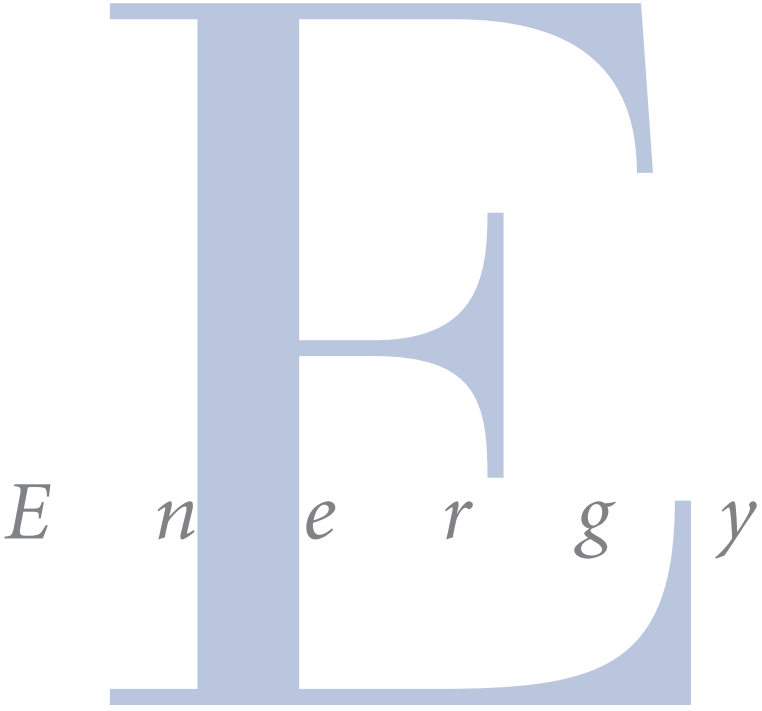
Fuel Choice, Supply, and Reliability in the 21st Century



1999 Aspen Energy Policy Forum
James R. Schlesinger and John E. Bryson, Co-Chairs
Elizabeth L. Malone, Rapporteur
John A. Riggs, Program Executive Director

THE ASPEN INSTITUTE

Fuel Choice, Supply, and Reliability in the 21st Century

1999 Aspen Energy Policy Forum
James R. Schlesinger and John E. Bryson, Co-Chairs
Elizabeth L. Malone, Rapporteur
John A. Riggs, Program Executive Director

THE ASPEN INSTITUTE

For additional copies of this paper, please contact:

The Aspen Institute
Publications Office
109 Houghton Lab Lane
P.O. Box 222
Queenstown, MD 21658
Phone: (410) 820-5338
Fax: (410) 827-9174
E-mail: publications@aspeninstitute.org
Web: www.aspeninstitute.org

For all other inquiries, please contact:

The Aspen Institute
Program on Energy, the Environment, and the Economy
One Dupont Circle, NW
Suite 700
Washington, DC 20036-1193
Phone: (202) 736-5823
Fax: (202) 467-0790

The Aspen Institute
One Dupont Circle, NW
Suite 700
Washington, DC 20036-1193

Published in the United States of America in 1999
by The Aspen Institute

Printed in the United States of America

ISBN: 0-89843-275-8

Table of Contents

Foreword

The Aspen Institute, through its Policy Programs, seeks to enhance public policy by providing an impartial venue for leaders from the public and private sectors to engage in informed dialogue on important issues. In wrestling with multidimensional challenges, Aspen participants are encouraged to suspend certainty, embrace complexity, accept the validity of competing values, gain perspective from others' perspectives, and achieve an understanding of policy choices that transcends self interest.

Each summer for 23 years the Program on Energy, the Environment, and the Economy has attracted a senior and diverse group of business, government, and other leaders to the Energy Policy Forum to discuss a topic of widespread interest and concern. From responses to the oil price shocks of the 1970s to the challenges of utility restructuring of the 1990s, the Forum has helped to frame the issues and explore possible solutions to the most vexing energy issues of the day.

In 1999, responding to continuing interest in the rapidly restructuring utility industries and to the low prices and merger activities in the oil industry, the Forum examined how these trends might play out in coming years. The topic, "Fuel Choice, Supply, and Reliability for the 21st Century," allowed consideration of the geopolitics, technology and economics of world oil supply; how policies and politics affect choices among fuels in the U.S. and other countries; and

where, when, and how technology advances may affect consumers and various segments of the energy industry.

As its distinguished Co-chairs, the Forum was privileged to have James R. Schlesinger, Chairman of the MITRE Corporation and former U.S. Secretary of Energy and Secretary of Defense, and John E. Bryson, Chairman and CEO of Edison International and former President of the California Public Utilities Commission. Their extensive experience enabled them to frame the discussion and guide the contributions from diverse expert participants, bringing focus and perspective to a broad topic.

A major strength of the Forum lies in the lively dialogue and the expert contributions from all of the participants around the table, but initial presentations from selected "discussion starters" begin each session. This year's expert group of presenters provided a wealth of information and a variety of perspectives, contributing substantially to the richness of the dialogue.

Elizabeth Malone of Pacific Northwest National Laboratories (PNNL) served as rapporteur. She captured the important threads from a wide-ranging discussion and worked tirelessly to weave them into this necessarily brief report. We are grateful to her and to PNNL for supporting her work.

We acknowledge and thank our sponsors for their very important financial support. Without their generosity and commitment to our work, the Forum and other projects of the Program could not continue. Contributions were received during the past year from the following:

ABB Alstom Power
Aramco Services Company
Arête Corporation
Booz•Allen & Hamilton
Cinergy Corporation
CMS Energy
Paul Dragoumis Associates
Edison Electric Institute
Electric Power Research Institute
Enron Corporation
Exxon Corporation
Bill and Julie Fulkerson

Gas Research Institute
GPU, Inc.
McKinsey & Co., Inc.
Orange & Rockland Utilities, Inc.
PEPCO
PHB Hagler Bailly
Ruhrgas AG
Santa Fe Center
Sempra Energy
Southern California Edison
Southern Company
The Summit Foundation
Trigen Energy Corporation
Verner, Liipfert, Bernhard, McPherson & Hand

This report is issued under the auspices of the Aspen Institute, and neither the Forum speakers, participants, or sponsors are responsible for its contents. Although it is an attempt to represent the views expressed during the Forum, participants were not asked to agree to every word and not all were present until the end.

John A. Riggs
Executive Director
Program on Energy,
the Environment, and the Economy

Forum Agenda

Aspen Energy Policy Forum
Fuel Choice, Supply, and Reliability for the 21st Century
July 1–5, 1999

Co-Chairs: **James R. Schlesinger,** Chairman of the Board, The MITRE Corporation

John E. Bryson, Chairman of the Board and CEO, Edison International

Session I: **World Oil Supply** **Friday, July 2**
8:30–12:30 pm

Conflicting predictions of when world oil productive capacity will peak lead to different scenarios for industry structure, exporting countries' policies, Saudi attitudes toward foreign equity investment, Caspian Basin development, production levels in high-cost countries, and ultimately, the market share of other fuels. What are some of the implications for national policies and company planning?

Chair: **James R. Schlesinger,** Chairman of the Board, The MITRE Corporation

Speakers: **Dan Yergin,** Chairman, Cambridge Energy Research Associates

Anthony Cordesman, Senior Fellow and Co-Director of Middle East Studies, Center for Strategic and International Studies

Jim Ragland, Director, Economics Research Group, Aramco Services Co.

Session II: National Actions—Non-U.S. **Friday, July 2 2:00–5:30 pm**

Political, financial, and other developments in Europe, Japan, and various developing countries are affecting current and future fuel choices. A reconsideration of nuclear options in Germany, France, and Japan; restructuring and environmental considerations in many countries; and questions of energy dependence in some countries are changing the way governments and companies see regulatory and investment decisions. What are some of these developments and their possible impacts?

