reopening shipping lanes in the Arctic. In 2004, hydrocarbon exports via the Barents Sea amounted to 9.9mt. A breakdown in million metric tons is as follows: Archangelsk 4.1mt, Murmansk 3.2mt, Vitino 2.2mt and Varandey 0.6mt. For refined products, the breakdown is: Vitino 1.5mt, Arachangelsk 1.1mt and Murmansk 0.2mt. Crude comes mainly from West Siberian fields and is delivered by pipeline to railroads, which are linked in turn to port facilities. These export figures are relatively small compared to Baltic Sea routes.

The North Atlantic drift allows the port of Murmansk, on Kola Peninsula, to operate at full capacity 12 months a year. In the shallower waters of the White and Kara Seas, as well as in Indiga Bay, oil tankers need icebreaker assistance for 6-9 months a year. In the last five years, ice analysis has shown that Indiga is locked in young ice (0-30cm) during the Arctic winter. In January, ice cover can reach 80cm, classified as first-year ice by Russia's Arctic and Antarctic Research Institute.

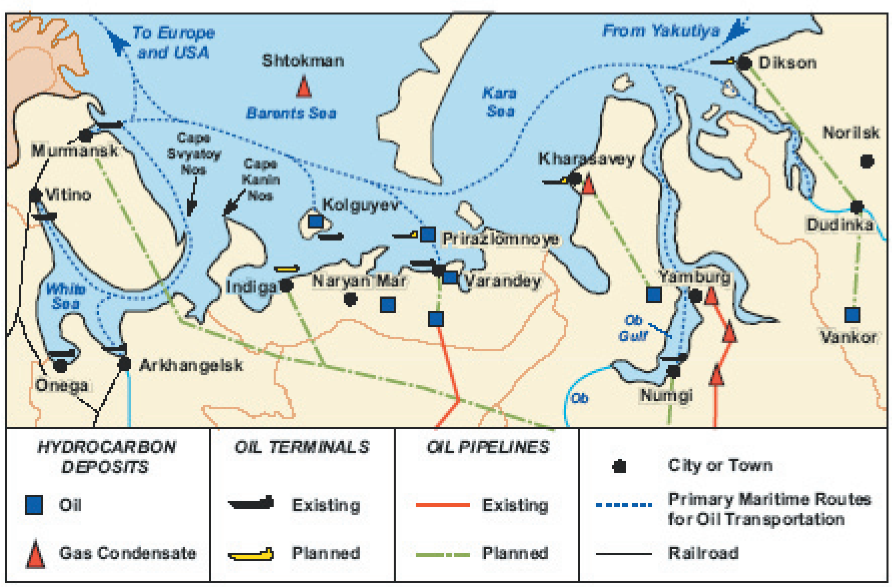
When ice-resistant tankers are not needed, Cambridge Energy Research Associates (CERA) thinks netbacks from Barents Sea routes could compete with Black Sea routes because of the shorter distance to oilfields. For example, the cost of reaching the White Sea terminal of Vitino, the largest source of refined products shipments in the Northwest, is lower than combined pipeline and rail routes. In 2004, Yuganskneftegaz paid $37.95 per ton to reach the port of Vitino. The company paid $48.47 per ton via Syzran to the port of Feodosiya in the Black Sea.

Private energy companies in Russia have long considered a strategic terminal in the Barents Sea. In part, this option would immunize them from unpredictable policy shifts at Transneft. A deepwater terminal at Murmansk backed by the Russian majors has been on hold since 2003. If realized, it could become an outlet not only for Timan-Pechora, but also for natural gas from prospective offshore fields in the Barents Sea. Together, the ports of Murmansk and the smaller port of Varandey, at the eastern end of Barents, could provide 2-3mbd of deepwater export capacity.

Direct access to North America would turn Murmansk into a geo-strategic lynchpin. But for now, the port is likely to see only a 5-10mt/yr (100,000-200,000bd) transshipment terminal. At a London conference in February 2005, Transneft's CEO Semyon Vainshtok argued that private companies had miscalculated the costs involved with a pipeline to Murmansk. "*Together with the Ministry of Transportation, the Hydrological Institute and individual transportation companies, we have carried out research that shows that Murmansk is the least viable option*," said Vainshtok. He argued that Murmansk involves a crossing of the White Sea, a costly engineering feat.

As a counteroffer, Vainshtok backed the construction of a 400km trunkline connection to Indiga in Nenets Autonomous Okrug (area). Despite research that shows severe winter ice conditions in Indiga Bay, as well as extremely shallow waters (less than 2m at the mouth of the Indiga River), Vainshtok assured the audience that initial capacity could go online within 20 months.

Map of the Barents Sea Region Showing Shipping Lanes, Hydrocarbon Deposits and Oil Terminals: Existing and Planned



Source: Cambridge Energy Research Associates. The use of this graphic was authorized in advance by CERA. No other use or redistribution is permitted.

Indiga Port

Transneft officials have decided that an export terminal at Indiga will serve the expected output growth at Timan-Pechora through 2010. Indiga is a sleepy town east of Chesha Bay in Nenets Autonomous Okrug, a region characterized by volatile gubernatorial politics. The supposed advantages of an export terminal here include lower construction costs and shorter distances from Kharyaga, the northern end of Transneft's pipeline system. Estimated costs are $1bn, with initial capacity for 25-30mt/yr.

According to CERA analysts, the new export terminal at Indiga would ramp up capacity at Varandey to 12mt/yr by end-2007 (up from 1.5mt/yr). It would create a natural transportation corridor beginning in Varandey and ending at the refineries of Rotterdam and Antwerp. According to the Arctic Operational Platform (ARCOP), a Scandinavian project financed by the European Union, the target value for transportation costs is $15 per ton.

In London, Semyon Vainshtok said that sea depth and ice conditions in Indiga Bay are "*not that much worse than at Primors*k" (Primorsk is Russia's export terminal in the eastern Gulf of Finland and an end-point for Transneft's Baltic Pipeline System). Information on ice conditions at Indiga Bay has proven contradictory. In theory, icebreaker fees can triple shipment costs during the winter, making Indiga unprofitable for 9 months out of the year.

The high costs of marine transportation affect oil company netbacks. While the government can lower fees at Transneft, it cannot control the cost of tankers. In Indiga Bay, ice-resistant tankers also face size limitations because the piloting vessels are only 30m wide. When there is no ice, ocean-going tankers of 150,000dwt would not be able to berth because water depths at existing facilities are just 2 meters high.

If one adds the premiums associated with environmental hazards, the projected Indiga terminal is a sub-optimal choice. It makes sense only in the context of political interest peddling. Transneft, a state-owned company, primarily serves the interests of the federal center. It needs to satisfy fuel supplies to powerful domestic companies, as well as maintain high employment. Private players are often forced to share pipelines with well-connected freeloaders. Meanwhile, hard data on Transneft's exact export capacity is lacking because its technical parameters are considered a state secret.

The Putin administration views Murmansk as a threat to state control over oil flows. Transneft has chosen instead to put money into a third-stage expansion of the Baltic Pipeline System, increasing Russia's risky export dependence on Europe.

Nenets Autonomous Okrug: Oil Politics

Indiga is located in Nenets Autonomous Okrug (area). Nenets borders the Komi Republic in the south and Yamalo-Nenets Autonomous Okrug in the east. The area extends in a belt along the Arctic coast, with shorelines on the White, Barents and Kara seas. Naryan-Mar (pop. 26,600) is the capital and administrative center. The city has a river dock 110km from the Barents Sea.

Other than severe winter conditions, the region is politically sensitive for the Kremlin. Nenets is officially a donor region, which means that transfers to the federal center are greater than what the autonomous administration receives from Moscow. Taxes from energy companies provide more than 50% of the local budget. CERA estimates there are 1bn metric tons (7.3 bn barrels) of oil deposits in Timan-Pechora, or 7% of total Russian reserves.

Natural gas from the Shtokman fields in the Barents Sea (estimated reserves: 3.2 trillion cubic meters) will become the region's main energy producer by 2010-20. There are 80 discovered oilfields in Nenets and a total of 40 exploration licenses. Foreign participation has been crucial in developing the region. The Russian Federation wants to turn Indiga into an export terminal in part to mollify the region.

Nenets Governor Vladimir Butov has a long history of conflict with Moscow since he took office in 1997. He is popular in the area and was reelected in January 2001 with 68% of the votes. As a result of his maverick politics, E&P licenses in Nenets are often the object of legal battles. Butov himself is the object of seven criminal cases.

President Putin has tolerated Butov for lack of an alternative. To wrest power away from obstructionist governors, the Russian Duma (lower house) approved legislation in December 2004 giving Putin executive powers to appoint regional governors. Vladimir Loginov, the governor of Koryakia, was the first governor to be sacked by Putin in March 2005.

To prevent regional governors from wielding excessive power, Putin has also transferred licensing of oilfields to the federal center. Previously, a *two keys* system meant that both federal and regional authorities issued licenses. The Federal Agency for Subsoil Use, a division of Russia's Ministry of Natural Resources, has limited foreign participation in field development, including acreage in the Barents Sea.

Ice Conditions

Ice thickness in the eastern Barents Sea can exceed 80cm, with ridges sometimes as high as 3m. The shortage of ice-class tankers is a major obstacle for a Barents Sea export route. For most of the year, oil tankers need icebreaker assistance in the eastern and southern waters of the Barents Sea, as well as in the White and Kara Seas. The *Yamal* is 148m in length and can break ice of up to 2m when traveling at a speed of 20km per hour. But the largest nuclear-powered icebreakers are only 30m wide and limit the size of tankers to 60,000dwt.

In the White Sea, ice cover begins in late October and lasts until early June. Average ice thickness in 2001-2004 ranged from 50 to 60cm. But during cold snaps, it can reach 70-80cm. The Kara Sea has ice cover year-round, although shipping lanes tend to open up from May to October. In the Kara Sea, ice can reach 3m, with ice ridges up to 6m high. Along the Ob Gulf, river navigation is possible for 91-117 days out of the year. For 8-12 months a year, average ice thickness is 2m.

According to CERA reports, the largest tankers in

Russia's Arctic are currently the 20,000dwt vessels operated by Norilsk Nikel. Winter conditions influence the design of these ice-strengthened ships. Large ice-resistant tankers of up to 120,000dwt can navigate the Arctic Ocean, but tanker width exceeds the paths opened by icebreakers. Unless two icebreakers are used simultaneously, the 30m width is a serious logistical constraint on crude transportation.

There are also legal restrictions on navigation depending on local ice regimes. The port of Arkhangelsk allows navigation in the White Sea if ice is less than 35cm and if the ice class of the ship is no lower than LU1/L4 (Class II in the Western standard). If ice is 35-50cm, navigation is open for LU4/L1 (1A in Western standard) ice class vessels, with a maximum size of 10,000dwt. If ice is more than 55cm, vessels require icebreaking support.

Exporters in Russia's Northwest not only face icebreaker fees, but also an acute shortage of piloting vessels. This often falls into federal policy because the atomic icebreaker fleet is a state monopoly. A private operator cannot equip a vessel with nuclear reactors. Diesel-fueled icebreakers can in theory be built and operated by private companies, but they are only able to cut channels through ice of up to 1.5m in thickness. From June to October, ice-class tankers do not require icebreakers. Late August is the period with the least amount of ice.

Scientists at NASA's Jet Propulsion Laboratory have used high-resolution photographs to observe ice development in the Arctic Ocean. The NASA images show ice growth during the Arctic winter. Brighter features signal thicker ice and darker areas show young, recently formed ice. The cracks in the ice expose water to frigid air, thus facilitating further ice formation. Meteorologists argue that changes in Arctic ice cover impact the global heat balance because of sheer volume.

Ice Scenarios

The Arctic Ocean could become seasonally ice-free within 50 years. A panel of experts from the US Arctic Research Commission has factored in the effects of climate change into ice models for the mid-21st century. The scenarios are based on time series of Arctic and North Atlantic weather oscillations.

The Arctic responds to global warming in an amplified way because it absorbs more solar radiation than other parts of the northern hemisphere. Greenhouse gas entrapment over the North Pole has led to a steady decrease in ice volume since 1950. Longer melt seasons, thinning ice cover and the reduction of multiyear ice can therefore be expected.

According to the UN Intergovernmental Panel on Climate Change (IPCC), winter temperatures in the Arctic will rise mid-century by an average 8-9 degrees Celsius. A baseline model projects a decrease of 40% in ice concentration by 2050, down to 5,400 cubic kilometers. Satellite photographs show an average rate of decline of 3% per decade. The Fridtjof Nansen Institute in Norway has observed a 14% decrease in multiyear ice (per decade).

As a result of climate change, low pressure points will become increasingly common in Arctic waters. This means more ice formation will accumulate onboard vessels. Implications for shippers include a redesign of plate thickness and stiffeners to the bow and stern. Ships seeking to navigate the Northern Sea Route (NSR) will need to be equipped with thin-skinned sonar devices to avoid hitting underwater ice drafts. There are different specifications for tankers operating in first year ice (<100cm), as opposed to multiyear ice (>200cm). Propellers, rudders, fin stabilizers and sea chests will be affected.

