IAEE INTERNATIONAL ASSOCIATION FOR ENERGY ECONOMICS

IAEE Newsletter

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Editor: *David L. Williams* **Contributing Editors**: *Paul McArdle, Tony Scanlan and Marshall Thomas*

First Quarter 2000

President's Message

I am delighted to have the honour to assume the Presidency of the IAEE for 2000. I am particularly pleased to take over at a time when the Association has so firmly established itself as the world's leading association for energy economics and energy economists. The commitment and hard work of the members and officers over the last 20 years or so have progressively created an international organisation with 23 affiliates in 70 countries and a global membership of over 3200. At the same time our Journal, *The Energy Journal*, has also established itself firmly as the leading refereed journal of energy economics.

I am also reassured that the IAEE is also now on a very sound financial footing. This gives us the opportunity to enhance the services that we provide our members around the world. Last year we established a scholarship scheme for students of energy economics. We will be repeating this again this year (see page 10 of this newsletter). I am sure, however, that we can do much more. I have already asked the members of the Council and the Board of Editors of *The Energy Journal* for their views as to how we can move forward constructively. I would also value any suggestions from the rest of the membership. Please contact me with any proposals that you may have. What would you value? What do feel it is reasonable, realistic or even ideal for the IAEE to provide especially in this increasingly open and digital world?

I am delighted to welcome 5 new members to the Council for 2000. Jean-Phillipe Cueille of the Institut Français du Pétrole has been elected Secretary, taking over that position from the new President-elect, Arild Nystad. David DeAngelo, of Philadelphia Light and Power, joins as elected member for North America. Keiichi Yokobori, President of APERC in Tokyo is a new Appointed Council Member. Marianne Kah of Conoco and Leslie Deman of Coral Energy - organisers of the 2001 IAEE Conference in Houston also join the Council as appointed members. We all look forward to their contributions. We also bid farewell to Council Members Paul Stevens and Mike Lynch, and the organisers of this year's Sydney conference Tony Owen and Bob Bartels. Finally past-President Dennis O'Brien has also left the Council after many years of dedicated service and outstanding contribution. I would like to thank them all on behalf of all the membership.

Please ensure that you have the dates of the two major conferences in your diaries. First there is the IAEE Conference in Sydney, Australia 7-10 June. This will be followed by the North American Conference in Philadelphia, PA 24-27 September. Full details are on the IAEE web pages. I really hope that you will be able to attend at least one, if not both, conferences. You may also wish to note that it has been agreed that the 2001 IAEE Conference will be in Houston 25-7 April and the 2002 Conference will be in Aberdeen, Scotland (June).

Peter Davies

Editor's Note

Mike Lynch joins us this issue as guest editor and has assembled several pieces on the Kyoto treaty. He writes:

"As all members in good standing know, the Association's flagship publication, *The Energy Journal*, recently published a special issue to "The Costs of the Kyoto Protocol: A Multi-Model Evaluation" representing the views of many prominent economic modelers on the GHG reduction accord signed in Kyoto. We include four articles in this issue which are intended to reflect views of practitioners.

"Regrettably, all the pieces here are from North American authors, which reflects a combination of start-up difficulties and bias in my personal network which I was, in this instance, unable to overcome. A future issue will feature articles by authors from outside North America, as well as responses to the articles appearing here.

"The four articles are fairly diverse in opinions and

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23rd ANNUAL IAEE INTERNATIONAL CONFERENCE

Hilton Sydney Hotel, Sydney, Australia, 7-10 June 2000

Theme

Energy Markets and the New Millennium:
Economics, Environment, Security of Supply

The year 2000 is an ideal time to reflect on the dominant role of fossil fuels over the past century and assess how this pattern of reliance will change in the context of the liberalisation of energy markets and environmental pressures and concerns. This conference will consider: electricity market liberalisation: international experiences and expectations; the economics of renewable energy technologies; Asian energy markets and macro-financial management; liberalisation of international trade in energy resources; the geopolitics of energy supply: social, cultural, political and philosophical dimensions of energy sector restructuring; transport policy in the new millennium; and carbon sequestration and recycling.

Sydney (the Olympic City in the year 2000) has many attractions for both participants and accompanying persons, in addition to the world famous Harbour Bridge and Opera House. City and harbour tours are readily available, while longer trips into the Australian "bush" can be made with a hire car. World class vineyards are just two hours drive to the north of Sydney, sharing the area with some of Australia's largest open cast coal mines. The nation's capital, Canberra, is a 40-minute flight to the south of Sydney.

CONFERENCE AND HOTEL REGISTRATION

Please consult the AAEE web site (www.aaee.unsw.edu.au) for conference information and conference and hotel registration forms that can be down loaded and returned to the Secretariat by mail or fax.

POST-CONFERENCE BARRIER REEF TOUR

Billed as "The Ultimate Cruise", the highlight of the conference recreational programme is the opportunity to undertake a four-night post-conference cruise on the Great Barrier Reef, ex-Cairns in North Queensland. This is an opportunity to see one of the wonders of the world at a very reasonable price. The cruise sails from Cairns at 2 p.m. on Monday 12 June and you will spend four nights at sea in a comfortable twin-share Stateroom. Full details of the tour itinerary, the tour vessel and advice on minimising air fares to Cairns are available on request from the Secretariat.

The cost of the four-night cruise is A$1660 per person twin share (A$2490 for single occupancy). This cost includes all accommodation, all meals, snorkelling, glass bottom boat tours, guided walks, and use of all on-board facilities. A marine naturalist accompanies all cruises. The cost does not include optional tours, beverages, gift shop purchases, scuba diving (there is a nominal fee per dive), or the Environmental Management Charge (currently A$12).

Note: Current exchange rate is approximately US$1.00 = A$1.50.

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

Transforming Energy

21st USAEE/IAEE Annual North American Conference – September 24-27, 2000
Philadelphia, Pennsylvania, USA – Wyndham Franklin Plaza Hotel

We are pleased to announce the 21st Annual North American Conference of the USAEE/IAEE, ***Transforming Energy***, scheduled for September 24-27, 2000, in Philadelphia, Pennsylvania at the Wyndham Hotel.

Please mark your calendar for this exciting meeting. This year the conference has been organized to focus on selected themes. Leaders from industry and academia have been invited to share their views and concerns for the transformation in energy markets expected for the next decade. The five plenary sessions will be followed by concurrent sessions designed to focus attention on major sub-themes. Industry participants, bringing sharp focus to the emerging analytical challenges the industry faces, will lead these sessions. Ample time has been reserved for more in-depth discussion of the papers and their implications. Key sessions and themes of the conference are as follows:

Transportation: Implications of the Technological Sea Change
Session Chair: Jim Sweeney, Stanford University
- Vehicles: Challenging the Internal Combustion Engine
- Transportation Fuels: Challenging Petroleum's Dominance
- Enticing Consumers: The Ultimate Challenge

Evolving Electricity Markets: From Ratebase to Revenue – The Roles of Technology Investment
Session Chair: Steve Connors, MIT
- Grid Operation and Expansion: Success and Failures
- Bulk Power – Investment, Economic and Environmental Performance
- Retail Competition – Delivering Value to Consumers

Power, Gas & Coal: Maximizing Opportunity as Commodity Markets Merge
Session Chair: Steve Warwick, Koch Industries
- Commodity Convergence
- Risk Management
- Policies and Regulations

Paper Markets: Expanding their Scope and Impact on Energy Markets
Session Chair: Louise M. Burke, New York Mercantile Exchange
- The Role of Paper Markets in Price Formation
- Special NYMEX Trading Session

Charting the Path: Forces and Forecasts
Session Chair: Peter Davies, BP Amoco Plc.
- Global Economic Outlook
- Identifying Key Forces in Oil and Gas Markets
  - Global Oil Outlook
  - Global Gas Markets
  - North American Gas Markets
- Identifying Key Forces in Coal and Power Markets
  - Global Power Markets
  - North American Power Markets
  - Coal Markets: Prospects for North American and Global Markets

The final session of the conference may become a standard for the new millennium. Peter Davies, President of the International Association for Energy Economics and Chief Economist of BP Amoco Plc., will host the plenary session "Charting the Path: Forces and Forecasts." Dr. Davies has invited experts from industry and academia to discuss what the new energy market may look like a decade from now, and provide their insight into what are expected to be the key drivers in the transformation. This session is expected to be particularly insightful as energy markets stand on the cusp of a technological revolution.

There are 20 planned concurrent sessions (note the enclosed information on Call for Papers for this meeting); please submit papers that address the transformation in energy markets and the themes listed above. Given the location of the meeting in Philadelphia this year, we anticipate an even larger draw to our concurrent sessions. The conference organizers STRONGLY SUGGEST that you get your abstract in extra early so that prompt follow-up can be given.

Your registration fee includes two lunches, a dinner, two receptions and numerous coffee breaks, all designed to increase your opportunity for networking. Special this year will be an evening at the famous Franklin Institute Science Museum.

Philadelphia, Pennsylvania is a wonderful and scenic/tourist place to meet. Single nights at the Wyndham Hotel are $150.00 (contact the Wyndham Hotel at 215-448-2000, to make your reservations). Conference registration fees are $500.00 for USAEE/IAEE members and $600.00 for non-members. Special airfares have been arranged through Conventions in America. Please contact Conventions in America by calling 619-232-4298 and reference our group code #606. These prices make it affordable for you to attend a conference that will keep you abreast of the issues that are now being addressed on the energy frontier.

There are many ways you and your organization may become involved with this important conference. You may wish to attend for your own professional benefit, your company may wish to become a sponsor or exhibitor at the meeting whereby it would receive broad recognition or you may wish to submit a paper to be considered as a presenter at the meeting. For further information on these opportunities, please fill out the form below and return to USAEE/IAEE Headquarters.

Transforming Energy

21st Annual North American Conference of the USAEE/IAEE

Please send me further information on the subject checked below regarding the September 24-27, 2000 USAEE/IAEE Conference.

____ Submission of Abstracts to Present a Paper(s) _____ Registration Information _____ Sponsorship Information _____ Exhibit Information

NAME: _____
TITLE: _____
COMPANY: _____
ADDRESS: _____
CITY,STATE,ZIP: _____
COUNTRY: _____ PHONE/FAX: _____

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Modeling Analyses of the Costs of Kyoto: What Did We Learn?

*By Ronald J. Sutherland**

The Kyoto Protocol requires developed (Annex 1) countries to reduce their greenhouse gas emissions (GHG) to a specified amount below their 1990 level and to achieve this result during the 2008 to 2012 period. The U.S. emissions target is 7 percent below the 1990 level. The economic cost of Kyoto is the cost required to achieve these emissions targets. The Special Issue of the 1999 Energy Journal contains 13 articles that summarize modeling analyses that have the explicit purpose of estimating the cost of the Kyoto Protocol. Indeed, the title of the issue is "The Costs of the Kyoto Protocol: A Multi-Model Evaluation." In this paper, I focus on the question: what do we learn from these models about the cost of the Kyoto Protocol? I address this question by considering three questions. First, what are the conclusions of the 13 articles with respect to the costs of the Kyoto Protocol? Second, do the articles convey a good understanding of the economic analysis behind these conclusions? Third, are the conclusions persuasive and reliable? The 13 articles contribute significantly beyond the main question I address; however, my question is the explicit purpose of the articles. In addition to considering the cost issue, I will comment briefly on the modeling results with respect to the international trading of permits.

Not surprisingly, these models conclude that the costs of attaining the Kyoto targets are high, for the U.S. and for other developed countries. Most economists probably agree with this result. Environmentalists and energy efficiency advocates – the Green Team – argue that we can reduce greenhouse gas emissions in the near term at very low cost. Still others may be uncertain about the economic costs of reducing emissions quickly. What is the likely influence of the Special Issue on the views of the agnostics and the Green Team? My contention is that the Special Issue may not persuade critics and agnostics that the cost of achieving Kyoto is high. First, the modeling analyses do not easily communicate to most readers. Second, the papers typically do not present a conceptual explanation of the results. Third, the models are designed to address long-run issues and not the short-run responses required by Kyoto. On a more positive note, the Energy Modeling forum makes the important contribution of assembling a first-class international field of modelers to compare their simulations under controlled conditions. The modelers make a highly persuasive case that the threat of climate change requires a long run perspective. Further, the optimal path of GHG emissions lies above that specified at Kyoto.

Several years ago the Department of Energy sponsored a modeling analysis intended to project the market shares of various solar energy technologies in the electric utility generation sector. The author, who prefers to remain anonymous, produced the projections using a sophisticated electric utility modeling system. The modeling system included a demand and revenue module, a financial module and a capacity expansion module that selected generating technologies. A published report described the modeling system in detail and included the computer code. The utility modeling system had achieved a wide level of respectability, having provided the basis for numerous journal articles and government policy analyses.

The capacity expansion sector of the utility module used a logit function to forecast market shares, which was the conventional way to model market shares. A single parameter, l, was crucial in projecting market shares. Actually, this parameter determined market shares, with the remainder of the utility modeling system having little influence on the projections. The value of this parameter was merely assumed based on judgement, because there was no credible evidence to do otherwise. The report to the DOE contained the modeling projections of the market shares of the various solar technologies.

How would we assess the modeling projections of this DOE study? One assessment is that they were highly credible, state-of-the-art projections, based on a sound modeling analysis. Another interpretation is that the projections were nothing more than arbitrary input assumptions, disguised by a complex modeling system to convey a false sense of rigorous analysis. Readers of the final report, including the DOE, could see the market share projections, but were unaware of the critical assumption that produced the results. Most readers were unaware of the sensitivity of the results to various input assumptions and they could not determine whether the results were were reasonable. Although the equations of the model were explicit, the model was a black box to almost all readers. This lesson suggests a measure of caution in assessing modeling results.

Quantitative modeling analyses are a primary tool used by economists to provide information about economic behavior. Many energy economists are model consumers, rather than model producers. My impression is that model consumers are typically apprehensive and cautious in assessing modeling results. Model producers are often distrustful of modeling results, especially the results obtained by others. As model consumers, how do we assess the results of energy models? How should we assess these highly complex economic – climate change models? Are they state-of-the-art analyses that provide the most reliable results that we can obtain, or, are they merely mathematical manipulations of precarious input assumptions? The analyses are state-of-the-art. However, skeptics and agnostics will find the results unpersuasive.

To illustrate the application of the above three questions, consider the hypothetical case of an econometric estimate of a short-run price elasticity of demand. Suppose that such an analysis produces a large price elasticity for a particular good. We can readily understand what the conclusion is; it is the large estimated price elasticity. In the absence of explanation, we do not know the economic behavior behind the price elasticity and we will probably not study the econometric analysis to assess the reliability of the results. Furthermore, we are likely to dismiss the results because price elasticities are typically small in the short run. The econometric estimate could achieve credibility if confirmed by some independent evidence. For instance, the author could explain that the particular good has close substitutes and historically market shares are highly sensitive to price changes. Coupled with this explanation, we have a good intuitive understanding of the large price elasticity and we may accept it as a credible estimate. The econometric estimate by itself may not be believable. The estimate achieves credibility when comple-

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mented with an explanation based on economic behavior. I consider the Special Issue articles from this perspective.

What are the Costs?

A brief review of the abstracts, introductions and conclusions of the 13 articles indicates the main conclusions about the estimated costs of the Kyoto Protocol. The following quotes are taken from the Special Issue and are identified by author and page cited.