Chair: **Wilfried Czernie,** Senior General Manager, Ruhrgas

Speakers: **Ambassador Ryukichi Imai,** Distinguished Research Fellow, Institute for International Policy Studies, Japan

Paul Hanrahan, Senior Vice President, The AES Corporation

Irwin Stelzer, Director, Regulatory Policy Studies, The Hudson Institute

Session III: National Actions—U.S. **Saturday, July 3 8:30–12:00 pm**

Various U.S. policies will affect generation planning and fuel choice, perhaps in unanticipated ways. Clean air regulations and

tight deadlines for compliance may lead to short-term reliability concerns and to the retrofit of coal plants rather than construction of more efficient gas-fired combined cycle generation. Concurrently, the advent of competition and questions about relicensing and decommissioning may reduce nuclear generating capacity, and restructuring may disperse the responsibility for planning generation. If regulation does not discourage increased reliance on gas, supply restraints caused by low prices and pipeline capacity may do so. How will these factors impact fuel choice, supply, and reliability?

Chair: **John E. Bryson,** Chairman of the Board and CEO, Edison International

Speakers: **Allen Franklin,** President and Chief Operating Officer, Southern Company

Ralph Cavanagh, Senior Attorney, Natural Resources Defense Council

Marvin S. Fertel, Senior Vice President, Nuclear Energy Institute

James E. Rogers, Vice-Chairman, President & CEO, Cinergy Corporation

Session IV: Technological Change and Business Risk **Sunday, July 4 8:30–12:30pm**

Changes in energy supply, conversion and demand technologies can affect fuel choice, supply and reliability in incremental or in dramatic ways. What are the prospects for developments that could alter current expectations? What changes in the technologies of existing fuels could make a difference? How will the rate of penetration of new fuels or technologies be affected by energy prices or by government policies? How do companies prepare for these risks?

Chair: **John H. Gibbons,** Senior Fellow, National Academy of Engineering

Speakers: **Kurt Yeager,** President, Electric Power Research Institute

John McTague, formerly Vice President for Technology, Ford Motor Company

Etienne Deffarges, Head of Energy and Chemical Practice, Booz•Allen & Hamilton Inc. *

Session V: **Breakouts & Wrap-up** **Monday, July 5 8:30–12:00pm**

The Forum will divide into three groups for the first half of this session for additional discussion and to determine whether guidance for policy-makers can be derived from the presentations and discussions. The three groups will report their conclusions back to the Forum plenary during the second half of the session.

Chair: **Susan F. Tierney,** Partner, The Economics Resource Group

Speakers: **Michael L. Beatty,** President, Michael L. Beatty Associates

Cheryl M. Foley, Vice President & Secretary, Cinergy Corporation

Les Silverman, Director, McKinsey & Co., Inc.

* As of September, 1999, Etienne Deffarges is Global Managing Partner for Utility Strategy, Andersen Consulting

Summary and Recommendations

The 1999 Energy Policy Forum focused on technical and political elements that influence choices of fuels for energy supply. Forum discussions focused principally on oil, gas, and nuclear fuels, and on electricity production and distribution. The growing energy needs of a globally expanding population and economies are constrained by the geographic locations of oil and gas; the effectiveness and efficiency of markets to extract, produce, and deliver fuels to consumers; the geopolitical issues that affect the availability of fuels; and the ability of policy to guide fuel choices that make sense both environmentally and economically.

Supply Issues: Despite some persistent predictions that the world will run out of low cost energy resources, Forum participants generally felt that plentiful supplies of oil and gas were available for the decades immediately ahead and that new potential reserves (either extensions of existing reserves or new sources, such as methane hydrates) will become available, given advances in technology of exploration and production. However, chronic political tensions, such as those in the Middle East; uncertain market infrastructure, such as that of Russia; and a disproportionate concentration of reserves in one country—Saudi Arabia—make energy security and dependence important issues for fuel importers.

The Outlook for Fuel Choice: The energy market is changing. In industrialized countries, probably the most notable change is the

restructuring of the electricity industry. In less industrialized countries, demand for energy is growing rapidly, with the implication that the overall energy system could develop differently in these countries. The fuel and technology mix of the developing world might be quite different from that of the OECD, as new technologies and new fuels compete for market share in as yet relatively undefined energy systems. Nuclear technologies, renewables, and distributed generation may be far more important in these countries, for example. In the US environmental regulations, decisions on nuclear re-licensing, and distributed generation in a restructured utility system may change and diversify the fuel mix.

The Market and the Environment: A recurring theme of the Forum was the economic benefit of more efficient markets and the desirability of changing public policy where necessary to encourage such markets. It is less clear whether market forces will help or hinder efforts to reduce pollution or climate change. In the case of the US utility industry, laws and regulations have led to major environmental improvements in recent decades. Whether industry restructuring and greater competition will help or hinder further improvements is still being debated, and the long-term outlook may be more encouraging than the immediate results. Development of a more predictable business environment through an integrated set of environmental performance standards for power plants may allow more rapid reduction in air pollutants and CO2 emissions than the current piecemeal regulations.

Technology and Risk: New fuels and technologies can transform the global energy system, posing challenges for businesses and public policy. Electricity is generally a preferred end-use form of enegy, but where and how it will be produced is in question, particularly as customers exercise a greater ability to manage the systems that deliver power to them. The transactions that the grid must manage are growing astronomically, but current policy provides only uncertainties and disincentives to improve the grid. Globally, decarbonization of the electricity system will require an innovative set of generatation options and farsighted climate policies. Passenger transportation will be shaped by new markets, as most new demand occurs in developing countries, and by new technologies that may lead to vastly different vehicle fuels/power plants.

Session I: World Oil Supply

Oil's position as a primary fuel is today subject to the uncertainties of its supply, its location, international politics, the environmental implications of its use, and competition with other fuels. These factors are affected, at least to a certain extent, by the technologies of extraction and distribution and by the prospects for global environmental agreements. The expansion of markets into less industrialized nations may also mean new types of competition for oil-fueled technologies; that is, technologies appropriate for these nations may involve the use of natural gas or renewable energy, for instance, or eventually the use of new fuels such as hydrogen.

The oil industry is changing—its location, its structure, its technology, and perhaps its place in the global energy system. Questions abound. Will the Caspian Sea live up to expectations? When mergers have reduced competition, then what? Why is there no public outcry today about US dependency on foreign oil (55%), or about the mergers in the oil industry, where a lower rate of dependency and less concentration caused great concern in the 1970s? Will oil lose its place as the fuel of choice in the future?

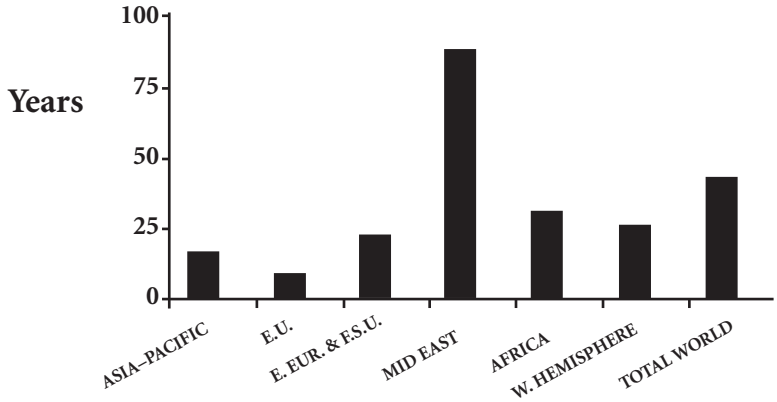
The Current Situation–Resource Base

Petroleum supplies from outside the Gulf have increased throughout the 1980s and 1990s. Technological advances have made

it possible for these increased supplies to reach market, and to do so while real oil prices have generally decreased. As the new century nears, some analysts have begun to suggest that petroleum may be forced to seek new applications in power markets as producers attempt to meet revenue needs by increasing output. Others continue to warn that the depletion of the resource base and the continuing political and economic troubles in the Gulf make reliance on petroleum unwise.

Figure 1

1998 Reserve to Production Ratios



Source: *Oil & Gas Journal,* Dec. 28, 1998

The latter group of analysts (the "Malthusians"), basing their beliefs on the established methods of petroleum geology and engineering, holds that the world has finite resources of known location and size and that almost one-half of the total reserve base will be depleted within the next decade, leading to an inevitable drop in output and a sustained and sharp rise in real oil prices. The opposing camp of analysts (primarily economists) points to the steady

decrease in real prices and the fact that the price surges of the 1970s were temporary and the result of supply disruptions caused by political developments. These "Cornucopians" base their argument on the belief that technology will provide new means of meeting the demand for energy services more rapidly than the inevitable depletion of the resource base results in fuel shortages.

