PROGRAM ON ENERGY, THE ENVIRONMENT, AND THE ECONOMY

Vulnerability and Resilience

2002 Aspen Energy Policy Forum
J.Bennett Johnston, Chair

Paul Runci, Rapporteur
John A. Riggs, Program Executive Director

THE ASPEN INSTITUTE

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Foreword

In the wake of the turmoil in energy markets starting in 1999, the September 2001 attacks and subsequent war on terrorism, and the growing awareness of the constraints climate change will impose on energy production and use, the 2002 Aspen Energy Policy Forum took as its theme "Vulnerability and Resilience." A look at future scenarios, the imperatives of geopolitics, dependence on oil, and the unevenness of electricity restructuring provided a new and perhaps more urgent opportunity to consider themes that have regularly recurred since the Forum's inception in 1977.

In keeping with the Aspen Institute's method of informed dialogue among people of diverse backgrounds and viewpoints, the Forum convenes leaders from business, finance, government, academia, and environmental and consumer groups to explore policy questions that require crosscutting, interdisciplinary approaches. Challenged to avoid easy answers based on a single area of expertise, the participants seek to weigh competing values and approach policy issues holistically. A not-for-attribution rule encourages candor and the exploration of new ideas, and the informal atmosphere and collegiality encourage respect for different opinions.

The 2002 Forum was chaired by J. Bennett Johnston, whose many years as member and chairman of the Senate Energy and Natural Resources Committee give him the knowledge and experience to guide the discussion of a broad range of energy issues, bringing

focus and perspective to a large topic. The Institute and the Forum participants are grateful to him.

The greatest strength of the Forum lies in the expert contributions from all the participants around the table, but presentations from invited experts start each session, and knowledgeable session chairs guide the ensuing dialogue. The experts provided a wealth of information and a variety of perspectives, contributing immensely to the richness of the discussion, and the chairs helped frame the dialogue and guide the contributions of others as well as adding their own substantial experience. We appreciate the contributions of these presenters and session chairs, who are listed in the agenda.

Paul Runci served as rapporteur and admirably captured, distilled and organized the highlights of a free-ranging discussion. Katrin Thomas managed the administrative details of the Forum with her customary efficiency and good nature.

The Institute's Program on Energy, the Environment, and the Economy acknowledges the generous support of our sponsors. Without their confidence in our work, this Forum would not be possible. We gratefully recognize and thank the following for their support during the past year.

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

Agenda

"Vulnerability and Resilience"

July 3 – July 7, 2002

Forum Chair: **J. Bennett Johnston**
Partner, Johnston and Associates, LLC

Session I: Looking Over the Horizon

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

Speakers: **Kurt Yeager,** President, EPRI

Ged R. Davis, Vice President, Shell International

Gerald M. Stokes, Director,
Joint Global Change Research Institute

Session II: The Geopolitics of Energy

Chair: **J. Bennett Johnston,** Partner,
Johnston and Associates, LLC

Speakers: **Anthony Cordesman,** Senior Fellow,
Center for Strategic and International Studies

Philip K. Verleger, Senior Fellow,
Council on Foreign Relations

R. James Woolsey, Partner, Shea & Gardner

Session III: Reducing the Reliance on Oil

Chair: **Paul Portney,** President and Senior Fellow,
Resources for the Future

Speakers: **Dermot Gately,** Professor of Economics,
New York University

David Greene, Corporate Fellow,
Oak Ridge National Laboratory

Lester Lave, Professor of Economics,
Carnegie Mellon University

Session IV: Creating a Resilient Electricity Sector

Chair: **Susan Tomasky,** Executive Vice President,
American Electric Power Co.

Speakers: **Nora Brownell,** Commissioner,
Federal Energy Regulatory Commission

Roger Hamilton, Energy Advisor,
Oregon Governor's Office

Sally Hunt, Special Consultant,
National Economic Research Associates

Doug Kimmelman, Chairman,
Global Power, Goldman Sachs

Session V: What Does It Mean?

Chair: **Richard H. Truly,** Director,
National Renewable Energy Laboratory

Breakout Group Moderators:

Anne Cleary, President, Mirant California

Bill Dickenson, Managing Director,
Cornerstone Research

Ernie Moniz, Professor of Physics,
Massachusetts Institute of Technology

Introduction and Recommendations

The 2002 Aspen Energy Policy Forum convened at a time of heightened urgency with respect to questions of energy vulnerability and resilience. The recent California crisis, the increasing volatility of oil and gas prices, and the sudden collapse of Enron and other energy companies have kept energy in the headlines and focused attention on the nation's enduring energy problems. Moreover, the events of September 11, 2001 have raised a host of new questions about the vulnerability of the nation's energy systems and moved the threat of terrorism to the top of the list of urgent energy challenges.

Each of the serious energy challenges that the U.S. faces highlights an inherent tension between government regulation and free markets as instruments of policy. While markets have gained significant ground as the arbiters of energy decisions, recent events have contributed to a reassessment of the appropriate mix of regulation and market economics in energy policy in an effort to find a balance that better safeguards national security, environmental quality, and the interests of consumers, investors, and producers.

The 2002 Aspen Energy Policy Forum addressed the question of energy vulnerability and resilience in the context of four key issues: the development of the energy systems of the future; the evolving geopolitics of energy; the reduction of America's reliance on oil; and the creation of a resilient electricity industry. Each of these

issues was the subject of a dedicated Forum session. In the fifth and final session, breakout groups focused on the Forum's key findings, which were synthesized into the set of domestic and foreign policy recommendations presented below.

Domestic Policy Recommendations

- Reinvigorate energy efficiency. Energy efficiency constitutes a latent strategic energy reserve, and should be treated as a critical component of national security and environmental quality. Higher technology-based efficiency standards, especially in the transportation sector, and aggressive public education should be central components of energy efficiency policy programs.

- Address energy infrastructure vulnerabilities. All major energy systems exhibit serious vulnerabilities that will have to be addressed to create resilient systems of the future. For example:

    - The electric power grid needs expanded real-time grid management capability, increased interconnectivity, built-in storage capacity, surplus transmission and bypass capabilities. Increased use of DC transmission, distributed generation, and micro-grids can also play important roles in bolstering system resilience.

    - Expand the interconnectivity of the gas transmission pipeline system and build in greater gas storage capacity at the point of use.

    - Examine the limitations of the petroleum refinery distribution system and reduce both military and non-military refined product needs, whether procured from domestic or foreign sources.

- Review the rationale for, and operation of, the Strategic Petroleum Reserve. Expand strategic reserves to include natural gas, and coordinate U.S. reserves with those of allied nations. Formulate clear guidelines on the conditions under which strategic reserves are to be used and the appropriate size of inventories.

- Recognize the strategic importance of energy research and development (R&D) to energy security and use it as an instrument for the expansion of the energy supply portfolio and for the reduction of security and environmental risks associated with fossil fuel dominance of the nation's primary energy. The R&D portfolio should use incentive-based mechanisms and emphasize several key technology areas including renewable energy, energy efficiency, carbon capture and sequestration, and the management of nuclear waste and proliferation risks. The U.S. should take the lead in coordinating energy R&D programs with those of allied countries to reduce collective energy vulnerabilities.

- Encourage the Federal Energy Regulatory Commission to issue quickly its orders on regional transmission organizations (RTOs), standard market design, real-time metering and pricing, and infrastructure development and grid improvement. Congress should consider granting FERC greater authority, if necessary, for the swift implementation of these measures.

- Seek to restore trust in electricity markets by subjecting all participants equally to market rules and policies, ending opt-outs for municipal and federal utilities and other power provider classes. Enable the development of free and efficient markets and improve government oversight and policing.

- Implement strong air and water quality standards, and strong non-voluntary greenhouse gas mitigation standards. Incentive-based mechanisms (including tax credits and trading systems) should be preferred instruments for a four-pollutant strategy (i.e., sulfur, nitrogen, mercury, and carbon dioxide). Tradeoffs across pollutants or media should not be permitted.

Foreign Policy Recommendations

- Recognize the importance of U.S. re-engagement in international agreements to mitigate global climate change. In addition to their explicit goals of climate management, these institutions can spur decreased fossil fuel dependence and help to maintain strong ties with key allies.

- Recognize the strategic importance to U.S. security, economic, and environmental interests of energy assistance and cooperation in developing countries. Consider programs aiming to:

    - Accelerate development of a 21st century energy infrastructure in high-growth (e.g., China, Mexico) and moderate-growth countries (e.g., India, Philippines) and encourage technology "leapfrogging." Such efforts might be enhanced by the creation of a global credit institution to underwrite the financing of new energy technologies and systems, and by efforts to increase investor confidence in legal, regulatory, and intellectual property regimes in these countries.

    - Promote accelerated rural electrification and community-building efforts in slow-growth developing countries (e.g., Nigeria, Bangladesh, Yemen). Electrification programs in these areas can serve as both a catalyst of quality of life improvement and, in combination with other development efforts, as a mechanism for slowing the world trend of rapid urbanization.

