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ENERGY AND ENVIRONMENT IN THE MARKETPLACE

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FOREWORD

FOREWORD

The Twenty-Fourth Annual Illinois Energy Conference entitled, "Energy and Environment in the Marketplace" was held in Chicago, Illinois on November 14 and 15, 1996. It was organized by the Energy Resources Center, College of Engineering, University of Illinois at Chicago with support provided by the U.S. Department of Energy, the Illinois Department of Commerce and Community Affairs, and the U.S. Environmental Protection Agency.

This year's conference took up the debate of marketplace competition in the areas of energy and the environment. In particular, the deregulation of the electric utility industry was of special concern considering Illinois' major commitment to the nuclear option. The conference program posed such questions as: What will be the economic impact of increased competition between electric power generators? How will the merger of small electric companies into large, interstate utilities affect the market sectors? Other issues of concern focused on the substantial growth of the natural gas sector; and environmental topics including SO_2 emissions trading, influence of free markets on environmental regulation, the future for renewables, and alternative transportation vehicles.

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, Dean Eastman, Argonne National Laboratory; Val Jensen, U.S. Department of Energy; and Bharat Mathur, Illinois Environmental Protection Agency. I also thank the conference planning committee for their outstanding efforts which are reflected in the final conference proceedings. 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.

J P Hartnett

James P. Hartnett
Conference Chairman

INTRODUCTORY REMARKS

INTRODUCTORY REMARKS

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

Welcome to the 24th Annual Illinois Energy Conference, *Energy and Environment in the Marketplace*.

Over the last several years, it has been my pleasure to open several of these important conferences with a few words intended to help focus the conference themes and to challenge us to think creatively about the future. That has more often than not been a discussion about the changes that confront us and how we might meet them.

This year, we find ourselves in the unusual position of looking ahead to a number of *continuations*:

- For the first time since the Reagan Administration, we have a President about to begin a second term in office; and

- We will also experience one of the least dramatic changes in Congress as a result of an election in quite some time; Republican majorities have been sustained in both houses.

We will, of course, have some changes in Cabinet leadership, including the Energy Department, and will see some Congressional committee memberships and chairs change. But on the whole, I believe we can expect a substantial continuity of policy and approach to energy, science, and technology issues from both the Administration and the new Congress. And what does that imply?

- Continued stress on a deficit reduction and a balanced budget;

- Strong competition for federal "discretionary spending;

- Strengthening pressure on budgets for federal agency technology and science programs, with flat or declining funding for many activities;

- Emphasis on increased efficiency and getting more for less in environmental cleanup; and

- Few if any new *federal* initiatives in energy and environment.

It will be the **marketplace**, I believe, where new initiatives, innovation and real change will take place in energy and environment in the years ahead.

- In many ways, this has always been true. The most aggressive federal programs of the past aimed at jump-starting the commercialization of new technology through R&D, regulation and market incentives.

- But today, the center of gravity in energy and environmental policy leadership has shifted significantly toward the private sector and marketplace decisions that make sense on their own merits.

- A more conservative Congress has rejected many programs as "corporate welfare."

- The perceived role government can play has changed.

- The resources for a dominating federal role are not there, and will not be for the foreseeable future.

- As never before, the private sector marketplace will be where the action is.

KEYNOTE PRESENTATIONS

ENERGY AND ENVIRONMENTAL POLICY IN A COMPETITIVE MARKETPLACE: THE ROLE OF THE NATIONAL LABS

Dean E. Eastman
Director
Argonne National Laboratory

It is both a pleasure and a honor to be invited here today as your keynote speaker for the 24th Annual Illinois Energy Conference.

For almost a quarter-century, the Energy Resources Center has organized these annual conferences as one vehicle to present critical energy issues to government policy-makers and the public. This year the conference focuses on "Energy and Environment in the Marketplace" — a subject characterized by change and flux as competitive markets evolve, energy supply and consumption are globalized, the perceived role of government shifts, and American industry increasingly adopts a short-term focus.

There are potential hazards ahead as we contemplate the 21st Century, now just a few years away. However, there is no national sense of urgency ... no consensus call for high-level discussions of energy and environment in the marketplace ... no widespread recognition that America needs substantive change in the way energy and environmental policy is formulated, prioritized, coordinated, and administered.

Based on recent history, only another national or international energy crisis will focus national attention on this important issue and stimulate change. I sincerely hope I am wrong about that, and I am here today to help contribute to or at least stimulate interest in a significant improvement in the energy and environmental dialogue *before* a crisis forces it.

I will review recent history, highlight clear and unclear elements of America's energy and environmental position, offer several guideposts to perhaps help us find our way, and discuss the role and potential contributions of the national labs in that process.

If we are indeed to engage in a national dialogue on energy, one of the first tasks in any such discussion is to force oneself to look beyond the short-term, because when it comes to energy the short-term is deceptively reassuring. Indeed, it is difficult to get the public and its government to pay attention to energy when the U.S. today is within a temporary "resource bubble" of abundant electricity and natural gas ... a bubble that should last a decade. But we *must* pay attention now because, if we wait to act until the shortfall arrives, even the most aggressive actions will not forestall a period of energy-related hardships lasting years.

My laboratory, Argonne, has been in the energy business for 50 years and in the environmental business for more than 20. So we know something about those markets. And frankly, we are worried.

RECENT HISTORY OF ENERGY AND ENVIRONMENTAL MARKETS

Change from surplus to scarcity and back is a primary characteristic of the U.S. energy system. One could even say that the past three decades have been an energy roller-coaster.

The oil shocks of 1973 plus 1978 to 1979 raised world oil prices by 450 percent. Since then, prices have declined in real dollars almost to the 1973 level. Petroleum consumption in the United States decreased by 25 percent in the period following the oil shocks, but has since increased by 15 percent from its lowest point. After a drop of more than 23 percent between 1970 and 1985, natural gas production has increased by 15 percent from 1985 to 1995. Coal declined as a major source of energy in the United States over the last two decades largely due to environmental constraints, and nuclear power plant construction ceased due to safety requirements constraints and costs. Now, deregulation is well along in the gas industry and is just beginning in the electric utility industry — the latest curves in the energy roller-coaster track.

THE ROAD AHEAD

As we look forward from the surroundings of our temporary "bubble" of U.S. energy sufficiency, some things are clear and some things are not. Let me first offer the easier list — the things that are clear.

Without question, worldwide energy demand and consumption will continue to grow, spurred by population growth and industrialization of developing countries. Based on World Energy Council projections for the year 2020, total primary energy demand will increase anywhere from 28 percent to 95 percent, depending on the economic growth rate and energy conservation assumptions that are made, and Asian primary energy demand is forecast to be almost twice that of North America. Oil use in Asia will almost double to become 20 percent higher than current North American oil use.

There is *no* scenario under which long-term energy demand decreases ... short of worldwide recession or similar crisis.

What is more, consumer demand for energy-related services is very inelastic — people want to own and drive cars, to have warm homes in winter and cool ones in summer, to acquire and use all the latest electronic equipment and electric appliances. These desires are worldwide, although they are more readily realized in the developed nations. Inelastic demand means that only major changes in price or government regulations will change consumer behavior.

Industrial energy demand patterns are driven more by productivity and competitiveness issues than by energy conservation concerns. Energy is only one of many raw materials used by industry — conserving it makes no economic sense to industry if conservation does not improve overall productivity and marketability of the product.

Not only do consumers and industry want energy, they demand energy that is reliable, cheap, safe, and environmentally benign. Unfortunately, those are and likely will remain mutually conflicting objectives.

Now let us move to the longer, more difficult list — things that are *not* clear. Primarily these center on our inability to forecast the result of specific actions on the marketplace.

An example is the deregulation of the electric utility industry now in progress. We also know that recent and planned changes in energy policy will have major impacts on the energy industry, but the nature and extent of those impacts are uncertain.

Starting in 1990, deregulation of the natural gas industry led to expanded exploration and helped create a surplus which is now being considered for uses not previously allowed — for example, using recently improved gas-turbine generators for electric power. In a deregulated electric utility industry, there will be more opportunities and challenges for independent power producers and distributors, as well as opportunities for consumer choice. This is analogous to the ongoing deregulation of the telecommunications industry.

In developing countries, we know that energy consumption will increase markedly, but we do not know what impact that will have on pricing.

From a political point of view, we do not know what will happen to perturb the energy market, one of the most dynamic, complex, volatile and non-linear of all markets. For example, the market is inordinately sensitive to political stability in the Middle East.

In the energy market, small perturbations can have enormous impact. You will recall that the oil crises of 1973 and 1979 actually involved only about a ten percent change in oil supplies; and the recent brief confrontation in Iraq almost immediately raised the world price of crude oil, even though there was *no* change in actual supply. It frequently takes national government action to deal with this type of uncertainty.

GUIDEPOSTS ALONG THE WAY

Although the road ahead is far from clear, there *are* several guideposts that can help us find our way. I have in mind *three*:

- A thoughtful, balanced national energy policy;
- Commitment to flexibility and multiple capabilities in energy supply, distribution, and utilization; and
- Effective research and development with realistic short-, mid-, and long-term goals.

Let me discuss each of the three in detail.

National Energy Policy

Some say the United States is the only developed country in the world without a national energy policy. I disagree. We not only have a national energy policy, we have *many* national energy policies. We just rotate them every few years like tires on a car.

In most of our lifetimes, we have seen the startup and shutdown of the synthetic fuels program, the startup and shutdown of the breeder reactor programs, the Project Independence effort to make the United States energy self-sufficient, the on-again/off-again tax credits for renewable energy systems, the on-again/off-again appliance efficiency standards, the imposition and relaxation of the Corporate Average Fuel Efficiency (CAFE) standards for automobile mileage, and the rise and fall of the 55 mile-per-hour-speed limit to conserve energy. There are many more examples.

As a nation, we also seem to have missed recognizing that energy policy also is but one component of national economic policy and national security policy. It needs to be blended into these overall policies in a non-adversarial fashion.

Energy policy also must be consistent with environmental policy. Too often these policies have been at odds.