The consensus viewpoint of firms in the petroleum industry is that resource availability is not an issue for the near future (i.e., at least the next 20 years). Historically, the ratio of remaining reserves to current production for most regions of the world has remained relatively constant. For example, the United States' reserve-to-production ratio has averaged over 15-to-1 for the last 50 years. Even if one assumes a sharp discontinuity in the historical pattern of constant reserve-to-production ratios, the current estimated ratios (see Figure 1) ensure the ability of the world's resource base to meet demand for many decades. Additions to known fields and improved extraction technologies would extend the life of the resource base, while increases or decreases in demand (e.g. increased population growth and economic development, or technological advances in competing fuels) could accelerate or delay the eventual depletion of the reserve base.

The Current Situation–Political Factors

Nevertheless, the geographic distribution of the known reserve base remains a major issue for energy security. Well over 60% of the world's petroleum reserves are located in the Persian Gulf region. Assuming demand for petroleum-based transportation fuels continues to grow over time, dependence upon the core OPEC nations will also increase. As a group, these nations have experienced very poor economic growth despite the vast influx of revenues caused by the sharp price increases during the 1970s and early 1980s. Since the mid-1980s price collapse, their economies have been buffeted by persistent boom and bust patterns in their revenue flows. With the exception of Kuwait and the United Arab Emirates, they currently are afflicted by high levels of foreign debt and persistent deficits in

their fiscal accounts, and have as a group been unable to achieve any sustainable growth in the non-oil sectors of their respective domestic economies.

At present, the nations of the Gulf region are experiencing the highest rates of population growth in the world. Both Iran and Iraq have been unable to fully reconstruct their economic base in the 11 years since they ended their war. The conservative monarchies of the Gulf either have significant minority populations with longstanding grievances or rely on expatriate workers for the bulk of their private workforce. The development of amicable relations between these nations has been difficult because of the religious split between Sunni and Shia Muslims, the 20-year history of antagonism between Iran and the other states since the Islamic revolution, the 1980–1988 Iraq-Iran War and the 1990 invasion of Kuwait. Both Iran and Iraq have systematically been developing major programs related to the production of weapons of mass destruction.

Outside of the Gulf, Russia and Venezuela are the largest oil exporters. Both nations have experienced the same set of economic problems as seen in the Gulf nations, but economic conditions are much worse in these two nations and both are facing massive political and economic challenges.

US political relations with Iraq and Iran continue to be troubled. In the current state of international sanctions, the United States is relatively isolated, while Europe is more involved in the region. Support for UN sanctions against Iraq is diminishing. Meanwhile, the United States is slightly modifying sanctions against Iran, although Iran is building up militarily in the lower Gulf (including biological weapons). Sanctions that are not broadly multilateral may have political implications but only a minor financial impact on their targets.

The Outlook for Oil

What is the outlook for US dependence on Mideast oil? DOE forecasts that OPEC's share of exports will rise to 61–70% by 2020; IEA

forecasts 50–60%. When such high levels of dependence will occur is in doubt; lower prices encourage concentration of exports in the Mideast, and Saudi Arabia can drive down prices (although at greater internal political cost than in 1986, when it had greater foreign exchange reserves and higher oil prices relieved internal economic pressures).

Geopolitical issues are as important as the supply uncertainties. Although there are no critical "smoking guns," some significant security threats exist. Selective regional problems are more likely than global ones ñ but the "world's only superpower" is unlikely to avoid diplomatic, military, and economic challenges. Internal security-driven risks include Russia, the Caspian states, the Persian Gulf states, West Africa (Nigeria and Angola), and Latin America (Venezuela and Mexico). Conflict and tension-driven risks exist in the Caspian energy supply, the Gulf energy supply (Iran and Iraq), and Algeria; many of these risks are exacerbated by nuclear proliferation issues. Russia, Iran and Iraq are particularly critical. The Caspian may be a greater business risk (i.e., firms may go broke) than a risk to the security of the world's oil supply. Overall, however, there is a risk over the next 20 years of supply interruptions resulting from political instability in one or more of these areas.

Saudi Arabia remains a special case because it alone has sufficient production capacity to increase output enough to make up for any supply disruption. However, no other producer or set of producers could make up for a disruption in Saudi exports. Continued close political, military and economic relations between the United States and Saudi Arabia remain an essential goal of US policy. The United States has promised to defend Saudi Arabia but some feel may not be able to offer an adequate defense against new offensive weapons for another decade or two. Given this situation, the Saudis may feel that they must develop their own nuclear weapons.

Current activities in the oil sector are dominated by the consolidation of the commercial oil companies and the new cooperation among oil exporters to control their output after crude prices collapsed in 1997 and 1998. The wave of mergers currently underway is

perhaps a result of the improvement in technology. The 1986 price collapse accelerated the industry's drive to reduce costs, a trend that had been at work since the late 1970s.

Yet most of the gains have been in the exploration and production stages of the value chain, and the industry has failed to implement information technology systems that have been so crucial to improving performance in other industries. Moreover, "synergies" claimed by advocates of the current merger movement are too often simply reductions in labor costs flowing from the removal of redundant workers. While these economies are real, their contribution to improved performance is a one-time phenomenon and does not produce a sustainable competitive advantage. Overall, the merger movement is simply the last attempt by the acquiring firm's management to achieve improved operational effectiveness by reducing costs and upgrading asset portfolios. According to some industry observers, the new "super-majors" achieve no additional economies of scale.

Profits in the petroleum industry remain dominated by upstream economic rents from oil production in equity fields. As the percentage of non-OPEC equity production decreased over the 1980s and 1990s, the major oil companies were forced to increase investments in smaller fields, requiring higher costs per barrel produced. This dilemma is perhaps another major driver behind the consolidation of the industry, as more companies have proved unable to gain sustained support from equity markets. If the gains from the consolidations are truly one-time effects, the surviving companies will be forced back into competition based solely on operational effectiveness, placing even more pressure on reducing costs through technological improvements. As this process moves forward, petroleum technology will continue to improve and continue to be most thoroughly applied to the least prolific reserves.

OPEC is also undergoing major changes. Recent agreements between OPEC producers Saudi Arabia and Venezuela, and non-OPEC member Mexico have resulted in the current price recovery. There are other signs of change and potential reform in the oil

exporters. Venezuela is undergoing a massive reevaluation of its political system and government structure. In Kuwait, the parliament has been reassembled and the government has begun to investigate a potential role for women in the electoral process, discussing not only expanding suffrage rights but also parliamentary membership to women. Government leaders in Saudi Arabia and Iran have announced their joint desire for better relations and have visited the other's capital. The Iranian president has taken several measures to decrease Iran's isolation from western governments and has supported reform elements inside Iran. Finally, Kuwait, Iran, and to a limited extent even Saudi Arabia are discussing the possibility of commercial oil firms taking an active role in the development of their upstream energy sectors.

Whether these trends will result in sufficient improvements to allow the important oil exporters to manage their substantial economic and political challenges remains unclear. Continued low or falling oil prices will have different effects on different countries, as well as on different producers. Outside the Gulf, the breakeven cost of a barrel of oil in various locations will be increasingly important as the industry moves toward being a commodity industry.

Many of the Gulf states are already feeling the effects of sustained low prices. For example, Iran's standard of living is two-thirds of its 1979 level. In Saudi Arabia also demographic growth and low oil prices are exerting downward pressure on per capita GDP. Most exporting countries can survive if they undertake economic reform and demographic planning and if given enough time. A few may be in such difficult economic situations that a further drop in the price of oil is only an incremental negative factor. There are signs that Iran and Iraq are undertaking necessary changes; Iran, for instance, is seeking investment funds with a debatable degree of success.

What is certain, however, is that petroleum will continue to play a crucial role in the world's energy system. A major disruption in oil trade would be a significant threat to economic growth, and policies designed to minimize that possibility while prudently preparing for such an event must still be a priority for the United States.

Increasing world oil trade and import dependence will require substantial improvements in downstream infrastructure, such as ports and storage as well as production capacity. Closer cooperation between importing and exporting countries, and a move beyond the adversarial relationship growing out of the oil embargo of the 1970s, could lead to joint importer-exporter investments in both production and downstream infrastructure. Meeting future energy needs will require consistent investment in petroleum related infrastructure, and it is in the interest of all parties to find methods of doing so.