    - Encourage the creation of regional institutions and organizations by which faster-growth countries might play a leading role in capacity-building and development efforts in slow-growth countries.

Session I: Looking Over the Horizon

The decisions that energy policymakers and executives make cast long shadows into the future. By virtue of their long-lived infrastructure, high capital costs, and large networked systems, the energy industries may present some of the toughest challenges from this perspective, making large-scale system change seem next to impossible. Nonetheless, many leaders and energy analysts recognize a pressing need for a transition to energy systems that are cleaner, more secure, and more sustainable. Moreover, assuming that a major energy transition must be well under way by mid-century to mitigate global climate change and to respond to the likelihood of diminishing fossil fuel resources, leaders must now begin to articulate a vision of the energy future that lies just over the near horizon. Preparations for a global energy transition away from fossil fuel dominance must begin now.

By attempting to gaze over the horizon and think about developments in energy and the environment over the next half century, leaders may gain greater insight into both probable and possible energy futures, and think more clearly about the signals they might send to markets. The creativity and vision that public and private sector decision makers can bring to bear in that exercise will go a long way in deciding whether the global energy future will be one that fosters greater prosperity and sustainability, or one that exacerbates mounting environmental and resource problems.

To assist decision makers in looking over the energy horizon, the first session of the 2002 Energy Policy Forum featured presentations of alternative visions to 2050, each prepared using different sets of analytical tools: roadmapping, scenario planning, and computer modeling. While none of the presentations aimed to "predict" the global energy future, each offered a plausible vision that yielded many policy-relevant insights. While each of the presentations had a different focus, there were significant areas of convergence among them in their visions of the long-term future and of the key, intertwining variables that are likely to shape it. Major factors that will shape the energy world of the future include demographic trends such as population growth in the developing world and population decline in the industrialized countries, changes in energy intensity associated with industrialization, and the pace and direction of technological innovation.

Demographic Change and Energy Intensity

The world is now in the midst of unprecedented population growth facilitated in large part by man's increasing ability to harness energy—from less than 2,500 calories per person per day in the pre-Neolithic hunter-gatherer era, to more than 50,000 calories per person in modern industrial society. The increasing ability to harness energy has, in turn, enabled the development of science and technology that have steadily extended life spans and improved living standards for populations around the world over the last century. There are, of course, vast regional differences in population and energy use trends, with the industrialized countries exhibiting the lowest population growth, greatest longevity, and highest energy intensity, and the poorest and least developed countries exhibiting the highest population growth, lowest longevity, and lowest energy intensity. Considering the strong correlation between per capita energy use and other key development indicators, energy consumption is often regarded as an important indicator of human development. That said, recent history in developed countries has shown that energy consumption need not grow at the same rate as economic growth, and significant oppor-

tunities exist for greater energy efficiency through technical innovation in industrializing economies.

However, the causal relationship between per capita energy use and human development is complex. While some analysts suggest that energy use is a key development indicator, since it is a catalyst for economic development, others argue that economic development, measured as per capita income, is the chief determinant of energy consumption levels. The latter have observed, for example, that countries have historically begun to embark on the process of industrialization and energy demand has risen sharply at an income level of approximately $3,000 per capita. At $10,000 per capita, the industrialization process is largely complete; at $15,000, energy demand growth decelerates; and at $25,000 energy demand reaches a plateau and eventually declines as priorities shift from greater energy access to more efficient energy production and use. In any case, a key to global sustainability and atmospheric stabilization will be the acceleration of developing countries' efforts to attain higher levels of income and, correspondingly, lower levels of energy intensity.

Figure 1

2000 Development Comparisons

	First World	Second World	Third World
Per Capita Energy (10^3 Calories/day)	155	33	17
GDP/Capita (10^3 $ Purchasing Power Parity)	26	5	2.5
Urban Population (%)	77	45	35
Middle Class (%)	55	4	0.4
Human Development Index	0.916	0.730	0.537

Source: EPRI

In this regard, it will also be important for investors and decision-makers in industrialized countries to improve their understanding of specific developing countries. There is, of course, great diversity among countries that are commonly lumped together under a "developing world" heading. A more nuanced appreciation of the conditions and challenges facing individual countries will foster more effective assistance and development. While there may be problems common to many countries (e.g., the need for rural electrification), there can be no "one size fits all" solution for the various energy and human development challenges that countries face.

The extension of greater levels of energy services to a growing global population must be a key policy objective in this regard. Yet, the sustainable provision of those services will demand that humanity find an alternative to the dominant "hunter-gatherer" model of seeking and extracting fossil energy resources. Given the quantities now consumed, this practice is far less sustainable today than it was even a century ago and will have to change, especially in the light of ongoing global demographic changes. With an estimated population of 9-10 billion by 2100, the planet will be incapable of providing the resources and processing the wastes associated with an energy economy dominated by fossil fuels. Currently, fossil fuels provide more than 70% of global primary energy and, under business-as-usual projections, are expected to retain that share throughout the century.

Attaining global sustainability in the twenty-first century will require, among other factors, the attainment of at least 2% global annual improvement in economic productivity, energy efficiency and the reduction of carbon emissions—eventually to a level that does not exceed the uptake by carbon sinks. By virtue of its efficiency, electricity could play an important role, by contributing to the reduction of the world's energy and carbon intensity. However, electrification will have to reach an additional 100 million people annually for the next 50 years for it to have its full effect. This growth in electrification is the equivalent of 10,000 gigawatts (GW) of global generating capacity, or a tripling of current world power plant capacity by 2050. To put this seemingly daunting growth rate in perspective, however, it is actually the equivalent of less than 5

years of current automobile engine production in energy (horsepower) capacity and could be achieved at a cost less than 0.5% of gross world product over the next fifty years. Although not easy to achieve, this vision is within the realm of possibility, if leaders were to commit to it.

Technological Innovation and Global Sustainability

To begin realizing a vision of sustainability that includes atmospheric stabilization, the world will need a portfolio of technologies to facilitate a global system transition away from the current dominance of conventional fossil systems. Such a portfolio might include a suite of advanced fossil, nuclear, and renewable energy technologies, carbon sequestration technologies, and innovations in energy storage and end use.

Technology's role is critical because it will be a key determining factor on both the energy supply and demand sides. Fueling a more populous, more urban, and more market-oriented world, while pursuing the goal of environmental sustainability, poses a major technological challenge. In this regard, it is important to think not only of energy technologies in the strictest sense, but of those in a number of supporting technology areas, such as materials, communications, and biotechnology. Developments in these areas collectively hold great potential as multipliers of the global energy resource base and as minimizers of humanity's future ecological footprint.

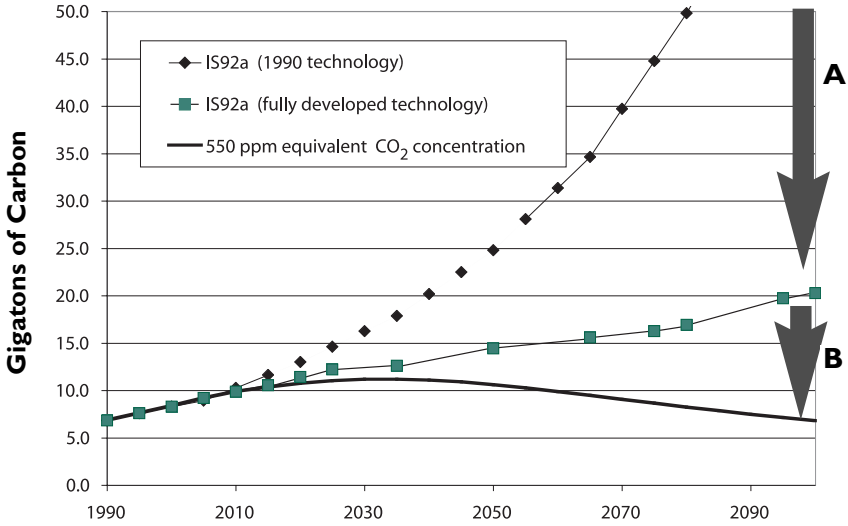
In the opinion of several Forum participants, there is an essential role for policy in ensuring both the existence and the deployment of such a broad technology portfolio. Governments must provide incentives for both the continued and accelerated development of advanced energy technologies, and for their wide deployment. This does not mean that governments should attempt to pick specific "winning" technologies, but rather provide broad support and incentives, in partnership with industry, that will promote the viability of a wide variety of new technologies. The existence of a broad portfolio is especially necessary since, as history has shown, no one

has been able to foresee major developments that have emerged to shape energy policy and markets. Thus, hedging of technological bets is an important strategic approach in an uncertain world.