If we choose to "just say no" to revolving-door energy policies — if we choose to finally develop one effective, coordinated, long-term energy policy for our country — we must take *four* key steps:

1. Make the monitoring, analysis, and evaluation of the energy situation both in the United States and in the world a *continuing process*;

2. Involve *all* the stakeholders in formulating the policy — including energy producers, the industrial and general public energy consumers, multi-national energy companies, and the government;

3. Formulate a national energy policy consistent with economic policy, environmental policy, national security policy, and foreign policy; and

4. Develop and adopt the national energy policy as a bipartisan effort that will not swing violently with changing administrations. To be effective, energy policy needs the same relative continuity and stability across administrations and political parties that our foreign policy has had.

Flexible Energy Supply, Distribution and Use

The second of my three guideposts to help us chart our energy future is flexibility and multiple capabilities in energy supply, distribution, and utilization.

Our energy system is what the mathematicians and analysts call a non-linear "complex adaptive system" — one extremely sensitive to initial conditions, where a small change "up front" ... either real or perceived ... can cause enormous and only partially predictable changes downstream — or even reconfigure the system entirely.

To ensure the energy system is not overly dependent on any *one* initial condition — and thus overly vulnerable to changes in that condition — we need to have a portfolio of energy supply sources, distribution channels, and end-use equipment to insure our ability to adapt to the uncertain future. Well into the 21st Century our energy system will continue to rely on oil, natural gas, coal, and nuclear power, as well as renewable energy resources such as hydropower, solar, wind, and biomass to a lesser degree. We must keep *all* those options open.

Each fuel and technology tends to have its ardent supporters. Despite their fervor, there is no "silver bullet" that can take care of all requirements both short-term and long-term.

As for the energy efficiency proponents who argue that we can meet all our needs by using what energy we have more efficiently, certainly much can be done in this country to improve our overall energy efficiency. However, conservation is not a substitute for supply.

Another indicator of the need for a broad energy *portfolio* is the environmental consequences of a technology. All energy technologies have environmental consequences — there is no "free lunch." Therefore, a portfolio of options allows situation-by-situation choices *and* increases the probability that the least environmental damage can be done while meeting the energy needs.

Effective Research and Development

The third of my three guideposts for the road ahead is effective research and development with realistic short-, mid-, and long-term goals. This is the surest way to identify, develop and maintain the flexible energy supply, distribution and utilization capabilities we need.

The major responsibility for this R&D will continue to rest with industry. Government will continue to be involved through its activities with industry, universities, and national labs.

The national labs are a key part of America's R&D community. The system of laboratories that includes Argonne complements the research of universities and industry. A core competency of the national labs is our ability to address complex problems or systems with multi-disciplinary skills. The role of the national labs in the energy R&D picture must adjust to changes in market demands and funding. With the current corporate focus on short-term R&D, we at the national labs must structure our research efforts to mainly deal with the nation's mid- and long-term energy needs.

I can illustrate this structuring by using Argonne as an example.

For the **short-term needs**, the labs must concentrate on bringing incremental technology developments that are based on existing knowledge and are close to commercialization into the marketplace. Development of cleaner, more energy-efficient industrial processes and energy supply technologies are examples.

Argonne's work in diesel engine technology is one such. We are forecasting a 20 to 30 percent increase in environmental and energy efficiency over the next several years for certain diesel applications.

Also in the energy efficiency area, Argonne is working on the recycling of materials from scrapped automobiles, from brass and bronze scrap, from aluminum castings that contain antimony or strontium, and even from starchy food wastes. These recycling technologies reduce the need for energy used in producing virgin materials, as well as reduce the quantity of solid waste destined for landfills. We are working with several companies interested in commercial applications of these technologies, and commercial-scale pilots are underway in industry.

In a unique area, nuclear power, the United States is still a leading source of technology expertise. Although our country no longer is building nuclear power plants, many countries in the world — particularly in Asia — are pursuing nuclear power development programs. Also, the global need for safe, efficient decontaminating-and-decommissioning (D&D) and nuclear plant life extension technologies continues to increase as the current generation of reactors near the end of their technical lifetime. Part and parcel of this will be development of cost-effective environmental assessment and restoration technologies and risk-assessment tools.

If our country maintains its capability in nuclear power technologies through effective utilization of its skills, such as those that exist at Argonne, the United States will remain a leading contributor of R&D, technical, safety, and environmental expertise as these nuclear programs evolve.

For the **mid-term needs**, the labs must continue to work with industry on collaborative research needed to maintain America's competitiveness in the global market. This includes technologies that often require a government-industry partnership because of risk and uncertainty or time-frame. The Partnership for a New Generation of Vehicles (PNGV) is an example of this type of arrangement. En route to the program's long-term benefit — the vehicle itself — we achieve short-term benefits in increased manufacturing efficiency and reduced manufacturing cost, and mid-term benefits such as advanced materials.

The Departments of Energy and Transportation, the Environmental Protection Agency, and a number of other federal agencies are partners with General Motors, Ford, and Chrysler to develop the next generation automobile — an 80 mile-per-gallon vehicle that can match the performance of current vehicles while meeting stringent environmental and safety standards.

In the PNGV program, Argonne has a significant role and several other national labs are part of the team, working with a key American industry to help maintain our nation's leadership in a highly competitive global market.

Another example of collaborative effort is Argonne's research in superconducting materials. We are working with several startup companies to produce superconducting materials for use in commercial applications. Argonne was the first to make coils of brittle, ceramic superconducting wire, and we developed simple, inexpensive methods for producing the superconducting levitators needed for applications such as flywheels for energy storage.

By the way, this applied superconductivity program draws much strength from what is widely recognized as the best basic research program in High-Temperature Superconductivity at Argonne, with partners at the University of Chicago, Northwestern, and the University of Illinois.

To meet **long-term needs**, the labs contribute basic energy science R&D — the foundation for technology development. In this capacity, the labs provide the facilities and technical staff that cannot be supported by individual companies or by universities. The Advanced Photon Source at Argonne is an example.

The Advanced Photon Source generates exceptionally intense x-rays directed into beamlines used by more than 30 laboratories in a variety of energy- and environment-related research. For instance, our first-rate photosynthesis research project could lead to better ways of trapping the sun's rays, thereby leading to development of more efficient solar energy technology. The APS was commissioned this year and is building up a unique array of experimental laboratories around it for many fields of science and technology that will involve thousands of users each year. It is the only such facility in the United States and produces the highest intensity x-rays in the world.

Currently, Argonne is planning to redirect its nuclear engineering resources into advanced Light-Water Reactor R&D, and we also have developed an electrometallurgical technology for the treatment of spent nuclear fuel. That technology could save taxpayers billions of dollars by reducing the quantity of spent fuel that must be disposed of.

CONSTRAINED R&D FUNDING

Although I have been addressing why an energy R&D program should focus on strengthening our list of supply, distribution, and utilization capabilities in the short-, mid-, and long-term, I must tell you that what *actually* is happening now is a decline in interest in "option-expanding" energy R&D. It should come as no surprise that this decline results in part from our current — and temporary — period of ample energy supplies and energy price stability.

A recent General Accounting Office study noted that Department of Energy funding for electricity-related R&D in 1996 fell 23 percent from 1995, to a level about equal to that of 1993. In the period from 1993 to 1996, R&D funding by electric utilities declined by about 33 percent.

Availability of relatively low-cost natural gas ..., the emergence of high-efficiency gas-fired combined-cycle generating units in the 200-300 MW range ..., the opening of the electricity markets to independent power producers ..., and customer choice in electricity purchases will put even *more* downward pressure on electricity R&D spending as power producers opt for off-the-shelf technology that can provide a rapid return on investment.

Californians today expect that, thanks to recently enacted legislation to deregulate the electricity market, electricity bills for residential and small-business customers will be 20 percent lower by 2002. It is difficult to see how this situation would encourage anyone in the U.S. to invest in more options for demand-side management programs and energy efficient technology R&D.

Nationally, there are several trends in energy R&D that we see or expect to see:

1. Federal funds for energy R&D will decline in real dollars. Pressures to reduce the federal deficit combined with the emphasis on market-driven energy supply systems will cut into the research funds available to universities and the national laboratories.

2. Much of industry's energy R&D will continue to focus on producing shorter-term results that can be brought into commercialization quickly.

3. For mid-term objectives, energy R&D by industry will move into focused research that is implemented by consortia of concerned companies and various R&D contributors, in addition to the sponsoring company.

4. Long-term energy R&D will more and more be the province of consortia and the federal government, with some industry participation.

In this environment the national labs need to look much more carefully at how their programs fit with market demands. With the broad multi-disciplinary skills at national labs such as Argonne, the labs do have a role in short- and mid-term R&D — but these projects must be tightly coupled to industry's objectives. The labs' unique capabilities are especially well-suited to mid- and long-term pursuit of large, complex challenges requiring multiple disciplines and skills. Again, however, in my view these must be done in close concert with industry — for example, jointly developed strategic roadmaps and key focused programs such as PNGV. This approach is what we are following at Argonne.

SUMMARY

To summarize the key points I hope to leave you with:

- Our energy system is in continual change ... the road ahead is unclear ... and the uncertainty includes the unknown effects of actions that have been or will be taken, as well as unknowable actions that will perturb the energy system.

- Three guideposts that could help guide our path are:

  1. A balanced, bi-partisan energy policy that includes the input of all the important stakeholders, and that is modified and continuously improved on a regular basis rather than a crisis basis.

  2. A flexible portfolio of energy supply, distribution, and utilization capabilities to allow our energy system to adapt and adjust to change.

  3. Effective research and development to maintain our flexible portfolio. In such R&D, the national labs complement the research of industry. Large, complex, multi-disciplinary energy and related environmental research that addresses large, complex, and important opportunities and problems is a mainstay of national laboratory programs.

- Finally — and most important — to avoid hardships when worldwide energy demand surpasses supply, we need to open a national dialogue ... **now**.

Thank you for giving Argonne and me the opportunity to present our "case for the future" from such a prestigious podium.

NATIONAL POLICY IN A DEREGULATED MARKETPLACE

Val Jensen
Special Assistant
Energy Efficiency & Renewable Energy
U.S. Department of Energy

First of all, I would like to pass along Christine Ervin's sincere apologies for her inability to be here this morning. I know that several years ago she spoke at this conference and enjoyed herself very much. She also has a strong interest in the subject of this year's meeting. Unfortunately, she has suffered a major schedule collapse with heavy collateral damage.

Christine's misfortune is perhaps my good fortune, providing a chance to reintroduce myself to old acquaintances many of whom I will have a chance to work with again. This month I am returning to Chicago to assume responsibility for DOE's downtown program facilities. My compliments to Dr. Hartnett and Mr. Jim Wiet and the staff at the University of Illinois at Chicago for putting together another excellent program.