Global Markets and Environmental Considerations

The outlook for oil presumes increasing demand from both developed and developing countries, but this could be modified by the penetration of other, emerging technologies. In many markets, energy resources are competitive and therefore oil demand and prices are influenced by developments in other fuels. Oil is not the only problematic energy source. If the supplies of natural gas, coal, or nuclear energy are disrupted, or if their prices increase, demand will increase correspondingly for the other sources, including oil. Projected increases in gas use, for example (up 97% by 2020, according to EIA's *International Energy Outlook, 1999*) will require major new infrastructure, giving rise to new vulnerabilities in both production and transportation.

Decreases in oil demand could also result from different fuels or technologies, including better end-use and combustion efficiency, driven by a shift in other values (e.g., superior service, better distribution). In developing countries without extensive distribution and transmission grids, consumers may prefer more reliable, distributed sources to large central plants; in this scenario, renewables may have a chance to meet immediate demands. However, demand for energy will grow to encompass other sources, including transportation. Furthermore, consumers in both developing and developed countries may demand products that do not conform to technology planning objectives; for exam-

ple, they will buy cars with attributes they want, not necessarily those with the lowest emissions.

Rising energy demand also means rising greenhouse gas emissions, intensifying the debate between industrialized and less industrialized countries about the tradeoffs among environmental concerns and economic development. Some believe the Kyoto Protocol, while perhaps not implementable in the short term, is important as a signal of things to come and as an impetus to action. For example, the agreement has spawned trading agreements within the oil industry, in countries such as Norway, Denmark, Britain, Australia, New Zealand, and within the European Union. However, the problems of bringing China, India, and other developing countries into the trading system are enormous. Developing countries generally do not trust the developed countries' arguments, will be driven by their own development needs, and will need to be negotiated with singly. Nevertheless, if additional scientific evidence and public opinion cause governments to adopt even more stringent carbon abatement policies, the impact on oil demand would be significant.

Session II: National Actions, Non-US

International energy markets are becoming more important, with energy consumption in developing countries rising by the equivalent of one Germany per year. In these global, open markets, each country and company faces increasing competitive pressures which are complicated by climate and other environmental issues.

In developing countries, fuel choices are influenced by economic, environmental, security, and employment factors. Factors include the availability and cost of fuels, available technologies, tariff policies, and economic and investment policies. In current circumstances, gas is gaining share globally, but there will be significant regional variations. Worldwide, oil is gaining share slightly, nuclear losing share. Several countries reflect the diversity of conditions driving fuel choice.

Asia

Japan is 80% dependent on imported energy and therefore more concerned about security than most other countries, and the cost structure of its electric utility sector differs from many. According to one estimate, in order to meet its Kyoto pledge, Japan would have to build 17 nuclear power stations, a highly unlikely scenario. Projections are for nuclear power to increase, then decrease because restructuring will result in higher prices for nuclear power relative to IGCC plants. The fast breeder reactor is the most expensive because

it is the smallest reactor yet must have the same safety features as larger reactors. No new nuclear plants are planned after 2010, but they have not been ruled out.

China, with an installed electric power production base of 250 GW and growth rates of 5.7% per year, is expected to add more capacity than any other nation in upcoming years. Abundant coal has caused the government to focus on meeting environmental objectives with cleaner coal technologies rather than through other fuels, although there is interest in increasing hydropower and nuclear power. China has natural gas resources but some analysts think very little interest exploiting these resources.

India, too, has tremendous capacity needs. Coal will continue to play a big role, but natural gas will become more important, with nuclear and hydropower slightly more important.

In the rest of Asia, natural gas is expected to begin to supplant oil and renewables, increasing from approximately 21% to 33% of energy used in 2020, with oil dropping from about 20% to 16%.

Latin America

Central and South America, expected to grow at 4.5% per year, will rely increasingly on natural gas, reducing reliance on hydropower. (In Brazil 90% of electricity comes from hydropower.) Growth in gas use will depend on completion of several pipelines linking Argentina and Bolivia to Brazil and Chile.

In Argentina, market forces drove electricity prices down after liberalization. Since Argentina has excess electricity capacity, new capacity at lower prices merely drives out old capacity.

Europe

In Britain, "The Project"—that is, the effort to remake the constitution and institutions of Britain—has pushed energy and envi-

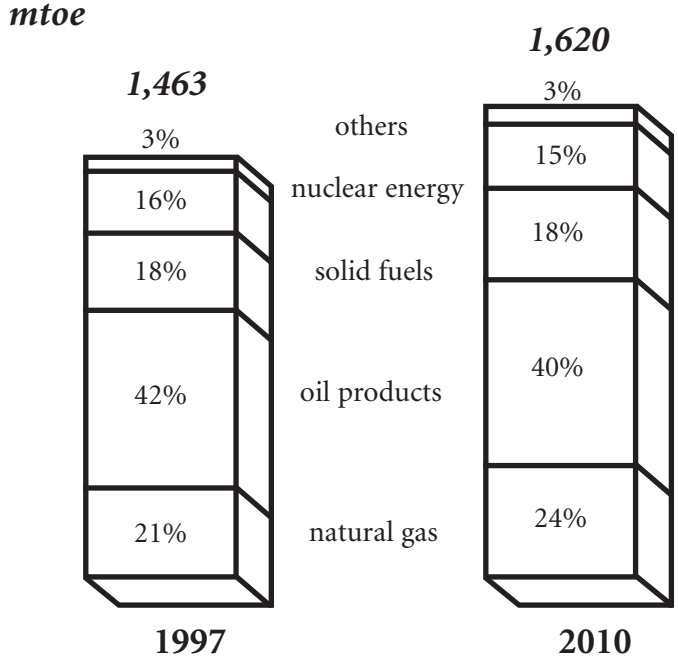
ronmental issues to the side. US analysts tend to think of the new Labour Party as a sort of "softer Thatcherism," but Prime Minister Blair has moved to fulfill goals of more competition and stricter regulation, in the process curbing utilities' profits and protecting the last remaining coal miners. Its policies to reduce greenhouse gas emissions focus first on transportation: "car-less" days, bus lanes, higher taxes on heavier cars, subsidies for public transit, and gasoline taxes 6% higher than the rate of inflation. Energy-intensive industries are being taxed, along with rebates to those who file acceptable energy conservation plans. The government is subsidizing non-emitting power generation, with some success in nuclear energy but more limited success in wind farms. The government is watching BP's internal trading scheme as a possible model for implementing the Kyoto Protocol.

In the European Union, restructuring of the electricity supply system ranges from 100% complete in Britain to 26% complete in France; all restructuring is scheduled to be accomplished by 2007. In this process, changes are occurring in fuel preferences, mergers are taking place, and customers are gaining choices. France generates 78% of its energy from nuclear plants, Belgium 60%, and Germany 29%. Germany has announced its intention to phase out nuclear power, but must deal with issues of the next 30–40 years of production, waste disposal, reprocessing, and transport.

The IEA predicts a large increase in use of natural gas, along with decreases in solid and nuclear fuels. Figure 2 indicates that a slight decline in nuclear and oil, offset by an increase in gas, may occur by 2010. The increases in European gas consumption will increase dependency on Russia (with perhaps risks of price vulnerabilities, although long-term contract prices are tied to oil prices). Italy is using more gas almost without discussion, and the politics of importing gas are not discussed in Germany, which must have it as an alternative as the new government seeks to phase out nuclear power. Italy and France both depend upon gas from Algeria and Russia.

Figure 2

Primary Energy Consumption in Western Europe



1997 provisional
Source: Ruhrgas

In the negotiations over establishment of a trading system for greenhouse gases, the Europeans have proposed a limit on the amount of a country's goal that can be met by trading. The EU feels strongly that trading should be limited and that the US should be required to scale back its own emissions rather than simply buying credits to finance its heavier, higher-emissions cars and other emissions-producing activities. However, one model, using marginal abatement cost curves, projects that in a worldwide trading system the US would achieve substantially less of its goal through trading

than the EU or Japan. Gasoline is a particular sore point, with Europeans favoring higher gas taxes in the US. A $1.20/gallon price in the US includes about 50–60¢ in taxes, which arguably covers the social costs involved in energy security, health, aesthetics, highway wear and tear, and congestion, with perhaps a portion left over for climate change. Taxes in Europe are generally higher (i.e., not just gasoline), reflecting a different type of governance.

