ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION

PROCEEDINGS OF THE TWENTY-THIRD ANNUAL ILLINOIS ENERGY CONFERENCE

1995

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The University of Illinois at Chicago
ENERGY RESOURCES CENTER

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION

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PROCEEDINGS OF THE TWENTY-THIRD ANNUAL ILLINOIS ENERGY CONFERENCE

HOLIDAY INN CITY CENTRE
CHICAGO, ILLINOIS

NOVEMBER 20-21, 1995

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Energy Resources Center
University of Illinois at Chicago

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FOREWORD

FOREWORD

The Twenty-Third Annual Illinois Energy Conference entitled, "Energy and Environmental Policy in a Period of Transition" was held in Chicago, Illinois on November 20-21, 1995. It was organized by the Energy Resources Center, University of Illinois at Chicago with support provided by the U.S. Environmental Protection Agency, the U.S. Department of Energy and the Illinois Department of Commerce and Community Affairs.

In past years, the annual conference has focused on one particular energy issue such as electric power generation, natural gas, coal, nuclear, etc. This year the cycle was altered by centering the conference program on the political change in Washington as reflected by the legislation proposed during the 1995 session of Congress. The conference program explored how federal policy in energy and environment is changing and how these shifts will impact the economy of the Midwest.

The conference was divided in four plenary sessions. Session I focused on the national policy scene where speakers discussed proposed legislation to change federal energy and environmental policy. Session II looked at the future structure of the energy industry, projecting the roles of natural gas, the electric utility industry, and independent power producers in the overall energy system of the 21st century. Session III examined current federal policy in research and development as a baseline for discussing the future role of government and industry in supporting research and development. In particular, it looked at the relationship between energy research and development and global competitiveness. Finally, Session IV attempted to tie these issues together and consider the impact of national policy change on Illinois and the Midwest.

Appreciation is extended to the excellent speakers whose papers appear in this publication. The high quality of the program reflects the considerable time and effort expended by the speakers in the preparation of the presentations. In particular, I thank the keynote speakers, Kelly Carnes, Theodore Eck, George Bugliarello and Porter Womeldorff. I also thank the conference planning committee for their outstanding efforts which are reflected in the final conference program. In addition, a word of thanks is given to the University of Illinois Energy Resources Center staff who handled the detail work of the conference.

I hope you find these conference proceedings useful in understanding the critical issues facing the nation's energy and environmental policy.

James P. Hartnett
Conference Chairman

INTRODUCTORY REMARKS

INTRODUCTORY REMARKS

Cherri J. Langenfeld
Manager
Chicago Operations Office
U.S. Department of Energy

Believe me, as a federal employee when I say I am happy to be here, it is more than just a formality. Being on-the-job is not something any federal employee can take for granted in these times.

I am sure you are thinking of the great debate on the deficit and budget unfolding in Washington as we meet here today. So am I, and so are those who would have liked to have been here today to discuss these issues, but who are not. But I am also thinking about the other great changes sweeping government, and indeed, all of our society.

In the last year, the Department and its many subordinate offices and laboratories have been jointly and separately threatened, or perhaps I should say "challenged," with extinction, downsizing, rightsizing, realignment and re-engineering. Some of this has been blatant political grandstanding. Some has been thoughtful, necessary and overdue re-examination of roles, responsibilities and missions.

When our planning committee decided to focus on the changing national policy scene as it relates to energy and environmental issues, I am sure they never anticipated how unsettled that policy picture would be this November. This last year has been a challenging one for all those associated with energy policy, research and development, our National Laboratory system and our efforts to find consensus on matters of the appropriate role of government.

Today we will talk about a wide array of events and activities that combine to make the looking glass into the energy and environmental policy future a cloudy one indeed. Some of these forces at play include:

- The Galvin Task Force and the President's Technology Policy and associated Review of the National Laboratories, which challenged our management of these facilities and their justification, efficiency and mission focus.

- The Yergin Task Force on Energy R&D which sounded an alarm about the decline in federal and private investment in energy research and development.

- The Department of Energy's strategic alignment, restructuring and related efforts to improve efficiency and effectiveness within the DOE system.

- The new Congress' efforts to eliminate the deficit and reduction in support for basic, and particularly applied R&D.

- The redefinition of technology transfer and the role of government in commercialization of new technologies.

- And the reconsideration of a wide range of environmental regulation and legislation by a Congress determined to redirect the nation onto a different path.

That should certainly be enough to keep us talking over the next couple of days. And I strongly suggest that we all commit to do just that at this conference. Let's make this a dynamic exchange in keeping with the nature of the times. Events have already shaken up the program; let's continue the process. It will be terrific if we can all learn as much or more from all of you out there as you do from those of us up here! In my experience, this is a conference where the audience reflects tremendous expertise, experience and insight. As they say now, let's "dialogue." I am not really sure what that means, but let's try anyhow. It is *our* conference after all.

INTRODUCTORY REMARKS

Frank M. Beaver
Deputy Director for Energy and Recycling
Department of Commerce and Community Affairs

Welcome to the 23rd Annual Illinois Energy Conference. I bring you greeting from Governor Edgar, Lt. Governor Kustra and Dennis Whetstone, Director of the Illinois Department of Commerce and Community Affairs. The theme of the 1995 conference, Energy and Environmental Policy in a Period of Transition, certainly is timely because in both federal and state government, transition is the watchword for many programs, especially energy.

Many of you already know that my former department, the Department of Energy and Natural Resources, has been eliminated with the formation of a new Department of Natural Resources. However, the energy conservation, alternative energy, coal and recycling programs have been moved under the Department of Commerce and Community Affairs (DCCA), the state's economic development department.

Since moving to DCCA on July 1st, the notion that energy and recycling are of great economic development interest to the State of Illinois has become even more apparent. Excessive waste disposal and energy costs are robbing Illinois citizens and industries of their economic competitiveness in the nation and around the world. Our exports will compete with the exports of other regions and nations, and the extent to which our costs for materials and energy are reduced, we will be in a better competitive position to market our goods.

Recycling, waste reduction and energy conservation, and the efficient use of coal can help to make Illinois' economic development more sustainable into the future. Delivering Illinois coal by wire to states south and east by building clean electric power plants at the mine mouth can bring mining related jobs back to southern Illinois. Building a strong recycling industry in Illinois can add value to the materials which were once considered waste. In fact, the Chicago Board of Trade has recently begun trading recycled materials as a commodity.

Ethanol fuel has always been an important economic development issue for Illinois. Over 17 percent of the Illinois corn crop is used in the production of fuel ethanol. Half of the ethanol produced in the nation is produced in Illinois, and 30 percent of Illinois gasoline is a 10 percent ethanol blend. In January, the E-85 flexible fueled Taurus will roll off the assembly line. This vehicle will use blends of ethanol from zero to 85 percent, automatically adjusting for the fuel percentage in the tank. These Fords will be built right here in Chicago, providing Illinois jobs and increasing the market for Illinois corn and ethanol fuel.

We believe that the energy and recycling programs now at DCCA are particularly well prepared for the transition which is occurring in this nation. By focusing on the longer term and quantifying the costs of our wastefulness, we can become more efficient in our use of resources, more competitive in the marketplace, and less burden on the environment.

KEYNOTE PRESENTATIONS

FEDERAL TECHNOLOGY POLICY IN TRANSITION*

Kelly H. Carnes
Deputy Assistant Secretary for Technology Policy
U.S. Department of Commerce

I want to thank the sponsors for giving me the opportunity to be with you today as you discuss federal energy and environmental policies and their impact on the economy. These topics are extremely important for all businesses today as we cope with the enormous changes occurring in the global business environment.

As the conference theme reflects, we are living in a time of great change — both political and economic. Many authors say that American business is in the midst of a triple revolution — driven by the globalization of markets; fierce competition, and rapid advances in technology. I do not believe they are exaggerating. Any one of these changes *alone* would be revolutionary. But they are all happening at the same time, and very fast. The combined effects are staggering.

Since the fall of the Berlin Wall, we have seen countries in the third world and the former Soviet block embrace market-friendly economic reforms and open their borders to trade and investment. Who would have imagined even a few years ago that we would see so much entrepreneurial activity in Russia and China? Or the Middle East? Or see Nelson Mandela elected President of South Africa?

These sweeping political changes around the world have accelerated the globalization of commerce that has been underway for the past two decades. The forces of globalization both expand and crowd world markets. In the next 20 years, developing countries will spend trillions of dollars on sewers, roads, health care, telecommunications, technology and consumer products, and Americans are well positioned to capture our share of that business. However, it is also painfully obvious that we will be competing for business against an ever increasing array of technologically sophisticated foreign competitors. Consider a few trends:

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*The author prepared this keynote address but was unable to deliver the presentation in person because of the temporary closure of federal offices resulting from the budget crises of 1995.

- From 1985 to 1990, the Asian economies grew at an average annual rate of 7.8 percent. DRI/McGraw Hill predicts that by the end of the decade, one-tenth of everything produced in the world will come from Asia.

- Although short term prospects for Latin America and the former Eastern block countries are much less healthy, many economists predict that these economies are ready to generate growth rates of 3.5 to 6 percent over the next several years.

- In 1994, *Economist* magazine predicted that by the year 2020 China will overtake the U.S. as the world's largest economy; and that in 2020, as many as nine of the top 15 economies in the world will be from today's third world. Just imagine what this shift in economic power would mean. If we believe competition is intense now, what will the world be like when more than three billion people in Asia, Latin America and Eastern Europe join us in the global marketplace?

As if the prospect of increasingly intense foreign competition were not daunting enough, consider the enormous impact of technology on the way we live, work and play in the United States. Nothing has more power to improve the quality of our lives. And nothing contributes more to competitive success in world markets.

Technology has enabled us to turn the traditional American system of mass production on its head. This rigid system for high-volume production of standardized products prevailed in the U.S. for most of this century. Mass production enabled a leap in productivity that fueled U.S. economic growth for several decades. But traditional approaches to manufacturing are too slow and inflexible for a world characterized by constant change, accelerating technological progress and fragmented global markets. As a result, high volume standardized production is giving way to flexible manufacturing systems and more customized products and services.

Technology is enabling small businesses to perform high-quality design and manufacturing work that previously required the resources of big business, while allowing big businesses to achieve the speed, flexibility and closeness to customers that were once the sole domain of smaller firms. Technology has allowed us to tear down corporate hierarchies; vest new responsibilities and decision-making in front-line workers; organize in teams that cut across business functions; and establish close links between producers, suppliers and customers.

Technology is transforming the performance of the economic system itself — by revitalizing old industries such as automobiles and steel; and creating whole new industries such as biotechnology, advanced materials, optical storage, and electronic commerce. Forty years ago, there was no computer industry. Today, the communications and information industries are among America's largest, constituting about 10 percent of the U.S. economy and employing more than 4.5 million Americans. And the economic importance of these technologies extends past the

borders of the communications and information industries. These technologies make it possible to access and manage vast quantities of information, which is transforming every sector of our economy — manufacturing and services, health care, education and government.

And the pace of progress is simply stunning. The power of the microchip has doubled every 12 to 18 months over several generations. To put this in practical terms, one of those greeting cards that plays "Happy Birthday" has more computer processing power than existed in the entire world before 1950. And children's video games today run on more advanced processors than the original 1976 Cray super computer, a machine that was accessible in its day only to highly trained physicists.

The implications of these trends are breathtaking. If raw computing power continues to double every 12 to 18 months, in a decade the typical home computer will be 1,000 times more powerful than the PC of today, and a single strand of fiber optics will have 100,000 times the capacity that it has today. It will not be too long before a single strand of fiber will be able to handle the entire volume of telephone calls on Mother's Day, the busiest calling day of the year.

Global competition and rapid technological change certainly present challenges for Americans. And there is every reason to believe that these trends will intensify as we move toward the 21st century. However, although we face a rapidly moving and complex world, there is one fact of which we can be certain. More than ever before, technological leadership is essential to our competitive success and to the national interests of the United States. As we enter the 21st century, our ability to harness the power and promise of leading edge technologies will determine, in large measure, our national prosperity, quality of life, global influence and national defense.

Much of America's economic growth has resulted from the willingness of the American people to embrace change and welcome new technology. Economists estimate that over the past 50 years, innovation has been responsible for as much as half of our nation's economic growth. And America's success at innovation is the product of a 200 year partnership between our public and private sectors. Sadly, some in Congress seem to have forgotten this fact — a point to which I will return later.

Our founding fathers envisioned a country of perpetual innovation and saw a need to encourage the champions of technological progress. Our strong system of intellectual property protection — codified in the Constitution — has long provided incentives to invent, to invest and to commercialize technology.

The federal government also played a key role in the early development of America's scientific and technological infrastructure. The Land Grant Act of 1862 led to the

land grant colleges of agriculture and industrial arts. Fifty years later, the establishment of the Agricultural Extension Service ensured that farmers across the nation received the benefits of the ground-breaking knowledge generated by these educational institutes. Both have played key roles in increasing the productivity of U.S. agriculture and making America the breadbasket of the world.

World War II saw a growing federal role in research, as America turned to science and technology for a battlefield edge. Perhaps no war effort better illustrates this role than the Manhattan Project. During the course of the project, the nation's first national laboratories were established in New Mexico at Los Alamos and in Tennessee at Oak Ridge.

The end of World War II marked the beginning of a watershed period in which the role of government in science and technology expanded dramatically. Vannevar Bush's 1945 report to President Truman, *Science the Endless Frontier*, suggested a vision that led to the largest and strongest scientific and higher education enterprise the world has ever seen. The federal government has provided the funds to enable these institutions to generate new knowledge and train world class scientists and engineers.

Since World War II, the government's R&D investments have paralleled its great missions — the fight to end communism, a man on the moon, the discovery of new knowledge, a clean environment. Federal R&D funding increased steadily following the end of World War II, and in the early years, was concentrated almost exclusively in defense. The space budget expanded rapidly in the 60s, and spending on energy and environmental R&D rose in the 70s when concerns in these areas emerged. Health research has grown steadily to where today it is approximately one-third of all civilian R&D spending. Between 1945 and 1980, defense and civilian expenditures were roughly equal, but defense spending accelerated rapidly in the 1980s. In 1993, defense R&D spending accounted for approximately 59 percent of the federal total.

The benefits of our public R&D investments far exceeded the attainment of those five government missions. For example:

- The aeronautical technologies that emerged from our defense and space missions positioned the American aerospace industry as the world's leader and America's leading net exporter of manufactured goods. Today, this industry produces the largest trade surplus of any American manufacturing industry.

- Government-driven advancements in electronics, computers, and satellite communications sowed the seeds for our world class computer and telecommunications industries which have allowed America to lead the world into the Information Age.

- And from public health research, we have seen a flow of blockbuster drugs and medical therapies propel our pharmaceutical industry. And that research base gave birth to the biotechnology industry, viewed by many as one of the major technological opportunities of this century. Today, the National Institutes of Health are recognized as the world's premiere health research enterprise.

In short, as a result of the vision, commitment, and investment of those who have come before us — in both the public and private sector — the U.S. has today a science and technology infrastructure second to none — an unparalleled R&D enterprise; a world class cadre of scientists and engineers; the world's most diverse and productive manufacturing base; a broad and technologically sophisticated service sector; and a climate and culture that encourage competition, risk taking and entrepreneurship. These assets provide American firms and workers with a competitive advantage in the global economy.

To sustain that competitive advantage into the 21st century, we must plan for the future and invest as wisely as the generations before us. We must recognize that in a world where goods, capital, technology and knowledge flow swiftly around the globe, we must build a set of competitive assets that remain within the borders of the United States, and we must develop strategies to attract wealth and job creating activities to our shores. We cannot rest on our past technological successes. Nor can we assume — as some in Congress do — that "market forces" will inevitably drive all the activities needed to maintain our technological leadership.

We need a national technology policy. And all the key players in the U.S. economy — private companies, the government, the academic community, and state and local economic development institutions — must come together to create it. This policy must be built on the firm foundations of our past success, grounded in the competitive realities of today, and designed to maintain American leadership in the world of tomorrow. I would like to spend my remaining time outlining briefly what I believe are some of the key elements of that policy.

First, and perhaps most important, is creating a business climate in which the innovative and competitive efforts of the private sector can flourish. We know that tax and fiscal policies, trade policy, antitrust policy and regulatory policy all have a significant impact on the ability of companies to develop technology, turn it into products and services and bring them to market.

The Clinton Administration has given a high priority to implementing pro-innovation policy reforms. For example, we have significantly eased export controls on U.S. advanced computer products, opening new and valuable markets to American firms. We won a three year extension of the R&E tax credit and are fighting to make it permanent. We won a targeted capital gains tax reduction for investments in small business, and we have freed up more capital for business investment by reducing the

federal deficit from almost $300 billion dollars in 1992 to $160 billion in 1995. We are working to replace our current "command and control" environmental regulatory system with a more flexible incentive based system. And we are working to make our food and drug regulatory reviews faster and more flexible and are eliminating the requirements for prior FDA approval for sales to many export markets.

The Administration carried through to success the fight for NAFTA and GATT. Since NAFTA took effect, our exports to Mexico have jumped 23 percent. The benefits of GATT will be perhaps 20 times greater than NAFTA. GATT will lower tariffs around the world by a third, strengthen the protection of intellectual property rights, and manufacturers of medical instruments, drugs and electronics will be immediate winners.

These market opening initiatives have been complemented by aggressive export promotion efforts that began with the development of a National Export Strategy. To assist smaller firms in increasing their exports, we have established one stop shops for export promotion services in 12 U.S. cities, with three more coming on line later this year. These include centers in Seattle, Long Beach, Cleveland, Denver, St. Louis, Baltimore and New York. We have also engaged top officials — from the President to Secretary of Commerce Ron Brown — in high-level advocacy on behalf of American companies. Their efforts have helped secure billions of dollars in sales for U.S. companies.

Second, to support U.S. industry and facilitate commerce in the Information Age, we must develop a world class national information infrastructure — a seamless web of communications networks, computers, databases and consumer electronics that will put vast amounts of information at users' fingertips. America's superior infrastructure — our roads and highways, seaports and airports, telecommunications and power systems, and even our financial and legal systems — is the product of a public-private partnership which has provided American firms with a competitive edge throughout this century. While these are still essential elements of American commerce, new kinds of infrastructure are needed to preserve America's edge in the new knowledge-based economy.

Private sector firms are leading this effort today through the development and deployment of the infrastructure. Nevertheless, there remain essential roles for government in this process. Carefully crafted government actions will complement and enhance the efforts of the private sector and ensure the growth of an information infrastructure available to all Americans at reasonable cost. Government should act as a leading edge customer by developing new applications for delivery of government services over the network; promote seamless, interactive user-driven operation of the National Information Infrastructure, through federal efforts in standards, measurement and testing; ensure network information security and reliability; and protect intellectual property rights by strengthening domestic copyright laws and international intellectual property treaties to prevent piracy and to protect the integrity of intellectual property.

Third, we must promote the rapid diffusion of new technology throughout the private sector. Economic growth and industrial competitiveness do not stem simply or automatically from the development of new technologies. Growth occurs because advances in knowledge are put to work in the private sector. However, technology diffusion can be a slow and uncertain process in the U.S. A study by the National Institute of Standards and Technology found that it takes 55 years for 90 percent of U.S. manufacturers to adopt a technology, compared with 18 years in Japan.

New manufacturing technologies and approaches are available that can lead to dramatic improvements in product quality, cost, and time to market. Although a few U.S. firms have begun to adopt these technologies and approaches, most firms still lag behind — especially our 370,000 small and medium sized manufacturers. Representing more than 95 percent of U.S. manufacturing firms, these companies form the backbone of the U.S. industrial base. Millions of jobs rest on their competitive performance.

To assist U.S. firms in adopting manufacturing innovations, the Commerce Department is leading the effort to implement President Clinton's vision of establishing a nationwide network of manufacturing extension centers — modeled after America's enormously successful agricultural extension program. This Manufacturing Extension Partnership is truly a public-private partnership among governments at the federal, state and local level, the academic community and various private sector institutions. These centers — each one designed to meet the needs of the local manufacturing community — provide assistance to U.S. manufacturers ranging from assessment of manufacturing and business practices to developing custom processes specific to a particular manufacturing problem. During the last two years, the manufacturing extension network has grown from seven to 44 centers.

The manufacturing extension centers are helping these firms become more competitive by reducing scrap, adopting computers, cutting lead times and increasing exports. In fact, in a limited study of our return on investment in manufacturing extension, companies working with the original seven manufacturing centers estimated collective bottom-line results totaling $320 million — achieved through a federal investment of $54 million. That is a six dollar return on every federal dollar invested. And those returns translate into jobs, growth and a more competitive America.

Fourth, in crafting a national technology policy for the 21st century, we must also acknowledge the growing role state and local governments and regional institutions play in fueling technology based growth in all regions of the country. Each level of government has unique and complementary experiences and resources. Strengths at the federal level include basic research, mission-driven R&D, and the ability to address national technology issues. Strengths at the state level include close

interaction with entrepreneurs and young companies, small and medium sized manufacturers, regional industrial coalitions, local boards and councils which support entrepreneurship and nurture technological leadership at the grass roots level. Our goal must be to integrate these complementary efforts more effectively to create synergies that will allow all levels of government to achieve more than would be possible acting alone or in isolation.

Last, but certainly not least, I want to talk about the importance of maintaining our public and private commitment to investment in civilian technology. I have saved this topic for last because it is the leading source of controversy in the technology policy debate taking place in Washington right now.

When you look at the way we live and work in America today, it is clear that we are now reaping the benefits of wise investments made ten, 20 or 30 years ago. While private investment has done the lion's share of the work in creating today's living standards, as I described in detail earlier, federal investment has also played a very important role.

This strong track record of success led policy makers from both political parties over the past 15 years to create a portfolio of civilian technology programs designed to more directly address issues of industrial competitiveness. These programs — such as the Commerce Department's Advanced Technology Program — represent a small fraction of the federal R&D investment, but promise large economic benefits to the nation. They are focused on high risk, pre-competitive technology development and on civilian utilization of federal laboratory expertise and resources.

These programs address the development of enabling and emerging technologies. New enabling technologies support advances across a wide range of industries, while emerging technologies promise to drive the development of entirely new industries and new classes of products and services.

While such technologies are the fundamental building blocks for future economic growth and competitiveness, often they are not pursued by individual companies in a competitive time frame, if at all, due to their high cost, high risk, complexity, distance from the market, and delayed returns. For example:

- Technology and product life cycles are getting shorter. In the electronics industry, the lifetime of a new model of personal computer is less than two years. A competitive player in commercial high technology may have to fund and manage three generations of technology simultaneously: one in full scale production, one in pilot production, and one in manufacturing process design and development. This could tax the budgets of even our largest firms.

- The cost and complexity of technology development are increasing. It can take $350 million to find a new drug and bring it to market. The price tag on

semiconductor fabrication facilities today can exceed $1 billion, and the next generation of fabs will probably run two to three times that. Moreover, our technologies are increasingly multi-disciplinary in nature. In short, cost and complexity may exceed the technical capabilities and financial resources of individual firms.

- Finally, enabling technologies have multiple uses. The potential application can exceed the product portfolios of most firms; an individual firm may not be able to justify the costly investment in R&D based on its segment of the technology's potential market.

Such characteristics often make pre-competitive technology development an unattractive investment for venture capitalists and for individual firms that must address more immediate business concerns and meet stockholder demands. And, while the pursuit of these enabling and emerging technologies may not make economic sense for individual companies, it makes good economic sense for the nation. Although these programs are relatively new, early results are very promising.

Despite these benefits, Congress is on the verge of enacting substantial cuts in federal civilian R&D investments. Current proposals would reduce federal spending on civilian R&D by 30 percent annually over seven years — that is about an $11 billion cut annually after adjusting for inflation. And these are cuts from current levels — not reductions in the rate of increase. All of the Clinton Administration's government/industry partnership programs are slated for elimination or severe reductions. And there are significant cuts to environmental technology development, technology for the safety of civilian aviation, and educational technologies.

These cuts, if enacted, will be serious and far reaching. In addition to reducing the pool of capital available for technology financing, they would eliminate more than 35,000 scientists and engineers from the U.S. R&D enterprise and may close world class facilities. They will also dramatically impact our world class university system. Charles Vest, President of MIT, estimates that MIT alone will lose at least $128 million per year in research funds.

While I support the goal of balancing the federal budget, I do not believe that now is the time to cut public investments in civilian research and development. Our R&D spending already lags that of our competitors. We invest about 2.6 percent of our GDP in R&D, while Japan and Germany invest about 3 percent. On a per capita basis, Japan out invests the U.S. by more than 35 percent; Germany out invests us by nearly 30 percent. In fact, the U.S. now ranks 28th in the world in the percentage of R&D invested in civilian technology. We rank behind every industrialized nation, and just ahead of the Czech Republic. And the Japanese are proposing to double their investment from 3 percent of GDP to 6 percent.

Americans have wondered and worried for the last two decades about our competitive position with Japan. If we slash our investments in civilian technology support while they double theirs, the consequences should be apparent relatively quickly. We must make a long-term commitment to sustained public and private investment in research and development if we want to maintain our technological leadership in the 21st century.

I would like to leave you with two final thoughts. The first is that all of the Administration initiatives and priorities I have described are based on the notion that it is absolutely essential to the future competitiveness of the U.S. that we end the traditional adversarial relationship between government and industry, and that we forge new and innovative partnerships that leverage and enhance our national technology assets. In today's global economy, partnerships make things possible. And other nations will not wait to see whether or not we Americans can get it right.

And finally, I want to emphasize that each of us in the technology business community has a responsibility to ensure that the U.S. maintains its technological leadership. There is a great debate taking place all across the country — at the federal, state and local level — about what it will take to ensure America's technological leadership into the next century and about the proper roles of the government and the private sector in achieving this leadership. I urge you and the organizations you represent to join that debate and help us shape a new civilian technology vision and strategy for the United States. All of us must take part if we hope to get it right. I believe the future of our children and grandchildren depends on it.

AN EVALUATION OF PENDING ENERGY AND ENVIRONMENTAL POLICY

Theodore Eck
Chief Economist
Amoco Corporation

INTRODUCTION

In 1994 we launched the first major restructuring of Amoco Corporation in more than 30 years, making profound changes in the organization of our business to improve our financial performance and position Amoco for long-term growth. The restructuring was the natural result of the renewal of our corporation, a bold initiative launched several years ago to make a successful organization even more so. In that time we have made significant changes in how we do our work, altering processes and systems to increase our effectiveness and efficiency. We instituted Amoco Progress to unite the best practices of quality management throughout the corporation.

We have taken the necessary steps toward being a strategically managed company. We are resolute that Amoco's degree of success will not be determined solely by external forces, but by our ability to create the future we desire and to manage to our benefit the appropriate response to external forces.

Unlike our 1992 cost-cutting efforts, the 1994 restructuring goes far beyond eliminating jobs and expenses and creates a new organization. But the impact of the two efforts combined leaves us with a streamlined work force and annualized pretax savings of about $1.2 billion.

The goals of our restructuring are improved profitability, cost leadership, long-term growth, enhanced customer focus and increased speed and agility. In support of these objectives, we eliminated the operating-company level of management and staff that has long formed the "middle" layer of most major integrated petroleum

companies around the world. The new organization is structured around 17 business groups divided into three sectors — exploration and production, petroleum products and chemicals. These sectors generally follow the segments we use for external reporting.

The operations of the business and primary profit-and-loss accountability now belong to the 17 business groups. They are closer to their customers, more flexible and nimble, better able to react quickly to the marketplace and better able to focus on costs than large operating subsidiaries. With the business groups less restricted by bureaucracy and red tape, they are better able to succeed in their operations. At the same time, senior corporate leaders on the Strategic Planning Committee are better able to focus on the future, serve the corporation as a whole and achieve a truly strategic view of the external world. We have designed a more responsive corporation that can better address the competitive pressures of today and tomorrow.

We also recast our 14 support departments into a Shared Services organization in which business units share the services they need and participate more fully in setting cost and quality levels. This allows us the best combination of in-house expertise, outside-vender perspective and relentless pressure on costs. Some other organizations have implemented this concept on a limited scale; we believe Amoco is the first to do so in such broad fashion. We believe this bold step will give Amoco a strong competitive advantage.

Corporations undertake a restructuring for many reasons, often in desperation during times of crisis. For Amoco, restructuring comes not from fear, but from confidence and our commitment to continuous improvement. Ours is a fundamentally sound business that can provide strong returns to shareholders, tremendous opportunity for personal and professional growth to our employees, and the challenge of developing the energy and chemical products needed for the future success of the global economy.

FIGURE 1

PETROLEUM'S SHARE OF TOTAL MERCHANDISE IMPORTS

FIGURE 2

U.S. OIL CONSUMPTION

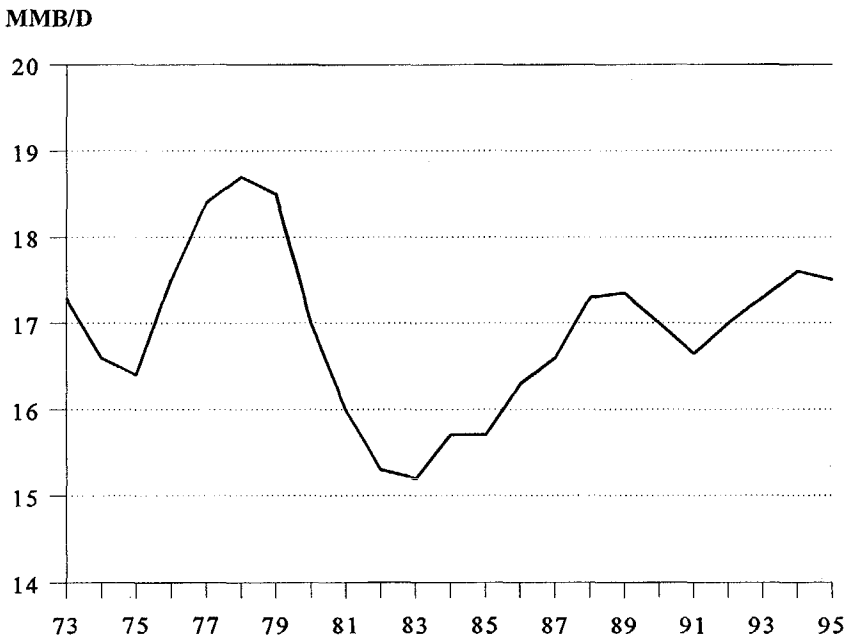


FIGURE 3

U.S. CRUDE OIL WELLHEAD PRICE

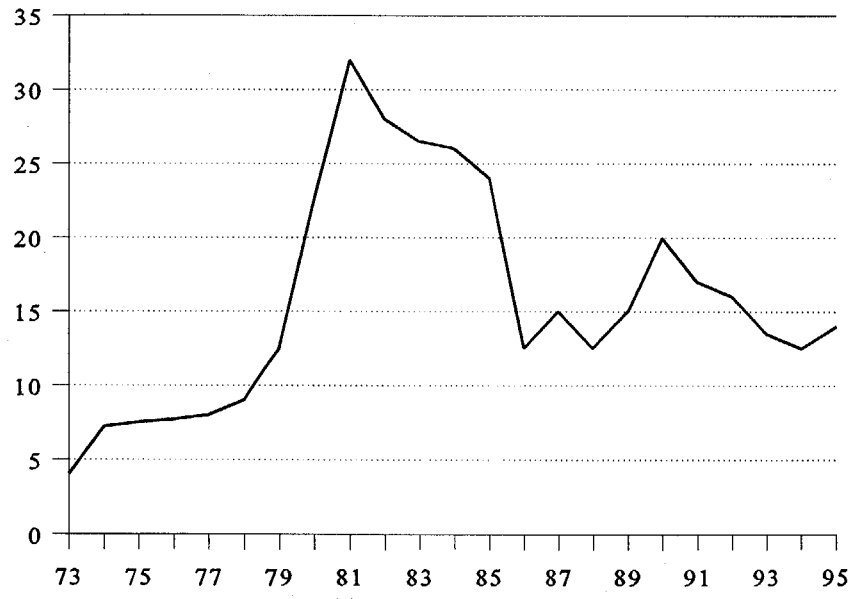


FIGURE 4

REFINERY GATE PRICE OF GASOLINE

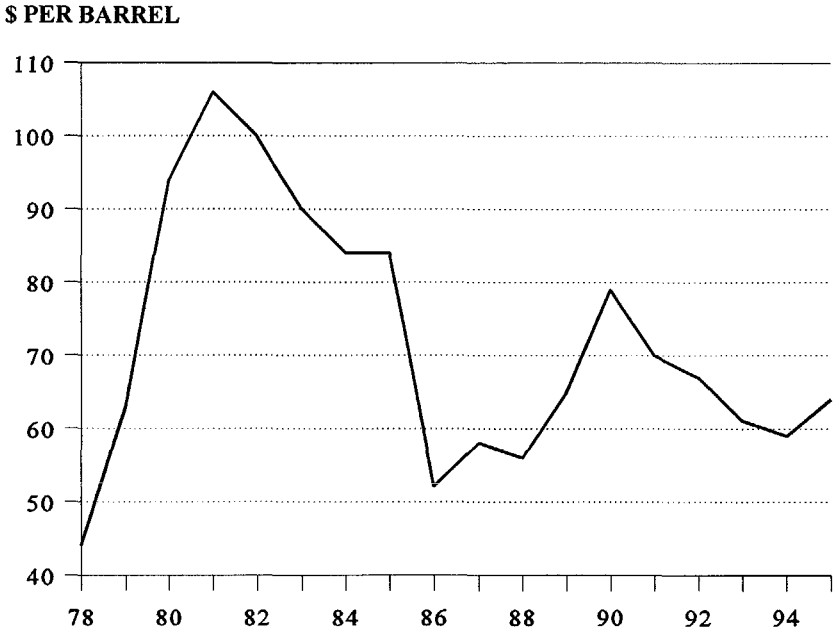


FIGURE 5

U.S. NATURAL GAS CONSUMPTION

FIGURE 6

U.S. NATURAL GAS PRICE AT WELLHEAD

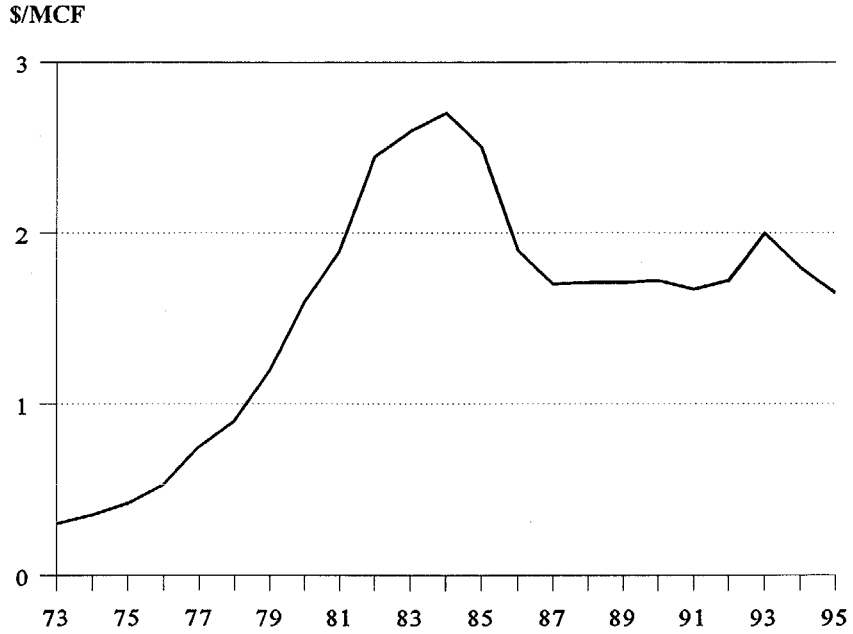


FIGURE 7

U.S. NATURAL GAS UNDISCOVERED RESOURCES

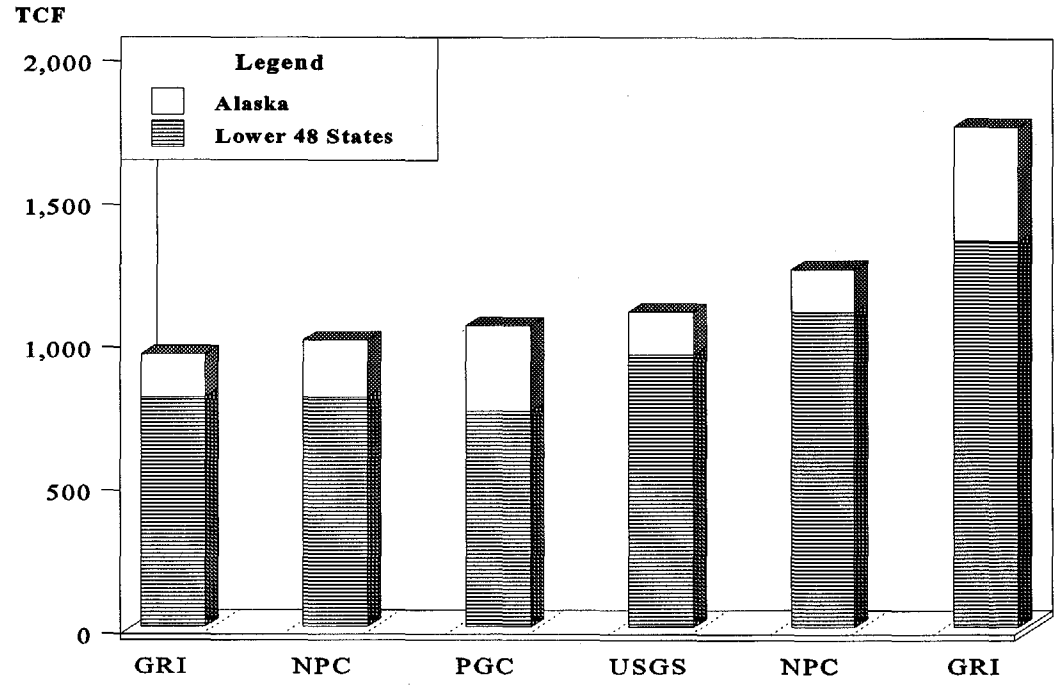


FIGURE 8

ESTIMATED WORLD CRUDE OIL RESERVES

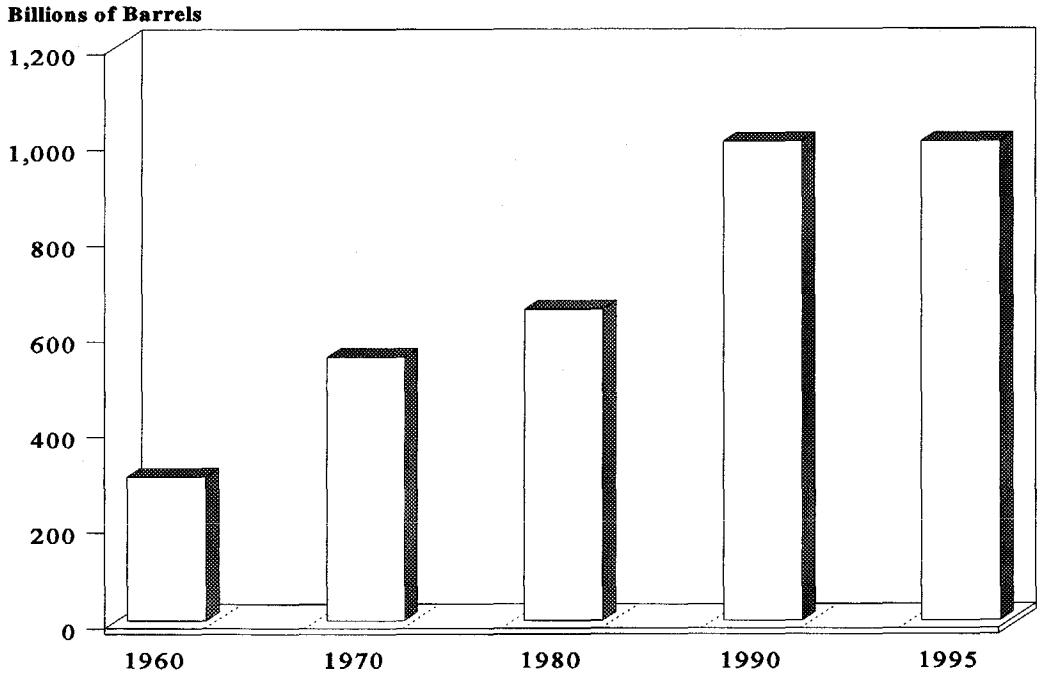


FIGURE 9

CHANGES IN OPEC PRODUCTION CAPACITY, 1994 - 2000 (MMB/D)

SAUDI ARABIA	0.5
IRAN	0.4
KUWAIT	0.7
IRAQ	2.3
VENEZUELA	1.4
AFRICAN OPEC	0.9
OTHER OPEC	0.5
TOTAL	6.7

FIGURE 10

TOTAL REGISTERED MOTOR VEHICLES IN U.S.