> "These studies generally show that the emissions trajectory prescribed in the Protocol is lower and the cost of mitigation higher than that required to meet long run objectives that were considered." (Weyent and Hill, p. xli). Note that Weyent and Hill are editors of the Special Issue volume and this quote summarizes several articles.
>
> As stated by Manne and Richards: "We find that the short-term U.S. abatement costs of implementing this protocol are likely to be substantial." (p.1). "Finally, and perhaps most important: unless the ultimate concentration target is well below 550 ppmv, the Protocol seems to be inconsistent with cost-effective long-term strategy for stabilizing concentrations." (p. 20).
>
> "The marginal cost in 2010…could also exceed $250 per tonne of carbon if the United States must meet its emissions limitations entirely through domestic actions, and if mitigation obligations are not adequately anticipated by decision-makers." (MacCraken, Edmonds, Kim and Sands, p. 25).
>
> "First, it appears that the strategy behind the Kyoto Protocol has no grounding in economics or environmental policy." (Nordhaus and Boyer, p. 125).
>
> "The emission reduction targets as agreed to in the Kyoto Protocol are irreconcilable with economic rationality." (Richard Tol, p.131).
>
> "From a welfare perspective, the major effect of the Kyoto agreement is to produce a large wealth transfer from A-1 to non-A-1, while realizing none of the potential benefits of CO_2 control." (Peck and Teisburg, p. 390).

This sample of quotes from the Special Issue is non-random, but it captures the sentiment of most, if not all, of the authors. The collection of articles concludes that the economic costs of reducing emissions to achieve the Kyoto targets are very high.

Why Are the Costs High? Are The Results Persuasive?

The articles clearly indicate that the costs of achieving the Kyoto targets are high. Therefore, we now consider how these articles account for such high costs. I present a sample of the articles to convey how they explain the empirical results. I then conclude whether the results are likely to persuade the Green Team or those who are uncertain about the costs of Kyoto.

Manne and Richels list four factors that explain why longer term adjustments may be preferable to short term adjustments: 1) allow more time for capital stock turnover, 2) allow more time to develop low cost substitutes, 3) allow more time to remove carbon from the atmosphere, and 4) the effect of time discounting. Manne and Richels use the MERGE model and they use a 10-year time interval through 2050 and a 25-year interval through 2100.

Skeptics of modeling analyses recognize that Manne and Richels identify the factors that produce high adjustment costs in the short run. However, Manne and Richels do not explain the relative importance in their modeling analysis. We cannot be sure whether the capital stock is modeled to reflect accurately the turnover of buildings, transportation vehicles and energy using technologies. Because the model apparently iterates every 10 years, it only iterates once during the Kyoto period. Such a model may be more useful for long run simulations than for estimating the costs of short run market adjustments.

MacCracken, Edmonds, Kim and Sands (MECS) note that the Kyoto target is achievable by capturing or sequestering carbon, fuel switching or conserving energy. In the MECS analysis substituting natural gas for coal in the electric generation sector accounts for roughly 40 percent of the reduction in emissions. Consumption of coal drops by three-quarters, while consumption of natural gas increases by three percent. If the Kyoto targets are anticipated and expected to be permanent, costs are lower ($168 per tonne) than if targets are unanticipated ($250).

The authors provide a good explain of adjustments in the electricity generation sector, but they provide less explanation of assumed price elasticities that induce energy conservation. The MECS model iterates every five years and hence iterates only twice to achieve the Kyoto targets. With only two iterations, we may question how accurately MECS can model new capital additions and capital retirement.

Nordhaus and Boyer present totally negative results about the feasibility of the U.S. achieving the terms of Kyoto at low cost. The authors use the RICE model, which is based on optimal economic growth theory. The model projects optimal paths of emissions and economic variables up to year 2100 and beyond. The model iterates (computes equilibrium values for the endogenous variables) for ten-year periods. This adjustment period of ten years precludes the model from estimating the response of variables as they adjust.

Nordhaus and Boyer do not discuss the adjustments required to achieve the terms of Kyoto. The RICE model is clearly a long run optimization model. We are uncertain in assigning accuracy to the first iteration, which gets us to the Kyoto commitment period. Furthermore, the paper does not convey an intuitive understanding of why Kyoto is expensive. The RICE model appears more useful as a simulation tool for long run (a century) comparisons, rather than as a model that estimates short term adjustment costs.

The Nordhaus and Boyer paper is likely to impress most readers as a first-rate effort that offers several important insights and conclusions with respect to climate change policy. My point is that the Nordhaus and Boyer paper would not persuade members of the Green Team, or even the agnostics, that the costs of Kyoto are high.

The modeling analysis of Richard Tol concludes that the Kyoto targets are political targets that make no economics sense. The model used by Tol iterates annually, which makes it more appropriate than other modes to assess the costs of Kyoto. Tol confirms my point: "Many of the models used for analysis of the Kyoto Protocol…are therefore not really suited to look at issues of when-flexibility before 2012." (Tol, p. 149) Tol is unmistakable in stating his conclusions, but he does not provide a simple intuitive/behavioral explanation in support of his results. Perhaps readers with interest in studying the model documentation can figure out the economic behav-

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Modeling Analyses of the Costs of Kyoto *(continued from page 5)*

ior behind Tol's result. I conjecture that students with this enthusiasm would be favorably impressed with the analysis. For most of us, the model is a black box that confirms what we already know, or, does not persuade us of an alternative view.

Although my sample of Special Issue articles is small, my view is that such models are not the appropriate tools for assessing the costs of Kyoto. Models that iterate every five to ten years are not the best tool for short run analysis. The modelers do not explain why the costs of the Kyoto targets are high. The energy macro models that iterate annually, such as the EIA, WEFA and DRI, are more appropriate to model the short run adjustments required by the Kyoto Protocol.

The Energy Modeling Forum (EMF)

Although my above comments on the Special Issue papers may appear critical, the Energy Modeling Form makes an important positive contribution. Simply bringing together the best of the international modeling teams with a common purpose contributes significant credibility to the findings. Much of the analysis of climate issues is sponsored by an interest group, such as industry, the government or the Green Team. The conclusions of the research reflect sponsorship. The EMF is widely respected for its impartiality, objectivity and high quality analysis. The collection of thirteen modeling analyses, including six from foreign countries, produces a highly credible result.

International Trading of Emissions Permits

The EMF papers conclude that the wider the sphere of international trading of emissions permits, the lower the cost of reducing emissions. Modelers reach this conclusion by specifying a marginal cost function for reducing emissions by region, where marginal costs tend to be lowest in developing countries. If the sphere of emissions trading includes the developing countries, then costs of reducing emissions are minimized.

Although this result is no doubt correct, I offer two qualifications. The important issues with respect to trading include the costs of operating the trading system. These costs include transaction costs of monitoring, measuring, verifying and enforcing trades. For instance, under the proposed trading system, the Clean Development Mechanism allows a developing country to sell a credit for the emissions reduced relative to a base case of no emissions trading. How can we know the base case emissions? Under trading, there is a strong financial incentive to exaggerate base case emissions and difficulty in confirming what would have occurred. The EMF modeling results show large gains from trade. However, the modelers do not reflect these operating costs, which are the main limitations of a feasible system.

International trading of emissions permits has the most potential to reduce costs if the developing countries are not themselves subject to emissions constraints. Kyoto does not constrain the developing countries. By not being constrained to reduce their own emissions, these countries can sell emission reductions at a low price. However, according to Nordhaus and Boyer, p. 104, if the developing countries do not reduce their emissions, global mean temperatures decline by only 0.13 degrees C over the next century. If developing countries were constrained to reduce their emissions, they would no longer have credits to sell to other countries. International trading of emissions permits has the largest potential to reduce total costs when the policy fails to reduce the threat of global warming. If the policy were potentially successful – by requiring developing countries to reduce their emissions – emissions would be less successful in reducing costs. International trading of emissions credits is not a panacea if it only reduces costs when the overall policy fails.

Conclusion

My opinion is the Special Issue papers will not persuade the agnostics and the Green Team that achieving the terms of Kyoto is enormously expensive. Although the quantitative results may be one-sided, the supporting conceptual explanations are not persuasive. I suspect further that Green Team analysts, given the opportunity, could change some of the coefficients in these models and produce the "free lunch" estimates associated with their energy conservation views. A clue may be to look at the capital-energy and carbon-energy coefficients in the models and then adjust the coefficients with a good dose of neoclassical substitutability.

The EMF modelers did not design their models to estimate short run costs. Most of the models iterate only once or twice over a decade. When the modelers look at their first period simulation results, they find that optimal emissions are above the Kyoto targets. They conclude therefore that the Kyoto targets are too costly. The models do not contain disaggregated capital stock by vintage and type, e.g., vehicles, buildings and technologies. Estimating short run costs of achieving the Koto targets should consider the rate of turnover of a disaggregated capital stock. These EMF models are not the best models for estimating the costs of achieving Kyoto. The EIA analysis "*Impacts of the Kyoto Protocol on Energy Markets and Economic Activity* is more appropriate for estimating short run costs.

The models discussed in the Special Issue are designed to simulate long run behavior. The models therefore iterate every five or ten years and simulate variables over the next century or even longer. The modeling analyses make the important contribution that addressing the threat of climate change requires a long-run policy focus. Further, the optimal path of GHG emissions does not go through Kyoto, but instead, GHG emissions decline gradually over a longer period. This contribution by the EMF modelers is persuasive, in my view, and it offers critical policy implications.

Mexican Affiliate Reconstituted

The Mexican IAEE affiliate – Asociación Mexicana para la Economía Energética (AMEE) — has completed the renewal of its Directive Council. It brings together outstanding individuals from the academic, public and private sectors. Linked to the different facets of the energy development of the country at senior levels, this council assures an active participation of the Association in the energy debate to be held in national and international fora.. It is currently preparing a joint Symposium with the private sector Mexican Association of Electrical Enterprises and the University Energy Program of the National Autonomous University of Mexico, to be held next January, and the third AMEE National Congress. It will also seek a closer collaboration with IAEE and the other affiliates.

The members of the AMEE Directive Council are:

President: Dr. Pablo Mulás P.

PhD in Engineering from Princeton University, U.S. (1965), former Director of the Division of Energy Sources (1976-1991) and Executive Director (1991-1996) of the Institute of Electrical Research of the power public sector. Currently Director of the University (UNAM) Energy Program and Regional Coordinator for Latin America of the World Energy Council (e-mail: pmulas@servidor. unam.mx or: pmulas@www.imp.mx)

Vice President (and President Elect): Dr. José Miguel Gonzalez S.

PhD in Mechanical Engineering from the Massachussetts Institute of Technology, U.S. (1972), former Director of the energy consulting firm IPRODET participating in national and international projects (1983-1997). Currently, Director of the Mechanical Systems Division of the Electrical Research Institute.

Secretary: Dr. Juan Rosellón D.

PhD in Economy from Rice University, U.S. (1993), since then professor at the Economic Research and Teaching Center (CIDE). Awarded the Economy National Prize in 1994. General Director of Economic Policy at the Energy Regulatory Commission (1995-1997), participating in the design of the structural reform of the Mexican Energy System.

Treasurer: Dr. Arturo Reinking C.

PhD in Engineering Sciences from the University of California-Berkeley, U.S. (1973), professional experience in General Electric, in the National Institute for Nuclear Energy and as Group Manager of the Investment Bank Division of Banca Serfin involved in financial engineering activities. Since 1998, Technical Secretary of the University Energy Program at UNAM

Officer: Dr. Francisco Guzmán

PhD in Physico-chemistry from Sheffield University, U.K. (1978), professor at the Universidad Autónoma Metropolitana until 1989; since then researcher at the Mexican Petroleum Institute, where later appointed Deputy Director for Environmental Protection (1996-1998) and from 1999 Deputy Director for Research and Technology.

Officer: Ing. Luis Vázquez S.

Chemical Engineer from the Ryerson Politechnical Institute, Canada, extensive entrepreneurial activity in the oil services and gas industry, at the head of several private companies, former President of the Mexican Association for Natural Gas (1992-1996) and member of the Administrative Board of the American Gas Association (1992-1997). Currently Director General of Servicio de Energía de México, joint enterprise with Lone Star Gas International that will distribute natural gas in Mexico City.

Officer: Dr. Javier Estrada E.

Master in International Economy (1980) and Doctorate in Political Economy (1982) from the University of Paris, Nanterre, former researcher at the Norvegian Fridtjof Nansen Institute (1985-1988, 1992-1996), economist in charge of market forecasts and strategic planning at Saga Petroleum, Norway (1988-1992). Currently Commissioner at the Energy Regulatory Commission of Mexico.

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Jane Carter Prize

The Jane Carter Prize is awarded by the British Institute of Energy Economics, the International Association for Energy Economics and the Association for the Conservation of Energy in memory of Jane Carter, former head of the Energy Conservation Division in the UK Department of Energy and a founder of both the BIEE and the IAEE. The Prize for 1999 was awarded for the best paper submitted to the 1999 BIEE Conference by an author under the age of 35 which was relevant to the theme of energy and sustainable development.

Ten papers were submitted for consideration. Several were of high quality. After considerable discussion the judges concluded that the Prize should be awarded to Melinda Acutt of the University of Liverpool and Caroline Elliott of Lancaster University for their joint paper on "National and EU Regulation of Electricity Generation". This paper develops an innovative approach to a major policy problem - the reconciliation of effective economic and environmental regulation of electricity generation. The discussion is based on a theoretical model of the interaction between economic and environmental regulators acting together to maximise their joint advantages.

The Prize was presented at the Annual General Meeting of the BIEE on 1 November 1999 by the Institute's President, Lord Lawson.

David Jones

Mainstream Economics and Climate Alarmism

*Robert L. Bradley Jr.**

Mainstream economic analysis has roundly rejected the "free lunch" case for regulating man-made greenhouse gases (GHG) to "stabilize climate." The short-term approach of the Kyoto Protocol has received consensus criticism by the economics modeling community as shown by a collection of essays by 46 economists published as a special edition of *The Energy Journal*. William Nordhaus and Joseph Boyer were speaking for many contributors when they concluded in one essay that "the Kyoto Protocol has no grounding in economics or environmental policy."[1]

The problem for global warming policy activism runs deeper than the Kyoto Protocol. A second recent anthology assessing agricultural benefits and costs rejected the high-damage conclusion from anthropogenic climate change that was reached in a 1995 report by the Intergovernmental Panel on Climate Change (IPCC). Concluded Robert Mendelsohn and James Newmann for the study's 26 authors,

> *New models and methods predict that mild warming will result in a net benefit rather than a net loss to the economy. The likely warming over the next century is expected to make the US economy better off on average.*[2]

This conclusion reinforces the findings of an earlier book published by economist Thomas Gale Moore that warmer is better.[3] The Mendelsohn/Neumann study also gives credence to an educational campaign by the Greening Earth Society that higher concentrations of carbon dioxide (CO2) in the atmosphere from fossil fuel combustion are a windfall to plant life and agricultural productivity. In Mendelsohn and Neumann's words, "Agronomic studies suggest that carbon fertilization is likely to offset some if not all of the damages from warming."[4]

Scientific Questioning of Warming Alarmism

A number of arguments against climate alarmism have complemented and in some cases have directly influenced the economists' case against short-term carbon reduction mandates. They include:

- High climate sensitivity models have overpredicted warming by a factor of two or more given a 50% buildup in the warming potential of greenhouse gas concentrations in the atmosphere to date. The oft-cited reason for model overestimation, the cooling presence of sulfate aerosols, is in dispute since sulfates can warm as well as cool. Another cited reason, ocean absorption of heat to delay the warming, is plausible but begs the question of climate sensitivity to greenhouse gases.
- The two global temperature measurements from satellites and balloons in their two decades of existence have not picked up the "greenhouse signal" where it should be most pronounced or at least discernible—the lower troposphere. This suggests that surface warming may be overestimated and/or the result of other factors than just the enhanced greenhouse effect.
- Taking the surface warming of recent decades at face value, the "greenhouse signal" shows a relatively benign distribution with minimum (night, winter) temperatures increasing more than maximum (daytime, summer) temperatures.
- The reduced growth rate of greenhouse gas buildup in the atmosphere in the last decade, as much as half the rate of some alarmist scenarios, extends the warming timetable to facilitate adaptation under any scenario. The reduced buildup is primarily related to greater carbon intake—the "greening of planet earth" phenomenon of robust carbon sinks.
- IPCC warming estimates from doubled atmospheric GHG concentrations [estimated to be between 1.5°C (2.7°F) and 4.5°C (8.1°F) with a best guess of 2.5°C (4.5°F)) crucially depend on strong positive feedback effects, especially with water vapor. These feedbacks are under increasing scrutiny from theoreticians. The warming with neutral feedbacks [around 1.2°C (2.2°F)] is well within the positive-to-benign range, particularly given the favorable distribution of the enhanced greenhouse effect to date.
- Scientists who are confident about pinpointing the greenhouse signal from the surface temperature record have not substantiated a greenhouse signal with weather extremes.