Ships without ice capabilities will ease into the traffic along the NSR by 2050. Summer ice at mid-century is projected to fall by 15%. In late summer, the entire Russian coast from the Barents, Kara, Leptev and East Siberian Seas will be open for commercial traffic. Russia argues that the Arctic straits are internal waters, while the US maintains they are international waters subject to the *right of transit*. As the transportation corridor opens, political conflicts will arise. Some factors to consider in the medium term are changes in ship technology, legal positions (UN Law of Sea), NSR tariffs and global environmental impact.

Climate change has other repercussions for Russian economic development. The downward demographic trend will accelerate in the northern territories. As the permafrost recedes, access to mineral resources will be less costly. As reserves deplete elsewhere, new discoveries are likely to be made in Timan-Pechora basin and the Barents Sea. For oil companies, marine infrastructure will have to adapt to permafrost degradation, changes in sea level and river flood patterns. All of these can damage rail connections, port terminals and rigs.

Nuclear-powered Icebreakers

Compared to diesel icebreakers, nuclear-powered icebreakers have clear advantages in terms of ship piloting in the Arctic. They have four times higher performance and 3-4 times longer endurance life. Diesel electrical icebreakers need refueling every 2 months, whereas nuclear fuel provides icebreakers with an average life of 7.5 months at sea. Maintenance is typically required every 6-8 months. Experience has shown that nuclear-powered icebreakers can perform over prolonged periods. The *Arktika* icebreaker worked for an entire year without calling to port from 1999 to 2000.

The downside of nuclear icebreakers is clearly tied to environmental risk. With nuclear reactors onboard, an accident at sea would affect not only Russia, but all littoral states. Stockpiling enriched uranium in the rusting shells of berthed vessels in Murmansk exposes 340,000 people in the immediate vicinity to unnecessary radioactive risk.

Nuclear waste can be in gaseous, liquid or in solid form, and can last for more than 100 years. The Atomic Fleet Department at the Murmansk Shipping Company has been carrying out technical management of vessels with nuclear power units. Sweden's Nuclear Power Inspectorate is helping to track spent fuels. But the Radiation Protection Authority of Norway has warned that the enriched uranium onboard icebreakers can easily land in the hands of terrorists.

The Murmansk Shipping Company has been renting nuclear-powered icebreakers to tourists at $20,000 per head. Meanwhile, the workers at the company are disgruntled and have criticized the tug-of-war between private and public firms for icebreaker use. Lukoil, Norilsk Nickel, Gazprom and Rosneft hire atomic icebreakers for their Arctic operations; competition for scarce piloting services has driven prices upward.

In Russia's Northwest, there are 4 nuclear icebreakers currently in operation. The Murmansk Shipping Company is the only business in the world with an atomic fleet. The home port for nuclear icebreakers is Atomflot, about 7km from the center of Murmansk. All of Russia's nuclear-powered icebreakers will reach decommissioning age by 2005. In November 1998, Lukoil acquired a controlling stake in the company and injected fresh capital into maintenance.

The company has two other nuclear-powered vessels: the *Lenin* and the *Sibir*. The *Lenin*, a first-generation nuclear icebreaker built in 1974, is in long-term berthing without nuclear fuel in its reactors since 1989. The *Sibir*, a second-generation icebreaker, is also in long-term berthing without nuclear fuel since 1993. There are two floating technological bases that service Russia's atomic fleet: the *Imandra* and the *Lotta*. A special tank vessel and a floating radiation monitoring vessel are part of a special fleet that maintains the nuclear steam output units.

Equipment onboard a nuclear icebreaker usually consists of one or two nuclear-powered steam generating units, a steam turbine and a propulsive electrical unit. The nuclear reactors provoke a chain reaction in which heavy elements lead to nucleus division. The reactors consist of an active zone and a reflector; the active zone contains protectively covered nuclear fuels (heat-generating elements) and a moderator. All nuclear vessels need to satisfy safety guidelines established by the International Maritime Organization (IMO).

Murmansk Shipping Company: Nuclear-powered Icebreakers

	Length (m)	Width (m)	Displacement (tons)	Power (MW)	# Reactors & Nominal Capacity (MW)	Speed (km/hr)	Ice Breakability (m)	Endurance (months)
Arktika, b. 1975	148	30	23,000	54	2x171	18	2.0	7.5
Rossiya, b. 1985	148	30	23,000	54	2x171	20.6	2.0	7.5
Taimyr, b. 1988	151.8	29.2	21,000	35	1x171	18.5	1.77	7.5
Sovetski Soyuz, b. 1989	148	30	23,000	54	2x171	20.6	2.0	7.5
Vaigach, b. 1990	151.8	29.2	21,000	35	1x171	18.5	1.77	7.5
Yamal, b. 1992	148	30	23,000	54	2x171	20.6	2.0	7.5

Nuclear Fleet Renewal

Revenue from icebreaker tolling fees is not enough to maintain the existing atomic fleet. To avoid a sharp drop in the number of icebreakers, Russia began to extend the working life of older ships in the 1990s. Engineers have resorted to servicing atomic steam output units up to 150,000 hours. This will allow three of the four nuclear icebreakers in operation to work from 2010 to 2015.

Vyacheslav Ruksha, of Russia's Federal Agency for Marine and River Transport, said in October 2004 that it was time to build a new generation of nuclear-powered vessels. According to Ruksha, a new generation would require 7-8 years from feasibility studies to final construction. The price tag on a nuclear icebreaker is $250-$300 million.

A non-official program to replenish the atomic fleet in Murmansk includes 4 double-draught, multipurpose 60MW icebreakers, as well as a 90MW lead icebreaker. In comparison, the propulsive power in the *Yamal,* which is equipped with two nuclear reactors, is 54MW.

The existing fleet of atomic icebreakers will be taken out of operation by 2015, long after decommissioning age. For now, the Russian Federation does not have the monetary incentives to renew the fleet. In 2005-2007, the federal budget only includes funding for 2 diesel-powered icebreakers. The development of oil and gas in Timan-Pechora may prompt a rethink, however.

Environmental Risk

Human error is behind the majority of accidents at sea. TNK became *Exhibit A* for environmental catastrophes in 2002 when the *Prestige* sank in a storm off the coast of Galicia (northwest Spain). Three years later, the single-hulled *Prestige* is still spilling part of its 77,000 metric tons (513,000 barrels) of heavy fuel into the Atlantic. Oil periodically washes up in the Bay of Biscay, reducing the density of marine habitats and depriving locals of their livelihood.

The European Commission banned single-hulled tankers like the *Prestige* from carrying loads of mazut, bitumen and tar. Russian shippers, and their sub-contractors, are likely to divert single-hulled tankers to the less-regulated Persian Gulf and Asia-Pacific region. But a resolution by the IMO to phase out these tankers is putting additional pressure on shipping companies.

Although small-scale, a number of accidents have taken place in the Baltic Sea. The Finnish Institute of Marine Research thinks large-tonnage tanker navigation under Arctic conditions will develop without proper training for shipping crews. It points to insufficient emergency services in the event of a sea accident. And it is largely unknown how crude might affect ice-associated organisms long-term.

Studies by the Arctic Operational Platform (ARCOP) show that the biggest risk in the Barents Sea is an accident involving an ice drift. ARCOP has calculated that the probability of a tanker running aground after a collision is 0.5%, over a 20-year period. During the pack ice season, a spill through the ice cover would form oil lenses and large sheets underneath the surface. The oil would fill ice cracks and be sealed in during new ice formation. As long as the ice does not melt, weathering processes are slow.

However, global warming patterns already affect the Arctic. Sightings of commercial species like salmon are being made well north of traditional feeding/breeding grounds, with implications for human consumption. Chemical processes have a bio-magnification effect in the food web. An oil spill would affect ecosystems on top, inside and below the ice. Birds and mammals would suffer mostly from thermo-regulation, while hydrocarbons would inhibit the growth of vital phytoplankton.

If Indiga port goes online, the transportation corridor would link Murmansk to Indiga, Varandey and Dikson. Given the lack of environmental controversy surrounding Indiga, this is bad news. Transneft is pushing the project at all costs and tends to steamroll criticism arguing its environmental standards are the highest in the world. This is certainly false at the enforcement level.

With the completion of the third stage of the Baltic Pipeline System, two to three 120,000dwt tankers will load at Primorsk every day. Transneft points at the fortified steel that it has used along the 130km pipeline segment underneath the Neva River in St. Petersburg. But trumpeting stringent requirements at other projects says little about Indiga.

A large unknown is the threat of a sea collision involving one of the nuclear-powered icebreakers. Radiological fallout is a serious concern given winter access difficulties at Indiga Bay. Transneft needs to consult with waterway risk analysts to determine tanker specifications and their atomic piloting vessels.

A Comparison to Primorsk

Primorsk was designed to free Russia from dependence on the Baltic republics. After the breakup of the Soviet Union, Russia was left without an export terminal in the Baltic Sea. The Baltic Pipeline System is not devoid of economic logic; expanding capacity here can be achieved with relatively little investment. Financing is possible through retained earnings and a so-called *investment tariff* applicable to domestic oil companies. But Primorsk is far from ideal because it faces the same types of constraints as the Bosphorus: tanker size and market access.

Primorsk is also more expensive due to winter ice locking. On average, ice cover in the eastern Gulf of Finland lasts from December to April. Ice in the Baltic Sea can effectively double or triple shipping costs. Average thickness is 40cm, although in the winter of 2002-2003 it reached 60cm. Winter tolls at Primorsk in 2002-2003 were $18 per ton ($2.47/b), versus $5.80 per ton ($0.79/b) during the summer. Tanker-loading fees and transshipment tariffs, as well as port fees are subject to policy agendas. Incidental costs include entrance and exit fees.

The St Petersburg seaport administration is responsible for icebreaker support in the eastern Gulf of Finland. St Petersburg has a fleet of 7 icebreakers. The Ministry brought in an additional icebreaker from Russia's Far East in 2004 to keep up with demand at Primorsk. However, Fortum Shipping, a Finnish energy services company, controls most of the Baltic Sea's 1A extra-strength tankers. Russian oil companies depend on its fleet of 30 ice resistant tankers (most are double-hulled) for periods of severe ice. For example, from February 1 to May 20, 2003, only 1A tankers were able to berth at Primorsk.

Icebreaker fees at Primorsk and Murmansk are approved by Russia's Anti-Monopoly Ministry. In November 2001, fees were set at $0.07 per meter of vessel volume for entrance and exit between December 1 and April 30. Vessels with extra safety features, such as double hulls, were charged only 85% of the rate. For a tanker with a volume of 220,000 cubic meters, an overall Primorsk entrance fee would be $15,400 in winter and $3,300 in summer. The same rate is applicable for port exits.

Baltic vs Barents

Transneft is unhappy about competition prospects from the Barents Sea. In a high-case scenario, CERA experts believe there would be enough oil crude to fill capacity at Primorsk (32mt/yr or 640,000bd), as well as at the proposed Murmansk export terminal (150mt/yr or 3mbd). In other words, Transneft does not need to play a zero-sum game with Russian producers because the benefits would multiply.

In essence, Primorsk does not add net export capacity, but simply diverts it away from terminals in non-Russian territory, mainly Ventspils (Latvia). The Baltic Pipeline System takes a larger share of overall flows reducing deliveries to other export points. It avoids costly transit fees, but slaps on a new cost structure related to winter ice.

An export terminal in Murmansk would guarantee access to North American markets year-round. Transportation costs to the U.S. would be $24.70/barrel compared to $29.50 from ports like Novorossiysk in the Black Sea. Russian crude would take 9 days to reach North America, much faster than Persian Gulf or West African routes.

The theoretical advantages of a Barents Sea outlet include a doubling of export capacity. Crude can be loaded directly onto ocean-going tankers at Murmansk (but not Indiga). A terminal in the Barents Sea would also preserve West Siberian crude quality, avoiding a mix with heavier grades from the Urals-Volga region.

There is no reason why Transneft cannot build Murmansk on its own. However, the Russian Federation has concluded that it is a secondary priority after investing in the Baltic Pipeline System. According to CERA, this reprioritization is due to skepticism about future production growth. Private oil companies tend to forecast higher growth rates and routinely over-report oil reserves.

Lukoil, Yukos, Sibneft, Surgutneftegaz and TNK-BP agreed in July 2003 to finance a Transneft feasibility study for Murmansk. Each consortium member guaranteed crude supplies to fill the pipeline and committed to financing construction. Estimated costs for the Murmansk project were projected at $3.4-4.5bn, with initial capacity of 80mt/yr (1.6mbd). It would have been the largest private oil transportation node in Russia.

Conclusion

Russia will need over 150mt/yr of new export infrastructure within a decade. The country has three outlets for crude: the Baltic Sea, the Black Sea and the Druzhba pipeline. The port of Primorsk in the Baltic Sea will soon displace

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Factors Behind the Recent Increase in International Oil Prices

By Ali Hussain*

In light of the significant rise in the price of oil over the past two years, people in the international oil market are surprised that the demand for oil remains high and why oil production has not increased sufficiently to meet the rise in demand.