Yet, even if new technologies continue to be developed and deployed, a more sustainable global energy system is by no means assured. Model analyses prepared by the Intergovernmental Panel on Climate Change, the World Energy Council, and other groups include an implicit assumption that energy technology "innovation as usual" will continue over the next century, slowing the rate of growth in global energy emissions. However, even with the expecta-

Figure 2

Implicit assumption of major technological change to reduce CO_2 Concentrations



A. This improvement presumes fully developed solar, nuclear, efficient fossil electric, advanced transportation, and end-use efficiency.

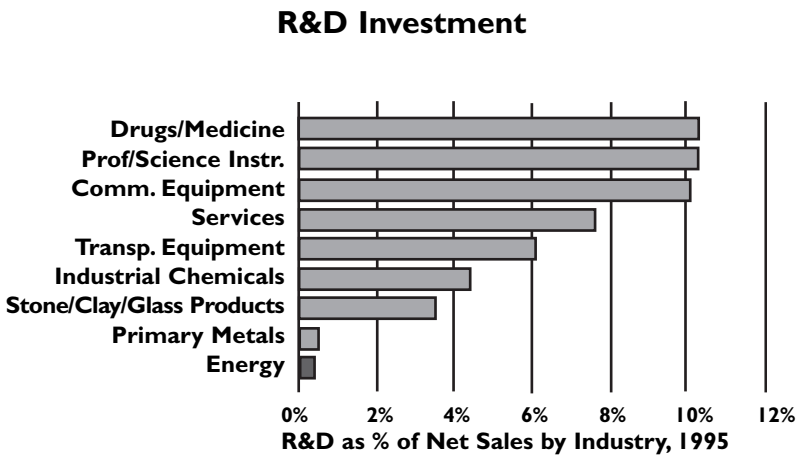
B. Stabilization requires additional policies and S&T–technologies that compete because carbon has a 'value'.

Source: Joint Global Change Research Institute

tion that advanced wind, solar, nuclear, and efficiency technologies continue to become available and are widely used, emissions of carbon and other greenhouse gases are expected to continue to rise due to rapidly increasing global energy demand. Thus, sustainability demands that energy technology development and system transformation proceed aggressively over the next fifty years (see Figure 2).

Considering recent trends in R&D investment, however, the proposition that advanced energy and related technological innovations will proceed, either "as usual" or along an accelerated path, now seems overly optimistic. Public and private sector energy technology investments have been declining sharply and steadily for more than two decades in the small group of industrialized countries that perform nearly all of the world's energy R&D. As one participant noted, the energy industries' rate of investment in R&D is lower than that of virtually every other major industry. Considering the key role that energy technology will play in the transition to more sustainable energy systems and a sustainable world, a reassessment of current investment priorities is needed urgently.

Figure 3



Sorce: Margolis and Kammen; EPRI

It is also important to recognize other barriers to energy technology change, including the imposing challenge that installed infrastructure constitutes. The sheer size and momentum of the current infrastructure, and its incumbent vested interests, suggest that a transformation will be exceptionally difficult to bring about over the next century. Consider, for example, that the electric power industry alone accounts for 3% of capital assets in the U.S. Other barriers, such as the continued existence of outdated policies and regulations, can present equally intractable problems, since they often protect the interests of key industry players.

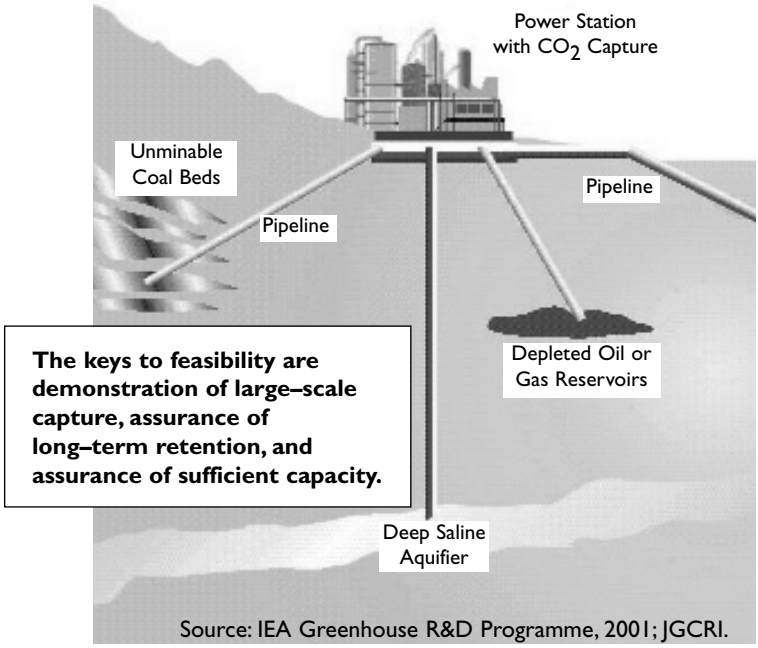
Assuming, as many analysts and policy makers now do, that emissions of carbon dioxide will eventually be capped in the interest of atmospheric stabilization and sustainability, there are a few classes of emerging technologies that appear to have particular strategic importance. Carbon capture and sequestration, for example, will be key areas for research since they could permit the continued use of fossil energy technologies, while significantly reducing their greenhouse gas emissions during the inevitable transition from fossil fuels.

By one analysis, achieving a 550 parts per million (ppm) atmospheric carbon concentration implies that 30% of the necessary reduction in global carbon emissions by mid-century would be achieved via capture and sequestration alone (see Figure 5). Should carbon capture and sequestration fail to become viable on a massive scale in coming decades, compliance with the 550 ppm stabilization pathway will necessitate the early retirement of hundreds of coal-fired power plants. Technologies to mitigate the emissions of greenhouse gases other than carbon will also be essential. Since several of these greenhouse gases—especially the so-called "trace gases" have radiative forcing potentials that are orders of magnitude greater than carbon, incorporating them in climate change response strategies will be essential.

Several Forum participants felt strongly that hydrogen-based technologies are likely to emerge as the new, dominant energy technology class to power a post-fossil fuel world. Yet, hydrogen technologies still face high hurdles prior to their wide diffusion. The potential sources of hydrogen fuel vary, and alternative methods of hydrogen reforming have significantly different implications for carbon emissions. It is not yet clear which of these methods might emerge as the basis for a global hydrogen economy.

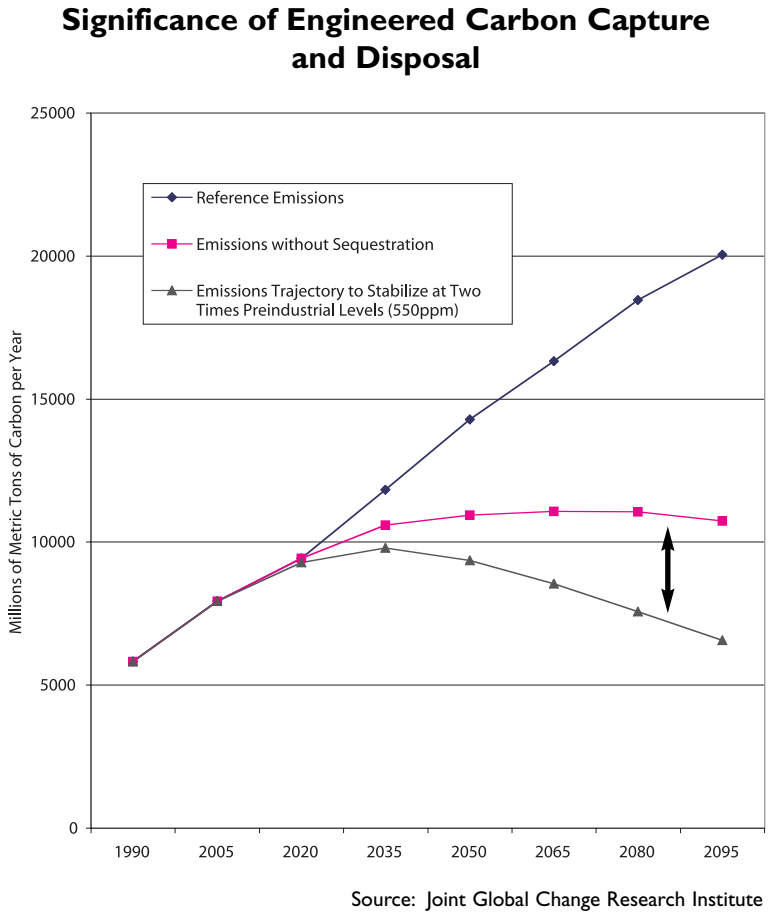
Figure 4

Geologic CO_2 Disposal



Breakthroughs can, of course, emerge in unexpected places. One vision of a hydrogen-based global energy future sees a hydrogen revolution emerging in the developing world, as growing energy giants such as China and India—which are still relatively unburdened by the legacy energy systems of the industrialized countries—embrace advanced technologies and "leap frog" the industrialized countries technologically. For instance, the faster diffusion of advanced technologies and processes such as fuel cells, in-situ extraction of methane, and reforming of hydrogen from coal and oil shales, could occur in developing countries and lead the global energy transition. While such a scenario is predicated on technological advances in OECD countries—such as the development of an inexpensive and widely-available "fuel in a box" to power fuel cells for transportation use—these advances may be closer to reality than most people now realize.