Climate Alarmism Today

Scientific alarmism continues to challenge the public policy caution of a large body of economic analysis. In a recent study for the Pew Center on Global Climate Change, Tom Wigley of the National Center for Atmospheric Research reported a higher forecast of temperature and sea level rise than concluded in the 1995 IPCC report. His 48-page summary and analysis of the current state of the science also concluded that anthropogenic interference with climate was "potentially serious," while not mentioning any possibility that such change could be benign or positive.[5]

Should economists take the new analysis by Wigley seriously? After all, he was the scientist who gave critics of Kyoto Protocol one of their most powerful arguments—that perfect compliance with the accord would have a very small impact on temperature and sea level rise and be "undetectable for many decades."[6]

Wigley makes a case for clearer detection of the enhanced greenhouse warming effect but never considered its distinct distribution profile. Surface measurements show that the recent-decade warming is twice as great at night as during the day (a decreased diurnal cycle). The warming signature is also most pronounced in the coldest regions of the world at the coldest times of the year.[7] Skeptic Robert Michaels and alarmist James Hansen have both used color-coded maps in their presentations that show that the recent-decade warming has been most pronounced in Alaska and Siberia. This distribution clearly weakens alarmism compared to a neutral distribution or a reverse distribution where maximum temperatures are increasing faster than minimum temperatures. In fact, IPCC scientists should recast the official estimate of enhanced greenhouse warming as the amount that is *above freezing* to replace dead warming with effective warming.

The *timing* of warming is also a threshold variable for energy and agricultural economists who must derive policy implications from estimated costs and benefits. Wigley's analysis is quiet on this as well as virtually all aspects of the carbon cycle. In fact, like the distribution of warming, the

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* Robert L. Bradley Jr. is President, Institute for Energy Research, Houston, TX.

[1] See footnotes at end of text.

timing of warming moderates the climate alarm and makes a case that anthropogenic warming is benign if not positive. The rate of growth of GHG buildup in the atmosphere in the last decade has been about one-half of some "business-as-usual" estimates of climate models.[8] The slowdown is prominently due to more robust carbon sinks than previously thought, elevating the argument of CO2 advocates that plant matter is putting the kingpin of the greenhouse gases to good use in a world that depends on fossil fuels for over four-fifths of its energy consumption.

Wigley's new estimate of a higher warming and sea level rise than concluded in the 1995 IPCC report rests on an assumption of reduced particulate emissions from greater pollution control that would have offset some of the future enhanced greenhouse warming. Yet fellow scientist James Hansen is less sure about the strength of the aerosol offset than is Wigley.[9] Hansen is also cautious about the ability of models to predict future temperatures given general forcing uncertainties. In his words, "The forcings that drive long-term climate change are not known with an accuracy sufficient to define future climate change."[10] On the question of climate sensitivity to greenhouse gases, however, Hansen remains confident of a strong enhanced greenhouse effect and will not be proven wrong until uncertainties with the all-crucial water vapor feedback effect are resolved.

Water Vapor Feedback: The Hinge of Alarmism

"Feedbacks are what turn the [enhanced] greenhouse effect from a benign curiosity into a potential apocalypse."[11] The most important driver of high warming estimates in today's climate models concerns feedbacks from water vapor, the strongest greenhouse gas. A warmer world from man-made GHGs increases evaporation from the surface, primarily oceans. Water molecules trap heat, and water molecules in the upper troposphere where the air is extremely dry trap substantially more heat than near the surface to thicken the greenhouse. The physics of *fixed relative humidity* in climate modeling above the cloud level (as below it) can *double* the primary warming from anthropogenic GHGs and *magnify* the warming estimates from other positive feedbacks with cloud cover and snow cover.

Enter Richard Lindzen, considered by some to be the top theoretical meteorologist in the profession today. Formerly the director of Harvard's Center for Earth and Planetary Physics, Lindzen is currently the Sloan Professor of Meteorology at the Massachusetts Institute of Technology. Like his most serious foe James Hansen, Lindzen is a member of the National Academy of Sciences where he was elected as one of its youngest members at the age of 37. Author of such works as *Dynamic Meteorology*, Lindzen is on the cutting edge of feedback research that is crucial to model estimates of future warming under different forcing scenarios.

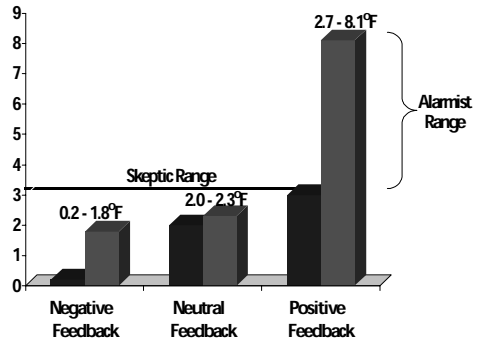
Lindzen was among the first to recognize how thoroughly dependent model warming estimates were on a strong positive feedback with water vapor (fixed relative humidity physics). He has trenchantly argued that humidity levels are *decoupled* at the cloud boundary level, with some or all of the surface area moisture not reaching the upper troposphere. Substituting climate physics for model physics reverses the water vapor feedback in Lindzen's estimation to make IPCC warming range from doubled CO2 (2.7°F to 8.1°F) entirely too high as seen in Figure 1.[12]

Figure 1 shows that *all* warming estimates from doubled CO2 are positive whatever the finding with water vapor feedback. Cloud and snow cover feedbacks are also neutral in the neutral water vapor case and are positive in the upper range of the positive water vapor feedback case. Of importance for the public policy debate, economic cost/benefit analysis is not necessary in the skeptic range (roughly at or below 2.7°F). It is in the upper half of the positive feedback range where warming costs may exceed warming benefits. Robert Mendelsohn's finding of a slight net benefit under the IPCC best guess (4.5°F warming and a 7% precipitation increase) suggests that higher warming would find costs exceeding benefits. This would bring into play the public policy question of adaptation versus mitigation—and source-versus-sink strategies if the latter strategy were chosen.

Figure 1

Water Vapor Feedback and Warming Estimates

Doubled Atmospheric CO_2 Warming Potential



Critics of Lindzen state that a lack of observational data makes his theory only a hypothesis. Yet increased relative humidity from GHG warming above the cloud level is little more than a hypothesis also. Both sides, in fact, are awaiting more observational data. But several things suggest momentum toward Lindzen in this debate. One, his theory that increased surface warming in the tropics leads to a net drying of the air in the 5 to 6 kilometer range due to a more efficient precipitation mechanism is consistent with what is now known about atmospheric processes in that important part of the world. Second, interest in Lindzen's hypothesis is widespread among feedback specialists who are not confident that climate models treat water vapor correctly. Third, the Lindzen hypothesis solves many existing climate puzzles such as the surface-atmospheric temperature discrepancy and model overestimation of warming. For economists evaluating what this debate means, the most important conclusion is that even a *partially correct* Lindzen hypothesis will lower the range of expected warming in the next century and beyond in mainstream modeling.

Cloud cover is treated as a positive feedback in models, but this is controversial even among alarmists. James Hansen has commented, "Uncertain variables such as size, brightness, and longevity result in cloud modeling [that] is so primitive that even the sign of the feedback is uncertain."[13] The 1995 IPCC report also commented, "[cloud] uncertainty represents a significant source of potential error in climate simula-

(continued on page 10)

Climate Alarmism *(continued from page 9)*

tions."[14] However, cloud feedback is secondary to water vapor feedback as a driver of warming estimates in today's climate models. Without water vapor feedback revision, much of the current estimated IPCC warming range can hold.

Conclusion

Economists are familiar with the rise and fall of the Phillips Curve. A postulated fixed relationship between inflation and unemployment, long a staple of macroeconomic modeling and public policy, was statistically falsified in the 1970s and has been expunged from the textbooks. The "Phillips Curve" of the global warming debate could well be the fixed relative humidity driver of mainstream climate modeling, a feedback that single-handedly turns a modest, beneficial warming into potentially problematic one. If Lindzen's theory passes the observational test in whole or part, many anomalies in the current debate will be solved. The tension between economic analysis and climate alarmism will lessen, and an anti-carbon crusade that promises only tenths of a degree temperature reduction a century out compared with business-as-usual will become less urgent to alarmists. For historians of scientific thought, Lindzen will also become the "F.A. Hayek" of the climate debate since he left the mainstream by emphasizing the inconvenient but crucial micro underpinnings of macroclimate modeling.[15] But for now, with uncertainties over aerosols, ocean delay, feedback effects, temperature records, and other factors continuing to rage, caution over climate alarmism can be expected to continue within the economics profession.

Footnotes

[1] William Nordhaus and Joseph Boyer, "Requiem for Kyoto: An Economic Analysis of the Kyoto Protocol," *The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, International Association for Energy Economics, 1999, p. 125.

[2] Robert Mendelsohn and James Neumann, *The Impact of Climate Change on the United States Economy* (Cambridge, UK: Cambridge University Press, 1999), p. 321. The authors state elsewhere (p. 5): "Efficient private adaptation is likely to occur, even if there is not official (government) response to global warming."

[3] Thomas Gale Moore, *Climate of Fear: Why We Should Not Worry About Global Warming* (Washington, D.C.: Cato Institute, 1997).

[4] Mendelsohn and Newmann, op. cit., p. 321.

[5] Tom M.L. Wigley, *The Science of Climate Change: Global and U.S. Perspectives*," Pew Center on Global Climate Change, June 29, 1999, p. 3.

[6] T.M.L. Wigley, "The Kyoto Protocol: CO2, CH4 and Climate Implications," *Geophysical Research Letters*, July 1998, p. 2288.

[7] See IPCC, *Climate Change 1995: The Science of Climate Change* (Cambridge: Cambridge University Press, 1996), pp. 4, 42, 61, 141, 144-45, 151, 168, 172, and 201.

[8] James Hansen et al., "Climate Forcings in the Industrial Era," *Proceedings of the National Academy of Science*, October 1998, p. 12758.

[9] James Hansen et al., "Radiative Forcing and Climate Response," *Journal of Geophysical Research*, March 27, 1997, pp. 6856-61; Richard Kerr, "Greenhouse Forecasting Still Cloudy," *Science*, May 16, 1997, p. 1042.

[10] Hansen, "Climate Forcings in the Industrial Era, p. 12753.

[11] Fred Piece, "Greenhouse Wars," *New Scientist*, July 19, 1997, p. 40.

[12] Richard Lindzen, "Can Increasing Carbon Dioxide Cause Climate Change?," *Proceedings of the National Academy of Sciences*, August 1997, pp. 8335-42: idem., "The Greenhouse Effect," *Oxford University Encyclopedia of Global Change*, forthcoming.

[13] James Hansen, "How Sensitive Is the World's Climate?," *National Geographic Research & Exploration*, 9(2), 1993, p. 144.

[14] *Climate Change 1995*, pp. 34, 197.

[15] The economics debate between F.A. Hayek (microeconomics) and J.M. Keynes (macroeconomics) is chronicled in J.R. Hicks, "The Hayek Story," in *Critical Essays in Monetary Theory* (Oxford: Clarendon Press, 1967).

International Association for Energy Economics
Student Scholarships

The Council of the IAEE is seeking nominations for 2000 IAEE Student Scholarships. The scholarships have been established in order to reward and support the studies of outstanding students of energy economics, especially those normally resident in emerging economies.

It is planned to make a maximum of 5 awards of US$2,000 each for 2000. The successful recipients will be studying energy economics or a related discipline at an internationally recognised university. They will also receive free membership in the IAEE for five years and admission to one IAEE or IAEE affiliated international energy conference.

The awards will be made by a committee of IAEE Council members comprising Prof. Peter Davies (British Petroleum, London), Dr. Michelle Michot Foss (University of Houston) and Dr. Jean-Philippe Cueille (IFP School, Paris). Their decisions will be final. A list of award recipients will be published in the IAEE Newsletter and posted on the IAEE internet site (www.IAEE.org).

Applications for scholarships should be made to:

David L. Williams, Executive Director
IAEE, 28790 Chagrin Boulevard, Suite 350
Cleveland OH 44122 USA

Fax: (1) 216 464 2737
e-mail: IAEE@IAEE.org

Applications should be accompanied by a brief explanation as to why the applicant considers themselves worthy of the award together with a letter of recommendation from the student's supervisor (in confidence if desired). Applications will close 1 April 2000 and awards will be announced by 1 June 2000 at the latest.

Davies Moves up to IAEE Presidency Nystad Named President-elect

Peter Davies, Vice President and Chief Economist of BP Amoco has moved up to the Presidency of IAEE succeeding Hoesung Lee. Davies was elected to the post of President-elect a year ago.

Peter Davies is well-known in energy circles and to the readers of this *Newsletter*, as he has been a frequent contributor. He holds a M.Sc. degree from London School of Economics and a B.Sc. degree from the University of Warwick. Before joining BP Amoco (formerly British Petroleum), he held a number of posts in the banking, academic and governmental fields, being affiliated previously with Chase Manhattan Bank, The World Bank, University of Warwick and various authorities of Swaziland. He is an honorary professor at the Centre for Energy, Petroleum and Mineral Law and Policy at the University of Dundee, Scotland.

In the Fall 1999 elections, just completed, Arild Nystad was elected President-elect of the Association. Nystad is president of RC Gruppen ASA in Norway. He holds an M.Sc. and Ph.D. from the Norwegian Institute of Technology and a postgraduate degree in Petroleum Engineering and Petroleum Economics from Ecole Nationale Superieure du Petrole et des Moteurs at IFP. He was formerly Managing Director of RC Consultants AS, Director, Petroleum Resource Management Division of the Norwegian Petroleum Directorate; Chief Scientist at the Centre for Petroleum Economics at Chr. Michelsens Institute and Scientist at the Continental Shelf Institute, both in Norway. He was IAEE Vice President for Conferences from 1994 through 1997, Vice President and Secretary, 1998-99 and was instrumental in the establishment of the Norwegian Affiliate.

Also elected were Jean-Philippe Cueille, Vice President and Secretary; Hossein Razavi, Vice President for Publications; and Michelle Michot Foss, Vice President for Conferences. Razavi and Foss were both elected for second two-year terms.

Jean-Philippe Cueille is professor at the IFP School, Center for Economics and Management in Paris. He holds a B.Sc. in economics from the University of Nancy, a M.Sc. in Chemical Engineering from Ecole Nationale Supérieure des Industries Chimiques, and a M.Sc. in Petroleum Economics and Management from IFP. Formerly he was a professor at the Ecole Polytechnique Fédérale, Lausanne, and a visiting professor at the University of Pennsylvania. Cueille has been active in IAEE as a Council Member, a member of the EFCEE, secretary of the French Affiliate and general secretary of the IAEE International Conference in Tours, France.

Hossein Razavi is Director of the Energy Department, Europe & Central Asia of the World Bank. He holds a B.S. and M.S. in Engineering and a Ph.D. in Economics from the University of Maryland. He was formerly Chief of the Oil & Gas Division of the World Bank. His IAEE involvement includes serving as an appointed Council member in 1994 and as member of the Board of Editors of *The Energy Journal* since 1995 and Vice President for Publications, 1998-99.