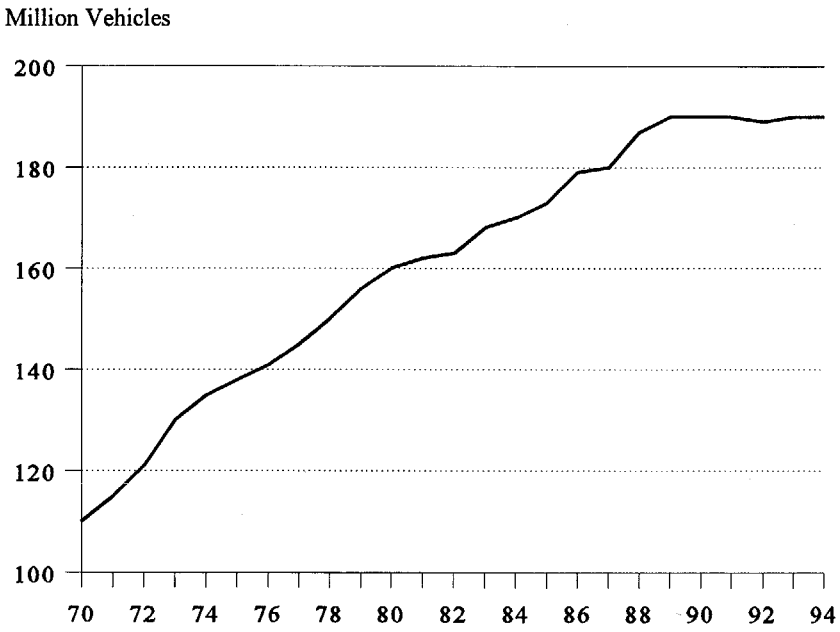


FIGURE 11

AVERAGE NUMBER OF CO EXCEEDANCES

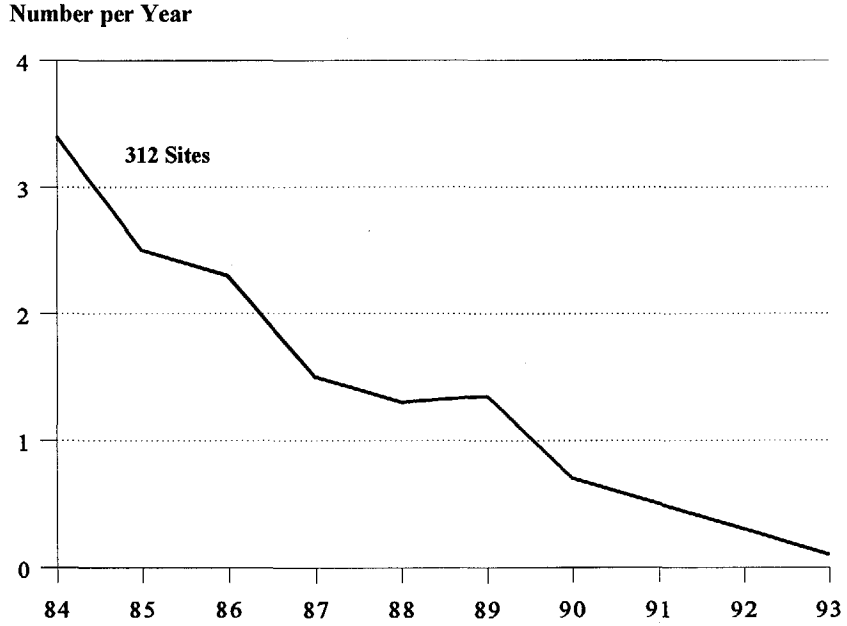


FIGURE 12

AVERAGE NUMBER OF OZONE EXCEEDANCES

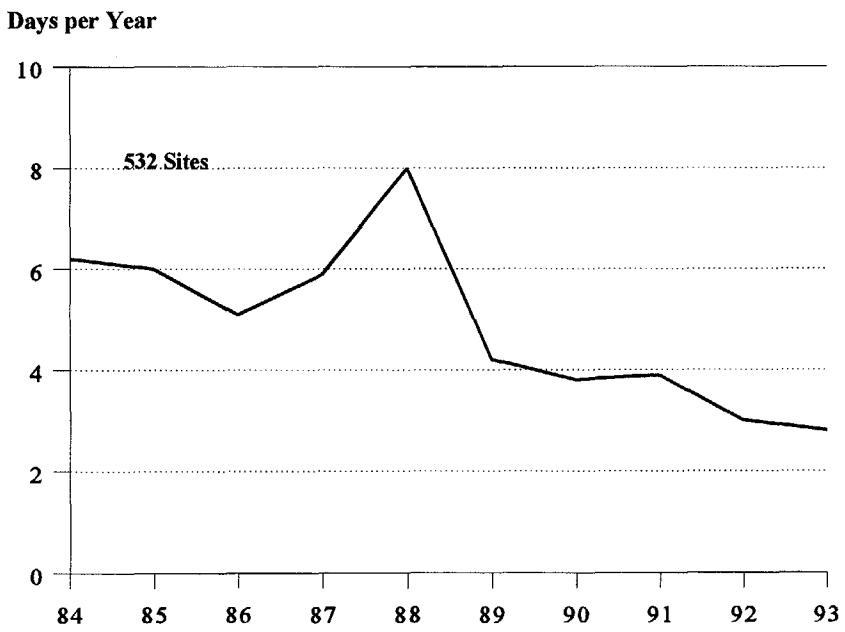


FIGURE 13

MOTOR VEHICLE EMISSION STANDARDS (NON-METHANE HYDROCARBONS)

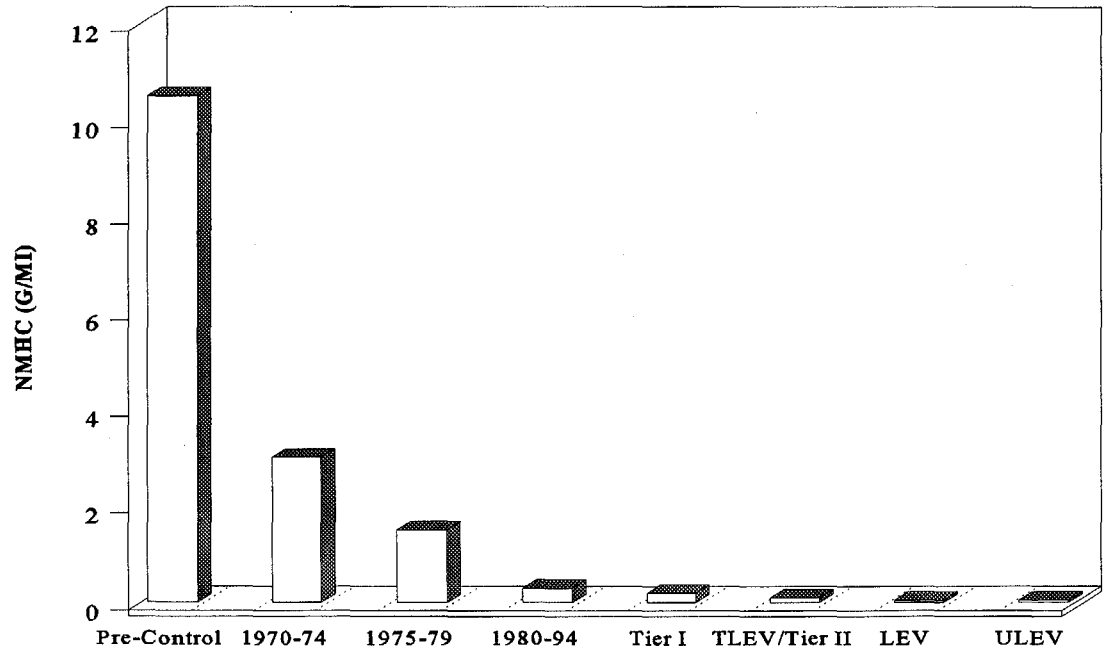


FIGURE 14

POLLUTION REDUCTION FROM REFORMULATED GASOLINE

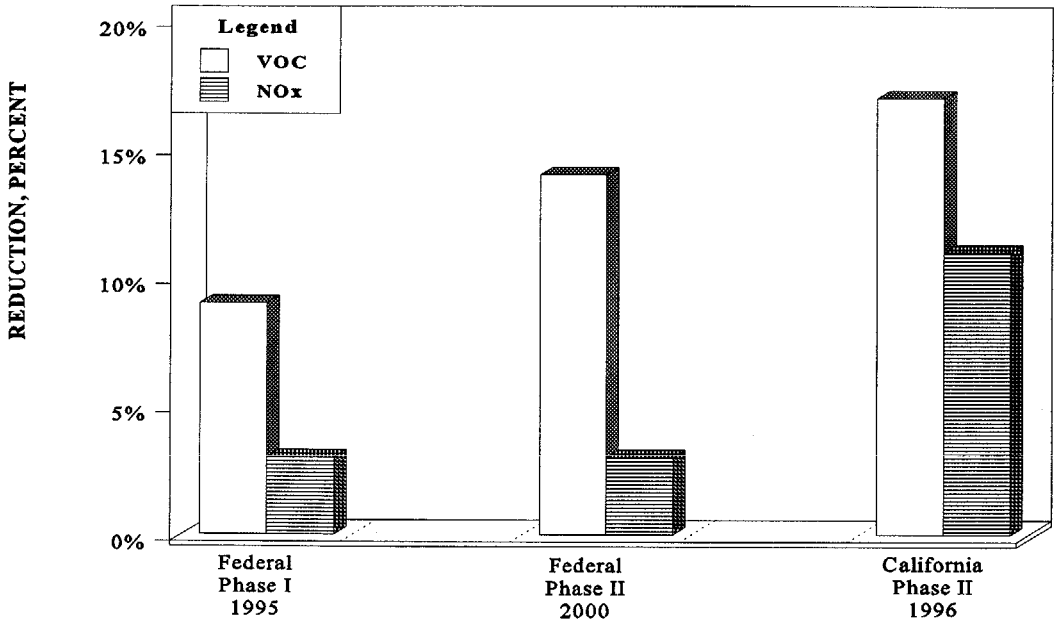
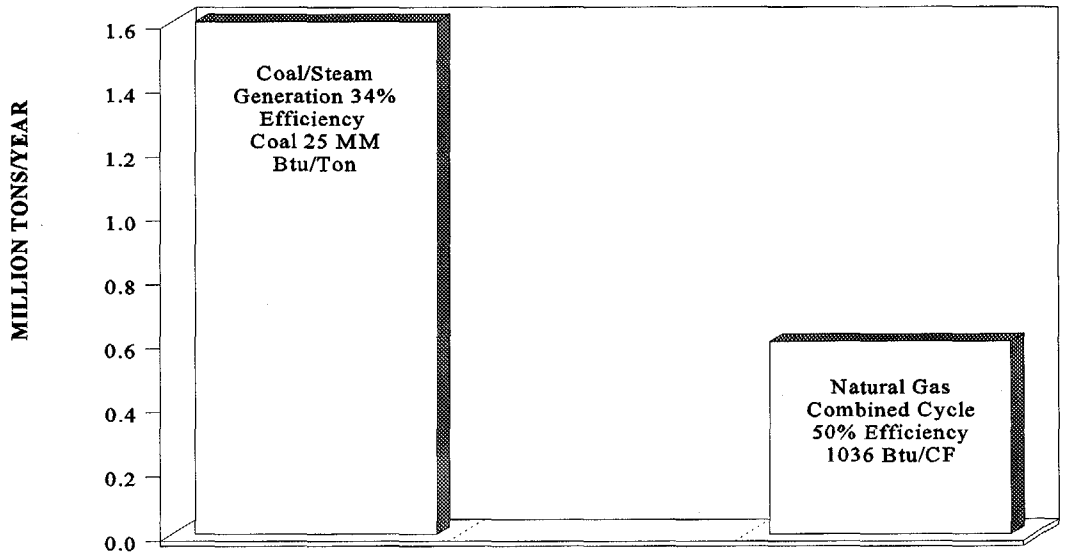


FIGURE 15

CARBON DIOXIDE EMISSIONS FROM 300 MW PLANTS



R&D IN THE U.S. TODAY: A DIFFICULT MOMENT AND NEW NEEDS

George Bugliarello
Chancellor
Polytechnic University

INTRODUCTION

That research and development in the United States are going through a difficult period is quite obvious. There are contractions in the support of research, and major uncertainties about the directions in which the federal government as well as our competitive environment will lead research. These uncertainties are accentuated by the recent election of a new group of legislators in Congress who are moving to the beat of a different drummer.

The difficulty and the climate of the moment are exemplified by the elimination of the Office of Technology Assessment, by the proposals that were advanced not too long ago for the elimination of the Department of Commerce (DOC), the Department of Education (DOEd), and the Department of Energy (DOE), and by the large amount of budget cuts proposed for a number of R&D agencies, from NIH to NASA to NSF to EPA. Thus, in the budget resolution passed by Congress on June 29, 1995 for nondefense R&D between now and the year 2002, DOE, DOC and the Department of the Interior are to be cut respectively by 47.4 percent, 50 percent and 44.4 percent. The total projected R&D budget cuts would amount to 32.9 percent — from 34.164 to 22.939 billion dollars between 1995 and 2002.

In industry, a wave of restructuring has led to reductions in R&D budgets of many companies and to the tendency to decentralize R&D and at times partially outsource it. The difficult moment for R&D is also underscored by the demoralization of academic science and engineering, which for quite some time have operated at nearly stationary budgets. The situation is aggravated by the relative decline of scientists

and engineers in the labor force (Figure 1) which has also contributed to the reduction in student interest in science and engineering (Figure 2). (All tables and figures appear at the end of this paper).

THE ROLE OF GOVERNMENT IN R&D

The role of the federal government in R&D should be viewed in terms of the government's — indeed of any national government — essential responsibilities. They fall into two categories: defense and the well-being of the citizens. Defense involves both a military component and a component addressed to issues of geopolitical security, such as the potential instabilities associated with energy dependency, with the situation in the former Soviet Union, and with the economic problems of developing countries. Ours is a world in which over half the population — 2.6 billion people in 40 countries — have a GNP per capita of less than 500 U.S. dollars, while at the other extreme, 25 countries with 700 million people have a GNP per capita ranging between 6,000 and 9,000 dollars (and 70 countries with 1.4 billion people have a GNP per capita falling between these figures).

The government's responsibilities concerning the citizens' well-being range from sustainable development (in part also an issue of geopolitical security) to issues of health, environment, safety, jobs and competitiveness — which in turn involve education, science, engineering, standards, infrastructure, etc. — to the long-range but essential goal of expanding our outreach as human beings, e.g., through space exploration or genetic engineering.

An early involvement of the federal government in R&D was through the establishment by President Lincoln in 1860 of the National Academy of Sciences. Abroad, a much earlier and very successful example of the involvement of governments in R&D was the school of navigation established in Portugal under the aegis of Prince Henry the Navigator at Sagres in the 1400s. That school was responsible for the great advances in navigation that led to great geographic discoveries from the 15th century onward. Other historic examples include the development of astronomy in ancient China, Egypt, and Babylon, as well as the pre-Columbian civilizations in the Americas, the support by the British Admiralty of the search for a marine chronometer, and establishment of the Water Magistrature in Venice for the study and regulation of that republic's rivers and harbors.

In the United States, significant government-sponsored R&D occurred in World War I. The period between World War I and World War II saw the creation of NACA — the forerunner of NASA — of the TVA and of other agencies that had some involvement in research. However, the great involvement of the U.S. government in R&D came with World War II, and grew enormously afterwards under the spur of the military and space competition with the U.S.S.R. That was the

period of Vannevar Bush's conception of science as the endless frontier, of the creation of the research offices of the armed forces, of the NSF, the NIH and, later, of the Strategic Defense Initiative. In that period the entire government establishment grew and so did the demand for federal support of all sorts of research. The universities — particularly the research universities — were among the major beneficiaries and the number of graduate students in engineering and science increased dramatically.

However, in the 80s the competitive position of some sectors of our civilian economy deteriorated significantly, not only because of the enormous stresses of the Cold War and the new geopolitical responsibilities we had assumed or had been thrust upon us, but also because of our inability or unwillingness to respond effectively to some technological changes, and to the inroads of products from abroad. The inroads had multiple causes: poor quality and unresponsive design of some of our products, high labor wages which, in spite of a substantial dollar devaluation, made it still much cheaper to produce abroad, and an imbalance of payments caused by a voracious consumer society. One of the consequences, unfortunately, was a reduction of R&D budgets in industry.

Today, federal budget deficits have brought about a political rethinking of our economic situation and, with that, a drastic reassessment of the role of government in R&D. This is exemplified by the views of the Chairman of the Committee on Science of the U.S. House of Representatives, Robert Walker, in a letter published in *Science* on July 13, 1995:

> "First, we should return the focus of government-sponsored research to the area of basic science where it belongs.
>
> ... every year the United States pumps billions of dollars into corporate welfare, shelling out money to the R&D departments of huge corporations ... the return to the American taxpayer is about 20 cents [on the dollar].
>
> ... by prioritizing basic science, government can leave technological development to industry.
>
> ... the federal science bureaucracy has become bloated and unmanageable ... it forces researchers to spend too much time competing for funds and not enough researching."

This is clearly an over simplistic view of the issues. Although the need for a balanced budget is imperative, also essential to the survival and well-being of the nation is that R&D be viewed in terms of the two fundamental responsibilities of the government outlined earlier. This means a government involvement in at least four research directions:

- Fundamental research
- R&D for defense and health-care
- R&D for some critical new technologies
- R&D for competitiveness

Fundamental research is the engine for the acquisition of knowledge on which a knowledge-based society vitally depends. It has two important characteristics: it is relatively cheap and it offers today many opportunities, particularly at the interfaces of different fields, as we have seen in the case of chemical engineering and molecular biology, or of optics and electronics. In a competitive market economy industry can afford to do only a limited amount of long-term basic research, as evident from the slow development of alternative energies. Neither is industry well equipped to do broad interdisciplinary research. Also, there are areas today in which U.S. industry, because of its structure, does virtually no research, as in the case of the construction industry or of many small and medium manufacturing enterprises. In all of these cases, research will not be done without some form of government intervention. Although the U.S. continues to be the largest performer of fundamental research in the world, the trend is downward, while it is up for Japan or Korea. The danger of a downward trend is enhanced by the fact that we are poor "hunter-gatherers" of information abroad.

The need for *government involvement in research for defense and health-care* is obvious. In the case of the military, we are moving increasingly away from large production grants toward R&D-intensive prototyping. In the case of health care there is a shift of emphasis toward prevention. This is necessary, but should not occur at the detriment of advanced basic research, which depends largely on forms of government support.

More debated today, but in my view essential, is the satisfaction of the other two needs, *R&D for some new technologies* that have promise but for which there is no sufficiently organized or critical-sized industry support, and *R&D for competitiveness*, in areas where R&D can make a difference, if rapidly and effectively deployed.

The key issues concerning federal R&D are basically three: the areas in which federal R&D should be involved, the level of support, and the methods of support. A number of *areas where federal support is necessary* have been discussed earlier, from military R&D to health-care R&D, to potential underpinnings for new technologies, e.g., in the biomedical sector and, indeed, in energy. Other obvious areas are the infrastructure and the environment, including nuclear waste, and sustainable development, which today is very much an orphan. The general health of the science and engineering disciplines needs to be maintained both in basic areas as well as in areas of applications. Finally, it is important to support some research that helps us to maintain a "window" on R&D developments abroad, even if we decide to downgrade our research effort in certain sectors.

The question of *level of support* needs to be addressed at least in three ways. The first is empirically, by looking at what the competition is doing. It is clear that the decreasing fraction of GNP we are investing in R&D reduces our competitive position abroad, particularly if we consider that a large fraction of our R&D is involved in defense and health-care.

Secondly, we need to consider in a rational way, like a zero base budgeting, what are the research needs of a knowledge-oriented society. The figure of 3 percent, which today seems to be empirically an upper limit for the GNP devoted by nations to R&D, may turn out be inadequate.

Thirdly, the level of support must also be considered by taking a perspective look at what may lie ahead — e.g., the potential changes in our own society, as well as the potential geopolitical instabilities mentioned earlier.

As to the *method of support*, the first decision, of course — one that affects, for instance, the national laboratories — is the extent to which federal R&D is to be done in-house and the extent to which it is not. For what is not done in-house, the issue is what is the appropriate mix of direct federal support and incentives. Both are necessary, but in what proportion? Even if we favor incentives, we need to remind ourselves that they can be counterproductive if not well designed.

THE ROLE OF INDUSTRY

It is clear that, for its own survival, industry cannot abandon R&D. For instance, the decline of non-military ship building in the United States is due to a variety of causes, but undoubtedly a significant contributor has been the almost total abandonment of research in that sector: innovations in new materials, new ways of joining materials, "intelligent" components, etc., have been sorely lacking, except for recreational boat building. Another negative example is the area of construction, where productivity has been negative in recent years, and R&D is at a minimal level.

In general, several recent trends are affecting R&D, usually negatively. Leveraged buy-outs, mergers, downsizing and privatization have led to less R&D and to an emphasis on short-range research.

Globalization has had a mixed impact. Although we do not have precise data, we know that it has led to increasing outsourcing abroad of R&D. At the same time, however, it has opened broader markets and therefore enhanced the R&D needs of U.S. firms.

The R&D in energy utilities, already limited under the aegis of the industry's regulated regime, paradoxically, is being further impacted in a negative way by

deregulation. Stranded assets have become a millstone around the necks of some utilities, and competitiveness has led to reduction in R&D investments — a situation which may change in the long term, however. Also, it is clear that alternative energies will continue to need to be subsidized.

All this can be summarized by saying that in several sectors of our economy there is a dangerous imbalance between innovation in marketing and finance and innovation in technology. Financial and marketing considerations have become dominant and innovation in financial instruments, particularly in the case of the infrastructure and energy utilities, often seems to be more vigorous than technological innovation. Finance, of course, is driven in turn not only by the investor, but also, and increasingly, by the convenience of the consumer to whom technology must become more responsive, including R&D.

FEDERAL R&D IMPACT ON OUR ABILITY TO REMAIN COMPETITIVE

The impact of federal R&D has been historically extremely significant in selected areas, such as aerospace, nuclear power or communication satellites. In general, however, industry itself is in the best position to address competitiveness in most other areas. But this does not obviate the need for involvement of the federal government in the enhancement of U.S. international competitiveness through at least five sets of actions:

- Supporting basic science and technology education and research as the underpinnings of the knowledge base of the U.S. and its industry.

- Providing enlightened support of other key elements of the R&D infrastructure — research laboratories, instrumentation, networks, etc.

- Providing broad R&D incentives to industry in general, as well as specifically in areas where internationally we are not faced with a level playing field.

- Enhancing competitiveness through support of R&D in areas such as system integration, in which at this moment we may have a definite advantage.

- Providing R&D support to encourage industry to enter difficult areas which may offer, nevertheless, prospects for commercialization, such as some aspects of the environment or technologies for developing countries. We need to keep in mind, however, that more than just R&D is needed; appropriate business and financial infrastructures are also essential.

FEDERAL R&D IMPACT ON U.S. UNIVERSITIES

Federal R&D has an enormous impact on U.S. universities. However, the federal support is diminishing, particularly in more applied areas, as exemplified by the new emphasis on plasma physics rather than fusion. The impact of decreased federal R&D support of the universities is magnified by the current decrease in job opportunities — and hence in student interest and enrollments — in science and technology and by the changes in industry support of R&D.

It is clear that to respond to the changes in federal R&D policy and support, the universities must rethink themselves. They need to undertake at least four sets of actions:

- Be more imaginative in their organization. Universities need to concentrate on their strengths and rely on the complementary strengths of other institutions, through appropriate alliances, or cooperative agreements. They also need to look systematically at the possibility of operating, jointly with other institutions, research laboratories, libraries and other facilities.

- Find aggressively their niches in interactions with industry R&D. The universities need to be viewed by industry as partners in research and to modify themselves so as to become effective partners. As suggested earlier, they are, in principle, better suited for interdisciplinary R&D and long-term fundamental research than for short-range applied research.

- At the same time, the universities must better equip their research students to operate in industry by giving them, in addition to research training, a better sense of the opportunities that they will encounter in industry, of industry's R&D needs, and of entrepreneurship.

- Last but not least, the universities need to communicate more effectively the meaning of research to the community, because a community ignorant of how the research process operates and of what research can mean to its future is bound to view research as a low priority and not to support it at the government level.

In brief, the universities must be more conscious of the fact that they are a key knowledge node in our society — a node that must be understood and better integrated with the many pressing needs that confront our nation today.

SOME SPECIFIC ENERGY ISSUES

As we look at R&D in the context of the interactions of federal government, industry and the universities, there are several specific issues that underscore the need for making these interactions more effective.

- The low productivity growth in utilities. As shown by Table 1, while manufacturing in the period 1977 to 1993 experienced an annual productivity growth of 2.2 percent and communications twice that — 4.6 percent — utilities' productivity grew only 0.2 percent annually. This low productivity growth of the utilities is due to a variety of factors, including regulation, deregulation, lack of critical mass, and the lack of advanced technologies, as discussed next. It has, unfortunately, the effect of deflecting investments to more productive sectors.

- The lack of "killer technologies." The great advances in telecommunications have been due to revolutionary technologies such as the silicon chip, fiber optics, software and communication satellites. There are today no equivalent killer technologies in the energy area, except nuclear energy, which has brought with it major unresolved environmental problems. One of the key questions for energy R&D is whether there is a possibility to develop such killer technologies and what should be done to make that possibility a reality. Among the potentially long-term promising areas, one may look for instance at the efficiency of energy generation in the cells of biological organisms.

- The uneven performance of the Department of Energy. DOE has been good in succeeding in maintaining our nuclear weapons arsenal in spite of the limitations of international treaties, in keeping the three important nuclear weapons laboratories open, and in providing broad support to the universities. The Department, however, has performed poorly in the area of civilian nuclear power — not because of a lack of fundamental research, but because of a lack of research in how most effectively to bring the technology to the public and have it accepted. It has also been ineffective in the disposal of nuclear waste. Of course, the Department is not the only player in these areas, but it still has or should have a major influence.

- The defeats of megaprojects such as the SSC and the 2.8 billion dollars advanced neutron source. The canceling of these projects has contributed to the demoralization of elements of the research community. The issue needs to be addressed, possibly also through more effective international alliances.

- The struggle between universities and national laboratories. That struggle has been unproductive and has deflected the focus from the common need to address key issues of energy, including, to reiterate, that of killer technologies.

- The ineffective cooperation with former Soviet Block nations. Yet, such a cooperation could be particularly promising in the area of energy, and of nuclear waste disposal R&D, as exemplified by the opportunities offered by an energy-rich but environmentally at risk country like Kazakhstan.

- The stalled drive for automotive fuel economy (Figures 3 & 4). Fuel economy needs to be readdressed, as potential fuel crises are a dangerous source of geopolitical instability and the general public reacts very rapidly and nervously to changes in automotive fuel supply. In this context, the quest for a more diversified set of energy sources should remain a major goal.

CONCLUSION

R&D in the U.S. is in a dynamic restructuring stage. We are confronted with a new game that requires re-examination of the roles of the various players in the R&D enterprise. There are pressing energy problems that remain unresolved and there is a need to make the energy industry more competitive. Unfortunately, at this moment the trend for R&D is downward, at least in terms of volume of support. Ways must be found to reverse the trend, to increase the R&D utilization by industry, to strengthen university research and to develop more productive interactions among government, industry and the university.

The fundamental fact that cannot be forgotten is that the future belongs to knowledge-based societies and that R&D is their essential underpinning.

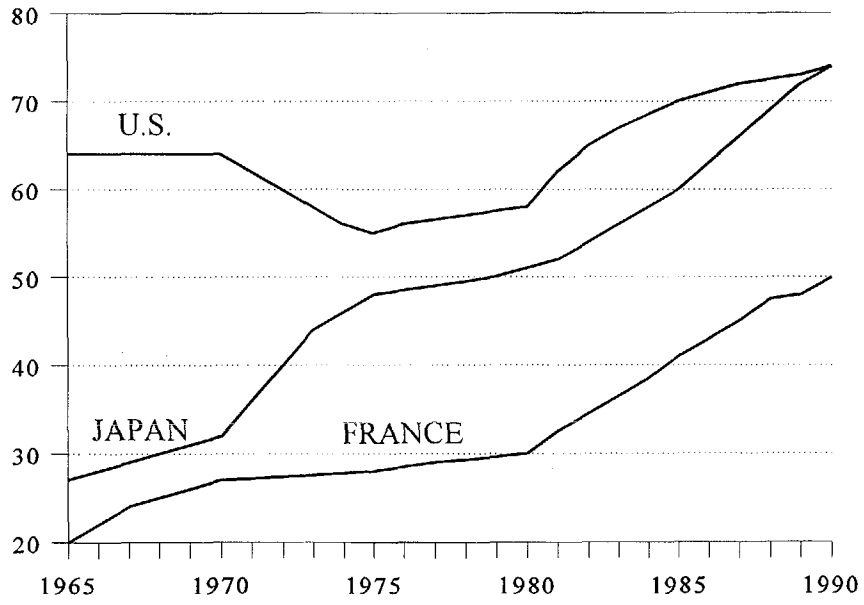
TABLE 1

GROWTH OF PRODUCTIVITY IN SELECTED INDUSTRIES

	Share of Manhours (%)	Annual Productivity Growth, 1977-93 (%)
Manufacturing	16.8	2.2
Communications	1.1	4.6
Utilities	0.9	0.2

FIGURE 1

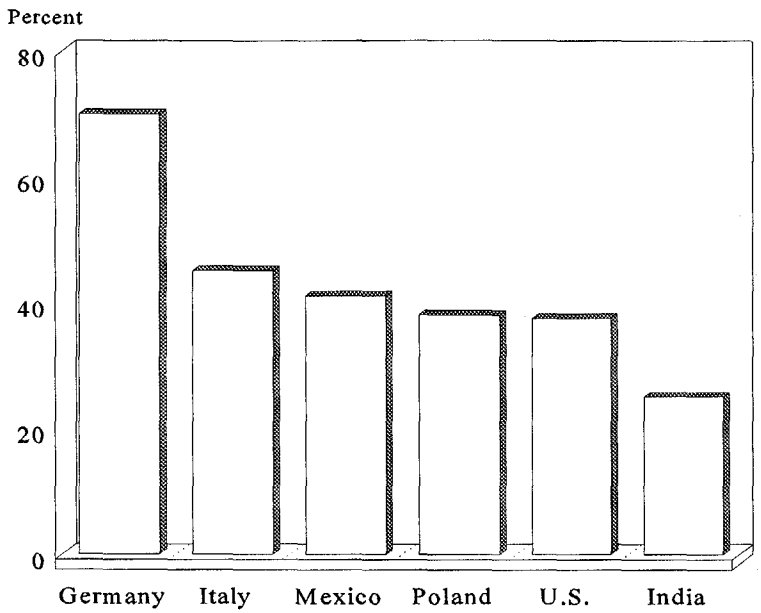
SCIENTISTS AND ENGINEERS PER 10,000 LABOR FORCE



Focus, N.Y. Academy of Sciences, Aug/Sept 1995

FIGURE 2

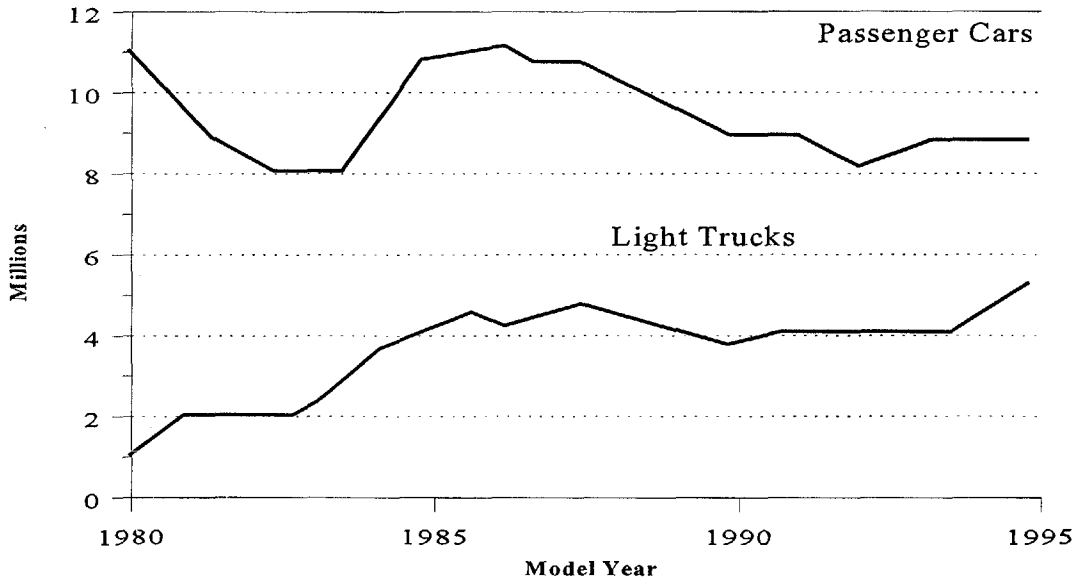
RATIO OF SCIENCE & ENGINEERING DEGREES TO TOTAL FIRST UNIVERSITY DEGREES (VARIOUS YEARS)



Focus, N.Y. Academy of Sciences, Aug/Sept 1995

FIGURE 3

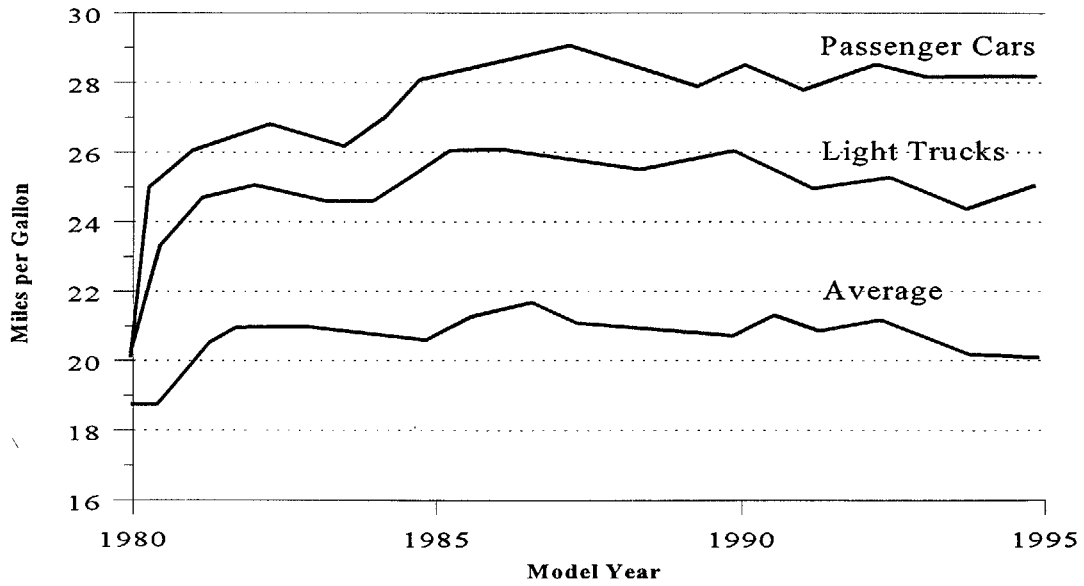
SALES OF PASSENGER CARS AND LIGHT TRUCKS



New York Times, Sept. 5, 1995 from Department of Transportation Data

FIGURE 4

FUEL EFFICIENCIES OF PASSENGER CARS AND LIGHT TRUCKS



New York Times, Sept. 5, 1995 from Department of Transportation Data

GLOBAL CLIMATE CHANGE: A STRATEGIC ISSUE FACING ILLINOIS

Porter J. Womeldorff
Global Climate Program Executive
Illinois Power Company

Illinois is dependent on energy. Coal is produced and sold, both in state and out of state. Manufacturing, a source of jobs, uses great quantities of energy. Agricultural production and processing uses energy. And energy contributes to the quality of life, health and safety of Illinois residents. Transportation throughout the state is dependent on energy. Energy abundance is key to the economic health of Illinois.

Thus, it is quite apparent why the Illinois Energy Conference has provided and continues to provide important input for policy makers in Illinois. This conference tends to focus on the future, providing insight on issues which will shape policy over a planning horizon. That focus has been reasonable in legislative terms, perhaps two to ten years.

Now an issue looms on our energy horizon which will probably not begin to impact our state policy in this decade. When it does in the next decade and beyond, it will be so pervasive to our energy usage and policy that current planning must begin to consider the issue, both in shaping national and international policy and in preparing for the impacts that may result from international and domestic policy. The issue is *climate change*.

The State of Illinois, its legislature and its administration are to be commended for the foresight that led to the formation of the state task force on Global Warming. The task force has been active, studying the issue, taking balanced and responsible positions and communicating those positions to the Congress and the Administration. However, the importance of the issue may suggest even more aggressive action.

Today, I will discuss the dimensions of climate change, report on domestic and international activities, and suggest possible outcomes of the current debate. At the very least, I will suggest greater awareness of the issue. Beyond that, I will discuss possible impacts of international agreements focusing on the year 2005, 2010 or 2020.

CLIMATE CHANGE

Climate change is not a new concept. The comfort and perhaps the very inhabitability of the earth depends on the trapping of heat by so called greenhouse gases (GHG). These gases operate in the upper atmosphere to trap heat that would otherwise be reradiated into space. Natural sources of GHG account for about a 40° warming of the planet, a so called greenhouse effect.

Until about 1860, scientists report that the greenhouse effect was not significantly affected by anthropogenic, or manmade, sources of GHG. With the beginning of the industrial revolution, these scientists tell us that emissions from man's activities have added GHG emissions to the atmosphere at an increasing rate. They show an increasing concentration of CO_2 in the atmosphere, the most important GHG. Even with numerous caveats, they further suggest that the apparent rise in global mean temperature, ranging between 0.3 and 0.6°C., exceeds natural variability and probably suggests anthropogenically induced warming of the atmosphere. This has been confirmed in the Second Assessment Report of the Intergovernmental Panel on Climate Change. The Summary for Policy Makers of the IPCC Working Group I states:

> "Our ability to quantify the human influence on global climate is currently limited because the expected signal is still emerging from the noise of natural variability, and because there are uncertainties in key factors. These include the magnitude and patterns of long-term natural variability and the time-evolving pattern of forcing by, and response to, changes in concentrations of greenhouse gases and aerosols, and land surface changes. Nevertheless, the balance of evidence suggests that there is a discernible human influence on global climate."

These changes were first reported a century ago. However, in the 1970s U.S. scientists testified before the Congress that global warming posed a threat to the planet. The Congressional response was an accelerated research program into this threat.

By the 1980s, scientific interest and concern was worldwide. In 1988, the World Meteorological Organization and the United Nations Environmental Programme

brought the Intergovernmental Panel on Climate Change into existence to assess the science of Climate Change and to report on their findings. The reports of 1990 (First Assessment Report) and 1992 galvanized the United Nations into action. The U.N. General Assembly called for the negotiation of a Framework Convention on Climate Change.

Further IPCC reports in 1994 and 1995 (the Second Assessment Report or SAR) have made progress in better understanding of the issue and resolving the uncertainties identified in the First Assessment Report. The SAR identifies additional uncertainties related to scientific understanding. However, the reported scientific consensus is that a problem of some magnitude will exist at some time in the future. Many parts of the report are stronger than this; however, some competent scientists continue to argue that other interpretations of data are possible.

The 1995 SAR contains reports on impacts and economics also. The impacts section foretells of land loss to sea level rise, loss of ecosystems due to their inability to shift as fast as climate shifts, possible human health impacts and agricultural shifts due to changing regional climate. The economics section emphasizes the importance of matching response strategies to infrastructure replacement to minimize the cost of global response. There is support for taking any no cost or low cost actions which reduce, avoid or sequester GHG whenever those actions are available.

DIMENSIONS OF THE PROBLEM

Climate change differs from other environmental problems in several respects, to the extent that it does or will exist.

First, the GHG have very long lives in the atmosphere. Some persist for a hundred or more years. Thus, stopping the emission of the GHG does not immediately reverse any impacts which may exist; they persist as the GHG persists in the atmosphere. Second, there is no technological "fix" such as a scrubber. Although technology innovation and change are keys to modifying processes which emit GHG, there is no evidence that a removal system is practical. To date, such systems are very energy intensive, and the problem of disposing of the captured CO_2 has yet to be solved. Third, the issue is global. Due to the long lifetime of the emissions, they span the globe rather than exerting a localized impact. Everyone is affected by the emissions of everyone else. Fourth, it is commonly believed that economic growth is dependent on increased energy use. Developed countries want to continue growing; lesser developed countries cry out to grow. The issue then becomes one of fitting this growth into a world in which GHG emissions are first stabilized and then reduced. And finally, any global effort to permit growth without growing emissions of GHG will be very expensive. New technologies must be developed. Technology must then achieve worldwide penetration.

It is possible that the end result will be a change in lifestyle, particularly in developed countries. Thus, climate change is seen as a north-south issue, an equity issue and an intergenerational issue.

WHAT IS HAPPENING

The Framework Convention on Climate Change (FCCC) was adopted at Rio in 1992. The FCCC includes an aim for developed countries to return their GHG emissions to 1990 levels by the year 2000. The FCCC is silent on the period beyond 2000. However, the objective of the FCCC is the stabilization of GHG in the atmosphere at a level which will prevent dangerous anthropogenic interference with the climate system.

The U.S. Senate ratified the FCCC in December 1992. On Earth Day 1993, President Clinton accepted the aim and pledged the country to accomplish the return of GHG emissions to 1990 levels by 2000. Later in the year, the Administration issued a *Climate Change Action Plan (CCAP).* The CCAP listed about 50 programs designed to reduce, avoid or sequester GHG, which in aggregate would accomplish the aim. The programs are voluntary in nature, representing a new approach to environmental accomplishment. The CCAP is subject to review and adjustment if necessary.

The FCCC entered into force 90 days after ratification by 50 parties, which occurred in December 1993. The FCCC provides that the Conference of the Parties is its governing body and was to first meet a year after the FCCC entered into force. The first meeting was held in Berlin this past March.

The FCCC provides that parties report on their national circumstances. The report for the U.S. and several other developed countries was due in September 1994. The U.S. reported on the CCAP and noted that higher economic growth and lower petroleum prices were threatening its progress. Other parties also reported difficulty in achieving the aim of the FCCC.

At the Conference of the Parties (COP), little attention was paid to the aim. Debate focused on the post-2000 period and resulted in a "Berlin Mandate" to negotiate a protocol or another legal instrument for strengthening the commitments of the developed countries. It calls for the setting of quantified limitation and reduction objectives within specified time frames such as 2005, 2010, and 2020. The instrument is to be completed as early in 1997 as possible with a view of adopting the results at the third meeting of the Conference of the Parties later that year.

Two meetings of the negotiating group have been held. Four more are anticipated. The Alliance of Small Island States, which offered the first proposed protocol which

called for developed country reductions to 20 percent below 1990 levels by 2005, continue to plead the case of the possible extinction of their cultures by sea level rise. The "Berlin Mandate" precludes any new commitment for developing countries, but they sit at the table and argue that there must be room for their growth. And in spite of the reported difficulties in achieving the 2000 aim, most European countries argue for new reductions. Thus, there is a very strong majority favoring new targets, common policies and measures, and international standards. The European community seems to favor a common carbon tax for all developed countries, although it has rejected a tax for the community.

U.S. ACTIVITY

The Administration is active on the issue; the Congress is not, beyond occasional hearings. The biennial review of the CCAP is currently underway. It is expected that a shortfall will be identified, claimed to be larger due to the lack of funding for government programs that would help in meeting our goal. It is less clear what new programs will be proposed to fill the gap, although the Administration continues to suggest that voluntary programs will continue to be the vehicle for meeting the U.S. goal.

Internationally, the Administration is very active. Although the President has assured the Congress that nothing will be agreed to that would hurt jobs in the U.S., there is intense international pressure to move forward to targets and timetables. The international pressure may increase as the IPCC issues its Second Assessment Report. The report was approved in Rome in December 1995 and will be published early in 1996. Although future scenarios have not changed greatly since 1990/1992, many of the uncertainties that existed earlier are better understood now. This, along with the "detection" finding quoted earlier, will present some validation of the urgency suggested in earlier reports, essentially ignoring the new uncertainties that are listed. Unfortunately, while the economic conclusions suggest that a reasoned approach will be much less expensive than some rush to action and will not offer any climate improvement, these conclusions may be ignored.

WHAT IS NEEDED

The key to a rational future program lies in the findings of IPCC Working Group III that suggest that pacing response to technological development and infrastructure turnover makes both economic and environmental sense.

This suggests that at the very least:

- We must work to understand the climate change issue, not just as a legislative issue but as one which is perceived very differently in other parts of the world. We must be sensitive to activities taking place beyond our boundaries which have the potential to have major impacts on us.

To the extent that the issue is perceived to be real:

- We should continue to do all cost effective projects and programs which reduce, avoid or sequester GHG.

- We should work jointly with other countries to identify opportunities for projects jointly implemented which will be consistent with their sustainable development, will offer GHG advantages, and will be economically attractive.

- We must continue the R&D, as the IPCC urges, that will reduce uncertainty, identify timing and magnitudes of impacts, and define regional impacts. These programs should also offer insight into possible adaptation as well as mitigation.

- And we must ensure technology development programs which result in a growing economy but which accomplish that with decreasing GHG emissions over the next century.

Beyond these steps, actions to more aggressively reduce, avoid or sequester GHG will be required whenever the issue is so clearly identified that there is no rational alternative to such action. Some countries and their citizens would suggest that we have reached the third stage already. Others are more cautious, favoring one of the other of the approaches.

CONCLUSION

The FCCC speaks of the "precautionary principle." The activities that I have suggested are not an endorsement of any point of view of the issue. Instead, I would suggest that the evidence suggests that a problem may exist, at some place and at some time. In suggesting what is needed, I am suggesting that a prudent person might well get ready for a future which could be much more difficult if we are not prepared.

SESSION I: NATIONAL LEGISLATION AND REGULATION

ENERGY/ENVIRONMENT/TECHNOLOGY TWO VISIONS, TWO DIRECTIONS

Peter Fox-Penner
Principal Deputy Assistant Secretary
Energy Efficiency and Renewable Energy
U.S. Department of Energy

INTRODUCTION

These are interesting times in Washington — for everyone watching us from outside the beltway, and certainly for those of us whose jobs, organizations, and communities have a large stake in our nation's energy, environment and technology policy. What I would like to talk with you about today, however, goes even beyond our policies in these tremendously important areas. Today, I want to examine two different visions of our nation's future.

Let me introduce these two visions by reading a few energy policy ideas from an old book by Henry Petroski called "Beyond Engineering." Petroski outlines a rather — creative? — energy policy based entirely on revisions of long-established engineering principles. Here are a few of his suggested policies:

- Amend the law of gravity
- Abolish entropy
- Lower the boiling point of water
- Outlaw rolling friction
- Develop a breeder diesel
- Impose quotas on weather
- Require mandatory personal insulation
- Raise the absolute zero of temperature
- Require the forced mixing of oil and water

Unfortunately, some of the energy, environment, and technology policies actions we see emanating from the 104th Congress these days are almost as unrealistic ... and if it wasn't possible that they might severely and adversely impact our nation, they might also be as funny.

In my remarks today I will explain what we mean by an energy policy, why we think the American people deserve one, and why the main alternatives proposed by the Congressional leadership will leave our nation worse off, not better. I want to let all of you weigh the facts and decide which path makes more sense to you and your family, and which you think is better for our nation.

LINKAGE OF ENERGY, ECONOMY, ENVIRONMENT & TECHNOLOGY

Before we begin, I must dispense with any notion that this Administration's "energy policy" stands as something divorced from our economic strategy, our environmental programs, and our technology policies. In isolation, energy is most noticed when it isn't there. Power outages, oil disruptions, and other energy emergencies highlight the uniqueness of energy because they remind us that most forms of energy must flow with little or no interruption as a matter of health, safety, and national security. Electricity outages and oil shortages threaten our health and the very fabric of our society. We have again been reminded of this critical fact this summer, when occasional power outages during the extreme heat led to hundreds of heat-related deaths.