To answer these legitimate questions one should consider the following:

1. The most important factor behind the increase in oil prices during the last two years has been the rapid increase in the growth of the world economy which was about 4% annually. This rise included an important annual increase in the growth rate of the U.S. economy, 4%, China, 9% and India, 6%. It is true to say there is always a strong correlation between the economic growth rate and the demand for energy including oil.
2. International oil prices are also affected by expectations of future oil demand. Therefore, when an international organization, such as the IEA, predicts that the demand for oil will tend to increase by about 40 m. b/d in the next 25 years, this prediction gives rise to speculation about future increases in oil prices, which in turn helps keep these prices at their relatively high levels.
3. Due to the fact that oil is a strategic commodity and in the fields of lubricants, transportation and petrochemicals, oil can not be replaced with alternatives, the demand for oil is relatively inelastic. In other words, the increase in the price of oil does not bring with it a similar decline in demand. Therefore, as oil prices in real terms increased significantly, the demand for oil remained relatively high. This is why Goldman Sachs stated in its recent report that a price of $105 per barrel is necessary to cause a significant decline in the demand for oil.
4. It is useless to continue talking about nominal oil prices which have little value in real life in so far as their effect on demand. Let us take just one of the factors which has a negative effect on the real price of oil and that is the value of the U.S. dollar which is used to price oil in the international market. During the last two years the U.S. dollar fell significantly vis-à-vis some major currencies such as the Euro, the Yen and the Pound Sterling. During this period the U.S. dollar fell by more than 30% against the Euro. Consequently and due to this factor, during the last two years the real price of oil to the Euro zone countries has declined by more than 30% compared to its nominal price. In other words, the burden of higher nominal oil prices on the euro zone countries has not been so severe and in fact has been reduced during this period by 30%. Also during the same period the U.S. dollar fell against other major currencies such as the Yen and the Pound Sterling which also reduced the real price of imported oil to Japan and the U.K. by the same percentage of the decline in the U.S. dollar vis-a-vis their currencies.
5. As far as oil producing countries are concerned, a lower real price of oil due to the fall in the value of the U.S. dollar, together with imported inflation, has always had negative effects on their economic performance. This is due to the fact that oil producers who receive their oil revenues in the U.S. dollars have always been obliged to pay higher prices for the goods and services these countries import from the countries whose export prices increased as the U.S. dollar fell against their currencies. As major oil producers are developing countries that need significant investments to develop their economies, the decline in the real price of oil in the international market has had a big negative impact on their economies and consequently left a lesser amount of investments in these countries to be used for the expansion of their oil production. This is one of the factors which forced OPEC countries to maintain oil production capacity at 32 m. b/d since 1973 until now. Consequently during the last two years as oil demand absorbed more oil, the surplus capacity of major oil producers was reduced to almost 1.5m. b/d. This situation in turn made oil supplies less secure and kept oil prices at high levels.
6. Another factor which kept oil prices relatively high in the last two years was the type of crude oil demanded in the international oil market. During this period of time, the market has witnessed a significant increase in the demand for light crude oil. The main reason for this is the increase in the demand for light oil products, particularly in the U.S. In addition, and sometimes for environmental reasons, the demand for light crude has been high in other countries including China and India. As producing light oil products from heavy crude is expensive and requires special refining technology, the demand for such crude did not keep pace with the demand for light crude. This is why the surplus capacity in Saudi Arabia of 1.5 m. b/d, most of which is heavy crude, did not have a great influence on the price of oil in the market.
7. Oil prices have been kept up in the last two years due to speculation. Speculation in the form of using hedging and mutual funds in oil futures encouraged speculators to capitalize on the conditions in the oil market to gain some profits. Therefore, such investments in huge amounts (i.e., in billions of U.S. dollars), played a major role in keeping international oil prices at relatively high levels.
8. Security concerns and uncertainty of future oil supplies also helped to increase the demand for oil and hence played a role in the rise in oil prices. For example, some major oil producing countries such as Saudi Arabia, Iraq, Nigeria and Venezuela witnessed some security problems during the last two years. As a result and in order to secure enough oil supplies for the future, oil consuming countries have been willing to pay higher oil prices.

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Global Challenges in Energy

By James P. Dorian, Herman T. Franssen, and Dale R. Simbeck*

Introduction: An Increasingly Complex Industry

By 2030, the world is projected to consume two-thirds more energy than today, with developing countries replacing the industrialized world as the largest group of energy consumers. Fossil fuels, including oil, coal, and gas, will remain the dominant sources of energy, accounting for more than 90% of the projected increase in demand, according to the International Energy Agency (IEA) of Paris (2004). Owing to its relative abundance and environmentally-friendly character, natural gas will be the fastest-growing fuel, estimated to double in volume over the 2000-2030 projection period. Oil consumption will continue to rise, with much of the increase in demand geared to the transport sector. Renewable energy will increasingly contribute to electricity generation, though wind and biomass will expand from an extremely small base.

Over the next few decades four key challenges will confront the world's energy industry—challenges which will require significant government initiative and industry innovation to overcome. These include growing oil scarcity, achieving energy security, combating environmental degradation, and meeting the growing needs of the developing world. Other challenges certainly exist. Clearly, though, sometime during the first half of this century a transition from fossil fuels to a non-carbon based world economy will begin, seriously affecting the kind of environment future generations will face. While science may suggest the optimal time for the transition to begin, economic and political influences will play an even more pivotal role.

Future Challenges

Growing Oil Scarcity

In 1956 M. King Hubbert predicted that U.S. oil production would peak at about 1970 and decline thereafter—he was right. A debate today is over the timing of an inevitable peak of world oil production, with pessimists suggesting 2010 is a likely target, while optimists cite new non-conventional sources of oil such as heavy oil, tar sands, and shale oil, and predict the peak will not occur for at least 30-40 years. In either scenario, the world will face declining oil production sometime in the next few decades.

Optimists believe that improvements in recovery technology and discoveries of new reserves will keep global oil output growing for the foreseeable future. The pessimists view was bolstered in 2004 when questions were raised about Saudi Arabia's national oil reserves and whether or not major fields are peaking. The actual timing of a peak in world production will probably fall in between these scenarios, but of greater concern for the immediate future is *produceability* and *accessibility* to oil fields. The problem may not be lack of conventional oil resources in the world, but developing and producing the resources. The physical resources in place are only one factor, while accessibility to those resources, which in part may depend on opening up to international oil companies and the attractiveness or unattractiveness of fiscal regimes, is another determining factor.

To put global oil needs in context, if the world's economy grows as expected over the next two and one-half decades, oil demand is projected to rise from nearly 80 m b/d today to just more than 120 m b/d by 2030, or more than 50% greater than today. Where will the additional oil come from? The OPEC nations are currently operating at near full capacity and are finding it difficult to meet rising worldwide oil demand causing record high prices. Surging economic growth in China is responsible for nearly one-third of recently escalating demand for oil, and consumption in the country may rise from 6.3 million b/d to around 13 million b/d or more by 2025, according to the U.S.-based Energy Information Administration (EIA) (2004). Other industrializing countries, especially India and other emerging Asian economies, have become major consumers of oil, but even demand growth in the U.S. may be two to three times higher than Europe's based on EIA projections.

If the optimists are right, the supplies of oil needed to satisfy growing world demand will be made available due to a combination of price and technology incentives, but how produceable and accessible these reserves are remains a key concern, given that newly identified reserves are also associated with significant technical, economic, commercial, and political risks.

Outside of Saudi Arabia, which holds the most reserves of any country at 260 billion barrels, Iraq contains an estimated 115 billion barrels ranking second, but supplies are constrained with continuing security concerns. In the immediate term it is necessary to search elsewhere for new oil supplies, including the West African nations of Angola, Equitorial Guinea, Nigeria, and Chad, where oil production may rise from 4 mbd to 9 mbd by 2030. The Caspian region too is expected to increasingly contribute to world oil output over the next two decades, where proven reserves of Azerbaijan, Kazakhstan, and Turkmenistan top 30 billion barrels, or the equivalent of the North Sea deposits already extracted. Russia also is aiming to become a 'surging producer' of oil, with ambitions to increase output from almost 8 m bpd to as much as 10-14 m bpd by 2020.

Importantly, as costs and, therefore, prices of oil continue to rise as remaining reserves are more difficult to find

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and develop, other energy forms including renewables and ultimately hydrogen will become more competitively priced, greater efforts will be made towards conservation and increased energy efficiency, and a transition away from oil will occur before the world runs out of the resource.

Security of Supply

Before oil production peaks in the world, a more immediate concern to many nations will be security of supply of transported energy. The critical linkage between energy and economic growth and employment has led many countries to seek secure and reliable supplies of energy through various means including diversification of oil supply sources, achieving a more balanced energy mix, and energy conservation. Concerns over global terrorism have exacerbated ambitions for security of supply. Broadly speaking, a government enhances its own country's energy security by ensuring a reliable supply of energy resources at reasonable prices to support the domestic economy and industry. However, governments define energy security differently across the globe, and the means by which they seek to enhance their own security varies even more widely.

In an era of terrorism and continued heavy dependence on Middle East oil and ultimately gas, concerns over energy security will clearly influence the direction of future world energy trade and production. Concern over security will likely increase as energy supplies become more costly and continued economic growth in such countries as China, India, and Brazil eat into available supplies. China, for example, attempting to diversify its oil supply sources for security reasons, now imports oil from more than twenty countries around the globe. The country may build a blue-water navy in part to safeguard its oil import shipments. To shift emphasis toward domestically-produced energy, China recently announced the most ambitious nuclear development plans anywhere in the world, the construction of 24 to 32 new nuclear reactors by 2020.

So important is the concern over energy security that a sense of urgency or even panic exists in some countries leading to uneconomic or risky investments in an attempt to gain access to energy. Pursuits for new energy supplies have also led to geopolitical competition over resources. For example, Japanese and Chinese efforts to convince Russia to move East Siberia oil to either Daqing, China or Vladivostok, Russian Far East, where it could be exported to Japan. Japan's interest in the Siberia field for its own energy security is so pronounced that the country has offered billions of dollars towards 'social projects' in Russia as enticement for the Putin government to choose the Pacific coast route.

Looking to the future, energy security concerns will influence the world energy industry in a number of ways including:

- An effort away from Middle East oil due to perceived threats.
- A movement toward domestically produced or available resources including nuclear power and coal (combined with CO_2 sequestration).
- A movement toward energy conservation, improved efficiency and increased use of renewable energy to reduce reliance on fossil fuels.
- Increased reliance on advanced energy technologies including for vehicles, ultralight diesel powered hybrids, for power generation, combined cycle heat and power systems and distributed generation.
- Building new global alliances between producer and consumer countries like the recent Iran-China agreements under which China plans to purchase $50 billion worth of Iranian oil and gas; in return, Iran can expect China's support in the United Nations' Security Council.

Building Sufficient Infrastructure

Infrastructure bottlenecks are commonplace today in the world energy industry, particularly in oil and gas. The exploration for new energy supplies and particularly hydrocarbons has taken international companies to remote regions with little access, including West Africa, Siberia, and the Caspian Sea Region. Building sufficient infrastructure to move the resource from source to market will require trillions of dollars alone over the next 30 years. In this context, energy supply may not be as much a problem as development and expansion of infrastructure.

Much of the West including the United States is expecting Russia to initially expand and after 2010 maintain oil production sufficiently to challenge the dominance and influence of OPEC. But, with Russia's interest in high oil and gas prices to enhance the power of the state and diversify the economy, Putin's current Russia may become a defacto OPEC member in the future. Moreover, unless oil and gas export capacity in Russia and other parts of the Former Soviet Union are expanded, any new oil and gas supplies coming out of the region will be constrained. In addition to capacity bottlenecks, political, economic, and logistical factors are all complicating new efforts to move the oil to European and perhaps ultimately U.S. markets.

In Central Asia, vast oil and gas resources are constrained mostly to the old Soviet pipeline network in and out of Russia, and the only new route which avoids Russian territory is the Baku-to-Ceyhan oil pipeline, which took years of U.S. leverage and delicate negotiations to move forward. The Baku-to-Ceyhan pipeline is outside of Transneft's control but the pipeline crosses Russian territory and the oil is shipped from a Russian port.

Natural gas was for decades a local or regional industry but is now rapidly becoming a global industry. Plans are to move supplies as much as 10,000 miles from source to consuming center requiring, according to many experts, the most complex supply chain in history. Nearly half of all investment in global gas development over the next three decades will be directed toward infrastructure improvement and expansion, including LNG tanker ports and re-gasification terminals located along coastal areas.

The Cambridge Energy Research Associates (February 2004) predict that over the next 8 years, the world's gas industry will expand as much as it did during the past 40 years. This *40 in 8* campaign is meant to satisfy the strong movement towards gas—a cleaner fuel than oil—throughout Asia and in the United States. China alone has plans for as many as nine new LNG terminals this decade, which would cost billions of dollars.

Environmental Degradation

The world energy economy is carbon-based, with oil gas, and coal accounting for 88 percent of global primary energy consumption. Heavy reliance on fossil fuels is in fact nearly two centuries old, preceded by the wood-burning, deforestation era of the 1600s-1800s. Such a long history of fossil fuel dependence indicates how difficult a transition to a non-carbon based economy would be. Clearly, such a transition would be revolutionary in scope, and necessarily involve almost unprecedented commitments and actions by government and industry throughout the world. Yet, given the increasing levels of SO_x, NO_x, carbon, and other pollutants emitted through the burning and utilization of fossil fuels, a transition to non-carbon energy is inevitable, though the exact timing is subject to debate.