Figure 5



Source: Joint Global Change Research Institute

The area between the two lower curves represents the potential contribution that engineered carbon sequestion can make to addressing climate change. In a 550 ppm stabilization scenario, carbon capture and sequestration could account for fully 30% of all emission reductions below "business as usual" by the end of the century.

Because hydrogen systems may not be deployed quickly, policymakers might encourage other technology classes, such as renewables, to fuel an interim transition from fossil fuels. For example, some analysts envision a renewables revolution beginning with a policy push to improve existing renewables technologies (chiefly

wind, solar and related storage technologies) and deploy them widely for power generation. Associated advances in biotechnology, materials, and vehicle efficiency could also pave the way for breakthroughs enabling a smooth transition from fossil energy to liquid biofuels (e.g. cellulosic ethanol) for the transportation fleet. Considering that China and India alone are likely to add more than 300 million new vehicles to the global fleet by 2020, biofuels could play an indispensable role in forestalling growth in emissions of local air pollutants and greenhouse gases.

In any case, global population growth, rising energy consumption, and increasing demands for higher living standards intensify the need for a global energy transition away from the dominance of fossil fuels. While this does not necessarily imply an end to fossil fuel use, it does suggest that the conventional use of fossil fuels and free venting of greenhouse gases to the atmosphere must end in the interest of global sustainability. While technology holds a key to such a transformation of the global energy system, both governments and the energy industries have been slow to see the strategic importance of energy R&D to the long-term habitability of the earth—and, in looking over the horizon, to recognize their joint responsibility for action to catalyze technological change.

Session II: The Geopolitics of Energy

Each of the energy crises of the past thirty years has prompted U.S. policymakers to issue calls for lower dependence on foreign oil and greater energy self-sufficiency overall. In response to the 1973-74 oil shock, for example, President Nixon unveiled Project Independence, the goal of which was complete energy independence for the U.S. within one decade. During the 1979 oil shock, President Carter declared that the U.S. response to the interruption Persian Gulf oil should be the "moral equivalent of war," and issued another call for energy self-reliance. More recently, the 1991 Persian Gulf War prompted policymakers to call for greater energy—and political—independence from the volatile Middle East. Yet, despite the many oil crises and impassioned policy responses to the problem of energy import dependence, the U.S. today relies on foreign oil, from the Persian Gulf and elsewhere, more than ever before.

Energy crises, despite the economic harm they have caused, have had some unexpected benefits as well. Since the market distortions caused by oil and gas price controls loomed larger as prices rose, the process of decontrol began in the late 1970s and was completed in the 1980s. Similarly, the crises of the 1970s forced a major rethinking of the assumption that energy prices and demand were both inelastic in the long run; most analysts anticipated that, as gas and oil prices rose, people would have no choice but to continue to buy and use them at the same rate as they had previously. Most analysts

also assumed that the world would soon run out of economically recoverable natural gas, since global reserves had been steadily dwindling for some time. Yet, in the middle run, high energy prices prompted both decreases in energy consumption as the economy became more efficient, and major new oil and gas discoveries. Today, energy is cheaper and more abundant than ever. As one Forum participant noted, hindsight shows that energy policy projections beyond the five year horizon have proven to be little more than expressions of analysts' and policymakers' faith.

While several energy barriers have been surmounted over the past thirty years, another major surprise event—the advent of global climate change—has erected what may be the highest barrier yet. Where the concentration of oil reserves in the Middle East and high world prices had once been the world's chronic energy ailments, oil abundance and low prices were being recognized as potentially even greater threats to global security in the light of climate change concerns. Although continued dependence on the Persian Gulf is still a major problem for importing countries, dependence on fossil fuels now entails dangerous global environmental risks as well.

The second session of the 2002 Energy Policy Forum addressed several dimensions of continuing dependence on petroleum and its implications for U.S. policy and security. As the following discussion shows, the risks, potential for surprises, and difficulties of system change in the energy realm may be evolving in important ways, demanding new and sustained attention from policymakers.

Evolving Risks of Persian Gulf Oil Import Dependence

Since world energy production and energy markets are far more diversified now than they were in the 1970s, the potential for supply disruptions originating in the Persian Gulf could be smaller than before, in the opinion of some analysts. As non-OPEC oil producers have steadily increased output and market share, OPEC itself has grown increasingly fractious and undisciplined, as evidenced by major world oil price collapses in 1986 and 1999. Although Saudi

Arabia and Venezuela ultimately succeeded in coercing the cartel into significant production cuts in 1999 after the price collapse, sharply divergent political interests among OPEC countries continues to make cooperation among its member states increasingly difficult to achieve. The cartel's share of the world oil market has been flat at roughly 28 million barrels per day for several years, while that of non-OPEC countries has grown steadily.

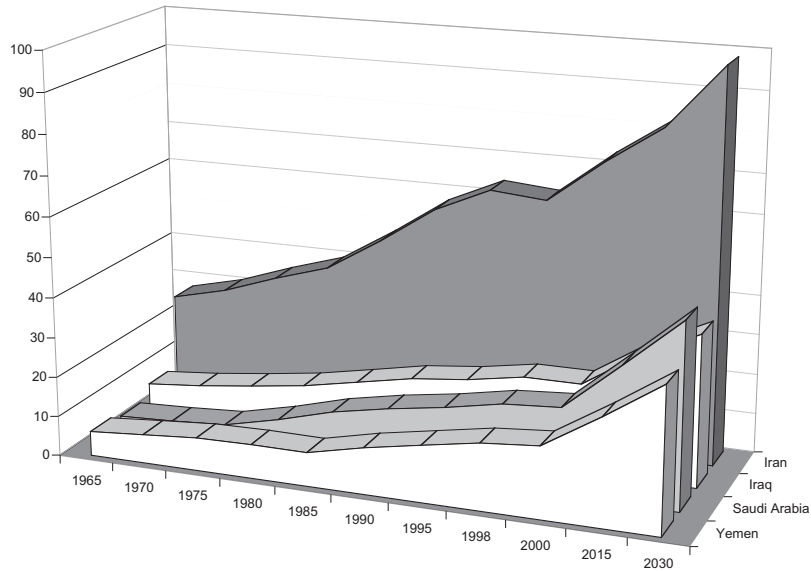
Although OPEC may now have less market power and less internal cohesion than it has in the past, a few Persian Gulf producers still sit atop the majority of world oil reserves and have the potential to use the "oil weapon" against the world. Saudi Arabia wields a particularly formidable weapon in its 3 million barrels per day (mbd) of excess production capacity, which it could use at its discretion to reduce world market prices. More problematic for importing countries and the world economy, however, is Saudi Arabia's routine 7 mbd production, the interruption of which would significantly raise world oil prices. Other Gulf countries have smaller but significant shares of the world export market. The replacement of that much oil from other sources would be a difficult task and one that would entail protracted adjustment in the world economy. Moreover, since the global economy has become increasingly integrated in recent decades, no country has the ability to insulate itself fully from the disruptive power of oil supply shocks. Thus, policymakers in the U.S. and other Western countries continue to fear the oil weapon for good reason.

Despite OPEC's apparently diminishing market power, it is also important that policymakers deepen their understanding of the changing conditions in several key Persian Gulf countries, since these changes are creating major new policy risks and uncertainties for the U.S. and its allies. For example, the Gulf states are in the midst of a population explosion that places growing strains on government services and institutional capacity. In many countries, declining real oil prices have diminished government coffers significantly, given the Gulf countries' almost exclusive dependence on oil revenues. The lack of economic diversification in the region also suggests that the employment of its rapidly growing population will

Figure 6

Living in a Crowded Desert: Population Growth in the Major Gulf Countries

(Population in Millions)



	1965	1975	1985	1995	2000	2015	2030
Yemen	6.1	8.3	8.4	14.1	17.8	26.6	36
Saudi Arabia	4.8	6.2	13.2	18	21.7	33.7	46
Iraq	8.2	11.1	15.7	19.9	22.3	31.3	38
Iran	26.8	34.9	47.6	63.1	72.7	82.1	98

Adapted by Anthony H. Cordesman from data provided by the U.S. State Department and the World Bank database for World Development Indicators, 2000, pp. 40 and 44.

be a major social and political problem in the future. Most governments have thus far done little, however, to increase non-petroleum foreign investment in the region and also are among the least democratic and least transparent regimes in the world.

Beyond the general risks to long-term political stability posed by demographic trends, there are other emerging risks associated with

specific religious and political groups in the Persian Gulf. Any of these groups has the potential to disrupt world energy markets through terrorist activity within the region. For example, the extremist Shia, based in Iran, have been a destabilizing influence since the Iranian Revolution of 1979. They and their Hezbollah proxies still present serious threats to several governments including Saudi Arabia, Kuwait, and Israel.