In all the time that I have worked in and around these issues, one remark sums up our collective experience with the utility industry and regulation better than anything I have heard from the mouths of the industry sages. The remark was delivered after a long night at a famous Chicago restaurant.

> Regulation (and I am paraphrasing) is a lot like breakfast in your hotel ...
>
> It takes forever. What you get never looks like what you ordered, and it costs twice as much as it should.

So, we have concluded that we do not like our current dining experience. But do we change the cook, the menu, or the waitress? Should we switch restaurants? Should we make our own breakfast?

That, in essence, is the electric utility restructuring debate, and frankly, I am not sure we know what to change to ensure a breakfast with which we are satisfied. We have, in effect, decided that we will leave the hotel confident that we will find something better, faster, and cheaper on the street.

The point is, we have decided to make a change — there no longer is much debate on the question of whether we should restructure, despite what I think is a tendency to act based on a recognition of symptoms rather than causes. The remaining policy questions fall into three groups:

- Given that we believe competition is a better approach to governing the industry than regulation, how do we know what competition looks like? How do we ensure that no one exercises market power? What kinds of institutions are needed to make things work. These questions, I call structural.

- How do we allocate the existing overburden of stranded assets and ensure that all consumers gain from restructuring? These are allocation or equity issues.

- How do we ensure that the important collateral activities associated with regulation continue to happen — things such as low income programs, investments and energy efficiency and renewable energy and so forth? These I call simply the collateral issues.

The first two sets of questions arise some very thorny and contentious issues having to do with the structure of independent system operators, divestiture, transmission pricing, definitions of market power, gaming, and the responsibility for past decisions that have turned out bad. How we resolve them will determine whether this new system works as promised. These also are issues that I suspect will come up in the public meeting with the Secretary tomorrow in Chicago, and so am going to respectfully defer any detail on them today.

The third set of issues masks a variety of public purpose programs variously classified as stranded benefits or strandable benefits. We call them benefits because we have concluded, often as the premise for undertaking the program, that the public benefits from having the utility system promote energy efficiency, renewable energy, environmental quality and affordability. And, in fact, the public probably has benefited to some extent.

We call them stranded out of a belief that if the utility regulatory system does not provide them, they will be lost. The implication is that in restructuring our system we must put in place devices to ensure that the new utility regulatory system continues to provide these benefits.

At this point, I think it is critical that we make a distinction between those benefits that the market, acting on its own, will never provide, and those that conceivably can be provided by the market properly structured. My personal view is that affordability is a challenge that the market will not meet on its own. If we believe it is important to ensure some basic level of universal service, we are going to need to build this principle into the restructuring process.

Similarly, competition will not deliver environmental quality. We can have market-based schemes for achieving environmental objectives, but the market acting on its own is unlikely to produce the level of clean air and water we consider acceptable. So, a second basic principle of restructuring is that we should not make the environment worse than it now is.

These two public benefits will never be provided by competitive markets — they are inherently non-market goods.

I do not think we can say the same thing for energy efficiency and renewables. While there may have been and continue to be market barriers to widespread adoption, there are not the same kinds of basic market failures that demand policy action no matter what. Under the existing system of regulation, monopoly control of electricity and gas service at retail are major barriers to efficiency and renewables. Take away that control and things begin to look different, I think.

The one defining characteristic of markets as we know them as opposed to how they are described in theory, is that the lowest price guy does not always win. Consumers have complicated preferences — they will pay more for status, they will pay more for certain colors, and they will pay more for products and services that are green. Given a fair chance at really minimizing their energy service costs, we think they also will pay for energy efficiency, and in this case, they will pay less.

National willingness to pay studies have found that from 40 to 70 percent of the public is willing to pay for environmentally friendly energy sources. These numbers are much higher than those depicting the percentages of customers who have been willing to date to sign up for utility green pricing programs. What they indicate, therefore, is less a clear willingness to pay, than a receptiveness to environmentally friendly products.

The experience that we have had with utilities attempting to market efficiency and renewables does not account for very much. With few exceptions, most utilities who were made to engage in efficiency and renewables did not, shall we say, have their whole hearts in it. The attraction of full-scale restructuring is that it gives companies who do actually know how to market, direct access to consumers. It gives companies driven by the desire for profit the ability to manage total building and process energy use in a way that bundles efficiency with other services. This is not just my view — this is the position of the renewables and efficiency industries, who have become some of the most ardent supporters of a rapid move to full retail competition.

The hitch, of course, is that in any jurisdiction and under any scenario, we are a long way away from having the sort of real competition that will drive a prosperous market for renewables and efficiency. We have legislation in California and Rhode Island that will open markets beginning before the turn of the century, and we have active and interesting experiments in retail competition in several states including Illinois. Over 40 states are considering restructuring in some form, and probably 20 states will take some action in the next couple of years. For the most part, however, we have a system that does not even qualify as effectively competitive at the wholesale level. On the margin, the wholesale trade is free, but the system provides little protection against the exercise of market power in long-term power. At the same time, many states have dispensed with, if not aggressively dismantled, IRP processes which provided one, albeit crude mechanism for making efficiency and renewable energy investments.

We have, in short, the worst kind of system for efficiency and renewables. Wholesale prices have dropped through the floor, virtually freezing any new renewables development. Without direct access to consumers, renewables developers are in fact frozen out of the market. Without the ability to bundle energy and efficiency services, providers of energy efficiency are deprived of a significant ability to manage prices and costs. And utility possession of customer billing information confers an important monopoly advantage on the incumbent utility.

We are in the proverbial transition — the dinosaurs are starting to feel a chill, but it will be a long time before they are extinct. And if, as a matter of public policy, we believe that investment in energy efficiency and renewable energy is a good thing, we need to discover ways to keep the investment alive until a competitive market arrives.

Two general types of policy options are under consideration:

- First are what I call Bridge policies — mechanisms that provide a direct economic boost to efficiency and renewables. The two ideas that have received most attention in this category are non-bypassable wires charges, and portfolio standards. Nationally, a levy of one mill per kWh would raise just under $3 billion — two mills would raise enough to fund most of the DSM, renewable energy and low income programs now in place. A portfolio standard would impose an obligation on all sellers of electricity to hold a certain percentage of its portfolio in renewable resources. The bill offered by Cong Schaefer last session would set the standard at two percent now rising to four percent within several years. A third idea which is beginning to emerge nationally, but has already been adopted by a number of states, is net metering for small renewable systems that would effectively pay these systems at the same rate the customer is charged.

- Second, are things I call consumer provisions. These include ideas such as supplier disclosure of generating sources, and are intended to ensure that consumers have access to good information. Problems have already arisen in the New Hampshire retail wheeling pilot with respect to how green "green" is.

Let me use that as a segue into where we stand with federal policy. Fortunately, it is a policy that has a couple of legs to stand on. It is a policy that is likely to be reflected in an Administration bill next year. And to ensure that my legs are not chopped off, I want to emphasize that DOE's position is not fixed nor final. In fact, the point of the Secretary's trip to Chicago tomorrow is to give her and other senior policy-makers an opportunity to hear from people besides Washington types. It should go without saying that until the Secretary speaks, anything I say should be regarded as tentative.

First, an overriding concern is that federal policy and legislation leave to the states those things that states are best suited to do. The federal role should be limited to removing obstacles to effective competition that may exist in federal law, and to resolving issues of a truly interstate nature.

Second, the position rests on a number of principles first laid out in California two years ago. With regard to renewables and efficiency, those principles include increased reliance on renewable generation technologies, maintenance of environmentally quality, support for electricity related R&D and minimum standards of service for low income customers.

Beyond this, I think it is likely that any legislation will clarify state authority to levy wires charges and to require retail access.

It will likely dispense with PURPA Section 210, although perhaps retaining interconnection requirements.

UPDATE OF NATIONAL OZONE STUDY: WHERE ARE WE NOW?

Bharat Mathur
Chief
Bureau of Air
Illinois Environmental Protection Agency

Mr. Bharat Mathur addressed the issue of national ozone research in focusing on the regional task force, Ozone Transport Assessment Group (OTAG). He first reported on the overall objectives of the OTAG initiatives. These included development of a comprehensive regional emissions inventory, selection of appropriate research models and protocols, identifying criteria for selecting emissions control strategies, and finally, development of a framework for a NO_X trading system. The following material provides details on the above objectives as well as specific information on OTAG's preliminary findings.

TABLE 1

OTAG'S PROGRESS TO DATE

- Completed comprehensive regional emissions inventory
- Selected model and protocol
- Established four modeling centers
- Developed criteria for selecting control strategies to be modeled
- Developed framework for NO_X Trading System
- Initiated modeling runs

TABLE 2

OTAG MODEL SENSITIVITY TESTS

• **OTAG 2007 Baseline (Base 1)**			
88919395	a.	OTAG 2007 Baseline (Base 1)	
• **Nonattainment/Urban Attainment/Rural Attainment**			
91	a.	In nonattainment areas: -30% VOC (all anthropogenic)	-15% NO_X (all low level sources)
91	b.	In urban attainment areas: -30% VOC (all anthropogenic)	-15% NO_X (all low level sources)
91	c.	In attainment areas: -30% VOC (all anthropogenic)	-15% NO_X (all low level sources)
88919395	d.	In all areas: -30% VOC (all anthropogenic)	-15% NO_X (all low level sources)
88919395	e.	In rural areas: -0% VOC	-60% NO_X (elevated point sources) -30% NO_X (all low level sources)
88919395	f.	In urban/rural areas: -30% VOC [urban]	-60% NO_X (elevated point sources) [rural] -30% NO_X (all low level sources) [rural]

TABLE 2 (Con't)

OTAG MODEL SENSITIVITY TESTS

• **Point Source Impacts — Applied Regionwide**			
88919395	a.	-0% VOC (all anthropogenic)	-60% NO_X (elevated point sources)
88919395	b.	-0% VOC (all anthropogenic)	-30% NO_X (elevated point sources)
88919395	c.	-0% VOC (all anthropogenic)	-30% NO_X (low level point sources)
• **Mobile Source Impacts — Applied Regionwide**			
919395	a.	-30% VOC (mobile sources)	-15% NO_X (mobile sources)
• **Mixed Impacts — Applied Regionwide**			
919395	a.	-30% VOC (mobile sources)	-15% NO_X (mobile sources)
919395	b.	-30% VOC (mobile sources)	-15% NO_X (mobile sources) -30% NO_X (elevated point sources)
88919395	c.	-30% VOC (all anthropogenic)	-60% NO_X (elevated point sources) -30% NO_X (all low level sources)
88919395	d.	-30% VOC (all anthropogenic)	-0% NO_X
88919395	e.	-0% VOC	-60% NO_X (elevated point sources) -30% NO_X (all low level sources)