What is pushing the debate to new levels is commitments made by Europe, Japan, Russia, and other signatories of the Kyoto Protocol, which requires significant reductions in CO_2 emissions. While initially carbon trading will help signatories move towards their CO_2 reduction targets, in the end, these ambitious targets can only be achieved through major efficiency and conservation gains. Importantly, the longer plans and policies to facilitate this transition are delayed, the more costly and difficult they will be to implement.

Making Renewables Competitive

Record high oil prices and increasing environmental awareness are boosting interest in renewable energy, but no rapid transition from fossil fuels is expected worldwide. Renewable energy—including solar, wind, and geothermal—provides just 3 percent of current world energy demand, excluding biomass. The relatively high costs of most renewables, lack of government-provided economic incentives, and easy access to oil, gas, and coal hinder growth of renewables. Research continues, however, around the world, as many renewable and alternative forms of energy supply are still at the stage of research and development. Over the longer term—perhaps 20 or 30 more years—renewables will likely make a more significant contribution to world energy supplies in volume terms as technologies become more cost competitive with oil and environmental concerns rise. The IEA (2004) projects that by 2030 renewables will provide about 4 percent of total demand (excluding biomass).

While most observers agree that renewable energy is more environmentally-friendly than fossil fuel and beneficial to enhance energy security, except in some local or regional markets, the contribution of renewables remain limited in use. Why?

An obvious first answer is that the cost of a unit of electrical output generated by solar, wind, or geothermal generally exceeds that of oil-, coal-, or gas-fired electricity. Until the costs become more competitive with fossil fuels, their use will remain limited.

In addition to costs coming down for renewable energy technology, governments can improve the prospects for renewable energy development through tax credits and other economic incentives effectively lowering the costs to consumers. Hawaii, for example, has the largest penetration of installed solar hot water heating units per capita within the United States in large part due to a 35% tax credit to residents who purchase passive or active systems. After a few to several years, solar water heating units more than pay back their investment.

In light of the current security risk premium of several US dollars on a given barrel of oil, a renewable energy tax credit can be viewed as a *risk reducer*, because of the resulting drop in reliance on imported fossil fuels and seriously polluting energy forms. The same could be said for CO_2 avoidance credits, used to help expand enhanced oil recovery.

But any increase in the contribution of renewable energy to the world's primary energy mix will be from a small base and have relatively little impact on world energy use. If for example, there is 20 percent growth in wind and solar for 20 years, the combined contribution will still be less than 1 percent of the world's energy.

Nuclear and Hydrogen

In addition to renewable energy forms, nuclear power and hydrogen could constitute a rising share of the world's energy needs by 2030 and beyond. Notwithstanding the problems with nuclear power in the 1970s and 1980s, most energy officials today agree that the use of nuclear energy—to supplement conventional energy—must be revisited in many parts of the world, particularly in light of CO_2 restrictions inherent in the Kyoto Protocol. China, for example, being so heavily dependent on coal, is perhaps the most suited country in the world for nuclear power given its growing energy needs and poor air quality, assuming the safest most technologically-advanced reactors are employed.

Other options for producing electricity for homes and cars include the use of fuel cells, which convert hydrogen and oxygen into water, and in the process produces electricity. While there are many different possible scenarios for vehicle transportation in the future, most long-term visions of global transport systems beyond 2025 feature the eventual emergence of a fuel or *energy carrier* that is non-carbon and derived from processes that do not produce carbon. Hydrogen—the lightest and most abundant element in the universe—can be derived from a variety of primary sources, including fossil fuels, renewables and nuclear power and can be used in mobile and stationary applications. Hydrogen would become the stored fuel used by fuel cells in the vehicle to generate power, and with only water as an emission. While attractive from an environmental and energy perspective, hydrogen is inherently expensive and inefficient to produce, transport, store, and distribute—thus technological breakthroughs will be needed to reduce the overall costs of using hydrogen as a transport fuel. Hence, the future contribution of hydrogen as a transportation fuel is by no means assured. Other energy carriers are also being considered for fuel cells, including di-methyl ether (DME), methanol, ammonia, and syngas.

Energy and the Poor

Over the next few decades the energy thirst of the industrializing, developing world will continue to grow to meet the expectations of rising living standards and fuel economic growth. Developing countries will use any form of energy to create economic growth even if the use of energy is associated with growing local and regional pollution. Once standards of living improve such as today in Chinese and Indian cities, environmental requirements become increasingly important. Vast volumes of clean energy at affordable prices will be required to curb environmental degradation and help countries in Asia, Africa, and elsewhere move towards a path of economic prosperity. Electricity is the foundation of modern society, yet according to the IEA (2004), more than 1.6 billion of the world's population remains without power today, limiting economic prospects, adequate health care, and communications. A majority of the people who currently lack electricity live in South Asia and sub-Saharan Africa. The linkage between lack of energy and poverty is so overwhelming in some parts of the world that the World Bank and Manila-based Asian Development Bank have devoted large parts of their programs to alleviate the problem.

With a world population expected to reach 8 billion persons by 2030, increasing energy availability for the poor will be critical to maintaining economic growth, jobs, and health care to an aging population. Without major government incentives, roughly 1.4 billion or 18% of the world's population will still be without power in 2030, despite global economic expansion and advances in energy technologies. Poor people living in most developing countries rely on traditional biomass—wood, dung, and agricultural residues—for their basic energy requirements, leaving many of them ill from the inefficient use of biomass fuels.

China's Unstoppable Thirst

No country will have more impact on the future world energy industry than China, with 1.3 billion persons now and a rapidly growing economy (Table 1). China surpassed Japan last year as the second largest consumer of oil behind the United States, and the Asian giant is currently the largest producer and consumer of coal. On its present course China may approach the United States in carbon emission levels by around 2025, with 6,700 million metric tons of carbon dioxide projected to be released that year, according to the EIA (2004).

In the early 1990s, China's leaders abandoned any thoughts of energy self-sufficiency, recognizing that the country's demand for energy was far surpassing domestic output capability. As such, Beijing began to search for new supplies of energy in neighboring Russia and Central Asia, as well as far off areas like Sudan and South America. Today, the country is depending on new supplies of pipeline oil and gas from East Siberia, Russia to supplement its energy requirements for the next decade. If the Siberia to China oil and gas pipeline projects never materialize, China will have to seek new sources of energy elsewhere and perhaps through other means.

Table 1
The China Factor

- China's soaring economy is running up against constraints as demand for energy is outpacing supplies.
- China plans to double energy consumption between 2000 and 2020 to support a quadrupling of economic growth during the period.
- China's vehicle fleet may increase from 20 million to as many as 200 million vehicles by 2025 under present trends, placing additional strains on world oil supplies.
- China is now the world's second largest user of oil after the United States, and China is likely to provide the largest increment in world oil demand growth through 2020.
- China's heavy dependence on coal will remain in tact for decades given the country's limited oil and gas supplies and coal's dominant role in power generation, contributing to poor air quality both inside and outside of China.
- On its present course China may approach the United States in carbon emission levels by around 2025.
- China has ambitious plans to boost renewable energy use that include raising wind power generating capacity by nearly one hundred-fold by 2030.
- Despite a planned dramatic boost in nuclear power generating capacity to 2020, the contribution of nuclear to China's overall energy mix will still likely be below five percent by the end of the next decade.
- Looking to the future, China is actively pursuing research and development on hydrogen fuel cells for use in transportation and localized power.

China's future raises several questions about future energy use worldwide:

- If Russia's gas and oil export projects to China are not realized, how will China cope?
- Could innovative and aggressive public transportation development, electrically driven transportation systems, the use of hybrids or diesel vehicles considerably slow oil use in the country? How effective will new fuel economy standards be?
- Will current problems in coal and power generation constrain future economic growth?
- Are there still meaningful efficiency and conservation gains to be achieved in the Chinese energy economy?

Rising Vehicle Use

Transport demand, mostly for oil, will grow more rapidly than consumption in the residential and services sectors, and overtake industry sometime after 2020 as the largest final-use sector, according to the IEA (2004). Nearly half of world oil consumption is dedicated to the transportation sector, and barring any breakthroughs in advanced transportation technologies, such as hydrogen fuel cell vehicles, alternative fuels including gas-to-liquids, coal-to-liquids, and biodiesels, are not likely to make a significant inroad in the conventional transportation fuel market before 2030 except on a regional basis. The outlook for alternative fuels could however become slightly more favorable if global oil production does plateau sooner than expected or concerns over national security increase.

While transport demand will rise everywhere, the fastest growth will be in the developing world, notably China, India, and other Asian economies (Figure 1). Goldman Sachs (October 2004) recently predicted that if present economic and car ownership trends in China continue, more than 180 million new cars could be added to the current fleet by 2025, placing additional strains on world oil supplies. In 2003, passenger car sales rose 75% in China, and the country is on the cusp of dramatically soaring vehicle sales as incomes rise and consumer credit is made more readily available. Like China, India is poised for rapid growth in vehicle use through 2030, and Asia's mid-sized markets, including Thailand and Indonesia, are also projected to post strong growth.

The expected growth in oil consumption for transport use in coming decades could be slowed with the penetration of advanced transportation technologies, including gasoline-powered electric hybrids and advanced diesel engines, though governments worldwide will need to take unprecedented policy actions to promote their use. Ultimately clean diesel-powered hybrids may offer even greater fuel efficiency and reduced carbon emissions. Currently there are about one-half million hybrids and 30 million advanced cleaner diesel engines globally, with hybrid use growing in the U.S. and Japan and advanced cleaner diesels mostly concentrated in Europe. Increasing concerns over high oil prices, oil supply shortages, air pollution, and energy security may prompt many nations to further promote fuel efficient cars and improved public transportation. If the Chinese become committed to improve fuel use efficiency through gasoline-hybrids or diesel with or without hybrids, production costs of gasoline and diesel hybrids may follow the path of consumer electronics bringing vast volumes of less expensive product on the world market.

Figure 1

Vehicle use in China and many other developing countries is expected to rise dramatically over the next two decades, placing additional strains on the global oil industry.
Location: Shanghai, China

Cross-Cutting Issues

Rising Capital Needs

If current trends continue, the world will need to spend an estimated $16 trillion over the next three decades to maintain and expand energy supply, according to the IEA (2003). Electricity generation, transmission, and distribution will absorb almost two-thirds of this investment, while capital expenditures in the oil and gas sectors will amount to almost 20 percent of global energy investment. While the world energy industry met its financial challenges during the past three decades, competing needs for domestic investment to 2030 including in health services for an aging population in Asia, the United States, and Europe, environmental clean-up, and infrastructure expansion, will likely lead to difficult decisions governments will have to reach. Meeting this financial burden will be especially challenging to the developing world, where investment needs are typically larger than in North America or the European Union in terms of absolute dollar levels and relative to the sizes of their economies. Many African nations and India for example will require huge investments in power generation and transmission, though only deep reforms will lower barriers to investment and improve the investment climates.

Over the longer-term, plans to dramatically expand the worldwide LNG market will be extremely capital intensive, requiring the development of reserves (often in remote regions), liquefaction facilities, transportation, and marketing through re-gasification plants. Development of non-conventional hydrocarbons including heavy oil deposits in Venezuela, oil sands in Canada, and gas-to-liquids in Qatar will require major companies to mobilize substantial capital resources to proceed with very large-scale projects.

Foreign investors in oil will face a world of declining supergiant fields and a shift toward less accessible and more costly reserves in parts of the Former Soviet Union, Asia, and Africa, as well as offshore regions in West Africa, the Pacific

Rim, and ultimately Antarctica. If global oil prices remain relatively high during this decade, producers in many countries may expect and demand greater financial concessions from buyers, leading to lesser attractive investment climates. Expenditures in new oil exploration activities did not rise significantly in 2004 despite the higher oil prices, as many oil corporate leaders still remember the unexpected price declines of the 1980s, which resulted in lower rates of return on many of their investments.

The Misinformation Phenomenon

Trillions of dollars and millions of jobs are tied to energy production and utilization activities worldwide and, as a result, information released through publications, speeches, advertisements, or other venues can be misleading, misinterpreted, or just plain wrong, depending on the vested interests of the messenger involved, level of expertise, and a host of other factors. Without placing blame, this *misinformation phenomenon* has led to uninformed or poor decisions being made by governments and industry alike, resulting in billions of dollars sometimes being used in inefficient energy activities. Examples could include the continued use of traditional, central electric power plants in many parts of the world—as compared to higher efficient and less polluting cogeneration facilities—because regulated utilities earn returns on their investment regardless of how efficient their plants are. In many areas regulated utilities view the cogen plants only as competition, rather than a technological improvement that may be worth pursuing. Cogen facilities using improved intercooled gas turbines at high power to heat ratio can be twice as efficient as central power plants.

Significantly, when looking to the future, the misinformation phenomenon will serve as a drag on any transition because of short sightedness, unwillingness, or inability to make a change.

Conclusions: A Look Ahead

Key decisions will have to be made by governments and the energy industry worldwide over the next few decades on how best to confront growing pollution caused by continued use of fossil fuels and how to facilitate an eventual revolutionary-like transition to a non-carbon based global economy. Governments will be faced with choices as to the level of financing and economic incentives to commit towards promotion of energy efficiency and conservation, more advanced energy technologies, and environmental clean-up as well as on the extent of cooperation needed between nations to facilitate a smooth transition away from fossil fuels. Energy companies will need to revamp their research and development and investment strategies to coincide with changing consumer preferences and government policies. Clearly, the sooner these decisions are made the less difficult and costly the choices will be.