While it is crucial that we protect against these harmful extremes, it is equally important that we recognize that energy has long been and remains a critical element in economic and environmental progress. To illustrate this, I've prepared a figure that reflects the essential ingredients of sustainable economic growth (Figure 1). (All figures and tables appear at the end of this paper). In this figure, I suggest that sustainable economic growth rests on four critical elements: a sound fiscal climate; an adequate infrastructure (including a strong environment, which is the "natural infrastructure" that sustains all economic activity); a healthy and well-prepared workforce; and finally, adequate investment in science and new technology. Let's spend a moment looking at how energy figures into each of these four elements.

Sound Fiscal Climate

We are very proud of many of this Administration's overall fiscal accomplishments (Table 1). We have created 7.1 million jobs since January 1993 and presently have very low unemployment. Inflation is near a 30 year low and interest rates are also quite low. Real income and GDP are growing and so is new business activity, from incorporations to housing starts.

We are also proud of the fact that we have made tremendous progress towards getting the deficit under control and making our government leaner, more efficient, and more effective. We have lowered the deficit as a percentage of GDP from 4.9 percent in January 1993 to above 2.0 percent today. Indeed, the deficit today exists entirely because we are paying too much interest on poor fiscal management by the federal government during the 1980s. Were it not for the huge debt we inherited from past Republican administrations, the federal deficit would be zero!

Many folks are also surprised to learn that we also made great progress streamlining the government long before the present Congress came to town. We have brought the federal workforce down every year since 1992, and today it is the smallest since 1963. If you benchmark U.S. government employment against other nations on a per-capita basis, the U.S. has a smaller government workforce per citizen that most other nations.

Unfortunately — and it is here our energy policy begins — energy is not nearly the contributor to our economy that it could be. First, as Figure 2 shows, we presently import over 46 percent of our oil. At an annual price tag of $50 billion, oil is the largest single item in our trade deficit. What's worse, imports are expected to rise to 70 percent of our consumption by 2020, with a price tag of $150 billion, in part reflecting an increasing trend toward reliance on the Persian Gulf.

Most Americans today have lived through several oil shocks and wars in the Persian Gulf. Although there are many positive developments in the area of energy security — the futures market, new supply diversity, and our strategic petroleum reserve, for example — it is simply premature to conclude that we are "out of the woods" with respect to our future energy security.

Economic growth in the newly industrialized states, Asia, and many other parts of the world makes it likely that the demand for personal mobility is going to skyrocket in the next 50 years. The prestigious Shell International Forecasting Group, which produces forecasts in the form of scenarios, foresees one scenario in which world automobile ownership more than doubles between now and the year 2020, going from about 500 million autos to over 1.2 billion. This scenario would require adding to the world's oil supply the equivalent of, in Shell's own words, "five new Saudi Arabias or eight new North Seas."

Mind you, I am not claiming that we are "running out of oil." We are not about to embark on immediate and extreme federal energy emergency measures. However, we cannot go forward with our eyes closed and ignore geopolitical reality. Most of the world's low-cost recoverable oil is in the Persian Gulf, and we cannot entirely rely on economically stable oil supplies as the world triples its oil demand over the next 50 years or less.

Concern over our long-term energy security is widespread and bipartisan. Senate majority leader Dole, and many other members of Congress on both sides of the aisle agree that energy security is a real and growing concern. Former energy official Don Hodel said recently that America must not "sleepwalk into the next energy emergency."

Energy Costs and Productivity

Energy fuels all of our economy, not just transportation, and here again we are not realizing our economic potential. American businesses spend over $100 billion a year on energy and $47 billion a year on environmental compliance investments, many of which are energy-related. It is no surprise that some of America's smartest firms have discovered the importance of leading edge energy/productivity investments. To cite just two examples:

- Compaq, the world's second largest personal computer manufacturer, recently determined that cutting their electricity bill from 1 percent of operating costs to 1/2 percent would have the same effect on their bottom line as increasing their sales by over 10 percent. I know that any of you who have tried to boost sales by 10 percent can attest to the magnitude of this kind of achievement.

- In Seattle, Washington, Boeing has discovered that more efficient electricity use, such as lighting, increases productivity and worker safety while simultaneously lowers production costs. At their 500,000 square foot plant in Washington state, new energy-efficient lighting improved by 20 percent workers' ability to detect imperfections.

There are many encouraging signs that our homes, businesses, and factories are learning that they can save money and prevent pollution by adopting energy-efficient, high-productivity technologies. But in many respects, the energy efficiency of our economy lags that of our major global competitors, and we thereby cede them a source of competitive advantage.

It really should not have to be this way. If we act wisely, energy technologies of all kinds will become a source of huge global trade opportunities and jobs for our industries. Today, more than 2 billion people in the world live without electricity — 50,000 villages in Mexico alone. The World Bank estimates that the world will invest $1 trillion in added electrical generating capacity through the year 2000, most of this in Asia, the U.S., and Latin America. Energy efficiency, pollution prevention, and environmental cleanup technologies also promise enormous export potential (Figure 3).

We have a tremendous amount to offer this ravenous energy market. U.S. utilities, engineering firms, and non-utility developers have led the world for decades in new

technology and environmental control. These organizations have much to offer utilities around the world in technology, planning, management and finance, the integration of environmental responsibility with corporate success.

Similarly, the U.S. energy efficiency industry is a world leader in utility-based and market-based energy efficiency programs. Thankfully, many of our user technologies can still hold their own in world markets, and we have as much experience as any nation in running programs that marry utilities, private sector firms, and government agencies in partnerships to diffuse efficient technologies into the marketplace.

Finally, in the area of renewable energy, we have regained some technological leadership and international strength, thanks in part to our public-private R&D partnerships. After losing our lead to others in the booming global market for solar power cells, for example, the U.S. has recently regained the Number 1 position, and now ships over $300 million dollars a year in solar exports.

Adequate Infrastructure and the Environment

It requires little more than our common sense to understand that energy is one of the main elements of modern society's infrastructure. Energy enabled railroads and steamboats to help build our nation, and utilities and the automobile have totally transformed American urban life in the past 50 years. Today's transformation into an information society with industrial ecology continues to require reliable, sustainable energy networks — in some ways more than ever.

While energy is a critical part of our man-made infrastructure, it is also tremendously important to our environment. As the *Economist* magazine puts it, "the production and use of energy causes more environmental damage than any other single economic activity." Energy is directly responsible for 100 percent of man-made carbon dioxide, 95 percent of nitrogen and sulfur dioxides, and 73 percent of airborne volatile organic compounds (Figure 4). It is also a significant contributor to waterborne, solid, toxic, and radioactive waste streams. One would have to be blind to fail to see that energy policies *are* environmental policies, and vice-versa.

In recent months it has become fashionable to assert that our society has overreacted to environmental concerns; that environmental regulations are overblown and out of control; and that the environment has gotten clean enough in the U.S. that we can roll back environmental standards and stop worrying about this problem.

Throughout this Administration, we have acted on their belief that environmental regulation should rely as much as possible on markets and market-based mechanisms. We reject regulation for regulation's sake, and we know that our environmental laws and rules must rely on common sense and flexibility. We are striving to build these principles and procedures into every environmental policy and enforcement activity

we undertake. Recognizing the vital importance of these changes, we nevertheless reject — and we know the American people reject — any notion that we should roll back environmental rules and abandon environmental protection as a national and global priority.

Let's take urban air quality as a kind of "case study" (Table 2). We have made tremendous progress reducing air pollution since 1970, when a bipartisan effort led to the first Clean Air Act. During the past 25 years, a period in which our domestic economy grew 71 percent and personal auto travel more than doubled, total air pollution has *dropped* 24 percent. During the same period, sulfur dioxides were cut by 30 percent and carbon monoxide by 24 percent.

This progress is a wonderful testament to the power of technology, but it hardly justifies going backwards or even standing still. One hundred million people still live in areas where air does not meet EPA's three year standard. Air toxins cause an estimated 1,000-3,000 premature deaths each year. In a study recently released by the Harvard School of Public Health, fine particulates were also linked with premature deaths. The example that strikes closest to my home and my family are the 13 ozone alerts we have had in Washington so far this summer, each of which has prompted my wife to keep our 18 month old daughter inside for the day.

This "case study" shows why the American people are interested in — and absolutely deserve — environmental quality and a government that protects the health and safety of their families, without sacrificing economic efficiency or common sense. The public's widespread support for federal environmental protection is particularly unique. Stanley Greenberg, in a May 1995 summary of public opinion poll entitled "Against the Tide," asserts that "the public remains committed, as ever, to a clean environment." In a major national opinion poll conducted last December, a strong majority of American adults — 64 percent — agreed that renewable energy and energy efficiency should be the number one research priority at DOE. Even with federal programs being cut, 75 percent of the adults questioned believe that resources should be redirected to energy efficiency and renewable energy research. The public also continues to show strong support for the federal government working with the private sector. When asked if the government should support partnerships with business to support the commercialization of renewable energy technologies, 85 percent said "Yes." This support cuts across partisan politics and ideology, with no significant differences in response from voters identified with any party or outlook.

Research and Development

In the interests of time I will skip over education and training, which are clearly critical for economic and environmental security, and move on to talk about the relationship between energy and technological change.

Let me first give you a little economic background that explains the importance of R&D investments to our nation. There is widespread agreement that technical change has been responsible for one-third to one half of our economic growth in the postwar U.S. Between 1947 and 1985, the U.S. added more than *40 million* new jobs to the labor force and we doubled our real, per-capita income. During this period we were, without question, the world leader in R&D investment.

Many studies show that the total economic return to the economy from R&D investments is 30-50 percent — several times the return a typical firm can hope to realize on a successful project. A recent census bureau study shows that firms that adopt leading-edge technologies grow faster, pay better wages, and add more jobs. Manufacturers using eight or more advanced technologies in this study grew 14 percent larger than those that did not — and meanwhile paid an average of 14.5 percent higher wages.

Technological change is important to every industry, and the energy industry is no exception. The pace of change in energy technologies is accelerating, and global competition is fierce. All this is doubly important because, in the energy business, technological change has also been our main means of achieving environmental, health, and public safety improvements. From paint booths to power plants, modern energy conversion equipment is much cleaner than earlier versions — often dramatically so.

As the energy industries internationalize, research and development is a prerequisite for job growth in our nation and continued environmental improvement everywhere. As with most domestic industries, the winners will be those with the cleanest, most productive hardware and software — in other words, those who invest aggressively in research and development.

OUR ENERGY POLICY

I hope that you now see that energy is an integral part of our nation's economy and critical to its environment. Where does this leave us? What should we as a nation or DOE do to foster sustainable economic development and sound energy policies?

Let me try and briefly outline some broad answers to these questions. The Department of Energy has just issued the first National Energy Policy Plan in over three years, which we call our "Sustainable Energy Strategy." This document is an excellent compendium of our policies and activities, and my remarks today can hardly do it justice.

Very briefly, our Strategy contains five major elements (Table 3):

- Increase the Efficiency of Energy Use

  This element is pursued via "market and technology programs that help our citizens use energy more efficiently and maximize energy productivity and value," to quote from the Plan.

- Develop a Balanced Domestic Energy Resource Portfolio

  We pursue this element by, again quoting from the Plan, "expanding the role of ... natural gas, encouraging the continued development of renewable energy resources, reducing the environmental impacts of coal, and maintaining the safe contribution of nuclear energy."

- Engage the International Market

  Here our activities include programs that help build market-friendly institutions in other countries, increase the effectiveness and export capacity of domestic energy firms, and provide targeting financial and technical assistance.

- Reinvent Environmental Protection ...

  ... which is our way of saying initiatives that "combine market forces and technology" to minimize the use, cost of, and inflexibility of so-called "command and control" environmental rules, and finally

- Invest in Advances in Science and Technology ...

  ... about which I will say more in a moment.

Rather than go into these elements in greater detail, let me emphasize a few aspects of these policies that are worth keeping in mind. There are several integrating principles embedded in these strategies that bear on our methods for pursuing our energy, environment, and technology policies — in other words, *how* we do our job and what we view as the proper role for the federal government. These integrating principles are (Table 4):

- Invest adequately in energy R&D on supply side and demand side.

- Maintain environmental and other national goals, but minimize use of command and control.

- Reduce the federal government's role to the lowest possible level. Catalyze utilities and the private sector — never attempt to duplicate their strengths.

Let's briefly discuss each of these.

Invest Adequately in Energy R&D on Supply Side and Demand Side

The first and probably the largest element in our energy policy is working with industry to discover and develop new technologies. New technologies help us make better, cleaner use of both renewable and non-renewable resources; they lower energy costs for firms and households; and they help our industries find new markets and create new jobs.

One unfortunate development in our present political climate is a frequent assertion that the federal government has never had significant success helping industries develop new technologies. Virtually all members of the energy industry and researchers who have carefully studied this issue reject this myth. Indeed, there are a number of successes of which we are especially proud. In the mid 1970s, DOE supported the development of the modern high frequency electronic ballast, the small device that takes the hum and flicker out of fluorescent lights. Lighting with electronic ballasts are 33 percent more efficient, and by the end of this year will have saved consumers $1 billion on their energy bills. Along the way, 54 million of the new ballasts have been sold, creating a new industry and new jobs, along with saving consumers money.

Dozens of our products are in the marketplace now without continuing government support:

- High-performing, durable ceramic engine parts, which hold the promise of cutting consumers' automobile repair costs and reducing fuel consumption;

- New wind turbines, which have helped the U.S. wind industry make the cost of electricity produced from the wind cost-competitive with fossil fuels;

- Low E-Windows, which will help cut the cost of heating and cooling our homes.

The fact is, if you purchase a new double-pane window, drive a new Cummins diesel engine or a Ford Ecostar, use a food or beverage can, turn on almost any major household appliance, or use a modern industrial ceramic part, you are using a technology that the Department of Energy has helped invest, standardize, or expand in applications or market share.

Our partnership with industries complement our policies and our strong commitment to scientific research. They are an essential and irreplaceable underpinning to our economic and environmental policies.

Minimize Inflexible "Command and Control" Regulation

As our strategy document points out, reinventing environmental regulation is a new part of our energy policy. In our entire energy efficiency and renewable energy program, there is really only one program based on mandatory rules, our building codes and appliance standards program. This particular program, enacted most recently by a wide bipartisan merger in the Energy Policy Act of 1992, has a superb payoff for the American economy. As a result of this program, American families will save $1.2 billion in net costs by the year 2000.

Beyond this, our modus operandi has been cost-shared R&D and voluntary partnerships to accelerate products into the marketplace. Our strategy largely relies on developing new products ("technology push") and voluntary collaboratives to speed deployment ("demand-pull") — not rules.

Catalyze Utilities and the Private Sector — Do Not Duplicate their Strengths

We firmly believe in the need to work in partnership with industries to develop and diffuse technologies into the marketplace. We know that this is a task that must be done carefully, so we do not substitute for, or displace, private R&D investment.

With respect to R&D, this means that we must pursue R&D where there is persuasive evidence of a national need, and also where aspects of the marketplace make it impossible for firms to do adequate amounts of technology development. But even in these all-too-common situations, we require that industry take leadership, take risks, and match our dollars with theirs. Our intention is to create collaboration among industry players that would not occur without our presence and our seed capital.

With respect to technical assistance and other programs to hasten the diffusion of new technologies, here our reliance on the marketplace is greater still. Although our nation has a tremendous stake in getting cleaner, more productive technologies into the marketplace quickly, we know we are not designers, marketers, architects, or installers — you are. We know our job is to provide you with the information, tools, assistance, and occasionally the capital to get energy efficient products into the marketplace fast. Our policy is to help markets work better — to direct the power of the marketplace at our national and international objectives.

As an example of how we apply these methods to achieve our strategic objectives, let's briefly examine our policies on natural gas. Consistent with our "balanced portfolio" strategic objective, this Administration has attempted to maximize the economic, environmental, and national security benefits of increased natural gas use. We have attempted to do this via increased collaboration with the industry and the Gas Research Institute towards investment in advanced natural gas technologies.

Consistent with our reinventing regulation objective, we have supported regulatory developments at FERC that have increased market opportunities and market flexibility, removed regulatory barriers to increased gas use, increased cost-effective federal and state use of alternative fuel vehicles, and other policies designed to promote gas use in the national interest.

THEIR PATH AND OURS

By now I hope I have convinced you that energy is an integral part of sound economic and environmental policies. I also hope I have convinced you that our approach is sound, sensible, and in the long-term best interests of the nation. Just to drive the point home, however, let me contrast our approach with what we have encountered in trying to implement our policies this year.

First, our activities have been targeted by Congress for some of the deepest, most systematic reductions. As the next figure shows, the House Budget Resolution cuts total research and development expenditures by the U.S. Government by almost 33 percent by the year 2000, in real terms (Figure 5).

Within this total, R&D on energy efficiency and renewable energy were singled out for some of the deepest of all cuts: a 39-43 percent cut from the President's request. Here are just a few of the specific cuts that trouble us most in the current appropriations process:

Partnership for a New Generation Vehicle (PNGV)

The aggregate reductions across the 11 agencies in this historic, industry-led collaboration are $225 million, or 56 percent of the President's request. The Department of Energy funded PNGV programs have been cut $177 million, 35 percent below the request. These cuts will place U.S. automotive technology research and development efforts behind the foreign competition, increase our trade deficit, and make it more difficult to clean up urban air pollution caused by trucks, buses, and automobiles. As I have mentioned, these cuts occur at a time of record-high oil imports (more than $50 billion per year or 50 percent of oil consumed in the U.S.).

Climate Change Action Plan

The House and Senate cut approximately 46 percent of the Department of Energy's funding for technology programs under the Climate Change Action Plan. These severe cuts will drastically reduce the development and deployment of renewable energy and energy efficiency technologies and cause the loss of thousands of jobs and millions of dollars in energy savings for consumers.

Federal Energy Management Program

The Federal Energy Management Program has been cut by $22 million, or 40 percent. We estimate that this cut, over five years, will *cost* the government a cumulative $1 billion in higher energy costs, not to mention 2.9 million tons of additional pollutants added to the air and water that could have been avoided.

Lighting and Appliance Codes and Standards: Building Codes and Standards

The House Appropriations Bill contained $12.5 million in cuts to the Lighting and Appliance Codes and Standards and Building Codes and Standards Programs. The Bill contained a prohibition on any new cost effective energy saving standards or regulations. The Energy Information Administration has estimated that the new codes and standards blocked by Congress would save U.S. consumers $40 billion in cumulative energy costs from 1998-2010 and displace 129 million barrels of imported oil per year by 2010.

Loss of International Markets for U.S. Renewable Energy Products

The House Appropriations Bill eliminated the Solar International Program and other international programs which have helped U.S. renewable energy companies capitalize on an enormous global market for energy technologies. During the past year, for example, Secretary O'Leary has led trade missions to India, Pakistan and China, resulting in direct sales of more than $2.7 billion and commitments of more than $20 billion for U.S. renewable energy products. The House's efforts to terminate these successful programs will slow down U.S. renewable technology manufacturers' efforts to create U.S. jobs with sales in these growing foreign markets.

The political rhetoric upon which these cuts are based is the assertion that the federal government has no legitimate role to play in energy policy — and that, even if it did, our government is so ineffective and counterproductive that federal R&D investment is worse than nothing at all. Our opponents assert that, if the federal government ceases to fund energy-related R&D, that private firms will make up the difference.

The first part of the assertion is a falsehood rejected by the American people and inconsistent with conservative principles of economic efficiency. Open any advanced economics textbook and you will find an explanation of the fact that there is a need for government action to protect public goods such as the environment. The same textbooks will tell you what many CEOs of technology firms will also tell you — that R&D has become so complex and costly, and many technologies so broad-based, that they cannot afford to do as much R&D as the national interest merits. In other words, there is a public interest in maintaining strong national R&D, particularly at a time when global competition is putting pressure on all firms to *reduce* their R&D.

Many of the biggest names in corporate R&D are reducing their outlays, and this trend extends to all U.S. business. In contrast to all but one other G-7 nation, our R&D outlays have dropped in real terms by 1.67 percent per year since 1988. Economists Linda Cohen and Roger Noll state flatly that "Investment in research (in the United States) is not keeping pace with the economy," and many prestigious groups and business leaders agree.

For decades, the United States led the world in R&D investments and, consequently, in science and technology. As non-military R&D has risen in importance, Europe and Japan have increased their share of R&D dramatically. As a percentage of GNP, U.S. civilian research in 1970 was well above Japan's and comparable to that of Germany. As of today, Japan and Germany are spending significantly larger fractions of their GDP on civilian R&D. In fact, the imbalance has gotten so large that the Japanese recently exceeded our national spending in absolute terms — in spite of the fact that their economy is only 4/7 as large as ours!

Of even greater importance, our global competitors are recognizing that now is the time to continue to pursue aggressive federal-private funding and cooperation in applied research. The Japanese government recently announced long-term budget plans much like ours. Between now and the year 2002 — the same period in which our Congressional leadership proposes to cut federal R&D by 33 percent — the Japanese propose to *double* their *federal* R&D spending. This projected divergence between U.S. and foreign R&D spending is a multibillion dollar investment gap that grows larger and larger over time.

Another assertion used to justify slashing R&D budgets is the assertion that federal R&D has never produced any products of value to the economy. As I have explained, this assertion can only be made by persons utterly ignorant of the facts of technological progress in the U.S. and elsewhere.

Finally, there is simply no evidence that suggests that federal R&D *displaces* private R&D, as Congressional leaders conveniently assert. In separate studies, economists Lorne Switzer and Christopher Hill examined the history of ups and downs in American R&D spending and found no support for the contention that private firms jump in when the federal government cuts back. Instead, there is ample evidence that carefully managed, industry-led R&D consortia with substantial industry co-funding enable industries to overcome spillover effects and high development costs and accomplish things they cannot and will not do on their own. With modest seed capital, the federal government can anchor larger amounts of private capital — dedicated not to picking winners, but to establishing robust competitive industries that go forth on their own to slug it out in the global marketplace.

Surely we in the federal government have much to improve in our management and execution of federal R&D programs. To cite one very important example, we have

completely gotten away from the idea of complete federal control of applied R&D, with no industry co-funding or co-management. During the past two years alone we have many improvements, and found many more, and we continue to work at this. In the Department of Energy, for example, the Galvin Commission carefully studied the best use of our laboratories and made many excellent suggestions for improving their value to the nation. Another distinguished group led by economist Dan Yergin examined our applied R&D programs very closely and reached a resounding conclusion that our applied R&D efforts in energy efficiency and renewable energy made sense for the nation.

In short, the justification Congress is using to cripple America's technological future is deeply flawed. The desire of Congressional leaders to cut spending in this area has little to do with the long-run national interest. We know they want to cut spending in the short term, and it appears that they do not care whether their cuts damage job growth, economic productivity, and the environment for years to come. Their contention that federal funding of R&D accomplishes nothing flies in the face of many specific accomplishments, the judgments of our leaders in business and science, and international and historical evidence. Their assertions that our process for conducting federal R&D is counterproductive is likewise out of touch with our true practices and policies. And their contention that the private marketplace will take up the slack is wishful, shortsighted thinking masquerading as good government.

We began this talk intending to understand why we have a federal energy policy, and what the policy consists of. Happily, my friends, we are not in the midst of an energy crisis. Energy is cheap and plentiful in the U.S. and our economy is relatively good.

It is precisely now — when we have a chance of winning the global marketplace — that we need to buck up and face the music.

Cutting spending is the easy way out. It is penny-wise and pound foolish — and it is not easily reversed. Japan has had five years of recession and sluggish economic growth. Yet they *already* spend more absolute dollars on applied R&D than we do — and as Congress prepares to slash our budgets, they are *doubling* their funding for R&D.

By now most of us have lived through at least one — if not several — corporate restructuring exercises. Most of us know that there is a right way and a wrong way to do them. If you downsize too fast, and you cut the investments that provide future growth, you essentially ruin the company. Or as one ex-CEO said to me, "You can't cut your way to market leadership."

What is true of our firms is true of our nation. Either we maintain a prudent level of investment in future economic strength or we impoverish ourselves. If the

Congressional leadership think they have a way to induce private investment to suddenly reverse course, we would like to see the evidence. Until then, we think it irresponsible to gamble with our economic and environmental future.

We want to keep every person in this room productive and successful doing what they are doing. You are the people who invent and deploy new energy technologies — who make the marketplace for energy efficiency work. If you don't succeed, we don't succeed. We know that we need your help, and we think that you deserve a government that is effective and capable. We think that a federal energy efficiency investment of about $10 per person — about what the President's budget calls for through the year 2000 — is a wise investment in the future of our nation and the future of your industry and your jobs. Our hope is that we can continue to be a full-fledged partner — a partner who helps you develop and deploy the best, most-efficient, most environmentally friendly products in the world, and a partner that helps create a clean, productive, healthy nation we can all be proud of (Table 5).

UTILITY RESTRUCTURING

The importance of one our technology partners — electric utilities — prompts me to take a moment to discuss utility restructuring. The scope of the utilities' energy efficiency delivery infrastructure, combined with $280 billion in annual sales, makes the electricity end use sector the anchor of the marketplace for end use energy efficiency investment. In 1993, utilities spent 1.5 percent of electric revenues on Demand Side Management and cut electricity sales and peak demands by 1.6 percent (equal to about 53.3 gWh) and 6.8 percent respectively. These investments, in turn, translate into over billions in annual savings to consumers, savings accomplished at an average cost of about 3 cents per kWh — well below the average cost of electricity, though not far from some new supplies.

In addition to continuing DSM and load management programs, domestic electric utilities are expected to invest $20 billion in new generating capacity through the next decade. Capital consumption of this magnitude can have enormous influence over the success or failure of emerging technologies, from super-efficient superconducting transformers, grid-connected photovoltaics, and energy storage. These and many other new products become important as utilities seek to increase value to shareholders and consumers and reduce operating costs in the face of uncertain conditions, the most crucial situation being the restructuring of the American utility industry.

Electric industry restructuring may be the greatest policy and business challenge many of us will ever face. It is forcing us to rethink every premise that our understanding of the industry and regulation was based on. In doing that, we are rediscovering some basic truths that long years of regulation have helped some to forget.

We are remembering that competition is a more effective and efficient regulator of economic activity; we are remembering that there are few, if any, perfect markets and that competition is a messy enterprise; and we are remembering that competition promises great opportunity and rewards.

While the changes we will witness will be fundamental, they do not necessarily dictate an end to the utility industry's role in promoting energy efficiency and alternative generating technologies. The scope, scale, and unique characteristics of the industry continue to point towards an ongoing and significant role.

Consistent with this view, the Department of Energy has been an active participant in the utility restructuring debate. Our position has been outlined in various proceedings and can be summarized as such:

- DOE strongly supports restructuring. The overall objective should be to reduce consumer costs and contribute to increasing the productivity of the U.S. economy, while maintaining system reliability and other system benefits.

- We do not believe that complete deregulation is an option, at least for the foreseeable future. The transmission and distribution systems have natural monopoly characteristics and will require economic regulation to protect the public interest.

- In addition to reducing consumers' costs, a new structure for the industry must enable the continued achievement of several other important electricity-related public policy objectives, including:

    - System reliability
    - Cost-effective environmental protection
    - Efficient production, transmission, and use of electric energy
    - Increased reliance on renewable generation technologies
    - Support for electricity-related R&D
    - Reduced greenhouse gas emissions
    - Minimum standards of service for low-income customers
    - Equitable treatment among ratepayers and stockholders

- We believe that most of the opportunity for additional gain will come through wholesale market efficiency. We support increasing consumer choice, but believe that retail competition in the form of retail access should be pursued with caution. State/federal jurisdictional issues remain to be resolved, and we are not yet convinced that retail access will allow us to achieve the important policy objectives I just listed.

- We believe that performance-based ratemaking at the retail level offers opportunities to make retail service more efficient by 'incentivizing' regulation.

- With respect to environmental quality, specifically, DOE's position is that restructuring of a state's electricity industry should be undertaken in a manner that:

    - Ensures no net increase in damage to the environment and no adverse effects on progress toward mandated environmental goals;
    - Takes into account the vital role of energy efficiency and renewable technologies in facilitating attainment of health-based clean air standards;
    - Facilitates continued consideration of environmental externalities (including residual emissions) within the revised framework; and
    - Considers risk and uncertainty with respect to fuel prices and changes in environmental regulations and sends appropriate market signals that encourage parties to anticipate the risks and rewards of such uncertainty.

The message behind this principle is that we regard restructuring as a "package deal". The cost-savings, increased efficiency and increased consumer choice stemming from restructuring are essentials, but so is the protection of the environment. We cannot accept, and simply don't believe, that there is a tradeoff between economic gains and environmental quality.

TABLE 1

PRESENT FISCAL CLIMATE: VERY GOOD

- 7.1 million new jobs created since January 1993 — 92 percent in the private sector
- Near-record low inflation: Low interest rates
- Deficit as a percentage of GDP has *dropped sharply*: From 4.9 percent (January 1993) to 2.3 percent (July 1995)
- 3.2 percent annual rate of growth of GDP

Source: *More than 2 years of Economic Progress,*/ U.S. Department of Treasury, August 4, 1995.

TABLE 2

CASE STUDY: URBAN AIR QUALITY

Since 1970	•	Economy grew by 71 percent
	•	Vehicle-miles traveled grew by 104 percent
	•	Urban air pollution reduced by 24 percent
Technology and regulation have had a tremendous impact		
However	•	100 million Americans still live in areas that exceed standards
	•	3,000-5,000 premature deaths per year from air toxics
	•	*Serious Unresolved Issues*: Particulates — Ozone — Global Climate Change

TABLE 3

FIVE STRATEGIES FOR SUSTAINABLE ENERGY POLICY

- Increase the efficiency of energy use
- Develop a balanced domestic energy resource portfolio
- Invest in science and technology advances
- Reinvent environmental protection
- Engage the international market

TABLE 4

SUSTAINABLE ENERGY STRATEGY — UNDERLYING PRINCIPLES

- Invest adequately in energy R&D — New supplies and more efficient user technologies
- Minimize use of command and control — Emphasize prevention and flexibility
- Integrate our activities with those of utilities and the private sector — Never attempt to duplicate their strengths

TABLE 5

TWO VISIONS, TWO PATHS

President Clinton

- Balance budget by 2005
- Invest in research and development to create jobs, increase productivity and wages, and win global markets
- Invest in technologies that help prevent pollution and cleanup the environment

Congress

- Balance budget by 2002
- Cut technology spending by almost one-third

Which path do you think will create a stronger economy for our children?

FIGURE 1

FOUR COMPONENTS OF ECONOMIC PROGRESS

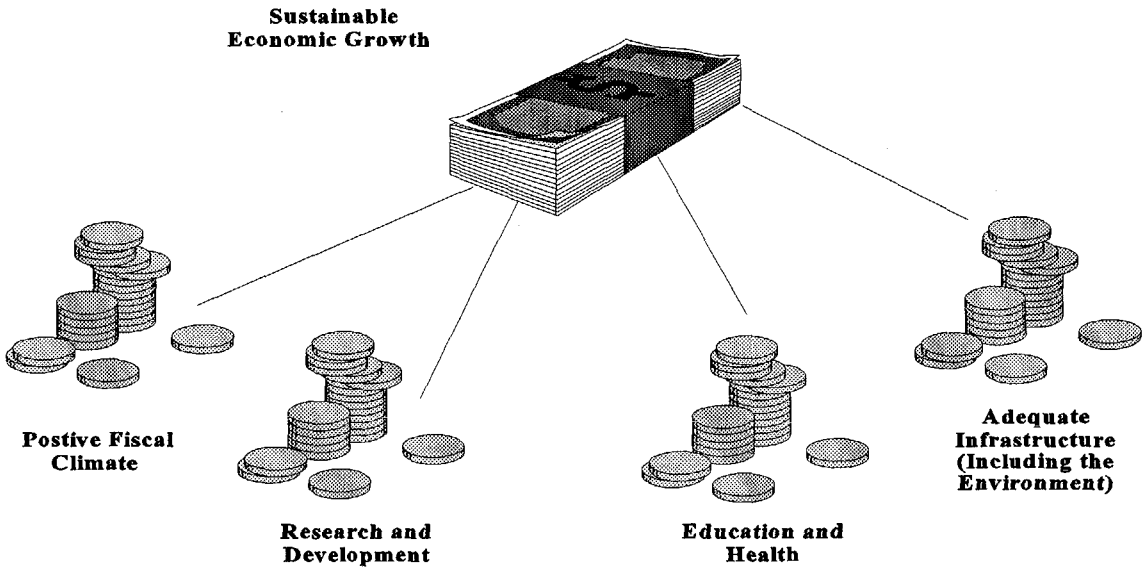


FIGURE 2

U.S. OIL IMPORTS

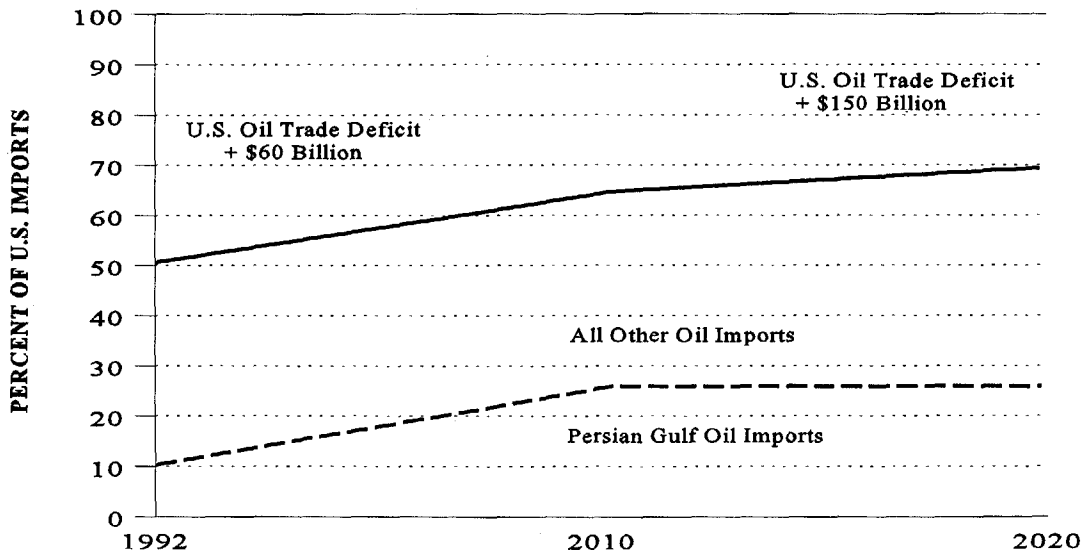
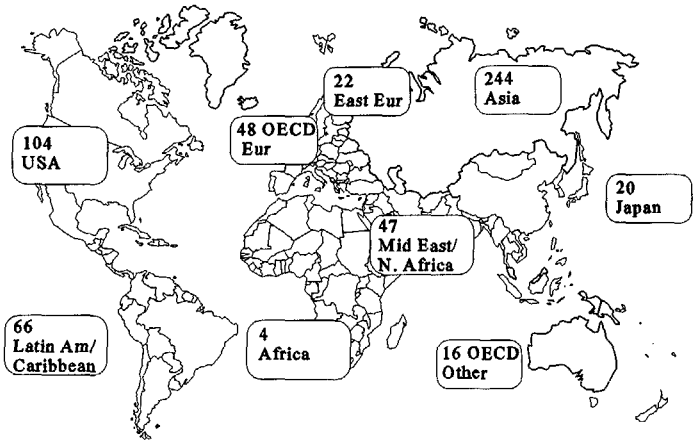


FIGURE 3

INCREASING WORLD ENERGY DEMAND

New Electric Generating Capacity Requirements in the 1990s ≈ 600 GW*



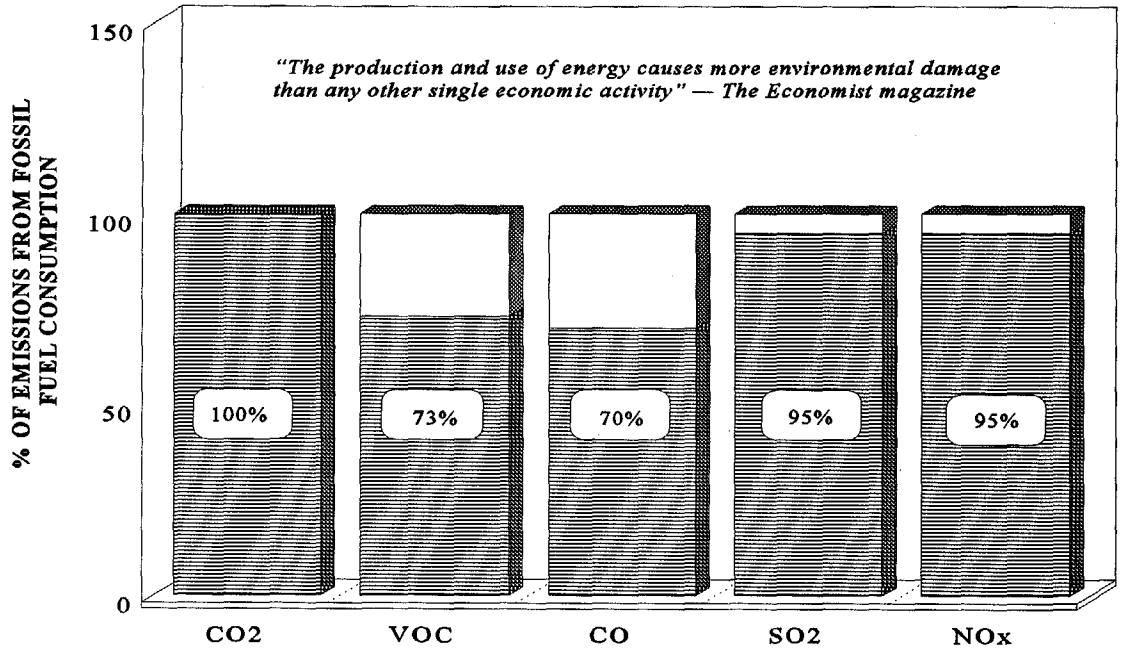
- Nations will spend $1 trillion this decade to meet new electric generating needs. (World Bank)
- The global market for energy efficiency technology and services is $84 billion per year. (International Institute for Energy Conversation)

***1 GW is enough power for 500,000 US homes for 1 year**

Source: Financial Times, May 1995

FIGURE 4

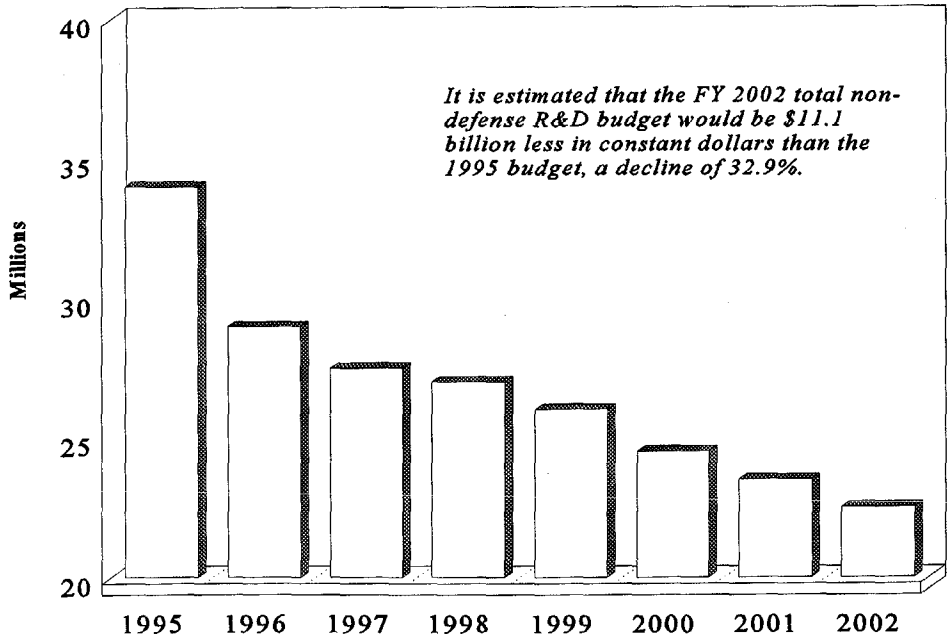
ENERGY AND ENVIRONMENTAL QUALITY ARE INTIMATELY LINKED



SOURCE: Council on Environmental Quality, 1992

FIGURE 5

PROJECTED NON-DEFENSE R&D, 1996 BUDGET RESOLUTION CONSTANT DOLLARS



Expressed in FY 1995 dollars, adjusted for 3% inflation rate annually

Source: AAAS Preliminary Data

PRIVATIZING POLICY: MARKET SOLUTIONS TO ENERGY AND ENVIRONMENTAL PROBLEMS

Richard Stroup
Senior Associate
Political Economy Research Center

INTRODUCTION

Around the world, privatization is recognized an important — if not always easy and not universally appropriate — step in reducing inefficiency and promoting prosperity. Policies in many nations are moving that direction. Energy policy in the United States is discussed in those terms also, as in plans to privatize Power Marketing Authorities. I want to explain how and why privatization very often can improve policy, not only in terms of managing production, but also in terms of regulation. "Private" regulation, like private ownership and control of the means of production, centers on the protection of property rights, and the ability of owners of rights to trade and market them through contracts to sell, lease, and make rental arrangements.

For many people, privatization suggests an abrogation by government of its duty to protect citizens against destructive or opportunistic behavior on the part of buyers or sellers. When privatization and private regulation are done properly, however, that is simply not the case. To understand and appreciate the power of this market approach to policy, it is crucial to recognize that markets, unlike direct governmental regulation, begin with justice, in the form of rights determination, often in common law courts ruled largely by precedent, and only then move to offers to buy, sell or trade. It is the latter trading that produces the constant flow of information and incentives that automatically weeds out inefficient tradeoffs of all sorts. There is relatively little acrimony because offers to buy, sell or trade will not be falsified when it is the traders' own budgets involved. The sincerity of the information supplied is hard to question under those circumstances.

The ability of markets to produce efficiency and prosperity are seldom questioned today, but the effect of markets on environmental quality is another matter. This paper aims to show that both logic and empirical evidence strongly support the claim that markets nearly always enhance environmental quality, just as they enhance prosperity, and for the same reason: enforced, tradable property rights protect the interests of all. The connection of environmental quality with prosperity and property rights does not stop with process; prosperity is important to the ability and willingness of citizens to achieve environmental quality.

In the next section, we examine the importance *for the environment* of economic efficiency and prosperity. "Pollution Policy: A Property Rights Perspective" considers the role of private law and a rights-based policy for controlling pollution, with special attention to hazardous wastes. "Looking to the Future: Government or Private Ownership?" examines the claim that privatization would replace farsighted government decisions with shortsighted decisions by owners. A conclusion follows.

EFFICIENCY: A KEY TO ENVIRONMENTAL QUALITY

For some who care very strongly about the human health, aesthetic and moral benefits of environmental quality, economic efficiency may seem inconsequential. The cost of obtaining high environmental quality may seem largely irrelevant. That view is incorrect on its own terms, for four major reasons.

First, wealthier is healthier for human beings. That is, people who are more prosperous live healthier lives in general, and live longer.[1]

Second, economic efficiency brings resource-conserving technical efficiency. Mikhail Bernstam has compiled data comparing the energy use in the largest 12 industrialized market economies with its use in the Eastern European socialist countries (plus North Korea). The more efficient market-based economies used only 37 percent as much energy per $1,000 worth of output as the socialist nations in 1986. Similarly, socialist economies used more than three times as much steel per unit of output as market economies did.[2] The governmentally produced data gathered by Bernstam show that across a variety of command-and-control economies, resource use is far greater per unit of output than across a variety of market-oriented economies. (See Figure 1) (All figures appear at the end of this presentation).

A third reason that environmentalists should seek efficiency is that empirically, less efficient economies tend to be poorer and less clean. The demand for environmental quality is very strongly a function of income. Economist Donald Coursey finds that in the United States and in other industrial nations, citizens' support for measures to improve environmental quality is highly sensitive to income changes.[3] In economic terms, willingness to pay for environmental measures, such as costly environmental

regulations, is highly elastic with respect to income. He estimates that in industrial nations the income elasticity of demand for environmental quality is 2.5. Thus, a 10 percent increase in income leads to a 25 percent increase in citizens' willingness to pay for environmental measures. Similarly, a 10 percent decline in a community's income leads to a 25 percent decline in that community's support for costly environmental measures. Coursey's data show that the demand for environmental quality has approximately the same income elasticity as the demand for luxury automobiles like the BMW and Mercedes-Benz.

A fourth reason for efficient environmental policy, from an environmentalist point of view, is that people will choose more of a good or service, including a stronger environmental policy, when it costs less. Inefficient policies will not sell as well to voters, *ceteris paribus*. Efficient policies will be an easier sale.

