

ENERGY: THE NEW NORMAL?

2006 Aspen Institute Energy Policy Forum
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Foreword

High energy prices, coupled with intensified fighting in the Middle East and broader acceptance of the need to act on global climate change, have suggested to many in the past year that the world of energy has changed. Others believe that world is still cyclical, and that what appears to be a new paradigm may just be the top of another cycle. The 2006 Aspen Energy Policy Forum considered which is more likely, exploring the question from various perspectives: policy drivers such as energy supply and demand, climate change, and geopolitics; the R&D and financing challenges of new technologies; demand reduction possibilities; and how various fuels are likely to fare as utilities make decisions on new generation capacity.

This 30th annual Forum also broke new ground by bringing to bear on energy policy considerations more of the thoughtful discussion of values that is central to the Aspen Institute's mission of fostering enlightened leadership. Small, half-day, readings-based seminars on *Values in a Global Village* and *Business and Social Responsibility* were led by experienced Institute moderators and focused the attention of Forum participants on some of the difficult aspects of leadership in today's world.

The rich dialogue that has characterized the Forum since its beginning in 1977 is based on interaction among people with diverse views trained in different disciplines. The multidimensional chal-

Challenges of energy policy require crosscutting approaches, and participants are challenged to avoid easy responses that draw on a single area of expertise. A not-for-attribution rule encourages candor and the exploration of new ideas, and the informal atmosphere and collegiality encourage respect for different opinions.

This year's Forum was chaired by Phil Sharp, President of Resources for the Future. His extensive experience with energy policy, anchored in his 14 years as chair of the U.S. House Subcommittee on Energy and Power, allowed him to bring focus and perspective to a broad topic. A highly qualified group of session chairs and speakers provided a wealth of information and contributed substantially to the richness of the dialogue. Their names are listed in the Forum Agenda that follows.

The Institute's Energy and Environment Program is grateful for 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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Greg Eyring served as rapporteur for the Forum, skillfully extracting the major themes and illustrative points from the excellent presentations and wide-ranging discussions. Katrin Thomas once again managed the administrative arrangements for the Forum with her pleasant efficiency.

This report is issued under the auspices of the Aspen Institute, and neither the speakers, nor participants, nor sponsors are responsible for its contents. It is an attempt to represent views expressed during the Forum, but all views expressed were not unanimous and participants were not asked to agree to the wording.

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Executive Director
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**ENERGY:
THE NEW NORMAL?**

Greg Eyring
Rapporteur

Energy: The New Normal?

The title of the 2006 Energy Policy Forum — *Energy: The New Normal?* — raises two primary questions: (1) has the world crossed a threshold into a qualitatively different energy environment in which the era of cheap and plentiful energy is over, and (2) does the interaction of energy issues with other considerations, such as national security, foreign affairs, and global climate change, require fundamentally new ways of thinking about U.S. energy policies?

Shortly after the conclusion of the Forum, the nominal price of oil reached an all-time high—over \$76 per barrel—and the U.S. national average price per gallon of gasoline was over \$3. Wholesale natural gas prices in the United States were above \$6 per million Btu, down from a recent peak of \$13 per MBtu in the Fall of 2005 but up from average levels of \$2 per MBtu that had held for more than a decade prior to 2002. Residential electricity prices also increased dramatically in most markets in the past year. These energy price increases were having an effect on Americans' daily lives—changing driving habits and reshuffling the budget priorities of many families and businesses. One recent survey indicated that one out of four residential customers isn't able to pay monthly utility bills on time.

Consumer anger over these higher energy bills has attracted the attention of elected officials, and many new proposals addressing energy issues are being debated in Congress and in state legislatures. If there is a silver lining in this energy picture, it is that the higher

prices are stimulating conservation and improved efficiency, investment in new technologies and new sources of energy supply, and renewed interest in energy policy.

The history of energy policy in the United States has been one of alternating periods of crisis and complacency. In the apt summary of one speaker, periods of complacency are characterized by a proliferation of SUVs, while periods of crisis are characterized by a proliferation of speeches. Skeptics of the ‘new normal’ view will note that this is the third or fourth energy ‘crisis’ the United States has experienced in the past 35 years, and that while the real prices of gasoline, electricity, and natural gas seem high today, they are actually a smaller fraction of U.S. personal disposable income than they were in the mid-1970s and early 1980s. Many government energy initiatives from that period—e.g., to reduce U.S. dependence on foreign oil through domestic development of synfuels, and to promote energy efficiency and renewable energy sources—largely fell by the wayside as fossil fuel prices dropped back near earlier levels. Indeed, many long-time Forum participants felt a strong sense of *déjà vu* as policy options for addressing energy challenges were discussed. Countless studies over the past several decades have made the same recommendations:

- Reduce fossil fuel emissions,
- Deploy non-fossil technologies in utility, industry, commercial, and residential sectors,
- Reduce the amount of oil used in the transportation sector, and
- Maintain or accelerate the rate of reduction of energy intensity in the economy.

So, what is really new? The problem is not that we don’t know what needs to be done or, in most cases, that we lack the appropriate technologies. Rather, the problem is that we have failed to develop a convincing business case for continued technology innovation in the private sector, and failed to adopt public policies to address

the long-term environmental and energy security consequences of our energy and development choices.

Truly fundamental changes in policy direction tend to come about as a result of dramatic events in which the public feels a genuine sense of threat or alarm. In the United States, such events have included the attacks on Pearl Harbor in 1941 and on New York City and Washington D.C. in September 2001. Forum participants generally agreed that no comparable sense of public alarm exists regarding energy issues. However, they felt that public concerns about rising energy prices have led to a ‘teachable moment’—an opportunity to educate both policymakers and the public regarding three major factors that, if not fundamentally new, are nevertheless shaping the landscape of our energy future in potentially threatening ways:

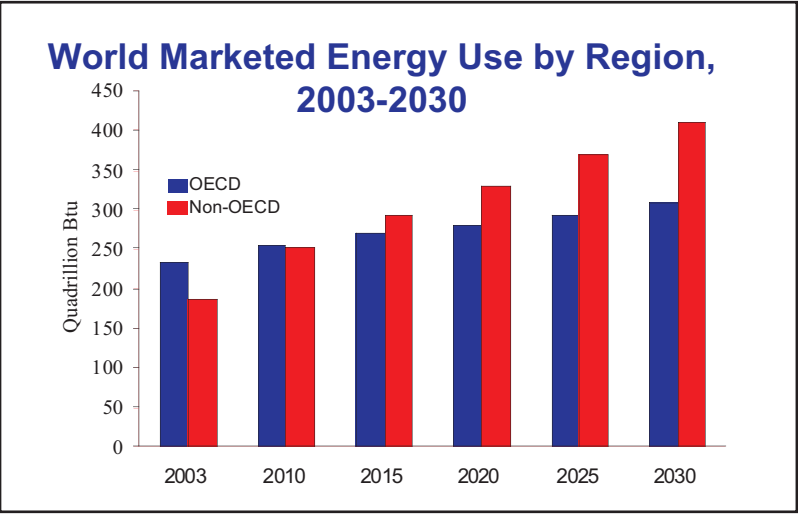
- Increasing demand for energy in developing as well as developed countries, in a world with increasingly global energy markets,
- New national security and foreign policy concerns, and
- New urgency of global climate consequences of fossil fuel use.

The Forum participants’ views on the implications of these three factors are discussed below, followed by a summary of their ideas for taking action.

Growing Demand Will Put Continued Pressure on Supplies

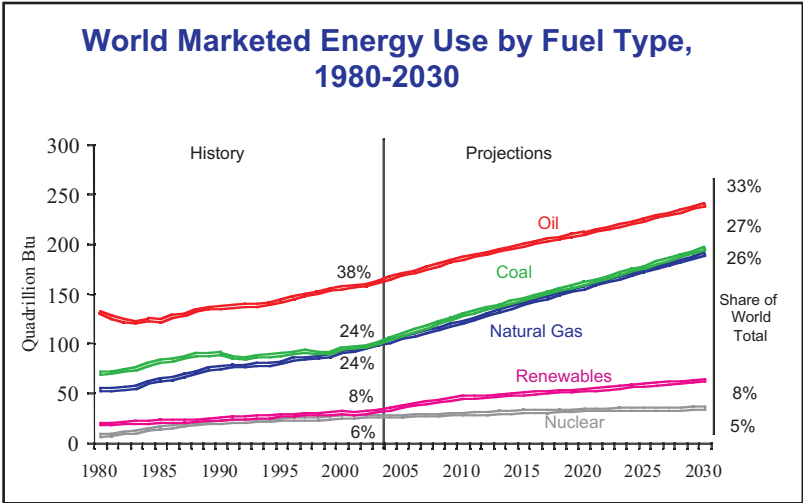
By 2050, the world’s population is projected to grow by about 40 percent to approximately 9 billion—up from 6.5 billion today. There is expected to be a tripling of the number of people in mega-cities, each with aspirations for clean water, clean air, utility services, and transportation.

Figure 1 shows the projected growth in marketed energy in the developed (OECD) and developing world through 2030. The growth rate in the developing world is higher, and energy use there begins to overtake that in the OECD countries after about 2010. This growing demand is expected to place pressure on sources of supply, lowering reserve margins and raising energy prices in the long term, though there may be short-term fluctuations.



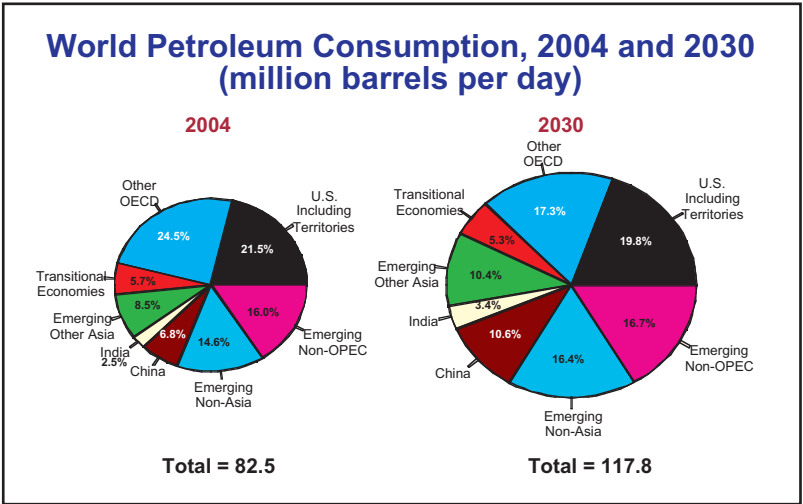
Source: EIA, International Energy Outlook 2006

Figure 1. Energy use is projected to increase in both the developed (OECD) and developing countries through 2030, with energy use in the developing countries overtaking that in OECD countries after about 2010.