Given that every European country has electric generation overcapacity and significant transmission problems exist, how will a pan-European trading system evolve? Britain and others are using a trial-and-error approach, with very little trading among countries. Many projects may be developed to bring more gas into the market, such as projects to bring gas from Norway to Switzerland. Perhaps the endgame should be to allow the market (i.e., businesses taking appropriate risks) to build 30–40% excess capacity; however the danger in this strategy is pressure for government bailouts if it fails.

Distributed generation (DG) could also lessen the pressure to coordinate centralized markets and build big generation plants. DG technologies would also reduce emissions and thus the need to trade emissions permits.

Session III: National Actions, US

Major fuels in the US electricity sector are coal, nuclear and natural gas. Currently coal accounts for 56% of electricity generation (70% in the Southeast and Midwest). Coal has increased its share since the 1970's, partly as a result of the prohibition of gas-fired plants in that decade. However, almost no new coal-fired plants are currently coming online; almost all incremental capacity will be fueled by gas. The contribution of coal will increase because base loads will increase, but, as Figure 3 shows, step decreases of uncertain magnitude are also possible in the future because of the costs of environmental regulations. Actual costs of regulations are not known because they are being put into effect one at a time. However, even if utilities had had perfect foresight about these regulations, they probably would have bought coal-fired plants because most coal plants are still cheaper to operate, even considering environmental compliance costs.

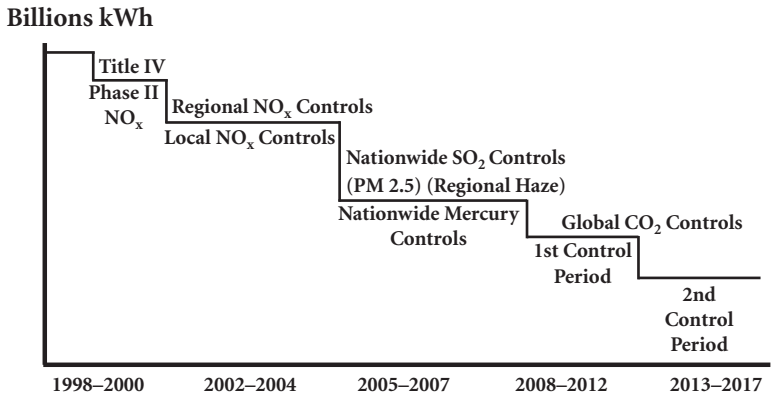
The US electricity generation sector emits two-thirds of all the US sulfur dioxide emissions, and one-third each of nitrogen oxides and mercury. Coal use is a major contributor to these statistics, yet coal use has risen 70% in the last 20 years, while petroleum and natural gas use has remained flat.

The demand for natural gas should rise, but transmission problems are possible. In the Southeast more gas is currently used in the winter, but planned capacity will go well beyond current use. If

demand for additional capacity will be primarily for peak loads in the summer, the necessary additions to the pipeline infrastructure may not make sense.

Figure 3

Coal's Energy Future in the U.S. With Environmental Regulations?



Source: Southern Company

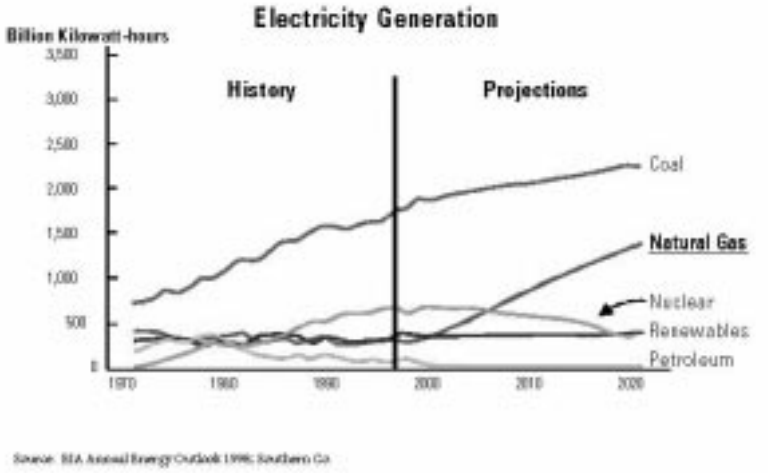
Natural gas has several advantages over coal for new capacity. It has lower capital cost, dramatically greater conversion efficiency (60%), environmental advantages, faster installation time, and lower prices (although prices could rise). The current lead time for a coal-fired plant in China or the Philippines is 4–5 years; although no large base load plants are currently being built in the US, the time here would probably be longer. The lead time for a new gas plant in the US is probably about 3–4 years, of which actual construction is about two years.

At 103 plants (101 currently operating), the US nuclear power industry is twice the size of the French industry, although it contributes only about 20% of US electricity production. In recent years, partly as a result of restructuring, applications for license renewals are being submitted or planned, there have been some premature shutdowns, and at

least three companies are seeking to buy existing nuclear plants. Supporters note that nuclear energy is an alternative to carbon-dioxide-emitting sources, a sole supplier in some areas, and a significant electricity source that would be hard to replace. The State Improvement Plans being developed under Clean Air Act regulations include air quality benefits from nuclear as well as hydro and renewable power sources.

Figure 4

U.S. Fuel Choices



On the other hand, no new nuclear plants have been ordered since 1978, partly because of Three Mile Island and subsequent requirements and partly because price increases in the early 80's reduced demand. New plants would need to have lower capital costs and shorter lead-times. Another nuclear accident could alter the public's current acceptance of existing plants, but an accident in a non-Western designed reactor may make less of a difference in the United States.

Restructuring of the Electricity Industry

Two viewpoints concerning the results of restructuring are in direct conflict with each other—except in one area. One viewpoint

states that the open grid provides automatic environmental dividends in breaking up monopolies, allowing the addition of less polluting alternatives, and unbundling services. Restructuring of the electricity industry means that the responsibility for planning is now with the firm, so that decisions can be made in a more businesslike way. New capacity is coming online, and plants are getting better environmentally. The other view is that, as competition intensified, costs became the driver that favored the cheaper, more polluting installed base. The point of agreement between the two views is that whether or not competition means less pollution in the future will depend on policy decisions.

So far no overall environmental dividend can be seen. There are instances of utilities or IPPs buying old coal plants and operating them more cleanly. However, in 1996–1997, coal use was up 8%, natural gas down, and renewables flat. "Green energy" options have resulted in only 50 MW of new capacity. Important decisions are yet to be made at the federal level (about how reliability will be ensured, whether clean air legislation and standards will be overhauled, and how financial incentives will be structured) and at the state level (whether the grid can be operated reliably without monopolies and without the rate cap mindset), and these decisions will largely determine the overall results of restructuring.

Public Policy and Fuel Choice

What is the role of public policy in fuel choice? We still have a regulatory mindset, public policy may need to influence choices for environmental reasons, and policymakers may wish to ensure a diverse selection of fuels. However, the government should not mandate fuel choice; businesses have lost millions over the past 30 years from switches in government policy regarding fuel selection. Perhaps the best role for government is to remove obstacles to market mechanisms and to set consistent, comprehensive environmental standards and incentives. Although based on evidence from the oil companies and on security issues at the time of enactment, the Fuel Use Act is now widely believed to have been a mistake, and

PURPA and PUHCA have largely outlived their usefulness. New Source Performance Standards under the Clean Air Act have resulted in the perpetuation of older, polluting coal-fired plants because meeting the standards is expensive for new plants.

As utilities become energy companies, they need to shift their thinking to focus more on business and environmental aspects. However, under competition the public service obligations of utilities may be irrelevant or even pernicious. A mixed monopolistic-competitive system will exist for some time to come, however. The wires system will still be monopolistic (some believe this is the appropriate place for public service obligations), and indications from some states (e.g., Florida) are that half the new capacity will be built under the old system.