Worldwide, by the way, a fifth reason for environmentalists to seek economic efficiency and prosperity is the "demographic shift." Beginning from very low incomes, population growth slows over time when income rises. In an inefficient economy, greater population growth puts more pressure on the environment. The demographic shift may not apply, or is probably much less important, in developed market economies where population growth already is low or even negative. In summary, then, environmentalists, like efficiency-loving economists, have reasons to favor efficient means of achieving environmental goals.

In what follows, we will see how a property rights-based market approach could improve environmental policy as well as provide a more forward-looking approach to energy policy in general. The focus will be on two examples of the advantages that such an approach can bring, along with a brief policy history and an explanation of how important advantages are produced by a market approach.

POLLUTION POLICY: A PROPERTY RIGHTS PERSPECTIVE

Over the past decade, we have seen a proliferation of laws designed to protect people against harm from hazardous waste — laws ranging from the Resource Conservation and Recovery Act of 1976 through Superfund to, most recently, the passage of California's Proposition 65. Most people assume that such laws have improved safety. The evidence suggests otherwise.

In the past, pollution was largely dealt with by the common law, which forbids invasion of person or property by pollution and allows a person suffering damage from pollution to sue for compensation. Under common law doctrine, a producer or innovator has the freedom to act unless and until sufficient evidence is brought to warrant "bringing in the sheriff." The evidence required is less stringent than proof beyond a reasonable doubt, as in criminal law, but the plaintiff must show that the preponderance of evidence justifies action. If substantial damage is foreseen, injunctive relief can be sought to forbid the damaging activity before it begins.

In the mid-1960s, a reversal took place in the U.S. Activities suspected of causing harm were increasingly controlled by political and bureaucratic means, rather than by the common law. The burden of proof shifted away from those who claimed injury to the person or corporation charged with causing damage. This change has been generally endorsed by environmentalists. Yet it has had harmful consequences that even today are poorly understood.

The goal behind the restrictive legislation was to reduce personal health and safety risks, with the ultimate goal "zero risk" or a completely safe society. This seems rational at first glance because it appears unfair to allow industrial activities to take place which might later be shown to be hazardous. But, in fact, programs geared to attaining zero risk have failed to reach that goal, they are very costly to society, and in many cases they reduce safety.

Politicizing Risk: The Problems

Many programs designed to ensure safety are politically misused. The Superfund program, for example, which now has a budget of about $9 billion, was pushed through in a crisis atmosphere.[4] It is widely criticized by analysts and is more easily explained as pork barrel politics than as a carefully designed measure to reduce risk.[5]

Even when the expenditure of government funds is not the issue, the authority granted in safety and environmental legislation is irresistibly drawn to other political uses. A recent case, but already a classic, involves the 1977 amendments to the Clean Air Act. By requiring the use of expensive scrubbers on coal-fired power plants, the amendments effectively protected Eastern coal interests while harming both the health and the pocketbooks of millions of Americans.[6] The same amendments were used by Eastern and Midwestern manufacturing interests to stifle competition from new Sun Belt factories.[7] In the world of congressional politics, players who are unwilling to impose large costs on the unorganized public on behalf of organized special interests often are at a competitive disadvantage in garnering the support they need for their own political goals.

Since producers and innovators often have to prove the safety of their activities before they are allowed to carry them out, innovation is placed at a severe disadvantage relative to old technology. Innovators must devote strenuous efforts to do the impossible — to prove a negative, such as the proposition that apples do not cause cancer. This is very expensive in terms of time and real resources. Regulatory procedures and delays add to the cost of potential technological advances and the resulting cost increases mean that some never see the light of day.

Current policy in the political arena does not link payment to damages caused. The desired degree of safety for any specific case is seldom analyzed by careful comparison of alternative policies, and cost-effectiveness is seldom a major goal.

Rather, risks subject to EPA regulation are deliberately exaggerated (this is known as a "conservative" safety approach). The result can easily be an actual decrease in social safety,[8] by misdirecting scarce attention and dollars away from the more important risks. Yet this "conservative" approach is emotionally satisfying (especially when corporations are the potential villains and are expected to pay the bills), and thus politically profitable. For agency staff members, exaggerated risks enhance the notion that their mission merits "emergency" status, providing a certain glamor and the prospect of additional funding for their work.

Another problem of the political bureaucratic approach is that costly technologies are often specified by law or regulation, rather than performance standards of any kind, and little freedom is given to seek cost-effective ways to minimize damages.

Indeed, Congress sometimes explicitly eliminates cost as a consideration, as if the emergency were so great that cost simply should not be a factor. Yet no emergency exists.

Despite claims of a cancer epidemic from toxic chemicals, there is no such thing. Corrected for age, cancer is not increasing in the U.S. and our best estimates place the percentage of cancers caused by all manmade chemical and radioactive sources at less than 5 percent.[9] As in the case of Love Canal, there is a lack of generally accepted data showing long-term health effects from the many famous hazardous waste sites all over the country, despite extensive epidemiological investigations.[10] Supporters of the "emergency" theme point out that sufficiently small health effects might evade detection. But if they existed, effects large enough to indicate an emergency would surely have been detected after the many years of study by many scientific groups at many well-known hazardous waste sites.

Making Society Less Safe

Most troubling, perhaps, is the fact that government controls aimed at reducing risk to zero can actually make society less safe. We have seen that a "conservative" policy stance, by distorting the true picture of alternative risks, can actually increase danger. Researchers Albert Nichols and Richard Zeckhauser, of Harvard's Kennedy school, provide several illustrations of how this can and does happen in the context of EPA risk assessments, where some dangers are exaggerated much more than others.[11] The late Berkeley policy scientist Aaron Wildavsky, in his important book, *Searching for Safety*, provided many others.[12] For example, he points out that additional safety devices on nuclear reactors can be hazardous due to the increased complexity they impose, and the added difficulties of maintenance.[13] Keeping new pesticides off the market increases the dangers from the pests they would control, and from greater use of older, more dangerous pesticides. Keeping new drugs off the market for years, until exhaustive tests can "prove" that they are safe, does, of course, reduce the risk of unexpected side-effects from the drugs, but it also keeps

potentially helpful drugs from patients who might benefit from them, including those who are desperately ill and dying. Research indicates that on balance, this "risk reduction" measure harms the nation's health.[14]

Seeking Safety through Resilience and Wealth

There are better ways to increase health and safety in society. Wildavsky, in his book, observed that resilience and agility in response to threats are often a more effective strategy for safety than anticipation. Unlike the turtle, which anticipates blows to its body by growing a shell to hide under, the human body reacts quickly to danger and repairs injuries. Less protected than the turtle in an anticipatory sense, humans are more agile and resilient. He illustrates the point by noting that a person who exercises by running initially may be at higher risk of suffering a heart attack, from the running itself, than a person who does not run. The runner, however, by continuing to run, builds resilience to ward off future health threats.

Similarly, a resilient society often is safer than an anticipatory one that attempts to protect itself from specific expected threats. Of course there are costs. If our society is to reap the benefits of technological change, we must also accept some personal risk from innovative products and technological missteps. But refusal to accept the need for individual adjustments and dangers is, to borrow Edward Banfield's book title, "The Moral Basis for a Backward Society." Life in backward societies tends to be nasty, brutish and short compared to life in advanced societies.

Wildavsky surveys existing literature which shows that people in rich societies, whatever their income level, live longer, healthier lives than do those in societies with simpler lifestyles. This is true even though they face risks from advanced technological development. He notes that an earthquake in California in 1971 caused 62 deaths. The next year a slightly less powerful earthquake in Nicaragua killed tens of thousands. Why the difference? The wealthier country had better-built houses, better transportation and communication, and better health facilities.

Even within a given society, more income increases health and safety. There is evidence, for example, that for a 45-year-old man working in manufacturing, a 15 percent increase in income has about the same risk-reducing value as eliminating *all* hazards from the workplace.[15]

Under its current hazardous waste policy, the United States, like Wildavsky's turtle, is retreating under a shell to avoid risk, thereby stifling technological development. A better strategy for society is to recognize the potential danger of hazardous wastes and develop policies to handle the risks without further harming people by hampering technological and economic advancement. To do this, we should go back to reliance on our system of property rights and liability, enforced in common law. As we shall see, a properly functioning system of private property rights holds decision-makers accountable for results, both good and bad.

Achieving Safety in a Common Law/Property Rights Regime

At first blush, emphasizing property rights may seem to be going back to a system that has not served us well so far. Traditionally in the United States much of the economy, including protection against hazardous waste, has been controlled through the exercise of private property rights. The system has not been perfect because, as we shall see, in some cases private property rights cannot be established or cannot be enforced. Such failures (sometimes called "market failures") have been one force leading to the governmental intervention that has failed to correct the problem. Along with the zealous pursuit of "zero risk" it has landed us in the situation we experience today.

The key to whether a system of human relationships is working well is accountability. Economists view decision-makers as accountable if they face incentives that reward or penalize them according to the gains and losses that their decisions impose on society. If a chemical company that produces waste in the course of its business, for example, makes outsiders bear some of its costs — imposing significant health risks or obnoxious odors, for example — the system is not working properly. In contrast, if that company takes care of its waste without endangering outsiders or forcing them to bear significant costs, the system is operating in a socially desirable way.

Most people will agree that the system of property rights works most of the time to keep people accountable in dealing with objects such as cars or tracts of land. That is because property rights to these things exist and are efficiently configured in three dimensions; they are "3-D property rights."

Property rights must be 1) *defined* clearly so as to reside with a specific person or entity; 2) *defended* easily against non-owners who might wish to use or "steal" the asset; and 3) *divestible*, or transferable, by the owner to others on whatever terms are mutually satisfactory to buyer and seller.

When property has these "3-D" characteristics, and when trades can be transacted easily, the owner of any asset, whether land, house, factory, or some other commodity has both the incentive and the authority to use that asset in such a way as to maximize its value to society.[16]

What do we mean by maximizing its value to society? The owner has an incentive to use the land in the manner most valued by members of the society. An owner of property considering whether to use it to store chemical wastes, must consider both a) the reduction in value imposed by the storage and the resulting limits placed on subsequent uses for the land, and b) the benefits gained by (and revenue received from) those who want chemical storage. If the asset is used in a way that reduces services available from it, its value falls and the owner loses commensurate wealth.

But if it is not used at all (that is, if the desires of others who want to pay for its use are ignored), the owner reaps no immediate income. Of course, a key feature of a private property rights regime is liability. If the owner misuses the land in a way which damages others — by chemical leaks, for example — he or she is liable for damages.

Property rights also provide long-term incentives for maximizing the value of property, even for owners whose personal outlook is short-term. If I use my land as a toxic waste dump and impair its future productivity or its groundwater, the reduction in the land's value reduces my wealth. That is because land's current worth reflects the value of its future services: the revenue from production or the aesthetic pleasure I receive from the land minus the costs (including liabilities) which may arise from the presence of wastes. Fewer services or greater costs in the future mean lower value now. In fact, the day an appraiser or potential buyer first can see future problems, my wealth declines by the amount of the reduction in potential buyers' willingness to pay for the land. Not only does using the land to store hazardous waste reduce future options for the land's productivity; the value also may be reduced by increasing my future liability from lawsuits due to leakage and resulting damage to other people or property. The key fact here is that any reduction in *future* services and *future* net value due to potential liability is visited on me now as they directly affect the present capitalized value of my asset.

In effect, the value of the property right, which gives the asset owner the privilege as well as the responsibility of control, serves also as a hostage to the owner's socially responsive stewardship of the asset. Any decision resulting in less value produced, either now or in the future, reduces the land's value now. The reverse also is true: Any new and better way employed to produce more value now or in the future is capitalized into the asset's present value. Even a short-sighted owner has the incentive to be alert to new possibilities and new dangers and to act *as if* he or she cares about the future usefulness of the land.[17]

But what if the land is owned by a corporation, and the corporate officers, rather than the owner-stockholders are in control? Corporate officers may be concerned mainly about the short term, not expecting to be present when future problems arise. Contrary to much popular opinion, property rights hold such decision-makers accountable, too. If current actions are known to cause future problems, or if current expenditures are seen to promise future benefits, corresponding changes in the stock price captures the reduction or increase in future net benefits. Current profits do not look to the future, but buyers and sellers of the corporation's stock do. Even the rumor of future benefits or expenses can strongly influence today's stock price. For this reason, even short-sighted decision-makers are visited by the fruits of their actions immediately, even though the "bottom line" of the profit and loss statement may not reflect the results of bad decisions and good investments for a long time to come.

In addition to their implications for stewardship and conservation, three-dimensional ("3-D") property rights also play an important role in stimulating creative and anticipatory investments. A creative investment might result in new technology to clean up hazardous waste — bacteria that eat waste, for example — more efficiently than isolating and capping it with clay, thus freeing the land of the hazardous waste encumbrance. Since the property value would immediately rise if no wastes remain, the long-term benefits accrue immediately to the landowner. For this reason, the landowner becomes an eager customer for improved techniques. Without ready customers who can gain by adopting new technology, innovation becomes more difficult to finance.

In summary, a property rights regime encourages good stewardship, responsiveness to the wishes of others, and care in preventing damages to others. Does the property rights paradigm apply in the real world? Consider the case of hazardous waste management at Love Canal. Its history, as reported by Eric Zuesse in *Reason* in 1981, and highlighted by an investigative report by ABC's Nightline, is revealing.[18]

The Hooker Electrochemical Company began dumping chemical waste into abandoned Love Canal in 1942, but only after seeing that the canal was lined with impermeable clay. The clay prevented the escape of chemicals, so as to avoid future damages to others, and liability for Hooker. After the canal was filled, a clay cap was installed over the top, sealing the chemicals' "tomb" so that rainwater could not penetrate and wash the chemicals out. In fact, the chief of EPA's Hazardous Waste Implementation was quoted in June 1980 as saying that Hooker's disposal of the wastes at Love Canal would meet even the stringent 1980 RCRA regulations.[19] To this point, the property rights system was working well, and no danger was apparent. Soon after the canal dump site was sealed however, the situation changed.

The local Niagara Falls school board, searching for a site for a new school, inquired about the Love Canal site, under which the sealed wastes lay. Hooker warned them of the chemicals below, and provided for their representatives a tour of the site, where they took some test borings into the ground, to demonstrate that chemicals were indeed present, and where they were. Despite warnings of liability from its own attorney, the school board was eager to get the site and prepared for eminent domain proceedings. Under these conditions, Hooker donated the site in 1952 to the school board in return for $1. Hooker insisted on writing into the transfer papers the presence and potential danger from the chemicals sealed below. The school board now had the land, but they, as decision-makers, were not personally liable. No stockholders, vigilant for the opportunity to gain by buying, or avoid windfall losses by "bailing out" of their stock position early, were looking over their shoulders. The discipline of private property rights had not, for them personally, followed control of the property into their hands.

The school board subsequently built the school and scraped away part of the clay cap to provide "fill dirt" for other school sites. Some of the construction plans had to be changed to avoid the partially exposed chemicals. Now, however, rain could get into the dump. Then, over the strong public objections of Hooker (noted at the time in the local press), the board tried in 1957 to sell the remaining land. Hooker won that fight, though, and the land was retained temporarily.

At about the same time, however, apparently without the knowledge of Hooker, the city was constructing a sewer line, surrounded by permeable gravel, that punctured both the clay walls and the cover of the canal dump site. A storm sewer was placed through one wall of the canal in 1960, again in a bed of gravel. These and later punctures in 1968, when the state built an expressway through the end of the site where Hooker had done most of its dumping, meant that incoming rainwater and the stored chemicals inside could escape, and could flow freely through nearby neighborhoods along the gravel beds of the sewer pipes. Escape they did.

The Love Canal area, sparsely populated when Hooker was using the dump site, had become a residential area. The south end of the site itself, where the chemical wastes were concentrated, was sold by the school board (after the first sewers were constructed through the canal walls) and had become residential developments. The escaped wastes began to invade the neighborhoods, and the disaster hit the national press. Little attention was paid to the history of the property rights, however, or the fact that when Hooker had the land it had acted responsibly. The fact that the avenues of chemical waste escape were punched into the walls of the canal by units of government, after strong and repeated warnings against such practices by Hooker, was overlooked. Hooker was judged guilty by the press and the public, and private rights were assumed insufficient. Superfund was born.

The tragedy was compounded for many local residents by a buy-out with federal funds of most of the contaminated neighborhood, followed by years of indecision by federal authorities, primarily the EPA, about whether the Love Canal area is a safe place for people to live. To this day, despite many detailed health studies, there is no generally accepted evidence of a threat to long-term human health from living in the neighborhood, despite the obvious presence of noxious pollutants. It is still possible that serious long-term risks will yet turn up, after all these years, though the evidence to date is against that possibility.

The fact that long-term health damages are apparently absent does not in any way make right the very real chemical invasion of the Love Canal neighborhood or excuse those responsible. What the Love Canal story does illustrate, however, is the positive role of property rights and liability laws. It also shows some of the weaknesses of public policy, which is so often made and carried out in a crisis atmosphere based on the false assumption of emergency.

When Property Rights Are Not "3-D"

The property rights system, like all other human institutions, is imperfect. Sometimes assets and resources are not controlled by property rights complete in all three dimensions. Property rights can be poorly defined; they can be difficult to enforce; or they may not be transferable. If the person in control of the asset does not have "3-D" property rights then that person's ability and incentive to control the asset for maximum net value are impaired. Full "3-D" property rights or some other form of social control are required to hold all actors accountable for their actions.[20]

Sometimes property rights can be enforced against polluters, even when the threatened water or the air is not privately owned. Consider fishing rights in England and Scotland. There, unlike the U.S., sports and commercial fishing rights are privately owned and transferable even though the streams themselves are not. Owners of fishing rights can sue polluters of streams and they have obtained damages and injunctions against polluting activities. Such suits occurred well before Earth Day or before pollution control became part of the politically controlled public policy. Once established by precedent, such rights seldom need to be defended in court. Where property rights can be established and defended, owners can protect those rights, often more effectively through the courts than with extensive bureaucratic controls. Owners do the job on a self-interested and cost-effective basis.

However, the problem of indefensible property rights frequently occurs in the pollution area. It may be difficult to defend one's property right to clean groundwater, for example. In order to protect such rights, a plaintiff before a court of law needs good information, and good information is not free.

Suppose, for instance, that I contaminate your groundwater with my hazardous waste. In order to sue me with guaranteed success in court you must show that a) you suffered the damage for which you are demanding compensation, b) the cause of the damage was groundwater contamination, and c) I was the source of the contamination. If my pollution flowed underground to your groundwater, and the concern is long-term health, it may be difficult for you to get adequate information.

For hazardous wastes, the effects are usually local enough that tracing the contaminants is not such a severe problem. But the health effects typically are uncertain. For air fumes from my car or factory, which may damage your property (including your lungs), the source may be harder to trace and the health effects equally uncertain. This lack of good information about source and cause makes it more difficult to defend your rights to breathe clean air and drink uncontaminated water.

Without reliable information on which to base a damage suit, courts are unable to defend property rights effectively against invasion or takings. The polluter is allowed to take something — air or water quality — which rightfully belongs to another, without consent of the rightful owner.

The difficulty of providing adequate legal protection of property rights against polluters is the major problem to overcome in implementing a property rights regime to handle hazardous waste storage and disposal. And it is the problem of information that makes legal protection so difficult. This problem has been used to justify a great deal of government intervention in the pollution area. Yet it is critical to realize that *the same problem hampers any policy* intended to deal with hazardous waste. Government agencies have no better access than the courts to reliable information about the source and effect of pollutants, which is inherently elusive. Without this information, it is impossible rationally to decide how much control is justified. Since expending resources or stifling productive activity reduces society's wealth (and thus its health also), such controls should not be taken lightly.

Not only does the government lack the necessary information; often, politicians have no incentive to obtain it. For a politician, it is easier and more popular to adopt a stance of outrage against any and all polluters. In fact, generating outrage may be the best way to overcome public apathy and stir political action.[21] Yet rational decision-making is made all but impossible in the political sector when outrage prevails.

By contrast, the courts are much less political when dealing with a pollution case, and typically less responsive to the emotions stirred by generalized outrage. Juries are swayed by emotion, but they are forced to sit through highly competent arguments on each side, in the context of rules of evidence, before rendering judgment. Courtroom results are generally less satisfying to those who want extreme results such as the total elimination of specific risks. In particular, there is the bothersome need for hard evidence — not conclusive evidence, as in a criminal trial, but simply a preponderance of evidence that harm was done by the defendant.

Toward a More Productive Policy

The challenge in hazardous waste policy is to develop and strengthen institutions that will protect the public while minimizing the constraints that keep us from increasing wealth and prosperity.

In today's system of control by political and bureaucratic processes, lip service is often given to the idea that "the polluter should pay." When this means that a polluter should pay for damages, it is a sensible principle. Not only is it just, but it provides an incentive to avoid damage. It spurs individuals and companies — like

Hooker, while it was still in control of Love Canal — to look ahead and act responsibly.

But the political system is driven, partly by public ignorance and outrage and partly by inherent political incentives, to a different set of criteria and different goals. Since determination of damages is not part of the political process, policy-makers must determine what it is that the polluter should pay for. They tend to push for making the polluter pay excessive costs: Cleaning the soil to drinking-water standards, for example, even in a secure, non-leaking dump site, is the thrust of current policy under Superfund. The cost is likely to be very large — often many millions of dollars in real resources — and yet the benefits tiny or nonexistent when the wastes are in fact secure.

Since identification of the polluter through the preponderance of evidence is not part of the political process, the concept of "polluter pays" has evolved into "producer pays." That is, producers in a potentially polluting industry are deemed responsible for potential pollution linked in some way to the manufacture of their products. Petroleum and chemical companies pay under Superfund, for example, not according to how much damage they do, or even how much waste they generate, but, rather, according to the amount they produce in the course of satisfying consumer wants. The firm is charged for the production of a desired product, even if no pollution is produced and no damage is done. The money collected is used for enormously expensive public works projects that often add little of demonstrated value to public health.

Yet the common law has its flaws, too. Not only is the problem of information sometimes severe, as we have seen, but also since the 1950s,[22] legal activists have been working to change this system from one of compensating victims for harms wrongly done by the defendant, to one of compensating victims from whatever deep pocket might be found.[23] Unfortunately this approach misuses the common law and destroys the accountability of potential polluters, and even destroys much of their incentive to avoid damaging others. The original system, holding polluters accountable for whatever damage they do, without telling them how to do it, is good for public health in the long term, and good economics. It may not be as popular politically, however, unless and until voters come to understand the unintended consequences of overriding the system.

A number of steps can be taken to restore the accountability provided by property rights and to strengthen the common law approach, with its rules of evidence and its evenhanded treatment of specific risk versus other human values. These would make our traditional system more effective in protecting the overall wealth and the associated health of society. Doing so should also increase its political palatability as our primary defense against illegitimate invasion of one's person and property by pollution. The following proposals are offered:

- Strengthen the Common Law through Statute

  Much could be done, possibly by the states, to restore the role of insurers in helping to control risks from unintended pollution. In their search for "deep pockets" from which to compensate victims of illness that conceivably could have been affected by hazardous wastes, some courts have in effect voided insurance contract clauses explicitly specifying (and thus limiting) coverage. Similarly, when property has been transferred and hazardous liability with it by contract, the courts have sometimes voided that transfer, making all parties liable.[24] This destruction of contract reduces the incentive and ability to put hazardous properties into the hands of competent (and solvent) specialists. When such transfers of risk, fully disclosed, are made among competent, solvent parties, contracts should be honored. That is part of the essence of markets in general, and insurance in particular.

- Provide for Greater Freedom of Action by Requiring Proof of Financial Responsibility

  Accountability through liability is meaningless if a polluter is found to be at fault but insolvent and thus unable to compensate his victims. Insurance, or its near-equivalent, the posting of a bond as a "hostage" to the successful control of risks that are known to be substantial, is an answer to this problem. It can provide the appropriate incentives for cost control, both for internal costs and for external liability. The insurance company, after all, wants to avoid damages for which it will have to pay, so it will only insure acceptable risks, and will work with firms to develop low-risk management techniques and require use of those techniques. Yet the insurer must sell policies competitively, so it must also make its demands on customers cost-effective. The insurer that finds a cheaper way to keep risk low will out-compete an insurer requiring more costly ways of reaching the same low risk levels.

  A firm operating with a large bond posted to guarantee solvency in case of liability claims, will similarly have a strong incentive to be both safe and cost-effective in its handling of hazardous materials. To get cost-effective risk control, we would like decision-makers to act in just this way.

- Make "Orphan" Waste Sites Private

  Orphan waste sites — the kind that Superfund was created to clean up — could be transferred to an owner willing (for a price) to take on the cost of cleanup and the potential for liability. Some sites could be sold, but most would probably have a negative price.[25] Using Superfund money, the government could pay the firm making the lowest bid, to accept ownership. *The new owner would be free to implement its strategy, but would be liable for any damages it caused or any threat*

of imminent danger. A bond posted by the firm could be required as a guarantee that damage would, in fact, be avoided. The interest-bearing bond, big enough to match the potential danger of the site as judged by EPA, would remain in the hands of the EPA. Its income, over and above that needed to keep the bond "whole" in the face of current inflation, would go to the firm. The EPA would hold the bond until the danger has been permanently eliminated — perhaps indefinitely, if the danger is best avoided simply by containing the waste securely.

With such a plan, the firm — perhaps a biotech firm with a new waste-eating organism — having the least-cost way to minimize the sum of expected liability costs plus control costs for that site would become the owner. The firm which invented or purchased the best technology for handling a given site could make a profit while underbidding all others for the responsibility of dealing with the site. This plan would supplant the Superfund program, and provide firms with an incentive to find cheap and effective ways to deal with hazardous waste — something that is largely lacking today. No federal funding or political decisions would be needed for the research, and no bureaucratic or political approval of the results would be needed. Firms would adopt a new technology at their own risk, since their bonds would be hostage to their successful avoidance of damage. They also would capture the benefit if the new technology reduced total costs.

- Restore Basic Responsibility for Hazardous Waste Policy to the State Level

  Hazardous waste problems are almost always local problems. Pollutants seldom migrate very far beyond their source, in dangerous concentrations. When policies beyond application of the common law are needed, state and local governments can implement them. Many policy nuances and innovations are tried at the state level without the need for national consensus or a national commitment. Differing policies are tested. Jurisdictions choosing more rigorous control learn what the costs are, and whether they are justified by the benefits. It is possible to learn whether, in jurisdictions with less stringent (and less costly) controls, the problems which alarmists claim in fact materialize. This time-honored variety of approaches among the states is part of American life, and is an important part of the genius of the federal system. Experiments are small rather than national in scope, and more of them are tried. The information produced is useful nationwide. Would we have had airline deregulation had California and Texas intrastate airlines not been able to escape CAB regulation and reduce their prices? Experimentation is more likely at the state and local level than nationally, and errors much less costly.

- Require Branding of Chemicals when Feasible

  Chemicals which might escape into the water or air could probably more often be "branded" by dyes, radioactive isotopes, or other means, so as to help identify their source if later they escape and appear where they are unwanted, causing damage.

- Provide Federally Funded Research and Criminal Investigation.

  Since political demands for a federal role are inevitable, they should be focused where they are most useful — on basic research on the effects of toxic chemicals, and technical forensic mechanisms to help in branding or tracing pollutants as they are emitted. The purpose here is to help hold polluters accountable in court, so that responsibility can be enhanced. Polluters would more often be made to pay when harm is done, and innocent parties would less often be forced to pay in error. Some of this research will be done privately of course, since a careful firm storing chemical wastes, for example, would *want* to be able to show that its stored wastes, having been branded, did *not* show up where damage occurred. The investigation of criminal activity can be another important federal contribution, since organized crime is widely believed to be involved heavily in the disposal of hazardous wastes.

THE FUTURE: GOVERNMENT OR PRIVATE OWNERSHIP?[26]

It is increasingly obvious that market systems make more efficient use of resources for human purposes. Yet the distrust of private ownership, especially in the context of environmental resources, remains widespread. The claim has long made that markets by their nature are shortsighted, even though the economic logic put forth by such economists as Nobelists Ronald Coase and James Buchanan suggests the reverse. In past decades, however, economists have often argued that markets are more shortsighted. It is revealing to review briefly some history and some recent evidence bearing on this question.

The assumption that private owners would be unwilling to make the necessary investments and have the patience needed to provide the future with sufficient forest resources was the chief reason why the U.S. Forest Service was founded at the turn of the century, when 8 percent of the nation's land was allocated to its care. As Bernhard Fernow, first Chief of the Forest Service (then called the Division of Forestry) said, "the time element, together with the large capital required in timber-wood production, renders the forestry business undesirable to private enterprise of circumscribed means." Fernow said that forests should be owned by government because "the maintenance of continued [timber] supplies ... is possible only under the supervision of permanent institutions with whom present profit is not the only motive. It calls preeminently for the exercise of the providential functions of the state to counteract the destructive tendencies of private exploitation."[27]

Fernow was far from alone. Harold Hotelling, a prominent natural resource economist, warned in the 1930s that the world's finite supply of natural resources was being rapidly, and perhaps irrevocably, depleted for personal gain. Hotelling recommended governmental regulation of natural resource exploitation for the good

of future generations.[28] More recently a resource economist with the Washington-based think tank Resources for the Future, Sterling Brubaker, repeated the familiar claim that "securing the interests of future generations ... can only be protected by public intervention."[29]

Despite its widespread acceptance, the claim that the public sector is more far-sighted in its investment strategies than the private sector has not been confirmed either empirically, as in the Eastern European experience, or in theory. Our view, which we believe to be well-supported in logic and in fact, is that when property rights are established, the private sector's market-oriented decisions tend to allocate resources to their highest valued uses across time, while the political and administrative decisions made in the public sector tend to allocate resources to uses for which current political supporters exert the strongest immediate political pressures.[30] If this is true, it has profound implications for the social utility of using private property rights where possible, rather than governmental ownership, to encourage efficient energy production.

How can we test the hypothesis that private stewardship, when it can be arranged, is superior in producing energy while minimizing pollution? Since publicly owned resources are seldom bought and sold, and thus seldom valued in the market, a direct test of our hypothesis is difficult. Other market evidence, though slightly less direct, can help us compare the market and government sectors, however. This article compares and contrasts the time horizons reflected in decisions in three areas in which both public and private decisions are made: assets used to provide public services, employee compensation and pension funding, and electric utility regulation.

Investment Incentives for Private Owners

Private ownership gives people the right to use or sell their assets as they desire, subject to social and legal constraints. Economic theory suggests that property owners will make resource-use decisions designed to reap benefits in the form of greater personal wealth. Property owners' wealth is directly linked to the value of owned assets — natural resources for example, such as land or forests. Property owners can choose to benefit by immediately consuming a portion of their asset's value by consuming its returns rather than reinvesting them, by borrowing against the asset value, or by selling off a portion of them. Alternatively they can enhance their wealth and future income by postponing consumption now and investing more in the asset.

Within the marketplace, an asset's value is measured by its price. The price that people are willing to pay for an asset today is determined by the projected value of its future returns. The current market price reflects the present, discounted value of all future revenue flows that are expected to stem from the asset.

The ability to capitalize future value into an asset's present value induces property owners to consider the long-term implications of their asset-use decisions. It creates a strong incentive for owners to fully consider the effects of deferring consumption of their asset returns. Furthermore, it implies that property owners will be responsible to future users. Any activity that reduces the future benefits or increases the future costs stemming from an asset results in that asset's lower current value. As soon as an appraiser or potential buyer anticipates future problems, their assessment of a property's value falls, and the owner's wealth declines immediately. Even if one is not personally concerned with the future, it is nevertheless in a property owner's current financial self-interest to consider future generations by attempting to maximize his or her property values.[31]

Potential buyers interact with owners to maximize asset value over time. Individuals who believe that an asset will be worth more in the future stand to increase their wealth by buying the asset now and deferring its use. Their wealth will rise when others recognize the future value, and begin to bid up the asset's price. Again, these profit-maximizing buyers might not consider themselves to be future-oriented, but in their attempts to maximize their wealth, their investment decisions encompass a long-range perspective.

Corporate behavior can be expected to reflect this economic logic.[32] Corporate officers who do not expect to be present when future problems arise may well be concerned mainly with the short term. But current stock prices reflect the knowledge available to market participants. Wealth-maximizing stockholders immediately incorporate any new information they can find concerning the future effects of current activities into the price they are willing to pay to hold a company's stock. Corporate actions that are perceived to increase a firm's future value will cause its stock prices to rise, just as behavior that is perceived to reduce future value will be reflected in falling stock prices. In such a manner are short-sighted corporate officers held accountable by the asset market, for the effect of their actions on future generations.[33]

Investment Incentives in Government

Public choice theory suggests that public officials are not unlike individuals in the private sector, and also make decisions designed to further their self-interest,[34] and the slightly broader (but still socially narrow) interests of their bureau. However, unlike private decision-makers, public employees are legally barred from reaping any financial reward from their investment decisions. Bureaucratic "wealth" is more closely linked to the size, budget, and influence of the agency with which a public official is associated. The direct benefits of bureaucratic wealth-maximizing behavior are realized through an agency's expanding status and power, and can be enjoyed only during a public official's tenure in office.

To survive politically, politicians must satisfy voters at the next election. Politicians are accountable to current voters, and have strong incentives to concentrate on the current benefits their constituents will enjoy as a result of their resource-use decisions. Self-interested voters could generally be expected to support political decisions to incur costs now and enjoy the benefits later only to the extent that they are willing to be altruistic toward future citizens at their own expense.[35]

Since politicians and bureaucrats do not own the assets they manage, nor can public property be bought or sold by public officials for personal profit, any decision to defer taxpayer or resource-user consumption in order to increase asset value does not directly affect their personal wealth, and is likely to decrease rather than increase the political support for their bureau. When asset ownership is public and non-transferable, decision-makers are motivated to focus on the short-run effects of resource-use decisions, and have less incentive to postpone consumption in order to increase asset value or future output.[36]

Likewise, taxpayers own no transferable shares in public assets that can be traded to augment their personal wealth. Consequently, with the notable exceptions discussed below, an individual taxpayer stands slight chance of increasing his or her personal wealth by initiating a change in political activity that benefits everyone. The non-transferability of publicly-owned assets thereby dissuades the individual citizen from closely monitoring political resource-use decisions.[37] This fact contrasts sharply with the incentives facing a stockholder in a corporation. The latter can, upon diligently monitoring the corporations of specific interest, a) "bail out" of stock ownership when trouble (e.g., shortsighted management behavior) is suspected; or b) buy more heavily into the stock of a more promising firm. Either way the owner's decision is decisive, quite unlike a citizen's vote at election time. Stockholders, unlike taxpayer/voters, have an incentive to monitor organizations in which they have a saleable ownership stake.

Special Interest Pressures

When private asset owners can capture the future benefits of public investments in the market price of their property, they may bring about political decisions favoring long-term (though not necessarily efficient) investment projects. Empirical analysis has shown that property owners who are able to privatize public benefits are strongly motivated to lobby politicians to create such benefits; thus, special interest groups — organized coalitions of selected voters engaged in wealth or benefit-maximizing behavior — typically exert a powerful influence on political decisions.[38]

As an example of how catering to special interest pressures can yield public investments yielding long-term benefits, consider farmers who own land surrounding a proposed dam site, or merchants and residents who own land adjacent to possible future subway entrances or highway access ramps. Attempting to maximize their

own wealth by increasing the value of their property, these property owners have a strong incentive to support construction of a new dam, mass transit system, or highway. When property owners can capture the benefits from public investments without bearing full responsibility for their direct costs, we would anticipate abundant political investments of this nature. The fact that most new public investment projects undertaken in the past decade have been sports stadiums, convention centers, and arts and entertainment complexes, rather than bridges and sewers, attests to the influence special interest pressures exert in the political decision-making process.[39]

Expected Actions

Since public officials cannot directly benefit from decisions to defer consumption, we would expect to see a bias in political decisions toward projects that yield visible and immediate benefits and defer less visible costs into the future; and against projects that have clearly identifiable current costs and generate future benefits that are less apparent.[40] Since property owners can increase their personal wealth through decisions to defer consumption, we would anticipate their consumption and investment decisions to more fully consider their long-term ramifications.

Evidence from the case study described below supports this hypothesis.

Case Study: Evidence from Public Infrastructure Management

In the United States, infrastructure assets are predominantly publicly owned. Sewers, water systems, streets, roads, and mass transit facilities are principally owned by local and county governments. The interstate highway system as well as other major assets (including several Power Marketing Administrations) are owned by the federal government.

The decay of much of the nation's infrastructure has become apparent as accidents involving exploding underground water mains, subway fires, collapsing bridges, pothole-ridden roads, and buckling highways have occurred with increasing frequency over the past decade. Pat Choate and Susan Walter chronicled this deterioration in their 1983 expose of the public capital stock, *America in Ruins: The Decaying Infrastructure*. They estimated that $700 billion would be required to repair and maintain existing highways; $33 billion to repair bridges; $110 billion to maintain municipal water systems; and $25 billion to meet existing water pollution control standards. They projected that annual public investment levels throughout the 1980s would need to be between 5 and 10 percent of GNP merely to restore the nation's existing capital stock.[41]

However, actual public investment during the 1980s fell far below that. Spending between 1980 and 1984 averaged 0.4 percent of GNP,[42] and reached its apex at 2.2 percent of GNP by 1987.[43] According to Choate and Walter, the under-investment

in infrastructure reflects growing pressures on public officials to provide both social and infrastructure services, to restrain tax increases, and to operate within shrinking budgets. Choate and Walter contend that while inadequately investing in infrastructure may meet short-term budget-balancing goals, it imposes serious long-term social costs.[44]

George Peterson of the Urban Institute has extensively studied investment in public works across the nation, and attributes infrastructure's decay to a political environment that encourages its neglect. Peterson states that "if public officials have to choose between trimming maintenance or trimming current services, or between cutting back expenditures and laying off public employees, there is a built-in bias against capital preservation." In addition, the consequences of deferred maintenance are not immediately visible. "They may not show up for four or six years, which is a political lifetime ... Deferred maintenance is a debt that is passed forward from one generation to the next."[45]

Consequences of Deferred Maintenance

Several studies support the claim that political decisions are biased toward addressing immediate and visible needs, and away from less visible, long-term responsibilities. The National Council on Public Works Improvement (NCPWI), established by Congress to assess the nation's infrastructure, stated that maintaining public assets is "perhaps the single most important element of government's stewardship obligation. It also is the element that is easiest to defer, and the one most likely to be cut from the current expense budget."[46] A 1978 National Urban Policy Report commissioned by President Carter concluded that "failure to keep up a city's infrastructure is often a politically less sensitive action than cuts in the work force."[47]

A 1985 study of nine U.S. cities conducted by CONSAD Research Corporation found that "among all mechanisms that hold down total spending, limiting infrastructural outlays usually has the least immediate repercussions: city employees seldom lose jobs; perceived necessary services are not cut back; officials are not blamed for callousness towards the poor." CONSAD researchers Michael Pagnano and Richard Moore reported that "the effect of limiting infrastructural expenditures is almost imperceptible. Over time, however, it may create problems. The trick is predicting when these problems will occur. Some water lines are over 100 years old and in no need of repair, while others are much newer and need immediate attention. The gamble taken by city officials is that the effect will not be immediate but long-term."[48]

New York State Comptroller Edward Regan reported to the NCPWI that "when highways and bridges are regularly maintained there is no press coverage. When they are rebuilt it is an "event." There is a ribbon-cutting and plenty of press coverage. The incentives, therefore, are for public officials to purposefully starve the maintenance budget."[49]

A recent report by The House Wednesday Group, a caucus of delegates to the House of Representatives, acknowledges the effect of short political horizons: "The postponement of maintenance exacts little short-term political cost because the negative consequences of deferral take time to become obvious ... Thus maintenance is likely to suffer as a political priority."[50]

An Urban Institute survey of over 40 municipal public works agencies documents the routine neglect of preventive maintenance by public officials.[51] Preventive maintenance practices, such as cleaning and flushing pipes, painting bridge components to prevent corrosion, and sealing road joints, are known to slow asset deterioration, extend productive life spans, and avoid more extensive and costly future corrective maintenance.[52] The same officials who reported their knowledge of the long-term benefits of routine maintenance also acknowledged that such practices were consistently considered to be low expenditure priorities, and were rarely incorporated in their overall investment strategies. Furthermore, few officials reported that they had ever quantified the actual costs that would result from deferring maintenance.

How Government Budgets Reflect Short-Term Biases

The Urban Institute's findings are consistent with the theoretical premise that decisions made in a political/bureaucratic system will tend to defer costs for current benefits whenever possible.

Businesses distinguish between maintenance procedures that increase an asset's value and extend its usable life, and those that do not. The former are treated as capital expenses. These expenses are added to an asset's original cost and result in a higher asset value. The latter are treated as current operating expenses. This accounting distinction indicates an awareness by businesses that maintenance is a form of investment in the existing capital stock. Since maintenance that extends asset life is a capital expense that is capitalized over the life of the asset, a structural incentive exists for private firms to include preventive maintenance in their long-term investment strategies.

Government budgets, however, treat all maintenance expenditures as current operating expenses that must be financed through current revenues. This has important implications for government's long-term investment strategies in public works assets. It forces public officials to choose between spending on services that yield visible and immediate results, and spending to preserve the public capital stock, which yields real, yet deferred benefits. Moreover, it provides public officials with a strong incentive to defer routine maintenance until major restoration or new capital purchases, which can be financed with borrowed funds, are required.

Choate and Walter document that public officials routinely allow existing public works to deteriorate when rehabilitative efforts could restore assets at a lower cost than that required for new construction. As an example, they cite General Accounting Office findings that old cast-iron water mains could often be restored to an almost new condition through in-place scraping and relining. The cost would be between 30 and 50 percent of the cost of replacing the mains.[53] Despite the potential saving, this is not done.

A Federal Reserve study indicates that neglect of the existing capital stock is exacerbated by federal capital grant policies. By excluding operating expenditures from federal grant eligibility, a financial bias is created for new capital purchases.[54] A 1984 Lehman Brothers study found that public officials deliberately allow assets to deteriorate to the point that federal funds become available for major rehabilitation. Ninety percent of the state and local officials interviewed in this study confirmed that federal capital funds cause them to lower the priority they attach to maintenance and repair.[55] A 1988 Congressional Budget Office report lends further support by concluding that cities regularly retire municipal buses before the end of their useful lives and purchase new vehicles with federal capital subsidies.[56]

Private Sector Investment Comparison

Does the practice of systematically deferring maintenance differ in the private sector? Few empirical studies have compared maintenance practices and their effects on service-life duration between publicly and privately owned assets. But one such study of the local mass transit industry is consistent with the claim that private companies attempt to preserve the value of their capital assets to a greater extent than government organizations.

Federal Reserve economist Brian Cromwell, in a study of mass transit systems around the U.S., observed the maintenance practices of owners of mass transit vehicles. He found that private companies expend greater resources on maintenance, and that privately owned transit buses have longer in-service lives and do not deteriorate as rapidly as public buses.[57]

The study also showed that privately owned transit companies devote more labor hours to fleet maintenance than public agencies do (14 to 17 percent more, after controlling for wages, operating conditions, fleet composition and age).[58] Private companies also keep their buses in service longer. Over 38 percent of the buses in private fleets are more than 12 years old, as compared to 22 percent of public fleets.[59]

His findings also indicate that public equipment depreciates more rapidly than private equipment. Cromwell collected price information on 645 mass transit vehicles sold in 1987 and 1988 as shown in Figure 2.

The difference in resale prices supports the contention that maintenance increases an asset's value. It also indicates that the maintenance of privately owned assets is superior to that of publicly owned assets, and supports the claim that asset owners more fully consider the effects of future asset values in their investment strategies than do public officials.

Evaluating Government's Long-Term Management of Infrastructure

In its investment strategies affecting public works assets, the public sector has demonstrated a strong tendency to focus on immediate pressures rather than society's long-term needs. Public officials face hard choices in setting spending priorities between providing services that yield visible and immediate benefits, and those that yield less obvious future benefits. The structural and political incentives they face create an apparent preference to maximize current services and defer costs into the future.

George Peterson indicates the extent of the government's pattern of postponing payment for current services when he compares deferred maintenance of public works to unfunded pension liabilities: "These are all ways," he says, "that the current generation of taxpayers can consume public services, yet shift some of the costs of paying for them to future taxpayers."[60]

Case Study: Public Regulation of Prices

Politically short time horizons are also evident in governmental control over private industry. Regulation of the electric utility industry provides an example of how political pressures can discourage private investors from addressing long-term needs. Utility investments require a long-range perspective. It takes a minimum of six to eight years to build a power plant, and financial and regulatory constraints can extend the lead times for new generating capacity closer to between ten and fourteen years.