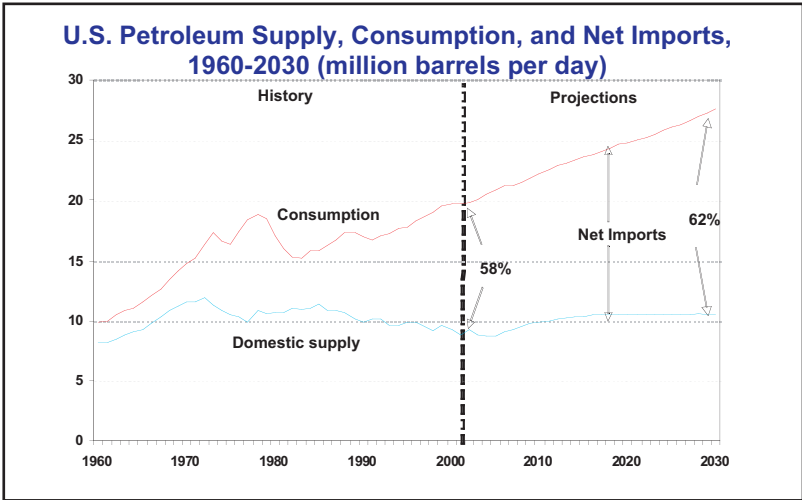
Source: EIA, International Energy Outlook 2006

Figure 2. Oil is projected to remain the dominant fuel through 2030, though its proportion of the fuel mix is expected to decline, while proportions of coal and natural gas are expected to increase.



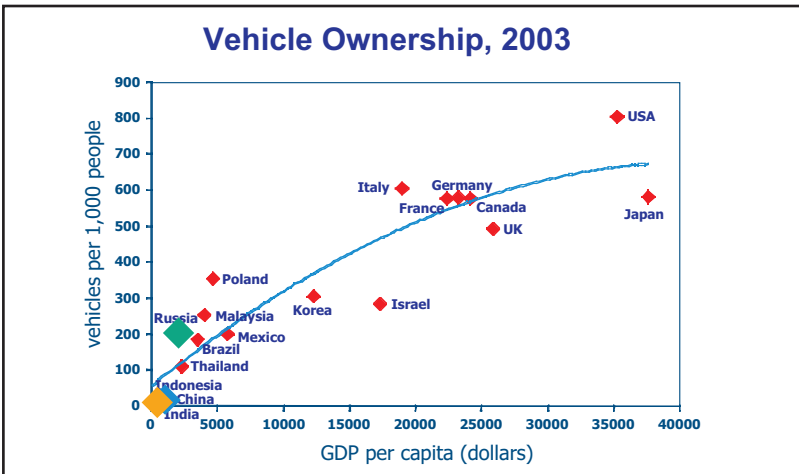
Source: EIA, World Energy Outlook 2006

Figure 3. World petroleum consumption is projected to increase by 43% from 2004 to 2030. The proportion consumed by the U.S. and other OECD countries is expected to decline by 9%, while the proportion of China, India, and other emerging countries in Asia is expected to increase by 14%.



Source: EIA, World Energy Outlook 2006

Figure 4. U.S. net oil imports are projected to grow from 58% to 62% of consumption between 2001 and 2030, while consumption rises by about 35%.



Source: EIA, World Energy Outlook 2006

Figure 5. The rate of vehicle ownership in the developing world lags that in OECD countries by a wide margin, but is poised to grow dramatically as these developing economies expand and incomes rise.

What fuels will be used to power this growth? Figure 2 shows the historical and projected growth in world marketed energy use by fuel type from 1980 to 2030. All fuels show usage increases in absolute terms over this period, but their proportions in the mix change somewhat, with the share of oil projected to decrease, while the shares of coal and natural gas increase slightly. Not pictured in Figure 2 is the amount of energy consumption avoided by increased conservation and energy efficiency, but this is expected to be an important component of the future energy picture as well. Supply and demand issues for these various energy components are discussed in greater detail below.

Oil

The United States is the world's largest consumer of oil, accounting for 22 percent of total world consumption, or about 20 million barrels per day. Figure 3 shows that by 2030, world consumption of oil is expected to grow by 43 percent. The U.S. will still be the largest single consumer, but with a somewhat smaller overall share of the total. As shown in Figure 4, the U.S. produces less than half of its petroleum needs, and must import the balance. The gap between U.S. production and consumption is expected to grow slowly through 2030. Meanwhile, a growing view on the supply side is that the production of cheaper conventional oils may be close to peaking, and that future demand growth will be met by exploiting more difficult-to-get, difficult-to-process, more costly, and more polluting unconventional oil, e.g. that derived from oil sands or shale.

Transportation (air, marine, rail, and ground) accounts for two-thirds of the 20 million barrels of oil consumed by the U.S. each day. Cars and light trucks alone account for about 9 million barrels per day. Every day, the world's auto industries produce 160,000 new cars, and by 2050 the total number of vehicles on the world's roads is projected to rise to about 2 billion, with huge consequences for environmental quality and fuel supplies. Rising incomes in the developing world will be responsible for much of this increase. Figure 5 shows the number of vehicles per thousand people in various countries around the world in 2003. The United States tops the list with about 800 vehicles per 1000 people, while some of the most

populous nations such as China, India, and Indonesia average only 50, but are poised for enormous growth as their economies develop. Increased fuel efficiency, low emissions, alternative fuels, and new technologies such as hybrids will be critical in limiting growth in oil demand while maintaining environmental quality.

Natural Gas

As with oil, natural gas usage is expected to show significant worldwide growth in the future. Current consumption of natural gas in OECD countries is around 50 trillion cubic feet (Tcf) per year, and this is projected to increase to about 70 Tcf by 2030. Natural gas usage in developing countries is expected to grow even faster, from about 50 Tcf currently to over 100 Tcf by 2030. With the limited number of international pipelines and limited shipments of liquefied natural gas (LNG), many natural gas markets are more local or regional than markets for petroleum, but they are expected to become more global as more LNG shipping infrastructure is built worldwide. In the United States and Canada, LNG imports are expected to increase by a factor of five over the next 20 years, albeit from a low base.

In the United States, tight margins between supply and demand for natural gas, the high price of oil, interruption of production caused by hurricane Katrina, and seasonal increases in demand have all driven natural gas prices up from 1990 levels of around \$2 per MBtu to above \$6 per MBtu, though with significant volatility. In the medium to long term, growth in LNG shipments is expected to create a world-wide market for natural gas and may bring U.S. prices down into the \$4-5 per MBtu range.

Electricity generation is the fastest growing use of natural gas. During the 1990s, when natural gas prices were around \$2 per MBtu, natural gas began to replace coal as the choice for new generating capacity in the United States. Between 1999 and 2004 there was a spike in construction of new gas-fired capacity, with over 200 GW of new capacity added (one-third peaking capacity, two-thirds base load). In general, gas-fired plants have lower capital costs, shorter

construction times, lower water, land, and infrastructure requirements, and lower emissions than coal plants.

If combined heat and power (CHP) designs are used, thermal efficiencies are typically 75% compared with 49% for a turbine-only plant. However, with natural gas prices currently in the \$6 range, gas-fired plants are generally less competitive, and some of the newly built capacity has a very low utilization rate. In restructured markets, electricity prices are tracking the higher gas prices. This is creating an incentive for new non-gas-fired plants, especially in parts of the U.S. where coal-fired power plants can be sited.

Coal

As shown in Figure 2, worldwide use of coal is projected to increase steadily through 2030. In 2005 alone, China brought on line about 70,000 MW of new generation capacity, nearly equal to the total capacity of the United Kingdom; about 50,000 MW of that new capacity is coal-fired. Coal markets are more national or regional than those for natural gas and oil. In the United States, coal accounts for about half of electricity generation, and the fact that there are huge domestic resources makes it an attractive fuel from an energy security perspective. However, coal is the most carbon-intensive fuel, and a major uncertainty associated with the future use of coal is the extent to which emissions of carbon dioxide will be constrained by policies to limit global climate change. These policies could make coal use significantly more expensive, but under most plausible scenarios, global coal use continues to grow.

The most likely technology for using coal depends on one's assumptions about future climate change policy. As long as the U.S. continues with no cost assigned to carbon dioxide emissions, the most economical and reliable choice is a supercritical pulverized coal plant. However, if the world aims to stabilize the atmospheric concentration of CO₂ at 550 parts per million, the level at which many scientists believe dangerous human interference in the climate system will occur, the cumulative amount of CO₂ that can be emitted to the atmosphere is about 2,500 gigatons over a couple of cen-

turies. Currently, about 25 gigatons are emitted per year, which is expected to about double by mid-century in “business-as-usual” (BAU) projections. In a BAU scenario generated by the MIT Emissions Prediction and Policy Analysis (EPPA) model, coal uses up 40% of this cumulative carbon budget by 2050; if 450 ppm is the target concentration, then coal uses up the entire budget by 2050 in the BAU scenario. A significant pricing of CO₂ emissions is needed to change the overall emissions trajectory sufficiently to meet the concentration targets. Only if we are able to capture and sequester a large fraction of the carbon released will the world be able to continue burning large amounts of coal in the presence of stringent CO₂ emissions constraints.