Michelle Foss is Director of the Energy Institute of the University of Houston's College of Business Administration and an Assistant Research Professor in the Department of Decision and Information Sciences. She holds a B.S. from the University of Southwestern Louisiana, an M.S. from the Colorado School of Mines and a Ph.D. from the University of Houston. Dr. Foss has done extensive consulting on energy and other natural resources, environmental permitting and industrial siting in the United States, Mexico and Indonesia. She has broad IAEE involvement including being a past president of the USAEE Houston Chapter, President of the USAEE, and IAEE's Vice President for Conferences, 1998-99, serving on the Board of Editors of *The Energy Journal* and as chair or co-chair of various conferences.

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

coverage. Ron Sutherland opens by reviewing the articles in The Energy Journal while Rob Bradley expresses skepticism about the scientific case for GHG reduction policies. In terms of implementation, Robert Lempert, Mark Bernstein and David Robalino argue for employing incentives and punitive measures in combination, and Paul Monfils says that economic modeling implies that use of a "double bubble" emissions trading systems has significant benefits."

In future issues Mike will cover petroleum industry strategy, energy industry restructuring in Asia, and comparative electricity deregulation. He welcomes suggestions for topics and authors, as well as submissions, including responses to published work. Contact him at MIT.

Also in this issue, Fereidun Fesharaki and Sara Banaszak look at Japan's LNG demand and ask, where is the consumer? They note that Japan is the world's largest LNG importer with roughly 70 percent of LNG imports being used in power generation. Though exporters are expecting Japan's utilities to markedly increase LNG imports, the utilities are thinking otherwise. Rather than a large increase in LNG imports the utilities are planning a doubling of their use of coal in the ten years to 2008. There seems to be a large difference between expectations and reality.

Fereidoon Sioshansi comments on the process of U.S. electric power restructuring and lists some of the setbacks that have occurred, including the fact that in some cases the savings, at least in the short-run, are either nonexistent, small or elusive. Nevertheless competitive pressures have unleased forces that will reduce costs and improve efficiencies.

Darrel Nash examines the annual operation and maintenance costs of a number of U.S. nuclear power plants and benchmarks them against the costs of the low cost producer. He concludes that there is significant potential for lower overall production costs by within plant reallocation of resources among the components.

DLW

Future IAEE Events

June 7-10, 2000	23rd IAEE International Conference Sydney Australia *Sydney Hilton*
September 24-27, 2000	21st Annual USAEE/IAEE North American Conference Philadelphia, PA, USA *Wyndham Franklin Plaza Hotel*
April 25-28, 2001	22nd IAEE International Conference Houston, TX, USA

Combining the Carrot and the Stick: The Best Policy Approach to Reducing Greenhouse Gas Emissions

By Robert Lempert, Mark Bernstein and David Robalino

Introduction

Governments worldwide are pursuing many different types of policies designed to reduce emissions of greenhouse gases. In particular, the Clinton Administration has proposed a phased approach to meeting U.S. commitments under the Kyoto treaty, by first using R&D spending, tax incentives and voluntary actions, followed by emissions trading. The R&D spending and tax incentives are intended as "carrots" to encourage the development and use of new, greenhouse-gas-emissions-reducing technologies. Emissions trading provides a "stick" designed to reduce emissions by increasing the price of using high emitting energy technologies.

Such a combined approach of carrots and sticks seems to have a compelling logic. New technologies will likely be critical to any significant reduction of greenhouse gas emissions during the 21st century and "carrots" such as technology incentive programs may speed their development. In addition, such incentives may be politically more attractive than emissions trading because the latter raises costs for many industries and other stakeholders. On the other hand, economic theory implies that policy-makers should employ only "sticks" such as tradable emissions permits or carbon taxes, which, in the absence of market failures, are the most efficient policies for fostering both technological innovation and reducing emissions. By comparison, technology incentives may distort the market by diverting resources from more to less productive investments**.** Finally, technology incentive programs have had a mixed record of achieving practical success independent of their relative efficiency.

Using an innovative new approach to computer simulation under conditions of extreme uncertainty, our recent RAND Science and Technology Policy Institute study[1] finds that technology incentives are likely to be an important part of a cost-effective climate change strategy. We find that if decision-makers hold even modest expectations that market failures are likely to inhibit new, emissions-reducing technologies or that the impacts of climate change will turn out to be serious then technology incentive programs are a promising hedge against the threat of climate change.

Approach

In the past, it has been difficult to systematically compare such "carrot" and "stick" policies because of the extreme uncertainty involved with technology forecasts and because of difficulty representing mathematically many of the market failures that might suggest a role for a technology incentives. We employ two new analytic innovations to assess the conditions under which technology incentives are an important building block for effective and feasible climate change policies. First, we use what is known as an "agent-based" model of technology diffusion. Agent-based models provide a convenient framework for representing several important features of technology diffusion, including information exchange among economic actors and the heterogeneity among different actors, which are often missed in analytic studies of climate change policy.

Second, we employ a new method of decisionmaking under extreme uncertainty — exploratory modeling[2] — that allows us to compare alternative policies without requiring predictions of the future cost and performance of new technologies. Rather than calculate the expected value of various policies as a function of projected costs and performance, we simulate the performance of alternative policies against a wide range of potential climate change scenarios. We then use search and visualization tools to examine the resulting outcomes to address questions of interest to policymakers. In particular, we can search for strategies that are robust across a wide range of expectations about the future.

In the analysis, we compare a strategy that only uses only "sticks" such as tradable permits[3] to limit emissions of carbon dioxide, which we call the *Limits-Only Strategy*, to a strategy that combines such mechanisms with "carrots" such as technology subsidies, which we call the *Combined Strategy*.

Both sets are adaptive-decision strategies, [4] that is, they evolve over time in response to observations of the emerging economic and environmental conditions in our simulation model. Using the exploratory modeling approach, we conducted a computer search through a huge number of plausible scenarios generated by the agent-based model, looking for those that distinguish one policy choice from another.

Figure 1, a typical result of such comparisons, shows the relative performance of these two strategies as a function of the heterogeneity of economic actors, one of the key, uncertain factors describing the future state of the world. The figure shows that the Limits-Only Strategy (green dashed line) performs better than the Combined Strategy (blue solid line) in a world where there are no potential early adopters.

As the number of potential early adopters increases, the Combined Strategy quickly becomes more attractive. More diversity favors the Combined Strategy, because it creates a number of potential early adopters that are well disposed to use the new, low-emitting technology. The incentives encourage many of these agents to adopt, thus generating learning and cost reductions above and beyond the social benefit gained by any individual adopting agent.

Findings

We considered a large number of results such as those in Figure 1, and find that under three plausible conditions, a strategy of technology incentives combined with tradable permits, or even carbon taxes, is a more effective approach to climate-change policy than an approach based on "getting the prices right" alone. These three conditions are:

- The existence of at least modest expectations among policymakers that the diffusion of new, emissions-reducing technology will significantly reduce the future costs of emissions abatement. Such technologies might include some combination of fuel cells, hydrogen, solar, wind, biomass, or even new nuclear. Numerous studies suggest that the emissions reduction potential of these technologies may in fact be large.
- Some economic actors must be more willing to adopt such technologies than others. While such heterogeneity of

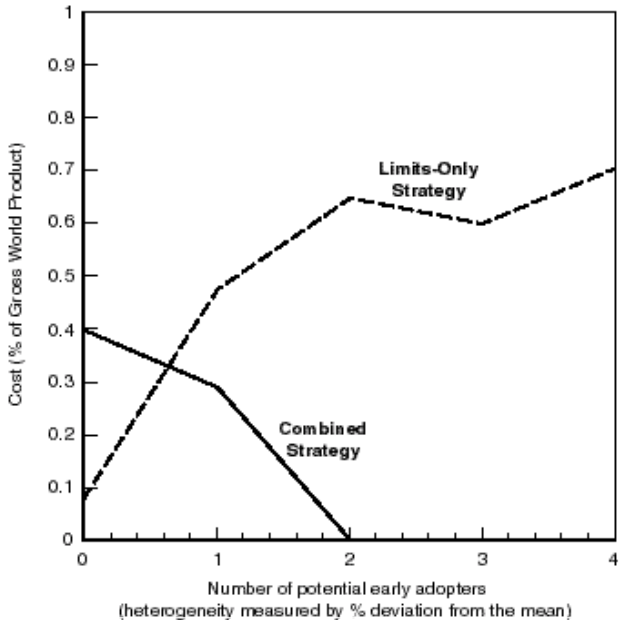
* Robert Lempert, Mark Bernstein and David Robalino and with Rand Corporation, Santa Monica, CA.

[1] See footnotes at end of text.

preferences is clearly the case in practice, it is often neglected in quantitative policy studies of climate change. Recently proposed early credit programs may encourage early adopters.

- Finally, there must be broad social benefits to the early adoption of such technologies by a small number of early users. Such benefits can arise from several sources, including cost reductions due to increasing returns to scale and improvements in the information available to economic actors about the performance of new technologies.

Figure 1

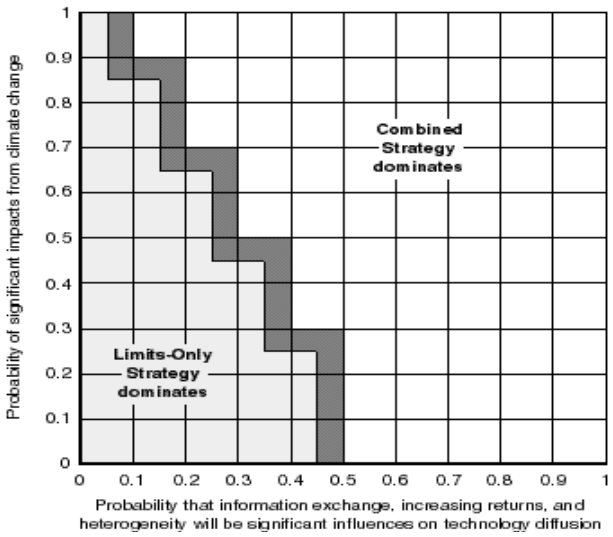


If these conditions are met, and it is likely that they are in practice, then technology incentives are an important component of an integrated climate change strategy.

These results are summarized in Figure 2. The figure shows the expectations about the future that should cause a decision-maker to prefer the Limits-Only strategy to the Combined Strategy. The horizontal axis represents the range of expectations a decision-maker might have for how likely it is — from very unlikely on the left to very likely on the right — that factors such as the potential number of early adopters and the amount of increasing returns to scale will significantly influence the diffusion of new technologies. The vertical axis represents the range of expectations a decision-maker might have that there will be significant impacts due to climate change (greater than 0.3% of the global economic product). The figure shows that the Combined Strategy dominates even if decision-makers have only modest expectations that impacts from climate change will be significant and that information exchange and heterogeneity among economic actors will be important to the diffusion of new, emissions-reducing technologies.

It is important to note that our analysis does not justify technology incentives as a substitute to a perfect market. Rather, we find that technology incentives are a complement to, not a substitute for, flexible mechanisms designed to limit emissions. An effective response to climate change will often require both. However, our work suggests that policymakers may not need to implement both at the same time and that a combined strategy of technology incentives and tradable permits may in fact provide considerable flexibility in choosing when to introduce each type of policy.

Figure 2



Future Work

Significant research steps remain, however, before the innovative methods and models used in this study can be translated into more specific policy recommendations. For instance, our treatment of learning about new technologies among economic agents neglects the institutional networks that help transmit information among economic actors. In addition, our treatment of new technologies is sufficiently aggregate so that it is difficult to relate our technology incentives to specific recommendations for spending levels. Thus, while we argue that technology incentives are likely to be an important part of any climate change strategy, we have not answered the question as to whether the subsidies currently in place and proposed by governments are sufficient or too much or too little. We believe, however, that the methods laid out in this paper provide a powerful framework for addressing such questions.

Footnotes

[1] David A. Robalino and Robert J. Lempert, "Carrots and Sticks for New Technology: Crafting Greenhouse Gas Reduction Policies for a Heterogeneous and Uncertain World," forthcoming.

[2] Steven C. Bankes, "Exploratory Modeling for Policy Analysis," Operations Research, 41, 3, May-June 1993.

[3] Since the impact of permits will be higher energy costs, in this study we use the cost of carbon or carbon taxes as a proxy for tradable permits.

[4] Robert J. Lempert, Michael E. Schlesinger, and Steve Bankes, "When We Don't Know the Costs or the Benefits: Adaptive Strategies for Abating Climate Change", 33, 235-274, Climactic Change, 1996.

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Fifth Annual Washington Energy Policy Conference

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The Double Bubble: Definition, Available Literature and Estimated Impacts

*By Paul Monfils**

This note briefly examines the concept of the "double bubble" in the context of international emissions trading. The double bubble is defined and the policy context of its development is given. References to recent literature are provided, in particular, studies which estimate its economic impact.

Definition

On the path leading to the Kyoto Protocol and its aftermath, the "double bubble" was proposed as a potential trading regime within the boundaries of Annex I. Under the double bubble, Annex I countries meet their commitment under two separate trading groups: the European Union (EU) and the rest of Annex I, hence the name "double bubble".

IPolicy Context

Article 4 of the Kyoto Protocol allows Annex I countries to fulfill their quantified emission limitation and reduction commitments jointly (i.e., to form a bubble).

The EU has formed a bubble and adopted an overall target of 92 percent of its 1990 emission levels. As per its burden sharing agreement, the EU has defined country-specific targets varying from 72 to 127 percent of 1990 levels. The EU bubble implies that European countries are working together to meet the overall EU target and that significant "trading" of emission credits will take place, at least implicitly, among EU countries. More recently, the EU has taken a policy position in favour of restricting the use of 'hot air' and, in an attempt to quantify the "supplementarity" provision of the Protocol, it proposed a formula by which the use of the Kyoto Mechanisms would be capped.

In consideration of these factors, countries of the so-called Umbrella Group, namely, the United States, Canada, Japan, New Zealand, Australia, Norway, Iceland, Russia and Ukraine, have suggested a double bubble concept as a possible trading regime. The creation of a second bubble would ensure unrestrained trading among its participants (i.e., the non-EU Annex I countries).

Available Literature

The Energy Modeling Forum (EMF) held a series of workshops in 1998 leading to the EMF-16 exercise. The goal was to compare results from various models on the cost of implementing the Kyoto Protocol. Thirteen modeling teams participated to EMF-16. The modeling teams were asked to run a common set of abatement scenarios to serve as a basis for comparison of their results. This extensive research is reproduced in a 1999 Special Issue of *The Energy Journal*, entitled *The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, published by the International Association for Energy Economics.

Although the double bubble was <u>not</u> part of the four "core" scenarios (i.e., Reference case, No trading of emission rights, Full Annex I trading and Full Global Trading), it was analyzed by five modeling teams. Their key findings are summarized below. The price of international credits under double bubble as compared to estimates for full Annex I trading are shown in Table 1.

Double Bubble: Its Economic Impact

A country's take-up of international credits is primarily a function of the difference between its domestic cost of abatement and the international price of emission credits. The larger the difference, on a per tonne basis, the larger the incentive for a country to acquire international credits for meeting its target.

Under the double bubble, the EU is removed from Annex I trading. Since the EU is a net purchaser of international credits under a full Annex I trading regime, its removal from the international market is expected to reduce the demand for credits. This would reduce the international price of credits, assuming there is no change in the international supply which would originate, for the most part, from the former Soviet Union[1]. Consequently, countries on the international market, facing a lower price, have the incentive to acquire a larger amount of credits. Effectively, as shown in Table 1, the double bubble results in two prices for tradable credits within the Annex I region: one price for the EU, and another one for the rest of Annex I (i.e., Umbrella Group countries).