Evaluating the impact of regulation on the utility industry's performance lends a slightly different perspective than direct comparisons of public and private decisions. While its suggestions are less conclusive, they are consistent with our hypothesis that public decisions are designed to maximize visible and current benefits and defer less visible costs into the future.

Public Utility Regulation

Throughout the United States, state Public Utility Commissions (PUCs) regulate the selling price of electricity generated by private, investor-owned utilities.[61] PUCs set electricity prices that will, in theory, allow a utility to fully recover its costs, including a "fair and reasonable return" on its investments.

Electric utility regulation operated relatively smoothly throughout the 1960s. The cost of generating electricity fell as utilities built larger and more efficient power plants. Cost savings were passed on to electricity users through lower rates. The amicable relationship between utilities, PUCs, and electricity consumers began to change in the early 1970s. Inflation, interest rates, fuel costs, and environmental regulation rose, and caused the industry's capital and energy costs to increase dramatically.

From 1973 to 1986, the nominal cost of capital nearly tripled for most utilities. Petroleum prices after the 1973 OPEC oil embargo were 400 percent higher than their pre-embargo levels. The electric utility industry is highly capital and energy-intensive; 75 percent of electricity's generating costs is accounted for by the cost of these two inputs.[62] Utilities attempted to pass their higher capital and energy costs on to their customers, and the average price of electricity rose from 2.38 cents in 1973 to 7.44 cents per kilowatt hour by 1986.[63]

Political Pressures Facing PUCs

In the mid-1970s, PUCs confronted not only utilities routinely requesting rate increases, but also well-organized and well-funded consumer coalitions demanding rate relief. Several industry analysts have documented that the electricity prices allowed by state PUCs have been inadequate to cover utilities' escalating costs.[64] A University of Florida study estimated that, by the early 1980s, the utility industry earned a return on its invested capital that was 3 percentage points below the industry's real cost of raising capital.[65]

In studies conducted for the Department of Energy, economist Peter Navarro found that elected utility commissioners face strong political pressures to restrain rates. His empirical analysis indicates that the stronger the political pressures facing a PUC, the more likely that PUC is to pursue rate-suppressive policies. In Navarro's judgment:

> "... commissioner-candidates know that campaign promises to hold rates down are likely to woo ratepayer votes, and once in office commissioners have to worry about reelection. Because elections are held every three to six years and power plants take eight to twelve years to build, the benefits of allowing utilities higher returns so that they can undertake capital investment programs typically are not felt before commissioners' terms expire. This short-term political horizon is reinforced by the tendency of consumers to focus more on the immediate costs to them than on the future rewards when evaluating commissioners' performances."[66]

Higher Capital Costs from Rate Suppression

Rate suppression benefits current electricity consumers by restraining immediate increases in the price of electricity. However, it also impedes utilities' ability to recover their expenses, including their cost of capital.[67] Moreover, rate suppression intensifies the upward pressure on utilities' capital costs by increasing the risk that purchasing utility stocks and bonds will yield below-market returns. Navarro documents that rate suppressive regulatory environments have led to greater volatility in industry earnings and more frequent episodes of earnings attrition.[68] Earnings attrition refers to the loss utility shareholders experience when inflation drives a wedge between the return allowed by PUCs at the beginning of a rate period and the return actually earned by the utility at the end of the rate period.

To attract investors, utilities have had to promise investors higher returns, a "risk-premium" on their invested funds. Stephen Archer of Williamette University estimated that investors demand a one to two percentage point risk premium when buying the stocks and bonds of utilities operating within rate-suppressive regulatory environments.[69] Navarro estimated the risk premium to be in the range of several hundred basis points (a 100-basis-point increase represents a one percentage point increase in the interest rate).[70]

Falling utility stock and bond values indicate that investors have viewed utility stocks and bonds as risky assets. When the market price of a company's common stock falls in relation to the book value of its assets, so does the real value of a shareholder's common stock. During the 1980s, the market-to-book ratio consistently fell for the utility industry.[71] During the same time period, Moody's and Standard & Poor's downgraded the credit-worthiness rating of most utility bonds from the low risk range of AAA and AA to the higher risk ranges of A and BBB and lower.[72] As bond ratings decline, the interest charges on borrowed funds rise.

Navarro illustrates the impact that bond derating can have on capital costs:

> "Assume that a utility's bond rating falls from AAA to BBB and that the company must issue $500 million in bonds for a new power plant. Also assume that the interest rate on a BBB bond is 200 basis points higher than on an AAA bond. This two percentage point gap, which approximates the average spread witnessed (in the early 1980s) means that the BBB-rated utility has to pay $10 million more per year in interest charges than if it were rated AAA. These charges are passed on to consumers in the form of rate increases worth $300 million over the 30 year life of the bonds."[73]

Consequences of Higher Capital Costs

Utility executives have responded to higher capital costs by minimizing their use of capital. Several utility industry analysts contend that the pattern of rate suppression and capital minimization observed during the past two decades has raised the costs of providing power, and will ultimately result in higher prices for less reliable power.[74]

Pursuing cost-minimization strategies, utilities have bypassed opportunities to build new power plants and convert old plants to utilize efficient, low-cost fuel mixes.[75] The costs of generating power are therefore higher than they would be if otherwise economically viable investments had not been discouraged by rate suppression's higher capital costs. Higher operating costs represent forgone potential savings in a utility's fuel bill. While estimating the lost savings is difficult, Navarro projects that they could easily total hundreds of millions of dollars through the year 2000.[76]

Further minimizing their use of capital, utilities frequently purchase electricity to meet demand rather than build new power plants. Purchasing low-cost power from utilities with excess supply is sometimes cheaper than self-generated power, but it can also contribute to higher power costs over time. For instance, the National Energy Information Center estimated that the Power Authority of the State of New York (PASNY) could have provided its customers with cheaper power by 1995 if it had built a coal plant in the early 1970s instead of opting to buy Canadian power. While Canadian hydroelectric power is cheaper to generate than PASNY's coal, oil, or nuclear generated power, the price of Canadian power sold to the U.S. is not linked to generating costs, but rather to the price of oil. Consequently, in 1985 PASNY paid almost a nickel per kilowatt hour for power costing less than one cent to generate. Had PASNY invested in a new coal-fired power plant, the cost of its self-generated power would have been about four cents per kilowatt hour.[77]

In a 1983 study conducted for the Department of Energy, Navarro compared future electricity rates for electric utilities across the country under two different regulatory conditions. The first scenario reflected the rate suppressive/capital-minimizing environment utilities have experienced since 1973. The second set of assumptions allowed utilities to earn their market cost of capital and undertake all economically viable investments. The study estimated the costs of rate suppression for the sampled utilities to range from $242 million to $2.8 billion through higher fuel costs and foregone investment opportunities. Navarro projected that suppressing electricity rates throughout the 1970s and early 1980s would result in electric bills as much as 11 percent higher for Pacific coast utility consumers, and 33 percent higher for Southeastern utility consumers by the year 2000.[78]

The North American Electricity Reliability Council recently estimated that the demand for electricity grew by slightly more than two percent during the late 1980s.[79]

According to Navarro, utilities cancelled construction plans for new power-generating facilities during the 1980s to an extent that jeopardizes their ability to meet this projected growth.[80] At this growth rate, the Department of Energy warned that utilities' underinvestment in new power plants will seriously reduce the reserve capacity of utilities in several states and increase the risk of power shortages and failures.[81]

Rate suppression poses an additional, more subtle, threat to the continued reliable supply of electricity through its squeeze on utilities' operations and maintenance budgets. Economist Marie Corio investigated the relationship between rate suppression, reduced O&M expenditures, and the probability of power failures. She concluded that "if a utility's earnings are squeezed, poor (power plant) unit performance follows — although it takes a couple of years for this to become apparent in lower (equipment) availability and ... higher costs to the ratepayer."[82] According to a National Electric Reliability Study, 75 percent of all power interruptions reported to the Office of Emergency Operations, the Assistant Secretary for Environment, and Safety and Emergency Preparedness during the 1970s were due to problems related to facilities operations and maintenance.[83]

Evaluating the Effects of Rate-of-Return Regulation

Rate-of-return regulation discourages efficient resource use over time by distorting the incentives of regulators and utility executives to address long-term needs. Political pressures motivate utility commissioners to appease current users by holding electricity rates below the industry's costs of providing power. The ultimate costs of this decision are borne by future electricity consumers. Utility executives, in turn, focus on earning allowable returns on investment rather than designing investment strategies that will maximize their assets' value over time. In the past, when permitted returns exceeded the industry's capital costs, utilities generally overinvested in new plant and equipment. More recently, when allowable rates-of-return fell below capital costs, utilities responded by failing to undertake the investments required to provide low-cost power and meet projected load growth. In either case, investment decisions reflect the immediate political concerns that control utility commissions' decisions rather than maximization of long-term resource values. Utility commissions are politically controlled bodies. There is no market, analogous to a stock market, where the quality of their decisions is judged and implicitly compared to competitors' judgments, the way that a board of directors' decision or a corporate CEO's decision is judged by investors in those markets.

CONCLUSION

Private ownership, with enforcement of rights via common law and with cooperation arranged via markets, offers much promise for policy makers seeking prosperity and

environmental quality. The command-and-control system has not worked producing wheat; it has not worked in conserving energy or regulating its price; and it is not working well in providing environmental quality. No system is perfect, and the failure to meet the goal of perfection should not cause the rejection of either traditional government control, nor of the market mechanism, as we seek improvement. However, having examined several areas where reliance on private solutions can be compared with governmental, that is, political and bureaucratic control, this paper has argued that private ownership and control, and the market system, are seriously underrated and, in fact, have worked far better than traditional beliefs would suggest.

NOTES

[1] Aaron Wildavsky, *Searching for Safety*, (New Brunswick: Transaction Books, 1988), Chapter 3.

[2] Bernstam, Mikhail, *The Wealth of Nations and the Environment* (London: Institute of Economic Affairs, 1991), p. 1-28.

[3] Donald Coursey discussed this topic in "The Demand for Environmental Quality," a paper presented January 1993 at the annual meeting of the American Economic Association in Anaheim, California.

[4] See Richard L. Stroup, "Environmental Policy," *Regulation*, No. 3, 1988 (pp.43-49) for a brief recounting of the circumstances surrounding the Love Canal crisis and its policy results.

[5] See for example Paul R. Portney, "Reforming Environmental Regulation," *Issues in Science and Technology*, Vol. IV, No. 2, 1988; Office of Technology Assessment, *Are We Cleaning Up?*, 1988, Government Printing Office, Washington, D.C.; Environmental Defense Fund, et al., *Right Train, Wrong Track*, (mimeo, June 1988); and Fred L. Smith, Jr. "Superfund: A Hazardous Waste of Taxpayer Money," *Human Events*, August 2, 1986.

[6] See Ackerman, Bruce A. and William T. Hassler, *Clean Coal/Dirty Air or How the Clean Air Act Became a Multibillion Bail-Out for the High-Sulfur Coal Producers and What Should Be Done About It* (New Haven: Yale University Press), 1981.

[7] Crandall, Robert W., "Economic Rents as a Barrier to Deregulation," *The Cato Journal*, Vol. 6, No. 1, Spring/Summer 1986, p. 186-189.

[8] See Nichols, Albert L. and Richard J. Zeckhauser, "The Perils of Prudence: How Conservative Risk Assessments Distort Regulation," *Regulation*, Nov./Dec. 1986, pp. 13-23, and the more technical article by the same authors cited therein. These articles document the problems in EPA's "conservative" approach.

[9] See Richard Doll and Richard Peto, *The Causes of Cancer*, New York: Oxford University Press, 1981.

[10] See Amanda M. Phillips and Ellen K. Silbergeld, "Health Effects Studies of Exposure From Hazardous Waste Sites — Where Are We Today?" *American Journal of Industrial Medicine* 8:1-7 (1985), p. 1-7.

[11] See Nichols, Albert L. and Richard J. Zeckhauser, op cit.

[12] Aaron Wildavsky, *Searching for Safety*, (New Brunswick: Transaction Books, 1988).

[13] See Wildavsky, Aaron, op cit., esp. Ch. 6.

[14] See Peltzman, Sam, *Regulation of Pharmaceutical Innovation*, (Washington: American Enterprise Institute, 1974) and citations therein.

[15] See Peter Huber, "The Market for Risk," in *Regulation*, March/April, 1984, at p. 37, for the basis of this calculation.

[16] The incentive is to maximize value as expressed by buyers and sellers in markets. Markets aggregate the values of individuals, self-centered and altruistic, as does the political "marketplace." In both cases, values without substantial resources behind them will typically be ignored.

[17] For example, had the Kesterson Wildlife Refuge in California, which received irrigation drainage waters that damaged the refuge's waterfowl, been privately owned, it seems likely that the owner (unlike the U.S. Fish and Wildlife Service) would have investigated the possible consequences and discovered the potential disaster brought on by the drainage waters. In fact, it was a neighboring landowner who "blew the whistle" on the problem, causing it to become a public concern. Certainly a private owner has more wealth at stake, and a greater personal incentive to do so, than a bureaucratic manager.

[18] See Eric Zuesse, "The Truth Seeps Out," *Reason*, Vol. 12, No. 10, Feb. 1981.

[19] William Sanjour, quoted in the *New York Times*, June 30, 1980 (reported in Zeusse, op cit.).

[20] It is the role of entrepreneurs to find ways to contract around or to solve technically the problems of market failure, including information, externality, public goods, and monopoly problems. Franchising, shopping centers, and planned unit developments in which protective covenants constrain potentially harmful activities are examples of entrepreneurial approaches to internalizing external costs and benefits. Each provides information, amenities with public goods aspects, and property rights protection in situations where asset owners previously were not easily able to capture the benefits of socially responsible action.

[21] See Peter M. Sandman, "Apathy vs. Hysteria: Public Perception of Risk," in L.R. Batra and W. Klassen, ed., *Public Perceptions of Biotechnology* for a summary of literature on the problem of outrage.

[22] If substantial and irreparable harm is threatened, and no other legal remedy is available, then anyone threatened by a polluting activity can seek a court's injunction to stop the dangerous activity. But injunctive relief is not lightly granted.

[23] For a thoroughgoing and rather pessimistic view of this process and its effect on tort law, see Peter Huber, *Liability*, New York, Basic Books, 1988.

[24] See Peter Huber, *Liability*, (New York: Basic Books, 1988) Ch. 9.

[25] Authorities probably could receive money for some orphan sites, due to their location or other intrinsic value. For example, in southern California investors are trying to clean up and develop the former site of what was the Kaiser Fontana steel plant, even though it is contaminated by many sorts of hazardous waste. To do so, they must invest many millions of dollars in cleanup expenses in addition to other development costs. See Stanton, Russ, "Cleaning up Kaiser," *Orange County Register*, Oct. 23, 1988. p. 1.

[26] This section is adapted from Richard Stroup and Sandra Goodman, (Spring 1992) "Property Rights, Environmental Resources and the Future." *Harvard Journal of Law and Public Policy*, Vol. 15, No. 3, pp. 427-454.

[27] Bernhard Fernow, quoted in Barney Dowdle and Steve H. Hanke, "Public Timber Policy and the Wood-products Industry," in Robert T. Deacon and M. Bruce Johnson, *Forestlands Public and Private*, San Francisco: Pacific Institute for Public Policy Research, 1985) p. 89.

[28] Hotelling, Harold (1931). "The Economics of Exhaustible Resources," *Journal of Political Economy*, Vol. 39, No. 2, 137.

[29] Brubaker, Sterling (1983). "Land Use Concepts," in Governmental Interventions, Social Needs, and the Management of U.S. Forests, Roger A. Sedjo (ed) Washington, D.C.: Resources for the Future, 103.

[30] Indeed the argument can be made that uncertainty about future resource availability and prices, together with speculator inability to "bet" against a resource price increases by selling short, while other speculators can bet in favor of a price increase by buying a claim in the resource, markets tend to price resources too high currently. This is consistent with the fact that despite Hotelling's observation that mineral resources' in situ price should rise over time at a rate equal to the interest rate (otherwise why would anyone invest in holding or developing them?), most resource prices seem to fall or stay about the same over long periods of time.

This suggests that the market has invested too much, rather than too little, in providing minerals to the future; too little is consumed over time (by generations that are poorer than those which follow), if maximum total value is the criterion in a world with a positive opportunity cost of time. Other investments, rather than the provision of minerals, would have yielded more value to succeeding generations. See Richard L. Stroup and John A. Baden, "Property Rights and Natural Resources Management, *Literature of Liberty*, Vol. II, No. 4, (Oct./Dec., 1979).

[31] Stroup, Richard (1991). "Controlling Earth's Resources: Markets or Socialism?," *Population and Environment: A Journal of Interdisciplinary Studies*, Vol. 12, No. 3, Spring, 265-284.

[32] When an asset owner no longer makes the decisions regarding his or her asset's use, conflicting wealth-maximization goals may arise between the principal owner and the investing agent. For a thorough analysis of the principle/agency issue, see: Alchian and Demsetz (1972). "Production, Information Costs, and Economic Organization," 62 *American Economic Review*, 777; and Jensen and Meckling (1976). "Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure," Vol 3, *Journal of Finance & Economics*, 305.

[33] Stroup, op. cit.

[34] Two of the seminal works in public choice theory are Niskanen, William A., (1971). "Bureaucracy and Representative Government," Chicago: Aldine-Atherton; and Buchanan, James and Gordon Tullock (1962). "The Calculus of Consent," Ann Arbor: University of Michigan Press.

[35] Stroup, Richard L. (1985). "Comments on Marian Clawson's Problems of Public Investment in Forestry," in *Investments in Forestry*, Roger Sedjo (ed) Boulder, CO: Westview Press, p. 201.

[36] Crain, Mark and Asghar Zardkoohi (1978). "A Test of the Property-Rights Theory of the Firm: Water Utilities in the U.S." *Journal of Law and Economics*, October 1978, 395-408; and Stroup, "Controlling Earth's Resources," op. cit.

[37] This is especially true regarding state and local investments (or lack thereof) for individuals who are likely to move out of their current political jurisdiction before long run costs or benefits are felt. It will pay them to act as if the present matters far more than the future. A partial exception is that individuals who own real estate will find that its market value captures the net benefits and tax costs of current policies' effects on future users and owners of the property.

[38] Cohen, L. and Roger Noll (1984). "The Electoral Connection to Intertemporal Policy Evaluation by a Legislator," Stanford University, Center for Economic Policy Research, Publication No. 36, 1984; and Dobra, John and William Lee Eubank (1985). "Political Survivorship: An Interest Group Perspective," *Southern Economic Journal*, Vol. 54, No. 4, April 1985, 1038-1052; and Weingast, Barry, Kenneth Shepsle, Christopher Johnson (1981). "The Political Economy of Benefits and Costs: A Neoclassical Approach to Distributive Politics," *Journal of Political Economy*, August 1981, 89, 642-64.

[39] The House Wednesday Group, Congress of the United States, "The Rules of the Game," Washington, D.C., February 4, 1991.

[40] Gwartney, James D. and Richard L. Stroup (1994). "Economics: Private and Public Choice" 7th ed., Fort Worth: The Dryden Press, p. 107-108.

[41] Choate, Pat and Susan Walter (1983). *America in Ruins: The Decaying Infrastructure*. Durham, NC: Duke Press, 1-7.

[42] Aschauer, David (1987). Chicago Fed Letter, The Federal Reserve Bank of Chicago, No. 2, Oct. 1987.

[43] Aschauer, David. "Infrastructure and America's Economic Future," Committee on Public Works and Transportation. U.S. House of Representatives, June 13, 1990.

[44] Choate & Walter, op. cit., 7.

[45] The Urban Institute: Policy and Research Report (1980). America's Urban Capital Stock: An Interview with George E. Peterson. Vol. 10, No. 1, Spring 1980, 8.

[46] National Council on Public Works Improvement (1988). "Fragile Foundations: A Report on America's Public Works. Final Report to the President and Congress," Washington, D.C.: U.S. Government Printing Office, February 1988, 21.

[47] National Urban Policy Report (1978). Department of Housing and Urban Development. Washington, D.C.: U.S. Government Printing Office.

[48] Moore, Richard J.T. and Michael A. Pagnano (1985). "Cities and Fiscal Choices: A New Model of Urban Public Investment," Durham, N.C.: Duke University Press, 84.

[49] Ibid., 21.

[50] The House Wednesday Group, op. cit.

[51] Hatry, Harry P. and Bruce G. Steinthal (1984). "Guide to Selecting Maintenance Strategies for Capital Facilities," Washington, D.C.: Urban Institute Press.

[52] Hatry and Steinthal cite studies of water distribution and sewer systems in New York City and Savannah, Georgia, and bridge maintenance programs in Minnesota that show how preventive maintenance programs targeting identified "high-risk" segments within public works systems are effective means of preventing serious future problems. These studies include: Betz, Converse, and Murdoch, Inc. "New York City Water Supply Infrastructure Study: Manhattan," Plymouth Meeting, PA, May 1980); and Savannah Management and Auditing Department, "Water and Sewer Operations Study," Savannah, GA, September 1980; and Tracy, Robert G., "Priority Assignment for Bridge Deck Repairs," State of Minnesota Department of Transportation Research and Development Section, 1978; Dallas Office of Management and Budget, (1982) "Deferred Maintenance Issue Paper," Dallas, TX, January 13, 1982.

[53] Choate & Walter, op. cit., 62.

[54] Cromwell, Brian, (1989). "Capital Subsidies and the Infrastructure Crisis: Evidence from the Local Mass-Transit Industry," Quarter 2, Vol. 25, No. 2, Federal Reserve Bank of Cleveland.

[55] Lehman Brothers Kuhn Loeb (1984). "Public Infrastructure: Problems, Priorities, and Financing Alternatives. New York: Lehman Brothers Kuhn Loeb.

[56] Congressional Budget Office (1988). "New Directions for the Nation's Public Works," Washington, D.C.: U.S. Government Printing Office, xvii-xviii.

[57] Cromwell, (1989). op. cit.

[58] Cromwell, Brian, (1988a) "The Impact of Federal Grants on Capital Maintenance in the Local Public Sector," Working Paper 8812, Federal Reserve Bank of Cleveland, November 1988. — (1988b) "Federal Grant Policies and Public Sector Scrappage Decisions," Working Paper 8811, Federal Reserve Bank of Cleveland, November 1988.

[59] Cromwell's study focuses on the effects of federal capital grants administered by the Urban Mass Transit Administration (UMTA) on maintenance and scrappage rates of public sector fleet vehicles. The UMTA requires local transit agencies to operate buses purchased with federal funds for at least 12 years or 500,000 miles. Failure to do so results in ineligibility for federal assistance with new capital purchases.

[60] The Urban Institute, Policy and Research Report, op. cit., 8.

[61] Slightly more than 80 percent of the nation's electricity is provided by over 150 investor-owned utilities. The remaining 20 percent is supplied by the federal government's Tennessee Valley and Bonneville Power authorities, and state, city, and rural cooperatives.

[62] Navarro, Peter, (1985). "The Dimming of America," Cambridge, MA: Ballinger Publishing Company.

[63] Navarro, Peter (1989). "The U.S. Regulatory Environment and International Trade: Lessons from the Electricity Sector," *Journal of Policy Analysis and Management*, Vol. 8, No. 3, 467.

[64] Bolton, Craig J. and Roger E. Meiners," The Politicization of the Electric Utility Industry," in *Electric Power, Deregulation and the Public Interest*, John C. Moorhouse (ed). San Francisco: Pacific Research Institute for Public Policy, 259; and
Fenn, Scott A. (1983). "America's Electric Utilities," Washington, D.C.: Investor Responsibility Research Center, 6-7; and
Navarro, "The Dimming of America," op. cit; and
— (1982). "Public Utility Commission Regulation: Performance, Determinants, and Energy Policy Impacts," in *Energy Journal*, March/April 1982, 119-139; and
— (1989). "The U.S. Regulatory Environment and International Trade: Lessons from the Electricity Sector," *Journal of Policy Analysis and Management*, Vol. 8, No. 3, 466-481; and
— and Jeffrey Dubin (1982). "Regulatory Climate and the Cost of Capital," in *Regulatory Reform and Public Utilities*, Michael Crew (ed). Lexington, MA: Lexington Books, p. 141-166.

[65] Brigham, Eugene and Dilip Shome (1982). "Equity Risk Premiums in the 1980s," University of Florida, Working Paper No. 58. Cited in Navarro's Policy Game.

[66] Navarro, Peter (1982). "Public Utility Commission Regulation: Performance, Determinants, and Energy Policy Impacts." *Energy Journal*, (March/April 1982), p. 119-139.

[67] Navarro, Peter (1983). "Long Term Consumer Impacts of Electricity Rate Regulatory Policies," prepared for U.S. Department of Energy, Washington, D.C., January 1983.

[68] Navarro, "The U.S. Regulatory Environment and International Trade: Lessons from the Electricity Sector," op. cit., 468.

[69] Archer, Stephen H. (1981). "The Regulatory Effects on Cost of Capital in Electric Utilities," *Public Utilities Fortnightly*, Feb. 26, 1981, 36-39.

[70] Dubin and Navarro, op. cit.

[71] Navarro, Peter (1984). "The Policy Game," New York: Lexington Books, p. 160.

[72] According to a 1982 report prepared for the U.S. Department of Energy by the consulting firm Booz, Allen, and Hamilton, Inc.; "The Impact of Electricity Cost and Availability on Economic Growth and Competitiveness," Standard & Poor's made 100 more downgradings than upgradings of utility bonds between 1973 and 1981. By 1983, only one utility held an AAA bond rating and the median rating was A versus AA in 1973. Cited in Navarro's "The Dimming of America," op. cit., 45.

[73] Navarro, ibid., 46-47

[74] Archer, op. cit.; and Fenn, op. cit.; and Gormley, William (1983). "The Politics of Public Utility Regulation," Pittsburgh: University of Pittsburgh Press; and Navarro, Peter (1989). "The U.S. Regulatory Environment and International Trade," op. cit.; and — (1985). "The Dimming of America," Cambridge, MA: Ballinger Publishing Company; and — Dubin, op. cit.

[75] Electricity can be generated by many power sources: coal, oil, natural gas, hydro, nuclear, solar, geothermal, biomass, or wind. A particular power plant's optimal generation mix depends primarily on its location to various energy sources and on the mix of its existing plants.

[76] Navarro, "The Dimming of America," 29-42.

[77] Navarro, ibid., 39-40.

[78] Navarro, ibid., 84-91.

[79] Phone conversation with NAERC, 5/5/91.

[80] Navarro, "The Dimming of America," op. cit., 13-25.

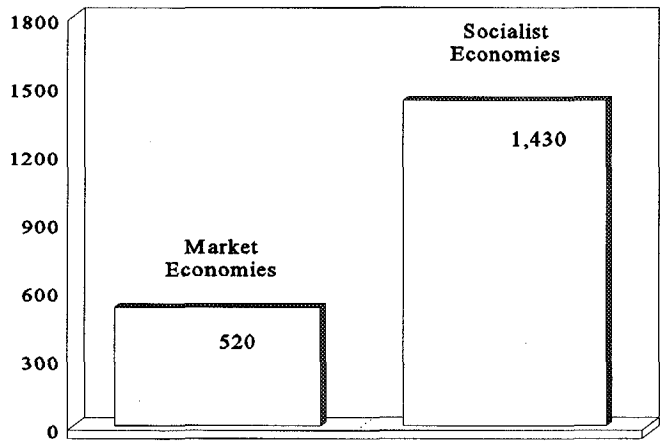
[81] Navarro, ibid., 56.

[82] Corio, Marie R. (1982). "Why is the Performance of Electric Generating Units Declining?" *Public Utilities Fortnightly* (April 29, 1982), 25.

[83] Walldorf, S.P. and L.C Markel (1980). "The Electric Utility Industry — Past and Present: Background Information for the National Electric Reliability Study," Technical Study Reports, October 1980. — cited in Navarro's "Dimming of America," p. 62.

FIGURE 1

ENERGY USE PER $1,000 OF GNP
(1986)

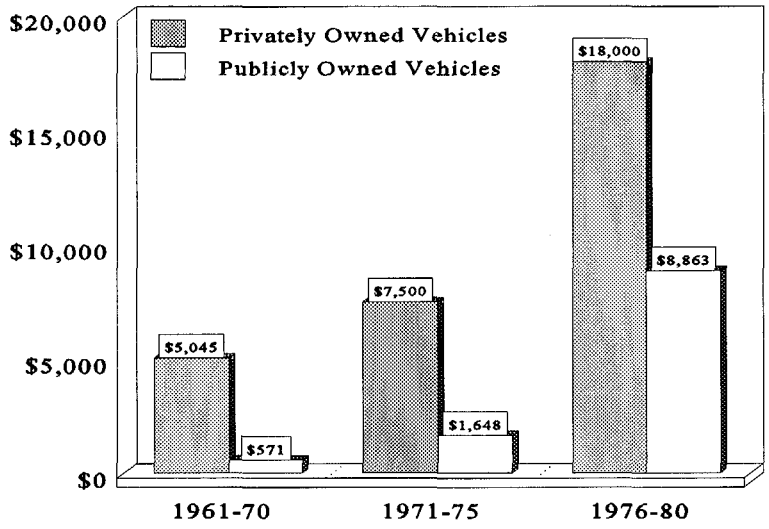


Note: Energy consumption is measured in kilograms of coal equivalent. Market economies are the United States, Canada, Japan, UK, West Germany, France, Belgium, Switzerland, Austria, Denmark, Sweden and South Korea. Socialist economies are the USSR, Czechoslovakia, East Germany, Hungary, Poland, Romania and North Korea.

Source: Mikhail S. Berstam, The Wealth of Nations and the Environment, 24, Tbl.. 5 (1991)

FIGURE 2

AVERAGE RESALE PRICE IN 1987-88



Private owners of bus lines personally pay for current upkeep expenditures, but also personally capture the future benefits of greater selling prices for the buses. They are willing to spend more for maintenance to protect those benefits than are public bus line officials, who constantly face demands for greater service at the present time, not in the future.

Source: Cromwell, Brian (1989). "Capital Subsidies and the Infrastructure Crisis: Evidence from Local Mass-Transit Industry." Qtr. 2, Vol. 25, No. 2, Federal Reserve Bank of Cleveland.

SESSION II: RESTRUCTURING THE ENERGY INDUSTRY

NATURAL GAS IN THE ENERGY INDUSTRY OF THE 21ST CENTURY

John Cuttica
Vice President
End Use Technology
Gas Research Institute

It is a pleasure to be here today and have the opportunity to participate in this section of the conference dedicated to the restructuring of the energy industry. I have been asked today to provide you a little insight from a gas industry perspective on how we believe the restructuring of both the natural gas and electric industries will affect the natural gas industry as we enter the 21st century.

We all know what has transpired as the natural gas industry has gone through the deregulation process (over the last ten years or so). We have seen:

- The downward pressure on natural gas prices.
- The unbundling of the transmission or pipeline business with the result being that segment of the gas business is virtually out of the gas merchant function and into a transportation and service business.
- The gas-to-gas competition become quite intense.
- The unbundling of the distribution function (the LDCs).
- The advent of gas marketers and brokers.
- The rebundling of services to better meet the needs of the customers.

What I want to do is review the next big step which is the restructuring of the electric industry and how we see this affecting the gas industry and the markets we

serve. I want to warn you up front, my views are through the eyes of an engineer and technologist with the bent on what we at the Gas Research Institute must wrestle with to keep natural gas products, processes, and technologies viable in the market place well into the 21st century.

The outline I will try to follow today is to provide what GRI sees as the recent market trends and strategic positioning going on today in the electric industry. I will then outline just some of the significant implications that our industry (gas industry) must consider as we continue functioning in these changing times. The four principal implications I see are:

- Market trends
- Strategic positioning
- Significant market implications
- Issues for the future

MARKET TRENDS

I would like to start by quickly reviewing with you what I see as the ongoing market trends in the electric industry (Table 1). (All tables appear at the end of this presentation). First of all, historical rate-of-return regulation is being phased out in favor of market competition. Already, regulatory reform has removed some significant barriers to the generation market for non-utility power producers. Today, over 50 percent of the new generation capacity brought on line annually is through non-utility power producers. We are also seeing the electric utility transmission system being opened up at the wholesale level as a result of FERC's proposed rule.

I recently heard an electric utility executive talking about open access and opening up the transmission system, and as he got more excited during this talk, he referred to the FERC NOPR on Open Access as the mega NOPR-giga NOPR and then the can opener. I thought that was an interesting analogy.

Another market trend (which, of course, we see ongoing in the gas industry also) is toward more customer choices. We see the unbundling of services first occurring with the non-core customers (industrial and large commercial customers) and then with the core (residential and small commercial) customers. The timing associated with the last step, the unbundling of the core customers, is a key issue.

However, regulation will continue to exist in some way, shape, or form for several reasons:

- To ensure the obligation to serve at the local level
- To provide protection for low income and other special customer classifications
- To ensure a mechanism to support designated social programs (Table 2)

STRATEGIC DIRECTIONS

While debates go on and electric utility executives are publicly taking one position or another on the key restructuring issues, most are preparing themselves quickly for a restructured and much more competitive market. One of the keys is to reduce their operating costs in every way possible to become more competitive. Most electric utilities are downsizing and re-engineering. That sure is a familiar sound in the gas industry. I recently heard an industry analyst state that on average, electric utilities must reduce operating costs by 25 to 30 percent to begin to operate profitably in a truly competitive market.

Table 2 also shows that many electric utilities are using more sophisticated and flexible pricing techniques today, to try to "lock in" their non-core (mainly industrial) customers. Some are even selling assets that are not part of their future business strategy.

They also are trying to write down any large expensive capital assets such as nuclear plants to better position themselves as low cost generators. Stranded assets and how they will be treated is the biggest single factor on how the restructuring or deregulation of the electric industry will take place.

Table 2 also shows that the gas industry needs to worry about the fact that all electric utilities are quickly recognizing that a key to success on the distribution side is to develop and expand customer services. Selling the commodity alone will result in smaller and smaller margins. The future direction is to understand the customers' needs and then provide the services (not just the commodity) to meet those needs. This is true on both the electric and gas side.

Finally, we are seeing and will continue to see acquisitions and mergers. One of the reasons we are seeing these mergers/acquisitions is that to play in this unregulated competitive market, you must position yourself to play not on a local basis, but on a regional, a national, maybe even a global basis. It is very similar to what we see going on in the banking business, with the advent of the mega banks. The lesson is to reduce operating costs through mergers while offering more services.

MARKET IMPLICATIONS

Now that I have mentioned what I see as some of the market trends and how the electric utilities are starting to position themselves to better compete, let's look at what the implications of electric industry restructuring may be on some of our natural gas markets (Table 3).

The first area I would like to talk about is the electric generation market. The restructuring scenario that is most often put forward is one that anticipates large reductions in electric reserve margins, along with opening up access to the electric transmission system and increasing competition between utility and non-utility generators. With increased levels of wheeling at the wholesale and eventually the retail level, it is believed that the electric industry will not need as much surplus capacity, nor will it be able to afford such surpluses in a highly competitive environment.

The U.S. electric reserve margin in 1994 was approximately 25 percent. Some industry analysts predict reserve margins being allowed to drop below 10 percent within the next eight to ten years. (GRI baseline projects 13 to 15 percent). Also, as the electric industry prepares for increased competition, the mind set is to reduce operational costs, increase the output capacity of existing power plants (Mw), and increase the utilization factor or MwHs of existing plants.

What the decline in reserve margins and the increase in capacity and utilization factors suggests is that, on net, little new electric generating capacity will be installed over the next ten years or so. The scenario suggests that the role of natural gas as we enter the 21st century in the bulk power market should focus on what natural gas can do to extend the value of existing electric utility generation assets.

To me (as an engineer/technologist) that means such things as:

- Repowering of existing plants;
- Gas conversion technologies applied to coal and oil plants if the conversion makes economic sense;
- Emission control technologies such as reburn and combining reburn and SNCR (selective non-catalytic reduction);
- Co-firing to improve operations when burning low cost-off spec coals; and
- The development of a new opportunity in distributed power generation technologies.

I do believe one of the market opportunities for natural gas in the near future is distributed power generation, and I would like to just take a minute to describe what I mean by this term (Table 4). My definition of distributed power generation is:

- Modular systems that produce power on a relatively small scale (usually in the 1 to 10 Mw per unit range)
- Can be easily sited throughout an electric utility's service territory
- Can be quickly and inexpensively installed usually at the distribution substation
- Has the potential to provide low cost service

The reasons I believe distributed power generation may be of interest in this new environment are as follows (Table 5). Today, transmission and distribution or T&D expenditures represent more than 67 percent of the electric industry's total annual capital expenditures. In addition, roughly 97 percent of electric outages experienced by the customer are the result of problems associated with T&D lines (not the generating plant).

Siting new T&D lines is very difficult due to public pressure about electromagnetic fields. And finally, distributed generation offers both low financial risk and good operation.

I believe that if we see this market grow, that natural gas is the logical fuel of choice and the gas technologies to be considered include reciprocating engines, diesels, small gas turbines, and fuel cells.

The second element of the restructured scenario most often talked about is the transmission element. Here, I believe some form of regulation will remain. I do not see any direct gas interaction in this segment of the restructured electric industry, so I will skip over this area and go to the other end of the industry, the distribution or disco function (Table 6). Here I see significant implications on the competitiveness of natural gas products in the residential, commercial, and industrial end use applications. The main issues are:

- Lower electric prices and the challenges this presents to marginally competitive gas products.
- Emerging energy service business and other new entrants into the industry (the ESCOs and Marketers).
- Customer information systems which are providing a critical competitive advantage.

As a result of the FERC NOPR, we expect to see open access of the electric transmission system and wholesale wheeling expand from approximately 21 utilities that were offering open access at the time the NOPR was issued, to all the 137 utilities that come under FERC jurisdiction (Table 7).

Some 32 states have initiated some form of evaluation or study regarding retail wheeling. We know that California, Michigan, Wisconsin, and Rhode Island, for example, are all moving rather fast towards experiments and possible adoption of retail wheeling.

What will result from this is a much more competitive market that will put severe downward pressure on electric prices. As electric prices drop, the competition between gas and electric products becomes much more intense. One question, of course, is how much downward pressure will there be? GRI's own baseline projects potential reductions in electricity prices are:

- 20 to 30 percent in the large industrial market
- 10 to 20 percent in the large commercial market
- 5 to 10 percent in the residential and small commercial market

This means much stiffer competition for natural gas products and processes that compete head to head with electric options. Those gas products that have shown only marginally competitive advantages may be in trouble (Table 8).

For GRI and our end use R&D program, it means an even greater emphasis on reducing first cost premiums usually associated with natural gas appliances and products. As we proceed through the deregulation process and experience the downward pressure on electric prices, we will see the electric utilities and marketers offering real time marginal pricing. Electric prices which more closely reflect the cost of generation may open up the potential to improve gas market share in selected applications such as peak loaded applications, space cooling as an example.

But, even in these applications, we have to closely evaluate the level of coincidence between the total on time of the gas appliance and the time of peak electric rates. As we see competition stiffen, I believe we in the gas industry will have to become much more adept in retail marketing where success depends more on the price/performance ratio than on the price of the commodity or service itself.

We will have to exploit the advantages or value added of utilizing natural gas products. And finally, but probably most importantly, market and customer information is going to be the key to success.

That takes me to the new entrants that we are seeing as a result of deregulation of both the gas and electric industries (Table 9). We are familiar with the "gas marketers" that have sprung up as a result of the gas industry deregulation and unbundling of services. We will see more "power marketers" spring up as the electric industry goes through restructuring.

But, what will happen (in my opinion) is that the gas and power marketers will merge and in essence, become energy marketers that will not care very much if they are providing electrons or molecules. These fuel neutral marketers/brokers will be both customers of the gas industry, as both the pipeline and gas utilities transport gas for them through their pipes, and they will be competitors to the LDCs as they will also start to provide the services the local gas utilities once provided to their end use customers.

I also believe the business will be very cutthroat and the larger brokers will start offering much more than the electric and gas commodities. They will start offering more and more energy services and become ESCOs.

NEW ENTRANTS

That leads me to the second entrant, or what I see as the real future competition to what we traditionally think of as the gas LDC. The ESCOs (I believe) will be the future link to the end use customer (especially the non-industrial customers). These ESCOs will provide engineering services, provide the energy (electric or gas), advise the end user on product purchases, and possibly manage all their utility accounts (not just electric/gas).

Although the local utilities (both gas and electric) are in the best position to offer these energy services, they are not the only ball game in town. Today, we see companies like Honeywell, Johnson Controls, Enron, Utilicorp, Entergy, and others. Tomorrow as the electric industry deregulates, we will see electric utilities get in this game also.

Again, the true ESCO (as I see it) are companies that are driven to fill the energy needs of their customers and they really do not care very much whether they fill the need with gas products or electric products. They are driven to fuel neutrality.

The key here is to ensure that these companies are fully aware of the array of natural gas products and advantages they can provide the customer. Remember, these companies are not selling a commodity alone, they are selling services that best meet the customer's needs.

Another opportunity that the gas industry should watch very closely is home automation or customer/utility interfaces using the Information Highway (Table 10). At first glance, it may not be obvious why the gas industry needs to be concerned about this opportunity. But, if you just think about it for a second or two, linking up customers through two-way, direct broad band communication will provide ready access to the home. This ready access will allow delivery of new, tailored services to each customer segment (residential and commercial and industrial).

These link ups go beyond entertainment and merchandising and can provide security, library, medical, telephone, and energy services, just to mention a few. The link ups are happening. The infrastructure is being put in place by the telephone and cable TV industries (at their expense). With the promise of new business opportunities, a whole host of manufacturers and entertainment, information and service providers (including forward looking electric and gas) are actively developing their own business strategies and products.

I believe this market opportunity will happen with or without the gas industry. These systems are a means of getting closer to our gas industry customers (especially the residential customers). How does this affect GRI? We want to make sure that gas products can communicate in these home automation systems. We believe its important for us to develop the right protocols and interface modules to ensure compatibility. We also are assembling a wealth of information on this subject for our member companies.

This area is an opportunity for the gas utilities to form very powerful alliances or on the other hand, it is one heck of a threat, if we allow the alliances to pass us by. I can assure you the electric utilities are very heavy into this market opportunity.

The last area I would like to touch upon is the overall gas industry's competitive response to what is going on in the electric industry (Table 11). Electric restructuring, if it works as the theory predicts, will force the electric utilities to become leaner and meaner, to become much more customer oriented, to broaden their business horizons beyond generating, transmitting, and selling a commodity, and to become much more skilled in a competitive market.

Even if this happens only in part, there will be increased competitive pressures put on all gas companies, whether they be producers, pipelines, or LDCs. The pressure on the gas industry will be to ensure that competitively priced gas supplies and services are available in the marketplace. The table points out the role that GRI and technology must play in ensuring competitive gas prices This role includes:

- Reducing the risk of finding gas;
- Reducing the cost of extracting gas;

- Getting maximum production from every well; and

- Ensuring the delivery of new supplies of gas in more flexible, convenient, and cost-effective ways.

The last two bullets point out a trend we may well see as electric restructuring continues to unfold: The convergence of the electric and gas industries into an energy industry, and the increase in mergers and acquisitions to reduce operating costs and offer fuel neutral energy services.

To summarize, I want to outline five key issues that I believe will have significant implications on the gas industry as we enter the 21st century (Table 12).

- What is the outlook for gas as a fuel for power generation: Both as the electric industry tries to extend the life of existing plants and as they expand in the future in both bulk and distributed generators?

- Another issue is electricity prices and the competitiveness of gas fired end use technologies. The competition will become much more intense.

- New entrants in the field (marketers and ESCOs): Are they competitors or customers and how do we deal with them?

- What is the role of customer information systems? How does the natural gas industry keep it from passing us by? I am convinced it is the way of the future.

- The gas industry competitive response of low cost (yet profitable) natural gas supplies available through a flexible transmission system.

I hope that gives you a little feel for how I see things playing out and what it means to the gas industry. Of course, I am biased, but throughout this presentation, I hope you get the flavor that technology is going to play a big role in our energy future as we open up our utility system to market competition.