Although comprehensive regulations that specify standards and deadlines for all air pollutants would be helpful to electricity generators, both businesses and EPA feel that the other is unwilling to begin such discussions. Utilities would like a predictable business environment, e.g., to be able to foresee all the environmental costs involved in operating a coal-fired plant. It may be that smaller investments can achieve environmental goals. Since lack of trust is an issue among various concerned parties and the differences are large, achievement of an agreement on an integrated set of standards will be difficult. Furthermore, rationalized environmental controls may be a matter for legislation, not EPA regulatory action—although there may be actions that can be taken under current authority, especially with regard to fuel diversity. And environmental policy has frequently been tentative, with legislation often enacted by small majorities.

Pricing issues also complicate the emerging market. The industry has a tendency to average costs over time and space, but the range of costs can be more than an order of magnitude. Also, transmission and distribution costs are factors in total cost, especially when competing against distributed generation. Customers do not see these price signals—just the averages.

Reliability must be addressed, but how? The government may help ensure reliability by creating integrative mechanisms, or market operations and a multiplicity of suppliers may be enough to build reliability into the system.

Session IV: Technological Change and Business Risk

The energy system itself is characterized by change – change driven by technology. Technology has changed the ways we locate and exploit energy resources. In relatively mature technologies and nuclear power, we are still on a learning curve. In less mature areas we have made remarkable improvements in solar technologies and chemical and physical advances in biomass energy. Change, perhaps transformative change, is resulting from gas turbines, catalytic combustion, fuel cells, chemical processing of fuels, and on the demand side, buildings, technologies and other end-use innovations. Information technologies enable improvements in efficiency and admixing of technologies.

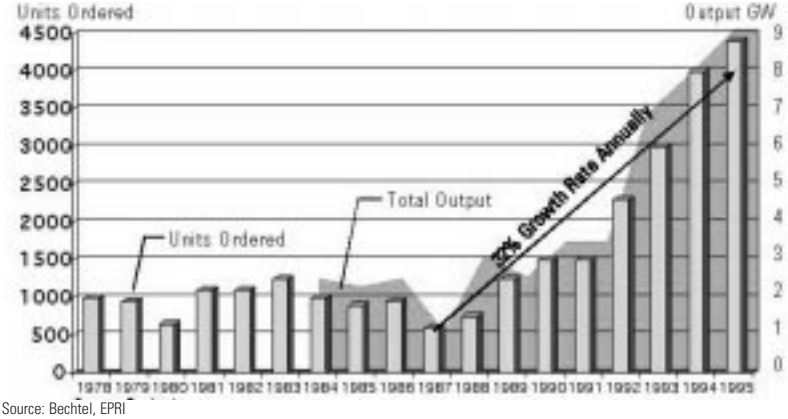
As we think about a future of rapid change, we need to engage all stakeholders with their aspirations and concerns. Customers will be able to manage the systems that deliver electricity to their homes and businesses. Electricity is generally a preferred end-use form of energy—but where will electricity be produced? As Figure 5 demonstrates, the sale of small (<1MW) generators has grown at a 32% annual rate since 1987. When distributed generation comes to sites such as homes, the industry must be ready with integrated DC, AC, and local sources in high-quality "power parks" that will deliver universal access. If the grid cannot accommodate such a system, it will become the provider of last resort. And the transactions that the grid must manage are growing astronomically. In order to realize a vision

of an integrated system, bottlenecks must be avoided and removed, mechanical switches must be replaced by electronic controls, and advanced transmission systems and management must be installed. However, current policy provides only uncertainties and disincentives to improve the grid.

Figure 5

Power Delivery Vulnerability

1 MW Gen Sets Market



Source: Bechtel, EPRI

At the global scale, we face simultaneously problems relating to population, pollution, and prosperity. We need to accommodate increased numbers of people, especially in developing countries; ensure growth in global productivity; and reduce pollution, including greenhouse gases. Between 1950 and 2050 global population will quadruple, and urbanization will grow even faster. Global sustainability requires perhaps a 2% or greater annual growth rate in productivity, agriculture, fresh water, and pollution reduction. De-carbonization leading to an electricity/hydrogen energy system is achievable, but it urgently requires an innovative portfolio of generation options and farsighted climate policies.

As Figure 6 suggests, cars will increasingly be sold in developing rather than developed countries, and automotive technologies will become increasingly diversified. Analysts consider the automobile market to be saturated at one car for every two people; by this defi-

nition, markets in developed countries are saturated. The new markets will be on the Pacific Rim, especially China and India. In new and old markets, there is a slow increase in alternative fueled vehicles, from about 251,000 in 1992 to 380,000 in 1997. The vast majority of these just use alternative fuels in internal combustion engines.

Figure 6

Emerging Motor Vehicle Markets

	Population	GDP/Capita	Vehicles/Capita
China	1,221,621	566	0.001
India	967,034	461	0.0008
USA	268,126	21,685	0.785
Japan	125,864	25,139	0.560
Germany	81,104	17,648	0.553
United Kingdom	58,526	14,210	0.503

Both the new markets and the new technologies will shape the passenger transportation sector of the future. On the one hand, emerging market nations differ among themselves in terms of population density, fuel and roadway infrastructures, culture, forms of government, and climate. On the other hand, technology will improve the fuel-to-work efficiency, from 16% for the gasoline-fueled internal combustion engine to 80% for the battery electric car, 47% for the hydrogen fuel cell vehicle, and 32% for the gasoline reformer fuel cell vehicle. These diverse factors may lead to vastly different fuels/power-plants, vehicles, and forms of personal transportation.

Many options are possible. Batteries are getting better but the cost of electric vehicles may never be competitive. Hybrid vehicles are being sold and are more efficient than the traditional internal combustion vehicles, but this may be an interim solution because of the complexity in design. The on-board fuel cell has been developed but

remains large and expensive. The vehicle developed by the Partnership for a New Generation of Vehicles (PNGV) may use an advanced diesel engine (currently at 62 mpg) because fuel cells will not be ready by the 2004 deadline. For all vehicles, the Internet is being used to target customers and as a resource for pricing information and data on dealer inventories.

Factors such as the internet's transformation of the customer-seller interface, and technological transformation of the electricity supply system and of passenger vehicles, challenge organizations to adapt and thrive in an environment of accelerating change. Hardware itself does not transform societal relationships, but enables structural, economic, and policy shifts that are transformative. Organizations must look at the whole value chain affected by a multitude of changes and position themselves around the chain to provide integrated services and products that will be demanded. Organizations should use the tools of cost estimating and forecasting to be ready to address a variety of different outcomes from the same set of circumstances. Companies that are good at this have a natural curiosity about technology and a good understanding of how new technology itself can define new ways of doing business and new markets.

Many of the uncertainties revolve around technology development. For example, the scale of technology changes in diverse ways. Computer hardware has evolved from large scale mainframe computers to small PCs, then to large-scale telecommunications, and today to interconnections at diverse scales. Even technologies that begin at a small scale will not necessarily aggregate in the "usual" ways. The lesson for businesses is to not attempt to frame a scale-up pathway, but to stay flexible.

Similarly, the role of public policy in technology development is problematic because of various kinds of uncertainties. For example, the decline in private funding for R&D—especially basic science – in gas and electricity may mean that governments should step up investment in R&D and seek R&D partnerships with industry. And perhaps government should provide structure (in the form of

RTOs) and incentives to develop the grid, in the absence of market forces. Government might also provide incentives to develop cleaner transportation technologies and to facilitate gas pipelines. However, opponents of a stronger role for government argue that government has guessed wrong in the past and that such mistakes could occur again; supporters note that industry has also guessed wrong, and that those predictions have "informed" government's mistakes.

An overarching uncertainty to be addressed by research is the amount and kind of energy resources that the Earth holds. With uncertainties about climate change and air pollution, the resource question needs to be the subject of sustained, basic research; methane hydrates are one obvious focus of such research. Hydrogen, although not per se a resource, is another. Obviously both industry and government have big stakes in the research results.

Most participants agreed that policy should not inhibit technical progress in energy supply: the policy process is often outpaced by technological change. Calls for stable policy and a predictable regulatory environment are undermined by the uncertainties of basic science and of technology/market development, i.e., it is hard to know what policies to enact today that will facilitate change tomorrow. Environmental regulations have been cobbled together over time, moving from technology standards to performance standards but then failing to account for market forces that result in perverse outcomes, for instance from the New Source Performance Standards. In policy, as in technology, we need to shy away from thinking in terms of unitary or "silver bullet" solutions. Being nimble and understanding the dynamics of technological advances are extremely important.