TABLE 2 (Con't)

OTAG MODEL SENSITIVITY TESTS

- **Mixed Impacts — Applied Regionwide (Con't)**

88919395	f.	-0% VOC	-0% NO_X (elevated point sources) -40% NO_X (all low level sources)
88919395	g.	-0% VOC	-80% NO_X (elevated point sources) -60% NO_X (all low level sources)

- **Regional Impacts**

88919395	a.	-5c in NE
88919395	b.	-5c in MW
88919395	c.	-5c in SE
91 95	d.	-5c in SW

TABLE 3

SUMMARY

The preliminary key findings from these sensitivity tests are as follows:

- Emission reductions, especially NO_X reductions, decrease regional ozone, high ozone, and ozone in nonattainment areas
- VOC reductions decrease ozone; decreases (benefits) are confined to urban areas
- NO_X reductions decrease and increase ozone; decreases (benefits) occur domain-wide, while increases (disbenefits) are confined to some urban areas
- NO_X plus VOC reductions lessen ozone increases (disbenefits) in urban areas
- Elevated and low-level NO_X reductions both produce benefits/disbenefits; disbenefits are greater due to low-level NO_X reductions
- Urban and rural NO_X reductions both produce benefits/disbenefits; disbenefits are greater due to urban NO_X reductions
- NO_X disbenefits (i.e., local increases in ozone due mostly to urban NO_X reductions) mostly affect lower ozone concentrations on a few days in few areas
- Emission reductions in a given region have the most benefit in that same region (i.e., benefits are highest near the source area and decrease with distance downwind); interregional benefits are most noticeable during the 1988, 1991 and 1995 episodes

TABLE 4

NO_X CONTROL PACKETS — FOR THE CONTROL STRATEGIES MINI-WORKGROUP

Strategy Packets	Utility System (Mostly Elevated)	Other Point/Area (Mixed Elevated & Non-Elevated)
Base 1 (Mandated CAA Control)	• Title IV Controls (Phase 1 & 2 for all boiler types) • 250 Ton PSD and NSPS • RACT and NSR in non-waived NAAs	• RACT at major sources in non-waivered NAAs • 250 ton PSD and NSPS • NSR in non-waived NAAs
Level 0	Base 1 plus: • OTC NO_X MOU (Phase II) • "9% by 99" ROP Measures (if substitute for VOC)[3]	Base 1 plus: • "9% by 99" ROP Measures (if substitute for VOC)[3]
Added Controls — Level 1	• 55% reduction from 1990 rate, or • Rate-base of 0.35 lb/mmbtu for coal units and 0.20 lb/mmbtu for gas and oil units, whichever is less stringent[7]	
Added Controls — Level 2	a • 65% reduction from 1990 rate, or • Rate-base of 0.25 lb/mmbtu for coal units and 0.20 lb/mmbtu for gas and oil units, whichever is less stringent[7] b • 75% reduction from 1990 rate, or • Rate-bate of .20 lb/mmbtu for all units, whichever is less stringent[7]	
Deep Controls — Level 3	• 85% reduction from 1990 rate, or • Rate-base of 0.15 lb/mmbtu for all units, whichever is less stringent[7]	

TABLE 4

NO_X CONTROL PACKETS — FOR THE CONTROL STRATEGIES MINI-WORKGROUP (Con't)

Strategy Packets	Non-Road Mobile	Highway Mobile (Non-Elevated)
Base 1 (Mandated CAA Control)	• Fed Phase II Small Eng Stds • Fed Marine Engine Stds • Fed HDV (> =50 hp) Stds-Ph. 1 • Fed RFG II[4]	• Tier 1 LDV and HDV Stds • Fed RFG II[4] • Enh I/M[3] • Low Enh I/M for rest of OTR • Basic I/M in mandated areas • Clean Fuel Fleets for mandated areas
Level 0	Base 1 plus: • Fed Locomotive Stds (not incl. rebuilds) • "9% by 99" ROP Measures (if substitute for VOC)[3]	Base 1 plus: • National LEV • HDV 3 gm std • FTP revisions • "9% by 99" ROP Measures (if substitute for VOC)[3]
Added Controls — Level 1	Base plus: • Fed Locomotive Stds (incl. rebuild stds)[1] [replaces fed locomotive stds (not incl. rebuilds)] • HD engine 4 gm std	Base plus: • High Enh I/M for LDV (LEV-specific cutpoints)[6] [Replaces Enh I/M,[3] Low Enh I/M for rest of OTR, and basic I/M in mandated areas] • HDV 2 gm std [Replaces HDV 3 gm std] • HDV I/M[6]

TABLE 4

NO_X CONTROL PACKETS — FOR THE CONTROL STRATEGIES MINI-WORKGROUP (Con't)

Strategy Packets	Non-Road Mobile	Highway Mobile (Non-Elevated)
Added Controls — Level 2	Level 1 Controls plus: • Fed RFG II[2,5] [Replaces Fed RFG II[4]] or low sulfur fuel (150 ppm)[2,5] • Reformed diesel (50 cetane)[2]	Level 1 Controls plus: • FED RFG II[2,5] [Replaces Fed RFG II[4]] or low sulfur fuel (150 ppm)[2,5] • Reformed diesel (50 cetane)[2] • Max I/M for LDV w/LEV-specified cutpoints[6] [Replaces high Enh I/M for LDV (LEV-specific cutpoints)[6]]
Deep Controls — Level 3	Level 2 Controls plus: • Cal. RFG II[2] [Replaces Fed RFG II[2,5]] • Reformed diesel (55 cetane)[2,8] [Replaces reformed diesel (50 cetane)[2]]	Level 2 Controls plus: • Cal. RFG II[2] [Replaces Fed RFG II[2,5]] • Reformed diesel (55 cetane)[2,8] [Replaces reformed diesel (50 cetane)[2]]

[1] National
[2] OTAG wide or specified
[3] Serious and above areas
[4] Statutory and opt in areas
[5] Currently evaluating OTAG-Optimized fuel (e.g., low RVP, low sulfur, low olefins) elsewhere in OTAG as alternative
[6] For all nonattainment areas and attainment MSAs/CMSAs >=100,000
[7] Qualifications on the use of lb/mmbtu numbers: 1) These numbers are for initial strategy modeling purposes only. They do not reflect any recommendation from OTAG on the desired level of reduction for these units. 2) OTAG reserves the right to do sensitivity analyses on any source in an effort to achieve a desired ozone impact. Such sources may include those that chose the lb/mmbtu option. The requirement for such analyses may exist in certain areas where the size and location of such a major source is critical to achieving the ozone goals. 3) The alternative lb/mmbtu limits shall not supersede an existing requirement that is more stringent (e.g., OTC MOU or NSPS requirements).
[8] Currently evaluating California diesel

TABLE 5

VOC CONTROL PACKETS — FOR THE CONTROL STRATEGIES MINI-WORKGROUP

Strategy Packets	Major Point Sources	Other Point/Area
Base 1 (Mandated CAA Control)	• CTG and non-CTG RACT at major sources in NAAs and in OTC • New source LAER and offsets for NAAs	• Initial phase of consumer and commercial products and one phase of architectural coatings • Stage 1 and 2 petroleum distribution controls-NAAs • Autobody, degreasing and dry cleaning controls in NAAs
Level 0	Base 1 plus: • "9% by 99" ROP Measures (NO_X may be substituted after 1996)[3]	Base 1 plus: • "9% by 99" ROP Measures (NO_X may be substituted after 1996)[3]
Added Controls — Level 1	Apply NAA Base 1 default control assumptions across domain down to 100 TPY sources	Apply NAA Base 1 default control assumptions across domain down to 100 TPY sources
Added Controls — Level 2	10% reduction in VOC emissions from major point sources in major metropolitan NAAs	Increased C/C products limits, increased AIM limits, increased autobody refinishing limits
Deep Controls — Level 3		

TABLE 5

VOC CONTROL PACKETS — FOR THE CONTROL STRATEGIES MINI-WORKGROUP (Con't)

Strategy Packets	Non-Road Mobile	Highway Mobile
Base 1 (Mandated CAA Control)	• Fed Phase II Small Eng Stds • Fed Marine Engine Stds • Fed HDV (> =50 hp) Stds-Ph. 1 • Fed RFG II[4] • 9.0 RVP maximum elsewhere in OTAG	• Tier 1 LDV and HDV Stds • Fed RFG II[4] • 9.0 RVP maximum elsewhere in OTAG • Enh I/M[3] • Low Enh I/M for rest of OTR • Basic I/M in mandated areas • Clean Fuel Fleets for mandated areas • On board vapor recovery
Level 0	Base 1 plus: • Fed Locomotive Stds (not incl. rebuilds) • "9% by 99" ROP Measures (NO_X may be substituted after 1996)[3]	Base 1 plus: • National LEV • HDV 3 gm std • FTP revisions • "9% by 99" ROP Measures (NO_X may be substituted after 1996)[3]
Added Controls — Level 1	Base plus: • Low RVP fuel (6.7 RVP) in non-RFG areas[2] [replaces 9.0 RVP maximum elsewhere in OTAG]	Base plus: • High Enh I/M for LDV (LEV-specific cutpoints)[6] [Replaces Enh I/M,[3] Low Enh I/M for rest of OTR, and basic I/M in mandated areas] • HDV I/M[6] • Low RVP (6.7 psi) in non-RFG areas[2] [replaces 9.0 RVP maximum elsewhere in OTAG]

TABLE 5

VOC CONTROL PACKETS — FOR THE CONTROL STRATEGIES MINI-WORKGROUP (Con't)

Strategy Packets	Non-Road Mobile	Highway Mobile
Added Controls — Level 2	Level 1 Controls plus: • Fed RFG II[2,5] [Replaces Fed RFG II[4]]	Level 1 Controls plus: • Max I/M (LEV-specific cutpoints) for LDV[6] [Replaces high Enh I/M (LEV-specific cutpoints)[3]] • Fed RFG II[2,5] [Replaces Fed RFGII[4]]
Deep Controls — Level 3	Level 2 Controls plus: • Cal. RFG II[2] [Replaces Fed RFG II[2,5]] • Cal Tier II small engine std	Level 2 Controls plus: • Cal. RFG II[2] [Replaces Fed RFG II[2,5]]