TABLE 1

MARKET TRENDS

- Rate-of-return transitioned to market competition
  - Competitive generation
  - Open-access transmission
  - Increased customer choice
- Some regulation will continue to exist
  - Obligation to serve
  - Protection for low income customers
  - Mechanism for social programs

TABLE 2

STRATEGIC DIRECTIONS

- Downsizing/re-engineering
- Discounting prices to lock in large customers
- Selling assets not part of business future
- Writing down large capital assets
- Developing/expanding customer services
- Considering acquisitions/mergers

TABLE 3

SIGNIFICANT MARKET IMPLICATIONS GAS-FIRED GENERATION

- New generation investment limited
  - Reduced reserve margins
  - Increase capacity factors
- Extend the value of existing plants
  - Repowering
  - Gas conversion technologies
  - Emission control technologies
  - Cofiring
- Opportunity for distributed power generation

TABLE 4

DISTRIBUTED POWER GENERATION

- Modular Systems (1 — 10 Mw per unit)
- Easily sited
- Quickly and inexpensively installed
- High potential for low cost
- Efficiency service

TABLE 5

WHY CONSIDER DISTRIBUTED POWER?

- T&D at 67 percent of annual capital expenditures
- 97 percent of customer outages due to T&D problems
- Electromagnetic fields
- Low financial risk
- High performance

TABLE 6

SIGNIFICANT MARKET IMPLICATIONS COMPETITIVENESS OF END USE APPLICATIONS

- Low electric prices
- Emerging energy services
- Customer information systems

TABLE 7

DOWNWARD PRESSURE — ELECTRIC PRICES

- FERC NOPR — Open access and wholesale wheeling
- State initiatives — Retail wheeling and energy services
- Market competition

Projected Electric Price Reductions

Industrial	20 — 30%
Large Commercial	10 — 20%
Residential	5 — 10%

TABLE 8

LOWER ELECTRIC PRICES

- Hurts marginally competitive gas products
- R&D emphasis on first cost reduction
- Real time marginal pricing may provide gas opportunities — peak load applications
- Retail marketing — price/performance ratio (not price only)
- Market and customer knowledge is key

TABLE 9

NEW ENTRANTS

- Marketers (gas and power)
  - Merge into energy marketers/brokers
  - Driven toward fuel neutrality
  - Both customers and competitors to LDCs
  - Larger marketers will offer broader services (ESCOs)
- Energy service companies (ESCOs)
  - Offer products/services
  - Non-industrial customers are prime market
  - Future link to the end use customer
  - Multi-billion dollar business
  - Utilities (E&G) are best positioned
  - Driven toward fuel neutrality

TABLE 10

CUSTOMER INFORMATION ALLIANCES (INFORMATION HIGHWAY)

- Means of getting closer to your customers
- Means of forming powerful teams
  - Utilities
  - Communications
  - Computer software
  - Entertainment
- Means of providing customer services well beyond energy

TABLE 11

SIGNIFICANT IMPLICATIONS GAS INDUSTRY RESPONSE

- Increased competitive pressure on gas companies
- Respond with competitive gas prices
  - Reducing risk of finding gas
  - Reducing cost of extracting gas
  - Getting maximum well production
  - Ensure delivery of gas supply
- Convergence of electric and gas industries
- Increase in mergers and acquisitions

TABLE 12

KEY STRATEGIC ISSUES FOR THE GAS INDUSTRY

- Outlook for gas as a fuel for power generation
- Electricity prices and the competitiveness of gas-fired end use technologies
- Energy service companies: new competitors or customers?
- The role of customer information systems
- The gas industry competitive response

TECHNOLOGY OPPORTUNITIES IN A RESTRUCTURED ELECTRIC INDUSTRY

Steven Gehl
Director, Strategic Synthesis
Electric Power Research Institute

The intent of the Strategic Research & Development (SR&D) program is to anticipate and shape the scientific and technological future of the electricity enterprise. SR&D serves those industry R&D needs that are more exploratory, precompetitive, and longer-term. To this end, SR&D seeks to anticipate technological change and, where possible, shape that change to the advantage of the electric utility enterprise and its customers. SR&D's response to this challenge is research and development program that addresses the most probable future of the industry, but at the same time is robust against alternative futures.

The EPRI SR&D technical program is organized into several vectors, each with a mission that relates directly to one or more EPRI industry goals. These goals are explained in the vector summaries described below.

BIOLOGICAL AND STATISTICAL METHODS

A major issue facing the electricity business is the possible effect on human health of exposure to a number of chemical and physical agents that accompany the generation, delivery, and use of electricity. These agents include electric and magnetic fields (EMF), particulate matter (PM10), and polycyclic aromatic hydrocarbons (PAH) related to manufactured gas plant sites. It is essential that the industry, regulatory bodies, and the scientific community have the soundest possible understanding of the magnitude of any risks and the mechanisms in order to respond to public inquiry, and to develop and evaluate appropriate risk management strategies.

Two primary scientific uncertainties hinder our ability to assess and respond to potential health risks from exposure to these agents:

- An incomplete understanding of mechanisms and biological responses to these agents, and

- The inability to confidently extract health risk estimates from available environmental exposure data and epidemiological studies.

This work will address both these issues using state-of-the-art approaches to cell biology, mutagenesis, DNA behavior, and multiple-stress effects for the former, and statistical techniques such as meta-analysis and cluster-analysis for the latter.

COAL SCIENCE

For the foreseeable future, coal will remain the primary fuel for electric power generation. Although much of the industry's current attention is on gas and combustion turbines, the economic use of existing coal plant assets will be a continuing business requirement.

The ability to burn coal at emission levels well below required standards will be a significant economic advantage for emissions trading and the use of lowest-cost local coals. Basic information on the structure and chemistry of coal and its combustion will result in methods for precombustion cleaning at a fraction of post-combustion cleanup costs. Improved control of the combustion process itself will lead to substantially reduced NO_x emissions at acceptably low levels of unburned carbon. This is not a field in which breakthroughs are expected. The chemistry of coal is a classically difficult subject for which a decade's more work is required. Characterization of the minor elemental constituents of coal and the associated mineral matter; their evolution during the conversion and combustion processes; their role in, for example, plant corrosion; and their environmental impact will continue to be of importance. For many years, there has been a substantial R&D effort on coal processing and coal combustion sponsored largely by the U.S. DOE and its laboratories. Support for this work faces an uncertain future. EPRI has been closely involved in these activities over the years, and will continue to play a vital role in demonstrating a continuing industry interest in this field, as well as guiding work done toward problems of special relevance to power generation.

COMMUNICATIONS AND INFORMATION TECHNOLOGIES

The continuation of deregulation of all the "wires" businesses could lead to a future where electricity, telephone, cable, computer, and entertainment services are

delivered by new entities, cutting across traditional business boundaries and leading to the creation of "info-electric utilities." Even if further deregulation is deferred, the rapid pace of development of information technologies will provide opportunities for the evolution of new differentiated electricity products and services.

In 1994-95 EPRI worked to focus national attention on the potential future role of the electricity industry in the development of the National Information Infrastructure (NII). In 1995, resources were used to aid in the formation of the new information Technologies and Communications Unit, which will be operational and funded in excess of $3 million in 1996. The new unit will focus on development of a sound cross-institute strategy to assure our industry role in setting the direction of emerging information technology and further development of the NII.

ECOLOGY AND GEOPHYSICS

Concern over the potential effects of human activities on global climate may lead to policy decisions and political actions that significantly affect the availability and cost of fossil-based energy. Electricity generation, as a major source of CO_2 emissions, may be particularly affected. An important aspect of the policy debate is the magnitude and cost of environmental change. A particularly difficult element of this cost to estimate — and one that is potentially very large — is the change to ecosystems, both managed (agriculture, timber, rangeland) and unmanaged (wilderness, desert, rain forest, tundra, etc.).

The objectives of this work are to develop well-founded integrated assessments of climate change, including evaluations of ecosystem impacts. Specific results will include effects of increasing greenhouse gas concentrations on important climate variables; responses of ecosystems to altered climate; global ecosystem models that incorporate effects of climate change and changes in land use on the distribution and function of ecosystems; and measures of the societal and economic value of potential ecosystem impacts.

ELECTRIC MACHINES AND DRIVES

Stationary and mobile motors and drives today use more than half of the electricity generated in the United States. The potential for further electrification of fossil drives is significant. For example, EPRI estimates that 30,000 MW of existing natural gas pipeline compressor loads are good candidates for electrification. In addition, only two percent of U.S. transportation and other mobile applications are electrified. Performance improvement in motors and drives will lead to higher operating efficiencies for motors and drives used by utilities and customers alike. Substitution of electric drives for combustion-engine-driven drives also reduces air emissions, because power plants have better environmental controls than small fossil-fired engines.

Work will focus on fundamental developments in motors and drives concepts through exploratory and innovative research, proof-of-concept demonstration, and subsequent integration of early results into prototypes. The proposed work seeks to improve the dynamic control of motors and drives, reduce their cost and weight, increase their torque density, and invent new drive concepts that will enable development of remote and mobile applications now dominated by fueled-engine drives. SR&D results will include improvements in permanent magnet materials exhibiting field strengths of more than two tesla; new materials for motor winding insulation that offer more resistance to the increased stress resulting from the ever-higher switching speeds of power semiconductor devices; improved manufacturing techniques that contribute to reduce system cost through higher levels of integration, lower part counts, and increased reliability; thick-film technology for magnetic motor components; and new motors based on high-temperature superconductors.

Specific targets of this effort include:

- Innovative design concepts to enable new stationary and mobile applications of electric drive (ongoing);
- High-magnetic-strength materials for permanent magnet motors (2005); and
- New dielectrics and polymer structures for improved motor winding insulation (2000).

EMERGING ENERGY ISSUES

After an extended period of relative stability, rapid changes are occurring in the structure of the electricity industry, in its regulatory status, in the products and services it provides, and in its technology base. In this new environment, utilities that lead the industry in the strategic application of new technologies will have an important advantage over those that do not. The optimum strategy for an individual utility depends on a host of interrelated global and local parameters, including economic and financial conditions regulations, markets, competitors, and the existing electricity infrastructure. The emerging energy issues effort will work out the interplay among these issues, develop tools and analyses to help utilities determine the role of technology in their business strategies, and identify approaches and plans for technology application.

The long-term objectives of this work are to map out the technology future of the industry and the associated uncertainties under a range of possible future scenarios; to work with utilities to define technology strategies; and to communicate the results of these analyses in appropriate venues to policymakers and all stakeholders in the electricity enterprise. Specific results include:

- Formation of an Energy Studies Center to bring together world-class experts to define and assess the factors that will shape the future uses of electricity and other energy forms, the electricity supply infrastructure, and associated business opportunities and threats;

- Assessments of specific technology advancements, economic issues, and regulatory/legislative developments that have the potential for profoundly changing the industry; and

- Publication of "Energy Issue White Papers" and other communication vehicles to present the results of this research to utility executives, policymakers, regulators, the investment community, and the general public.

ENERGY STORAGE — UTILITY

Economically acceptable storage systems will lead to improved productivity of existing and future assets while simultaneously improving the productivity of electricity consumers. Low utilization of system assets is a major factor contributing to the industry's large investment-capital base and a major inflationary pressure on electricity rates. Lack of cost-effective and energy-efficient technologies for bulk storage of electricity prevent the electric utility from providing low-cost services in response to customers' preferred consumption patterns.

Results to date are:

- The 1996 work will establish the basis for deployment of new storage technologies by identifying the performance characteristics that will maximize the value of storage applications to the industry.

- The technical barriers between currently available storage technology and those that are required in the future will be identified. Research to overcome these barriers will be planned for implementation in future years.

- In addition, some studies will be aimed at fundamental improvements in existing storage technologies. Specifically, the impact of advanced materials for flywheel fabrication and the design of more cost-effective superconducting magnetic-energy storage systems will be studied. This work will be completed in 1997.

ENERGY STORAGE

Transportation is the single largest energy market in which the penetration of electricity is small. Lack of commercial batteries with acceptable weights and life-

cycle costs are the primary deterrents to large-scale deployment of all electric vehicles. If owners of battery-powered vehicles can be encouraged to recharge off peak, the capacity factors of existing and future plants will be considerably enhanced, leading to lower real electricity costs. The 1996 work is primarily directed at the development of an intermediate-performance battery. Novel battery concepts are explored in parallel in a continuing effort to invent and discover even lower-cost battery systems for both electric vehicle and system grid applications.

EPRI has been involved in advanced battery research for many years, and its staff possesses the needed core competencies to plan, direct, and interpret research in this area. As a partner with the major auto manufacturers and Argonne National Laboratory in the U.S. Advanced Battery Consortium, we have been able to leverage a relatively minor financial contribution, via our technical inputs, to obtain a leadership role in the project. We represent the utility industry's interests in this program.

HIGH EFFICIENCY AND DISTRIBUTED GENERATION

The aging of the nation's generation fleet combined with the potential for early retirement of uneconomical nuclear capacity will require significant investment in replacement generation capacity during the first two decades of the next century. Gas-fired combustion turbine/combined-cycle technology is the current economic choice, but loss of a balanced fuel portfolio would eliminate the industry's ability to provide low-cost electrical service in the event of significant gas price increases. Thus, clean generation processes that do not depend on natural gas as a fuel continue to be a strategic need of the industry.

Re-regulation of the generation business creates a new business environment for generation technology. Uncertainty over the future of DOE and the role of federal funding in energy research requires that the utility industry and EPRI take a leadership position in developing a new and responsive national agenda for generation R&D. EPRI's skills in technology and economic analysis combined with awareness of the industry's new business challenges creates a unique ability to serve as a focal point for this effort.

EPRI continues to represent the industry's needs in the search for cost-effective renewable energy option; in the development of fuel cell technologies or near-zero emission applications; in advanced technology for gas turbines, including the design of advanced cycles and the analysis of existing and potential materials issues; and in the identification of the potential for distributed generation.

LIGHTING

Lighting represents 20 percent of the United States' total electrical use, 35 percent of commercial sector use, and as much as 50 percent of commercial peak demand. In addition, roughly 50 percent of U.S. utilities own, maintain, or service street lighting systems. Lighting has historically constituted over half of utility customer service activities. Currently, electrical loads from lighting are declining as a consequence of new lighting standards based more on energy budgets than on the quality of the lighting service. Advancing light source technologies is the straightforward route to improving customer lighting service quality within the constraints of today's lighting standards. An alternative higher-risk approach is to develop new performance and productivity-based standards for lighting design and work toward their adoption.

Most of today's fluorescent and high-intensity discharge (HID) sources contain mercury, lead, or other toxic or hazardous substances that complicates their manufacture and disposal and, further, creates the perception of future liability issues if regulation tightens. This research will seek to reduce or eliminate the toxic material content in light sources. Results are sought in two areas. Exploratory investigations and the discovery of new light sources that (1) deliver improved lighting quality within the constraints of today's energy budget-based standards and which (2) also eliminate hazardous or toxic materials, will be pursued through a collaborative matching funds program with the three large lamp companies. Experimental and theoretical areas to be investigated initially are:

- Two-photon cascade phosphors (2005);
- Discovery of new nonequilibrium, low-pressure electric discharge light sources (2000); and
- Non-local thermodynamic equilibrium (non-LTE) visible-emission with near-zero IR-emittance sources (2000).

EPRI has two distinctly different roles in this area. In the development of new light source technologies, EPRI's roles are a catalyst and participant with the lighting industry in organizing and funding precompetitive, long-term, exploratory research. In lighting and human performance and productivity, EPRI needs to take a leadership role in defining the essential research and focus industry and government research in this area. The financial requirement of both roles is modest in consideration of the roughly $40 billion revenue stream received by utilities from lighting.

MATERIALS

Improvements in materials, the detailed understanding of materials failures and degradation processes in service, the development of characterization methods for materials in situ, and the development of remaining-life prediction techniques will lead to increased equipment availability, reduced O&M costs, and larger permissible operating envelopes.

The availability of advanced generation, distribution, and transmission methods will involve development of advanced materials for structures, insulators, electrolytes, transformers, etc. The ability to use a wider range of energy sources effectively (fossil fuels, nuclear fuels, solar energy, wind, etc.) will require materials with a wide range of properties. In many cases, development of methods for utilization of these fuels will be paced by materials development.

SR&D Results:

- Mechanisms and models for the degradation and failure of materials in service include aqueous corrosion, high-temperature oxidation and corrosion; particulate, water droplet, cavitation erosion and wear; and degradation of polymers and polymer matrix composites. In all cases, this involves mechanistic studies of the degradation processes, methods to assess damage at an early stage in situ, development of quantitative predictive tools to assess remaining life and to guide operational procedures, and development of protection methods.

- Improved materials, protection, and repaid technologies for components at risk include advanced welding for repair and refurbishment; advanced coating, coating procedures, and other surface modification techniques; and improved polymer and polymer matrix composites, insulating materials, and dielectrics.

- Identification of opportunities for the utility industry in new developments, materials, and fabrication techniques.

NUCLEAR

The near-term activities related to the Advanced Light Water Reactor (ALWR) program have the potential to result in retrofit technologies with the capability to improve performance, reduce risk, and thus, lower costs in existing plants. A nuclear option must be maintained as a hedge against future environmental concerns over fossil-fuel emissions as well as longer-term limitations on fossil-fuel availability. The ALWR program achieves this goal over the mid-term (1997-2010). The future nuclear options program addresses the long-term.

Goals will be achieved by supporting development of the current ALWR program as well as the basic science and technology needs of the next generation of nuclear design concepts. The ALWR program also maintains and enhances the technology manpower resource in support of the nuclear option.

- The near-term objective is to provide basic science and technology support for critical design issues in the current ALWR program. The SR&D funded work is also expected to provide potential spin-off benefits to currently operating nuclear plants, as well as to advance nonnuclear generation alternatives. The highest priority goal is to provide data on thermal-hydraulic phenomena, which is required to predict the performance of gravity-driven safety systems in highly simplified, mid-sized (600 MWe) ALWRs.

- The long-term objective is to explore advanced concepts for use of nuclear energy in the production of electricity. This function includes monitoring international R&D programs, participation of international forums, and opportunistic R&D exploring high-potential/high-risk concepts as they are identified.

POWER ENGINEERING

Power systems engineering is the essential engineering discipline that underlies the production, delivery, and use of electricity. The electricity enterprise is the sole user of this engineering discipline. Without fundamental advances in our understanding and ability to control this world's largest "machine," large portions of the grid will remain underutilized, while a few sections limit transfer capacity, constraining power wheeling opportunities. Lack of precise knowledge of the dynamic behavior of the power system will continue to necessitate a very conservative operating approach. Finally, utilities will be ill-equipped to create markets for the myriad new transmission and ancillary services beyond those envisioned today. This work will open the door to the next-generation power system, one based on synchronized, precision measurements, wide-area information systems, and automated, intelligent controls.

The power engineering initiative establishes a theoretical and technology foundation for the next generation of transmission system measurement and wide-area automated control for the year 2010 and beyond. This work will advance measurement, control, and communications capabilities for power grids by building on emerging technologies in five rapidly advancing areas of science: precision measurements and sensors, communication networks (including satellites), power electronics (FACTS), computers, and intelligent controls. Specifically, results will include:

- Proof-of-concept studies to identify and evaluate advanced power system control and wide-area network security concepts (1997-2002);

- The role and architecture of advanced measurement, communication, and information processing systems for monitoring and operation of automated transmission systems (1996-2000);

- Methodologies suitable for real-time analytic/symbolic and measurement-based modeling and simulation of dynamic system behavior (1996-2001); and

- Performance standards for future automated transmission system operation (2000).

SPACE CONDITIONING

The maintenance of comfortable conditions for human habitation and the refrigeration of food are two of the major contributions of energy and technology to human welfare. These loads, particularly in continuing global economic development, can be primary growth areas for electricity. Environmental concerns have required the discontinuance of use of chlorinated refrigerants, which had become the sole working fluid of electrically driven, vapor-compression systems. Substitutable refrigerants reduce the capacity of existing systems and the efficiency of new ones while increasing their cost.

This work will seek to identify and develop acceptable alternative refrigerants for vapor compression equipment. A multidisciplinary approach will include thermodynamic cycle analysis to establish required refrigerant properties, system performance ranges, and chemical synthesis of new compounds. The search for preferred systems for refrigeration and space conditioning will include nonvapor compression systems (magneto-caloric, thermo-acoustic, etc.), the use of intelligent controls, inherent system storage, advanced space airflow management, and methods for controlling indoor air quality.

TABLE 1

A NEW AGE FOR ELECTRICITY

- Electricity is a productivity business — i.e., making customer operations more productive.
- The goal is a lean, light, dry global economy achieved through electricity.
- Future economies of scale are based on flexibly managing broadly networked resources to best market advantage.
- Business strategy determines technology choice and technology choices differentiate competitors.
- Networked, collaborative R&D performed through virtual organizations represents the future — cooperation *can* embrace competitiveness.

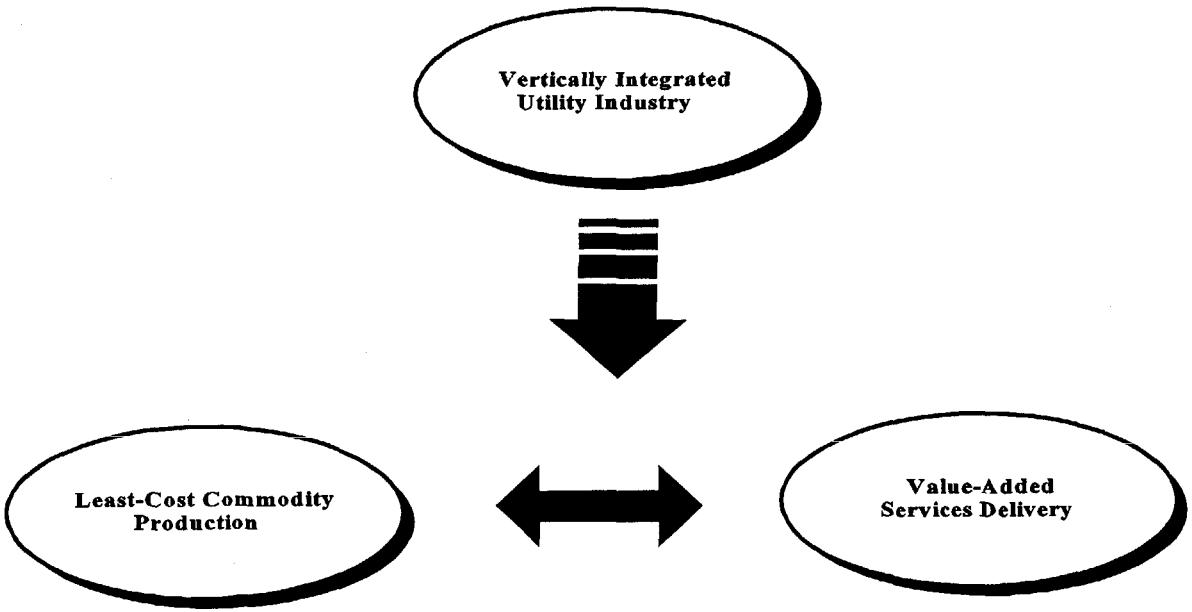
TABLE 2

ELECTRICITY AS A GROWTH ENTERPRISE

- The electricity industry is becoming disaggregated, diverse, global and unbounded.
- The customer's business is becoming the power industry's business.
- Electricity growth over the coming decades will accelerate as we enter the third wave of expansion.
- New technology will be the driver of this next wave of electricity growth by:
  - Fundamentally changing the electric power business
  - Fundamentally changing the customer's business
  - Changing the interface between supplier and customer

FIGURE 1

EVOLVING INDUSTRY STRUCTURE



ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION

Charles G. Stalon
Consultant on Energy Regulation
Oliver, Oliver & Waltz, P.C.

Widespread political values in the U.S. support, with quite a few exceptions, reliance on competitive markets when competition can be expected to produce efficient results. Consequently, opinion leaders have been increasing their support for a substitution of competition for regulation in the power generation industry for several years now. The debate has become very intense in the last year and a half, that is, since the California Public Utility Commission issued its Blue Book Orders[1] and the Federal Energy Regulatory Commission issued its Notices of Proposed Rulemakings, *Promoting Wholesale Competition Through Open Access Non Discriminatory Transmission Service by Public Utilities*, and *Recovery of Stranded Costs by Public Utilities and Transmitting Utilities*.[2] There are several positive proposals for organizing power trades within a control area. The two most widely supported models are the POOLCO model and Bilateral Trading model. Many versions of each model exists. Proponents of both models anticipate that users will gain the freedom to choose their supplier(s) rather quickly. This debate, in my view, is progressing constructively.

Another debate of equal importance is, however, lagging. That debate is how to create and preserve a governance system that will ensure reliable and efficient trades within and between control areas when many firms in the generating sector have no public utility-type responsibilities, that is, they are non-utility generators (NUGs).

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[1]California Public Utilities Commission, *Order Instituting Rulemaking (R. 94-04-031) and Order Instituting Investigation (I.94-04-032) on the Commission's Proposed Policies Governing Restructuring California's Electric Services Industry and Reforming Regulation*, April 20, 1994.

[2]Docket Nos. RM95-800 and RM94-7-000 respectively. 70 FERC para 61,357. March 29, 1995.

Interconnected control areas obviously cannot act independently, and the nation cannot expect to continue to reap the benefits of the existing governance system while simultaneously eroding its powers and legitimacy with competition.

WHAT IS THE TOPIC OF DEBATE?

The current debate can usefully be separated into debates over transition issues, that is, how to manage the transition to a new industry structure and debates over desired end-states, i.e., what should the industry structure be when the transition ends? Without a reasonably clear idea of the ultimate objective, it is unlikely that the transition can be orderly. Today I want to talk about a subset of the latter, that is, the essential characteristics of the governance system needed in the new industry structure for interconnected and interdependent trading areas. Such a governance system will be needed for the Eastern and Western interconnections, and for the ERCOT and Quebec interconnections if these bodies have two or more trading areas in them. Only the Quebec and ERCOT interconnections are plausible candidates for becoming a single control area soon. One subset of issues of my topic is relevant for non interconnected control areas, that is, the issue of defining and imposing responsibilities on NUGs.

On the Need for Defining Rules in a Market Economy

While one can find traces in the economics profession of an idea that markets are a natural, i.e., spontaneous, evolvement which produces "just" and efficient results in a free society, this idea has generally been restricted to 19th century continental economists, although the idea gained noticeable support the U.S. in the 1980s. The British and American traditions have been more modest, and, with exceptions, have insisted that markets and market systems are social expedients to be defended on their results. Moreover, the British and American traditions of political economy have insisted that a market system, like other social institutions and society itself, be viewed as an artifact. Permit me to support that assertion with a quote from Lionel Robbins in his 1952 study, *The Theory of Economic Policy in English Classical Political Economy*. He noted that:

> [A system of economic freedom] can only come into being if [things] are *not* left to take their course, if a conscious effort is made to create the *highly artificial environment* which is necessary if it is to function properly. (Emphasis added).[3]

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[3](Macmillan & Company Ltd., London 1965). p. 56. Se also, page 57, "But the fact that a mechanism is artificial does not mean that it can be made to do anything. A steam engine is artificial; but its workings are still governed by facts of its construction. And it was the central contention of the Classical Economist that, when the market conformed to the conditions which they postulated, then interference with its working was harmful and self-frustrating."

In respect for this conclusion, laissez-faire economic policies have received little support in the British and American traditions. These traditions have generally approached the self-interest motive with a respect similar to a technician handling dynamite. Again quoting Robbins:

> The invisible hand which guides men to promote ends which were no part of their intentions, is not the hand of some god or some natural agency independent of human effort; it is the hand of the lawgiver, the hand which withdraws from the sphere of the pursuit of self-interest those possibilities which do not harmonize with the public good.[4]

Without such a "firm framework of law and order," a framework which delegates only certain functions to well designed markets, Robbins noted that this tradition asserts that:

> Harmonious relations between individuals are unlikely to come into being; the pursuit of self-interest, unrestrained by suitable institutions, carries no guarantee of anything except chaos.[5]

These lessons deserve special respect as we contemplate how we create organizations and rules that will permit unregulated, profit maximizing generators in three nations to trade with users and distribution companies across complex transmission networks. The starting point of the discussion is to recognize that there currently is no government regulatory agency which has the power to create such an organization or to create such rules and there has not been such an agency since utilities interconnected their systems across state lines. Before examining this problem further, permit me to paint a backdrop to the problem by briefly surveying the diversity of the industry and the relevance of that diversity to the current debate over restructuring.

THE DIVERSITY OF THE ELECTRIC INDUSTRY

Table 1 describes the diversity of the U.S. component of the North American electric industry. (Table 1 appears at the end of this presentation). It will serve our purposes if the principal message of this table is kept in mind while I develop my discussion. That message is that although about 250 IOUs produce about 76 percent of all power produced for sale in the U.S., the industry is composed of over 3,000

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[4]Ibid.

[5]Ibid.

electric utilities.[6] That diversity has been recognized in the current industry governance system and must continue to be recognized. There are persuasive arguments that competition will increase diversity rather than reduce it.

In the 1930s, while the federal government was moving to reverse the erosion of state PUC regulatory powers over investor-owned utilities (IOUs) by creating a complementary system of federal regulation, it was also expanding the role of federally owned utilities (FOUs), publicly owned utilities (POUs) which may be owned by a state or municipality or regional entity such as a public utility district, and customer owned utilities (COUs). Table 1 demonstrates current results. Since economic regulation was seen largely as a device for holding prices down rather than as gaining efficient prices, PUC type regulation was not imposed on FOUs and seldom imposed on POUs.[7] The TVA was defined to be its own regulatory agency, and the power marketing agencies (PMAs) were executive branch agencies. The rural electric co-ops were regulated, but only lightly so by the Rural Electrification Administration of the U.S. Department of Agriculture. Some state PUCs have limited jurisdiction over municipal and/or COUs in their state.

Since the TVA, the PMAs and the generation and transmission companies created by POUs, and COUs, built transmission lines for their own needs, and interconnected those lines with IOU transmission lines; transmission networks became economic entities which no government regulator (and no possible coalition of government regulators) had authority to oversee. The networks grew incrementally as pairs of utilities interconnected for their mutual interests. The post World War II era saw an ever growing number of utility interconnections. Not surprisingly, many of these interconnections connected IOUs and/or FOUs and/or COUs and/or POUs in different states and across the U.S.-Canadian border, and later across the U.S.-Mexican border.

Three logical consequences of such interconnections were (1) a need for system standards and regulations for the interconnected utilities, (2) opportunities for power trades among utilities, and (3) opportunities for growth of power pooling.[8] Clearly, some regulatory organization, either government or private, was necessary to ensure that the pieces of the industry fit together to make an efficient and reliable whole.

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[6]Actual control of the IOU sector of the industry is more centralized than the number 254 suggest: some, perhaps 50, of these firms are non-traditional utilities, that is, independent power producers, and of the remaining, nearly one-quarter are subsidiaries of nine registered holding companies regulated under the Public Utility Holding Company Act of 1935.

[7]Some state public utility commissions have some jurisdiction over some POUs.

[8]When utilities form a group to examine their joint needs and resources and agree to operate and plan their systems for the best combined economy and reliability, they may be considered to be "pooling" their resources and such a group is often referred to as a "power pool." FERC, *Power Pooling in the United States*, op. cit. p. 2.

THE GOVERNANCE PROBLEM

The governance problem, briefly stated, is that the regulatory powers needed to plan, efficiently build and efficiently operate transmission networks with many interdependent control areas that did not and do not exist in any single government regulatory agency or in any coalition of all government regulatory agencies. Transmission networks are natural monopolies, as are the network control systems that coordinate the use of generators and loads and preserve system reliability. Organizations and assets necessary for the efficient exploitation of these natural monopolies are not likely to come into existence as a by-product of actions of rivalrous firms.

Industry Self-Regulation: Regional Reliability Councils and the North American Electricity Council

The historical solution adopted by the industry and acquiesced to by government regulators was self-regulation by industry cooperating committees, later formalized in nine Regional Reliability Councils (RRCs) and a coordinating agency for these regional councils, the North American Electric Reliability Council (NERC).[9] Events following the Great Northeast Blackout of 1965 solidified and firmly legitimized these non-government "regulatory agencies." The NERC and its nine RRCs have as their principal task the creation of "rules of the road" to ensure reliable and efficient operation of the networks by imposing such rules on the interconnected and interdependent control areas. NERC committees and committees of the regional councils provide utilities with organizations through which they coordinate operations and planning.

These government sanctioned, but "voluntary" organizations of utilities (including foreign and domestic FOUs, POUs, COUs and IOUs) are major components of the U.S., Canadian and Mexican regulatory systems. Their self-created charters allow them to ignore, when convenient, legal forms of ownership and state and national boundaries. In fact, it is these regulators that consumers depend upon to keep the lights on, since government regulators, under current allocations of responsibilities, have neither the power nor the competence to define and enforce rules necessary to ensure reliability of the system. At best they can help enforce the rules created by these "voluntary organizations."

The industry structure that has permitted the North American industry to work as well as it has was one of cooperating, vertically-integrated utilities. This system was dominated by the vertically-integrated IOUs. Those utilities, such as COUs engaged only in the distribution business and FOUs engaged only in the generation business,

[9]Note that the name of the principal coordinating body for the Regional Reliability Councils is called the "North American Electric Reliability Council," not the "U.S. Electric Reliability Council."

were vertically integrated by relatively long-term contracts that preserved the monopoly powers of the various firms of the system. While some of these firms — municipal utilities and cooperative utilities in particular — supported competition between IOUs in the sale of power, all these firms agreed that the protection of their own monopoly powers was desirable. Since government regulators generally agree that it was important to preserve existing monopolies, the system was permitted to function subject to the constraint that the powers of government regulators to control price and terms of service to users was not noticeably diminished.

With the development of wholesale markets both the vital vertical integration and the legitimacy of preserving existing monopoly powers of generators are being eroded. That gives rise to the current governance problem.

The current governance problem is that the inherited governance system does not appear to be sustainable in a restructured industry with competitive generation dominated by NUGs. Even competition among investor owned utilities, who have dominated the old system, has been corrosive of the cohesion of these utilities and of the legitimacy of their decisions. Clearly, the North American industry cannot assume that the governance system and the system of self-regulation that worked in the past will work in the restructured industry. United Airlines may accept as a necessary part of doing business the disruptions and economic losses imposed on it by the Federal Aviation Administration's air traffic control system, but it is not likely they would accept such disruptions and losses if the air traffic controllers were employees of American Airlines, even if the were named "independent system controllers."

The industry needs a new regulator or a set of regulators and a new governance system for the two natural monopolies that are truly interstate and international in character, the Eastern and Western interconnections. Equally clearly, that new regulator cannot be the U.S. Federal Energy Regulatory Commission: The FERC's jurisdiction, although extended for some purposes to all transmitting utilities in the Energy Policy Act of 1992, does not extend to control over planning and building transmission assets for U.S. utilities, and it clearly does not extend to Canadian and Mexican utilities who are included in the Eastern or Western interconnection. Similarly, the Canadian National Energy Board and the Mexican Regulatory Commission for the Power Sector have only limited area of jurisdictions. If a government agency is to fulfill the governance role, it must be some partnership of all three with the FERC responsibilities expanded by legislation. More likely, a new form of self-regulation needs to be developed. Existing reliability organizations will almost certainly be the foundation stones to the new structure.

To get a new regulatory and governance approach, the nation needs leadership. The FERC and the PUCs, by inherited position at this time in history, are in better positions than anyone else to provide that leadership to the Congress and to the nation. Leadership in this context means facilitators of debate. The FERC's NOPRs

cited above, the California PUC's Blue Book orders, and the many proceedings underway in PUCs are encouraging examples of such leadership. Almost universally, however, these proceeding focus on the question of how to organize a trading area. Only the FERC in its regional transmission group (RTG) proposals has focused on the need for a reformed governance system for the interconnected industry. For reasons discussed below, that initiative has produced, and will likely to continue to produce disappointing results.

In a sense, it is proper than only the FERC has focused on this issue, since the restructuring initiative is a federal initiative. Before discussing the FERC RTG initiative, it is useful to add some detail to the problem to be solved, and it is useful to do that by first reviewing important areas of agreement in the debate over the organization of trading areas.

IMPORTANT AREAS OF AGREEMENT/DEBATE OVER ORGANIZATION OF CONTROL AREAS

The debates over the desired economic structure for trading within a single control area reveal many areas of agreement. No one, to my knowledge, has yet articulated a detailed proposal for operating an extensively interconnected network containing many interconnected POOLCOs or many Bilateral Trading Areas or some POOLCO and some Bilateral Trading Areas. The areas of agreement of the proponents are, however, worth examining before discussing important details of the governance problem. Proponents of both POOLCO and Bilateral Trading models agree:

- Transmission and distribution remain natural monopolies and must continue to be regulated.

- There are no significant economies of scale in generation that cannot be exploited by competitive generators operating within an extensive transmission network *if* that provides the necessary services. That big *if* is the heart of the governance debate.

- Unless a single control area exhausts the interconnection, there will be trading between control areas and there will be inadvertent power imports and exports into and from each control area.[10]

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[10]Economic efficiency demands that there be only a single price at each point in space in each trading period, e.g., every half hour, and that the difference in prices between any two points in space in a trading period not exceed the cost of moving power from one point to the other. Proponents of POOLCO models insist that with locational pricing that recognizes transmission congestion both of these efficiency conditions will be satisfied for all points in the control area. Proponents of Bilateral Trading Areas, while not as explicit in their analysis, tend to build on analogies with the current North American natural gas industry and assert that privately created markets will arise that will satisfy all conditions for efficiency. To my knowledge, their emphasis has also been on single control areas.

- The task of coordinating use of the transmission system(s) remains a natural monopoly.

- Competitive power markets will be furthered substantially by an independent system operator who coordinates grid operations and preserves reliability. This ISO will be a regulated firm and will need to have great powers to act in emergencies, but it must also respect private property rights and competitive market positions to the extent possible. In particular, the ISO must have no special loyalty to any subset of generators, distribution companies or users. Its primary loyalty must be to the operating rules and standards essential for preserving system reliability on which a competitive power market will depend.

- Interdependent ISOs will be required to cooperate with one another to preserve the reliability of the system, and to facilitate trades.

- Interconnected ISOs will coordinate and cooperate under a set of objective rules that specifies their reciprocal obligations.

- Creating new control systems for a competitive generating sector and redefining ownership rights in transmission lines and rights and obligations of unregulated generators to complement a competitive generating sector must be done before the full forces of competition are released.

In recapitulation, the critical elements of the existing discretion of network controllers must be preserved to the extent necessary to pursue superordinate goals agreed upon as necessary to ensure the reliability of the network. In the past, the range of discretion of controllers (i.e., their abilities to dictate generating outputs and to refuse to meet demands for transmission services) was legitimized by the public utilities immediately involved, acting through their RRC and the NERC. As new players enter the industry, the discretion of controllers will likely need explicit FERC and/or Canadian and/or Mexican regulatory approval.[11] Price and access terms negotiated by buyers and sellers should not deter the preservation and legitimization of controller discretion necessary to preserve system reliability.[12]

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[11]Government authority will be especially important if the ISO or a non-government, industry governance body is given authority to impose fines on generators (and perhaps distribution companies and users) for performance.

[12]Compare: "The control area load dispatchers are charged with maintaining the viability of the grid. In emergencies, they may have to take drastic steps on only a moment's notice. In that event, they should not have to worry about possible lawsuits. Time is short and there should be no hesitation when the grid is threatened. Hence, contract language should be drafted to give those utilities that are responsible for the grid, and their load of dispatchers, full authority to direct emergency operations, and to indemnify them against damage claims resulting from emergency actions taken in good faith to ensure the integrity of the grid." Gordon Corey, "Some Observations on the Bulk Power Markets in the United States," *Public Utilities Fortnightly*, vol. 124, nos. 7 and 8, September 14 and 28, 1989.

The system in the future, as the system today, will of technological necessity be one in which ISOs with obligations to serve can satisfy that obligation with a reasonable degree of efficiency only with the help of neighboring ISOs. Consequently, there seems to be no disagreement with the conclusion that efficiency and reliability in the electric industry demands that cooperative organizations centered around the NERC, or a replacement organization, be preserved and protected until better ones can be developed. The "better ones" will probably be constructed to coordinate regional transmission corporations, each of which is large enough to encompass all but the largest regional reliability council areas.[13]

To my knowledge, no one has challenged these areas of agreement. Still, to my knowledge, no one proposed a governance mechanism in which these rules can be created and continually modified to meet new opportunities and new problems.

RTGs TO CREATE THE NEEDED GOVERNANCE SYSTEM?

As noted above, currently, the "only game in town" for creating the needed governance systems for interconnected networks is the FERC's RTG proposal. It is always painful to criticize "the only game," but in this case it is necessary. Although I endorsed the usefulness of the FERC RTG proposal when it was made, and I think the RTG debate has been a constructive and educational one, events in the last few years have persuaded me that the RTG effort will not be sufficient to produce needed reforms. A new proposal is needed. When circumstance are confused and objectives are unclear, a group representing all stakeholders is a logical group to create, and the FERC, behaving as a good regulator in the confused circumstances of early industry restructuring, responded logically by encouraging the creation of RTGs. In contrast, when the problem is reasonably well understood and objectives are generally agreed upon, it is time to create a body that can act and which can be held accountable to national regulators for failures to act in a timely manner, including failures to plan properly and to anticipate unplanned incidents and prepare for them. The North American electric industry has now reached the stage where it needs a governance system that can plan and act. Because RTGs have been slow in developing, and, more importantly, because there are good reasons for believing that RTGs that include all stakeholders are not likely to ever be able to create the kinds of governance systems needed, it is time that alternative systems be explored.

Essential Element of a New Governance System for Interconnections

As noted earlier, transmission networks are natural monopolies, and the control systems for coordinating generation and loads connected to the transmission network

[13]In order to preserve cooperation among such regional transmission corporation, the NERC, or a replacement organization which can fulfill the needed role, will remain essential.

are natural monopolies. The use of several control centers in a single network rather than a single one is an expedient, although a necessary one in networks as large as the Eastern and Western interconnections. Although these monopolies exist to serve generators, distributors and end users, that does not mean such interests need to be directly involved in the management of their management. It does mean they must be regulated, and, in accordance with customary regulatory practice, the regulatory process can provide forums in which all interests can make their preferences and dissatisfactions known to regulators and the regulated firm. By focusing the interaction of server and the served in the regulatory agency, the regulator can ensure that lines of authority and responsibility are clear. In particular, the regulator can make it unmistakable clear that the regulated monopolist is fully responsible for ensuring efficient and reliable outcomes.

The customary way in which regulators who cannot design detailed pricing rules for efficient use of networks have regulated such networks has been to encompass the network into a single legal entity and impose clear responsibilities on that entity for efficient planning and operation. This solution can be approximated in the electric industry by creating large regional transmission company (transco) monopolies. If that can be done, the RRC functions can be incorporated in the legal entity and the NERC function can be incorporated in a "voluntary" association of regional transcos.

The principal advantage of this approach is that such an organization can make decisions, decisions that might be reviewed under customary regulatory proceedings at a later date. Such an organization would not have to have all stakeholders directly involved in the formulation of detailed operating rules.

Given the urgency of creating governance systems for the interconnections, I believe the FERC can and should "coach" into existence such organizations. The essential ingredient of successful coaching is to recognize that transmission assets that are a part of a large regional transco are "worth more" than are transmission asset owned by a small transco, and an understanding that the FERC will recognize that increase in value when transmission assets are so transferred or merged.

RECAPITULATIONS AND CONCLUSIONS

While it is difficult to predict the pace of change in electric industry restructuring, it is noteworthy that, to date, the pace of change has been faster than expected by optimistic reformers. The relatively low cost of gas-fired, combined-cycle generation has added urgency to the need to adjust to a new industry structure. The current governance system for planning and operating interconnected, and therefore interdependent, control areas has worked well to preserve the reliability of the system. Since its functions are essentially regulatory, and those functions infringed and still infringe on decision areas assigned to state and federal regulators, that success was achieved by the industry-created, self-governance system maintaining a

very low profile in regulatory circles and perpetuating the regulatory fiction that this non government, governance system dealt only with reliability issues, not economic issues. Economic issues were left to government regulators.

Since the role played by these non-government regulators were vital to efficient and reliable operation of the system, government regulators and the U.S. Congress found it expedient to acquiesce to and in many cases actively endorse this regulatory fiction.[14] There simply was no other practicable way to achieve the benefits of an international grid.

The task today is to find a way to define and empower a comparable system that is founded on regulated firms and is acceptable to generators who will not be regulated by a government agency but will be regulated by this non-government regulatory agency in those "non-economic" dimensions of their activities essential for preserving system reliability.