If carbon capture and storage is eventually required, integrated gasification combined cycle (IGCC) may be best technology for generating electricity from coal. However, pulverized coal plants, gasification plants, and other advanced concepts not currently deployed are all expected to improve performance and economics appreciably with more RD&D, and it is likely that multiple coal technologies will be deployed (e.g., optimized for different rank coals). In IGCC, coal is converted to synthesis gas (carbon monoxide and hydrogen), which is then cleaned of impurities and burned in a combined cycle. In February 2003, President Bush announced the FutureGen initiative, a \$1 billion, 10-year project to develop the first zero-emissions fossil fuel plant, based on IGCC technology with carbon capture. Such advanced plants will not be cheap, and will present operational challenges, since they will require system integration of diverse technologies—the front-end gasification unit is essentially a chemical plant, combined with a power island and a back end sequestration program. Given the efficiency gains and improved cleanup technologies for advanced pulverized coal plants, IGCC is likely to be deployed at large scale only if CO₂ emissions bear a significant cost.

Today, the science, infrastructure, and regulatory regime for large-scale carbon storage have not yet been developed adequately. A 1,000 MW coal plant capturing 90% of its carbon would require 100,000 barrels of supercritical CO₂ injected into the ground each day, or more than 1.5 billion barrels over a 50 year lifetime.

Hundreds of such efforts would be required to dramatically reduce overall CO₂ emissions to the atmosphere. We have not yet grappled with this kind of scale in our thinking. One Forum speaker suggested that to demonstrate the feasibility of this approach, approximately 10 demonstration sites would be needed worldwide, with perhaps 3 in the United States. Each demonstration site would handle one to several million tons per year and would have appropriate monitoring and verification capabilities. The difficulty is not so much the expense—perhaps \$25 million per year to run each facility—but the logistical and public acceptance considerations. Operation for perhaps 10-15 years would be required to resolve issues and demonstrate the approach adequately.

Because CO₂ is a global problem, the U.S. should be developing these technologies in a global partnership to address monitoring, verification, insurance of risk, etc. Within the U.S., EPA may be the appropriate lead agency for implementing the program, but given the international context, it should be a multi-agency effort to design the framework.

Renewables

Renewable energy such as hydro, solar, wind, biomass, and geothermal is projected to be only about 8 percent of world marketed energy use in 2030, about the same fraction as today. Renewable resources are the most local/regional of the various energy sources from a market perspective, and most have the potential for low or zero carbon emissions. They are therefore attractive from both an energy security and a climate change perspective. Except for hydro, which offers few remaining prime sites, and geothermal, which is geographically limited, renewables currently are typically more expensive and can generally only compete with more conventional fuels with the help of dedicated subsidies and policies that are friendly to the integration of distributed power sources into the electricity grid.

Different types of renewables can be used for electricity generation, heating and cooling of buildings, and transportation fuels. In surveys of electric utility customers, renewables tend to have a very

high favorability rating (over 90 percent). In the Energy Policy Act of 2005 (EPACT), Congress set a Renewable Fuels Standard requiring that increasing amounts of renewable fuels be blended into gasoline, and legislation requiring a minimum amount of renewable energy in utility generation portfolios has come close to passage in the past several years. Similar legislation has passed in several states, and an initiative with this provision passed in Colorado. Interestingly, the Colorado initiative passed everywhere but in the rural areas most likely to be the sites of the renewable projects, suggesting that the NIMBY (Not In My Back Yard) syndrome applies to renewable projects as well as fossil fuel projects.

One characteristic shared by many renewable technologies is that the resource often exists far away from major population centers; e.g., the most efficient locations for wind turbines are often remote plains or mountain passes or offshore waters, and biomass resources are generally in rural areas far from major cities. Thus, bringing the power or fuel from the source to major markets is a challenge. Integration strategies are needed. For example, building dedicated transmission lines from a wind generation site to a faraway city rarely makes economic sense; however, building a spur from a wind site to a transmission line that can be shared with a conventional power plant may be a viable strategy.

One of the most popular renewable technologies, from the point of view of private investors, agricultural interests, and policymakers, is the production of ethanol. Today, the process converts the sugars in corn to ethanol, but from a life cycle point of view this process wastes much of the energy inherent in corn production and can only be sustained economically with extensive government subsidies and tariffs on imported fuel ethanol. In the future, ethanol could be generated enzymatically from cheaper and more plentiful cellulosic feedstocks such as switchgrass and agricultural and forest product wastes. Some advocates believe that ethanol produced from corn and cellulose in the long term has the potential to displace half of the gasoline used in transportation fuels, and hence reduce U.S. dependence on imported oil. When mixed with gasoline at a level of 10 percent, ethanol provides a source of oxygen that reduces emissions

with no adverse impact on engine performance. A mixture of 85 percent ethanol with gasoline (E85) displaces more gasoline, but driving range on a tank of fuel is reduced since ethanol has only about two-thirds the energy content of gasoline. Flexible-fuel vehicles that can run on gasoline, E85, or any blend in between are currently being sold by several manufacturers.

Another potential use of biomass would be as a direct fuel substitute for coal in electricity production. This would be a more energy-efficient use of the biomass, since a large fraction of the energy present in the original biomass is lost in the conversion to liquid fuels for transportation. Assuming no significant amount of fossil fuels were used in the production or transportation of the biomass, and no carbon 'sinks' were destroyed in its production, its use could be nearly carbon-neutral, and by displacing coal, it could greatly reduce carbon emissions that would otherwise result.

Nuclear

Figure 2 shows that nuclear energy is expected to remain a roughly constant 5-6% of the world energy market through 2030. Currently, 103 plants are operating in the U.S. at average capacity levels near 90%, up from 70% in the 1980s. Nuclear energy currently supplies about 20% of U.S. electricity demand, but no new generating plants have been ordered in the past 20 years due to a number of factors: high initial cost, safety and environmental concerns about possible leaks or releases of radioactive material, proliferation concerns, and concerns about the transportation and long-term storage of radioactive wastes. Nevertheless, because a number of recent technical, economic, and policy developments have come together, there is new interest in nuclear power. One year ago, only two companies were developing applications for new reactors before the Nuclear Regulatory Commission (NRC); now, 11 companies or consortia are developing 22 applications, largely in response to higher gas prices and incentives enacted in the Energy Policy Act (EPACT) of 2005.

The industry is now technologically mature, with stable, standardized and NRC-certified plant designs. Lessons have been

learned from overseas nuclear construction projects, especially the importance of using of modular construction methods. The regulatory approval process has been streamlined, and opportunities for citizens to intervene in the process have been limited to a few well-defined points. EPACT provided an investment stimulus for a limited number of new nuclear plants, including loan guarantees, tax credits, and risk coverage for delays resulting from licensing or litigation. This investment stimulus is estimated by some to make nuclear a lower cost solution for new generation capacity than pulverized coal, IGCC with carbon capture and storage, or natural gas combined cycle power plants. Finally, as concerns have risen about emissions of carbon dioxide from the electricity sector and their contribution to global climate change, nuclear plants are receiving renewed attention as carbon-free energy sources.

The worldwide expansion of nuclear energy is prompting renewed interest in the advanced fuel recycling technologies. The PUREX process, used in Europe, produces a stream of plutonium at the end that can be converted into fissile material for nuclear weapons. Research is underway on a new process in which the plutonium is bonded with an actinide to make it unusable in nuclear weapons. New reactors would have to be designed to burn this plutonium/actinide fuel. In the view of one speaker, development of these new reactors and reprocessing technologies may require \$50 billion over 40 years, but would result in a much smaller volume of waste requiring long-term storage. Other Forum participants were skeptical of the need for and desirability of accepting the cost and proliferation risk of reprocessing.

After 20 years of scientific study and an investment of \$6-7 billion, in 2002 the U.S. Secretary of Energy deemed Yucca Mountain, Nevada to be a suitable long-term repository for nuclear waste. A license application is expected in 2008, but political opposition makes final approval uncertain. The nuclear industry used to have a 'Yucca or bust' mentality, but new proposals are being floated for interim regional storage sites. One speaker suggested that technology development activities revolving around fuel reprocessing might be co-located with these interim storage sites.

Conservation and Energy Efficiency

Energy conservation and more efficient use of energy can be considered as new 'sources' of energy. According to one estimate, conservation and energy efficiency improvements since 1973 have reduced annual U.S. energy consumption by 43 quads (~30%), avoided 2.5 billion tons of annual CO₂ emissions, and saved roughly \$400 billion in energy expenditures each year. However, in the United States, efficiency gains in such areas as automobile propulsion and building heating and cooling systems have been offset by increased automotive power and size, and larger living spaces with more electronic amenities. Average fuel economy of the U.S. light duty vehicle fleet peaked in 1986 and has declined slightly since, while cars have become heavier, faster, and more powerful. On average, houses being built today are 30% more efficient than they were in 1980, but they are also 26% bigger. Worldwide, increasing population and rising incomes have meant that energy demand continues to rise despite improved efficiency.

The main reason current high oil and gas prices have not yet caused severe inflation and economic hardship in the United States is that the energy intensity of the U.S. economy is only about half what it was in the 1970s. Yet despite these improvements, there remain tremendous opportunities for reducing energy demand through conservation and improved energy efficiency. Some of the most significant opportunities are discussed below.

In the transportation sector there appear to be a number of routes to improved energy efficiency, reduced consumption of fossil fuels, and reduced emissions of carbon dioxide. In addition to the use of cellulosic ethanol fuel mentioned above, a major opportunity is hybridization of the vehicle power plant, in which an electrical storage device such as a battery or high-volume capacitor is combined with an efficient internal combustion engine capable of running on a variety of fuels. Recent increases in gasoline prices have stimulated renewed consumer interest in hybrids, and companies such as Toyota are betting that hybrids are a big part of the automotive future. In the near term, the hybrid power plant could be a highly

efficient gasoline or diesel engine; in the longer term, this could be replaced by a hydrogen fuel cell. Forum participants were particularly enthusiastic about synergies that are possible between the transportation and electric utility sectors via 'plug-in' hybrids that would feature large batteries that could be charged at night during off-peak hours.