1 National
2 OTAG wide or specified
3 Serious and above areas
4 Statutory and opt in areas
5 Currently evaluating OTAG-Optimized fuel (e.g., low RVP, low sulfur, low olefins) elsewhere in OTAG as alternative
6 For all nonattainment areas and attainment MSAs/CMSAs >=100,000
7 Qualifications on the use of lb/mmbtu numbers: 1) These numbers are for initial strategy modeling purposes only. They do not reflect any recommendation from OTAG on the desired level of reduction for these units. 2) OTAG reserves the right to do sensitivity analyses on any source in an effort to achieve a desired ozone impact. Such sources may include those that chose the lb/mmbtu option. The requirement for such analyses may exist in certain areas where the size and location of such a major source is critical to achieving the ozone goals. 3) The alternative lb/mmbtu limits shall not supersede an existing requirement that is more stringent (e.g., OTC MOU or NSPS requirements).
8 Currently evaluating California diesel

TABLE 6

OZONE TRANSPORT ASSESSMENT GROUP
STRATEGIES AND CONTROLS SUBGROUP
IMPLEMENTATION STRATEGIES AND ISSUES WORKGROUP
INITIAL CONTROL STRATEGIES TO BE MODELED

This initial set of control strategies has been selected to provide the maximum amount of information regarding the ability of various control strategies to reduce ozone transport.

The strategies are as follows and would be run using a baseline of:

- Base 1 = All Clean Air Act control measures through 2007 and state 15% plans.
- The first run, known as Level 0, includes: N LEV, the OTC NO_X MOU at Phase II, ROP through 1999, federal locomotive standards, HDV standards (3 gm), and FTP revisions.
- The second run, known as Level 3, includes: 85% reduction or a rate-based level of 0.15 lb/mmbtu for utilities and deep controls on other point sources, federal locomotive standards (including rebuilds), maximum I/M for both HDV and LDV, Cal reform, reform diesel (55 cetane), and HDV standards (2 gm).
- The third run is similar to the first run with the exception that utilities and point sources of NO_X are controlled at Level 3, the deep control level.
- The fourth run is similar to the second run except that utilities and point sources of both VOC and NO_X are controlled at Level 0, the minimum level.
- The first two runs define the boundaries. The second and third runs allow for an understanding of low level versus elevated level impacts.

TABLE 7

INITIAL CONTROL STRATEGIES TO BE MODELED

	High Level NO_X	**Low Level NO_X**	**Point and Area Source VOC**	**Mobile VOC**
Run 1	Level 0	Level 0	Level 0	Level 0
Run 2	Level 3	Level 3	Level 3	Level 3
Run 3	Level 3	Level 0	Level 0	Level 0
Run 4	Level 0	Level 3	Level 0	Level 3

TABLE 8

FIRST ROUND STRATEGY MODELING SUMMARY OF PRELIMINARY KEY FINDINGS

- Run 1 (Level 0):
  - Little additional benefit on regional scale
  - Benefits occur mostly in NE
- Run 2 (Level 3):
  - Results consistent with sensitivity Test 5c (kitchen sink)
  - Large areas of lower ozone (decreases on the order of 10-40 ppb)
- Run 3 (Level 3 Utility NO_X) and Run 4b (Level 3 Low Level NO_X)
  - Both runs effective in lowering ozone on regional scale
  - Relative effectiveness varies by region and episode (e.g., Elev. NO_X more effective in MW, low level NO_X more effective in NE and SE)
- Strategy runs show ozone increases in some areas on some days

TABLE 9

**TWO BASIC STRATEGY RUNS;
EACH WITH 4 VARIATIONS ON UTILITY EMISSIONS**

Run	(NO_x) Utility	(NO_x) Point	(NO_x + VOC) Area + Non-Road	(NO_x + VOC) Highway
5	3	1	1	0
6	2b	1	1	0
7	2a	1	1	0
8	1	1	1	0
9	3	2	2	1.5
10	2b	2	2	1.5
11	2a	2	2	1.5
12	1	2	2	1.5

TABLE 10

NO_X UTILITIES

•	Level 1	55% from 1990 base or 0.35#NO_X/mmbtu
		▪ Coal 0.20#NO_X/mmbtu — Gas and Oil
•	Level 2a	65% from 1990 base or 0.25#NO_X/mmbtu
		▪ Coal 0.20#NO_X/mmbtu — Gas and Oil
•	Level 2b	75% from 1990 base or 0.20#NO_X/mmbtu for all units
		▪ Oil, Gas and Coal
•	Level 3	85% form 1990 base 94 0.15#NO_X/mmbtu for all units
•	Runs 5-8	BG&E proposal varying utility emissions at all four levels
•	Runs 9-12	EPA/OAC/NESCAUM proposal varying utility emissions at all four levels

TABLE 11

OTHER POINT NO_X

- **Runs 5-8 at Level 1**
  - Level 1: RACT
- **Runs 9-12 at Level 2**
  - Level 2: About 55% reduction
  - The recommended non-utility point source control level was actually a mix of Level 1 control for smaller sources and Level 2 for larger sources

TABLE 12

NON-ROAD/AREA (NO_X AND VOC)

- **Runs 5-8 at Level 1**
  - Area sources: No change from existing/mandated controls
  - Non-road: Fed locomotive standards including rebuild HD engine 4 gm std.
- **Runs 9-12 at Level 2**
  - Area Sources: No change from existing/mandated controls
  - Non-road: Level 1 + Fed Phase II RFG

TABLE 13

HIGHWAY (NO_X AND VOC)

- Runs 5-8 at Level 0
  - National level as of 2001
  - HDV 2 gm std
  - Revised FTP
  - No change in I/M
- Runs 9-12 at Level 2
  - Level 0 + high enhanced I/M with level specific outputs for all MSAs > 500,000 population
  - RFG domain wide
  - No HDV I/M
- Levels 1 and 2 include I/M in all MSAs > 100,000 pop.
- 500,000 pop. cutoff applies to approximately 56 areas; 33 new areas 100,000 pop. cutoff applies to approximately 159 areas; 126 new areas

TABLE 14

OTAG CONTROL STRATEGY MODELING

- Round 1
  - Domain-wide
  - Examines the "book ends"
    - Level 0 (minimal additional controls)
    - Level 3 (deep controls; "kitchen sink")
- Round 2
  - Domain-wide
  - Examines all the different levels of controls on utilities against a static level of controls on other sectors
    - 4 runs with Level 0 for on-road mobile and Level 1 for all others
    - 4 runs with on-road mobile at half way between Levels 1 and 2, and Level 2 for all others
- Round 3
  - Will incorporate geographic considerations
  - Preparatory sensitivity modeling underway

TABLE 15

OTAG SCHEDULE

- **December 1996**
  - ANPR
    - Schedule for SIP calls
  - Complete Round 2 modeling
- **January 1997**
  - Identify Round 3 modeling
- **February 1997**
  - Complete Round 3 modeling
- **March 1997**
  - NPR
    - NO_X and/or VOC reductions for each state
- **April/May 1997**
  - OTAG's recommendations to US EPA
- **Summer 1997**
  - Final Rule/SIP calls