TABLE 1
OWNERSHIP OF U.S. ELECTRIC UTILITIES 1993

Item	Type of Electric Utility				
	IOUs	POUs	FOUs	COUs	Total
Number of Utilities	254	2007	10	941	321
Utilities (percent)	7.9	62.5	<1	29.3	100
Kwh Sales to final users (Percent)	76.4	14.2	1.6	7.7	100
Kwh sales for resale	44.8	17.3	17.7	21.2	100
Kwh retail "price"	7.2	6.1	2.8	7	6.9
Kwh Wholesale price	3.4	3.8	3.3	4.1	3.6

Energy Information Administration, U.S. Department of Energy, *Financial Statistics of Major U.S. Publicly Owned Electric Utilities,* (U.S. Government Printing Office, Washington, DC, February 1995) p. 3.

[14]Sec. 205 of the Public Utilities Regulatory Policies Act of 1978 permits the FERC to "exempt electric utilities ... from any provision of state law, or from any state rule or regulation, which prohibits or prevents the voluntary coordination of electric utilities ..."

SESSION III: NATIONAL POLICY ON RESEARCH AND DEVELOPMENT

THE ROLE OF UNIVERSITIES IN ENERGY AND ENVIRONMENTAL R&D: AN EXTENDED OUTLINE

Harvey Drucker
Associate Director
Argonne National Laboratory

1. Basic versus applied science

   As we all know, there is no clear line separating basic and applied research. The distinction is more operational than absolute and thus requires definition by example.

   - In biotechnology, gene splicing (basic research on alteration and repair of nucleic acids) results in research on insulin production by genetically engineered organisms (applied research on the insertion of insulin DNA into microbial genetic material).

   - In material science, basic research on buckyballs (basic research that defines a new form of carbon) results in research on their tribiological properties (applied research on forms of buckyballs that appear to be greasy).

   Basic research tends to be the province of universities; applied research lies in a number of organizations including universities. The difference being that universities in their applied work normally are not developing a specific product or process, whereas the converse tends to be true of research institutions and industry.

2. Applied science versus technology development

   Again, there are no precise definitions and example may be more appropriate than semantics. In general, here research becomes process or product. Two examples, amongst many possible, dealing with different aspects of commercial technology development:

- Issues of scale: From little batches of insulin producing organisms to large batches or continuous culture. Here we go from one liter of media carefully nurtured by a graduate student in fear for his/her life in case of error to 50,000 gallons watched over by members of the Atomic and Chemical Workers' Union. Very good folks, but not quite as fearful. In addition to the issues of scaling, process "hardening" (making the process repeatable under industrial conditions) is critical.

- Issues of application: From superconducting wire or tape to liquid nitrogen temperature monitor. This is as much art as it is science. What was the precise inspiration for the use of fiber optics in colonic examination? The use of lasers in inventory control at supermarket checkouts? Taking a very poor glue and using it to reversibly sticker memos and letters such that they always end up on our desks? The inspiration that marries commercial knowledge to science is not reproducible.

3. The issue here is the need for basic and applied research to resolve issues in energy and environment. Again, example seems more germane than word-play.

   - How do we clean sulfur from coal? The basic problem remains the chemistries of sulfur in a molecular spider web. The applied problem is the devising of ways to remove sulfur in any form at any stage of coal processing. Industrial technology will result in units that do this deed at costs commensurate with the economics of energy production.

   - How do we manage mixed wastes in groundwaters? A much tougher problem. Basic work here can be in the development of new forms of spectroscopy that allow us to identify and measure organics. Applied work is actual identification in groundwater samples.

4. What can universities provide in the resolution of these issues?

   - Universities are America's repositories for individual investigators in science and engineering. In addition to training all of the bodies involved in all aspects of science and technology, they are the home of the basic sparks in technology development. A really good university builds on people who are marginally nuts; who refuse to accept anything as gospel; and who are driven to frenzy in proof of their concepts of how some piece of the world works. How do we plug these people into the process of commercial technology development?

5. A model that builds on university strengths in basic and applied technology, the Plant Biotechnology Consortium.

In 1984, it was clear that plant biotechology was not yet applicable to new product/process development. The issue was how can basic research in plants be used to develop new commercial technologies. The consortium, which continued to function at least through 1995, was based on the following set of principles:

- Research for the consortium must be potentially germane to commercial needs and, of equivalent importance, technically excellent. Thus, review of proposed work should involve both industrial and scientific peer review.

- Technology transfer can be more easily affected if all partners in the transfer use practices familiar to them in the development and implementation of research programs and in the transfer and use of results.

- Efforts should be scheduled over a five year period and evaluated. Program funds should be used primarily for the training and support of students, research fellows, and other technical staff as appropriate; not for facilities and major capital equipment.

- Research participants should "own" rights to intellectual property commensurate with their institutional practices. Industrial participants should have access to first disclosure of information. Further development would require negotiation according to customary industrial practices with the research institution.

- Given the high risks of basic research and the inherent difficulties in capitalizing upon returns from basic efforts, governmental agencies appear to be the most appropriate primary funding source and the most appropriate administrators of the initiative.

- As much as possible, work should be relevant to Midwestern agribusiness. Communication of program development and implementation and access to investigators from both industry and research establishments should be facile.

6. Model works: Why can't it be deployed?

   - Government works in boxes: There are no niches for entire kingdoms of research (e.g., engineering, applied biotech, etc.).

   The net result of this is one can get involved in massive initiatives that are absolutely doomed to failure because there is no home for them.

7. What can be done? Right now, federal laboratories are doing a better job than ever in transferring applied research to industry.

The tool for this is the Cooperative Research and Development Agreement (CRADA). Very simply stated, the CRADA is a device by which government pays from 20 to 50 percent of the cost of research considered relevant to product development; industry pays from 50 to 80 percent, but payment can be either cash or kind, and information derived from the program can be held proprietary.

We need to consider ways to generate funding commensurate with university cultures but relevant to commercial technology development. If we are to do this, per the Plant Biotechnology Consortium, we might consider a few new wrinkles.

- Research fund set-asides for issues oriented basic/applied research with open competition based upon peer review.

- "Head tax" on the employment of engineers and scientists that is paid to the university granting their degree.

We cannot eat our seed corn, but we also need to show that the seeds universities plant truly have the possibility of becoming at least decent weeds. And that will be the basis for affecting a productive, strong role for university investigators in all fields, including energy and environment.

ROLE OF NATIONAL LABS IN ENERGY AND ENVIRONMENTAL R&D: AN INDUSTRIAL PERSPECTIVE

Nuno Vaz
Research and Development Center
General Motors Corporation

TABLE 1

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *THE STAKES*

ENERGY/ENVIRONMENT IMPACT
• Oil imports are responsible for approximately 40 percent of our annual foreign trade deficit (>$50 billion).
• Annual energy consumption is about $1,900 or 55 barrels of oil per every man, woman and child in the United States.
• Ground transportation accounts for approximately 25 percent of the total energy consumption in the United States.
• One in five Americans lives in an area where the air quality is below the Environmental Protection Agency (EPA) standards.

TABLE 1 (Continued)

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *THE STAKES*

ECONOMIC/SOCIAL IMPACT

- More than 13,000,000 people are employed in motor vehicle related industries in the United States.
- Automotive related industry accounts for 4.5 percent of the United States gross domestic product.
- The number of licensed drivers in the United States currently exceeds 170 million and continues to increase.
- Vehicle miles traveled have increased 43 percent over the last 15 years.

INTERNATIONAL COMPETITION

- Europe organizes EUCAR to coordinate automotive R&D programs.
- Europe launches the "4th Framework Program," a European Union-funded R&D program that will spend USD $13 billion in 1994-1998.
- Europe launches the "Car of Tomorrow" initiative to coordinate USD $500 million/year automotive R&D under the "4th Framework Program."
- Japan's Ministry of International Trade and Industry (MITI) provides significant direct and indirect support for Japanese Kieretsu to execute production-intent R&D with fewer constraints than is typical in the U.S.
- Japan spends more than twice as much on energy R&D as does U.S.

TABLE 2

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *AUTOMOTIVE CHALLENGES*

ENERGY EFFICIENCY: WHAT HAS BEEN DONE?

- The automotive industry has made major gains in fuel efficiency since the 1970s. GM's Corporate Average Fuel Economy (CAFE) *has more than doubled* during the last 20 years.
- GM is a full partner in a number of *United States Council for Automotive Research* (USCAR) energy conservation related R&D consortia:
  - United States Battery Consortium (USABC)
  - Automotive Composites Consortium (ACC)
  - United States Automotive Materials Partnership (USAMP)
  - Natural Gas Vehicle Technology Partnership (NGVTP)
- Over the last 20 years, tailpipe emissions from new cars have been *significantly* reduced:
  - 98 percent reduction in hydrocarbons
  - 96 percent reduction in carbon monoxide
  - 90 percent in oxides of nitrogen
- Currently, 94 percent of all cars and trucks in the U.S. are returned to dismantlers and shredders and 76 percent of the content is recycled.
- New vehicles will continue to incorporate even greater levels of recyclable materials.
- In February 1994, GM became the first major manufacturing company and first Fortune 50 company to endorse the *Principles of the Coalition for Environmentally Responsible Economies* (CERES).
- *GM PrEView Drive*: a *$32 million customer evaluation program* to gather real-world driving and charging data from potential electric vehicle customers and 15 utility partners.
- When the PrEView program concludes in 1996, hundreds of drivers will have logged more than 500,000 real-world miles in 12 cities.

TABLE 2 (Continued)

ENERGY AND ENVIRONMENTAL POLICY
IN A PERIOD OF TRANSITION: *AUTOMOTIVE CHALLENGES*

THE ENVIRONMENT: WHAT HAS BEEN DONE?

- All new GM vehicles use non-chlorofluorocarbon (CFC) refrigerants.
- GM is a signatory and participant in the North American Research Strategy for Tropospheric Ozone (NARSTO) organization.
- GM co-sponsors the "Hybrid Vehicle Challenge" program to excite and support academic participation in the development of "clean cars."
- GM co-chaired and supported the "Environmental Vehicles Conference & Exposition" (January 22-23, 1996, Dearborn, Michigan).
- GM is a full partner in a number of United States Council for Automotive Research (USCAR) environmental research consortia:*
  - Auto/Oil Air Quality Improvement Research Program
  - Low Emissions Technologies R&D Partnership (LEP)
  - Environmental Research Consortium (ERC)
  - Low Emission Paint Consortium (LEP)
  - Vehicle Recycling Partnership (VRP)

* In addition to the four other consortia mentioned before: USABC, ACC, USAMP and NGVTP that were mentioned as R&D initiatives supporting an energy efficiency strategy.

Whenever industry and the National Laboratories are both engaged in the same or inter-related aspects of a strategic technology area, *cooperative* R&D will save money (taxpayer's and stockholder's) and time (critical to be competitive in the global environment).

TABLE 3

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *NATIONAL LABS*

- Today's *weapons* require such a vast interwoven suite of technologies to meet performance, quality, durability and environmental friendliness that the underlying R&D needed to achieve and sustain those goals demands an enormous financial investment and long-term commitment of *qualified resources* and *specialized R&D facilities*.
- In GM's view, the best way to promote continued *support for the National Laboratories mission* is to *expand cooperative research efforts* to develop those technologies that both the National Labs and industry need, while exploring more cost-effective compliance programs that work with, rather than against, market forces.
- The *Galvin Report* entitled, "Alternative Futures for the Department of Energy National Laboratories," published in February 1995, suggests:
  - The laboratories should serve as nodes in a national network of R&D institutions.
  - Industrially relevant R&D is an appropriate activity for the U.S. Department of Energy laboratories.
  - However, it should focus on longer-term R&D within the traditional U.S. Department of Energy mission arenas.
  - In addition, cooperative R&D should be procured in a fashion that would help to achieve a higher commercialization rate by maximizing the available resources (both cash and in-kind).

TABLE 3 (Continued)

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *NATIONAL LABS*

- The *Yergin Report* entitled, "Energy R&D: Shaping our Nation's Future in a Competitive World," published in June 1995, states:
  - Investment in R&D — public and private — is America's investment in its future.
  - Widespread cutbacks ... may portend a brewing R&D crisis.
  - Federal energy R&D has been cut by 75 percent since the late 1970s.
  - Federal support for R&D is most strongly justified when the R&D serves national interests not adequately addressed by market action alone.
  - Cost-sharing with industry leverages federal R&D.

TABLE 4

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *INDUSTRY*

- Today's *consumer products* require such a vast interwoven suite of technologies to meet performance, quality, durability and environmental friendliness that the underlying R&D needed to achieve and sustain those goals demands an enormous financial investment and long-term commitment of resources.
- GM's R&D accomplishments to-date have been achieved through commitments of *major corporate financial and technical resources*. Further gains will be even more difficult to achieve, and greater creativity and more effective coordination of all available resources will be required to make meaningful energy-efficiency and environmental progress.
- In many instances, however, the *promising technologies* are *too risky* and expensive for individual companies to justify to their shareholders and/or *too immature* to attract venture capitalists.

TABLE 4 (Continued)

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *INDUSTRY*

- Thus in GM's view, the best way to promote continued progress is to expand *cooperative research* efforts to develop needed technologies, while exploring most cost-effective compliance programs that work with, rather than against, *market forces.*
- *Strategic alliances* are rapidly becoming the only economic way for industry to execute the enormous amount of R&D needed to develop today's products.

Industry and National Labs must cooperate in R&D programs to achieve sustainable development and reduce increased reliance on global and overseas R&D funding, collaboration and sharing of R&D results, while implementing federal budget cuts and meeting the pressure of foreign competition.

TABLE 5

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *THE GRAND CHALLENGE/PNGV*

- The Partnership for a New Generation of Vehicles (PNGV) cooperative R&D partnership between 11 government agencies and GM, Ford and Chrysler to develop commercially-viable vehicle technology that, over the long-term, can preserve personal mobility, significantly reduce the impact of cars and light trucks on the environment and reduce the United States dependency on foreign oil.

  Goal 1: Significantly improve national competitiveness in automotive manufacturing
  Goal 2: Apply innovations to conventional vehicles when commercially viable
  Goal 3: Develop a vehicle that gets up to 80 miles per gallon while maintaining the performance and cost of owning today's car

TABLE 5 (Continued)

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *THE GRAND CHALLENGE/PNGV*

TAKING A LOOK AT THE UP TO 80 MPG GOAL

- Develop a vehicle with fuel efficiencies up to three times today's comparable vehicle, and:
  - Comply with Clean Air Act requirements at time of production
  - Meet safety standards of the day
  - Carry six passengers with a comfort level equivalent of comparable vehicles
  - Be able to accelerate from 0 to 60 mph in 12 seconds
  - Have a luggage capacity and load carrying capacity (6 passengers and 200 pounds of luggage) of comparable vehicles
  - Have a metro-highway range of 380 miles
  - Achieve 80 percent recyclability
- Producing a lightweight, high-mileage car will be harder than putting men on the moon. In fact, lightweight materials, some of which were used in the Apollo space program, could play a critical role in producing the up to 80 mpg car, as specified by the PNGV.

HOW CURRENT VEHICLES LOSE ENERGY

- Engine and drivetrain losses (87.4 percent)
  - Engine losses 62.4 percent — Reduce engine losses by 5-15 percent
  - Drivetrain losses 5.6 percent — Minimize drivetrain losses
  - Idling losses 17.2 percent — Minimize standby losses
  - Accessories 2.2 percent — Increase accessory efficiency by 30 percent
- Total energy available to turn the wheels (12.6 percent)
  - Aerodynamics 2.6 percent — Reduce aerodynamics by 20 percent
  - Braking 5.8 percent — Implement regenerative braking
  - Rolling losses 4.2 percent — Reduce rolling losses by 20 percent

TABLE 5 (Continued)

ENERGY AND ENVIRONMENTAL POLICY
IN A PERIOD OF TRANSITION: *THE GRAND CHALLENGE/PNGV*

THE HYDBRID DRIVETRAIN USES ALL THE TECHNOLOGIES

- There are many hybrid system concepts using fuel cells, gas turbines, diesels, and lean burn gasoline engines in combination with flywheels, batteries and ultracapacitors. One goal of the PNGV is to advance technologies that could achieve dramatically improved fuel efficiency without sacrificing the performance or cost of owning today's cars. Major issues of emissions, system packaging, manufacturability, cost and consumer acceptance need to be resolved.

  - Fuel:
    Gasoline, diesel, methanol, ethanol, compressed natural gas or hydrogen.
  - Primary Engine:
    Fuel cell, gas turbines, and internal combustion engines run at a constant efficient speed and could be used to generate power to electric motor and energy storage devices.
  - Controller:
    Controls the energy flow into and out of the battery bank.
  - Energy Storage:
    Advanced batteries, flywheel or ultracapacitor.
  - Electric Drive:
    Primary drive motor used for acceleration.
  - Regenerative Braking:
    Recovering braking energy and reusing it to accelerate.

TO REACH THE GOAL

- To reach the PNGV goal of three times fuel efficiency (80 mpg), automotive thermal efficiencies will have to be improved 40 to 55 percent and vehicle mass must be reduced on the order of 20 to 40 percent, *even with the utilization of improved power converters and regenerative braking.*

  - Thus, PNGV is a program that will help meet challenges of improving *energy efficiency* and the *environment.*

TABLE 5 (Continued)

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *THE GRAND CHALLENGE/PNGV*

- *Simultaneous* major advances must be made in several *candidate technology areas* in order to achieve an affordable, safe, 80 mpg vehicle:
  - Advanced design simulations
  - Auxiliary power units (direct injection and turbine)
  - Advanced high power and high energy batteries
  - Efficient air conditioning systems
  - Efficient electric propulsion components
  - Low emission technologies
  - New lightweight materials and structures
  - Alternate fuels, fuel storage
  - Flywheels
  - Fuel cells
  - Ultracapacitors
  - Fuel reformers
  - Engine efficiency technologies
  - Joining/bonding technologies

PRIMARY ADVANTAGES OF THE PARTNERSHIP

- Industry focal point (one-voice) for specific interactions with the government
- Achieve economies of scale in R&D
- Elimination of unnecessarily redundant research
- Focus freed-up resources on other research
- Leverage monies, researchers and facilities
- Reduce time/cost associated with meeting federal regulations
- Horizontal and multiple competing vertical cooperative agreements
- Support of individual company suppliers through vertical agreements
- R&D alliance to counter similar European and Pacific Rim activities

TABLE 5 (Continued)

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *THE GRAND CHALLENGE/PNGV*

ADMINISTRATIVE CHALLENGES

- Balance industry led versus government cooperative programs.
- Reach consensus among and coordinate the activities of some of the world's largest bureaucracies in a timely fashion.
- Negotiate intellectual property ownership: Industry prefers exclusive licenses such as those proposed in the National Technology Transfer and Advancement Act of 1995 (H.R. 2196) by Rep. C. Morella.
- "New Government Math (3 - 1 = 0)" may eliminate legitimate, productive competing interests of the private sector.
- Avoid budget uncertainty and unilateral government disengagement.

EXAMPLES/SUCCESSES

- Reduction of NO_X emissions for lean burn engine technology (Cooperative Research and Development Agreement, CRADA)
  - Objectives: Develop advanced catalysts for lean-burn internal combustion engine vehicles with emphasis on reducing oxides of nitrogen (NO_X) emissions.
  - Partners: GM, Ford, Chrysler, and Sandia, Los Alamos, Lawrence Livermore, Oak Ridge and Argonne National Laboratories.
  - Achievements: Developed hydrous metal oxide and zeolite-based materials for sulfur resistant oxides of nitrogen (NO_X) reduction catalysts.
- Intelligent welding for thin metal sections (Cooperative Research and Development Agreement, CRADA)
  - Objectives: Develop weld diagnostics for laser beam welding of steel.
  - Partners: GM, Ford, Chrysler, Idaho National Engineering Laboratory and Argonne National Laboratory
  - Achievements: Patent application; technology being implemented on the plant floor.

TABLE 6

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *THE ROLE OF NATIONAL LABS*

THE GALVIN REPORT

- *National Security*
  - Enhance the ability of the nation to deter and defend against military threats, reduce nuclear danger, enhance the confidence in our own nuclear weapons in the absence of explosive testing.
- *Energy*
  - Enhance the nation's long-term prospects for adequate energy supplies and efficient end-use technologies that minimize adverse environmental impacts.
- *Environment*
  - Traditional areas are science and technology development associated with the clean-up of nuclear waste and R&D related to assessing the environmental impacts of energy use.
- *Fundamental Science*
  - National labs have a major mission to contribute to and expand the scientific foundation which underpins the Department's other mission areas: national security, energy and the environment. This includes providing unique, one-of-a-kind research facilities for the scientific community (government, academic and industrial) that would otherwise not be affordable.
- *Industrial Technologies*
  - *Collaborations* between the national labs and the private sector serve the *important function* of providing *dual benefits* to the partners, but such collaborations generally should be closely aligned with core mission areas of the Department. To the extent appropriate, such collaborations should be *cost-shared* and tied to *technology roadmaps* developed by and with industrial sectors.

TABLE 6 (Continued)

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *THE ROLE OF NATIONAL LABS*

- *Technology for a Sustainable Future*

  The Task Force believes that the laboratories could and should make a significant contribution to the integration of energy, raw materials, technology and environmental science throughout the nation's economy. The scientific and technological capabilities needed to advance our understanding of energy and material use in the economy, in an industrial ecology framework, include:

  - Energy supply, distribution, and end-use science and technology
  - Advanced manufacturing and process technologies
  - Materials science and technology
  - Environmental science and technology; and
  - Modeling and simulation of complex systems

- These capabilities are broadly resident in the Department's National Laboratories and are already being applied to a number of projects that hold the potential for substantial improvements in resource utilization by various industrial sectors.

  - For example, in the general area of *manufacturing and process technology*, projects at the ten laboratories amounted to more than $100 million in FY 1994.

PARTNERING WITH INDUSTRY

- *Issue: Different Missions*

  - Primary *government* funding based on *defense mission*
  - *Industry* funding and selection of project based on *business case*

- *Solution*

  - Develop joint technology umbrella programs that will bring together industry and government expertise in a complementary fashion to solve industry-led technology challenges that have a major national economic impact and establish appropriate minimum, stable funding level.

TABLE 6 (Continued)

ENERGY AND ENVIRONMENTAL POLICY IN A PERIOD OF TRANSITION: *THE ROLE OF NATIONAL LABS*

REDUCE COSTS OF R&D

- *Issue: Different Customers*
  - *Government* funding is taxpayer based, thus intended to support the *taxpayer* at the broadest level possible.
  - *Industry's* private funding is directed at improving the return of the *stockholder's* investments.
- *Solution*
  - Develop technology objectives and roadmaps for target technologies that are still too immature to attract venture capitalists and too risky and expensive for individual companies to justify to their shareholders, but that support the mission of the government laboratories and that, when jointly developed, can save taxpayers money.

FUTURE OF FEDERAL RESEARCH AND DEVELOPMENT

David T. Goldman
Executive Associate
Research and Development Management
U.S. Department of Energy

Federal funding for research and development received an enormous impetus during and immediately after World War II. Military requirements were the basis for a great deal of technological development since the beginning of recorded history, and were the basis for significant U. S. investment in science and technology to help fight the wars of the 20th century. Partially as a reward to academic scientists who helped win the war, partially as a realization that the results of science produced economic growth and an enhanced standard of living, and partially because of foreign military and economic competition, federal funds continued to be made available for research and development and supplemented those available in the private sector. As a result of federal programs, new institutions arose, prominent among them the Federally Funded Research and Development Center (FFRDC) including the government-owned, contractor-managed national laboratory and an enhanced role for both government laboratories and university research. Funds were also provided to private industry to stimulate technological development in areas where it was felt that the marketplace was unable to effect desirable economic goals in a timely fashion.

This approach has proven very successful over the past half century. As economic competition replaced a military one, the United States has continued to be the world leader in scientific discovery and translating those results into technological advancement and expanded economic opportunity. Nevertheless, we have reached what appears to be a watershed in the prospect of continued federal funding of research and development activities, at least at its historical level of growth. I would attribute this to a variety of factors, enumerated below.

The views presented in this paper are my own and are not to be considered those of my employer, the U.S. Department of Energy, which is given for identification only.

Politically, putting a limit on federal expenditures as part of the balancing of the budget process naturally restricts all discretionary expenses, even those which will contribute to future economic growth. Though by no means limited to a single political party, the election results of last November clearly reinforced those desirous of reducing outlays.

Financially, there is the rise in the cost of performing research as better trained personnel and more sophisticated equipment are needed to advance the state of knowledge. This is compounded by the fact that as competition for the more limited funds available becomes keener, there is a larger cost associated in securing these funds.

As industry shifted its attention to a shorter period to realize a return on its investment in research, private sector funding for major fields of research was withdrawn. In reducing or eliminating fundamental research efforts, companies could point to the success of major competitors both here and overseas as examples. Federal funds thus were stretched to cover more areas than hitherto had been the case.

As the funding for military research and development also shifted to more direct military applications, the cost of maintaining or upgrading the scientific and educational infrastructure necessary for the advancement of knowledge had to be borne more directly by federal scientific research funds.

In addition, there are intangibles that are nevertheless real -- public perception or realization that there are cases where scientific ethics mirror those of society as a whole, making it easier to make choices between science and other demands on the public purse. The concept of research as an investment in the future is more difficult to accept as we attempt to solve the social problems of the present. The cancellation of the Superconducting Super Collider Project for whatever reasons after it was well underway encouraged a new look at all major scientific programs and has indeed resulted in additional reductions.

With this as background, what can be projected as the future of federal funding of research and development and the institutions that carry it out? At one end of the spectrum — basic research — we can expect growth to keep pace with inflation, though I would expect science on a small scale to predominate over large scale construction projects. Research funding as a mechanism for enhancing the educational process is certainly politically acceptable. Fundamental research in the biological sciences and material and chemical sciences would appear to grow.

I am much less sanguine about the federal funding of technology development where industry would be expected to derive near-term economic benefit. There may yet be a chance to salvage funds for applied research whose results would not yield

commercialization prospects in the near term, but only if significant cost sharing by industry would be made available and the need to expend government funds to reduce the risk to an acceptable level could be demonstrated. To extend the cost sharing concept to even earlier in the more risky regime of the innovation process, I would propose joint program planning with industry, with the government funding the earlier stages of research and private sector funds guaranteed to be used once the concept proved feasible.

Since I believe that on the whole fundamental research will continue to receive firm support from the federal government, it is my opinion that generally universities as a whole will continue to spend the largest portion of these funds. However, I believe that like the rest of the providers of services in the economy, individual universities will have to demonstrate that they are clearly the recipients of choice to perform research, in terms of the quality of their output and their ability to control costs. Moreover, since the production of new research performers is growing at a faster rate than funding is likely to occur, careers other than research will have to be sought and it would be appropriate to plan for these as part of the educational process.

Certain sectors of industry, those supplying the government with needed research capabilities in technology areas which are clearly the government's responsibilities (defense, environmental cleanup, safety), will continue to receive funds from the government, although perhaps at a lower level due to the exigencies of the budgetary process or the political acceptability of the technology area. I am concerned that as industry reduces or eliminates its central research facility, it may reduce its capability to identify new areas ripe for potential commercialization or to participate creatively with the government in developing the new products and processes needed for growth both by companies and this country. Relying on the government to identify such opportunities is clearly not adequate.

Government laboratories that function for a defined mission will be judged on the basis of the need for this mission and how well and at what cost the research is provided. As budgets of sponsoring agencies are reduced or redirected, a review of these activities will become manifest.

Based on experience in the Manhattan Project, the Department of Energy and its predecessor organizations developed and funded a number of large laboratories, primarily managed by universities or university associations, for the purpose of generating scientific knowledge and its application in solving various aspects of nuclear energy problems. As it became clear that the competencies developed for these applications were also needed in the solutions of other energy related problems, these institutions were officially recognized as multi-disciplinary, multi-program laboratories. They were supplemented by single purpose laboratories that were focused on either a single aspect of science or technology or the operation of large facilities for the benefit of outside researchers from academe, other laboratories, or industry. With their

capabilities in broad areas of science and technology that were developed to support the missions of the Department of Energy, the laboratories also entered into many cooperative agreements with industry for shared research.

The future of these laboratories is clearly related to the future of the Department of Energy. As certain programs such as fusion energy are reduced in scope, they will affect any single purpose laboratory such as the Princeton Plasma Physics Laboratory, and also all other suppliers of research for the program. Other programs such as the Science-based Stockpile Assurance Program are clearly the sole responsibility of the federal government, and the three defense program laboratories have crucial roles to play in them. As long as the large user facilities such as Fermilab can demonstrate their continued usefulness in research programs, they can expect to continue to receive funding for operation and necessary upgrades. The multi-program laboratories have a special niche between the investigator-driven small research projects associated with universities and the industry-sponsored applied research and technology development with relatively short-term payoff. Over their 50 year history, they have demonstrated that they can bring to bear a multi-disciplinary approach on science problems, the solution to which is important to future economic growth of this country. Advances in information technology facilitated interlaboratory cooperation built upon a long-standing cultural relationship among the laboratories. By concentrating on their scientific capabilities and increased efficiency of operation both of the laboratories and their sponsoring organization, the future should be as bright as the past.

SESSION IV: REGIONAL IMPACT OF POLICY CHANGES IN ENERGY, ENVIRONMENT AND ECONOMICS

RESPONDING TO THE CHANGING REGULATORY SCENE

Peter Wise
Associate Director
Illinois Environmental Protection Agency

I have been back in Illinois since June, and I would like to talk about how I see things from the perspective of having been away for eight years. Some aspects of our regulatory approach have changed dramatically over that time, and perhaps equally as important, some activities have not changed at all. What is important is making sure the regulated community and those who work with us understand where the balance is today, and where we are applying new approaches and employing new flexibilities to achieve maximum environmental protection.

Let us talk about three things that I find important. First, we are witnessing a dramatic shift in the relationship between the U.S. EPA and the states, which has resulted in an exciting new concept called Performance Partnership.

Second, we are moving beyond traditional command-and-control measures and increasing our emphasis on pollution prevention techniques.

Third, we are developing a breakthrough environmental amnesty project for small businesses, which we call Clean Break. And we successfully tested this project in the Rockford area last summer.

BUDGETARY PRESSURES

For the first time since Harry Truman was President, we have a totally Republican Congress, which has made it very clear what they think about regulatory programs as evidenced by the House of Representatives adding 17 riders to the EPA appropriations bill.

We do not know how that is going to turn out, but there will likely be dramatic budget cuts, some of which will undoubtedly be passed on to agencies like the one in which I am involved. And those cuts will cause changes to our programs as well as to federal programs. But there are other factors that I think are equally important, and these factors are causing changes that we are seeing now in Illinois and around the country.

COMMAND AND CONTROL IS WORKING WELL

Last summer the Illinois Environmental Protection Agency celebrated its 25th anniversary. We were the first environmental agency in this country, actually preceding the U.S. EPA by five months.

Such longevity has meaning, beginning with the fact that we have been running state environmental programs for a quarter of a century. As an example of our effectiveness, we have had the water program delegated to us for more than two decades, and today 99 percent of major industrial water dischargers are in compliance. And compliance rates for municipalities are almost as high. Those statistics tell us that writing more rules, issuing more permits, and enforcing more vigorously against those permits are *not* going to achieve dramatic increases in environmental protection. The incremental differences are too tiny.

However, I want to stress that we are very successful at command and control, and that we have a sufficient legal staff. So if you are one of those one percenters who are not in compliance, I promise you this: We will find you and we will enforce against you.

The point is that where we are finding instances where we are not meeting our standards, it is not from major industrial sources of pollution failing to meet their permit units. Instead, our problems stem from pollution coming from small businesses that are not currently in our system, from pollution coming from non-point sources, and from pollution coming into Illinois from outside the region. These factors are requiring us to be more creative in dealing with vexing challenges to environmental protection.

PERFORMANCE PARTNERSHIP REPRESENTS MAJOR CHANGE

Permit me to make a couple of quick comments about the Performance Partnership. ECOS, the Environmental Council of the States, is a new organization of environmental commissioners. In May 1995, ECOS signed a landmark agreement with U.S. EPA, reforming the oversight relationship between U.S. EPA and the state agencies. The significance of this action is that it recognizes that the states have been running environmental programs for a long, long time.

There are several principles with this new partnership. The first is that we will track progress, not by how many inspections or enforcement actions we conduct, but rather by what is happening to environmental quality in Illinois. Can we measure cleaner air and cleaner water as the result of our activities? Can we plot the progress of our pollution prevention programs by measuring reduced toxics in the Illinois environment?

Earlier this year Illinois EPA completed its first Environmental Performance Self-Assessment and submitted it to the U.S. EPA. In this document, we explained what we believe we are doing well and what we are not doing well.

We admitted things about ourselves that we never before would have said. We reported, for example, that we are one of the last states to take the pretreatment program, but we acknowledged that we need to do that. We also confessed that we do not have a healthy relationship with the Hazardous Waste Research Center in the Department of Natural Resources, but noted that we should.

This critical self-assessment led to our Performance Partnership Agreement, which we finalized on October 27, 1995, making Illinois the first state in the country to sign such a document.

The Performance Partnership Agreement replaces our work plans for air programs, for water programs, for Superfund programs, and it says, in effect, "These are our priorities, and here is what we are going to do." I encourage you to look at the Performance Partnership Agreement because it has fundamentally changed the relationship between the U.S. EPA and the states. Related to this activity is a very interesting portion of the U.S. Senate appropriations bill that calls for taking 14 categories of state media specific grants — clean water, clean air, toxic substances — and merging them into block grants, giving each state the flexibility to move funds around to meet the priorities laid out in their Performance Partnership documents.

NONREGULATORY COMPLIANCE ASSISTANCE

Let me shift gears to talk about compliance assistance. As I mentioned earlier, one of the real issues right now is how do we reach the next increment of environmental protection, and if we are not going to get it by regulating major facilities, how are we doing to do it?

My job as Associate Director at Illinois EPA is a new one, and I have been given responsibility for all of the Agency's compliance-assistance programs: Pollution Prevention, Small Business, Community Relations, Total Quality Management, and Public Information. These are our nonregulatory programs aimed at achieving additional compliance.

We recently initiated a series of strategies, one of which says we should integrate pollution prevention into all of our activities: into permitting, inspections, and even enforcement. So now when we work with the Attorney General to negotiate a settlement agreement with a large industry or a municipality, w propose pollution prevention as an alternative to fines. If a company agrees to perform and implement the results of an environmental audit to reduce pollution at its facilities, we will substantially reduce the penalties under consideration.

We are also looking at new ways to promote pollution prevention. A recent study by Illinois State University made it very clear that businesses in general — and small businesses in particular — do not like to see Illinois EPA coming to their door. They do not trust us. What a surprise! So we are recruiting new messengers to sell the notion of pollution prevention, compliance assistance and the like.

The university's study also reported that small businesses are willing to listen to their suppliers, to their competitors and to their accountants. This last fact encouraged us to enter into an agreement with the Illinois Association of Certified Public Accountants to develop a series of pollution prevention courses for CPAs in this state.

This association has 28,000 members, and it stands to reason that those who work with small businesses; those who do their cost accounting and know their materials, processes and costs of wastes; can be instrumental in delivering positive pollution prevention messages to their clients. Sure, small businesses will not listen to us, but they listen to their accountants, and in doing so, they will learn the benefits of pollution prevention.

BEYOND COMPLIANCE PROGRAMS

Many of you are familiar with U.S. EPA's XL Program, which encourages businesses to go beyond compliance. Recently the 3M Corporation here in Illinois was recognized by the U.S. EPA as a Beyond Compliance XL Program company.

And we have recently submitted to the governor's office a piece of state legislation that would allow companies that have historically been in compliance to be further rewarded for doing innovative things in pollution prevention.

We are highly optimistic that companies can go way beyond what their permits require to reduce the overall burdens on the environment, to save themselves money, and to achieve those results through something other than a regulatory fix.

ENVIRONMENTAL AMNESTY

Lastly, I want to talk about an innovative environmental amnesty program called Clean Break, which we tested in the Rockford area with the help of our partners, the Department of Commerce and Community Affairs and the Greater Rockford Chamber of Commerce.

In 1994, Governor Jim Edgar formed a Small Business Task Force, and one of its most important recommendations was that we develop a no-penalty compliance program for small businesses. The concept was very simple, and we chose to pilot it last summer in Boone and Winnebago Counties on the Illinois-Wisconsin border. We selected those two counties because they form the second largest metropolitan area in Illinois in terms of business.

We basically told the small businesses in those counties — a small business being defined as having 200 or fewer employees — that if you come forward, and you can do so anonymously, and if you agree in writing to come into compliance by getting the permits you need and doing the housekeeping you should have done, we will forgive you for any historic violations.

Clean Break started very slowly, I will confess. But there was a reason for that; it is something we call the "fear factor." The best way I can explain how the fear factor slows down the process initially is to relate a little anecdote. In the Rockford area, there are a dozen autobody shops whose owners or managers get together for coffee every two weeks or so. On day these people got to discussing Clean Break. There were very suspicious at first, but after a lot of talking, they finally nominated one of their group to enter the program.

Well, the results of this were at last felt on the final day of eligibility for the pilot program, when the remaining 11 autobody shops signed up for Clean Break. Now we are not saying they learned to trust us, but one of their own went through the system and lived, and that was good enough for them.

So what were the results of Clean Break? We had about 400 companies make inquiries through DCCA and the Rockford Chamber. Roughly 100 of these companies actually initiated the process. About 20 companies were determined not to have any environmental issues, and 62 businesses, or some 86 percent of the remainder, eventually entered into amnesty agreements.

We calculated that we passed up about $680,000 in fines by giving out those 62 amnesty agreements. What did we get out of it? We got 62 companies into the system and into environmental compliance. We think it is a good program.

At our recent press conference, where Governor Edgar announced the results of the Clean Break pilot program, one of those business owners got up and said, "I have been hiding from Illinois EPA for 18 years, but now I can go to sleep at night without worry because now I have the permits I need."

Beginning January 1, 1996, we will take Clean Break statewide, initially involving two business sectors: printers and auto maintenance facilities. Those two sectors account for about 19,000 small businesses in Illinois. And if we succeed in working with them and if our resources allow, we intend to add sector after sector as the years progress.

As policies are changing in Washington and events change nationally, we are responding intelligently and with flexibility. And through the leadership of Illinois EPA Director Mary Gade, we are becoming as proactive as possible to protect human health and the environment in Illinois.

RESHAPING THE ELECTRIC UTILITY INDUSTRY: COMPETITIVE IMPLICATIONS FOR ILLINOIS

Dean C. Maschoff
Senior Vice President
Planmetrics, Inc.

I am pleased to be here today to talk about some of the forces that are currently reshaping the electric utility or, perhaps more accurately, the electric power industry. In addition, I would also like to discuss how these changes *may* impact the energy marketplace — not only in Illinois, but throughout the country.

I use the term "may" because the title, or theme, of this conference, "... in a Period of Political Transition," suggests that any predictions about where the energy industry is going to end up will need to be hedged around an industry that is evolving from regulation to competition. We know that we will end up with a competitive industry; we're just not sure how we'll get there.

Just how did this transition or evolution get started?

FEDERAL POLICY INITIATIVES

It is important to recognize that most of the changes that we are witnessing today in the electric power industry stem, either directly or indirectly, from the passage of the Energy Policy Act of 1992 (EPAct). Although most industry observers will acknowledge that the changes that we are currently seeing are really a result of the changes brought about by the Public Utilities Regulatory Policies Act of 1978 (PURPA), it was really EPAct that set in motion the present fast-moving changes.

EPAct is now several years old and, based on the pace of recent change, it would not be appropriate to dwell on what may well be regarded as ancient history. Nevertheless, it is useful to recall two aspects of EPAct that were somewhat overlooked at the time, but are now very relevant.

First, we must recall that, like PURPA, EPAct's policy directives implicitly challenged the value provided by a vertically integrated electric utility industry. Stated more plainly, EPAct implied that there may be greater benefit from an electric power industry that is not necessarily vertically integrated. EPAct went on to further encourage the development of independent competitive generating facilities.

The second aspect of EPAct that I would like to highlight was also not so much explicitly *stated* as *implied*: In EPAct's discussions of the need for open access transmission and competitive power supply options, it was recognized, for the first time *at the federal policy level,* that electric utilities were actually comprised of different businesses.

Since the mid-1980s, there have been discussions — and even specific company proposals — concerning the formation of a GENCO-TRANSCO-DISCO model. EPAct took the discussion from debate to reality by establishing a national energy policy based on the recognition that electric utilities are in different businesses. This acknowledgment was precedent-setting, and represented a force for subsequent change.

Following the passage of EPAct, the March 1995 issuance of the Federal Energy Regulatory Commission's (FERC's) Notice of Proposed Rulemaking (NOPR) related to nondiscriminatory open access transmission[1] (formally, RM95-8) was an obvious progression in policy to anyone familiar with the unfolding of events in the natural gas industry after the passage of the Natural Gas Policy Act of 1978 (NGPA).

The Mega-NOPR addressed a complaint made by many in the electric utility industry regarding FERC's failure to specify an overall vision for a restructured industry. The Mega-NOPR provided a vision for increased competition in bulk power markets, and outlined the Commission's perspectives towards electric utilities' previous attempts at voluntarily implementing open access transmission systems. FERC noted that:

- Third-party customers (of electric utilities' transmission service) have not been able to obtain the flexibility of service enjoyed by transmission owners (i.e., the electric utilities) (see page 49 of RM95-8), and

- Transmission-owning utilities may deny access to third parties — not only to avoid losing their own generation sales (i.e., sales of power from their own generation resources), but also to maintain other trading gains (see page 71 of RM95-8).

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[1]Federal Energy Regulatory Commission, *Promoting Wholesale Competition through Open Access, et al.*, RM95-8, March 29, 1995.

FERC has indicated that it expects to issue an order in this proceeding in the spring (March) of 1996. Even if the eventual rulemaking is not a "Final Order" along the lines of the natural gas industry's Order 636 (and it probably won't be), we can be certain that FERC will be relentless in the implementation of a transmission regime that is fully supportive of a competitive wholesale bulk power marketplace.

STATE REGULATORY RESPONSE

EPAct established the legislative foundation for subsequent federal and state regulatory initiatives. However, it was the Blue Book initiative by the California Public Utilities Commission (CPUC) that provided the first comprehensive description of a business and regulatory model in which end-use energy consumers could choose among competitively-priced power suppliers.[2] In the Blue Book initiative, the CPUC also clearly articulated the failure of "command and control" regulatory policies, and outlined the benefits that (at least) California energy end users might anticipate in the form of lower electricity prices resulting from the implementation of the proposed direct access (i.e., retail wheeling) regime.

Although the California Blue Book initiative has since gotten bogged down with politics and special interest debates, its bold and articulate vision nevertheless set the stage for subsequent state regulatory and legislative actions for increasing competition and customer choice related to power supply.[3]

For example, for some time, observers in the Midwest and throughout the country have watched and analyzed the proposals and discussions that have taken place in connection with Wisconsin's electric utility regulatory reform initiative. For now, Wisconsin seems to be backing away from the aggressive timing of initial proposals to implement retail wheeling. As the Wisconsin Policy Group continues to monitor changes in the industry, it may be able to learn from retail wheeling/customer supplier choice experiments taking place in a number of other parts of the country[4] For example:

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[2]CPUC, *Order Instituting Rulemaking on the Commission's Proposed Policies Governing Restructuring California's Electric Services Industry and Reforming Regulation (R. 94-04-031) and Order Instituting Investigation in the Commission's proposed Policies Governing Restructuring California's Electric Services Industry and Reforming Regulation (I. 94-04-032)*, April 20, 1994.

[3]The CPUC voted 3-2 on December 20, 1995 on a proposed transition to a competitive electric market beginning January 1, 1998, with all consumers participating by 2003.

[4]On December 9, 1995 the WPSC adopted a systematic and sequential approach to electric utility restructuring by the year 2000.

- On October 25, 1995, Equitable Gas Company proposed to the Pennsylvania Public Utility Commission that an experiment be conducted in which all classes of energy end-use customers in the borough of Pleasant Hills, Pennsylvania could have access to alternate suppliers of natural gas *and* electric power.

- Following the passage of new state energy legislation in June 1995, New Hampshire regulators are requiring that utilities develop retail wheeling pilots for at least three percent of their load (approximately 60MW overall), for implementation on May 1, 1996. The Public Utility Commission has indicated that they will neither review nor approve the prices paid for power supplied under any proposed retail wheeling arrangement. The Commission has also indicated that fifty percent of any resulting stranded investment costs should be borne by shareholders.[5]

- The Massachusetts Department of Public Utilities required all utilities to file retail wheeling plans by February 1996. The plans must provide proposals for customer choice (all classes), unbundled rates, and cost recovery. New England Electric System, the state's largest utility, indicated in its early filing that its plan is anticipated to provide rate relief for *all* customers by 1998.

Within the contextual backdrop of regulatory change, how are utilities responding?