Looking at how other countries are dealing with similar issues can guide the United States, but situational differences are important. Analyzing trends toward globalization must be balanced by the realities of diversity. The UK invests more in its electricity system than all of the US. Is this explained by a move from a rate-based to an investment-based mentality? Is the incentive to invest effective? Is the UK system more reliable than the US system? Looking at an

additional country, e.g., the Netherlands, may help us to sort out what can be learned from both for the US situation. However, the US appears to be under-investing in its electricity system, which to a great extent underpins its economic system.

The idea of "personal power," i.e., that an individual may control his or her own sources of energy, even selling back to the grid at times, is an exciting and compelling notion. With this notion as a vision of the future energy business, companies need to think through the value chain to assess their appropriate roles in these new markets. Stimulating investment in the grid, sponsoring basic research, setting standards for power interfaces such as meters, and developing flexible/comprehensive environmental standards may fall in the realm of public policy.

Advances in technology are bringing transformative, perhaps disruptive change to the energy sector. Whether driven by market forces or public policy choices, these changes have profound implications for the rules of the game in energy. Although the impacts on particular segments of the industry may be dramatic and painful, other segments will thrive. Even though their effects are uncertain and uneven, such technological changes have tremendous potential to help society deal simultaneously with problems relating to population, pollution, and prosperity.

List of Participants

Catherine G. Abbott
Chief Executive Officer and President
Columbia Gas Transmission Corporation
12801 Fair Lakes Parkway
P.O. Box 10146
Fairfax, VA 20033

P. J. Adam
Chairman and Chief Executive Officer
Black & Veatch
8400 Ward Parkway
PO Box 8405
Kansas City, MO 64114

Alvin Alm
Executive Vice President
The Columbus Group
2111 Wilson Blvd.
Suite 1200
Arlington, VA 22306

Merribel S. Ayres
President
Lighthouse Energy Group
1200 18th Street, NW
Suite 850
Washington, DC 20036

Richard Ayres
Partner
Howrey & Simon
1299 Pennsylvania Ave., NW
Washington, DC 20004-2402

The Honorable Vicky A. Bailey
Commissioner
Federal Energy Regulatory Commission
888 First Street, NE
Suite 11B
Washington, DC 20426

Stephen D. Ban
President and CEO
Gas Research Institute
8600 W. Bryn Mawr Ave.
Chicago, IL 60631

Michael L. Beatty
Federal Representative
Western Interstate Energy Board
10 Boulder Crescent
Suite 303
Colorado Springs, CO 80903

Roger A. Berliner
Managing Partner
Brady & Berliner
1225 19th Street, NW
Suite 800
Washington, DC 20036

Ellen Berman
President
Consumer Energy Council of America Research Foundation
2000 L Street, NW
Suite 802
Washington, DC 20036

Peter D. Blair
Executive Director
Sigma Xi, The Scientific Research Society
P.O. Box 13975
99 Alexander Drive
Research Triangle Park, NC 27709

John E. Bryson
Chairman of the Board and CEO
Edison International
2244 Walnut Grove Avenue
P.O. Box 800
Rosemead, CA 91770

Van Bussmann
Corporate Economist
Daimler Chrysler
1000 Chrysler Drive, cims 485-12-60
Auburn Hills, MI 48326-2766

John R. Butler, Jr.
President and Chairman
Houston Advanced Research Center
4800 Research Forest Drive
The Woodlands, TX 77381

Thomas Casten
President & CEO
Trigen Energy Corporation
One Water Street
White Plains, NY 10601

Ralph Cavanagh
Senior Attorney
Natural Resources Defense Council
71 Stevenson Street
Suite 1825
San Francisco, CA 94105

Julia Chen
The AES Corporation
1001 North 19th Street
Arlington, VA 22209

Greg Conlon
43 Virginia Lane
Atherton, CA 94027

Chester L. Cooper
Deputy Director
Emerging Technologies
Battelle, Pacific Northwest National Laboratory
901 D Street, SW
Suite 900
Washington, DC 20024

Benjamin S. Cooper
Executive Director
Association of Oil Pipelines
1101 Vermont Ave., NW
Suite 604
Washington, DC 20005

Anthony H. Cordesman
Senior Fellow and Co-Director Middle East Studies
Center for Strategic and International Studies
1800 K Street
Washington, DC 20006

Loren C. Cox
Associate Director
MIT CEEPR & Global Climate Change Program
350 Belaire Court
Punta Gorda, FL 33950

Charles B. Curtis
Partner
Hogan & Hartson, L.L.P.
555 13th Street, NW
Washington, DC 20004

Wilfried Czernie
Senior General Manager
Ruhrgas A.G.
Huttropstrasse 60 - D-45138 Essen
Federal Republic of Germany

Ged Davis
Vice President, Global Business Environment
Shell International Limited
Shell Centre - London SE1 7NA
United Kingdom

Etienne Deffarges
Global Managing Partner for Utility Strategy
Andersen Consulting
Suite 3700 Spear Tower
One Market Street
San Francisco, CA 94105

Bill Dickenson
CEO & President
PHB Hagler Bailly
1776 I Street, NW
Washington, DC 20006

Paul Dragoumis
President
Paul Dragoumis Associates, Inc.
P.O. Box 5
Cabin John, MD 20818-0015

Theodore R. Eck
Senior Economic Consultant
Amoco
271 New Boston Rd.
Norwich, VT 05055

Ing. Juan Eibenschutz
Subdirector de Distribucion Y Comercializacion
Luz y Fuerza Del Centro
Melchor Ocampo 171-5o. Piso
Col. Tlaxpana, 11379 Mexico, D.F.

Richard D. Farman
Chairman and Chief Executive Officer
Sempra Energy
101 Ash St. - 19th Floor
San Diego, CA 92101

Marvin S. Fertel
Senior Vice President
Nuclear Energy Institute
1776 I Street, NW
Suite 400
Washington, DC 20006-3708

Cheryl M. Foley
Vice President & Secretary
Cinergy Corp.
139 East Fourth Street
P.O. Box 960
Cincinnati, OH 45202

Dirk Forrister
Energy Program Director
Environmental Defense Fund
1875 Connecticut Ave., NW
Washington, DC 20009

H. Allen Franklin
President and Chief Operating Officer
Southern Company
270 Peachtree Street
Suite 2200
Altanta GA 30302

William Fulkerson
Senior Fellow
Joint Institute for Energy & Environment
2781 Wheat Road
Lenoire City, TN 37771

John H. Gibbons
Senior Fellow
National Academy of Engineering
PO Box 379
The Plains, VA 20198

Craig G. Goodman
President
National Energy Marketers Association
3220 N Street, NW
Suite 338
Washington, DC 20007

Paul Hanrahan
Senior Vice President
The AES Corporation
1001 North 19th Street
Arlington, VA 22209

Robert A. Hefner III
Chairman
The GHK Companies
6305 Waterford Blvd.
Suite 470
Oklahoma City, OK 73118

William W. Hogan
Lucius N. Littauer Professor of Public Policy and Administration
Kennedy School of Government
Harvard University
79 John F. Kennedy Street
Cambridge, MA 02138

Paul Holtberg
Group Manager Baseline/Gas Resource Analytical Center
Gas Research Institute
1600 Wilson Blvd.
Suite 900
Arlington, VA 22209

Ambassador Ryukichi Imai
Institute for International Policy Studies
Sumitomo Hanzomon Building 7F
3-16 Hayabusa-cho, Chiyoda-ku
Tokyo 102-0092
Japan

Ira H. Jolles
Senior Vice President & General Counsel
GPU, Inc.
300 Madison Avenue
P.O. Box 1911
Morristown, NJ 07962

Richard Kessel
Executive Vice President and COO
Trigen Energy Corporation
One Water Street
White Plains, NY 10601

Wilfrid L. Kohl
Professor and Director IEEP
Johns Hopkins University SAIS
1619 Massachusetts Avenue, NW
Washington, DC 20036

Thomas R. Kuhn
President
Edison Electric Institute
701 Pennsylvania Avenue, NW
Washington, DC 20004-2696

Amory B. Lovins
Co-CEO and CFO
Rocky Mountain Institute
1739 Snowmass Creek Road
Old Snowmass, CO 81654-9199