Iraq also presents a real and enduring threat to U.S. and Western interests. Saddam Hussein considers himself at war with the U.S., Saudi Arabia, and Kuwait, and continues to develop weapons of mass destruction, presumably for use against these enemies. In the opinions of several Forum participants, the U.S. will soon be involved in another war with Iraq. War with Iraq will mean the removal of several million barrels per day from the world oil market for an indeterminate period of time, and its replacement will place enormous strains on other major producers around the world. Moreover, many other OPEC countries in the region would welcome the short-term higher prices resulting from such a crisis and could be reluctant to ramp up production significantly to keep prices low for consumers.

Extremist Sunni Muslims, particularly segments of Saudi Arabia's Wahabi, also present a significant and complex security risk. According to one Forum participant, as the number and influence of fundamentalist Wahabis grew, the Saudi government entered into a Faustian bargain by effectively buying its way out of direct political confrontation. Under this implicit arrangement, the Saudi royal family was able to remain in power, and extremist Wahabis were able to gain control of the Saudi educational system and of several religious institutions, using them for the systematic spread of an extremist interpretation of Islam. The West and its key allies in the Middle East, such as Egypt and Israel, have been the primary targets of their virulent message.

Forum participants emphasized that extremists, and not Islam itself, are a radicalizing influence in the region. Yet, the wealth and increasing reach of many groups and individuals with extremist

views, in conjunction with the absence of democratic institutions in the Gulf, create conditions for the further radicalization of the region. However, as one observer noted, it is not political oppression and poverty that have produced terrorists in the Gulf states, but wealth, privilege, and education. Thus, the West must do a better job of understanding why things have gone wrong and aim to address root causes of the problem, rather than simply attempting to "disarm" the oil weapon. As the events of September 11, 2001 showed, radicalization of the region presents security risks beyond those associated with energy supply.

Risks of Energy Import Dependence: Factors Beyond the Persian Gulf

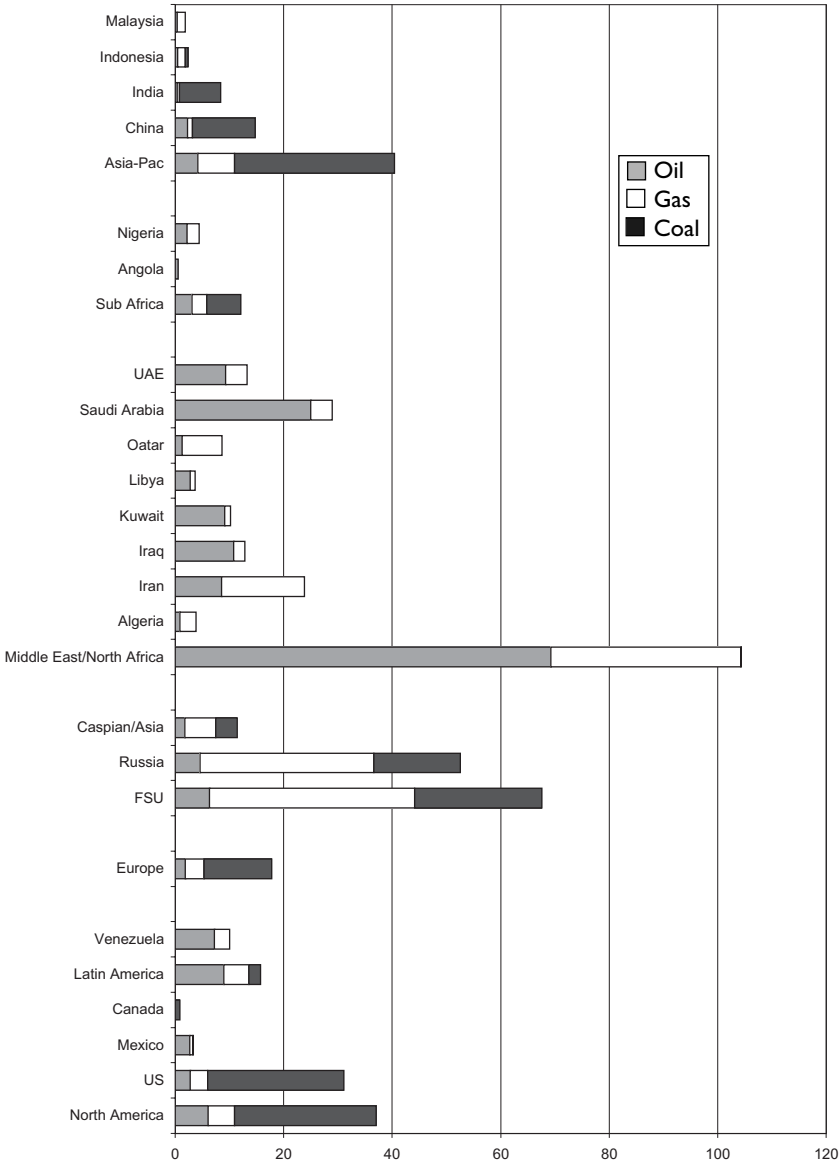
While the best-recognized risks of energy dependence are those associated with rising imports from the Persian Gulf, these are only a few of the myriad energy risk factors now confronting the U.S. and the world. Energy policy must address several other important non-Middle East risks that broaden the potential exposure to unpleasant future surprises.

One important and largely unrecognized risk arises from the inherent shortcomings of the modeling and analytical tools on which the U.S. government bases its energy analyses. These models, developed by the Energy Information Administration in the late 1970s and early 1980s, are incapable of incorporating several critical sensitivities and decision factors that directly affect world energy, such as demographic and economic trends in the Middle East and other key regions, and environmental impacts of energy use. They also frequently make unreasonable assumptions about the future development of vital infrastructure such as pipelines, refineries, and ports that could make major geopolitical differences in the energy outlook. These outdated tools cloud U.S. energy and foreign policy analysis and need to be replaced with more sophisticated ones that reflect the complexity of today's world. Despite such serious shortcomings, which are well known to many analysts and policymakers, these tools continue to furnish many of the analytical building blocks on which U.S. energy policy is built.

Figure 7

Strategic Influence and Energy: Who Has the World's Energy Reserves?

(Percent of Proven World Reserves)



Source: BP Statistical Review of World Energy, June 2001; Anthony H. Cordesman.

Other non-Middle East risks stem from security and political risks in other regions, including the Caspian Basin, Latin America, and West Africa, where simmering political conflicts could disrupt world energy markets, even if only for a short period of time. This conflict potential may be larger than most policymakers in the West realize. In most oil-producing countries of the developing world, oil has been a mixed blessing, since it has enriched the elites but failed to lift the general population and the economy as a whole. As populations continue to grow in oil-producing countries such as Nigeria, Colombia, and Angola, the widening gap between rich and poor and the failure of oil revenues to improve the lot of the general population raise the possibility of future social and political conflict.

Another potential risk arises from the projected growth of energy demand in Asia. Asian demand growth could tighten oil and gas markets over the long-term and heighten tensions between East and West, as the Chinese and other Asian governments now anticipate. In conjunction with the global proliferation of smart weapons and other advanced military hardware in the region, growing competition for energy resources could heighten the potential for political and military conflict that policymakers must at least contemplate, if not anticipate. Moreover, the West must also recognize that it now receives massive indirect energy imports from the Persian Gulf via Asia, embedded in traded manufactured goods. These imports also broaden the potential exposure to, and implications of, future energy supply interruptions, irrespective of the level of direct U.S. oil imports from the Gulf.

Responding to Import Dependence Risks

Western countries are not powerless in the face of the enduring security risks of oil import dependence. Seeking energy independence, however, would be neither a feasible nor desirable policy goal, especially since world oil markets are more diversified today than in the past. Some participants argued that a strategic policy aim should be to continue this supply diversification, for example by boosting Russian oil production capacity to a level in excess of 10 mbd. Since

the European Union (E.U.) is a more natural market for Russian oil and gas production than the U.S., coordinating with the E.U. to leverage European investment and political support to this end will be especially important. In addition to broadening world oil supply, Western investment in Russia would send a political signal of one kind to Gulf producers and of another to the Russian government, in effect rewarding it for having cast its lot with the West in recent years. Such investment could simultaneously serve Russian economic policy and U.S. strategic interest. In the short- to medium-term, the U.S. and other oil importing countries should build up their strategic petroleum reserves and agree on a joint plan for their use. At the same time, non-OPEC producing countries, such as Mexico, Russia, and Brazil, should be encouraged to build up their own reserves for sale in the event of a major supply interruption.