Table 1

Price of Tradable Credits: Double Bubble vs Full Annex I Trading
EMF-16 Double Bubble Modelling Results

Model	Price of International Credits in 2010 (1995US$ per metric tonne[2])		
	Double Bubble Trading		Full Annex I Trading
	EU Price	Umbrella Group Price	Intl. Price
SGM (Second Generation Model) Batelle Pacific Northwest Laboratory	$140	$69	$79
AIM (Asian-Pacific Integrated Model) National Institute for Environmental Studies (NIES-Japan), Kyoto University	$216	$50	$70
GTEM (Global Trade Environment Model), Australian Bureau of Agriculture & Resource Economics	$190[a]	$117	$123
G-Cubed (Global General Equilibrium Growth Model), Australian National University, Univ. of Texas & US EPA	$261	$32[b]	$61
Oxford Model (Oxford Economic Forecasting)	$906[c]	$163	$213

Notes: please see Annex A for footnotes a, b, and c.

- When removed from the Annex I trading bloc, under a double bubble, the EU is left to meet its obligations independently. The necessary carbon taxes and energy impacts are generally the same as under a <u>no trading</u> case, the EU facing a permit price that is roughly twice the amount than under full Annex I trading.
- EU's departure reduces the demand for international cred-

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[1] See footnotes at end of text

(continued on page 16)

The Double Bubble *(continued from page 15)*

its. Given a constant supply of credits from the former Soviet Union/Eastern Europe (FSU/EE) region, this results in a lower permit price than under full Annex I competitive trading.

- Countries of the Umbrella Group achieve a higher percentage of their target through trading and reduce their domestic carbon price for the share to be achieved domestically.
- While the double bubble has no benefit for the EU, it is advantageous to Umbrella Group countries.

In these five analyses, Canada is not identified as a region by itself but rather included as part of a larger trading entity including also Australia and New Zealand (i.e., the "CANZ" region). NRCan's own estimate, calculated with Charles River Associates (CRA) Multi-Sector Multi-Region Trade (MS-MRT) model is provided in the next section. MS-MRT model was also part of EMF-16. The analysis prepared by Paul Bernstein, David Montgomery and Gui-Fang Yang, of CRA, and Thomas Rutherford, of the University of Colorado, focused on different aspects of emission trading and did not address the impact of the double bubble.

MS-MRT Model Estimates

In general, the findings of other modeling teams are confirmed by our runs of MS-MRT, which are displayed in Table 2 and Figure 1 below[3]. The international price of emission credits is lower under a double bubble trading scheme compared to unrestrained Annex I trading. A non-trading EU reduces the demand for and the price of international credits.

Table 2
MS-MRT Model Estimates
International Prices and Percent of Obligation Met Through Trading

	International Trading Regime		
		Double Bubble	Full Annex I Trading
	EU Price	Umbrella Group Price	Intl. Price
Int'l Carbon Price (US1995$/tonne of c.)	$180	$69	$83

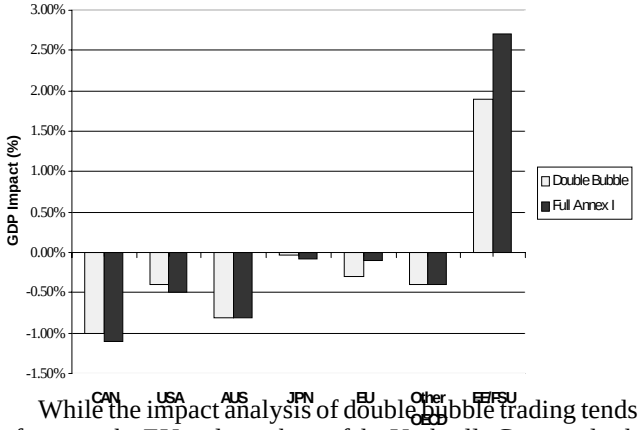
Region	Percentage of Obligation Met Through Trading	
	Double Bubble	Full Annex I Trading
CAN	70%	64%
USA	60%	52%
AUS	6%	no purchase
JPN	70%	64%
EU	Outside Umbrella Group	44%
Other OECD	86%	82%

In the double bubble case, Canada would have the incentive to achieve a larger share of its obligation through international credit purchases (70 percent rather than 64 percent under full Annex I trading). This is due to a lower permit price of 1995US$69 per tonne of carbon compared to $83.

The lower permit price implies that Canada would face a lower domestic cost of abatement for the share of its obligation to be achieved domestically. Instead of undertaking 36 percent of its obligation under full Annex I trading, Canada would only achieve 30 percent of its obligation domestically. As shown in Figure 1, a lower cost per tonne also explains the reduction in the cost estimate to 0.95 per cent of GDP by 2010, under double bubble versus 1.08 percent under full Annex I trading.

Not only Canada gains under a double bubble but also the USA and Japan. The EU, by contrast, faces a GDP cost which is nearly three times the cost under full Annex I trading.

Figure 1
GDP Cost Estimates - MS-MRT Model



While the impact analysis of double bubble trading tends to focus on the EU and members of the Umbrella Group, a look at the impact on FSU/EE is of interest. As a supplier of permits, the gains for the FSU/EE are reduced with the double bubble (+1.9 percent above business-as-usual GDP rather than +2.7 percent under full Annex I trading). This is thought to be due mostly to the decline in both the price and the quantity (i.e., 35 Mt of carbon, or 7.5 percent, less) of the international credits they sell. This may provide an incentive to that region, especially Russia, to exercise market power to raise its selling price to avoid such potential loss.

Concluding Remark

Analyses show that under a double bubble, the EU loses and FSU=s benefits from permits sales are reduced while other Annex I countries, including Canada, are better off.

A question that arises is whether the magnitude of the permit price differential among OECD countries, under a double bubble, is sustainable. Facing a permit price which would be twice that for other Annex I countries, the EU would face possibilities of leakage, not only to the benefit of non-Annex I countries, but also other OECD economies. International firms operating in Europe may not view this situation with equanimity.

Although a double bubble may not be currently subject to intense negotiations, it remains a strategic element that can help counterbalance EU's stance towards restricting international trading of emission credits.

Footnotes

[1] The question of whether the Eastern Europe (EE) region would be part of the double bubble group remains unclear because it would be negotiated primarily by the members of the Umbrella Group, which only includes Russia and Ukraine from the FSU/EE region. In general, the double bubble assumes that the whole FSU/EE region participates in a double bubble. GTEM applies a different geographic definition and its impact is detailed in Annex A (footnote a). EE represents about 5% of the 'hot air' that would be available by 2010, according to U.S. DOE Energy Information Administration 1999 forecast.

[2] U.S. GDP deflator used to bring published values into U.S.

1995 dollar.

[3] In terms of international carbon prices, MS-MRT estimates are at mid-point of the values generated by the other models, for each of the scenarios.

Annex A
EMF-16 Modelling Results on the Double bubble

Model	Key Result on Double Bubble Scenario Analysis
SGM (Second Generation Model) Batelle Pacific Northwest Laboratory	"In the "Double Bubble" case, the Western Europe region is removed from the Annex I trading bloc, leaving it to meet its obligations independently. For Western Europe, the necessary carbon taxes and energy impacts are the same as under its no trading case. But for the remaining regions in the permit market, the departure of Western Europe results in a 2010 permit price that is lower than in full Annex I competitive trading - $64 [1992 US $] per tonne as compared to $73 under full Annex I trading". (Op. Cit., p. 55)
AIM (Asian-Pacific Integrated Model) National Institute for Environmental Studies (NIES-Japan), Kyoto University	"The GDP loss of the EU in the double bubble case is larger that in the no trading case. This is because the EU has access to relatively low cost emission rights from EEFSU in the Annex I trading case, but loses access to that "hot air" in the double bubble case. Therefore, the double bubble scenario has no merit for the EU." (Op. Cit., p. 219)
GTEM (Global Trade Environment Model), Australian Bureau of Agriculture & Resource Economics	"Under the double bubble, the carbon emission penalty in the European bubble is substantially higher than the emission penalty under full Annex I trading. This is because the EU no longer has access to low cost emission abatement opportunities in the former Soviet Union. Instead it must purchase more expensive emission quotas from eastern Europe where pre-trade carbon emission penalties (marginal abatement costs) are higher than for the former Soviet Union. The change in carbon emission penalty for the umbrella group is relatively small because the removal of the EU's demand for quotas (which would tend to reduce quota prices) is offset to some extent by the removal of a similar quantity of quota supply by eastern Europe. The net effect is a small decrease in quota price for the umbrella group relative to full Annex I trading". Union (Op. Cit., p. 271) [This represents a slightly different definition of the double bubble, as the EU still acquire some credits from Eastern Europe.](a.)
G-Cubed (Global General Equilibrium Growth Model), Australian National University, Univ. of Texas & U.S. EPA	"The key difference between this scenario and full Annex I trading is that ROECD no longer buys...permits from the former Soviet Bloc. As a result, the effects on ROECD look much like the no-trading case and abatement costs in the rest of Annex I [i.e., USA, Japan and Australia as per G-Cubed definition] fall substantially. Permit prices fall to $32 (1995 US $) in 2010 [compared to a price of $61 under full Annex I]." (Op. Cit. p. 312). (b.)
Oxford Model (Oxford Economic Forecasting)	"In this case, the EU countries have to introduce carbon taxes effectively equivalent to those in the no trading case. In contrast, non-EU countries benefit from a lower international permit price (since, with the EU out of the market, the demand for permits is lower) - $170 (1997 US $) mmt in 2010 compared with $222 under full Annex I trading." (Op. Cit., p. 357) (c.)

Notes:
1. GTEM defines the double bubble scenario in a slightly different fashion than used by other modeling teams. Although the EU no longer has access to low cost emission abatement opportunities in the former Soviet Union (FSU), it, however, maintain access to some of the low cost emission credits from eastern Europe where pre-trade carbon emission prices are higher than for the FSU. GTEM estimates the permit price for the EU under the double bubble to be 1995US$190, higher than the price under full Annex I trading, but lower than EU 'no trade' price estimate (of $771), contrarily to other analyses.
2. G-Cubed applies a different, more aggregated, definition of OECD countries. G-Cubed defines Annex I regions as composed of the USA, Japan, Australia, FSU and Rest of OECD countries (i.e., ROECD). ROECD aggregates the EU and non-EU regions like Canada and New-Zealand into a single region. When running the double bubble with such aggregation of regions, all of ROECD countries are removed access from FSU permits, which results in a further reduced demand and a lower international (i.e., Umbrella Group) price than would be otherwise (i.e., if only the EU was removed from Annex I trading).
3. Oxford defines the EU as EU-4 comprising Germany, France, Italy and UK.

Japan's LNG Demand: Where is the Consumer?

*By Fereidun Fesharaki and Sara Banaszak**

Executive Summary

- Japan is the world's largest, most important LNG importer and consumer, accounting for over half of global imports in 1998. The regional LNG industry is fully dependent on Japan. Although LNG demand in Japan is not seen to have potential for fast growth, the large base of demand in Japan makes it the key factor underlying LNG supply and demand in the region for some time to come.
- In terms of consumption patterns, roughly 70% of LNG imports are used for power generation and 30% by town gas consumers. Thus, the most important consumer of gas in Japan is the electric utility system. As such, plans and strategies of the electric power companies are the real key to the future of LNG demand in Japan.
- Japanese utilities expect to consume less than 2 million tonnes of additional gas/LPG between 1998 and 2008. Oil consumption is also expected to grow only slightly. The most remarkable growth is that of coal use which is expected to almost double between 1998 and 2008.
- The Japanese utilities face two serious problems. First, uncertain economic outlook with potential weak or even declining gas demand. Second, the IPPs will take away from the gas seller around 10% of the market. As such, the traditional utility faces a double barrel: weak economy and loss of clients due to IPPs!
- Many gas projects planning on exporting to Japan are unlikely to happen for the next 10-20 years. Just a pipeline alone from Sakhalin would deliver the equivalent of 6 to 10 million tonnes of LNG. New LNG export projects, gas export from Russia, etc., will all have to wait for the 2010 to 2020 period before finding the right level of demand.

Introduction

Japan is the world's largest, most important LNG importer and consumer, accounting for over half of global imports in 1998. Within the Asia-Pacific region, the role of Japan is critical. The regional LNG industry is fully dependent on Japan. Although LNG demand in Japan is not seen to have potential for fast growth, the large base of demand makes Japan's LNG demand the key factor underlying LNG supply and demand in the region for some time to come.

Structure of Japan's LNG Demand

In Japan, LNG is imported via three different groups. The trading houses (led by Mitsubishi Corporation, Mitsui, and Itochu), city gas companies led by Tokyo Gas and Osaka Gas, and electric power companies led by Tokyo Electric, Kansai, and Chubu Electric among others. In terms of consumption patterns, roughly 70% of LNG imports are used for power generation and 30% by town gas consumers. Because LNG is used predominantly for power generation, Japanese consumption is not subject to the same seasonal fluctuation that occurs in Korea, where a significant portion of imports are used for winter home heating. In short, the most important consumer of gas in Japan is the electric utility system. As such, plans and strategies of the electric power companies is the real key to the future of LNG demand in Japan.

Outlook for Gas Imports into Japan

Japan is every exporter's favorite gas export target. Almost every LNG project has a close eye on Japan and every long distance pipeline from Russia (and even sometimes Central Asia) counts on imports into Japan. Indeed, there is so much euphoria about the ability of Japan to import gas, that there are prospects for serious miscalculations by gas exporters. Adding to the euphoria are statements by the Japanese government about the commitment to CO_2 reductions under the Kyoto accord. If, indeed, the Japanese government is to be believed, then the volume of gas consumption should rise dramatically. If that is the case, then Japan will need to import a great deal of additional LNG and pipeline gas. Or so the story goes!

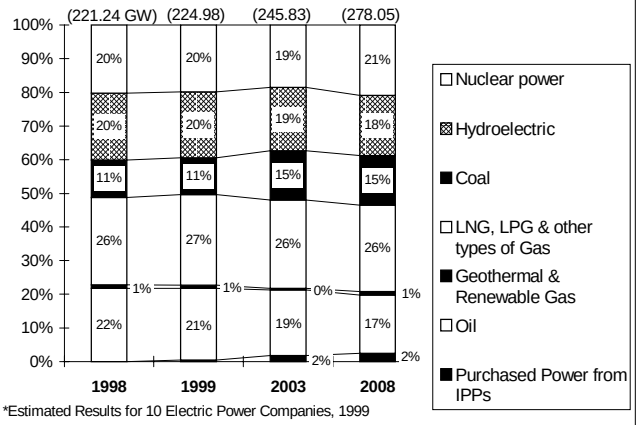
The Big Divide Between Euphoria and Reality

There is a huge gap between what the exporters expect Japan to import and how much actual gas is going to be needed. Indeed, while the government assertions regarding more gas use heighten expectations, the reality is different. There is likely to be far smaller amounts of new gas to be consumed in Japan than expected by the market.

Where Are the Consumers?

Rather than listening to the grand plans of the government and energy planners, it is particularly useful to focus on the plans for fuel use of Japan's 10 electric power companies, which generate nearly 90% of the country's total electricity supply. After all, these companies are the final determinants of gas demand in Japan. Figure 1 shows capacity composition ratios in the 10-year period, 1998-2008. Figure 2 indicates generated power composition ratios of the 10 power companies. Both charts show remarkably steady ratios of almost all fuels. While the gas (including LPG) capacity and generation are to rise from 1999 to 2003, there are almost no expectations of any growth between 2003 and 2008. The ratio of nuclear power actually declines from 1998 to 2008 in terms of power composition, though the capacity actually increases a little. The share of oil remains remarkably stable.