Jan W. Mares
EOP Group, Inc.
819 7th Street, NW
Suite 400
Washington, DC 20001

Joe L. Mauderly
Director of External Affairs
Lovelace Respiratory Research Institute
P.O. Box 5890
Albuquerque, NM 87185

John McTague
Vice President for Technology (retired)
Ford Motor Company
498 Live Oak Road
Montecito, CA 93108

James R. Metzger
Vice President & Chief Technology Officer
Texaco, Inc.
2000 Westchester Avenue
White Plains, NY 10650

Nancy C. Mohn
Director, Marketing and Strategy
ABB Alstom Power
2000 Day Hill Rd
Windsor, CT 06095-0500

William A. Nitze
Assistant Administrator
Office of International Activities
Environmental Protection Agency
Mail Code 2610R
401 M Street, SW
Washington, DC 20460

Dana Orwick
Program Director Emeritus
The Aspen Institute
6004 Winnebago Road
Bethesda, MD 20816

Erik W. Pearson
Director, Strategic Planning
Batelle,Pacific Northwest National Lab
PO Box 999, KI-50
Richland, WA 99352

D. Louis Peoples
Vice Chairman & CEO
Orange and Rockland Utilities, Inc.
One Blue Hill Plaza, 21st Floor
Pearl River, NY 10965

James Placke
Director, Middle East and World Oil
Cambridge Energy Research Associates
1133 Connecticut Ave., NW
Suite 903
Washington, DC 20036

Paul R. Portney
President
Resources for the Future
1616 P Street, NW
Washington, DC 20036

Tony Prophet
President & CEO
Allied Signal Power Systems, Inc.
8725 Pan American Freeway, NW
Albuquerque, NM 87113

Frank J. Puzio
Office Managing Partner
PricewaterhouseCoopers, LLP
370 17th Street
Suite 3300
Denver, CO 80202

Jim Ragland
Director, Economic Research Group
Aramco Services Co.
1667 K St., NW
Suite 1200
Washington, DC 20006

James E. Rogers
Vice Chairman & President & CEO
Cinergy Corp.
139 East Fourth Street
P.O. Box 960
Cincinnati, OH 45202

Ellen Roy
Senior Vice President
Intercontinental Energy Corp.
350 Lincoln Place
Hingham, MA 02043

Ji-Chul Ryu
Vice-President
Asia Pacific Energy Research Centre
Chuwa Kamichyacho Bld., 4-3-13 Toranomon,
Minato-Ku, Tokyo 105
Japan

Bryan Sanchez
Special Assistant to the Chairman
Seven Seas Petroleum, Inc.
1990 Post Oak Blvd.
Suite 960
Houston, TX 77056

James R. Schlesinger
Lehman Brothers, Inc.
800 Connecticut Ave., NW,
Suite 1200
Washington, DC 20006

Robert N. Schock
Senior Fellow
Center for Global Security Research
Lawrence Livermore National Laboratory
P.O. Box 808 - L189
7000 East Avenue
Livermore, CA 94551

George A. Schreiber, Jr.
President
Pinnacle West Capital Corporation
P.O. Box 53999
Mail Station 9042
Phoenix, AZ 85072-3999

Phil Sharp
Kennedy School of Government
Harvard University
79 JFK Street
Cambridge, MA 02138

Les Silverman
Director
McKinsey & Company, Inc.
1101 Pennsylvania Ave., NW
#700
Washington, DC 20004

Robert Smart
President
Framatome USA
1911 N. Ft. Myer Drive
Suite 705
Arlington, VA 22209

Steven R. Spencer
Senior Vice President - External Affairs
Southern Company
270 Peachtree St., N,
22nd Floor
Atlanta, GA 30303

Irwin M. Stelzer
Director, Regulatory Policy Studies
The Hudson Institute
1101 17th St, NW
Suite 202
Washington, DC 20036

Alain Streicher
PHB Hagler Bailly
1776 I Street, NW
Washington, DC 20006

Yuji Takagi
Vice President & General Manager
Mitsui & Co. USA, Inc.
1701 Pennsylvania Ave. NW
Washington, DC 20006

Herbert H. Tate
President
NJ Board of Public Utilities
Two Gateway Center
Newark, NJ 07102

Michael Telson
Chief Financial Officer
U.S. Dept. of Energy
1000 Independence Ave., SW
Washington, DC 20585

Susan F. Tierney
Partner
The Economics Resource Group
One Mifflin Place
Cambridge, MA 02138

Admiral Richard H. Truly
Director
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401-3393

Clinton A. Vince, Esq.
Co-Chairman
Verner, Liipfert, Bernhard, McPherson & Hand
901 15th Street, NW
Suite 700
Washington, DC 20005

Andrew W. Williams
Vice President Transmission & Marketing
Potomac Electric Power Company
1900 Pennsylvania Avenue, NW
Washington, DC 20068

Ben Yamagata
Senior Partner
Van Ness, Feldman, P.C.
1050 Thomas Jefferson St., NW
Suite 700
Washington, DC 20007

Kurt E. Yeager
President and CEO
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, CA 94304-0813

The Aspen Institute

Program on Energy, the Environment, and the Economy

The mission of **The Aspen Institute** is to enhance the quality of leadership through informed dialogue about the timeless ideas and values of the world's great cultures and traditions as they relate to the challenges facing societies, organizations, and individuals. The Seminar Programs enable leaders to draw on these values to enrich their understanding of contemporary issues. The Policy Programs frame the choices that democratic societies face in terms of the enduring ideas and values derived from those traditions.

The **Program on Energy, the Environment, and the Economy** provides neutral ground for dialogue among diverse participants from the energy industry, government, environmental and other public interest groups, research institutions, and elsewhere. Meetings in a non-adversarial setting encourage positive, candid interaction and seek areas of consensus or improved mutual understanding.

The annual **Energy Policy Forum** is the flagship of the Program. Now in its 23nd year, its high level participation, lively discussion, and congenial setting cause some of the most thoughtful and influential leaders in the energy sector to return again and again to grapple with timely topics facing energy policy makers. Session chairs and speakers serve only as discussion starters; participants with different perspectives contribute to and enrich the dialogue, with the goal of enhanced understanding and, where possible, consensus on policy recommendations.

The **Pacific Rim Series,** in its 17th year, consists of annual workshops for experts from industry, government, and other institutions to discuss Asian energy issues.

The **Series on the Environment in the 21st Century** is a continuing dialogue among business, environmental, and government leaders about developing a new, less prescriptive, and more effective environmental protection system for the United States. In its most recent phase, participants considered new ways to deal with natural resources and systems.

Valuing Environmental Performance, a dialogue among corporations and financial institutions, sought ways for corporations to better communicate the strategic value of their environmental behavior and for financial markets to recognize and reward improvements.

A series on **Disposition and Storage of Nuclear Waste—Implications for Nonproliferation and the Environment** is meeting periodically to allow a small number of experts and advocates from government, industry, academia, and public interest organizations to seek consensus on — and improve communication and understanding among adversaries regarding — civilian and defense nuclear waste.

The Mexico-US Border Environment and Economy is a dialogue among private and public sector leaders to identify for both Presidents factors that make a difference in managing growth at the border and ways of dealing with those factors.

* * * *

John A. Riggs is Executive Director of The Aspen Institute's Program on Energy, the Environment, and the Economy. Prior to joining the Institute he was Deputy Assistant Secretary and Acting Assistant Secretary for Policy in the U.S. Department of Energy and staff director of the Energy and Power Subcommittee of the U.S. House of Representatives. He has also taught energy and environmental policy at the University of Pennsylvania.

Susan OMalley Wade is Associate Director of the Program. With specialties in natural resources management and environmental dispute resolution, she has worked as an environmental consultant in the private sector, with the California Environmental Protection Agency, and on the staff of a U.S. House of Representatives Committee.

Peter A. Johnson is Senior Associate of the Program. He was formerly Director of the Marine Board at the National Academy of Sciences/National Research Council and Senior Associate at the Office of Technology Assessment, where he directed projects on cleanup of the nuclear weapons complex, dismantlement of nuclear weapons, management of nuclear materials, and environmental impacts of nuclear waste dumping in the Arctic.

Printed with soy ink on recycled paper. 99-038