While almost all Forum participants agreed that strategic energy reserves must be a central component of future energy policy, several participants disagreed on the question of their appropriate use. Some felt that strategic reserves should be used as a tool to help stabilize world oil prices within a specific range (e.g., $18-$22). During periods of low prices, supplies would be bought to fill strategic stocks and boost prices; conversely, reserves would be released to reduce prices should they climb above desired levels. In addition to softening the impacts of volatile prices on the U.S. and other consuming countries, use of strategic reserves in this manner would also help to preserve world oil supply diversity, by stabilizing producing countries most affected by low prices. Other participants argued, however, that markets themselves are the appropriate tools for short-term price management and that strategic reserves should be used only in the case of a prolonged supply interruption.

Despite this divergence of views, all agreed that U.S. strategic oil reserves should be augmented. On the other hand, attempting to increase domestic production would be an inadequate strategy. Since the U.S. is a mature oil province, additional production, either from existing fields or new ones such as those under the Arctic National Wildlife Refuge, would only slow the increase in import levels and would make little difference in the country's strategic sit-

uation. Greater energy supply diversity and more aggressive efforts to improve energy efficiency—rather than energy independence—are appropriate mid-term goals for U.S. energy policy. In the long term, developing non-petroleum transportation fuel systems would be the most effective response to the economic vulnerability that results from the world's heavy dependence on oil.

Session III: Reducing the Reliance on Oil

Reliance on oil presents policymakers with a broad array of risks and opportunities. The creation of sound policies, however, must be based on a thorough understanding of the problem of dependence, a term which is often used only in reference to oil imports. While the level and origin of imports are factors, U.S. dependence on oil, whether domestic or imported, is the cause of our vulnerability. As long as the oil market is a world market and the rest of the world relies heavily on oil imported from a small number of politically volatile nations, the U.S. economy is at risk.. Even though energy independence may not be a reasonable policy objective, aiming to reduce overall reliance on oil would be a policy course that could serve energy, environmental, and security goals simultaneously. Session III addressed several dimensions of the oil dependence problem and focused on fiscal, regulatory, and technology options that might be adopted to reduce the nation's vulnerability and increase its resilience.

Dependence is not strictly a question of oil imports, but rather a condition arising from several factors, including the large concentration of world oil reserves in a few countries, the importance of oil to the world economy, and the lack of short-run substitutes for oil.

The concentration of the majority of world oil reserves in a handful of OPEC countries presents many well-known security risks to importing countries. However, it is important to recognize that

OPEC's monopoly is imperfect; while the cartel has price power, it does not completely dominate the world market. OPEC's market power is a function of three factors: 1) the price elasticity of demand, a reflection of the economy's ability to use oil more efficiently or switch to alternative fuels; 2) the cartel's share of world oil production; and 3) the price elasticity of supply, reflected in non-OPEC producers' ability to increase production in response to the cartel's actions.

Taken together, these three factors indicate how far the cartel can go in cutting back production and driving prices up to maximize revenues. History has shown, for example, that the cartel has far greater opportunities to affect world prices in the short run, since the price elasticity of oil demand grows by an order of magnitude in the longer run. For example, after the 1973 and 1979 oil crises, OPEC's revenues and world oil prices both rose sharply and cartel members reaped windfall profits for several years. Over the course of the following decade, however, OPEC market share declined as high prices brought new supplies into the market. Moreover, the price elasticity of demand proved higher in the longer run, as consumers gradually deployed new technologies and switched to natural gas and other fuels in response to high oil prices. Ultimately, world market prices collapsed in the mid-1980s in response to Saudi Arabia's decision to abandon OPEC production limits and restore its market share, reducing the oil revenues of most producing countries. Effective collusion among producers has not been sustainable in the long run.

Of course, the fact that cartel behavior is untenable in the long run does not soften the short run harm that can be caused by producers' manipulations of market prices or supply disruptions such as the loss of Kuwait's production following the invasion by Iraq. In this regard, oil dependence has the enduring potential to inflict serious economic harm on consuming countries in several ways. Most obviously, dependence creates conditions for enormous transfers of wealth from importing to exporting countries. This ongoing wealth transfer also amounts to a loss of potential gross domestic product (GDP) for importing countries. A high level of oil dependence also sustains the potential for macroeconomic dislocation among con-

suming countries, since price shocks throw economies out of equilibrium and often result in protracted readjustment. By one estimate, oil price shocks have cost the U.S. economy approximately $7 trillion—one year of current U.S. GDP—since 1970.

Assessing U.S. Oil Dependence

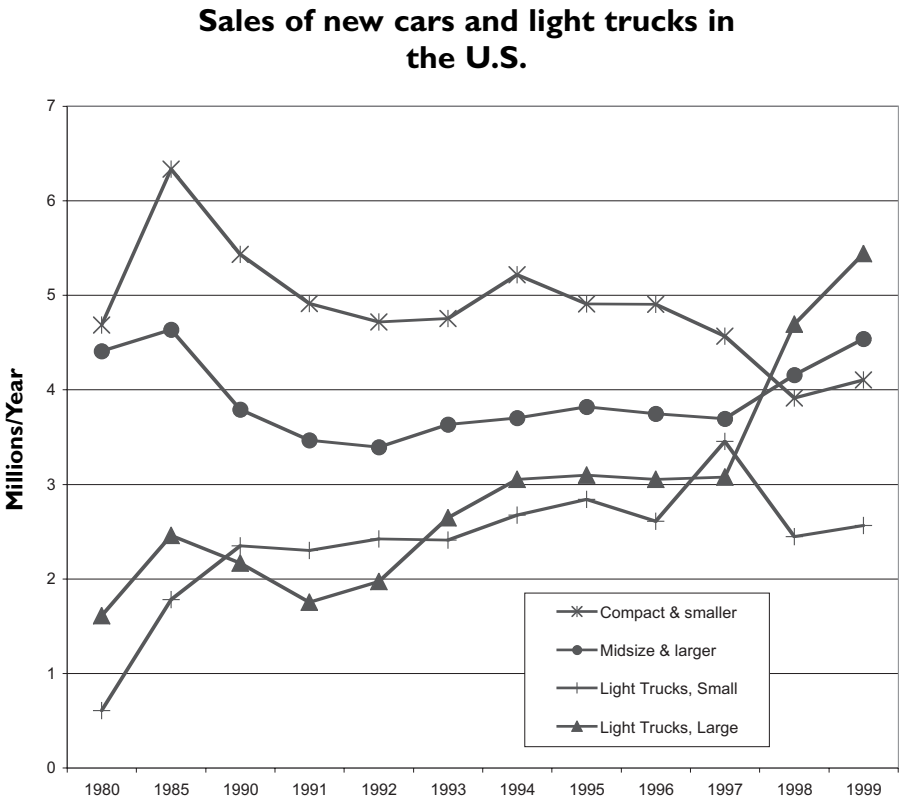
A few statistics can help to quantify U.S. oil dependence. Since 1980, the U.S. has consumed 5 quarts of gasoline per capita per day and, in total, the nation is now consuming roughly 20 million barrels per day (mbd) of oil—25% of daily world production. The U.S. now imports approximately 11 mbd, or 55% of its oil supply.

The transportation sector accounts for 66% of the oil consumed in the U.S., meaning that approximately 16% of world oil production is needed to fuel the U.S. auto fleet. Despite the high levels of U.S. oil dependence and consumption, the average efficiency of the U.S. car fleet has been declining over the past decade, and last year fell below 24 miles per gallon for the first time since the early 1970s. Driving this trend is the overwhelming popularity of light trucks and, especially, sport utility vehicles, which, despite significant efficiency improvements, still have lower average efficiencies than passenger cars. Over the past twenty years, both numbers and sales value of compact cars have declined continually, while those of light trucks have risen (see Figure 8).

Moreover, the number of vehicles on U.S. roads and the number of vehicle miles traveled have grown steadily. These factors, in conjunction with higher demand arising from declining real gasoline prices, have offset some of the previous improvements in U.S. fleet efficiency and led to even higher levels of oil dependence.

Another factor that has contributed to U.S. oil dependence is the decoupling of income level from gasoline consumption rates. While vehicle miles traveled had historically been linked closely with income, that correlation began to break down in the mid-1970s. Americans now spend an average of 2% of their annual income on gasoline—much less than they have at any time since the 1960s.