THE RESPONSE OF UTILITY MANAGEMENT

Within a few months following the passage of EPAct, almost all utilities began to recognize that they were facing the very real prospect of serious losses in shareholder value as a result of increased competition. Negative impacts on shareholder value could come either from lost customers or else from lower margins in transactions in the wholesale bulk power market. Negative impacts could also come from lower margins associated with the retail side of the business. If retail wheeling becomes a reality, the lower margins or lost sales that they might be experiencing in the wholesale market may also occur in their native load retail market. In an era where simply filing a rate case to raise prices in response to rising costs is even less of an option than what it had been prior to EPAct, failure to control or reduce costs would almost certainly result in lost shareholder value.

Facing the indisputable reality of increased competition and, therefore, the almost certain prospect of shareholder losses, utilities have responded in a number of ways.

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[5]On December 12, 1995 the state legislative committee approved a final version of principles for restructuring the electric utility industry which could allow the introduction of retail choice by 1998. The principles require all utilities in the state to file restructuring plans with the state commission by May 31, 1996.

First, they have taken steps to reduce costs. Today, almost all utilities have undergone some sort of workforce reduction/restructuring initiative. As an industry, over the past five years, electric utilities have reduced their workforce numbers by many thousands through layoffs, attrition, early retirement programs, etc. In addition, they have re-engineered their work processes in an attempt to reduce nonlabor expenses and improve service efficiency and effectiveness. In almost all cases, the benefits of these initiatives have been "passed through," either to customers, in the form of lower or "frozen" energy prices, and/or to shareholders, in the form of retained (although probably not increased) shareholder value.

The challenge for utilities related to cost cutting was aptly summarized by one CEO who said, "You can't save your way to heaven." As a result, utilities have also taken steps to focus on marketing. First of all, they have taken steps to increase the effectiveness of their sales and marketing functions related to existing products and services and current markets. Second, they have undertaken a broad range of initiatives to identify new products and services, as well as new markets.

In this regard, many utilities are busy implementing a strategic vision that involves the transformation of the integrated utility and its operations into an energy services company. Within the context of increased competition related to the asset/rate base side of the business (i.e., generation), the concept of a services-based vision, oriented to meeting market needs and providing customer value, offers an attractive alternative for many utilities.

The term "energy services company" has been widely used and has many definitions, and many utilities have declared themselves to be energy services for a variety of reasons.[6] Because the term "energy services company" is still evolving, it is best to develop a definition that is prescriptive and based on a future perspective. Accordingly, an energy services company may be defined as having involvement in several broad areas of service (and products), including:

- Energy commodity procurement and delivery management
- Energy efficiency advisory services and end-use products
- Energy facilities management
- Energy financial services

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[6]See, for example, "Comm Ed Pursues Restructuring to Meet Competition After Losing Big Customer," *Electric Utility Week*, December 21, 1992, p.5.

Few, if any, current utility energy services company initiatives cover all of these areas. We can expect, however, that, in the future, many utilities will opt for a energy services company strategy for the following reasons:

- Recognition of the lack of capabilities related to power plant development and construction has led many utilities to conclude that they are no longer in the "generation business."

- Translation of former demand-side management offerings into an energy services business initiative may seem to be a very natural transformation for DSM departments and related functional areas after the removal of regulatory incentives/programs supporting most utility energy efficiency initiatives.

- Desire to avoid significant capital commitments, coupled with an interest in experimenting with what are perceived to be low-risk new business initiatives.

- Lack of understanding and/or desire to participate in evolving energy commodity markets (i.e., "We're not an Enron").

- Lack of desire to participate in any global energy initiatives, including utility privatizations, independent power developments, or new infrastructure investments.

As noted earlier, FERC anticipates issuing an order in response to the Mega-NOPR early next year. We can expect that this order, and subsequent initiatives at both the federal and state level, will drive electric utilities towards the vision hinted at in EPAct — vertical disintegration. This vision may or may not require divestiture. What it will require is an increasing emphasis on arms-length relationships among business affiliates, consistent with the principles of unbundling and customer choice, and, perhaps, consistent with the separate business perspective of EPAct.

These initiatives will make it easier for utilities to form fuel neutral/supplier neutral energy services companies. This means that, as part of providing value to the customer, if natural gas works best in the overall customer solution, then gas — the commodity — will be part of the service offering. If an electrotechnology best meets the customer's needs, then electricity will be an element of the service offering.

While adopting a neutral stance concerning any particular energy commodity, the energy services company may have access to, or a relationship with, a primary energy commodity supplier. This "preferred" relationship may come from an affiliate relationship or an alliance. Note, however, that, if the energy commodity affiliate or alliance partner cannot make the deal work, the energy services company may (and probably will) seek out other energy suppliers that can fill the bill.

As utilities form energy services companies as a growth initiative, they will quickly recognize that a small scale or limited focus for this initiative is inconsistent with the following:

- The economics of the business (i.e., fixed and variable costs, economies of scale benefits)

- The logic of core capabilities/competencies (i.e., "If we are the best energy services company, why stop at our service territory limits?")

For all but the very largest utilities, the "numbers" associated with most energy services initiatives having a limited, service-territory-only market perspective "do not work." They do not work from the standpoint of profitability, and they do not work from the standpoint of producing any meaningful contribution to earnings and shareholder value. Utility energy services companies will need to focus on becoming big.

In addition, as utility energy services companies acquire and develop core capabilities in order to provide value in a competitive marketplace, the managers and employees of the energy services company are quickly drawn to conclude that, if they are so good at serving the markets defined by the utility service territory (or if they have intentions to be so good), why wouldn't they go "outside" — expand to regional, national, or even global markets?

The "to do's" associated with a more aggressive energy services company initiative are significant, and an energy services company initiative may start small. However, if it is to achieve any sort of status in the organization and serve as a vehicle for creating meaningful shareholder value, the energy services company will need to grow, or at least have a growth objective, to expand beyond the current utility service territory. Utilities' energy services strategies must drive towards establishing leadership positions and competitive advantages in larger, more broadly defined markets.

The challenge for utilities in connection with an energy services company initiative is that an energy services company initiative is just one more new business venture, subject to the same failure rate — 80 to 90 percent (?!) — that all new business ventures face. When considering the vision of a broad-based, full service energy services company, why should their odds of success be any higher?

Finally, a number of utilities have taken steps to address issues related to both costs and markets, and have initiated merger proceedings. For the past year or so, announcements of utility mergers have been so frequent that it almost appears to be

necessary to check the *Wall Street Journal* each Monday to see if any new deals have transpired over the weekend.[7]

If a number of companies are actually pursuing mergers, almost *all* utilities are considering mergers in some way, such as back-office analyses by planning departments, informal CEO dinners, investment banker engagements. Mergers make sense for utilities to consider for a number of reasons, including:

- The fact that fixed costs associated with administrative functions, customer service systems, and operational infrastructure can be spread across a broader customer base, that is, increasing economies of scale translate a merger initiative into yet another cost-reduction initiative.

- The perception that critical mass, whether in terms of generation assets or customers served, is an important strategic — albeit unquantified — benefit from a merger.

- Franchised, jurisdictional service territories may not have a lot of meaning in an era of increasing competition, especially increasing retail competition. A merger, however, can be seen as acquiring markets.

- Blurring distinctions between natural gas and electric power industries may obviate the need for separate investor-owned electric power distribution and natural gas distribution companies.[8]

From the perspective of the Midwest, the proposed merger of Wisconsin Energy and Northern States Power to form Primergy has had the most impact. This most recent example of a merger between two healthy, similarly sized utilities may have played a part in the Union Electric Company/Central Illinois Public Service merger announcement, but it almost certainly was a factor in the three-way deal recently announced between Interstate Power, IES, and Wisconsin Power & Light.

Using some or all of the logic noted earlier, these mergers may look eminently beneficial to customers and shareholders, and represent a rational response to the changing utility business environment. Accordingly, we can expect to see more

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[7]During a 10-month period between June 17, 1994, and August 23, 1995, five mergers were announced: Washington Water Power/Sierra Pacific Resources; Midwest Resources/Iowa-Illinois; Wisconsin Energy Corporation/Northern States Power Company; Union Electric Company/Central Illinois Public Service Company; and Public Service Company of Colorado/Southwestern Public Service Company. Even more recently announced deals include: Puget Sound Power and Light/Washington Energy, and Interstate Power/IES/Wisconsin Power & Light.

[8]The recently-announced merger between Puget Sound Power & Light and Washington Energy is an example of this phenomena.

utility mergers. However, it should be noted that "might," or, in this case, size, may not make "right," in that even the resultant merged companies need to address the regulatory, competitive, and growth challenges discussed earlier. A merger may just buy time. On the other hand, it takes time and management resources to combine functional areas, develop the merged organization structure, and meld potentially very different corporate cultures. Therefore, advantages may accrue to those mergers that can be completed quickly, allowing the combined management teams to address strategic issues related to business definition, core competencies, and growth.

POTENTIAL IMPACTS ON ILLINOIS

My assigned title indicates that, at a minimum, the wrap-up of my remarks should address how all of these macro trends and national events may impact Illinois. Accordingly, some (properly qualified) predictions for the next three years are in order.

- Utilities in Illinois will continue to cut costs. ComEd's recent announcement is one example of a cost-cutting initiative.

- National energy services companies, affiliates of utilities, and others will enter the Illinois energy marketplace. For example, UtiliCorp United's Energy One recently signed national account energy services contracts with a large hotel association, as well as with a large appliance chain. This is only one example of a new market entrant. Illinois business markets and mass consumer markets can expect offers from players to meet their energy (and related) needs.

- Federal and — yes — state regulatory actions will increasingly require electric utilities to adopt "business unit" separation, and to unbundle products and services.

  - Open access transmission will be the "law of the land"

  - Divestiture will not be required

  - Shareholders will be required to bear some of the transition burden associated with stranded investment

  Illinois will continue to lag behind other states in terms of direct access initiatives, though.

- Gas companies and electric companies will increasingly "cross the line" and, in a world that is more and more unbundled, compete in the area of services, products, and primary energy source.

- At least one additional Illinois utility will be involved in a merger.

- Wide disparities in power pricing between summer and winter periods, as well as during-the-day variations, combined with risk management tools, will result in power marketers, utility affiliates, and "independents" becoming increasingly active in the Midwest and, therefore, in Illinois.

With all of these changes on the horizon, utilities are finding out what firms in competitive industries have known for some time — that *the* critical success factor in the long run is the quality of management. Superior management will provide the leadership required to redefine the business and to be a catalyst for change, instead of just reacting to change. Superior management will develop winning strategies for competitive positioning and growth. Superior management will ensure that these strategies are executed.

However, utilities will also discover something else that firms in competitive industries have known — that superior management is tough to find and develop, and even tougher to maintain. On January 28, 1993, an editorial in the *Wall Street Journal* entitled "CEOs: The Vision Thing," appeared the same week that John Akers resigned from IBM, and noted the following:

> *There was a moment when Detroit recognized that Americans were beginning to buy large numbers of foreign-made cars, when IBM noticed that its industry was moving away from large mainframe computers, when Sears saw its first Wal-Mart, when Big Steel saw its product turn into a commodity. The time for decisions was then. They waited until later. Too late.*
>
> *Or, if they recognized that decisions were necessary, their institutions were long past the point of being able to act within the time frames mandated by the pre-21st century business milieu. They were imbedded in union bureaucracies, or more likely in a corporate culture that seems to dull the movements of otherwise forceful men.*
>
> *... By definition, it's going to be a visionary who sees the need for change first. And because change is coming faster than ever, the CEOs of the future are going to require more vision than ever.* ***The bottom line remains fundamental, but we suspect the future more than ever requires corporate leadership with the skills to integrate a lot of unexpected and seemingly diverse events into its planning.*** (Emphasis added.)

As the electric utility industry in Illinois and throughout the country struggles to address competition and industry restructuring, the winners will be those that first solve the "superior management" challenge that will occur.

RESTRUCTURING THE ENERGY INDUSTRY: A FINANCIAL PERSPECTIVE

William A. Abrams
President
William A. Abrams Company

TABLE 1

CAVEATS

- Post a Guideline
  - Never a Promise
- Major Volatility Dynamics
  - Government/Politics
  - Technoloyg
  - Economic
  - Social Purpose
  - Customer Priorities
  - Company Management Skills

TABLE 2

HISTORY

1875-1910	1910-1978
• Maverick Industry	• Strong Monopoly
• Highly Competitive	• Cost-Based Regulation
• Failures	• Solid Legal Structure
• Buy Outs	• Return on/of Capital Assured
• Most Financing Private	• Utilities *Premier* Investment

TABLE 3

HISTORY

1978-1994
• 15 Years Transition
• PURPA 1978
• Growth Purchased Power
• New Competition
▪ Forced
▪ Utility Financed
• Bankruptcy
• Regulation Fragmented
• National Energy Policy Act 1992
• Increased *Financial Risks*
• $20 Billion in Write-Offs

TABLE 4

PRESENT

1995

- Competition in the Open
- State Initiatives — Some Slowdown
- Niagara Mohawk Proposal
  - Spin Off
- Merger
  - Upsurge
  - Three Company Combination
  - More Coming
- Munipalization
- Construction Minimized
- Cash Generation Up
- Cost Containment
- Foreign Expansion
- Financial View Cautious

TABLE 5

FUTURE OF ELECTRIC UTILITIES

- Ability to Complete Unfettered
- Clear, Consistent Regulation
- Assured Recovery of Assets
- Fair Return on Regulated Portions/ Return on all Contracts
- Unlimited Profit Potential on Competitive Portions
- Termination of Social Programs
- Reduction of Local Taxes
- Stronger Capital Structures
- High Levels
  - Coverages
  - Cash to Debt
  - Cash to Construction

TABLE 6

FUTURE INDEPENDENT POWER PROCEDURES

- Consolidate
- Plants/Customer Diversification
- Strong Capital Structures
- Competitive on Merits
- No Social Programs
- Prepare for Higher Taxes
- Prepare for Regulation
- Improve
  - Debt Privileges
  - Cash Retention

TABLE 7

TOTAL INDUSTRY / NEAR TERM — 5 YEARS

- IOUs and IPPs will get Bigger
- Mergers will include IPPs
- Regulation will Aim at Both
- Failures in Both Groups
- Customers will have Choices — But get what they pay for
- Companies will Split up by Function
- Irregular Financial Picture
  - Size
  - Cost Structure
  - Minimum Funds Needs

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TABLE 8

TOTAL INDUSTRY / LONGER TERM — POST 2000

- Companies will Recombine
- Major Operate from Source to End User
- Boutique Firms for Specialized Service to Those who can Afford It
- Social Purpose will Change from Competition to Customer Satisfaction
- Regulation will Intensify
  - Prevent "Abuses"
  - Resubsidize the Constituency
  - Equalize Service
  - No Return to Old Compact
- Financial Posture — Mixed
  - Top — Well Managed, in Control, Durable Holdings
  - Middle — Fad Companies, Short-Term Opportunities
  - Bottom — High Cost, No Mission, Vanish

APPENDIX A

SPEAKERS BIOGRAPHICAL SKETCHES

WILLIAM A. ABRAMS

William A. Abrams recently established William A. Abrams Company to provide financial consulting for industry in areas of financial planning, investor relations, and personnel motivation in a changing utility world. Following 16 years of experience in industry, management consulting, and investment banking, Mr. Abrams joined Duff & Phelps as a Senior Analyst in 1967 and rose to Senior Vice President. From 1974 through 1994, he was in charge of the utility rating service and responsible for all utility credit ratings. He also has performed special utility financial feasibility studies and acted as financial consultant on various utility issues. He has testified as an expert witness on rate of return, financial integrity, accounting and other utility matters.

FRANK M. BEAVER

Mr. Beaver is the Deputy Director for Energy and Recycling of the Illinois Department of Commerce and Community Affairs. In this capacity, he is responsible for management oversight of the state's energy conservation, alternative energy and recycling and wast reduction programs. Previously, Mr. Beaver was Deputy Director of the Illinois Department of Energy and Natural Resources where in addition to the energy conservation, alternative energy and recycling programs, he directed the coal development and energy programs. A graduate of Kansas State University (B.S.) and Sangamon State University (M.P.A.), Mr Beaver has worked in resource planning for the State of Illinois since 1971.

GEORGE BUGLIARELLO

George Bugliarello, Chancellor of Polytechnic University, of which he was President from 1973 to 1994, is an engineer and educator with a broad background ranging from fluid mechanics to computer languages, biomedical engineering and science policy. He holds a Doctor of Science degree in engineering from the Massachusetts Institute of Technology, and was awarded honorary degrees from Carnegie-Mellon

University, the University of Trieste, the Milwaukee School of Engineering, the Illinois Institute of Technology, and Pace University. He has been honored by the *Engineering News-Record* as one of "Those Who Made Marks" in the construction industry in recognition of the creation of Metrotech, the nation's largest urban university-industry park, and in 1994 was awarded the New York City Mayor's Award for Excellence in Science and Technology.

KELLY H. CARNES

Kelly H. Carnes was appointed by the President in October 1993 as the Deputy Assistant Secretary for Technology Policy of the Technology Administration of the United States Department of Commerce. Under the direction of the Assistant Secretary for Technology Policy, she is responsible for developing policies to increase the role of technology in enhancing the economic well-being and competitiveness of the United States. The Office of Technology Policy also is charged with developing policies that promote U.S. international competitiveness. The Office of Technology Policy serves as liaison to the private sector to identify barriers to the rapid deployment of technological and managerial innovations, and to ensure that industry's interests are reflected in federal technology policy. The Office of Technology Policy also is responsible for assisting federal, state and local officials, industry and academic institutions in promoting economic growth and industrial competitiveness.

JOHN J. CUTTICA

John J. Cuttica is the Vice President of End Use Research and Development at the Gas Research Institute in Chicago, Illinois. His responsibilities include strategic planning, program implementation, and completion of research programs aimed at developing cost-competitive gas utilization technologies that will improve energy service to the residential, commercial, industrial, transportation and power generation market sectors. The End Use Division conducts R&D programs in appliance, space heating and cooling (including gas fueled heat pumps), cogeneration metals and non-metals industrial process, natural gas vehicle and large utility boiler technologies.

HARVEY DRUCKER

Harvey Drucker joined Argonne National Laboratory in 1983. He is presently the Associate Laboratory Director for Energy and Environmental Science and Technology. As such, he is responsible for programs relating to the development of new procedures for coal combustion and/or conversion to other fuels and processes for energy conservation/solar energy production. In the biological and environmental

area, studies concern the effects of energy-related effluents on man and the environment. These programs consider the toxic effects and the mechanisms of toxicity of organic chemicals, radioactive materials and radiation. Previously, Dr. Drucker was Manager of the Biology and Chemistry Department of Pacific Northwest Laboratories. Earlier at Pacific Northwest Laboratories, he served as Manager of their Molecular Biology and Biophysics Section.

THEODORE R. ECK

Theodore R. Eck joined Amoco Corporation as Chief Economist in 1970. Before joining Amoco, he served as Chief Economist for Creole Petroleum Corporation Exxon, after joining the company in Caracas, Venezuela as a Petroleum Analyst in 1964. He chaired the Department of Finance for Southern Methodist University from 1960 to 1963 and was a Petroleum Economist for the Federal Reserve Bank of Dallas. He is a frequent consultant to the U.S. Department of Energy and other federal government agencies on petroleum-related matters. Dr. Eck is one of the Directors of the American Council for Capital Formation Center for Policy Research. He is also on the Board of Directors of Heartland Institute, the Advisory Board of the International Oil and Gas Educational Center, the Advisory Board of MIT Energy Laboratory and is a member of the Gas Research Institute Advisory Council.

PETER S. FOX-PENNER

Peter S. Fox-Penner is an agency liaison serving as Senior Advisor for Technology Policy in the Office of Science and Technology Policy in the Executive Office of the President. In this role, he coordinates the activities of the Committee on Civilian Technology of the National Science and Technology Council and provides advice on civilian technology policy. Dr. Fox-Penner also is Principal Deputy Assistant Secretary for Energy Efficiency and Renewable Energy (EERE) in the U.S. Department of Energy. In this capacity, Dr. Fox-Penner led in the preparation and defense of EERE's $1.2 billion annual budget and directed the unit's policy and strategic analyses. He also played a major role in the planning and execution of many of the unit's programs including the Climate Change Action Plan, the Partnership for a New Generation Vehicle, the Natural Gas Strategic Plan, the Bioenergy Initiative, and Department activities involving electric industry restructuring.

STEVEN GEHL

Steven Gehl is the Director of Strategic Synthesis at the Electric Power Research Institute. He is responsible for development of Institute strategy and the integration

of corporate and business unit strategies. Prior to assuming this position, he was Program Manager for Fossil Plant Performance, with responsibility for issues such as heat rate improvement, fuel quality effects, combustion optimization, cycling operation and plant life optimization. Previously, he managed projects on light-water reactor fuel performance in the EPRI Nuclear Power Division. Before coming to EPRI in 1982, Dr. Gehl spent seven years at Argonne National Laboratory where he conducted research on nuclear fuel performance.

DAVID GOLDMAN

David Goldman is Executive Associate for S&D Management reporting to the Deputy Undersecretary for S&D Management, U.S. Department of Energy. Over the last decade, Dr. Goldman has held a series of high-ranking assignments within DOE focusing on energy policy and science and technology. Most recently he was Deputy Manager for the DOE Chicago Operations Office. He was responsible for federal research and related programs performed at DOE multi-program laboratories. Other positions at DOE include Deputy Science and Technology Advisor for Civilian Research and Development; Acting Manager, DOE Chicago Field Office; and Assistant Manager for Laboratory Management (covering six national laboratories). Prior to DOE, Dr. Goldman also has held positions as Associate Director for Planning, National Measurement Laboratory, National Bureau of Standards; Executive Associate for Science and Technology to the Assistant Secretary of Commerce; and Deputy Director of National Bureau of Standards Institute for Basic Standards.

CHERRI J. LANGENFELD

Cherri J. Langenfeld was named Manager of the Department of Energy's Chicago Field Office in October 1992. As Manager, she directs the activities of nearly 600 federal employees and is responsible for more than $2.4 billion in federal research and development and related cooperative activities, including technology transfer. Until her appointment as Manager, Ms. Langenfeld served as DOE's Director of Technology Utilization and key advisor to the Secretary of Energy on technology transfer matters. In this capacity, she also spearheaded DOE's Enhanced Technology Transfer Program and the National Technology Initiative. Prior to that, she served as Director, Technology Analysis in DOE's Office of Policy, Planning, and Analysis.

DEAN C. MASCHOFF

Dean C. Maschoff is a Senior Vice President of Planmetrics, Inc. in Chicago, Illinois and heads the firm's Strategic Services Practice. In this position, he concentrates on

positioning clients to anticipate and respond to emerging competitive pressures so they may meet the present and future needs of their customers, shareholders, employees and regulators. Mr. Maschoff has managed numerous engagements for electric and natural gas utility companies in the areas of business strategy, core competency analysis, supply resource analysis, acquisition analysis and long-range regulatory strategies. Prior to joining Planmetrics, Mr. Maschoff worked for a Midwestern energy company where his responsibilities included long-range financial planning, FERC rate case filings, capital budgeting analysis and corporate modeling efforts.

CHARLES G. STALON

Charles G. Stalon is an independent consultant on energy regulation. Prior to his retirement in 1993, he was Director of the Institute of Public Utilities and Professor of Economics at Michigan State University. Prior to joining Michigan State University, Dr. Stalon served for five years as a Commissioner on the Federal Energy Regulatory Commission (FERC). In the brief period between leaving the FERC and joining Michigan State University, he served as a Director of Putnam, Hayes & Bartlett, Inc. Prior to his appointment to the FERC, Dr. Stalon served for seven years as a Commissioner on the Illinois Commerce Commission.

RICHARD L. STROUP

Richard L. Stroup is a Professor Economics at Montana State University and a Senior Associate of PERC (the Political Economy Research Center) in Bozeman, Montana. Dr. Stroup is a widely published author and speaker on economics, including natural resources and environmental issues. He has also written on public choice, tax policy and labor economics. His work has been a major force in the development of the approach to resource problems known as the New Resource Economics. He is co-author, with James D. Gwartney, of a recent primer on economics, *What Everyone Should Know About Economics and Prosperity,* and of a leading economics principles textbook, *Economics: Private and Public Choice.* Other books include *Natural Resources: Bureaucratic Myths and Environmental Management* and *Bureaucracy vs. The Environment: The Environmental Cost of Bureaucratic Governance.*

NUNO A. VAZ

Nuno A. Vaz is currently Program Manager, Government Partnerships, in the Research Technology Partnerships Directorate of the GM R&D Center in Warren, Michigan. His group analyzes the GM R&D portfolio of advanced projects and develops strategies for creating partnerships that leverage the internal corporate

resources with additional resources primarily from the federal government and the national laboratories. Dr. Vaz holds a Ph.D. degree in NMR spectroscopy of liquid crystals from Kent State University. Dr. Vaz began his career at General Motors in 1983 in the Physics Department working on applications of liquid crystals to reconfigurable displays. He has since worked on heat load management in automobiles, glass coatings and electro-rheological fluids.

PETER L. WISE

Mr. Wise became the Associate Director of IEPA in 1995 following a career in government and private consulting. As Associate Director, he oversees the work of the Offices of Pollution Prevention, Small Business Assistance, Community Relations, Public Information and Quality Management. Mr. Wise was previously the Group Senior Vice President for Science Applications International Corporation's (SAIC's) Environmental and Health Sciences Group where he was responsible for $475 million of annual revenues and over 750 professionals who performed environmental policy and engineering and health sciences studies. As the Manager of SAIC's Environmental and Health Sciences Group, Mr. Wise provided technical and managerial oversight for environmental projects that included policy, legislative, and regulatory analyses; environmental impact statements; toxicological and risk assessments; statistical analyses; and data management and information systems development.

PORTER J. WOMELDORFF

Porter J. Womeldorff is the Global Climate Program Executive of Illinois Power Company. He is responsible for scientific and technical activities related to global climate issues. Mr. Womeldorff serves as an appointed member of the Illinois Coal Development Board and chairs its Research Committee. He has served on the Research Advisory Committee of the Electric Power Research Institute, chaired its committees on exploratory research, advanced fossil power, clean gaseous fuel, technology and fuels assessment, and served on its Integrated Energy Systems Division Committee and Committee on Exploratory Research. Mr. Womeldorff also serves on the Edison Electric Institute Clean Air Act Issue Group and Global Climate Issue Group. He chairs the Science and Technology Assessment Committee of the Global Climate Coalition and serves on its Operating Committee. He has served as a non-governmental observer at the Intergovernmental Negotiating Committee and the Conference of the parties of the U.N. Framework Convention on Climate Change.

APPENDIX B

CONFERENCE ATTENDEES

Nasri Abi-Mansour
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

William A. Abrams
President
William A. Abrams Company
550 Frontage Road
Northfield, Illinois 60025

Robert Albertini
Account Manager
Commonwealth Edison Company
1919 Swift Drive
Oak Brook, Illinois 60521

David W. Anderson
Energy Manager
Chicago Housing Authority
626 West Jackson
Chicago, Illinois 60661

David G. Arey
Assistant Director
Coal Research Center
Southern Illinois University
Carbondale, Illinois 62901

John K. Aslakson
Gas Research Institute
8600 West Bryn Mawr Avenue
Chicago, Illinois 60631

Dwight Bailey
Energy Manager
Chicago Department of Environment
2 North La Salle Street
Chicago, Illinois 60602

David Balderas

Research Architect
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60606

Irene Banas

Senior Research Engineer
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

John Bassett

General Manager Planning
The Uno-Ven Company
3850 North Wilke Road
Arlington Heights, Illinois 60004

Frank M. Beaver

Director
Bureau of Energy and Recycling
Illinois Dept. of Energy & Community Affairs
325 West Adams Street
Springfield, Illinois 62704

John Best

School of Public Health
University of Illinois at Chicago
2121 Taylor Street
Chicago, Illinois 60612

Subhash B. Bhagwat

Senior Mineral Economist
Section Head
Illinois State Geological Survey
615 East Peabody Drive
Champaign, Illinois 61820

Richard Biljetina

Vice President, Gas Industry Programs
Institute of Gas Technology
1700 South Mount Prospect Road
Des Plaines, Illinois 60018

David M. Birr

President
Synchronous Energy Solutions
2017 Allen
Geneva, Illinois 60134

Daniel Bodnaruk

Project Manager
U.S. Department of Energy
Chicago Regional Support Office
One South Wacker Drive, Suite 2380
Chicago, Illinois 60606

Athanasios D. Bournakis

Senior Research Economist
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

Patrick J. Boyle

Director
St. Charles Electric Utility
2 East Main Street
St. Charles, Illinois 60174

John P. Bradley

President
Murray and Trettel, Inc.
414 West Frontage Road
Northfield, Illinois 60093

Joseph J. Bruno

Supervisor of Utilities Management
Johnson Controls World Services, Inc.
2000 Spring Road, Suite 110
Oak Brook, Illinois 60521

Mary Buchheid

Project Manager
Chicago Department of Environment
2 North La Salle Street
Chicago, Illinois 60602

Eve Buckley

Department of Education
The Museum of Science and Industry
57th Street and Lake Shore Drive
Chicago, Illinois 60637

George Bugliarello

Chancellor
Polytechnic University
6 Metrotech Center
Brooklyn, New York 11201

Rex A. Buhrmester

Environmental Protection Specialist
Illinois Environmental Protection Agency
2200 Churchill Road
P.O. Box 19276
Springfield, Illinois 62794

Mark E. Burger

Technology Marketing Section
U.S. Department of Energy
Chicago Regional Support Office
One South Wacker Drive, Suite 2380
Chicago, Illinois 60606

Leticia Canchola

Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

Bart J. Cannon

Senior Technologist
County Environmental Company
R.R. 3, P.O. Box 646
Pontiac, Illinois 61764

Robert A. Capesius

Manager of Technical Support
The Peoples Gas Light & Coke Company
130 East Randolph Drive
Chicago, Illinois 60601

Jeff Carroll

Industrial Paper Engineer
Northern Illinois Gas
90 North Finley Road
Glen Ellyn, Illinois 60137

James D. Cavallo

Economist
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Michael J. Chimack

NAFA Certified Air Filter Specialist
Air Filter Engineers Inc.
100 Fencl Lane
P.O. Box 916
Hillside, Illinois 60162

James L. Christensen
Manager, Research and Development
Wisconsin Power and Light
P.O. Box 192
Madison, Wisconsin 53701

Jack B. Clark
Executive Assistant
Iowa Utility Association
P.O. Box 6007
Des Moines, Iowa 50309

Mary A. Collins
Director of Public Relations
Planmetrics, Inc.
8600 West Bryn Mawr Avenue, Suite 400N
Chicago, Illinois 60631

John Cuttica
Vice President, End Use Technology
Gas Research Institute
8600 West Bryn Mawr Avenue
Chicago, Illinois 60631

Gregory Deger
Research Engineer
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

Paul DeLacey
Coordinator, Market Planning
Northern Illinois Gas Company
1844 Ferry Road
Naperville, Illinois 60563

Larry P. Dombrowski
Product Manager
Gas Research Institute
8600 West Bryn Mawr Avenue
Chicago, Illinois 60631

Charles F. Drake
Director, Energy and Facilities
The Art Institute of Chicago
111 South Michigan Avenue
Chicago, Illinois 60603

Harvey Drucker
Associate Director
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 202
Argonne, Illinois 60439

Dale S. Duffala

Roy F. Weston, Inc.
1 Weston Way
West Chester, Pennsylvania 19380

Theodore R. Eck

Chief Economist
Amoco Corporation
200 East Randolph Drive
Chicago, Illinois 60601

Mark Enstrom

Manager of Environmental Programs
Illinois Dept. of Commerce & Community Affairs
620 East Adams Street
Springfield, Illinois 62701

John Evanoff

Manager of Chicago Programs
Illinois Dept. of Commerce & Community Affairs
100 West Randolph, Suite 3-400
Chicago, Illinois 60601

John Faber

Associate Director for Research
Office of the Vice Chancellor for Research
University of Illinois at Chicago
1737 West Polk Street, MC 672
Chicago, Illinois 60612

Robin B. Fortney

Senior Environmental Coordinator
MidAmerican Energy Company
P.O. Box 657
Des Moines, Iowa 50303

Peter Fox-Penner

Principal Deputy Assistant for Energy Efficiency
U.S. Department of Energy
1000 Independence Avenue, S.W., Room 6-C-016
Washington, DC 20585

Maryl Freestone

Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

Mark Frigo

Industrial Chemical Specialist
Northern Illinois Gas
90 North Finley Road
Glen Ellyn, Illinois 60137

Jeffrey Gahris

Environmental Engineering
Region V
U.S. Environmental Protection Agency
77 West Jackson Blvd.
Chicago, Illinois 60604

Edward L. Gallagher

Program Manager
Chicago Regional Support Office
U.S. Department of Energy
One South Wacker Drive, Suite 2380
Chicago, Illinois 60606

William J. Geekie

President
William J. Geekie & Associates
11 Evergreen Court
Springfield, Illinois 62704

Steven Gehl

Director of Strategic Synthesis
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94303

Eugene Goldfarb

Midwest Environmental Officer
U.S. Dept. of Housing & Urban Development
77 West Jackson
Chicago, Illinois 60604

David Goldman

Executive Associate for R&D Management
U.S. Department of Energy
1000 Independence Avenue, Room 3-H017
Washington, DC 20585

Amelia Gooding

Environmental Clearing House Coordinator
Illinois Dept. of Commerce & Community Affairs
620 East Adams Street, 3rd Floor
Springfield, Illinois 62701

Gail M. Gorski

Grounds Operations Manager
Chicago Zoological Society
3300 South Golf Road
Brookfield, Illinois 60513

Fred D. Graham

Director Environmental Assistance
Northern Illinois Gas
1844 Ferry Road
Naperville, Illinois 60563

Dan Greco

Marketing Manager for
Performance Contracting
Landis & Gyr
1000 Deerfield Parkway
Buffalo Grove, Illinois 60089

William M. Griffin

Residential Manager
Commonwealth Edison Company
1919 Swift Drive
Oak Brook, Illinois 60521

Norman F. Hansen

Project Manager
U.S. Department of Energy
P.O. Box 2000
Batavia, Illinois 60510

James P. Hartnett

Director
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

Linda Hinsman

Manager
Illinois Environmental Protection Agency
2200 Churchill Road
P.O. Box 19276
Springfield, Illinois 62794

Joanne C. Horalek

Senior Buyer
Inland Steel
3210 Watling Street, Suite 8-110
East Chicago, Indiana 46312

T. Jack Huggins

President and CEO
Pekin Energy Company
P.O. Box 10
Pekin, Illinois 61555

Charles S. Janek

Manager of Gas Sales
The Peoples Gas Light & Coke Company
846 West 63rd Street
Chicago, Illinois 60621

Arlene Jangaard

Programs Division
The Museum of Science and Industry
57th Street and Lake Shore Drive
Chicago, Illinois 60637

Frederick W. Johnson

Senior Principal/Vice President
Woodward-Clyde Consultants
122 South Michigan Avenue
Chicago, Illinois 60603

Robert A. Jones

Product Manager
The Chicago Park District
425 East McFetridge Drive
Chicago, Illinois 60605

Jill Jonkouski

Program Manager
U.S. Department of Energy
Chicago Regional Support Office
One South Wacker Drive, Suite 2380
Chicago, Illinois 60606

Daniel F. Keefer

Policy Analyst
Illinois Dept. of Commerce & Community Affairs
325 West Adams Street, Suite 300
Springfield, Illinois 62704

Shawn P. Kestler

Senior Contract Administrator
Commonwealth Edison Company
One First National Plaza, 34th Floor
Chicago, Illinois 60603

Phil Kiehn

Account Manager
Commonwealth Edison Company
1919 Swift Drive
Oak Brook, Illinois 60521

Scott Kimery

Industrial Applications Specialist
Northern Illinois Gas
90 North Finley Road
Glen Ellyn, Illinois 60137

Jon E. Kingstad

Attorney at Law
310 South St. Croix Trail
P.O. Box 318
Lakeland, Minnesota 55043

David A. Koelliker

Commercial Officer
Canadian Consulate
Two Prudential Plaza, Suite 2400
180 North Stetson Avenue
Chicago, Illinois 60601

Mike Kuk

Energy Engineer
Commonwealth Edison Company
1919 Swift Drive
Oak Brook, Illinois 60521

Venkat Kumar

Energy Manager
Fermi National Accelerator Laboratory
P.O. Box 500
Batavia, Illinois 60510

Henry C. Kurth

Energy Manager
Illinois Dept. of Commerce & Community Affairs
325 West Adams Street, Room 300
Springfield, Illinois 62703

Joseph L. Lakshmanan

Attorney
Illinois Power Company
500 South 27th Street
Decatur, Illinois 62525

Chris Lambesis

Research Assistant
School of Public Health
University of Illinois at Chicago
2121 West Taylor Street
Chicago, Illinois 60612

Cherri J. Langenfeld

Manager, Chicago Operations Office
U.S. Department of Energy
9800 South Cass Avenue
Argonne, Illinois 60439

Jack Link

Accountant
Illinois Commerce Commission
527 East Capitol Avenue
Springfield, Illinois 62706

Georges J. Malek

Senior Research Engineer
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

Gaby Mannheim

Marketing Technology Manager
Commonwealth Edison Company
P.O. Box 767
Chicago, Illinois 60690

Allie C. Mansker

Program Manager
U.S. Department of Energy
Chicago Regional Support Office
One South Wacker Drive, Suite 2380
Chicago, Illinois 60607

Dean Maschoff

Senior Vice President
Planmetrics, Inc.
8600 West Bryn Mawr Avenue, Suite 400-N
Chicago, Illinois 60631

Richard H. Mattoon

Senior Economist
The Federal Reserve Bank of Chicago
230 South La Salle Street
Chicago, Illinois 60604

Robert McDonald

Program Specialist
U.S. Department of Energy
Chicago Regional Support Office
One South Wacker Drive, Suite 2380
Chicago, Illinois 60606

William H. Miller

Senior Vice President
Sargent & Lundy
55 East Monroe
Chicago, Illinois 60603

Wade E. Minster
Energy Resources Specialist
Illinois Dept. of Commerce & Community Affairs
J.R. Thompson Center, Suite 3-400
100 West Randolph Street
Chicago, Illinois 60601

John Mrozek
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

Robert R. Mudra
Senior Market Planner
Northern Illinois Gas
1844 Ferry Road
Naperville, Illinois 60563

Ray Nierzwicki
Manager
The Peoples Gas Light & Coke Company
130 East Randolph Drive
Chicago, Illinois 60601

Roland A. Odenwald
Vice President
Gateway Petroleum Company, Inc.
7200 West Main Street
Belleville, IL 62223

Don Oltz
Senior Geologist and Head
Energy and Mineral Resources Group
Illinois State Geological Survey
615 East Peabody Drive
Champaign, Illinois 61820

Solomon Oriaikhi
Director of Finance
The Chicago Housing Authority
626 West Jackson Blvd.
Chicago, Illinois 60661

Mary F. O'Toole
Environmental Services Manager
Commonwealth Edison Company
P.O. Box 767
Chicago, Illinois 60690

William G. Peden
Energy Reporter
Center for Neighborhood Technology
2125 West North Avenue
Chicago, Illinois 60647

Michael D. Peterson

General Engineer
U.S. Department of Energy
Chicago Regional Support Office
One South Wacker Drive, Suite 2380
Chicago, Illinois 60606

Gary R. Philo

Manager, Coal Demonstration & Marketing
Illinois Dept. of Commerce & Community Affairs
325 West Adams, Suite 300
Springfield, Illinois 62704

Gerald D. Pine

Principal Product Manager
Gas Research Institute
8600 West Bryn Mawr Avenue
Chicago, Illinois 60631

Gary Pitchford

Director, Office of Communications
Chicago Operations Office
U.S. Department of Energy
9800 South Cass Avenue
Argonne, Illinois 60439

Julia Pollitt

Energy Program Specialist
U.S. Department of Energy
One South Wacker Drive, Suite 2380
Chicago, Illinois 60606

Amy L. Radcliff

Resource and Policy Analyst
University of Illinois at Urbana-Champaign
338 Henry Administration Bldg.
506 South Wright Street
Urbana, Illinois 61801

Mark G. Raulston

Energy Educator
Commonwealth Edison Company
100 Shiloh Blvd.
Zion, Illinois 60099

Gary Reed

Mechanical Engineer
Eastern Illinois University
Physical Plant
Charleston, Illinois 61920

Janice L. Reid

Assistant Planner
Northeastern Illinois Planning Commission
222 South Riverside Plaza, Suite 1800
Chicago, Illinois 60606

Robert G. Romo

City Planner
City of Chicago
2 North La Salle Street
Chicago, Illinois 60602

Frank T. Romweber

President
Rapo-Shrink, Inc.
P.O. Box 106
Olympia Fields, Illinois 60461

Thomas R. Roose

Group Manager
Gas Research Institute
8600 West Bryn Mawr Avenue
Chicago, Illinois 60631

Jon K. Rudolph

Planning Analyst
Gas Research Institute
8600 West Bryn Mawr Avenue
Chicago, Illinois 60631

Johanna C. Santer

Marketing Director
U.S. Environmental Protection Agency
77 West Jackson Blvd., AT185
Chicago, Illinois 60604

Art Scaccia

Account Manager
Commonwealth Edison Company
1919 Swift Drive
Oak Brook, Illinois 60521

Robert J. Schaefer

Corporate Studies
Amoco Corporation
200 East Randolph
Chicago, Illinois 60601

Jim Sherman

Senior Contract Administrator
Commonwealth Edison Company
P.O. Box 767
Chicago, Illinois 60690

Norman F. Sidler

Division Vice President, Sales
The Peoples Gas Light & Coke Company
130 East Randolph Street, Suite 1800
Chicago, Illinois 60601

Richard G. Simms

Superintendent
Kankakee Metro Wastewater Utility
P.O. Box 588
Kankakee, Illinois 60901

Larry M. Sindingland

Chief, Engineering Division
U.S. Army CERL
P.O. Box 9005
Champaign, Illinois 61826

Thomas R. Smith

Research Economist
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

Dale M. Sopocy

Associate and Project Manager
Sargent & Lundy
55 East Monroe
Chicago, Illinois 60603

Charles Stalon

Oliver, Oliver & Waltz, P.C.
400 Broadway
Cape Girardeau, Missouri 63701

Bruce Stephens

Accounting Manager
Steiner Electric Company
3755 Swenson Drive
St. Charles, Illinois 60174

David J. Stopek

Coordinator of Research and Development
Illinois Power Company
500 South 27th Street
Decatur, Illinois 62525

Richard Stroup

Senior Associate
Political Economy Research Center
502 South 19th Avenue, Suite 211
Bozeman, Montana 59715

Diane L. Timmer

Grant Manager
Illinois Dept. of Commerce & Community Affairs
100 West Randolph, Suite 3-400
Chicago, Illinois 60601

Cherlyn Tribble

Industrial Metals Engineer
Northern Illinois Gas
19199 Glenwood Road
Glenwood, Illinois 60425

Steven M. Ugoreta

Chair, WDNR Energy Team
Wisconsin Dept. of Natural Resources
P.O. Box 7921
Madison, Wisconsin 53707

Mary M. Vincent

Governmental Affairs Administrator
Commonwealth Edison Company
P.O. Box 767
Chicago, Illinois 60690

Musette H. Vogel

Attorney to the Chairman
Illinois Pollution Control Board
600 South Second Street, Suite 402
Springfield, Illinois 62704

Soyini R. Walton

President
Asset Environmental Services
1525 East 53rd Street, Suite 621
Chicago, Illinois 60615

Gene Wass

Manager, Market Analysis and Planning
The Peoples Gas Light & Coke Company
130 East Randolph Drive, Suite 1800
Chicago, Illinois 60601

Kenneth Westlake

Illinois/Michigan State Coordinator
U.S. Environmental Protection Agency
77 West Jackson, 19th Floor
Chicago, Illinois 60604

Shane White

East Peoria High School
1401 East Washington Street
Peoria, Illinois 61611

James J. Wiet
Assistant Director
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

Karen Winter
Research Engineer
Energy Resources Center, MC 156
University of Illinois at Chicago
400 South Peoria Street
Chicago, Illinois 60607

Porter Womeldorff
Global Climate Program Executive
Illinois Power Company
500 South 27th Street
Decatur, Illinois 62525

Cathy S. Woollums
Manager, Environmental Services
MidAmerican Energy Company
106 East Second Street
Davenport, Iowa 52801

William M. Worek
Professor
Department of Mechanical Engineering
University of Illinois at Chicago
842 West Taylor Street, MC 251
Chicago, Illinois 60607

Charlotte Young
Environmental Scientist
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439