Commercial retail spaces offer further opportunities for energy efficiency. Wal-Mart, for example, with 4,000 stores in the U.S., is the single-largest corporate user of electricity, about 1% of the total. Wal-Mart has initiated an aggressive program to promote energy efficiency in its stores, including: high tech skylights that 'harvest daylight' to reduce lighting needs; white roofs that reflect sunlight; reclaiming waste heat from the refrigeration system to provide hot water; and installing high-efficiency HVAC systems. Overall performance of systems in individual stores is monitored and assessed by sensors connected to a computer system at corporate headquarters. The goal is to reduce energy use in existing stores by 20% in the next seven years, and 30% in a new prototype store within 4 years. Key strategies for the future include installation of interior LED lighting, which Wal-Mart believes will transform the industry, and additional doors on refrigerated cases to reduce heat loss. Wal-Mart finds that investments in energy efficiency projects typically have a one- to two-year payback period, and it shares its energy efficiency strategies with competitors and suppliers as part of a long-term strategy for competitive advantage and boosting customer good will.

Energy costs for buildings of all kinds in the United States are about \$93 billion per year (about 75% of this is for electricity), and building energy use is responsible for nearly 30% of greenhouse gas (GHG) emissions nationally. Recent studies have concluded that a range of new technologies could reduce building energy use by 25-30%, but that 10-20% reductions may be achievable through demand side management programs, daylight dimming, more efficient HVAC systems, efficient glazing, etc. Energy efficient buildings have improved life cycle cost, increased resale value, and increased health and safety of occupants.

Utilities also have an important role to play in promoting energy efficiency. New approaches are needed to internalize environmental costs in economic decisions. Regulatory incentives need to be aligned with goals. If utilities are rewarded for investment in plant and receive more revenues with higher sales, why would we expect them to invest in efficiency? The rewards need to come from providing energy services to customers, not just more energy. There is also a need for utilities to conduct more regional planning. These changes represent major shifts in culture that will not come easily.

Energy efficiency leaders from utilities, businesses, government, and environmental groups have come together to produce a National Action Plan for Energy Efficiency. According to a report to the Forum on this effort, these leaders have committed to carry the message back to their sponsoring organizations and to measure and report back on progress in changing behaviors and cultures in what was described as a “push me/ pull you” approach.

It is widely accepted that investing in energy efficiency is much cheaper on the margin than investing in new capacity. According to one energy efficiency study, the U.S. could save 19% of total energy use by 2020, essentially flattening out the energy demand growth curve. Energy efficiency isn’t the only option, but it should be the first one.

Given the benefits associated with energy efficiency, especially the financial savings, why haven’t more companies and individuals taken greater advantage of these opportunities? Many reasons were offered:

- Energy efficiency is often not viewed as ‘sexy;’
- Cuts in energy efficiency programs at the Federal level have reduced efforts;
- Discrete actions are often required by many individuals to achieve energy efficiency goals, and each action requires that inertia be overcome;
- Companies may not be vertically integrated enough or of sufficient size (a la Wal-Mart) to capture the savings—e.g., they

may not own their own buildings and so may not have incentive to invest in efficient HVAC and lighting systems;

- Constraints exist on investment flexibility due to tension between capital and operating budgets.

The following are some ways suggested by Forum participants in which governments and organizations can promote energy efficiency:

- Uniformity of building codes and standards across states, with regular updating;
- Incentives such as 'green' tax credits;
- Replicability of energy efficiency guidelines and best practices;
- Recognition in the marketplace, e.g., Leadership in Environmental Design (LEED) approval;
- Collaboration with the Federal government; States are leading in the energy efficiency area, but need to be supported by national policies.

Providing consumers with information through technologies such as real-time metering of electricity can be an effective strategy, as can programmable heating and cooling equipment controlled by signals over the Internet. Marketing strategies in which utilities or retailers give away initial energy efficiency items (e.g., compact fluorescent lights) to gain consumer familiarity and confidence have proven effective. And, of course, continued high prices for energy are a critical catalyst for action.

Energy Issues Are Critical to Geopolitics and National Security

Access to affordable energy supplies has been a critical need of both developed and developing nations in the past. In today's world, countries with an excess of energy resources are emboldened to assert their will in international affairs, while countries that must import energy may be pressured to alter their policies in pursuit of energy security. The nexus between energy and the proliferation of weapons, especially nuclear weapons, is another troubling way in which energy influences national security and world affairs.

The use of energy resources to gain leverage in international relations is not new; the 1973-74 Arab Oil Embargo against supporters of Israel was an early example. Today, the dependence of the U.S. and its allies on foreign sources of oil and gas continues to limit their freedom of action and puts them in the awkward position of trying to balance the desire for energy security against other foreign policy goals. Western Europe and Ukraine need Russian gas. Italy buys energy from Libya and Algeria. India wants a gas pipeline from Iran. Japan and Korea are heavily dependent on the Middle East. And U.S. friends in Latin America are being pressured by Venezuela's Hugo Chavez. China's growing relationships with Iran, Sudan, and Venezuela are examples. Alliances of convenience between buyers and sellers can evolve into groups that are hostile to international norms and could influence international politics—e.g., U.N. Security Council votes on totally unrelated issues.

Many countries that are rich in energy resources are prone to corruption, are autocratic, and repress political dissent in the name of stability. If the U.S. associates with these countries to obtain energy supplies, it risks alienating the oppressed population and undermining its credibility on other foreign policy goals, such as the promotion of democracy and human rights. If it distances itself, the governments make decisions that are costly to U.S. interests.

The dependence of many countries on oil from the Middle East raises national security concerns that go beyond the threat of dis-

ruption of oil supplies. Inevitably, some of the petrodollars flowing to governments in the Middle East make their way into the hands of radical Islamist groups such as al Qaeda, leading to the feeling that the U.S. and its allies are “paying for both sides” of the war against these groups. Other oil and gas revenues fund other undesirable actions. As one speaker pithily noted, countries that have energy but believe they need more weapons and countries that have weapons but not enough energy have business to discuss. In the United States, the electric power sector depends primarily on domestic fuels, and so is not as vulnerable as the transportation system to supply disruptions from abroad; however, the electric power distribution system is vulnerable to terrorist attacks, and massive and sustained outages could result if strategic points were targeted.

Finally, nuclear power may be making a comeback globally due to increasing demands for energy and the fact that it is a carbon-free energy source. Unfortunately, the line between civilian nuclear energy programs and military nuclear weapon programs is difficult to discern and enforce, as illustrated by current concerns about Iran’s nuclear intentions. Yet the scope of actions available to discourage Iran’s nuclear ambitions are limited by Iran’s position as a major energy supplier. It also doesn’t help that the international nuclear nonproliferation regime is under siege. As more and more countries seek to develop nuclear power, there is a greater and greater risk that dangerous nuclear materials will fall into the hands of terrorist groups. New international institutions and strategies will be needed to manage these risks.

All of these examples suggest that the geopolitics of energy is becoming more complex and requires more careful attention than in the past.

Climate Change Is Real

It is now almost universally accepted among climate scientists that human-caused emissions of greenhouse gases are having an impact on global temperatures, weather patterns, and ecosystems. What is less widely appreciated is the magnitude of the challenge of stabilizing those emissions at levels that are not catastrophic to the global life support systems upon which we all depend. The challenge is particularly acute when viewed in the context of rising projected world population, incomes, and demand for energy.

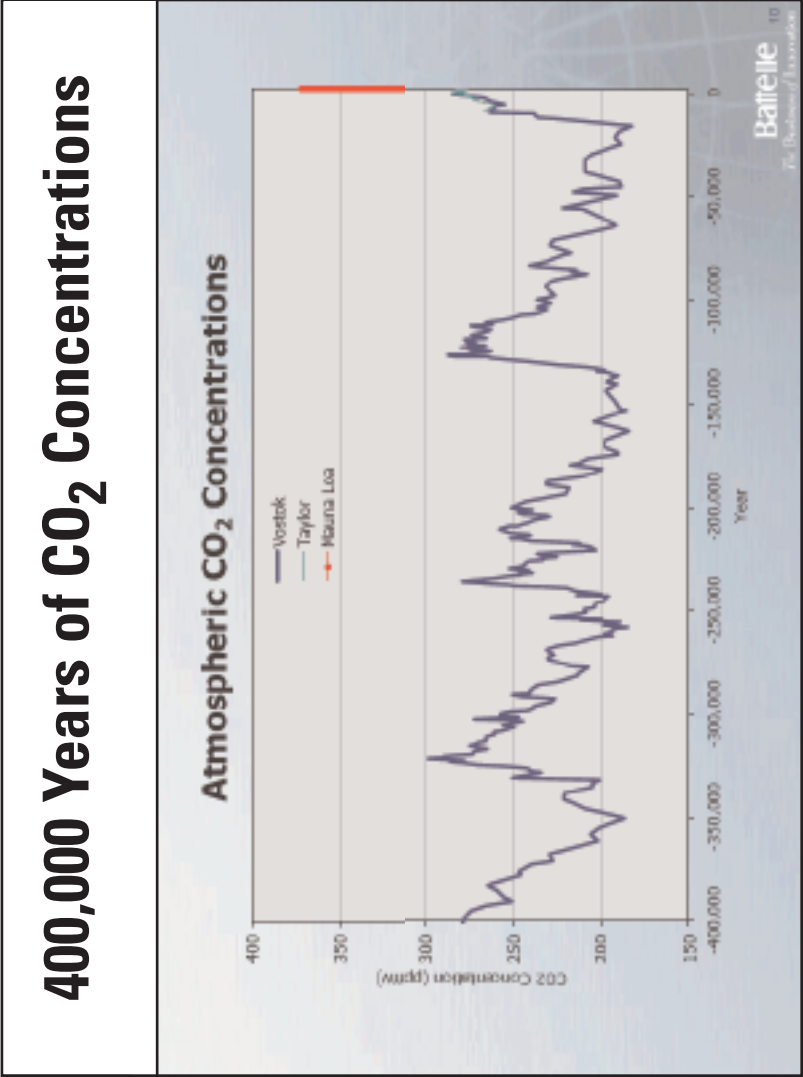
The dominant atmospheric gas causing global climate effects is CO₂.¹ Figure 6 shows the atmospheric concentrations of CO₂ during the past 400,000 years. The record shows that there have been oscillating increases and decreases in atmospheric CO₂ with a period of about 100,000 years and with a range from 182-300 parts per million (ppm). With the dawning of the industrial era around 1750, these concentrations began to climb due to the burning of coal and other fuels to meet growing energy demand. In 1959, the world average concentration of CO₂ was measured at 316 ppm, and in 2004 the annual average was 377 ppm (red line in Figure 6). With still-growing emissions and the long-lived nature of greenhouse gases in the atmosphere, the outlook is for much higher concentrations in the future.