Figure 1. Electric Power Supply Plan: Capacity Composition Ratios, 1998-2008*



*Estimated Results for 10 Electric Power Companies, 1999

power companies in Japan. It shows that Japanese utilities

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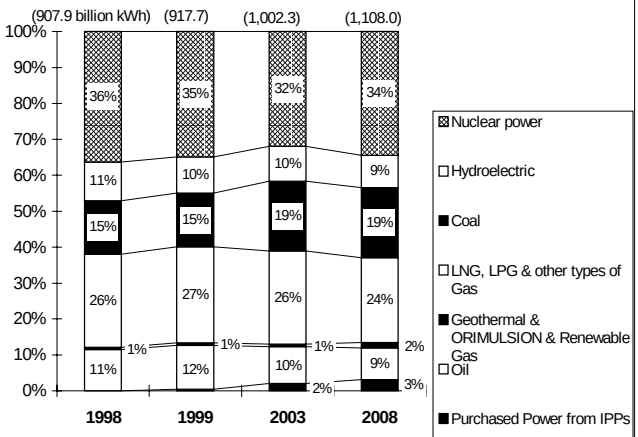
* Fereidun Fesharaki and Sara Banaszak are with the East-West Center in Honolulu, Hawaii where Fesharaki is Director of the Energy Program. The article is reprinted from a recent East-West Center's Energy Advisory.

Figure 2. Electric Power Supply Plan: Generated Power Composition Ratios, 1998-2008*



*Estimated Results for 10 Electric Power Companies, 1999

expect to consume less than 2 million tonnes of additional gas/LPG between 1998 and 2008. Oil consumption is also expected to grow only slightly. The most remarkable growth is that of coal consumption which is expected to almost double between 1998 and 2008. TEPCO (Tokyo Electric), the world's largest LNG importer and Japan's largest utility, has its own plans which are even more drastic. TEPCO will add barely one million tonne of LNG use, but will increase oil consumption by 50% between 1998 and 2008. Coal consumption is forecast to rise by nearly 400% in the same period!

Even if we assume that the city gas companies add 1 or 2 million tonnes to demand, we will only witness 3 to 4 million tonnes of new gas demand between 1998 and 2008. Indeed, these forecasts, rooted in reality and away from government's wishful thinking, indicate Japan faces an extremely difficult if not impossible task in meeting its Kyoto commitment.

Then what about all the planned projects exporting gas to Japan? These projects are somewhat unrealistic and are unlikely to happen for the next 10-20 years. Just a pipeline alone from Sakhalin would deliver the equivalent of 10 million tonnes of LNG. There certainly is no demand for these imports in the short to medium term. New LNG export projects, gas export from Russia, etc., will all have to wait for the 2010 to 2020 period before finding the right level of demand. Gas

Table 1. Requirements for Main Fuels (10 Electric Power Companies)

	1998	1999	2003	2008
Oil (gigaliters)	24.63	27.06	26.04	25.47
LNG (mmt)	35.74	36.96	38.55	37.67
Coal (mmt)	47.28	48.64	71.83	82.36

Note: LNG includes domestic natural gas and city gas

pipeline projects specially must be viewed in the long term, providing the means to build long-term economical political links with Russia via gas pipelines.

Why Such Low Utility Demand?

The Japanese economic downturn period is the most serious threat to the gas markets. Japan's weak economic performance meant that in 1998, Japan could not meet its contracted gas purchasing obligations. The same is true for 1999. The Japanese utilities face two serious problems. First, uncertain economic outlook with potential weak or even declining gas demand. Second, the IPPs will take away from the gas seller around 10% of the market. As such, the traditional utility faces a double barrel: weak economy and loss of clients due to IPPs! In the uncertain market, it makes good sense to use fuels which can be cut back if needed without too much penalty. Oil and coal offer such flexibility (and they have been the fuels of choice for IPPs in Japan). Gas requires long-term commitments and project financing, putting serious pressure on the utilities. It is, therefore, not surprising that the utilities have focused on coal and even oil more than gas, since the former do not require large investments and can limit potential financial losses for the utilities. Indeed, the Japanese utilities' fuel choice policies make ample economic sense from the point of view of the private sector which has to protect their shareholder's interest.

Restructuring Of U.S. Electric Power Sector Continues Despite Setbacks

*By Fereidoon P. Sioshansi**

What started as a strategic white paper by the California Public Utilities Commission (CPUC) in California 1994, has now spread to 24 states across the United States. More states are expected to follow suit in the coming months, exposing the U.S. electric supply industry (ESI) to a hodge-podge of competition and re-regulation. The map below shows the states which have already passed restructuring legislation, although the starting dates, and many of the specific details vary greatly from place to place.

Based on what is already on the books, over 73 million U.S. customers—roughly 60% of the total—currently can, or will soon have the option to, select a competing supplier. Yet, despite all the commotion about the new competitive markets, there have been a few setbacks and disappointments. For one thing, 26 states are still to adopt restructuring. Among these are five states —Alabama, Colorado, Idaho, Kentucky, and Louisiana—which have studied the issue and have decided that there will be no tangible benefits, at least in the short-run, from restructuring. This conclusion is presumably based on what they can see from developments in other states. These states have postponed any move towards liberalized markets for now, making them an awkward company in the midst of states that have restructured or will do so in the near future.

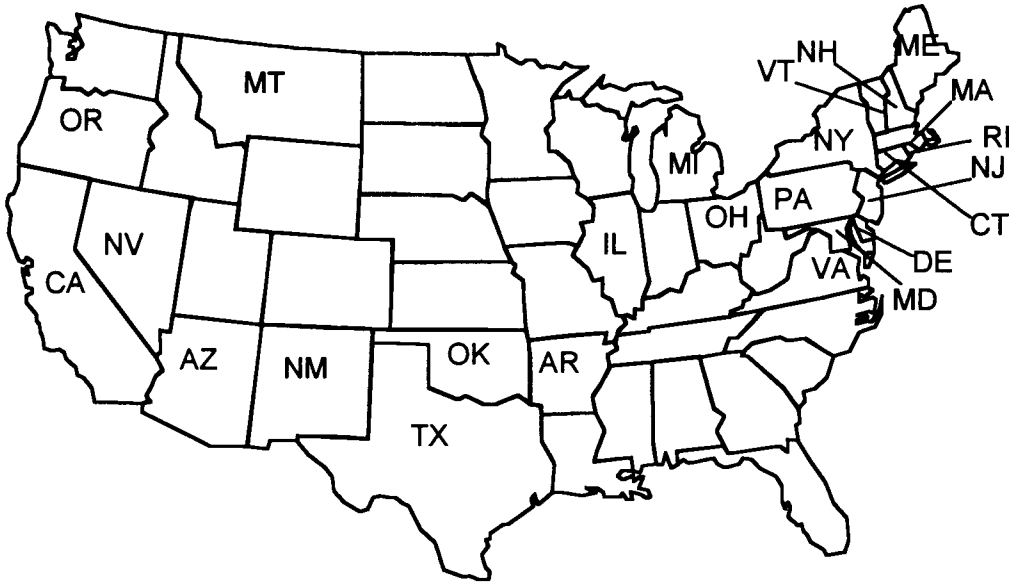
Nor is all well among the pioneering states that started the current fad. Two initiatives to essentially reverse significant provisions of restructuring legislation were defeated in California and Massachusetts last year. In a number of other states, notably Arizona, Michigan, Montana, New Hampshire, New Jersey, Nevada, Pennsylvania, and Vermont, there has been mild to significant opposition to the implementation of the legislation.

Moreover, policymakers, consumers (and their advocates), regulated utilities, new competitive suppliers, and environmental groups have all discovered that there is a dark side to restructured or re-regulated markets—since everybody realizes that there is no de-regulation, nor will there ever be such a thing. Among the setbacks are the following:

- Policymakers in a handful of states have decided to delay or postpone restructuring implementation for a variety of reasons.
- Consumers and their advocates have discovered that the savings—at least in the short-run—can be non-existent, small, or elusive. This is particularly true of states with significant stranded costs—such as California—which have to be paid off before meaningful competition can truly start. The scale of stranded costs, once estimated to exceed $300 billion, however, has turned out to be roughly half that figure—still a staggering sum.
- Regulated utilities have found that it is much harder to operate with the new rules of conduct, which in many cases further restrict their access to customers and limit their ability to compete effectively in the competitive markets.
- New energy suppliers have found—surprise—that it costs a lot to acquire customers; it is not easy to hang on to them; it is difficult to sell them additional value-added services; and enormously expensive to launch new brands and products. Many have left the business altogether, while others have concentrated exclusively on the large commercial and industrial customers, leaving the residential mass market virtually unattended.
- Environmental and advocacy groups have found that—surprise—all major players in the competitive environment are focused on the short-term bottom-line. Consequently, nobody will look after:
  - Environmental issues;

Who Has Taken The Plunge—So Far

States That Have Already Passed ESI Restructuring Legislation



- Long-term issues (e.g., research and development, particularly the high-risk, high-payback variety);
- Renewable energy technologies;
- Energy efficiency programs, particularly the variety that is socially desirable but may have little or no tangible commercial payback.

Competition In Supply Business

Number of registered electricity suppliers in selected states.*

State	# of Registered Suppliers
California	35
Illinois	11
Massachusetts	16
New Jersey	33
New York	58
Pennsylvania	91

* Not all *registered* suppliers are *active* in a given market.
SOURCE: William R. Huss, Xenergy, Inc.

But the glass is not just half empty. Competitive pressures have unleashed enormous forces to reduce costs, improve operational efficiencies, enhance customer services, and launch a host of other initiatives. The results of these efforts will undoubtedly reduce electricity costs, improve profitability, or both. Moreover, a number of new players have entered the previously closed electric power sector. The most notable among these are power marketers who can increasingly take advantage of federal and state legislation to operate in the competitive wholesale markets. While there were a handful of such companies as recently as 1992, at the end of 1999 there were 566, according to the Federal Energy Regulatory Commission.

In addition to power marketers, there are now a growing number of competing suppliers in all the major states with open markets, as the table above suggests.

Who Is Switching Suppliers?

Customer turnover in selected states

	By # of Customer Accounts			By Customer Load		
State	Resid	C & I	Total	Resid	C & I	Total
California	1.4%	3.5%	1.7%	1.6%	18.8%	13.1%
Massachusetts	*	2.4%	0.3%	*	NA	11.0%
New York	1.0%	2.7%	1.3%	1.0%	10.4%	7.9%
Pennsylvania	8.3%	16.1%	9.1%	8.7%	41.7%	28.7%

* There has been virtually no switchovers in the residential market in Massachusetts thus far due to regulatory price rigidities. C&I = commercial and industrial customers.
SOURCE: William R. Huss, Xenergy, Inc.

Despite frequent complaints about the *unfair* nature of competition in retail markets in many jurisdictions, customers are beginning to make choices. With the sole exception of Pennsylvania, the turnover rates are not impressive so far—particularly in the residential sector. But, as time goes on, the successful players are likely to gain additional ground.

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* Fereidoon P. Sioshansi is a President ofMenlo Energy Economics Inc. in Menlo Park, CA. He edits and publishes the *EEnergy Informer*, a monthly newsletter. This is an edited version of an article which appeared in the January 2000 issue and is available on the web at http://members.aol.com/eeinformer.

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Call for Papers

Allied Social Science Associations Meeting

New Orleans, LA – January 5-7, 2001

The IAEE annually puts together a session at the ASSA meetings in early January. This session will be structured by Carol Dahl of the Colorado School of Mines.

The theme for the session will be "Current Issues in Energy Economics and Modeling"

If you are interested in presenting please send an abstract of 200-400 words to Carol Dahl at (cadahl@mines.edu) by May 1, 2000. Final decisions will be made by May 29, 2000.

For complete ASSA meeting highlights please visit http://www.vanderbilt.edu/AEA/index.ht

2000 Directory Coming In May

IAEE members are urged to return their Directory Information forms to Headquarters by March 31 if they have any changes in their database information. These forms are sent to all Affiliate leaders along with the Affiliate dues invoice and to all individual members along with the first dues invoice and show the current information in the Association's database for each member. Changes to database information can be made on the form. Lacking the form, members may mail, fax or e-mail changes in address, phone, fax, e-mail and affiliation to Headquarters. All changes received by March 31 will be included in the new *Membership Directory.*

Book Review

"ELECTRICITY MARKETS: PROBLEMS OF DEVELOPMENT"

By Wolfgang Pfaffenberger, Leonid Melamed and Mikhail Lychagin

The edge of a new millennium is going to be a challenging period for the energy world. The decade gave a very wide range of electricity market developments in more than 50 countries, which correlated with the widening and deepening of the deregulation process. New problems have arisen, which are and need to be in the centre of attention of researchers, utility managers and regulation bodies. Education and training need to adapt to this flow of academic thought and practice.

There is a deficit of modern literature on electricity economics in Russian, especially for students and management training. Therefore Leonid Melamed suggested to elaborate and publish a complete set of textbook and training materials in this field that corresponds to international standards. Researchers and university professors from different countries supported the idea and made their contribution in order to realise it. The book that image you can see above is a result of international collaboration and the first volume in the projected complete set of educational materials for Russian readers.

The editors (the authors of this paper) had the absolute pleasure of working with the contributing authors who made significant efforts to prepare their papers for publication. Most of them have a vast experience in the areas of research, education and practice of management. A few doctoral students provided not only assistance but also additional flows of new proposals.

We are grateful to the International Association for Energy Economics, which encourages the debates and positive developments.

Mikhail Lychagin, Mikhail Bolotov, Svetlana Bekareva and Andrew Grekhov provided the translation from original languages to Russian. Galina Abramchik fulfilled a lot of organisational work that speeded up the publication. Persons from the Publishing House of the Siberian Branch of the Russian Academy of Sciences helped greatly in order to ensure high quality and speed of printing. The book was published in August 99 in two variants: paper and hard covers (ISBN 5—7692—0219—X, 224 p.).

The collection of papers of this book is intended to demonstrate the approaches in different countries to market transformations of the electricity supply industry (ESI). Traditionally this industry embraced four vertically related activities: generation, transmission, distribution, and supply. In 1978 Chile became the first country, which had changed radically the basic structure of ESI and its regulated framework. These measures were followed by privatisation. In 1988 the process of re-structuring and privatisation of the electricity industry was initiated in England and Wales. Then Norway and Sweden implemented an interesting model for ESI liberalisation that gave an impulse for many other countries.

In the European Union in June 1996 the European Council of Energy Ministers reached agreement and six months later passed the full *Directive Concerning Common Rules for the Internal Market in Electricity* which took effect in January 1997 with the intention to restructure the European electricity supply industry. The major issues of the EC directive are free choice of supplier (in the long run); unbundling of generation, transmission, and distribution and the possibility of different approaches for competition. Therefore Western Europe is currently a single world region, which demonstrated the turn to ESI liberalisation at the top level, and there exists the obvious logic to consider the electricity markets from the "European point of view" and from the countries that have the richest experience. Seven papers of Part I are devoted to the mentioned topics. Part II pays attention to Russian ESI problems.

The paper by Derek Bunn "Reflections on the Progress of Electricity Re-structuring, Privatisation and Regulation in the UK during 1988—1998" opens our book. This paper reflects upon the first ten-year's progress and privatisation of the electricity industry in England and Wales. It is argued that the country paid a high price for a politically expedient and risk averse privatisation, and that it will take some time for the strategic imbalances that were so created to become redressed by further structural reforms, market liberalisation and increased competition. There are many lessons to be learned on managing the transition from a vertically integrated public monopoly to an efficient, unbundled, competitive industry.

A paper by Lennart Hjalmarsson "The New Nordic Electricity Market: Problems of Development" contains very interesting material that gives an overview of the Nordic electricity supply industry. This industry is developing into the most liberalised in the world. It is argued that the electricity market reforms have been successful. In general, the reforms have been implemented in an efficient way without any serious problems. The impact on prices and productivity has been favourable. The joint Norwegian-Swedish-Finnish spot market, Nord Pool functions satisfactory, and the futures market is gradually expanding.

Wolfgang Pfaffenberger, Dagmar Münch, and Katrin Salge presented a paper "Electricity Markets: Experience of Germany". The liberalisation of the German Electricity industry has just begun. In 1998 the protection of the monopolies of supply was removed from the energy law so that now normal legal conditions of competition are valid also for the ESI. Network pricing is not (yet) subject of state regulation but has come about by an agreement between producer and consumer associations. The practicability of this way in regard to the fast introduction of efficient competition and the possibility of electricity trade is questionable. Competition has begun however and it is likely that institutions will change relatively soon after further experience.