TABLE 16

OTAG INFORMATION AVAILABLE ELECTRONICALLY

- OTAG Home Page
  - http://www.epa.gov/oar/otag/otag.html

  AQA Web Page
  - http://capita.wustl.edu/otag

  El Web Page
  - http://www.epa.gov/tut

  El via FTP
  - Earth1.EPA.GOV, located in the directory/pub/gopher/EMISINVENTORY

  TTN2000 Web Ste
  - http://ttnwww.rtpnc.epa.gov

  TTN Bulletin Board
  - (919) 541-5742 for modems up to 14,100 bps

  MCNC Data Clearinghouse
  - http://www.iceis.mcnc.org

FIGURE 1

BACK TRAJECTORIES FOR WHITEFACE MTN., NY
ARRIVING AT 3 PM ON July 7, 1994

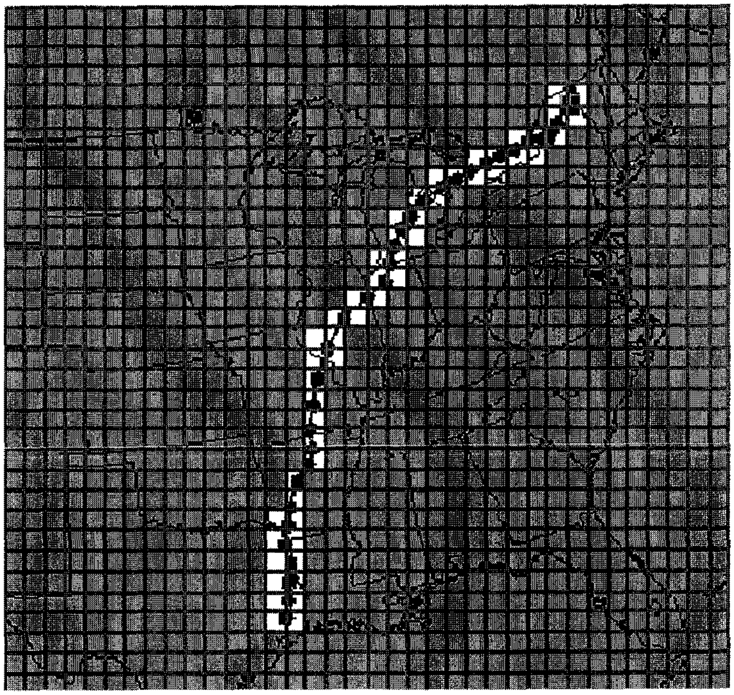


FIGURE 2

BACK TRAJECTORIES FOR WHITEFACE MTN., NY 1989-1995, WHEN OZONE > THAN 90 PPB

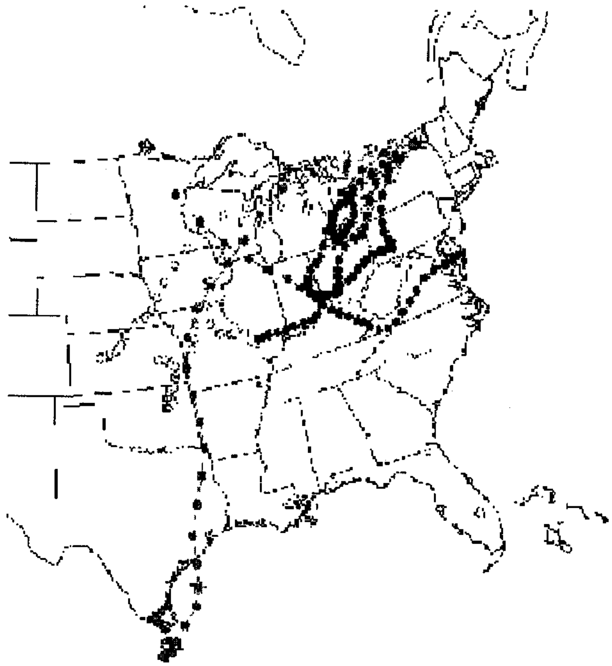
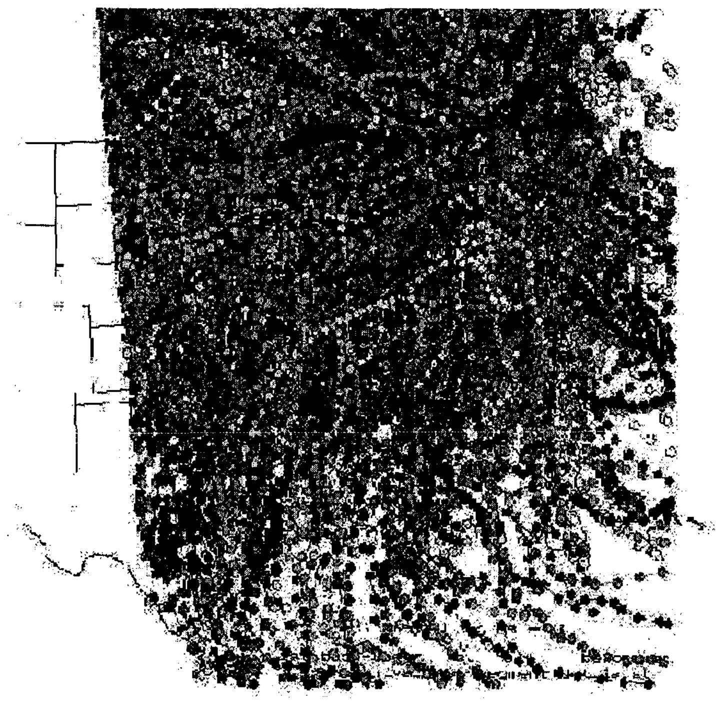


FIGURE 3

ALL BACK TRAJECTORIES ARRIVING AT WHITEFACE MTN., NY 1989-1995 (SUMMER)



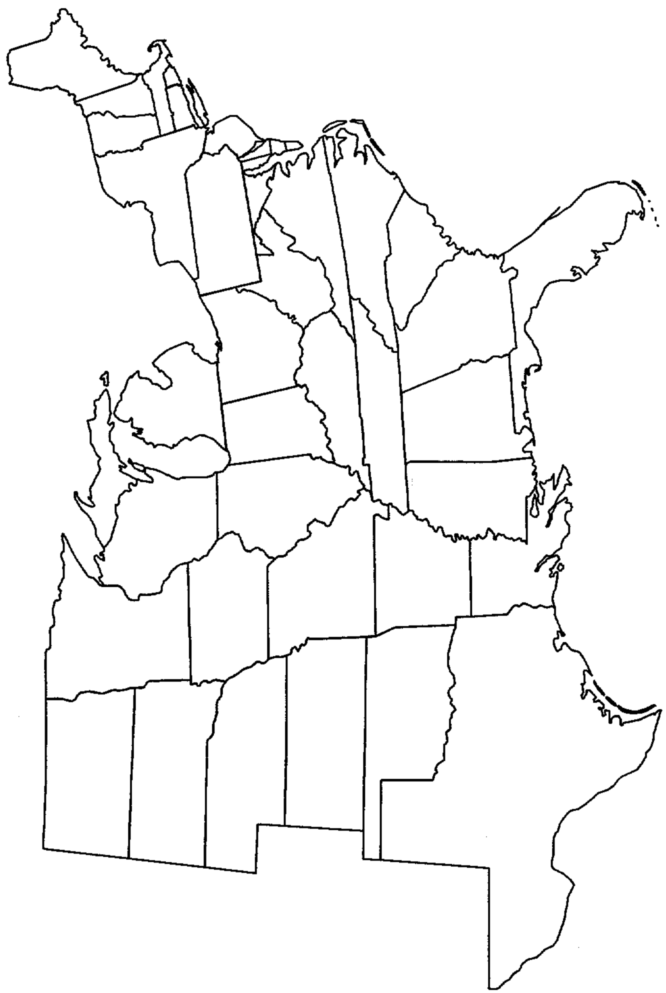


FIGURE 4

OTAG STATES

FIGURE 5

OTAG EMISSION SUMMARY

OTAG VOC Emission Summary (Total Emissions) | **OTAG NOx Emission Summary (Total Emissions)**

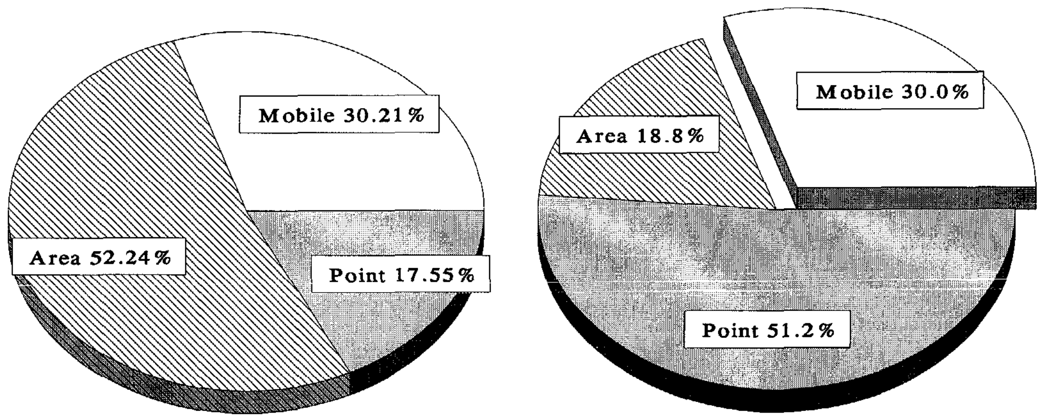
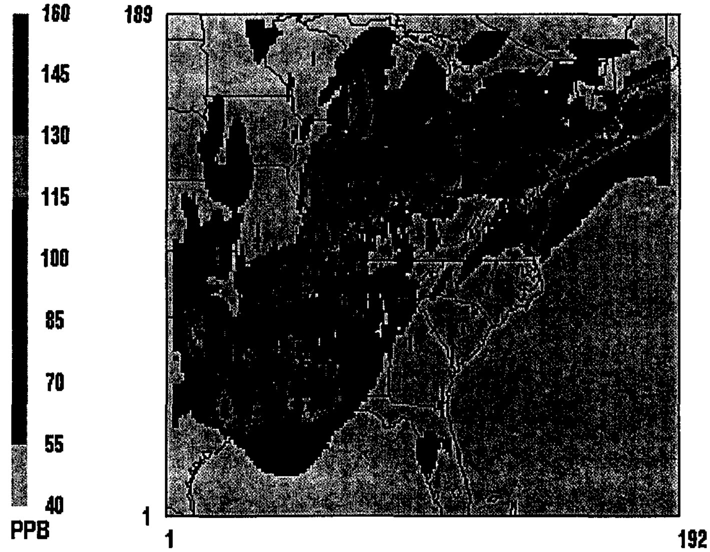


FIGURE 6

OTAG LAYER 1 OZONE: 1990 BASE (JULY 18, 1991)

XYMAX
c=pk. 18jul91 .90bas1D2.out

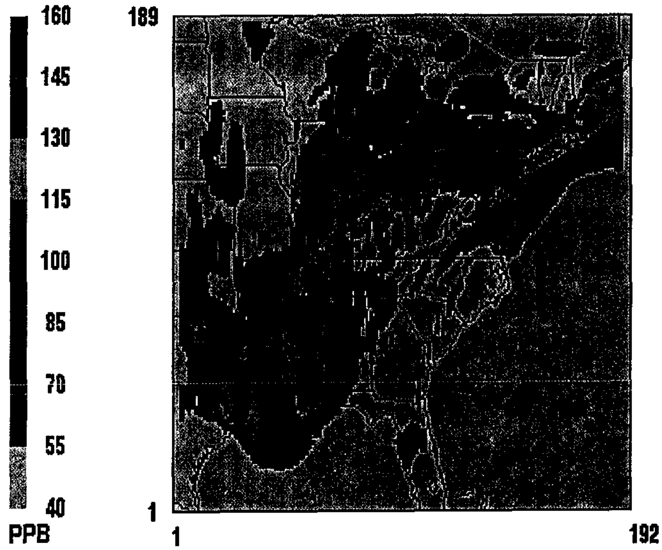


July 18, 1991 0:00:00
Min = 999 at (1,1), Max = 178 at (176,146)

FIGURE 7

2007 BASE 1 DAILY MAX 03: JULY 18, 1991

XYMAX
e=max 18-07bas1D2.out

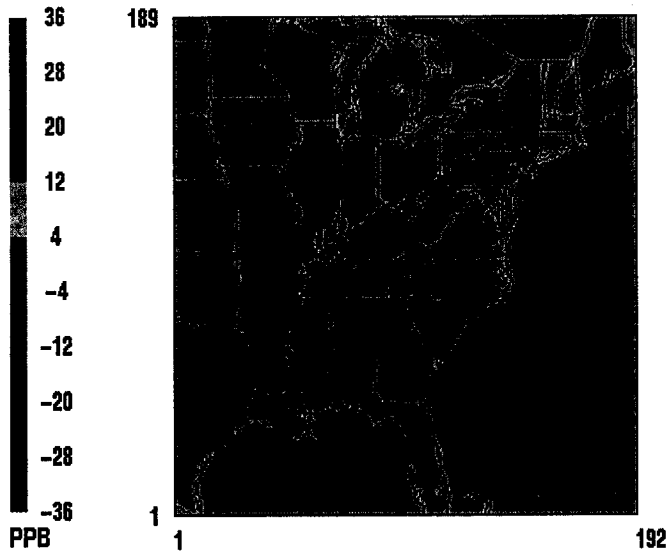


July 18, 1991 0:00:00
Min = 999 at (1,1), Max = 158 at (176,146)