By far, the greatest contributor to net GHG emissions is fossil fuel use, with smaller contributions from changes in land use (deforestation and soil cultivation) and industrial process emissions. In 2002 nearly 7 teragrams of carbon were emitted to the atmosphere from fossil fuel use. Oil was the dominant contributor, followed by coal and natural gas. The United States, which consumes around 20% of the world's energy, also produces around 20% of the world's CO₂ emissions.

Figure 7 illustrates the long-term challenge of stabilizing atmospheric CO₂ concentrations at various levels. The orange line represents a reference case that itself includes the introduction of many new energy and emissions mitigation technologies. Still, CO₂ is not stabi-

1. Other gases, such as methane, chlorofluorocarbons, and nitrous oxides, also contribute. For simplicity, the contributions of these other gases are converted to CO₂ equivalents in this discussion.

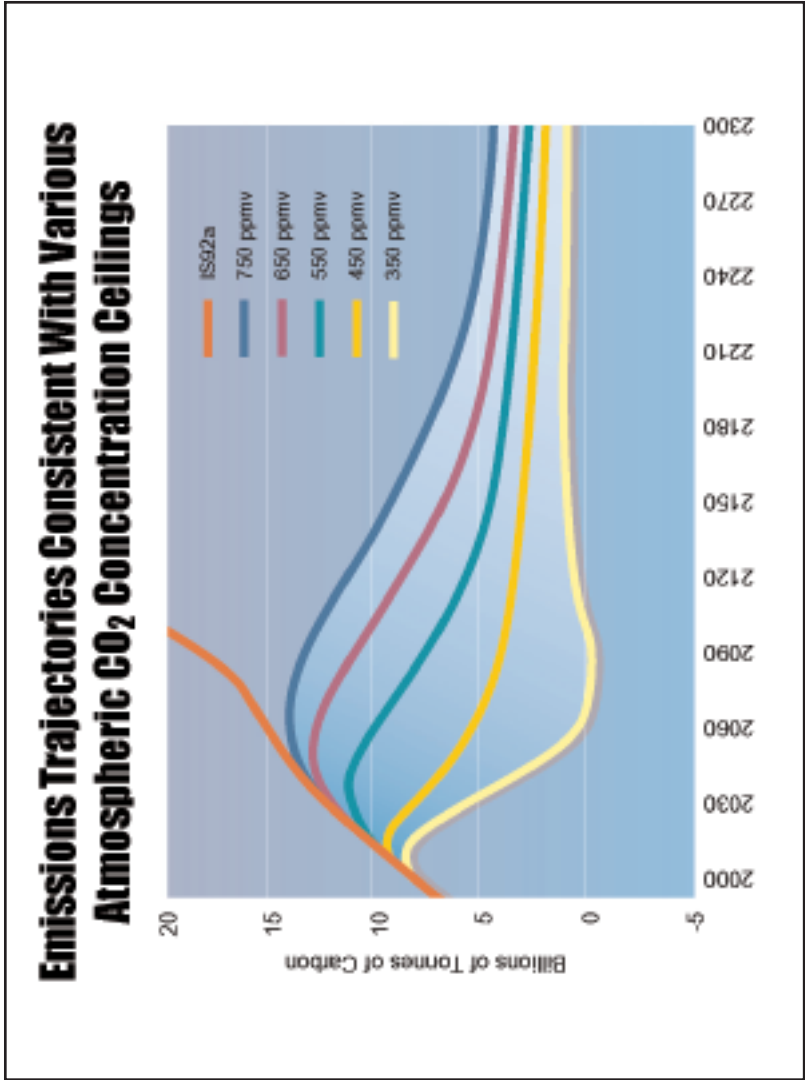
Figure 6. CO₂ concentrations in the atmosphere have fluctuated over the past 400,000 years, but are currently 25% higher than they reached in any previous peak.

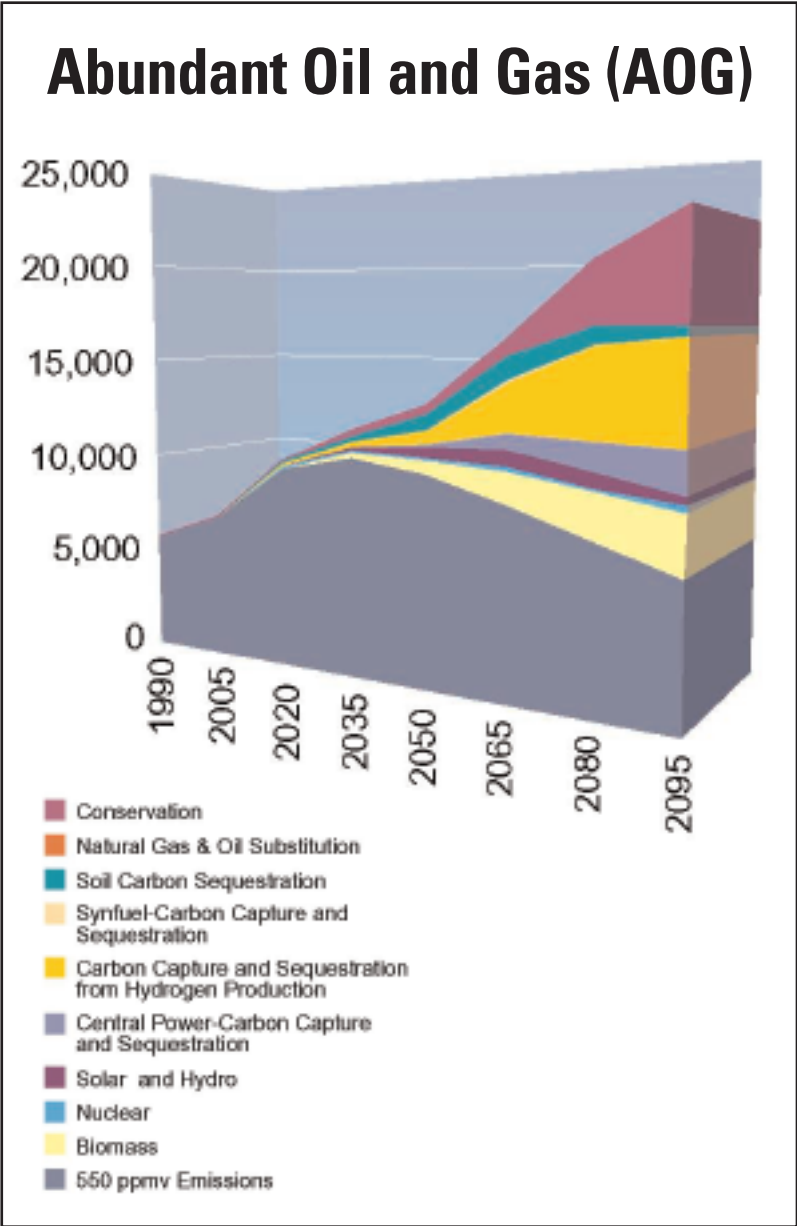


Source: Jae Edmonds, Pacific Northwest National Laboratory's Joint Global Change Research Institute at the University of Maryland.

Figure 7. It is cumulative global emissions that matter, not annual emissions. Stabilization of greenhouse gas *concentrations* is the goal of the 1992 Framework Convention on Climate Change. All CO₂ counts equally, regardless of nation or sector of origin. Achieving lower concentrations requires starting emissions reductions sooner.

Source: Jae Edmonds, Pacific Northwest National Laboratory's Joint Global Change Research Institute at the University of Maryland





Source: EIA, World Energy Outlook 2006

Figure 8. U.S. net oil imports in the absence of resource scarcity are projected to grow from 58% to 62% of consumption between 2001 and 2030, while consumption rises by about 35%.

lized in this case and the concentration rises indefinitely. The colored curves represent the emissions levels required over time to stabilize CO₂ concentrations at 350, 450, 550, 650, and 750 ppm. Stabilization at 550 ppm requires that world CO₂ emissions peak within 30 years and then decrease steadily year by year for the next 300 years to about half of current emissions levels. Achieving this steady state CO₂ goal requires dramatic worldwide changes in energy consumption habits and energy production technologies, as shown in Figure 8.

The rising top curve in Figure 8 represents the amount of carbon that would be emitted to the atmosphere in the reference case during the 21st century. The colored bands below it represent one possible mix of changes in global energy technology deployments for reducing carbon emissions down to the levels required to stabilize CO₂ concentrations at 550 ppm during this period (lower blue curve). Under any scenario, major contributions to emissions reductions will likely come from a portfolio of technologies potentially including the following: the capture and storage of carbon produced by burning fossil fuels, conservation/energy efficiency, and non-carbon or carbon-neutral technologies such as biomass, solar, wind, and nuclear. In the 550 ppm scenario, almost all CO₂ emissions from the electric power sector are captured and stored by the end of the 21st century, because it is easier to capture carbon in the electricity sector than in the transportation sector. In the transportation sector, emission reductions were obtained through improvements in vehicle efficiency, deployment of hydrogen as a fuel, and the use of liquid fuels derived from commercial biomass crops, with the latter showing significant potential.

The scale-up of CO₂ capture and storage technologies that could occur during this century as part of a global effort to reach a 550 ppm goal is astonishing. There could be an order of magnitude increase from today's levels by 2020, another order of magnitude increase by 2050, and another by 2095, when about 5,000 teragrams of carbon per year could be captured and stored in permanent repositories. Fortunately, it appears that the world has sufficient repository capacity available, but it is primarily in deep saline formations that will be costly to access.² The transportation and management of such huge

quantities of captured CO₂ from the power plants to permanent repositories raise siting, technological, and legal questions we have only begun to contemplate. These questions can only be answered by large-scale demonstration projects proving the costs and feasibility of this approach. In addition, many institutional preconditions would have to be satisfied for this technology to deploy, including acceptance of the technology within regional and national emissions accounting systems, a value of carbon sufficient to make the technology economically viable, the development and deployment of acceptable monitoring and verification technologies, and adequate resolution of long-term liability issues, to name but a few.