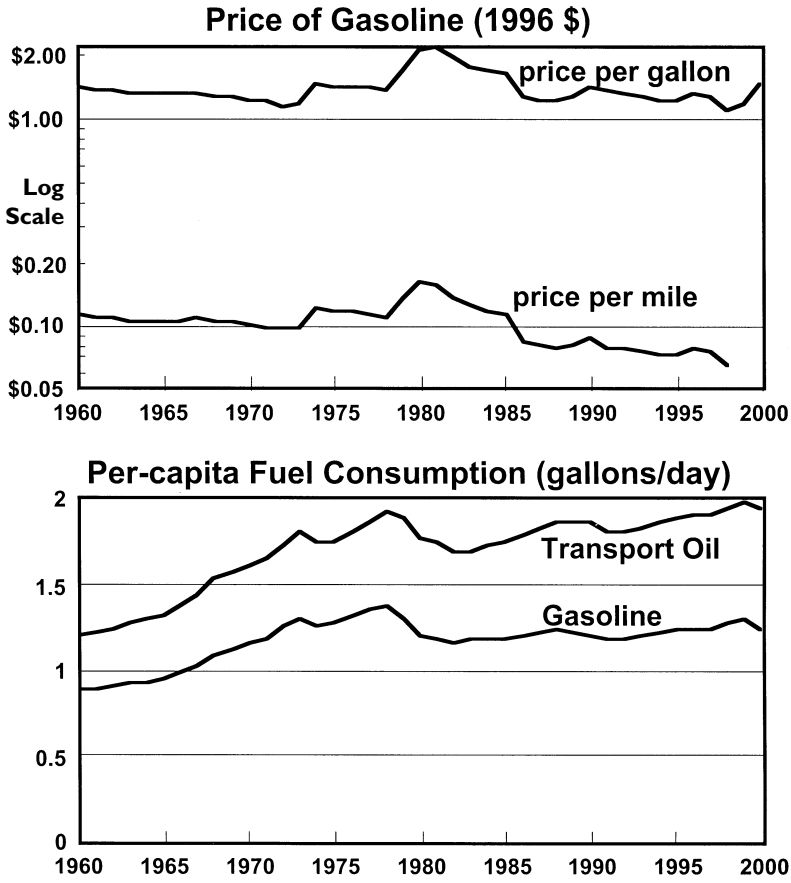
Figure 8



Source: National Transportation Statistics 2000, Tables 1-17 & 1-18; Dermot Gately.

Historically, rises in gasoline price have had little impact on the number of vehicle miles traveled in the U.S. in the short run, given low short-term demand elasticity. Even in the longer run, however, sustained higher prices have led only to marginal demand reductions. Population growth and increasing affluence in the U.S. have played a key role in buoying total vehicle miles traveled. Perhaps more surprising, however, is the fact that oil demand has not grown significantly when prices have declined. Thus, fuel efficiency of U.S. cars is unlikely to be affected much by gasoline prices alone (see Figure 9). Improvements in fleet efficiency and corresponding reductions in oil dependence are more likely to occur as a result of policy measures such as new corporate average fuel efficiency (CAFE) standards.

Figure 9



Source: Adapted by Dermot Gately from U.S. Department of Energy data.

Reducing Oil Dependence

Many Forum participants envisioned the coming of a hydrogen-based economy, while others suggested that renewable energy technologies, including biomass systems, could gain a greater share of the automotive fuel market in coming decades, with appropriate market and policy signals. In any case, policy will have a central role to play in spurring the development of alternative fuels and energy technologies, since fossil fuels are likely to remain cheaper than renewable energy sources for the foreseeable future.

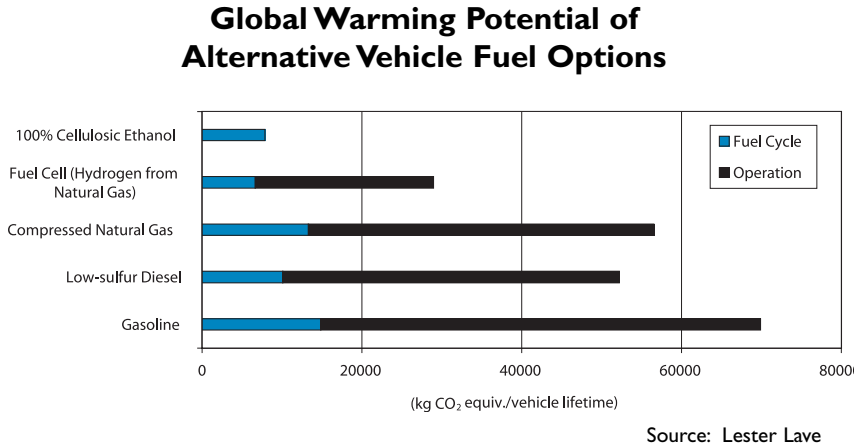
Energy taxes, tax credits, and regulations, for example, could be used in the U.S. as they have been in Europe to encourage higher levels of energy efficiency and conservation, and to promote the manufacture and purchase of non-petroleum fueled vehicles or, in the short run, hybrid electric vehicles. While hybrids have sold relatively well in the U.S. and state-level incentive programs have been successful, federal policies and incentives could greatly enhance the prospects for hybrid vehicle sales and related energy efficiency gains.

Many Forum participants felt that federal policy programs have an especially important role to play in encouraging higher automotive fleet efficiency. A revision of the CAFE program that included tougher average fuel economy targets and standards based on vehicle weight up to a certain level could help to give both auto producers and buyers incentives to favor more efficient vehicles. Since manufacturers need several years to implement more stringent standards, new CAFE standards should be adopted as soon as possible but should include adequate lead time. Also, a system of credits that could be traded either across vehicle classes or between auto producers could help to improve overall fleet efficiency at the lowest cost. However, energy efficiency remains hard to sell to auto producers, who note that efficient cars are slow sellers, especially when gasoline is cheap; at the same time, many consumers still associate energy efficient products with lower performance, comfort, or reliability. Thus, the current culture of inefficiency in the U.S. plays a prominent role in sustaining oil dependence.

Other Forum participants argued that renewable energy technologies offer even more promising avenues to lower oil dependence and better environmental quality. For example, biofuels such as ethanol could be produced domestically and have near-zero net emissions of carbon and other greenhouse gases associated with fossil fuels.

The U.S. already produces significant amounts of ethanol (approximately 1.5 billion gallons annually), which is currently made almost entirely from surplus corn. Lignocellulosic production—using fuel crops such as switch grass and plantation-grown

Figure 10



Source: Lester Lave

poplar trees rather than surplus food crops—could significantly improve both the economic and the environmental characteristics of ethanol production. Fuel crops have higher yield per acre than corn, require fewer inputs, and could also offer an alternative to farmers who are currently paid by the government to grow large quantities of corn that cannot be consumed.

One participant argued that, using lignocellulosic production, the U.S. could theoretically produce enough ethanol to fuel the country's entire light duty automotive fleet. For example, it was postulated that replacing the 130 billion gallons of gasoline annually consumed in the U.S. would require approximately 300-500 million acres of crop land; the lower 48 states have approximately 1800 million acres of crop land. In theory, current world consumption of gasoline could be replaced entirely by ethanol produced by four western countries alone: the U.S., Canada, Brazil, and Argentina.

Developing the necessary infrastructure—production facilities, distribution systems, and retail stations—for large-scale ethanol production, however, would demand some $900 billion of investment capital over a decade. While the cost of today's corn-based ethanol is approximately twice that of gasoline, some energy analysts believe that the large-scale production of ethanol from fuel crops, in

conjunction with ongoing improvements in biotechnology, could reduce the cost of ethanol to somewhere between $0.68-$1.12 per gallon of gasoline equivalent.

Whether or not large-scale biofuel production takes root in the U.S., one participant suggested that industrialized countries might consider the development of biofuels in some developing country markets. Of course the capital costs to develop such biofuels capacity must also be addressed. Wider use of biofuels in these areas, where energy demand is growing fastest, could help to stabilize world oil markets, address local and global environmental problems, and reduce global oil dependence in the long-term.

Session IV: Creating a Resilient Electricity Sector

The transition from regulation to competition in the electric power industry has been more protracted and more fraught with uncertainty than many analysts anticipated a decade ago. The introduction of competition has brought unanticipated surprises, such as the California energy crisis and the rapid rise and sudden decline of major energy trading companies. Equally important in the long term may be the sharp decline in energy research and development investments that has accelerated as a result of industry restructuring. Congress' failure over the past decade to pass comprehensive restructuring legislation establishing "rules of the road" and smoothing the way to competition has also surprised many analysts and industry leaders and sustained a climate of uncertainty.

Because of the many problems and uncertainties that have beset the U.S. electric power industry in recent years, enhancing its resilience is an urgent challenge requiring the coordinated action of industry and government officials. Compounding these problems is the rising threat of terrorism, which underscores the vulnerability of large, networked systems. In the light of these challenges, Session IV of the Energy Policy Forum addressed the issues of competition and resilience in the industry, and aimed to identify ways of improving its long-term strength and stability.

Making Competition Work in Electricity

According to some Forum participants, in order to create a well-functioning, competitive power industry in the U.S., it will first be necessary to assess and understand what has gone wrong with it over the past decade. A primary problem from this perspective is the existence of 51 separate jurisdictions for electricity in the U.S., which creates great inefficiencies and confusion in the power industry. This suggests that greater federal government jurisdiction may be a necessary condition for both stability and competition. The lack of a national vision and road map for the industry has also helped to perpetuate chaotic conditions out of which recent crises have grown. While the Federal Energy Regulatory Commission (FERC) has articulated a vision that could help to remedy this situation, it may not have the political or staff resources to see its vision implemented.