FIGURE 8

03 DIFF: SENS 3A — BASE 1 (2007)

XYMAX
c = pk. 18jul91. 07bas1D2.out, h = pk. 18jul91. bas1A-sns3a.out



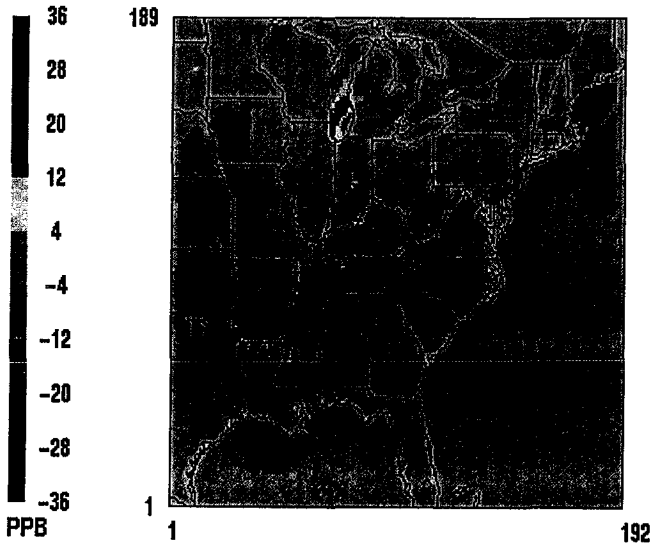
July 18, 1991 0:00:00
Min = 31 at (61,105), Max = 24 at (53,83)

FIGURE 9

03 DIFF: SENS 5F — BASE 1 (2007)

XYMAX

c = pk. 18jul91. 07bas1D2.out, g = pk. 18jul91. .07bas1D2-sns5f.out



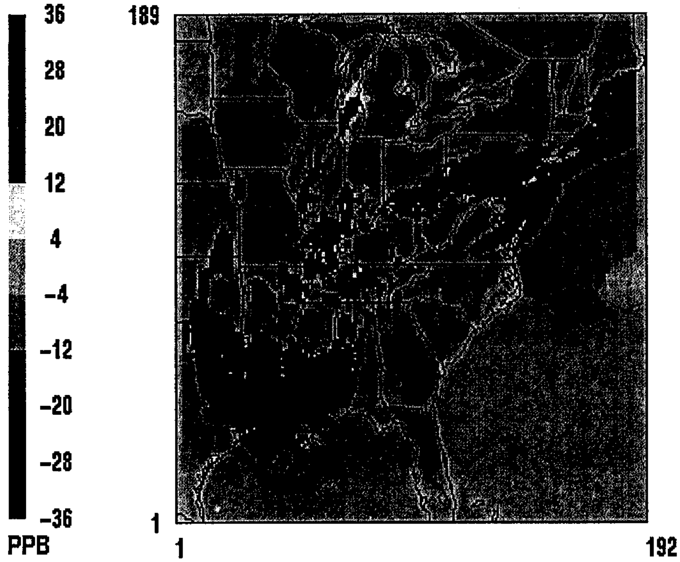
July 18, 1991 0:00:00

Min = 28 at (54,58), Max = 57 at (81,111)

FIGURE 10

03 DIFF: SENS 5E — BASE 1 (2007)

XYMAX
d = max 18-07bas1D2-sns5e.out, e = max 18-07bas1D2.out



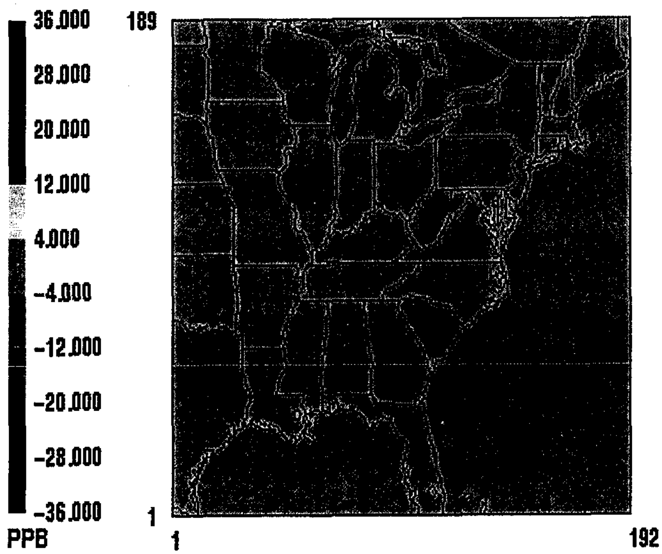
July 18, 1991 0:00:00
Min = 36 at (174,145), Max = 50 at (81,111)

FIGURE 11

03 DIFF: SENS 5D — BASE 1 (2007)

XYMAX

c = max 18-07bas1D2-sns5d.out, e = max 18-07bas1D2.out



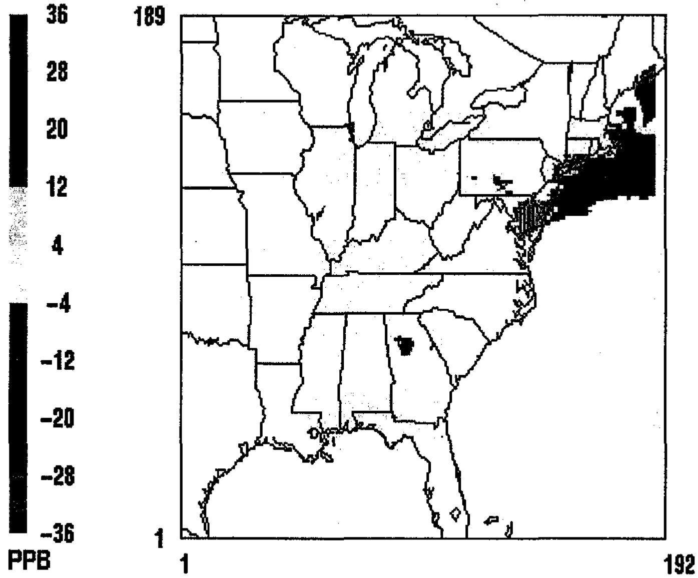
July 18, 1991 0:00:00

Min = 22.917 at (81,111), Max = 2.046 at (86,118)

FIGURE 12

LAYER 1 MAX 03 DIFF: RUN 1 — BASE 07

July 15: Run 1 Lev 0 cntrls for VOC and Nox
OTAG: Northeast Modeling and Analysis Center (NEMAC)

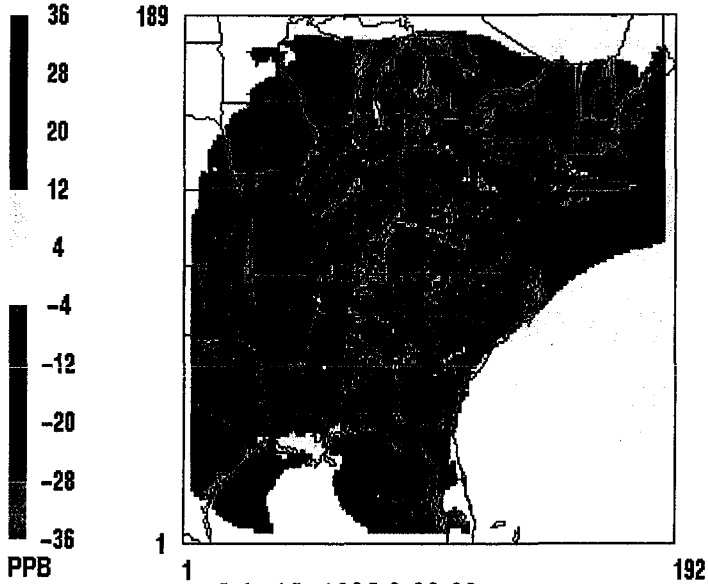


July 15, 1995 0:00:00
Min = 13 at (166,132), Max = 15 at (68,144)

FIGURE 13

LAYER 1 MAX 03 DIFF: RUN 2 — BASE 07

July 15: Run 2 Lev 3 cntl NOx and VOCs
OTAG: Northeast Modeling and Analysis Center (NEMAC)

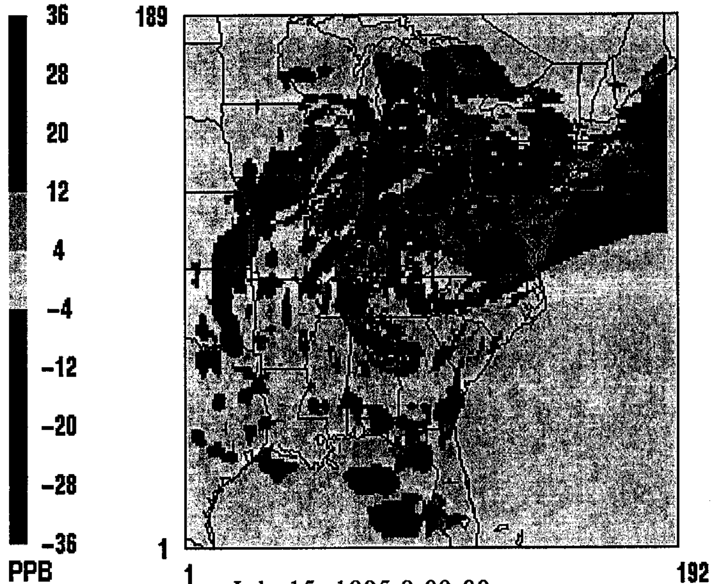


July 15, 1995 0:00:00
Min = 52 at (75,95), Max = 16 at (68,144)

FIGURE 14

LAYER 1 MAX 03 DIFF: RUN 3 — BASE 07

July 15: Run 3 Lev 3 NOx cntl Util; Lev 0 cntl for Others
OTAG: Northeast Modeling and Analysis Center (NEMAC)