Unfortunately, advanced technologies with carbon capture and storage will not necessarily be sufficient to stabilize CO₂ concentrations in the atmosphere. Affordability is also a factor. After initial reductions are made, wringing each additional ton of carbon emissions from the system becomes harder and more expensive. Thus, the price of removing carbon from the atmosphere goes up over time, not down, a trend that is unfamiliar to most technologists. Without climate policies in place to ensure that each incremental reduction in carbon comes from the cheapest possible source, precious financial resources will be wasted, or it may be necessary to settle for lower environmental quality.

Stabilizing GHG emissions also has implications for non-energy policies, particularly land-use and agriculture policies. For example, the clearing of forests for agriculture or development removes carbon-absorbing 'sinks' and therefore is effectively a net contributor to GHG emissions. Even the planting of biomass crops for electricity production or transportation fuel may not be carbon-neutral, depending on the previous uses of the land, specific crop involved, and cultivation and transportation methods used. Estimates of the carbon 'emissions' associated with changes in worldwide land use vary widely, but some studies suggest that they may be equivalent to 25-30% of fossil fuel emissions and therefore need to be addressed in any comprehensive GHG emissions policy.

2. A report released on May 10, 2006 by the Global Energy Technology Strategy Program titled *Carbon Dioxide Capture and Geologic Storage* examines the storage resources and locations available.

Action Items

Given the earlier ‘energy crises’ of the 1970s and 1980s, the many reports and recommendations of august commissions, the billions of federal dollars spent on energy research, and the current energy consumption habits of Americans, it is no doubt appropriate to approach a section called ‘Action Items’ with a fair degree of humility. Essentially, we face the same energy issues today that were discussed by President Carter in his famous speech on April 18th, 1977: competition between countries for limited oil and gas resources; wasteful use of energy; increasing dependence on imported oil; need for domestic energy sources; and mounting damage to the environment.

Yet, since Carter’s speech, the problems have certainly intensified, and new problems (e.g., global climate change) have come to the fore. If we are not in a completely ‘new normal’, at the very least our energy problems have become more complicated and challenging, and there is no prospect of them getting any easier in the future—quite the reverse, in fact. Below are some thoughts of Forum participants about action items for moving ahead.

R&D vs. Innovation

Innovation—defined here as the deployment of improved technologies and processes to do things faster, better, or cheaper—occurs in the private sector, and will be essential for meeting the energy challenges discussed above. But who should pay for it? R&D, which may range from basic science to applied work, occurs within both the government and the private sector, and may or may not lead to innovation. Basic research can generate ideas and give innovators tools to work with. But much of innovation is putting existing pieces together and making them work in new ways. There are models in which targeted government R&D investments have led to dramatic innovations in the private sector. Research sponsored by the Defense Advanced Research Projects Agency (DARPA) within the U.S. Department of Defense, for instance, is known to have stimulated the development of the Internet and the commercial semicon-

ductor and microelectronics industries. On the other hand, there have been many government programs, such as the ill-fated Synfuels Corporation in the energy area, that fell out of step with market trends and customer needs, and failed to produce innovation.

Currently the government is spending about \$500 million on basic energy research. Government R&D programs are most effective in stimulating innovation when they concentrate on areas that the private sector needs, but is unable to invest in. This includes fundamental basic research as well as applied research that is targeted toward solving specific industry problems. The U.S. Department of Energy (DOE) is getting better at doing applied work, but Congressional earmarks are diluting more and more of the effectiveness of basic research funding. The government should invest in principal investigators who have a passion for applying their knowledge to solve energy problems. It should also be cautious about investing in markets that don't yet exist.

Private Sector Investment

With energy prices near all-time highs and the need for new sources of energy supply clear, the energy industry is running flat out to drill new wells and develop new base load electricity capacity. Investment funds are pouring money into the energy area, including 'green' energy technologies. Automobile companies are rushing to produce more fuel-efficient hybrids to meet demand. The energy sector is currently 'hot' in part because other market sectors are in the doldrums, and in part because investors tend to forget past cycles of energy booms and busts. There is a sense of wanting to take advantage of the new interest in energy as long as it lasts.

Several trends can be seen in investments in the energy sector:

- Consumer spending on natural gas and electricity is increasing. Natural gas is the marginal price-setter in most regions. Base case demand projections and tighter reserve margins indicate that more generation is needed.

- Private equity capital is flowing into the energy infrastructure. Investors are particularly interested in a ‘pure play’ model, i.e., owning a specific piece of the natural gas or electricity infrastructure.
- The pipeline industry is coming back. Tens of billions in capital is going to pipelines.
- Interest in the liquefied natural gas (LNG) sector is growing rapidly, as well as the gas storage area. It is important to be able to receive the gas when it can come, and one can only capture the off-peak availability of LNG with storage.
- Utilities are facing a number of tough issues. Higher fuel prices are typically passed along to the consumer, but even though costs are going up, regulators may not be willing to make the consumer pay. There is a need for more robust access to market clearing information. Finally, there is investor appetite for new energy technologies, but it is important to keep R&D focused on solving problems, rather than R&D for its own sake.

The biggest factor affecting the flow of capital in the energy infrastructure area is the regulatory environment—whether positive or negative. A clear, consistent and constructive regulatory environment at the state and Federal levels is necessary to attract capital. One reason that so much capital is flowing into pipelines, for instance, is that there is only one regulator, the Federal Energy Regulatory Commission, with stable investment recovery rules.

The cost of capital for funding infrastructure investment will be directly related to investors’ perceived risks. Very high risk projects may have a 20% cost of capital, and low risk about 7%. Transmission lines are considered low risk, and pipelines somewhere in the middle. If regulations do not allow for the pass-through of increased costs to consumers or continually change the investment-recovery rules, this will drive capital away or signal higher risks for investors.

Venture capital is also flowing into the energy field, particularly the clean technology area. This is a big change, because returns from clean technology investments in the past have been abysmal. Small venture companies are pursuing a number of clean tech areas, including: flexible solar cells to reduce installation and service costs, fuel cells (both fixed and mobile) for electricity generation, supercapacitors to replace batteries for energy storage, and biofuels such as ethanol. However, technology innovation alone is not going to make these ventures successful. Financing and policy support must go hand-in-hand.

It is important to have the right incentives in place for utilities to take a systems approach to the services they offer. We have a world-class electric system because we allowed utilities to put money for investments into the rate base, so why not reward utilities for meeting goals such as service quality, renewable portfolio standards, demand-side management, etc.? It is important to have metrics and someone to keep track of progress, but we need to solicit proposals from utilities for how to run the system more efficiently.

To the extent that investment is made by regulated industries, sound judgment exercised by regulators is also an important issue. Forum participants felt that regulators' positions are increasingly being affected by the politicization of energy issues, including partisan fights. Utilities are demanding regulatory assurances to make investments, and are bypassing regulators and appealing to governors and state legislatures if they don't get what they want. While there has always been a political component in utility regulation, regulators now fear for their political lives when they try to make decisions in the public interest. In Maryland, the legislature dismissed all five regulators in response to consumer outrage over steep electricity rate increases. The goal should be to de-politicize this process.

Federal and State Roles

In view of all of this private sector investment, what more can the government do to stimulate innovation? At the Federal level, would it make sense to create an 'ARPA-E', an analog to DARPA in the energy field?³ Forum participants were divided on this question. DARPA

was created with several characteristics that may not be replicable in the energy sector:

- A clear mission—to aid the warfighter;
- A clear customer—the military services;
- A reputation for bringing the best minds to bear on a problem;
- Freedom from bureaucracy—e.g. Federal procurement regulations;
- A willingness to terminate projects that are not performing;
- A sense of threat that creates a willingness to risk some failures as the price of success.

The goals of civilian energy R&D would inevitably be broader than its military counterpart. Such goals might include: making energy more affordable and reliable; increasing supplies; promoting energy efficiency and conservation; developing domestic resources; and addressing carbon dioxide emissions and global climate change. Similarly, the customer for the work product of an ARPA-E is less clear than that of DARPA, and it is not clear where an appropriate home for such an agency in the Federal government would be.

Many state governments, led by New York and California, are funding innovative energy projects with local industries. In many respects, the distribution of energy resources is regional, and this approach makes sense. Some states have coal resources and may have a particular interest in developing clean coal technologies and in promoting economic development in coal-producing regions. Others have off-shore gas deposits, pipelines, underutilized biomass resources, or geothermal, solar, and wind resources; and efficiency opportunities may vary according to climate, population density, economic activity and other factors. State governments also tend to be closer to local industries and consumers.

3. This proposal was suggested by a recent NAS/NAE panel.

In view of these advantages, many Forum participants felt that it is best in some circumstances to allow the states to be the laboratories of innovation for energy technologies, with the Federal role limited to setting standards and collecting and sharing information about best practices. On the other hand, some energy issues, such as global climate change, or the national security implications of increased dependency on imported oil, are national or international in scope, and it would be an abdication of Federal responsibilities to leave innovation in these areas solely to the states.

Policies to Promote Innovation

Three other kinds of governmental policies to promote innovation were discussed by Forum participants: setting appropriate prices, regulations, and subsidies. The approach that gives the greatest scope to innovation is to send appropriate price signals (e.g., setting a carbon price to provide incentives to reduce carbon dioxide emissions throughout the economy). Less good is regulation. On the one hand, huge savings can occur if regulations are well conceived; for example, because of regulations on energy efficiency, refrigerators use 75% less energy today than they did in 1973, while being bigger and having more features. But poorly designed regulations can create an incentive to comply with the regulation rather than to maximize innovation, or can have other negative consequences. An amendment allowing a credit against Corporate Average Fuel Economy (CAFE) regulations for vehicles capable of running on either gasoline or ethanol resulted in the production of many such vehicles but also in additional gasoline consumption due to the effective lowering of the CAFE standard.