While the world will not *run out of oil* for both technical and policy reasons, it is reasonable to assume that global oil production (including Canadian and Venezuelan extra heavy oil) may peak sometime in the next two decades. Even before that happens, large investments will be required in infrastructure to unlock liquid hydrocarbons in hostile environments such as ultra deep water, the offshore arctic, and in remote areas of Canada and Venezuela where much of the extra heavy oil resources are located. The increased use of fossil fuels will inevitably result in more air and water pollution and rising global CO_2 emissions. China, with surging use of energy and particularly coal, may well be on a path to surpass the United States as the largest single source of CO_2 emissions within the next two decades.

Whichever non-fossil fuel path is ultimately chosen in the world, a transition will take years to complete and cost trillions of dollars. Cities may need to be redesigned, and infrastructure revamped to accommodate new modes of transportation. Before that change is likely to occur, technological advances must be encouraged by government policies and incentives to increase energy production and maximize the efficient use of energy, particularly in the transportation and electric power generation sectors.

References

Cambridge Energy Research Associates, February 2004, "CeraWeek 2004", Houston, Texas.

International Energy Agency, 2004, *World Energy Outlook 2004*, Paris, France.

International Energy Agency, 2003, *World Energy Investment Outlook 2003*, Paris, France.

Energy Information Administration, 2004, *International Energy Outlook 2004*, US Department of Energy, Washington, D.C.

Goldman Sachs, October 2004, *Global Economics Weekly*, "The BRICs and Global Markets: Crude, Cars, and Capital," Issue No. 04/36.

International Oil Prices *(continued from page 10)*

9. Finally it must always be remembered, expanding the production of crude oil and oil products is not an easy task. The oil industry is a capital intensive industry. It needs a lot of equipment, machinery, etc. It also requires exploration, drilling, pipelines, terminals, tankers, refineries, distribution and marketing facilities. Therefore, to expand oil production, even in oil rich countries with plenty of oil reserves, requires huge investments in billions of U.S. dollars. For example, in September 2004, Mr. Saeed Khori of Abu Dhabi Onshore Company (ADCO) estimated that the Gulf countries' investments in oil, gas and petrochemicals in the next 20 years will amount to $300 billion. In addition, the lead time in the oil industry is relatively long as it may take 3-10 years from the time oil is found to the time when oil products are delivered to the final consumers. Therefore, oil supplies are inelastic. In other words they do not respond easily and quickly to higher oil prices.

Due to above factors international oil prices will remain volatile for some time to come. The only way to stabilize the market is through a meaningful and serious dialogue between oil producers and oil consumers to arrive at a price which must reflect the real value of oil in the international market.

The Tribological Role of Energy Efficiency Within Society

By Matthew T. Siniawski *

tribology - tri·bol·o·gy, *n* the science of the mechanisms of friction, lubrication and wear of interacting surfaces that are in relative motion.

Introduction

Humankind has always relied upon tribological knowledge to help address and solve current issues and problems that each individual society and civilization has faced. The tribological knowledge that arises during specific historical times is typically problematic based. Problems and issues exist and direct practical solutions arise after the necessary contemplation, study and research. The majority of these problems arise as the result of seeking increased energy efficiency. Efficiency is the ratio, expressed as a percentage, of the output to the input of power (energy or work per unit time) [1]. Therefore, energy efficiency gives an indication of the losses, which are negative forms of energy transformation that occur during a process. Increased energy efficiency results in economic benefits, decreases in material waste, prolonged component life, etc. For this reason, efficiency has been the target of much needed component and system design analysis. Therefore, the field of tribology deals both directly and indirectly with increasing energy efficiency.

Tribology has evolved into a sophisticated scientific field, with significant contributions for increasing energy efficiency ranging from surface engineering and materials research to lubrication improvements and complex system simulations. Significant improvements in decreasing friction and wear have directly resulted in decreased economic losses and improved energy efficiency. However, with the alarming forecasts of future energy consumption rates, significant tribological improvements are necessary for future environmental stewardship and increasing energy efficiency. The major areas where tribology can increase future energy efficiency are the transportation sector, energy production technologies, implementing life cycle analyses and the promotion of recycling.

Historical Improvements

One of the first recorded examples of the implementation of tribological solutions to an energy efficiency problem involved ancient Egypt (*c.* 1880 B.C.). The major issue involved transporting a gigantic mass over a specific distance using a given amount of energy, as illustrated in Figure 1. In order to move the mass, a lubricant decreased the effective friction, thereby substantially increasing the efficiency of the entire process. Although the simple addition of a lubricant was rudimentary in comparison with current technological knowledge, this solution was highly effective, practical and simple.

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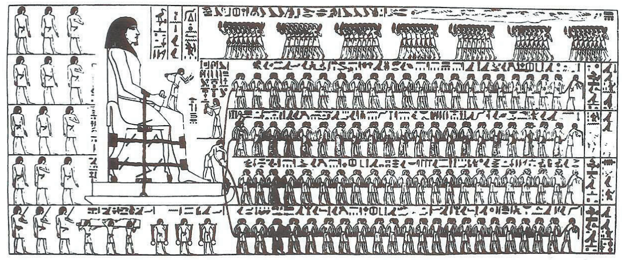
Figure 1
Transporting an Egyptian Colossus- From the Tomb of Tehuti-Hetep, El Bersheh [1]



As civilization advanced technologically, the complexity of specific problems and issues increased. Therefore, the energy efficiency related technology likewise became more complex. During the agricultural revolution, carts and vehicles in ancient China (*c.* 300 B.C.) utilized metallic bearings with lubricants and leather seals to prolong the component life and decrease friction and wear [2]. In addition, olive-crushing mills in ancient Greece (*c.* 400 B.C.) employed iron bearings to increase efficiency. One other technological advance involved using studded or rimed wooden wheels in order to decrease wheel wear during the Middle Ages. During the Renaissance period, researchers such as Leonardo da Vinci developed the first early tribological theories. During this period, many tribological improvements arose, including the use of gears, roller bearings and pulleys. With the beginning of the industrial revolution, the applications of tribological solutions increased substantially along with early scientific tribological studies.

The industrial revolution resulted in more complex bearing and steel shaft systems, cam-driven systems and more complicated lubrication uses. In addition, the rapid evolution of the steam power generation system greatly increased the complexity of the tribological field. Thomas Newcomen created the first atmospheric steam engine in 1712 for the purpose of draining a coal-mine [2]. This engine had a thermal efficiency of only about 0.5%. Throughout the industrial revolution, improvements in cylinder-boring techniques and better piston sealing increased the thermal efficiency of the steam engine to 17% by 1834.

Water-mills have provided power for over 2,000 years and supplied an especially valuable source of power to support the industrial revolution. Although windmills primarily provided power for agricultural purposes, such as grinding corn, water-wheels provided most of the industrial power. The efficiency of water-mills increased as the result of advances in bearing technology and materials selection. Around the late 1750s, John Smeaton reported maximum overall efficiency of undershot wheels of about 22% and of overshot wheels, 63% with the incorporation of cast-iron wheels replacing wooden wheels and the use of cast-iron shafts.

Windmills followed the water-mill as a source of mechanical power and provided a flexible energy alternative on sites remote from flowing water sources. The first reported windmill existed in Normandy nearly 800 years ago [2].

Similar to water-mills, improvements in materials selection and bearing design greatly improved the overall efficiency of windmills. However, the power losses from early windmill designs were considerable. Although the theoretical aerodynamic efficiency of windmills can only achieve a maximum value of 59% known as the Betz limit, the overall efficiency rarely exceeded 10% and was generally nearer to 5%. Immediately after the Second World War, Dutch engineers demonstrated that a significant improvement resulted by giving special attention to the aerodynamic performance of the sails and by using more efficient bearing systems [2]. Current wind turbine systems have efficiencies in the 40-50% range [3], which illustrates a significant improvement in windmill efficiency.

Many recent efficiency improvements have resulted from intensive tribological research. The majority of these efficiency improvements are specifically for automotive transportation. For example, recent tribological improvements in bearing design led to fuel efficient pinion bearings providing up to 2% better fuel economy in a vehicle and resulting in more than a 30% reduction in power consumption over conventional bearings [4]. In addition, at the 1997 24th annual Leeds-Lyon Symposium entitled "Tribology for Energy Conservation," Bartz presented recent information regarding fuel economy improvement by engine and gear oils [5]. Kamada et al. also reported fuel economy improvements of a passenger car equipped with an automatic transmission [6]. In addition to overall efficiency improvements in the automotive sector, one specific method of improving energy efficiency involves surface engineering of components. For example, Dearnley and Weiss presented specific methods of energy conservation through surface engineering [7], while Jones presented methods of energy conservation through extended component life [8].

Throughout the historical evolution of tribology, the main emphasis has been increasing energy efficiency. Initially, the main reason for increasing efficiency was to decrease required power input. More recently, however, an increased awareness of depleting natural resources and concerns of environmental impacts of design decisions have become important as well. Future projections of energy consumption and waste statistics indicate the necessity of increasing energy efficiency.

Current Energy Trends

Rapid increases in worldwide energy consumption and losses, along with increasing negative environmental effects, mean that increasing energy efficiency is now more important than ever. Global energy consumption has rapidly increased to unprecedented numbers over the past few hundred years. The energy consumption of the United States alone has increased by well over 100% in just the past 200 years. According to the Energy Information Administration, the U.S. alone, which is the largest consumer of worldwide energy, consumed about 98.16 quadrillion Btu (British Thermal Unit) of energy in 2003 [9], which is roughly equivalent to 17 trillion barrels of oil [10]. The future projections of energy consumption rates are even more disheartening. According to a 2004 projection, total world consumption of marketed energy is expected to expand by 54%, from 404 quadrillion Btu in 2001 to 623 quadrillion Btu in 2025 [11]. Although these energy consumption numbers are relatively large, the amount of energy that is wasted is even more disturbing.

Significant energy losses occur in the residential, commercial and industrial sectors. The amount of energy lost during the generation, transmission and distribution of energy for residential and commercial use is substantial. Energy loss statistics for industrial energy consumption are similarly disturbing. The energy losses for industrial use exceeded the total consumption of petroleum during 2000. These significant increases in energy losses are a direct indication of the failure to increase global energy efficiency.

Increased energy losses result in increased environmental pollution and decreases in natural resources. Carbon dioxide (CO_2) accounts for the largest share of combined anthropogenic greenhouse gas emissions. According to a finding by the Energy Information Administration, the 1999 U.S. anthropogenic CO_2 emissions totaled about 5.6 billion metric tons, 17% higher than in 1980 and 28% higher than in 1983 [12]. A startling fact is that nearly 99% of this total was energy-related emissions, especially from petroleum consumed by the transportation sector, coal burned by electric utilities, and natural gas used by industry, homes, and businesses [12]. Furthermore, the projected trend of emissions does not look hopeful. Increases in emissions strongly correlate with decreases in natural resources. A recent study by the World Wildlife Federation found that humanity's ecological footprint grew to exceed the Earth's biological capacity by 20% from 1970 to 2000, indicating that humanity is currently using 20% more resources than the Earth can replenish [13].

Future Directions

The American Society of Mechanical Engineers (ASME) presented an excellent strategy for increasing energy conservation, specifically through tribology, back in 1977. The objectives of this study were threefold: 1) to assess the possible impact of tribological innovations on energy conservation and on the promotion of advanced energy technologies; 2) to identify those areas where the application of existing or new tribological knowledge is expected to yield substantial benefits, whether direct or indirect; and 3) to recommend a research and development plan in the tribological sciences for possible implementation by government agencies and industry [14]. The principal areas considered by the strategy include rolling element and fluid film bearings, continuously variable power transmission, sealing technology, friction and wear mitigation, automotive engines, metal processing and advanced energy technologies. Table 1 shows a detailed summary of the potential savings of each of these items. The study also defined the benefit ratio of improving each of these areas as

$$\textit{Benefit Ratio} = \frac{1}{10} \cdot \frac{\text{Savings}}{\text{R\&D cost}}$$

Table 1
Potential Savings for Various Tribological Areas
(% of U.S. Total Energy Consumption)

Item	Estimated Savings	Non-Over-lapping Savings
Automotive Vehicle		7.4
Traction CVT	4.5	
Low Viscosity Oils with Additives	1.8	
Advanced Adiabatic Diesel	3.0	
Wear and Metal Processing		2.8
Wear	1.3	
Metal Processing	2.2	
Bearings and Seals		0.7
Bearings in Gas Turbines	0.4	
Bearings in Steam Turbines	0.1	
Sealing in Gas Turbines	0.1	
Sealing in Steam Turbines	0.1	

Table 2
Overview of Major Tribological Programs for Increasing Efficiency [14]

Program Area	Potential Energy Savings % U.S. Consumption	Potential Energy Savings Billions of 1976 Dollars Per Year	Estimated R&D Cost Millions of 1976 Dollars	Benefit Ratio
Road Transportation	7.4	11.0	12.6	87
Power Generation	0.2	0.3	2.1	14
Turbomachinery	0.5	0.75	5.2	14
Industrial Machinery and Processes	2.8	4.2	3.7	113
Total	**10.9**	**16.25**	**23.6**	

Table 2 presents an overview of the potential energy savings and the benefit ratio of the various program areas. Relatively large benefits exist with industrial machinery and processes and road transportation for increasing energy efficiency. Although this strategy was developed over 25 years ago, it represented the most appropriate and beneficial areas of tribology for increasing efficiency at that time. Since then, countless studies focused on materials research specifically for industrial machinery and processes. In addition, many automobiles now incorporate continuous variable transmissions for improving vehicle efficiency. The question thus remains: where does the field of tribology go from here?