In the middle of the book the reader can see the paper of the team of Austrian authors — Hans Auer, Reinhard Haas, Claus Huber, Wolfgang Orasch, and Manfred Tragner: "Liberalisation of Western European Electricity Markets – Prospects and Impediments. A Survey on Recent Developments with Special Focus on Austria". Besides discussing various competition models and country-specific differences arguments are raised that might curtail the success of the EC-directive, e.g. up to now it is unclear how to avoid increasing mergers and strategic behaviour due to inhomogeneous structures. Therefore, the major conclusion is that in the long run only a strong new and uniform regulation on an EC level can ensure real competition in Western European electricity markets.

Fereidoon Sioshansi and Art Altman presented a paper "Implications of Power Marketing in the Restructured Electricity Market in the USA" This article explains what power marketing is, who power marketers are, what they do, why they do it, and what's behind their explosive growth in the past few

years. The authors also point out what types of products and services they offer, why these products and services are in demand, and what are the fundamental drivers for this demand. Understanding the last item is particularly significant: namely, the rapid restructuring of the wholesale – soon to be followed by the retail – electricity markets in the US.

Mikhail Lychagin, Leonid Melamed, Svetlana Bekareva, and Andrew Rachkin prepared the chapter "Development of the Electricity Markets in the Different Regions of the World". This paper provides supplementary materials concerning the liberalisation of the electricity supply industry in different world regions. The presented essays reflect upon the performance and problems of ESI in the following countries: Chile, Argentine, Australia, Japan, Turkey, Italy, Spain, Switzerland, Bulgaria, Hungary, Poland and Czech Republic. Each essay contains a brief history of the liberalisation process, prerequisites, features, results and issues of the reforms.

The paper by Mikhail Lychagin and Leonid Melamed "Liberalisation of Electricity Supply Industry: Statistical Survey" contains specially collected statistical data that reflect upon the structure and development the economies and electricity supply industries in more than 50 countries which use different models of liberalisation of ESI. The authors try to show the impact of liberalisation on the levels of a set of indices. The total set of data for comparative analysis embraces 133 countries.

Part II of the book includes three papers that give a draft of Russian problems in the field of ESI and its liberalisation. Three levels are presented: the whole country, the Siberian region, and the administrative region in the centre of Siberia: Novosibirskaya oblast.

Part II begins with a paper by Leonid Melamed "Market Transformation of the Electricity Supply Industry in Russia". The author explores the six years history of the liberalisation process in the Russian ESI, describes achieved results and current problems of development which are concerned finance, investments, organisation, law and other aspects. The main stress is given to the creation of federal and regional markets of electricity and power. The alternative approaches to the market development are presented and discussed taking into account the regional features.

The paper, "Structural Organisation of the Siberian Energy system and Perspectives of its Reforming", which is presented by Mikhail Bolotov, describes the existing structure of the Siberian ESI, its organisation design and problems of transformation in the perspectives of markets development. Three approaches to competitive electricity and powers markets in Siberia are presented and discussed.

Finally, we close the book with the paper "The Influence of Energy Tariffs on the Levels of Industrial Production in Novosibirsk Region". Nikita Suslov and Boris Gamm show the role of unfavourable price structure in Russian economic problems. The paper makes an attempt to estimate the role of energy tariffs in causing industrial production reduction in Novosibirsk region and discusses some measures for stimulating its economic development. Both econometric analysis and input-output model are used as analytical tools providing some numerical estimates.

The editors hope that various chapters in this book will be of interest to all readers who are excited by the effective development of ESI.

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Benchmarking Nuclear Production Costs by Components

*By Darrel A. Nash**

As the United States moves into the competitive era for electricity generation, it remains to be seen what the generating mix will be. An important determinant will be comparative production costs among plants.

This report treats comparative annual production costs among nuclear power plants in the U.S.—specifically, operation and maintenance cost components. The relative homogeneity of U.S. nuclear plant technology enables a comparison of how plant owners and operators allocate resources for operation and maintenance. All these plants must perform very similar operations to produce the output. Shown here is a benchmarking of cost components of several owner/operators of nuclear plants against the low cost producer. We conclude there is significant potential for lowering overall production costs by within plant reallocation of resources among the cost components so that they are similar to those of the low cost producer.

In the late 1980s and early 1990s, several owners and operators of nuclear power plants began to aggressively work to cut production costs of their nuclear facilities. For several prior years, production costs had trended higher. Some of the increase was to pay for NRC requirements for new safety features in the aftermath of the accident at Three Mile Island, Unit 2, in 1979. There also seemed to be a general attitude among owners and operators that costs were outside their control or in any case might be recovered through regulated utility ratemaking. Many inside and outside the industry questioned whether nuclear plants could and should continue operating.

Just as several owners and operators were positioning themselves to control and reduce production costs, the nation embarked on electric utility deregulation. This introduced a new challenge to the industry, not only for its nuclear generating plants, but the entire generating system. Now, as competition spreads from state to state, each generating unit must be evaluated on the basis of whether it can produce at a cost below expected market price, or whether it should be closed down or sold.

The guiding premise for this report is that plant owners and operators primarily determine how successful a nuclear plant will be in operating at low cost. We believe the efforts by owner/operators are a major reason for differences in cost performance. Owners and operators have various options for moving forward to ensure plants can compete. They can put great effort into cost reduction or maintaining a cost competitive output. In practice, only some have been successful in achieving and sustaining low costs. What is needed is knowledge on how the low cost producers achieve their results.

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* Darrel A. Nash is the founder of *ENERGY ACCESS* and the author of this report. Dr. Nash has over 25 years experience in energy economics and finance, first at the U.S. Nuclear Regulatory Commission and more recently with a consulting company where he provided client services in evaluating the competitive position of the nation's nuclear and coal generating plants.This paper is based on a study by *ENERGY ACCESS LLC*, entitled, 1999 "Nuclear Plant Vulnerability Study." It is available on-line through www.energycentral.com/im.cfm?pub=11696

The Approach

The evaluation compares plants on the basis of how resources are allocated among the various operation and maintenance activities used to keep the plant in operation on a long-term basis. Comparisons are made among plants and among nuclear plants owners. We analyze the components of production costs (annual O&M costs/mWh) to find how the lowest cost plants deploy plant resources compared to higher cost plants. Only nonfuel costs are included in the analysis because these are more subject to internal control than fuel cost. Operation and maintenance (O&M) costs are parsed into their components as far as the data permit. Next a benchmark analysis is done to determine how low cost plants allocate resources among O&M activities compared to higher cost performers.

The data are from a UDI/McGraw-Hill database.[1] In turn UDI's database is derived from FERC Form 1, submitted annually by electric utilities. The basic nonfuel cost components from these sources are:

- operation supervision and engineering,
- nonsupervisory operation,
- maintenance supervision and engineering, and
- nonsupervisory maintenance.[2]

Benchmarking is used to learn how plants and companies compare to the low cost producer. Benchmarking not only is a tested means of identifying opportunities for improvement, it replicates what will happen in the market. In a competitive commodity market which electricity will be, each producer must strive toward the level of the low-cost producer. There are few other bases for choosing one plant as the supplier over another. Even for a company with large generating capacity and a large electricity customer base, cost comparisons may suggest purchasing electricity rather than supplying from internal production. Thus the owned plant may be shut down and equivalent power purchased.

Dominion Resources—through its subsidiary, Virginia Electric & Power Co.—is used as the benchmark because it operates the lowest cost nuclear electric generators in the U.S. and has maintained that position for more than a decade. The allocations of costs made by its plants, North Anna and Surry, might be considered the "ideal" allocation because these were used to achieve the overall lowest costs in the industry. As will be seen, there is justification for considering Dominion Resource plants as an ideal allocation because Vogtle, owned by the Southern Company, has similarly low total costs ***and*** cost allocation.

Two benchmarking reviews are done. The first compares nonfuel production costs of the benchmark with other selected companies that own a large amount of nuclear generating capacity. Among these companies are the industry leaders that have been generally successful in reducing production costs and/or are aggressively moving beyond a regulated status by expanding into other markets and related industries.

Companies owning single-unit nuclear plants are of particular interest because of the general concern for whether any of these plants can be made and kept competitive. Therefore, the second benchmark analysis is directed at single-unit plants.

Companies Operating Large Multiple Plants

Allocation

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[1] See footnotes at end of text.

The first analysis benchmarks the allocation of 1996 to 1998 nonfuel costs. This is followed by an analysis of trends in cost components from 1990 to 1998.

The allocation by each plant is somewhat unique, however, general patterns emerge. In some cases, all plants operated by a company have similar cost allocations. Others show marked differences within a company.

Patterns by Company

Here, we review companies and the allocations for all plants owned by the company. In Table 1, the benchmark, Dominion Resources, not only shows both its plants to be low-cost producers, the allocation among the cost components is similar for both.

Carolina Power and Light and Duke Energy are shown to have had low resource allocations to operation supervision and engineering, and very high allocation to nonsupervisory operation compared to the benchmark. In fact, the reported spending on operation supervision and engineering by Duke Energy is so low that it appears that some of it is because of errors in the data. A higher than benchmark allocation is also made to nonsupervisory maintenance.

Another case of allocations off the benchmark is PECO Energy. Its plants, Limerick and Peach Bottom, also have allocated higher percentages to nonsupervisory operation. In this case, Limerick seems to have suffered from too low an allocation to supervisory maintenance and Peach Bottom from too low an allocation to non-supervisory maintenance. Entergy Corporation appears to have not allocated enough resources to supervision and engineering, both operation and maintenance.

Among the companies here, the Southern Company appears to have fewer options for resource allocation in order to reduce total costs. Modest shifts by Farley and Hatch away from supervisory operation may be useful. It appears the Farley should allocate more to non-supervisory operation, and Hatch to supervisory maintenance. The allocation of cost components for Vogtle is very similar to Dominion Resource's plants. *As noted above, total nonfuel costs for Vogtle are very similar to those of Dominion Resources, providing evidence that Dominion Resource's and Vogtle's allocation of resources is the best for overall low costs.*

Patterns Within Companies

A surprising aspect shown in the table is the large differences within companies of both the allocation and total production costs. Particularly notable are the Southern Company and Entergy Corporation. The data suggest that reallocating resources within Farley and Hatch to an allocation similar to Southern Company's other plant, Vogtle, could enable some reductions in total costs at Farley and Hatch.

Entergy Corp. presents yet another instance of great variation of costs among the four plants. At Arkansas One and Grand Gulf, both operation and maintenance supervision and engineering appear to be starved at the expense of nonsupervisory operation which is much higher for both plants than the benchmark. In addition, nonsupervisory maintenance at Arkansas appears to be too heavily funded (40.6 percent) and at Grand Gulf, insufficiently funded (19.6 percent). Although total nonfuel costs at Waterford and River Bend are high, the allocation among cost categories is not greatly

(continued on page 26)

Table 1
Benchmarking of Operation and Maintenance Costs, Ave. of 1996-98, Large Nuclear Owners

Owner-Operator	Plant	Non-fuel 96 - 98	Oper. Supervis. & Engineer.	Non-supervisory Operation	Maint. Supervis. & Engineer.	Non-supervisory Maint.
		$/mWh	Percent Allocation of Nonfuel Costs			
Dominion Resources	North Anna	7.13	22.8	31.5	12.5	33.2
	Surry	7.92	21.6	38.3	9.6	30.5
Carolina Power & Light	Brunswick	10.17	5.9	52.9	10.8	30.5
	Harris	11.50	7.6	56.2	11.3	24.8
	Robinson 2	11.00	5.2	58.7	10.2	25.9
Duke Energy	Catawba	9.83	2.3	44.4	10.6	42.7
	McGuire	10.46	2.4	44.8	9.5	43.3
	Oconee	13.51	3.0	39.3	10.2	47.4
PECO Energy	Limerick (*)	9.75	25.2	42.2	3.8	28.7
	Peach Bottom	10.78	22.3	47.1	12.7	17.5
Southern Company						
	Farley	12.63	27.7	24.3	14.7	33.3
	Hatch	12.73	26.0	37.0	8.5	28.6
	Vogtle	*7.82*	18.7	37.4	13.1	30.7
Entergy Corp.	Arkansas One	10.80	8.9	43.2	7.2	40.6
	Grand Gulf	10.12	12.7	62.6	5.1	19.6
	Waterford 3	13.45	18.5	37.9	19.0	24.7
	River Bend	14.62	20.1	37.1	5.9	36.8

(*) 1997 data not available, average is 1995, 1996, and 1998

Nuclear Benchmarking *(continued from page 25)*

different from Dominion Resources plants. Thus, not only is there a lack of knowledge transfer among companies, the significant differences within Entergy Corporation plants and within Southern Company plants, leads to speculation that inter-company knowledge transfer is lacking.

Trends

It was noted above that some companies had very different resource allocations than the benchmark. Are reallocations occurring over time to bring these more in line with the allocation at Dominion Resources?

Table 2 shows the trend (average annual change) in nonfuel production costs and the components, from 1990 to 1998 for the plants reviewed above.[3] The first observation is that there is some bad news for all owners other than Dominion Resources. This company continues to cut costs at its two nuclear plants, even though it is already the low-cost producer. So other companies will have to cut costs faster than Dominion Resources if they hope to catch it. Dominion Resources is reducing its costs primarily by cutting both categories of maintenance (supervision and engineering and nonsupervisory maintenance). Similarly, Southern Company has continued to cut costs at Vogtle, showing that the current low cost operations may be reduced further.

The following table shows companies that have similar allocations for all their plants. None made notable progress in reallocation to bring them closer to the benchmark.

Progress Toward Allocations Closer to Benchmark

Company	Source of Allocations Different From Benchmark	Progress Toward Improvement
Carolina Power & Light	supervision and engineering, high allocation to nonsupervisory operation	operation reduced somewhat at Brunswick and Robinson 2
Duke Energy	Low allocation to operation supervision and engineering, high allocation to nonsupervisory operation	Little change
PECO Energy	High allocation to nonsupervisory operation	Modest trend in reducing

Next we revisit those companies with considerable inter-company differences in resources allocation. It would seem to be relatively easy to transfer knowledge and experience from plant to plant within the company. As the table below summarizes, however, little or no trend is evident in moving higher cost plants to a similar cost allocation as the low cost plant within these companies.

Progress Toward Allocations Closer to Benchmark

Company	Source of Allocations Different From Benchmark	Progress Toward Improvement
Southern Company	Over allocation to supervision & engineering at Farley	Little change
Entergy Corp	Under allocation to supervision & engineering, especially at Arkansas & Grand Gulf, Over allocation to nonsupervisory operation, especially at Grand Gulf	Most reductions in operation supervision & engineering

Single-unit Companies

A crucial test for several companies over the next few years is for those owning only a single nuclear plant. In the

Table 2
1990-1998 Trend in Cost Components, Large Nuclear Owners

Owner-Operator	Plant	Non-fuel 96 - 98	Oper. Supervis. & Engineer.	Non-supervisory Operation	Maint. Supervis. & Engineer.	Non-supervisory Maint.
				$/mWh/year		
Dominion Resources						
	North Anna	-0.30	0.03	-0.06	-0.14	-0.13
	Surry	-0.34	0.03	0.00	-0.16	-0.21
Carolina Power & Light	Brunswick	-3.44	-0.28	-1.76	-0.20	-1.20
	Harris	0.22	-0.07	0.10	0.11	0.08
	Robinson 2	-1.46	-0.39	-0.33	-0.11	-0.63
Duke Energy	Catawba	-0.19	-0.01	0.00	-0.05	-0.13
	McGuire	-0.48	-0.01	-0.05	-0.03	-0.39
	Oconee	0.77	0.02	0.28	0.05	0.42
PECO Energy	Limerick (*)	-0.61	-0.13	-0.08	-0.05	-0.34
	Peach Bottom	-1.35	-0.71	-0.30	0.02	-0.36
Entergy Corp.	Arkansas One	-0.60	-0.93	-0.10	0.03	-0.17
	Grand Gulf	-0.42	-0.22	-0.05	-0.08	-0.06
	Waterford 3	0.28	-0.01	0.26	-0.20	0.23
	River Bend	-2.40	-0.21	-0.58	-0.34	-1.27
Southern Company	Farley	0.05	0.10	-0.13	0.08	0.00
	Hatch	-0.41	0.18	-0.10	-0.20	-0.29
	Vogtle	-0.37	-0.07	-0.13	-0.03	-0.14

(*) 1997 data not available, year excluded

push by major utilities to grow larger, acquisition of single-unit plants has been and will likely continue to be of great interest. Creating or enhancing single-unit competitiveness is important either as income earners for the current owners or to increase the value to potential buyers. Table 3 considers whether there are characteristics of single-unit plants that put them at a cost disadvantage. We compare them again to the benchmark Dominion Resource plants because all plants will have to reduce costs toward the benchmark to remain competitive. The market is indifferent as to the characteristics of generating plants supplying the power.