While politically attractive, subsidies are the least effective for initial deployment of technologies. These tend not to work well unless the penetration rate for the new technology is high enough that the existing technologies are quickly displaced. To avoid wasteful spending on subsidies when they are not needed but still use them to protect emerging technologies from market fluctuations, subsidies for emerging technologies can be coupled to the price of existing technologies. For instance, to avoid destruction of the nascent ethanol

industry, the ethanol subsidy of \$0.51 per gallon could be decreased as oil prices rise and increased if oil prices drop below a threshold level.

Unfortunately, the political appeal of these different methods is inversely proportional to their effectiveness. Subsidies are popular and a commonly used approach with specific, potential beneficiaries supporting them; regulations can be more difficult, with typically organized opposition from the targets of regulation; and policies to “get the prices right” by, say, internalizing the costs of carbon emissions in the price of carbon-intensive fuel through carbon taxes or cap-and-trade systems, seem most difficult in today’s political climate.

Leadership and Values

Energy issues do not normally occupy a prominent place in the political discourse of American life. To the extent that politicians respond to consumer anger over high gasoline prices or skyrocketing home heating bills, their responses tend to focus on short-term relief strategies or assurances that market forces will eventually increase supplies and bring prices down. In some cases, sufficient incentives already exist to help companies and consumers conserve energy and implement energy efficiency technologies. Wal-Mart, for example, promotes energy efficiency for both competitive advantage and improved public relations. This particular corporation is large enough to exploit the economies of scale that often make such actions more profitable. Wal-Mart also has sufficient buying power in the market for energy efficient equipment and devices for its buildings in order to introduce changes in the mix and cost of products available in the market. For other companies, however, it is difficult to make a convincing business case based on short-term profit and loss for actions that may be in the long-term interests of the United States and the world. In these cases, committed leadership is needed, both in the government and the private sector.

Conservation and Energy Efficiency

Leadership is needed to accelerate investment in energy efficiency. It is clear from Figure 8 that conservation and energy efficiency must be an important part of our response to bringing carbon diox-

ide emission levels down to sustainable levels. The United States currently consumes 20% of the world's energy and is the single largest contributor to the problem of global climate change. Despite having reduced the energy intensity of its economy by a factor of two in the past 30 years, the U.S. still has per-capita energy consumption twice that of many countries in Western Europe. Opportunities exist for conservation and improved energy efficiency across the board—in the electric power sector, buildings, transportation, etc.—but leadership is needed to realize them.

Leadership is also required to expand public awareness of the climate change problem and to build consensus for policy change. One idea suggested is to develop a national advertising campaign around the idea that if Americans are going to continue to enjoy their current lifestyle, this comes with the responsibility to become more energy-efficient and to work with others to reduce carbon emissions. Such a campaign would have to offer tangible suggestions for change, but avoid picking winners or getting too far ahead of real markets. An example might be promoting the idea that “fuel economy matters.” This might not only encourage the purchase of new hybrid vehicles, but could also encourage buyers of used cars (70% of the vehicle market) to make more fuel-efficient choices—e.g., switching from a V-8 to a V-6 engine.

Energy and Foreign Policy

More self-conscious leadership is needed to build long-term and more effective strategic alliances as part of U.S. foreign policy. The United States sometimes pursues policies that divide its friends and unite its enemies. With some energy issues, it has an opportunity to reverse this. One example would be to work together with China and other oil-consuming countries in a cooperative effort to ensure that sea lanes remain open for oil shipments. Another is to explore international agreements in which the military applications of nuclear technology are restricted in exchange for cooperation on the peaceful uses of nuclear power. The United States needs to recognize that a functioning international system of treaties and agreements on energy matters can enhance its own security.

In the past, the United States has often supported autocratic and repressive regimes in the name of stability and to maintain reliable access to energy resources. These policies undermine its stated support of human rights and democratic values and create enmity that may express itself later when the supposed stability comes crashing down (e.g., in Iran). Leadership is needed to recognize that it is in the long-term interest of the United States to act in ways that are consistent with its core values, even if there are short-term energy costs. As one Forum participant put it, “Oil matters; democracy matters more.”

Another important area where U.S. leadership will be required is on global climate change. Since the U.S. is the largest current emitter of carbon dioxide in the world, no progress on a global treaty to limit carbon emissions can occur without U.S. participation. In the United States, it is considered politically difficult to join such a treaty without the participation of developing countries such as China and India which, because of their high economic growth rates, are collectively projected to surpass the U.S. in carbon emissions in the next decade. Unfortunately, in the judgment of one participant, China is structurally incapable of making more than an aspirational commitment at this point—there is insufficient organizational structure to implement such a program. However, sometimes implementation will follow an aspirational goal. Models suggest that if the U.S. joined a treaty now but China did not join for 10 years, this would shrink the remaining carbon budget by about 6%. This would be unfortunate, but not catastrophic. On the other hand, a 10-year delay by the U.S. would shrink the remaining carbon budget even more, and without U.S. leadership by example, there would appear to be no prospect for developing countries such as China to join at all.

Getting the Carbon Out: A Unifying Theme?

As discussed above, the development of a coherent energy policy has always been complicated by the fact that there have been many worthy alternative goals that have kept the objectives of energy policy somewhat unfocused. However, Forum discussions suggested that the goal of reducing emissions of carbon dioxide has the potential to be at the core of a coherent national energy policy.

Unlike some regional energy issues, carbon emissions are an urgent, global problem. There is little hope of stabilizing carbon dioxide concentrations in the atmosphere at levels even 50% above current levels unless worldwide emissions peak and then decline sharply after about 30 years. This will require not only expanded deployment of energy supply technologies such as wind, solar, biomass, and nuclear energy, but also dramatic increases in the use of end-use energy efficiency technologies and conservation strategies for buildings, industry and transportation, CO₂ capture and storage, and technologies to mitigate non- CO₂ greenhouse gas emissions.

Mitigating global climate change is potentially a unifying theme because it contributes to economic and energy security goals. For example, improved vehicle efficiency not only reduces GHG emissions, it also enhances national security by reducing oil demand/imports and improves the economy by using resources more efficiently. Conservation and energy efficiency more generally not only reduce carbon emissions, but also reduce the need for expensive new generation capacity. By reducing oil use and consequent carbon emissions in the transportation sector through deployment of more efficient plug-in hybrid technologies and substituting biomass-based fuels for oil, the domestic economy is stimulated, the scope of U.S. action in foreign policy is increased, and the petrodollars that might otherwise make their way to radical Islamist groups are curtailed.

Having the goal of reducing carbon emissions front and center suggests a number of areas where innovation is particularly needed. One is the area of biofuels, both the production of these fuels in a sustainable and economic way and their efficient use in evolving propulsion systems; i.e., achieving a better match between fuel and engine design. Another critical need is for scale demonstration of carbon capture and storage in underground repositories, as well as the monitoring and resolution of legal issues associated with storage, such as who is responsible if leaks occur. Finally, given the apparent inevitability of climate changes even if carbon emissions can be stabilized, strategies need to be developed for adapting to and managing these changes.

Most observers agree that the most efficient, politically acceptable means of addressing the carbon issue is a system that places a price on all greenhouse gas emissions regardless of their sector of origin. Suggested institutional mechanisms for setting such a price include a tax on greenhouse gas emissions and a cap-and-trade system for greenhouse gas emissions similar to the system that applies to sulfur dioxide emissions from power plants today. The cap-and-trade approach may be more administratively difficult but more politically feasible than a tax, and it gives maximum scope to innovation while ensuring that reduction of emissions will be carried out wherever they can be made most cheaply. The near- to mid-term future of some energy technologies, such as nuclear and CO₂ capture and storage, probably depends on setting a significant price on carbon emissions.

A purely private-sector approach was raised by some Forum participants: having the energy industry voluntarily contribute a small percentage of its revenues to a pooled fund to finance increased R&D expenditures for technologies to reduce carbon emissions. With consumers spending \$1 trillion per year on energy, even a tiny percentage of sales would raise a substantial amount of money. The fund would never pass through the Federal government, and industry would have a say in how it was spent. Anti-trust issues might be circumvented by creating a self-organizing industry board to oversee expenditures.

Conclusion

The Forum produced a lively discussion, some good ideas and some areas of consensus on taking advantage of the renewed attention to energy issues. There was strong support for the goals of stimulating the deployment of innovative energy technologies, promoting energy efficiency and conservation, reducing U.S. oil imports, and reducing carbon dioxide emissions as core aspects of energy policy. The stabilization of carbon dioxide concentrations in the atmosphere will be neither easy nor cheap. The good news is that there is widespread agreement on the most effective and feasible policy for addressing global climate change: putting a price on greenhouse gases through a cap-and-trade system. The bad news is that at the moment this still appears to be a non-starter politically. In the absence of such a program, success in slowing the growth of carbon emissions probably depends on fuel prices staying high. One question considered by participants is whether they would support policies that would create a *floor* for fuel prices—a level below which fuel prices would not be allowed to drop. Although this could help promote efficiency and the introduction of new fuels and technologies, many believed it would be a quick career ender in today's political atmosphere.

The consensus of the Forum seemed to be that, while we may not yet have irreversibly crossed a threshold into a 'new energy normal,' at the very least dealing with energy issues has become more difficult and urgent. The analogy was made to the old adage that a frog thrown into a pot of boiling water will be shocked into hopping out, but a frog placed in a pot of water that is being heated slowly to boiling will not perceive the same sense of urgency and will stay there until he dies. High energy prices, the threat of global climate change, and increased geopolitical risks may provide us with the needed shock, and the resulting attention to energy issues provides an excellent opportunity to face these issues squarely. Patient and courageous political leadership will be needed to make Americans more aware of the consequences of their energy choices, and to work with governments around the world to ensure the future security of our energy supply and the life-sustaining planetary systems upon which we all depend.

APPENDICES

Agenda

Energy: The New Normal?

Aspen, Colorado
June 30 - July 4, 2006

Chair: Phil Sharp, President, Resources for the Future

SESSION I: Timeless Values, Timely Action

Seminar A:

Values in a Global Village

Moderator: **Peter Thigpen**

Senior Fellow, Aspen Institute

Seminar B:

Business and Social Responsibility

Moderator: **Elliot Gerson**

Executive VP for

Seminars, Aspen Institute

SESSION II: The Big Picture — Policy Drivers

How serious are supply concerns, how inevitable are demand increases, and what will be the likely impact on prices? How does energy affect geopolitical concerns and vice versa? How quickly must the growth in carbon emissions be slowed and reversed to avoid dangerous impacts on the planet and on human wellbeing?