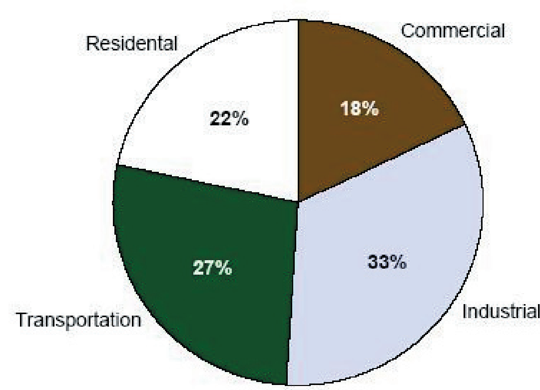
Spikes recently discussed some future challenges to the tribological community regarding energy efficient technologies [15]. One area involved developing low friction components. In particular to energy efficiency technologies, tribological issues regarding traction drives and high temperature engines are important. In addition, improvements of rolling bearing elements are necessary. Finally, Spikes recommends that for realistically optimizing the energy efficiency of complex systems, complete simulations of engines, transmissions and other lubricated systems over their entire service life is necessary. These excellent suggestions, which closely coincide with the suggestions by the ASME [14], involve some very specific tribological solutions to increasing energy efficiency. More generalized areas where tribology can increase future energy efficiency include the transportation sector, energy generation, materials related research, the incorporation of life cycle analyses and increasing recycling.

Transportation Sector

The transportation sector is one area where great potential for increasing efficiency exists, as it is the second largest consumer of energy in the U.S., consuming 27% of all energy in 2003, as illustrated in Figure 2 [9]. A 1990 study by the World Resources Institute looked at motor vehicle trends and their implications for global warming and energy strategies [16]. This study recommended four much needed major improvements in the transportation sector. The first recommendation involves improving new-vehicle fuel efficiency. The first step is to develop a better system to measure vehicle efficiency. Currently, mpg (miles per gallon) ratings measure the performance of transportation systems within the U.S. However, these ratings are under ideal conditions and are, therefore, highly misleading. A new efficiency rating system, along with a separate efficiency rating for the engine system, needs to be developed. Such a system would provide the public with more accurate knowledge of vehicle efficiency.

Tribological issues regarding alternative fuels, including liquid hydrogen fuel and bio-based fuels, such as ethanol and bio-diesel, need immediate examination. The tribological performance of these various fuels is highly important for improving the efficiency of alternative fuel vehicles. In particular, the incorporation of lubricant additives into alternative fuels needs investigation. Although there are many existing hurdles that prevent the widespread transition away from petroleum usage in the transportation sector, more tribological research using alternative fuels needs examination.

Figure 2
Breakdown of Consumption of U.S. Energy by Sector End-Use Shares, 2003



Energy Production

According to Dowson, advanced forms of windmill structures tend to hold the greatest tribological interest [2]. As previously mentioned, current wind turbine systems have efficiencies near 40-50% [3]. The area of tribology has the greatest potential to bring these efficiencies levels closer to the maximum level of 59%. Increasing the energy output capacity of wind turbine systems will decrease the usage of fossil fuel resources for energy production. Although efficiency changes from 40-50% to near 59% seem quite small for each turbine system, the overall increase in global wind energy production could increase wind energy production substantially. At the beginning of 2004, the total global wind energy capacity was 39,434 Megawatts (MW) [17]. Assuming a total efficiency of 50%, an increase in efficiency to 59% would increase the global capacity by over 7000 MW. This increase is approximately equivalent to the total existing capacity of North America (6678 MW at the beginning of 2004), which is the second largest wind energy producer in the world, surpassed only by all of Europe combined. Therefore, doubling the North American wind energy capacity through such an efficiency increase would provide a decrease on the dependence of fossil fuels by nearly 2 million equivalent barrels of oil annually. Therefore, the tribological issues related to increasing wind turbine efficiency need addressing. Some of these areas might include improved gear and bearing performance, as well as better maintenance and condition monitoring. Possible solutions include implementing ultra-low friction coatings and highly efficient lubricants.

Materials Research

Materials research and processing improvements both pose great potential for increasing efficiency. One particular area is decreasing friction and material wear through improved design of materials and coatings that exhibit ultra-low friction and wear properties. Utilizing materials and coatings with very low frictional coefficients could increase efficiency drastically. In addition, such materials could decrease the necessity of lubricants, which is another added benefit. In addition to materials research for specific high efficiency applications, the manufacturing process of such materials also is of great potential.

The efficiency of manufacturing processes varies widely, depending on the particular process, frictional conditions, die geometry and other process parameters, with typical values of 30-60% for extrusion and 75-95% for rolling [18]. There are many tribological issues involved in machining and these should be addressed to increase overall efficiency. Beynon recently presented the impact of tribological issues on energy conservation in metal forming operations [19]. The direct impact of tribology on issues such as reducing heating costs, simplifying overall processes and improving yields is not dominant, but the direct impact of tribological issues of energy conservation measures is very important. Metal working tribology, particularly for elevated temperatures, has tremendous scope for research and great potential for efficiency benefits.

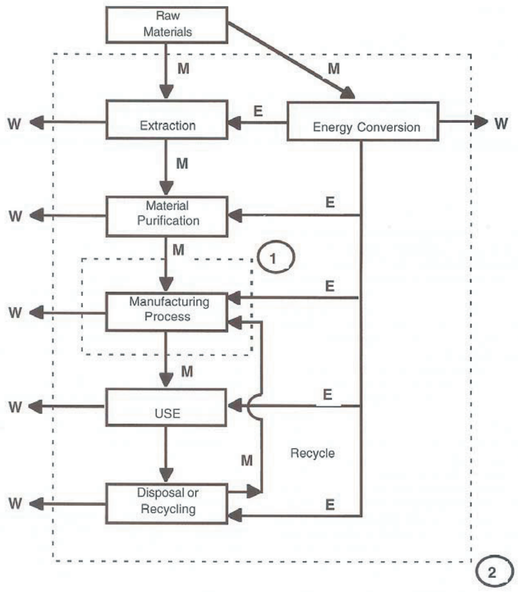
One other materials related area which has great potential for increasing energy efficiency is component condition monitoring. Condition monitoring increases efficiency by decreasing catastrophic failure that leads to increased costs in repair and machine downtime. Rajan and Roylance recently developed a mathematical model for predicting the cost of repairs for batch process machinery [20]. Such a program determines the associated cost benefits of practicing a condition-based maintenance program. Implementing such models into many tribological processes could determine the direct economic benefits and overall efficiency gains of condition monitoring. Such an analysis is one aspect now needed from tribologists looking at the larger impacts and benefits of different designs.

Life Cycle Analyses

The most common and widely used paradigm of design does not consider the entire scope of the impact of the product. According to activist David Suzuki, the producer of a product – any product – usually has no obligation to anticipate its total cost, including eventual disposal, yet that should be built into the initial costing [21]. Therefore, as available resources are rapidly decreasing and environmental effects such as pollution are now a major concern, design for the environment has become a focus. Life cycle analyses assess the full environmental implications of a product and of its benefit to society. Figure 3 shows the parameters of a typical life cycle analysis, including material input sources, energy conversion and materials processing for creation of a usable product and analysis of waste energy and losses. In terms of the tribological field, life cycle approaches provide broader insight of the effects of increasing energy efficiency through tribological improvements. Therefore, life cycle analyses convey a larger picture of the importance of tribological improvements for increasing energy efficiency. A recent study by Clift introduces how a life-cycle approach can identify the potential significance of developments in tribology [22]. Tribological improvements of many of the areas shown in Figure 3 will significantly increase the overall efficiency of any given product. However, Clift concluded that extending service life, facilitating disassembly and reuse of materials possibly play more important roles in terms of increasing efficiency than improving lubrication and decreasing friction. Therefore, future tribological goals also need to specifically address the issues of maximizing service life and reusing materials.

A recent study by Taylor, et al. investigated the long-term benefits of using highly efficient lubricants through a life-cycle analysis [23]. The authors suggested that rather than just concentrating on the initial purchase price of the lubricant, the customer should also consider the life-cycle cost of the product. This life-cycle cost takes into account the initial purchase price of the product, the effect on operating costs over the lifetime of the product, maintenance costs and finally disposal costs. For a heavy duty truck, a 3% overall improvement in fuel consumption resulted from using fuel efficient engine oil, gear oil and axle grease. This study rep-

Figure 3
Schematic of a Life Cycle Analysis [22]



1 Maufacturing Process 2 Life Cycle
M - Material flow E - Energy W - Waste and emission

resents the benefits of incorporating life-cycle analyses into all future tribological studies.

Recycling

The frequency, ease and economic incentives of reusing materials need to be increased. Recycling used oil is expensive and there is little incentive to do so when the price of refined crude oil is relatively more inexpensive. According to Suzuki, part of the problem is psychological – North Americans believe that re-refined oil is lower quality than virgin oil. Yet a study by the National Research Council of Canada showed that re-refined oil is as good as or even better than the refined [21]. In addition, Suzuki points out that another major part of the problem for re-refiners is political – all the tax incentives and subsidies go to the discovery and exploitation of crude oil. There are no economic incentive programs for the re-refiners where there should be every encouragement to conserve through recycling and to protect the environment [21]. This presents a major downfall and hurdle for the lubrication industry, which requires the direct cooperation of both governmental agencies and corporations alike. The government needs to take responsibility for promoting such incentives and the lubrication industry needs to demand such incentives. The lubrication industry needs to take the initiative and force the government to promote such measures, while tribologists need to promote the safety of using re-refined oil products and should incorporate these products whenever possible.

Conclusions

Tribology has always faced societal issues with the aim at increasing energy efficiency. Tribologists can play a key role in managing and hopefully solving the multitude of current societal issues such as global climate change, dependence on fossil fuels and diminishing natural resources through increasing energy efficiency. The areas that prove the most potential in increasing efficiency are:

1. Transportation related issues,
2. Wind energy production,
3. Life cycle analyses, and
4. Recycling.

In addition to tribological improvements in these various areas, the establishment of a regular feedback system is essential. Such feedback allows the field of tribology to examine its progress towards energy efficiency, identify the areas that need additional improvements as well as new emerging areas that pose great benefits. Such a system also provides the field of tribology with a specific roadmap of future energy efficient goals. Frequent re-evaluation of these goals allows tribologists to identify their exact roles in establishing an energy efficient future.

References

1. F.R.E. Crossley, “Efficiency,” in AccessScience@McGraw-Hill, http://www.accessscience.com, DOI 10.1036/1097-8542.213800, last modified: April 10, 2000.

2. D. Dowson, History of Tribology, 2nd ed., Professional Engineering Publishing, UK, 1998.

3. R. Boud and M. Legerton, “Wind Farm Performance,” New Review – The Quarterly Newsletter for the UK New and Renewable Energy Industry, Issue 33, http://www.dti.gov.uk/NewReview/nr33/html/wind_farm_performance.html, August 1997.

4. The Timken Company, “Timken fuel efficient bearings,” http://www.timken.com/industries/automotive/products/fuelefficient/, 2004.

5. W. J. Bartz, “Fuel Economy Improvement by Engine and Gear Oils,” Tribology for Energy Conservation – Proceedings of the 24th Leeds-Lyon Symposium on Tribology, ed. D. Dowson, 1997.

6. Y. Kamada, N. Wang, T. Kotanigawa, J. Kawabata, M. Araki and K. Mukaida, “Wet Fiction Materials for the Continuous Slip Torque Converter Clutch – Fuel Economy Improvement of Passenger Cars Equipped with Automatic Transmission,” Tribology for Energy Conservation – Proceedings of the 24th Leeds-Lyon Symposium on Tribology, ed. D. Dowson, 1997.

7. P.A. Dearnley and H. Weiss, “Energy Conservation through Surface Engineering,” Tribology for Energy Conservation – Proceedings of the 24th Leeds-Lyon Symposium on Tribology, ed. D. Dowson, 1997.

8. M.H. Jones, “Energy Savings through Extended Component Life,” Tribology for Energy Conservation – Proceedings of the 24th Leeds-Lyon Symposium on Tribology, ed. D. Dowson, 1997.

9. Energy Information Administration, “Annual Energy Review,” www.eia.doe.gov, 2003.

10. Energy Information Administration, “International Energy Annual,” www.eia.doe.gov, 2002.

11. Energy Information Administration, “International Energy Outlook,” www.eid.doe.gov, 2004.

12. Energy Information Administration, “Annual Energy Review,” www.eia.doe.gov, 2001.

13. World Wildlife Federation, “Living Planet Report,” www.wwf.org, 2004.

14. ASME Research Committee on Lubrication, “Strategy for Energy Conservation through Tribology,” The American Society of Mechanical Engineers, 1977.

15. H.A. Spikes “Some Challenges to Tribology Posed by Energy Efficient Technology,” Tribology for Energy Conservation

– Proceedings of the 24th Leeds-Lyon Symposium on Tribology, ed. D. Dowson, 1997.