Two of these plants—Union Electric's Callaway and Western Resource's Wolf Creek—have a history of successful low-cost operations, the other plants have mixed histories of success. The table shows the percentage cost allocation in the top section, and the 1990 to 1998 trend in the second section.

Nonfuel costs of all single-unit plants were considerably higher than the benchmark plants. However, this is also true for many multi-unit sites and owners. The striking characteristic of these plants is that as much or more is allocated to nonsupervisory operation than the benchmark. Summer, WNP 2, and Wolf Creek allocated considerably higher percentages. For most, this allocation resulted in maintenance supervision and engineering receiving a lower proportion of plant resources. Callaway is the exception—the allocation of resources among cost components is similar to the benchmark plants.

One might expect the opposite—that is, single-unit plants would spend more heavily on supervision and engineering—because of the expectation that supervision and engineering costs would tend to be invariant to output. The trend analysis shows only Summer, Three Mile Island and WNP 2 significantly cutting nonsupervisory operation costs and moving the allocation closer to the benchmark.

What conclusions can be reached on single-unit plants? The stable overall costs at Union Electric's Callaway and Western Resource's Wolf Creek compared to the continuously downward trend of the best multi-unit companies provides evidence that costs at single-unit companies may be about as low as they will get. However, there appears to be potential for Wolf Creek to reduce total costs by moving closer to the benchmark allocation. SCANA's Summer may show that single-units plants can produce at the industry low cost. The next few years will put this to the test. It has lowest nonfuel costs for single plants during 1996 to 1998, however, the reduction has been mostly achieved during the past five years.

Summary

This benchmarking analysis has shown very different nonfuel production cost allocations and cost trends among the U.S. nuclear plants. Much can be learned by comparison to the low cost leaders. It is surprising that after nearly a decade of aggressive cost-cutting by many nuclear owners and operators there is still so much variation. There appears to be important opportunities to reallocate resources at most of the plants shown here, enabling them to reduce overall costs. As prices are driven to the low cost producers, it is expected that resource allocation within plants will also have to move toward those of the low cost producers.

(continued on page 31)

Table 3
Benchmarking of Single-unit Companies

Owner-Operator	Plant	Non-fuel 96 - 98	Oper. Supervis. & Engineer.	Non-supervisory Operation	Maint. Supervis. & Engineer.	Non-supervisory Maint.
		$/mWh	Percent Allocation of Nonfuel Costs 1996-98 Average			
Dominion Resources	North Anna	7.13	22.8	31.5	12.5	33.2
	Surry	7.92	21.6	38.3	9.6	30.5
GPU	Three Mile Is.	13.25	31.7	39.7	6.2	22.4
SCANA	Summer	9.59	14.6	51.9	2.9	30.5
Union Electric	Callaway	10.25	22.4	37.1	8.1	32.3
Washington Public Power Supply	WNP 2	12.15	20.7	42.1	3.2	33.9
Western Resources	Wolf Creek	11.68	12.2	51.9	8.7	27.2
			Annual Change in Nonfuel Production Costs $/mWh/year, 1990-98			
Dominion Resources	North Anna	-0.30	0.03	-0.06	-0.14	-0.13
	Surry	-0.34	0.03	0.00	-0.16	-0.21
GPU	Three Mile Is.	-0.21	0.20	-0.19	-0.13	-0.09
SCANA	Summer	-0.55	-0.16	-0.29	0.06	-0.15
Union Electric	Callaway	0.12	0.11	-0.07	0.06	0.02
Washington Public Power Supply	WNP 2	-0.91	-0.39	-0.17	-0.26	-0.08
Western Resources	Wolf Creek	-0.12	-0.03	0.00	0.01	-0.09

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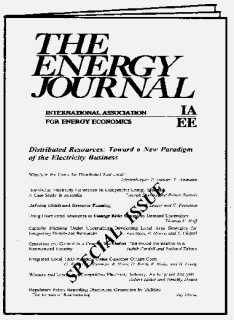

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Contents

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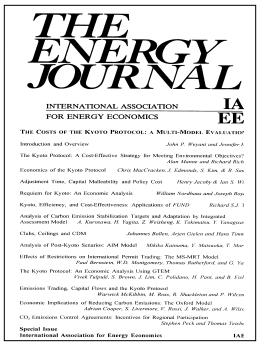

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Nuclear Benchmarking *(continued from page 27)*

Footnotes

[1] *Nuclear Plant O&M Cost Data 1980-1998*, UDI/McGraw-Hill, 1999.

[2] Nonsupervisory operation and nonsupervisory maintenance is further divided in FERC Form 1, however, it was considered not useful to pursue cost comparisons among these items. For example, nonsupervisory operation is composed of coolants, steam expenses, cost of steam from other sources, steam transferred, electric expenses, miscellaneous steam expenses, and rent. These are not particularly meaningful categories for cost management. Ideally other cost categories would be available, such as supervision and engineering being separated.

[3] The trend is a least-squares regression of O&M cost components/mWh for the years 1990 to 1998. The resulting coefficient is the annual trend measured in $/mWh.

Publications

Electronic Energy Trading. Peter Fusaro & Jeremy Wilcox. Contact: Global Change Associates, 211 West 56th Street, #23M, New York, NY 10019. Phone: 212-625-8801. Email: barbarawolf@global-change.com URL: www.global-change.com

World Petroleum Industry Outlook, 16th Edition. Robert Beck. Price: $195.00. Pages. 303. Contact: PennWell, PO Box 21288, Tulsa, OK 74121. Phone: 918-831-9421. Fax: 918-831-9555. URL: www.energycatalog.com

Energy Efficiency Policy and Technology Transfer: A Hawaii-Philippines Case Study, State of Hawaii Government (1999). 102pp. Contact: Dr. James P. Dorian, Energy, Resources, and Technology Division, PO Box 2359, Honolulu, Hawaii, 96804. Phone: 808-586-2352. Fax: 808-587-3839. Email: jdorian@dbedt.hawaii.gov

Trading Natural Gas in the UK. Liz Bossley. Price: £90 Contact: Mrs. Margaret Ko, Oxford Institute for Energy Studies, 57, Woodstock Road, Oxford OX2 6FA, United Kingdom. Fax: 44-1865-310527

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Electricity Markets: Problems of Development. Edited by Wolfgang Pfaffenberger, Leonid Melamed and Mikhail Lychagin. (In Russian). 224 pages. For electronic version please contact: Mikhail Lychagin, Novosibirsk State University, 2 Pirogova, Novosibirsk, 630090, Russia. Email: lychagin@nsu.ru

Arab Oil & Gas Directory 1999. Price: $490. Contact: Arab Petroleum Research Center. 7, avenue Ingres, 75016 Paris, France. Phone: 33-1-45-24-33-10. Fax: 33-1-45-20-16-85. Email: aprc@arab-oil-gas.com URL: www.arab-oil-gas.com

The Color of Oil. Michael Economides and Ronald Oligney. Price: $19.95. Contact: Round Oak Publishing, 1811 Breezy Bend, Katy, TX 77494. www.colorofoil.com

Asia Power 2000 & Beyond. Price: $4000.00. Contact: Mr. Nick Ornstien, PennWell Corporation, PennWell House, Horshow Hill, Upshire, Essex EN9 3SR, UK. Phone: 44-17080342-222. Fax: 44-1708-379-344. Email: nicko@pennwell.com

Power Electronics and Resources Saving. Monograph in Russian, 111 pages. Contact: Ya.Sh. Sosnovsky, 58-6, app. No. 8, Patrioticheskaya street, Zaporizhie, 69000, Ukraine. Phone: 0612-34-46-05. Email: postmaster@vit-oisp.marka.net.ua

Calendar

1-2 March 2000, Asia Natural Gas 200: Projects & Markets. Grand Hyatt Hotel, Singapore. Contact: Ms. Jolene Phee, Event Co-ordinator, 80 Marine Parade Road, #13002 Parkway Parade, Singapore 449269. Phone: 65-345-7322. Fax: 65-345-5928. Email: jolene@cmtsp.com.sg

2-3 March 2000, Brazil Ministerial Summit: The Changing Face of Brazil's Power Sector. The Biltmore Hotel, Miami. Contact: Mr. Jonathan Neale, CWC Associates, The Business Design Centre, 52 Upper Street, London, N1 0QH, England. Phone: 44 207 704 8815. Fax 44 207 704 8440. E-mail: jneale@cwconferences.co.uk URL: http://www.globalenergyintel.com

2-3 March 2000, National Oil Companies Summit 2000. Marble Arch Marriott Hotel, London, UK. Contact: Global Pacific & Partners International, Houston: Phone: 281-597-9578, Fax: 281-597-9589. South Africa: Phone: 27-11-782-3189, Fax: 27-11-782-3188. Email: babette@global.co.za URL: www.glopac.com

4-6 March 2000, Electric Power 2000. Cincinnati, Ohio, USA. Contact: Electric Power 2000, 1220 Blalock Road, Ste. 310, Houston, TX 77055. Phone: 713-463-9595. Fax: 713-463-9997. E-mail: warrens@tradefairgroup.com URL: www.electricpowerexpo.com

4-8 March 2000, Middle East Petroleum & Gas Conference & Middle East Oil Week. InterContinental Hotel, Abu Dhabi, U.A.E. Contact: Vimla Mulchand, Managing Director, The Conference Connection, Raffles City Post Office Box 1736, Singapore 911758. Phone: 65-226-5280. Fax: 65-226-4117. E-mail: mpgc@cconnection.org URL:www.cconnection.org

8-9 March 2000, 4th Latin America Energy Conference: Consolidation and Defragmentation in Latin America's Energy Sector. The Biltmore Hotel, Miami. Contact: Mr. Jonathan Neale, CWC Associates, The Business Design Centre, 52 Upper Street, London, N1 0QH, England. Phone: 44 207 704 8815. Fax 44 207 704 8440. E-mail: jneale@cwconferences.co.ukURL:http://www.globalenergyintel.com meetings@tnm.com.au URL: www.esaa.com.au

5-10 March 2000, Natural Gas: The Commercial and Political Challenges (Training Course). Cricklade Wiltshire, England. Contact: Margaret Coen, The Alphatania Partnership, Rodwell House, 100 Middlesex Street, London E1 7HD, United Kingdom. Phone: 44-20-7650-1405. Fax: 44-20-7650-1401. Email: training@alphatania.com, URL: www.alphatania.com

8-10 March 2000, Renewable Energy for the New Millennium Conference. Sydney, Australia. Contact: Kelvin Kent, Phone: 61-2-9241-2955. Fax: 61-2-9241-5354.

9-10 March 2000, World Sustainable Energy Day. Wels, Austria. Contact: O.O. Energiesparverband, Landstrasse 45, A-4020 Linz, Austria. Phone: 43-732-6584. Fax: 43-732-6584-4383. Email: office@esv.or.at URL: www.esv.or.at

13-14 March, 2000, Power in Asia. The Regent Hotel, Singapore. Contact: Gladys, 3 Raffles Place, #06-01, Singapore 048617 Phone: 65-536-8676. Fax: 65-536-4356.

15-16 March, 2000, The Future of Utilities 2000. The Dorchester, London. Contact: Global Business Conferences, Sycamore House, 5 Sycamore Street, London EC1Y 0SG. Phone: 44-207-608-0541. Fax: 44-207-253-2798. Email: admin@confs.co.uk

16 March 2000, Turmoil in Global Product Specifications. Speakers Martin Tallett (EnSys Energy & Systems) and Blake Eskew, (Purvin & Gertz) Contact: Peter Fusaro, Energy Forum at 212-802-6730 or 212-333-3979. Email: peterfusaro@global-change.com USAEE & IAEE members enjoy substantial discounts to this seminar.

20-21 March 2000, IT Strategies for the Oil & Gas Industry. San Antonio, Texas, USA. Contact: Sarah Ashmore, Strategic Research Institute. Phone: 212-967-0095, ext. 277 Email:

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sashmore@srinstitute.com

21 March 2000, National Energy Modeling System Annual Energy Outlook Conference, Arlington, Virginia. Contact: Susan Holte, Energy Information Administration, U.S. Department of Energy, Forrestal Building, EI-84, Washington, DC 20585. Phone: 202-586-4838. Email: susan.holte@eia.doe.gov

22-24 March 2000, Ethanol: Clean Air, Clean Water, Clean Fuel. San Francisco, California, USA. Contact: Bryan & Bryan, Inc., 5015 Red Gulch, PO Box 159, Cotopaxi, CO 81223. Phone: 719-942-4353. Fax: 719-942-4358. Email: etoh85@ris.net

27-28 March 2000, 4th Annual Worldwide Independents Forum. Westin, Galleria, Houston, USAEE. Contact: Global Pacific & Partners International, Houston: Phone: 281-597-9578, Fax: 281-597-9589. South Africa: Phone: 27-11-782-3189, Fax: 27-11-782-3188. Email: babette@global.co.za URL: www.glopac.com

3-4 April 2000, Ziff Energy Group's North American Gas Strategies Conference. Houston, Texas, USA. Contact: (p) 403-234-4285. Email: gasconference@ziffenergy.com URL: www.ziffenergy.com/gasconference

3-4 April 2000, Asia Upstream 2000. Marriott Hotel, Singapore. Contact: Global Pacific & Partners International, Houston: Phone: 281-597-9578, Fax: 281-597-9589. South Africa: Phone: 27-11-782-3189, Fax: 27-11-782-3188. Email: babette@global.co.za URL: www.glopac.com

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6 April 2000, Fifth Annual Washington Energy Policy Conference. Washington, DC, USA. Contact: Joseph Dukert, Energy Consultant, 4709 Cresent Street, Bethesda, MD 20816-1720. Phone: 301-229-7377. Fax: 301-229-4619. Email: dukert@erols.com

11 April 2000, Where in the World is the LNG Business Going? Speakers R. Gordon Shearer (Cabot LNG Corp.) and David Nissen (Poten & Partners). Contact: Peter Fusaro, Energy Forum at 212-802-6730 or 212-333-3979. Email: peterfusaro@global-change.com USAEE & IAEE members enjoy substantial discounts to this seminar.

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16-19 April 2000, 27th International Energy Conference. Boulder, Colorado, USA. Sponsored by IRCEED. Contact: Dr. Dorothea H. El Mallakh, Director, ICEED, 850 Willowbrook Road, Boulder, CO 80302. Phone: 303-442-4014. Fax: 303-442-5042. Email: iceed@stripe.colorado.edu

17-19 April 2000, Africa Power 2000. Sandton Sun & Towers Inter-Continental, Johannesburg. Contact: Global Pacific & Partners International, Houston: Phone: 281-597-9578, Fax: 281-597-9589. South Africa: Phone: 27-11-782-3189, Fax: 27-11-782-3188. Email: babette@global.co.za URL: www.glopac.com

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