Chair: **Phil Sharp**

Speakers: **Madeleine Albright**

Principal, The Albright Group, *“Geopolitics of energy”*

Howard Gruenspecht

Deputy Administrator, Energy Information
Administration, *"Supply and demand"*

Jae Edmonds

Chief Scientist, Joint Global Change Research
Institute, *"CO₂ timing, technology, and cost"*

SESSION III: RD&D and Financing Energy Development

Meeting the supply and environmental challenges will require new technologies and new investment. Who will set the priorities, who will provide the funding, and under what conditions?

Chair: **Jeff Sterba**, Chairman, President and CEO,
PNM Resources

Speakers: **Robert W. Fri**, Senior Fellow, Resources for
the Future, *"RD&D levels, priorities, sponsors"*

Samuel Brothwell, Director, Power & Gas
Equity Research, Wachovia Securities, *"Financing
oil and gas development"*

John Kiani, Director, Electric Utilities & Power
Equity Research, Deutsche Bank Securities,
"Financing electricity development"

John Doerr, Partner, Kleiner Perkins Caufield &
Byers, *"Venture capital in energy"*

SESSION IV: Reducing Demand

The magnitude of the energy supply and carbon reduction challenges will be greatly affected by the level of efficiency improvements. What is the potential for reducing demand and how can it be achieved?

Chair: **Kateri Callahan**, President, Alliance to Save Energy

Speakers: **Josephine Cooper**, Group Vice President,
Toyota Motor North America, *"Autos"*

Charles Zimmerman, Vice President, Wal-Mart Stores, *“Commercial”*

Peter Smith, President & CEO, NY State Energy Research & Development Authority (NYSERDA), *“Buildings”*

Diane Munns, Commissioner, Iowa Utilities Board, and President, National Association of Regulatory Utilities Commissioners (NARUC), *“Utilities”*

SESSION V: Utility Choices

In the long term, growing demand, resource availability, limits on carbon emissions, RD&D, financing availability, and efficiency improvements will affect price levels. How well will various fuels fare in the “new normal,” and what non-price factors will affect utility choices of fuels and technologies?

Chair: **Walt Higgins**, Chairman, President and CEO, Sierra Pacific Resources

Speakers: **Ernie Moniz**, Professor of Physics & Engineering Systems, MIT, *“Coal”*

Ron Lehr, Attorney, American Wind Energy Association, *“Renewables”*

Frank L. (Skip) Bowman, President and CEO, Nuclear Energy Institute, *“Nuclear”*

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SESSION VI: Conclusions

The Forum will develop a list of key conclusions and recommendations based on points raised during the preceding sessions.

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Selected Publications

Program on Energy, the Environment and the Economy

A High Growth Strategy for Ethanol

A distinguished group of business, government, environmental and academic leaders met for two and a half days at Wye Woods in late March to discuss the potential of biofuels to improve energy security, the environment, and the economy. Co-chaired by Booz Allen Hamilton Vice President and former CIA Director R. James Woolsey and former Congressman Tom Ewing (R. IL), they developed a series of recommendations to stimulate the widespread commercialization of both corn and cellulosic ethanol as a replacement for gasoline.

2006. 83 pages. ISBN: 89843-453-X, \$12 per copy

The New Energy Security

The first annual Forum on Global Energy, Economy and Security was held in October, 2005. Co-chaired by James R. Schlesinger, former US Secretary of Defense and Energy, and Luis Giusti, Senior Advisor at CSIS and former CEO of Petrol os de Venezuela, the Forum discussed recent increases in oil and gas prices, global competition for reserves, whether oil production will peak soon, growth in demand in China and India, prospects for increased production in Saudi Arabia and Russia, US reliance on LNG imports to meet demand growth, and the links between globalized energy markets and perceptions of national security.

2006. 55 pages, ISBN#89843-442-4, \$12 per copy

Slow Fuse: Journalistic Approaches to Climate Change

At the 2005 Conference on Journalism and the Environment, leading newspaper editors, broadcast producers, policy experts and environmental journalists explored coverage of issues like climate change that are slow to develop but likely to have serious long-term consequences. The report, written by Larry Pryor, suggests 10 steps to help news organizations develop innovative and compelling reporting. The conference was convened by two Aspen Institute Programs—Energy, the Environment, and the Economy; and Communications and Society—and the Nicholas Institute for Environmental Policy Solutions at Duke University.

2006. 53 pages. ISBN: 0-89843-448-3, \$12 per copy

Electricity: Who Will Build New Capacity?

The report of the 2005 Energy Policy Forum, chaired by Cinergy Corp. Chairman and CEO James E. Rogers, examines who will build needed new power generation and transmission facilities in a new regulatory environment. The report is organized around recommendations on market design, energy efficiency, innovation and technology choice, carbon management, and infrastructure security.

2005. 46 pages, ISBN# 89843-440-8, \$12 per copy

A Silent Tsunami: The Urgent Need for Clean Water and Sanitation

Based on a 2005 dialogue co-sponsored by the Aspen Institute and the Nicholas Institute for Environmental Policy Solutions at Duke University, this report provides a series of recommendations for governments, businesses, and other organizations. Co-chairs William K. Reilly and Harriett C. Babbitt highlight the urgency of the challenge and the array of public and private initiatives to tackle it.

2005. 40 pages, ISBN# 0-89843-435-1, \$12 per copy

Conserving Biodiversity

Co-chaired by Bruce Babbitt, former U.S. Secretary of Interior, and José Sarukhán, Professor of Ecology and former President of the National University of Mexico (UNAM), this 2004 dialogue was based on commissioned discussion papers and focused primarily on the policy drivers of ecosystem degradation and biodiversity loss. This report seeks to educate policy makers and opinion leaders on the loss of critical ecosystems and biodiversity and to recommend specific changes in policies that may affect biodiversity, such as trade, aid, and lending policies.

2004. 120 pages, ISBN# 0-89843-423-8, \$16 per copy

A Climate Policy Framework: Balancing Policy and Politics

The Aspen Institute, in association with the Pew Center on Global Climate Change, convened a diverse group of leaders to develop a politically feasible framework for a mandatory U.S. climate change policy. Co-chaired by Eileen Claussen and Robert W. Fri, the group did not discuss *whether* mandatory action is now warranted. It did, however, reach consensus on several fundamental elements of a national policy, *if* one is adopted.

2004. 100 pages, ISBN# 089843-397-5, \$8 per copy.

Tackling the Critical Conundrum: How Do Business, Government and Media Balance Economic Growth and a Healthy Environment?

Former EPA Administrator Christine Todd Whitman and former Undersecretary of State Frank Loy co-chaired a Forum in Aspen on balancing economic growth and a healthy environment. This report includes their conclusions and discussion papers exploring the tradeoffs from the perspectives of business leaders, elected officials, investment firms, journalists, and economists.

2004. 102 pages, ISBN# 089843-435-1, \$12 per copy.

Fossil Fuels, the Hydrogen Economy, and Energy Policy

The 28th annual Energy Policy Forum considered key variables affecting supply and demand for each of the fossil fuels, domestically and globally, including new technologies and the competition offered by alternatives such as renewables and nuclear. It then examined the problems and potential of hydrogen, including its primary fuel source. Finally, based on these discussions, it suggested guidance for the development of near-term government energy policy. Red Cavaney, President and CEO of the American Petroleum Institute, and Susan Tomasky, Executive Vice President and CFO of American Electric Power Company, co-chaired the Forum.

2004. 62 pages, ISBN# 0-89843-422-X, \$8 per copy.

Electricity Restructuring

The 2003 Energy Policy Forum focused on electricity restructuring. Chaired by former Director of Central Intelligence and Undersecretary of Energy John Deutch, participants discussed the advantages and disadvantages of national rules governing transmission, economic and market power issues affecting ownership, whether the market's choice of fuel is in the national interest, whether natural gas supplies are adequate, and how restructuring will affect the future of nuclear power, renewables, efficiency, and distributed generation. A series of Electricity Recommendations were sent to Congressional and Administration leaders following the Forum.

2003. 55 pages, ISBN#: 0-89843-389-4, \$8 per copy.

U.S. Policy on Climate Change: What Next?

Following U.S. withdrawal from the Kyoto Protocol, the Aspen Institute invited a distinguished group of scientists, business leaders, and environmental experts to discuss what the U.S. should do next. The non-technical discussion papers provide useful background and innovative policy suggestions. Forum co-chairs Frank Loy,

Undersecretary of State under President Clinton, and Bruce Smart, Undersecretary of Commerce under President Reagan, summarize the discussion and the Forum's conclusions in a compelling introductory essay. The group concluded that the U.S. government needs to send a signal now that carbon emissions will have a cost in the future.

2002. 200 pages, ISBN# 0-89843-344-4, \$16 per copy.

Dam Removal: A New Option for a New Century

This report offers a series of recommendations and practical advice to make it easier to integrate the consideration of dam removal into river management decisions, and to evaluate fairly and, if appropriate, to implement dam removal effectively. It is the product of a two-year dialogue among a group of people who represent a wide range of interests and disciplines. The imprimatur of this diverse group, with interests that are often at odds, lends a unique weight to the wide-ranging and practical recommendations.

2002. 68 pages, ISBN# 0-89843-360-6, \$12 per copy.

U.S. Policy and the Global Environment: Memos to the President

Prior to the 2000 election the Aspen Institute convened a distinguished group of leaders as a hypothetical committee to advise the new President on global environmental policy. Experts prepared this set of policy memos to tell the President, concisely and in understandable language, "what he should know" and "what he should do" about climate change, biodiversity, population, oceans, water, food and agriculture, and other problems. A thematic summary of the group's conclusions, written by co-chairs Donald Kennedy of Stanford University and Roger Sant of the AES Corporation, communicates the urgency of the challenges, the complexity of the inter-related issues, and the optimism necessary to tackle them.

2000. 220 pages, ISBN#0-89843-303-7, \$16 per copy.

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