16. J.J. MacKenzie and M.P. Walsh, "Driving Forces: Motor Vehicle Trends and their Implications for Global Warming, Energy Strategies and Transportation Planning," World Resources Institute, 1990.

17. Windpower Monthly News Magazine, "Wind energy facts and figures," www.windpower-monthly.com, 2004.

18. S. Kalpakjian, Manufacturing Processes of Engineering Materials, 3rd ed., Addison-Wesley Longman, Inc., 1997.

19. J.H. Beynon "The impact on tribological issues of energy conservation in metal forming operations," Tribology for Energy Conservation – Proceedings of the 24th Leeds-Lyon Symposium on Tribology, ed. D. Dowson, 1997.

20. B.S. Rajan and B.J. Roylance, Condition Based Maintenance – The benefits of counting the cost," Tribology for Energy Conservation – Proceedings of the 24th Leeds-Lyon Symposium on Tribology, ed. D. Dowson, 1997.

21. D. Suzuki, The David Suzuki Reader, Greystone Books, 2003.

22. R. Clift, "A Role for Tribology in Life Cycle Design," Tribology for Energy Conservation – Proceedings of the 24th Leeds-Lyon Symposium on Tribology, ed. D. Dowson, 1997.

23. R.I. Taylor, R.T. Dixon, F.D. Wayne and S. Gunsel, "Lubricants & Energy Efficiency: Life-Cycle Analysis," Life Cycle Tribology – 31st Leeds-Lyon Symposium on Tribology, 2004.

The Barents Sea *(continued from page 9)*

Novorossiysk in terms of throughput. But it reinforces export dependence on Europe as well as on tanker shipments. Meanwhile, the bottlenecks at Transneft have begun to cascade to GDP growth. A pipeline connection to Indiga would be less costly than Murmansk. But overall, Indiga would be the more expensive option because of severe ice conditions. If Transneft insists on Indiga, private players like Lukoil will develop their own transportation solutions for growing output from the Timan-Pechora basin. The Russian Federation should be prepared to lose future tax revenue and live without maximum economic growth if energy policy continues to serve political goals instead of commercial rationale.

Literature

Arctic and Antarctic Research Institute (AARI). Department of Satellite, Ice and Hydrological Information. 38 Bering Street, St. Petersburg, Russia 199397. http://www.aari.nw.ru

The Arctic Ocean and Climate Change: a scenario for the US Navy. United States Arctic Research Commission. Arlington, VA. http://www.natice.noaa.gov/icefree/NavyArcticPanel.pdf

Finnish Institute of Marine Research. Helsinki, Finland. http://www.fimr.fi

Gribanov, Ivan and Somov, Viktor. "Do not utter the word 'Murmansk'. Semyon Vainshtok explained why the Murmansk project is not viable" (Слово "Мурманск" не говорить. Семен Вайншток объяснил, почему Мурманский проект не имеет перспектив) RusEnergy, April 22, 2004.

http://www.rusenergy.com/export/a22042004.htm

Ikavalko, Johanna. *Report on oil spill effects. An experimental study of the effects of crude oil, and application of Inipol EAP 22 and fish food on the sea ice biota and hydrocarbon content in Svalbard in February-April 2004.* Arctic Operational Platform (ARCOP), Finnish Institute of Marine Research. December 2004. http://www.arcop.fi/reports/D4233.pdf

Kovalenko, Konstantin and Webb, John. *Russia's New Subsoil Licensign Rules: Closing the Door on Foreign Investment in Future Big-Ticket Oil Projects?* Cambridge Energy Research Associates (CERA Insight), March 23, 2005.

Kommersant (business daily) Information page on Nenets Autonomous Okrug

http://www.kommersant.com/tree.asp?rubric=5&node=370&doc_id=-27

"Major Russian oil and natural gas pipeline projects" Country Analysis Briefs (Baltic Sea Region and Russia). Energy Information Agency, United States Department of Energy. http://www.eia.doe.gov/emeu/cabs

National Aeronautics and Space Administration (NASA). Visible Earth, a Catalogue of Images and Animations of Our Home Planet. http://visibleearth.nasa.gov

Sapozhnikov, Petr. "Ministry of Natural Resources starts canceling auctions for fields" (Минприроды начало отменять аукционы на месторождения) *Kommersant* (business daily) Feb. 16, 2005.

Sagers, Matthew J. and Jackson, Peter M. *Russian Oil Production Outlook: Can the Recent Rapid Rise be Sustained, and For How Long?* Cambridge Research Energy Associates (CERA Private Report), February 2005.

Skorobogatko, Denis. "Resources Ministry continues its sale" (Минприроды продолжает распродажу). *Kommersant* (business daily) March 9, 2005.

Webb, John. *Transneft's Baltic Gamble: Key Signpost of the Statist Shift in Russian Oil Policy.* Cambridge Energy Research Associates (CERA Decision Brief), Cambridge, MA. February 2004.

Webb, John. *The New Baltic Crude Export Game: What Role Will Ventspils Play?* Cambridge Energy Research Associates (CERA Insight), Cambridge, MA. April 2003.

Webb, John. *Choking the Boom? The Looming Shortage of Russian Crude Export Capacity.* Cambridge Energy Research Associates (CERA Decision Brief), Cambridge, MA. May 2003.

Webb, John. *Russian Crude Exporters Reduce Rail Shipments As Costs Soar.* Cambridge Energy Research Associates (CERA Alert), Cambridge, MA. October 2004.

Webb, John and Kovalenko, Konstantin. *Russia's Next Oil and Gas Frontier? Projects in Arctic Northwest Claim Growing Share of Company Budgets.* Cambridge Energy Research Associates (CERA Decision Brief), Cambridge, MA. January 2005.

BEG-Center for Energy Economics

On June 1, the Bureau of Economic Geology at the University of Texas, Austin welcomed the new "BEG Center for Energy Economics" (BEG-CEE) to its growing list of research programs. The BEG-CEE, formerly the Institute for Energy, Law, and Enterprise at the University of Houston, is managed and directed by Dr. Michelle M. Foss. Dr. Foss' associates that transferred to the Bureau include researchers Dr. Gürcan Gülen, Ruzanna Makaryan and Dmitry Volkov and support staff Aisha Hanif and Natalie Silva. Although the group will remain in Houston, they will be supported by and interact with the Bureau in many research projects.

Since 1991, Dr. Foss and her team have built an interdisciplinary, university-based Center of Excellence that provides research, training and outreach on energy economics and markets; policy and regulatory frameworks for commercial investment; and training and capacity building for energy sector reform and related institutional development. The Center's mission is *to educate stakeholders on energy economics and commercial frameworks using comparative research to facilitate energy sector development*.

The Center concentrates on the policy and regulatory frameworks that facilitate sustainable, commercial investment in energy resource and infrastructure development, and optimal strategies for investment, trade, and problem solving – the ingredients for successful, "bankable" energy investments. The Center is externally funded through corporate and government partnerships, research grants and contracts and revenues from training programs and publications. The Center network of several hundred experts consists of senior professionals from corporate and government donors and sponsors; senior associates and international advisory boards; professional staff and international research fellows; current and former graduate student research assistants; and visiting scholars.

The Center focuses its interdisciplinary research on the economic fundamentals of the energy value chains and linkages to commercial frameworks; the role of government (at all levels) and policy and regulatory models for commercial energy development; business/government interactions; and strategic responses to more competitive energy markets. The Center's proven model for all of its research derives from working with corporate and government partners to help set priorities with balance assured through the Center's network of advisors, senior associates and faculty. Center researchers use conceptual models to define problems and to support quantitative models for solutions. Case studies contribute thorough treatment and monitoring. Ongoing evaluations of market fundamentals are maintained via outlooks and scenarios, with a focus on validating basic assumptions.

The main ongoing efforts of the Center include the following.

- Energy Sector Governance grant from the U.S. Agency for International Development. Through this grant, the Center has established a partner entity, Resource Center for Energy Economics and Regulation at the University of Ghana, which so far produced several reports and educational seminars, and an energy database.
- Grant from the Association Liaison Office of University Cooperation in Development to help develop energy economics research and teaching capacity at Bangladesh University of Engineering & Technology. A new energy course has been developed and offered; a professional workshop was held; and several research projects have been initiated.
- Annual international capacity-building program "New Era in Oil, Gas & Power Value Creation," which serves as the Center's main tool in the international efforts of capacity building and public education in energy economics and regulation. In five years, the Center has trained over 100 participants (in Houston and in-country sessions) from 24 countries.
- A research and public education consortium on "Commercial Frameworks for LNG in North America." The Center has established an independent, objective and widely accessible knowledge and education base on the role of LNG in North American energy security. This research and public education effort on LNG is supported by a number of public and private organizations. The U.S. Department of Energy - Office of Fossil Energy provides a federal interface to the federal and state agencies that play lead roles in ensuring public safety and security associated with LNG facilities. The Center's LNG research consortium also is a part of our overall research and public education efforts on natural gas and the role of natural gas in the U.S. and world energy mix, as well as our ongoing, overall research and education on the energy value chains, energy markets and energy policy and commercial frameworks.
- Various publications, such as the "Guide to Electric Power in Texas" which provides both background on our state's electric power industry and history and the points of debate on how best to provide free choices and a different set of options so that the benefits of competition can be introduced and flourish.

The Center expects to continue its international work in Africa, South Asia and Latin America through additional grants and sponsored projects. Associated with its international efforts, the Center will organize an International Development Assistance conference in fall 2006. On the home front, new areas of research for the BEG-CEE include CO_2 value chain economics through the Gulf Coast Carbon Center and commercial frameworks for newer generation technologies such as IGCC while continuing to monitor electricity restructuring, especially in Texas. The Center will also support degree programs at the Jackson School of Geosciences, the university's Energy and Mineral Resources program and the university's newly formed Center for International Energy and Environmental policy, a joint program of the Jackson School, the College of Engineering and the LBJ School of Public Affairs.

For more information on BEG-CEE, please visit www.beg.utexas.edu/energyecon or call 281-313-9763.

Scenes from the 28th IAEE International Conference

3-6 June, 2005 - Taipei, Taiwan


International Co

Taiwan Conference a Big Success

The 28th Annual IAEE International Conference held in Taipei on June 3 to June 6, 2005 was a big success. A total of more than 500 participants from 32 countries worldwide, including from Taiwan, contributes the success of the Taipei Conference. Over 150 papers were addressed in 11 plenary sessions, 4 special sessions, and 34 concurrent sessions. (Refer to www.iaee2005.org.tw for details)

Ms. Hsiu-Lien Lu

At the conference ceremony on June 4, the Vice President of Republic of China, Ms. Hsiu-Lien Lu, was invited to address the Welcome Remarks. Immediately after the opening ceremony, Dr. Yuan-Tseh Lee, the President of Academia Sinica and the Nobel Laureate, chaired the keynote plenary session and introduced Dr. Martin A. Green and his presentation. Dr. Martin A. Green, the Laureate of the Right Livelihood Award, and the Australian Federation Fellow and Scientia Professor of University of New South Wales, gave the brilliant presentation about The Future of Energy: Solar Energy and Photovoltaics. The splendid opening brought the conference to a wonderful beginning.

On the same day with the opening ceremony, the General Conference Chairman and also the CIER Chairman, Mr. Vincent Siew, and the CAEE President, Ching-Chi Lin, led the invited delegates to visit the President of Republic of China, Mr. Shui-bian Chen. President Chen mentioned the importance of Kyoto Protocol and introduced Taiwan's energy policies dealing with this protocol. They exchanged the opinions about global energy issues and, thus, had a very nice discussion. All these showed the great emphasis of the Taiwan government to the conference.

Beside the professional programs, the Taipei Conference also provided several interesting social and cultural programs. Many delegates around the world appreciated these programs: Opening Reception, Welcome Dinner, Taipei Cultural Night Party, and Farewell Dinner. They chatted, laughed, and applauded. They stunned when Lungshan Elementary School danced beautifully at the Welcome Dinner. They clapped with their big hands when the Muja Elementary School played the drum and danced with the lions. They opened their mouth wide when Hongdao Junior High School skipped the rope and played the yoyo skillfully.

As a whole, the conference has been greatly appreciated by all the attendants and they would like to have another Taipei Conference.

BIEE Academic Conference in Association with UK Energy Research Centre
22-23 September 2005, St. John's College Oxford
Conference Programme

Thursday 22nd September

10.00 a.m. Accommodation Registration (Residential Main Porter's Lodge)

From 10.45 a.m. Conference Registration

11.30 a.m. Opening and First Plenary Session

Security of Supply and transition to a Low Carbon Economy, Sir Crispin Tickell, Green College Centre for Environmental Policy and Understanding, Oxford

Efficiency, Technology and Emissions Trading, Michael Grubb, Carbon Trust/Imperial College

13.00 p.m.Lunch

14.00 p.m. First Parallel Session

Topic 1: Demand Policies: *Session Leader, Brenda Boardman, Environmental Change Institute, University of Oxford*

Topic 2: Emissions Trading: *Session Leader, Steve Sorrell, SPRU - Science and Technology Policy Research, University of Sussex*

Topic 3: Technology and Innovation: *Session Leader, Chris Hendry, Cass Business School*

Topic 4: Security of Supply: *Session Leader, Goran Strbac, University of Manchester*

16.00 p.m.Tea

16.30 p.m. **Student Market Place**

A highly interactive event in which students will set-up shop around posters, presenting their academic work in a 5-7 minute presentation followed by discussions with their audience. Students should submit title and short (one para) abstract.