While the power industry is truly competitive in a handful of large states, in the rest of the country, no single state has the ability to create a competitive power market on its own. Cooperation among states is necessary to create markets large enough to be competitive, yet states often regard such collaboration as contrary to their interests. Thus, the federal government has a key role to play in integrating markets across state boundaries to ensure that all consumers have full access to the competitive electricity marketplace.

To create a more competitive and resilient power industry in the U.S., several major changes may need to occur, including the enhancement of demand responsiveness. The most effective way to achieve this goal might be through better metering and hourly pricing of electricity, which some consider the best form of demand side management. In addition to promoting conservation, metering and hourly pricing give consumers greater control over their electric bills and can effectively limit prices. Had better metering and hourly pricing been in place, the California energy crisis might not have occurred or been so severe. In addition, incentives for higher levels of energy efficiency must be built into market structures. Currently, Oregon is the only U.S. state that provides equal incentives in its rate structure for energy efficiency and supply expansion investments.

Also, power trading arrangements must reflect the fact that electricity is different from other forms of energy. For example, the fact that electrons move at the speed of light creates the need for regional system operators to schedule and dispatch power. Similarly, the inability to store electricity necessitates the integration of imbalances with the spot market, while congestion management and other ancillary services must also be integrated with energy markets.

Some participants argued that competition in electricity would also be improved by the separation of the transmission and generation businesses, and the creation of regional transcos and independent system operators. New transmission regulations will also be necessary to resolve important questions about rates of return, physical transmission rights, and congestion charges. Some Forum participants also felt that all players in the power industry—including municipal utilities and the federal government, which now owns 25% of transmission assets in the U.S.—must be subject to new regulations, if there is to be a competitive, national electricity industry.

Congestion is a key problem that some participants felt would best be resolved by enlarging power markets and increasing the number of suppliers, perhaps by requiring the division of existing firms into more and smaller companies. In any case, a well functioning market will enable smaller firms to thrive. Some participants felt that the elimination of physical transmission rights and the use of financial transmission rights would make the market more competitive.

Once major problems in the generation and transmission businesses have been resolved, the question of retail access can be addressed. In order to serve millions of U.S. consumers, the industry will need new settlement software and will need to find new and innovative ways of educating the public about retail competition. The U.S. public is not well-informed about electricity deregulation. Reaching the many consumers who prefer to take no action and simply stay with their default provider will be a key challenge for the industry.

In sum, creating a competitive power industry in the U.S. requires three bold steps. First, there must be a national plan and road map to reduce confusion and help all firms to move toward a common vision for the industry. Second, regulators and firms must accept the need to restructure companies in order to create the conditions of competition. Finally, there must be recognition that jurisdictional boundaries in the U.S. may not remain where they are today, and in some case, jurisdictional authority may have to move toward Washington.

FERC's Role in Creating Competitive and Resilient Power Markets

Even though there have been crises over the past few years, the competitive agenda has continued to move ahead in the U.S. FERC has been working to advance competition in the power industry and to transform itself and its role for the new environment. The Commission is striving to become more flexible and analytical in its approach to regulation, and to engage itself in an ongoing dialogue with the industry and state regulatory commissions as restructuring proceeds.

FERC has an especially important role to play in ensuring that markets are structured to work, which is the key to stability and certainty for consumers. Well-functioning, competitive markets do not emerge full-blown on their own and require the efforts of policymakers and regulators to establish the structures and "rules of the road." For example, FERC is working to design and implement new interconnection standards to better integrate power markets in different regions, and to update and expand infrastructure. An important task for several state and federal agencies will be the removal of regulatory barriers to new technologies that have the potential to greatly improve both the nation's electricity infrastructure and the industry's overall environmental performance. (Editor's note: FERC unveiled its new standard market design shortly after the Forum, at the end of July, 2002.)

FERC is supporting the development of regional transmission organizations (RTOs) based on natural markets and reliability prin-

ciples. There has been some resistance to RTOs, particularly in the western U.S., where, for example, some states want to preserve their own cheap hydropower and none is anxious to integrate itself in an RTO with California. Yet, as markets grow more competitive, it will become too costly not to have regionalized transmission.

Market monitoring and enforcement will be an enduring function for FERC, especially as the rules and regulations governing electricity will evolve significantly incoming years. As these rules change, FERC will have to change its perception of its oversight role and learn to step aside when markets are working well.

Networked systems such as electric power must also be safeguarded against the risk of terrorism. Since that risk may be greater now than ever before, FERC and other government agencies face the additional and difficult task of working with asset owners to secure an enormously complex system from attack by determined and patient enemies. While nuclear power plants are a major security concern, there are many other points of vulnerability as well. In Oregon, for example, a man with a bolt cutter succeeded in toppling a transmission tower and interrupting service to thousands of consumers. Likewise, one participant noted that the sabotage of a single substation could interrupt power to thousands of customers for as long as six weeks, considering the long lead times for replacement of transformers, all of which are now manufactured outside the U.S. Thus, responding to the challenges of system vulnerability in addition to those of the competitive market will require not only an evolution of the power infrastructure, but of the institutional culture of FERC, state regulatory agencies, and the industry itself.

Investment Challenges for the Power Industry

Underinvestment in the electric power industry is a serious and often overlooked challenge that could derail competition. Clearly, if investors do not put sufficient capital into the industry, consumers will not enjoy all of the benefits that well-functioning, modern markets can bring.

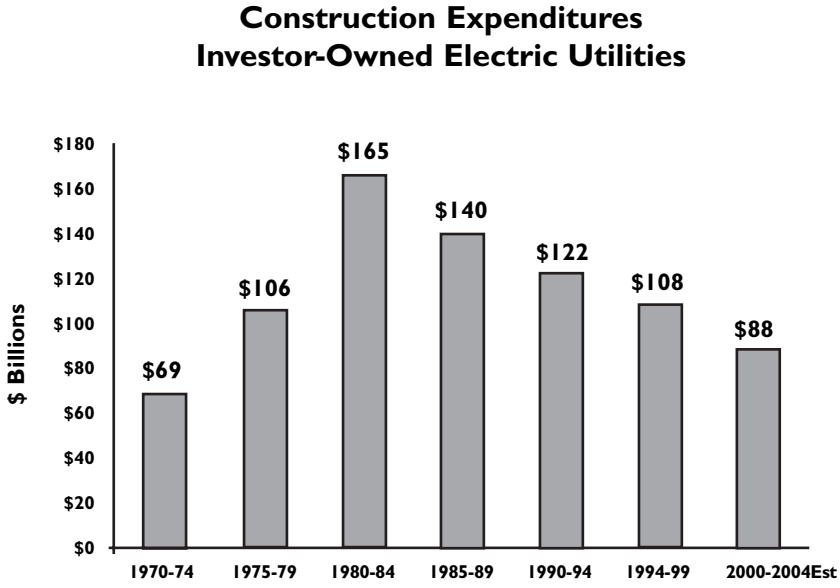
There are a few high priority issues that need to be addressed with regard to the industry's investment challenges. First, there are significant infrastructure build-out requirements, yet capital is still leaving the industry and many companies are under financial duress. Investor exodus has been a chronic problem since the mid-1980s and this trend has accelerated recently. Considering the ongoing crisis in investor confidence now affecting all sectors, the short-term outlook for energy is not especially bright. In 2002, many major energy companies have either postponed or cancelled construction projects already under way and several others are now trying to sell off assets to boost liquidity. Investment is further hampered by complex regulatory and legal requirements that lead to litigation, delay, and even denial of the necessary permits to build transmission and generation.

Since much of the needed new infrastructure has not yet been built, especially in the transmission business, creating competitive markets is more than a matter of market design. Solving the transmission bottleneck problem will be essential to true competition in the U.S., as will the replacement of generation stock that is grandfathered under current environmental regulations.

Yet, it is not yet clear where sufficient capital will be found to meet the major infrastructure needs of the power industry, especially since Wall Street, the insurance industry, and private equity firms are now reluctant to invest in the energy sector. Foreign utilities may be the most promising source of capital, since they are very focused on the power industry and have expressed interest in several U.S. utilities. Since European utilities are especially adept at operating in regulated environments, they may be the likely purchasers of regulated U.S. utility assets.

The largest energy trading companies in the U.S. are now greatly reducing their market exposure in response to the severe thrashing they have endured over the past year. As of July 2002, stock values of the top six energy traders ranged between 0% and 34% of their highest value of the past two years. Trading companies that have held on to regulated assets have fared better than pure trading companies, although even they have seen their stock prices fall by as much as 45% over the past two years.

Figure 10



Another key issue regarding adequate investment in the U.S. power industry is the question of business models. It is not clear which business models will survive under competition, nor is it certain how investors will show their preferences among the business models now in use. Zero dividend/high growth merchant energy companies, however, are all likely to disappear within the next three years, in the opinion of one Forum participant. Scale will continue to be essential to survival in the power industry.

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