18.30 p.m. Drinks

19.00 p.m. Conference dinner

Friday 23rd September

9.00am. Second Plenary Session

Global Energy Scenarios, Wim Thomas, Shell

10.00 a.m. Coffee

10.30am Third Plenary Session

EU, EU Neighbours and US: energy and climate policies: Frank Umbach, German Council on Foreign Relations (DGAP) Shirley Neff, Americans for Solar Power/President-elect, USAEE

12.30 p.m.Lunch

13.30 p.m. Second Parallel Session

Topic 1: Energy and Environmental Regulation*, Peter Pearson, Imperial College, London*

Topic 2: Social Cohesion and Energy Interdependence*, Session Leader, Patrick Devine-Wright, De-Montfort University*

Topic 3: EU Enlargement and Neighbours*, Session Leader, Jonathan Stern, OIES Oxford Institute for Energy Studies/ University of Dundee*

Topic 4: Fossil Fuel Futures – the transition*, Session Leader, Jim Watson, SPRU – Science and Technology Policy Research, University of Sussex*

Topic 5: Nuclear and Renewable Energies*, Session Leader, Robin Wallace, Institute for Energy Systems, University of Edinburgh*

Topic 6: Energy Modelling*, Session Leader, Paul Ekins, Policy Studies Institute*

15.30 p.m. Conference closes

Conference fee (including accommodation/dinner/lunch): £250; after 1 August £270

BIEE members: £220; after 1 August £270

Students: £50; after 1 August £75

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EUROPEAN ELECTRICITY LIBERALISATION

Edited by David Newbery
(Cambridge University)

This Special Issue represents liberalizing European electricity in accordance with the Euoropean Commission's Electricity Directives. Different countries have responded differently, notably in the extent of restructuring, treatment of mergers, market power, and vertical unbundling. While Britain and Norway have achieved effective competition, others like Germany, Spain and France are still struggling to deal with dominant and sometimes vertically integrated companies. The Netherlands offers an interesting intermediate case, where good economic analysis has sometimes been thwarted by legalistic interpretations. Investment under the new Emissions Trading system could further transform the electricity industry but may be hampered by slow progress in liberalizing European gas markets. This study produced a wonderful set of results. The 214-page volume consists of an introduction by David Newbery and other authors who provide richly illustrated descriptions of what was and is being done to liberalise the European electricity market.

CONTENTS

- Preface by *Campbell Watkins*
- Introduction by *David Newbery*
- Electricity Market Reform in the European Union: Review of Progress toward Liberalization & Integration *by Tooraj Jamasb and Michael Pollitt*
- Electricity Liberalisation in Britain: The Quest for a Satisfactory Wholesale Market Design by *David Newbery*
- The Nordic Market: Signs of Stress by *Nils-Henrik von der Fehr, Eiric Amundsen and Lars Bergman*
- Regulating the Electricity Supply Industry in Germany by *Gert Brunekreeft and Sven Twelemann*
- The Spanish Electricity Industry: Plus ça change… by *Claude Crampes and Natalia Fabra*
- Liberalising the Dutch Electricity Market 1998 - 2004 by *Eric van Damme*
- A Competitive Fringe in the Shadow of a State Monopoly: The Case of France by *Jean-Michel Glachant and Dominique Finon*
- Short biographies of the contributing authors

ABOUT THE EDITOR: David Newbery is a professor of applied economics and a Fellow of the Econometric Society and of the British Academy at Cambridge University.

Major Authors include: Eiric Amundsen, Lars Bergman, Gert Brunekreeft, Claude Crampes, Natalia Fabra, Nils-Henrik M. von Der Fehr, Dominique Finon, Jean-Michel Glachant, Tooraj Jamasb, David M. Newbery, Michael Pollitt, Sven Twelemann, and Eric Van Damme.

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SCHEDULE

The conference will begin on December 7 with a Welcome Reception followed with presentations and panel discussions on December 8 and 9.

SPEAKERS AND PANELISTS (AS OF JULY 10, 2005)

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Baker Arnold, chief economist, Sandia National Laboratories USA; president, IAEE
Benes Ivan, CityPlan Ltd.
Bubenik Josef, chairman, Czech Energy Agency
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Annual Oil Market Forecast and Review 2005. Julian Lee (2005). Price: £650.00. 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

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1-2 August 2005, Southwest Renewable Energy Conference at The Hilton at Santa Fe, New Mexico, USA. Contact: Amanda Ormond, Conference Director Email: swrec2005@yahoo.com URL: www.SWREC.org

1-5 August 2005, PV Industry Week at Carbondale, CO. Contact: sei@solarenergy.org, Solar Energy International, PO Box 715, Carbondale, CO, 81623, USA. Phone: (970) 963-8855. Fax: (970) 963-8866 Email: sei@solarenergy.org URL: http://www.solarenergy.org

1-5 August 2005, Micro-Hydro Power at Carbondale, CO. Contact: sei@solarenergy.org, Solar Energy International, PO Box 715, Carbondale, CO, 81623, USA. Phone: (970) 963-8855. Fax: (970) 963-8866 Email: sei@solarenergy.org URL: http://www.solarenergy.org

6-7 August 2005, Solar Water Pumping at Carbondale, CO. Contact: sei@solarenergy.org, Solar Energy International, PO Box 715, Carbondale, CO, 81623, USA. Phone: (970) 963-8855. Fax: (970) 963-8866 Email: sei@solarenergy.org URL: http://www.solarenergy.org

8-19 August 2005, Wind Power at Carbondale, CO. Contact: sei@solarenergy.org, Solar Energy International, PO Box 715, Carbondale, CO, 81623, USA. Phone: (970) 963-8855. Fax: (970) 963-8866 Email: sei@solarenergy.org URL: http://www.solarenergy.org

14-17 August 2005, Energy 2005 -- The Solutions Network at Long Beach, California. Contact: JoAnn Stirling Email: joann@fsec.ucf.edu URL: http://www.energy2004.ee.doe.gov

14-17 August 2005, Energy 2005-The Solutions Network at Long Beach Convention Center, Long Beach, CA. Contact: Maddie Harwood, Senior Conference Planner, Sage Systems Technologies, 10440 Balls Ford Road, Suite 200, Manassas, VA, 20109-2602, USA. Phone: 1(800)608-7141 or (540)937-1739. Fax: (540)937-7848 Email: energy2005@doeevents.com URL: www.energy2005.ee.doe.gov

17-18 August 2005, Stabilising Fiscal Terms in Upstream Oil and Gas at Café Royal. Contact: Gareth Owens. Phone: +44 (0) 207 368 9300. Fax: +44 (0) 207 368 9301 Email: enquire@oilandgasiq.com URL: www.oilandgasiq.com/GB-2497/ediary

August 22, 2005 - September 2, 2005, PV Design and Installation at Carbondale, CO. Contact: sei@solarenergy.org, Solar Energy International, PO Box 715, Carbondale, CO, 81623, USA. Phone: (970) 963-8855. Fax: (970) 963-8866 Email: sei@solarenergy.org URL: http://www.solarenergy.org

23-24 August 2005, Intelligent Wells Implementation & Optimisation Asia at Miri, Malaysia. Contact: Nazya Ayaz, Conference Manager, Oil & Gas IQ, a division of IQPC Worldwide, No 1 Shenton Way #13-07, Singapore, 068803, Singapore. Phone: +65 6722 9388. Fax: +65 6720 3804 Email: enquiry@iqpc.com.sg URL: www.oilandgasiq.com/AS-3111/f13

23-24 August 2005, Intelligent Wells Implementation & Optimisation Asia at Miri, Malaysia. Contact: Nazya Ayaz, Conference Manager, Oil & Gas IQ, a division of IQPC Worldwide, No 1 Shenton Way #13-07, Singapore, 068803, Singapore. Phone: +65 6722 9388. Fax: +65 6224 2515 Email: enquiry@iqpc.com.sg URL: www.oilandgasiq.com/AS-3111/f13

23-24 August 2005, Production Forecasting in Upstream Oil & Gas at Kuala Lumpur, Malaysia. Contact: Zhilin Yuan, Conference Manager, IQPC Worldwide, No 1 Shenton Way #13-07, Singapore, 068803, Singapore. Phone: +65 6722 9388. Fax: +65 6224 2515 Email: enquiry@iqpc.com.sg URL: www.oilandgasiq.com/AS-310/f13

23-24 August 2005, Production Forecasting in Upstream Oil & Gas at Kuala Lumpur, Malaysia. Contact: Zhilin Yuan, Conference Manager, Oil & Gas IQ, a division of IQPC Worldwide, No 1 Shenton Way #13-07, Singapore, 068803, Singapore. Phone: +65 6722 9388. Fax: +65 6720 3804 Email: enquiry@iqpc.com.sg URL: www.oilandgasiq.com/AS-3109/f13

28-30 August 2005, 7th IAEE European Energy Conference, European Energy Markets in Transition, Bergen, Norway. Contact: Kellis Akselsen, Conference Secretary. Phone: +47-55-959500. Fax: +47-55-959439 Email: kellis.akselsen@snf.no URL: www.snf.no

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29-31 August 2005, Prospects of Asian Agriculture in New Millennium at University of Sistan and Baluchestan Zahedan, Iran. Contact: Dr. Karim Koshteh M.H., Secretary of 5th ASAE Conference, University of Sistan & Baluchestan, Zahedan, Iran Email: asae2005@gmail.com URL: www.asae2005.com

August 31, 2005 - September 1, 2005, National Oil Companies Worldwide: Strategy Briefing at Steinberger Kurhaus. Contact: Jerry van Gessel, Marketing Manager, Global Pacific & Partners, 266 Groot Hertoginnelaan, The Hague, 2517EZ, The Netherlands. Phone: +31 70 324 6154. Fax: +31 70 324 1741 Email: jerry@glopac.com URL: www.petro21.com

1-2 September 2005, 4th Annual National Oil Companies Summit 2005 at Steinberger Kurhaus, The Hague, The Netherlands. Contact: Jerry van Gessel, Marketing MAnager, Global Pacific & Partners, The Hague, 2517EZ, The Netherlands. Phone: +31 70 324 6154. Fax: +31 70 324 1741 Email: jerry@glopac.com URL: www.petro21.com

6-7 September 2005, Gas Commercialisation Asia 2005 at Kuala Lumpur, Malaysia. Contact: Petrina Hu, Senior Conference Manager, Oil & Gas IQ, a division of IQPC Worldwide, No 1 Shenton Way #13-07, Singapore, 068803, Singapore. Phone: +65 6722 9388. Fax: +65 6720 3804 Email: enquiry@iqpc.com.sg URL: www.iqpc.com.sg/AS-3124/f13

12-15 September 2005, Bioenergy in Wood Industry at Jyvaskyla, Finland. Contact: Dan Asplund, Chairman of Conference, FINBIO, PO Box 27, Jyvaskyla, FIN-40101, Finland. Fax: 358-14-4451-199 Email: biowood2005@jsp.fi URL: www.finbioenergy.fi/biowood2005

13-15 September 2005, Eastern Biofuels Conference & Expo at Warsaw, Poland. Contact: Wendy Vincent, Global Events Manager, The Stratton Group, 100 S. Dakota Ave., Sioux Falls, SD, 57104, USA. Phone: (605) 338-6829. Fax: (605) 332-4880 Email: wendyv@thestrattongroup.com URL: www.easternbiofuels.com

13-20 September 2005, 1st Solarenergy Exhibition Middle East Qatar at Doha Qatar. Contact: Ruth Anna Sammel, Organizer, Doha, Qatar, Qatar. Phone: +974 444 0010. Fax: +974 444 5594 Email: firstsolarqatar@yahoo.com

15-16 September 2005, Derivatives and Structured Products in Energy Markets at Houston. Contact: Adriana Lobo. Phone: +44 (0) 207 484 9947 Email: adriana.lobo@incisivemedia .com URL: www.incisive-events.com/dspenergy

18-21 September 2005, 25th USAEE/IAEE North American Conference: Fueling the Future: Prices, Productivity, Policies, and Prophesies at Omni Interlocken Resort, Denver, Colorado, USA. Contact: David Williams, Executive Director, United States Association for Energy Economics, 28790 Chagrin Blvd., Suite 350, Cleveland, Ohio, 44122, USA. Phone: 216-464-2785. Fax: 216-464-2768 Email: usaee@usaee.org URL: www.iaee.org/conferences

19-19 September 2005, 9th Annual Africa Downstream 2005 at Arabella Sheraton, Cape Town, South Africa. Contact: Babette van Gessel, Group Mananging Director, Global Pacific & Partners International, 264 Groot Hertoginnelaan, The Hague, Netherlands. Phone: +31 70 324 6154. Fax: +31 70 324 1741 Email: info@glopac.com URL: www.petro21.com/events

20-20 September 2005, Third Scramble for Africa: Strategy Briefing 2005 at Victoria & Alfred Hotel. V&A Waterfront, Cape Town, South Africa. Contact: Babette van Gessel, Group Mananging Director, Global Pacific & Partners International, 264 Groot Hertoginnelaan, The Hague, Netherlands. Phone: +31 70 324 6154. Fax: +31 70 324 1741 Email: info@glopac.com URL: www.petro21.com/events

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