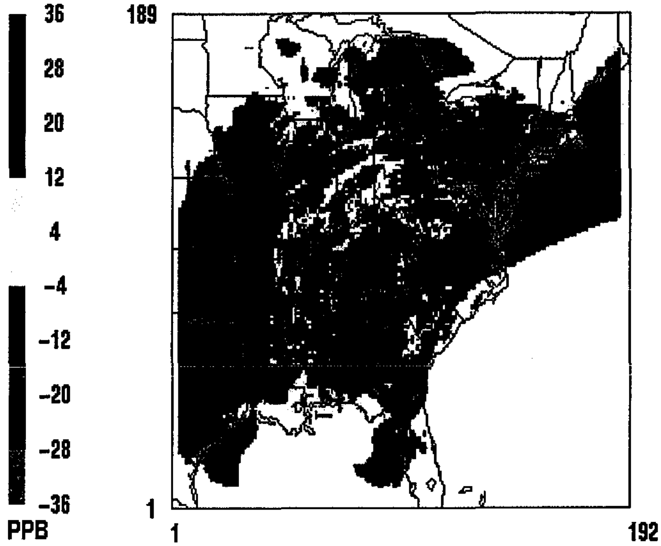


July 15, 1995 0:00:00
Min =44 at (77,106), Max = 19 at (147,128)

FIGURE 15

LAYER 1 MAX 03 DIFF: RUN 4b — BASE 07

July 15: Run 4b; Lev 3 NOx and VOC ar, mv, & non-util; Lev 0 Util NOx & Non-Util VOC
OTAG: Northeast Modeling and Analysis Center (NEMAC)



July 15, 1995 0:00:00
Min =39 at (71,89), Max = 20 at (68,144)

SESSION I:

ENERGY AND THE MARKETPLACE

CONVERGENCE: COMPUTING AND COMMUNICATIONS

Charles Catlett
Associate Director
National Center for Supercomputing Applications

The National Center for Supercomputing Applications (NCSA) is a scientific research center built around a national services facility. NCSA is developing and implementing a national strategy to create, use, and transfer advanced computing and communication tools and information technologies. These advances serve the center's diverse set of constituencies in the areas of science, engineering, education, and business.

When the center opened to the research community in 1986, researchers using the supercomputers were from the traditional disciplines of physics, chemistry, materials, and astrophysics. But researchers in other disciplines quickly realized they, too, could transform their fields by using supercomputing. Today's growth areas include commercial and financial data mining and networked World Wide Web multimedia asset management.

NCSA works closely with the computer science research community to bring users the most advanced methods in high-performance scalable computing. The center currently maintains these supercomputers: Silicon Graphics POWER CHALLENGEarray, HP/Convex Exemplar, and Thinking Machines CM-5.

Scientists and researchers associated with NCSA provide never-ending challenges in all areas of computational research. Their needs to solve complex problems, to comprehend billions of numbers, to collaborate, and to access information have led to advances in cyberspace technologies and virtual reality.

Since its beginning, NCSA has developed desktop software to help users navigate cyberspace. The 1992 release of the network browser NCSA Mosaic® provided the basis of a technology that is generating the "gold rush" on the Internet. NCSA is now creating a powerful desktop-based collaborative software environment that will help eliminate distance barriers for virtual teams. The following tables and figures highlight Mr. Catlett's presentation.

TABLE 1

1986 TO 1996

	1986 $	1996 $
Disk ($/GB)	10,000	400
Tape ($/GB)	250	2
Memory	2,000,000	20,000
Processor ($/GB)	6,000,000	25,000
LAN ($/GB)	3,000,000	30,000

TABLE 2

PC IN THE YEAR 2000

- Two gigaflops performance, $2,000
  - Equal to CRAY-2 supercomputer, $18M in 1987
- Graphics rendering capability equivalent to systems used to create *Jurasic Park* realistic animation
- Compression, signal processing, display capabilities to provide superior quality to HDTV

TABLE 3

LABORATORY TO MARKET — 5 YEARS

- Virtual environments and remote telepresence
- 10M document index overnight, search in seconds
- Real-time content search of 45 Mbit/s streams
- Construction of realistic 3-D scenes from multiple 2-D views in minutes
- Financial market analysis and prediction in minutes to hours
- Index/search of images and video using adapted intelligent text search methods
- Digital cash is already to market!

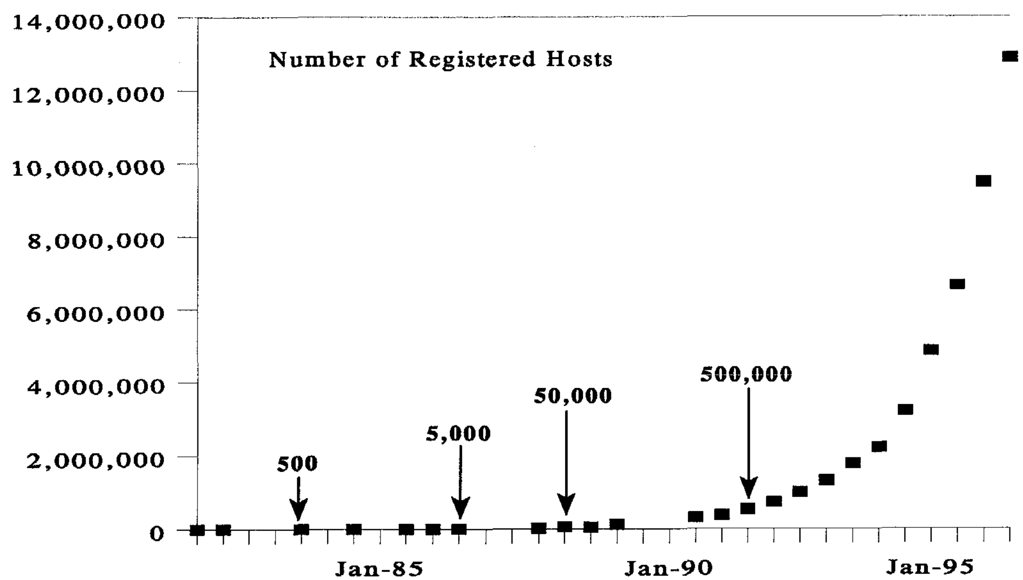
TABLE 4

HOW DO YOU USE A LAPTOP SUPERCOMPUTER?

- Information content filtering, summary
  - Intelligent algorithms "learn" your information interests
  - Filter incoming "push" media as well as polling information servers
- Natural language interface
  - Advanced index/search replacing file system paradigm
  - Speech in/out
- Information providers become commodity
  - Value added information tailoring software

FIGURE 1

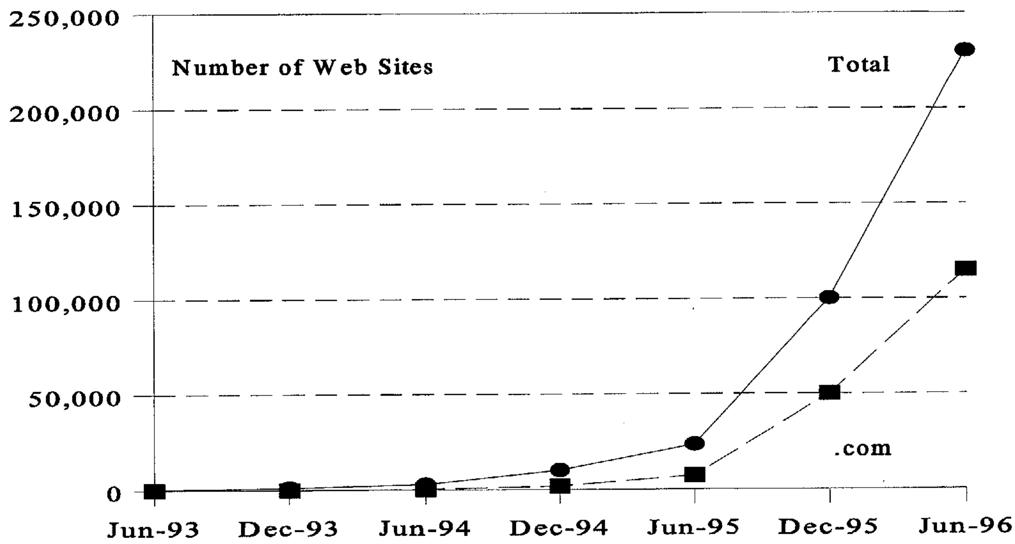
GROWTH OF THE INTERNET



Source: Internet Wizards

FIGURE 2

GROWTH OF WORLD WIDE WEB (SITES)



Source: Matthew Gray of the Massachusetts Institute of Technology

FIGURE 3

BEYOND SCIENTISTS AND ENGINEERS

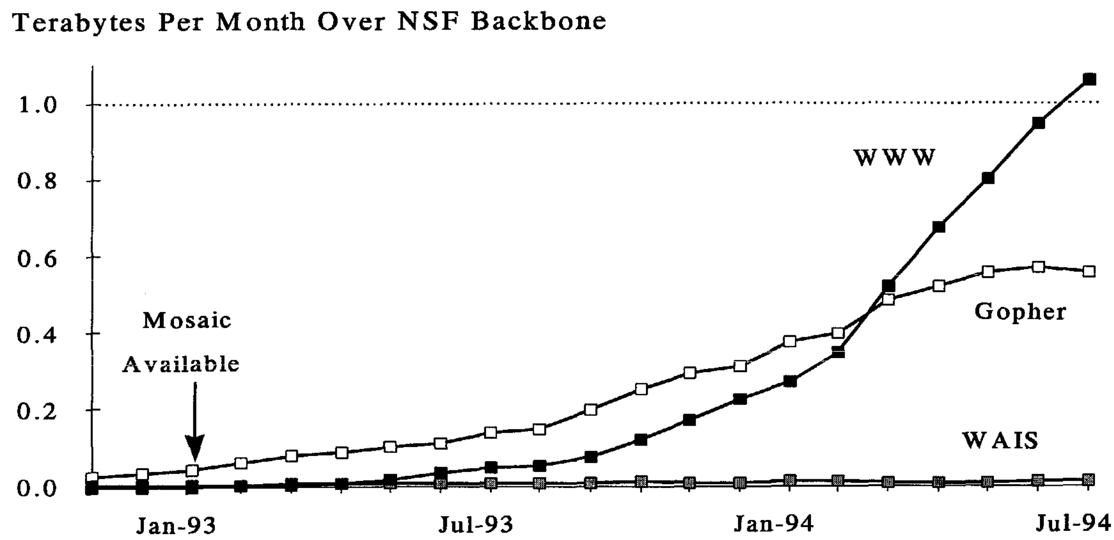
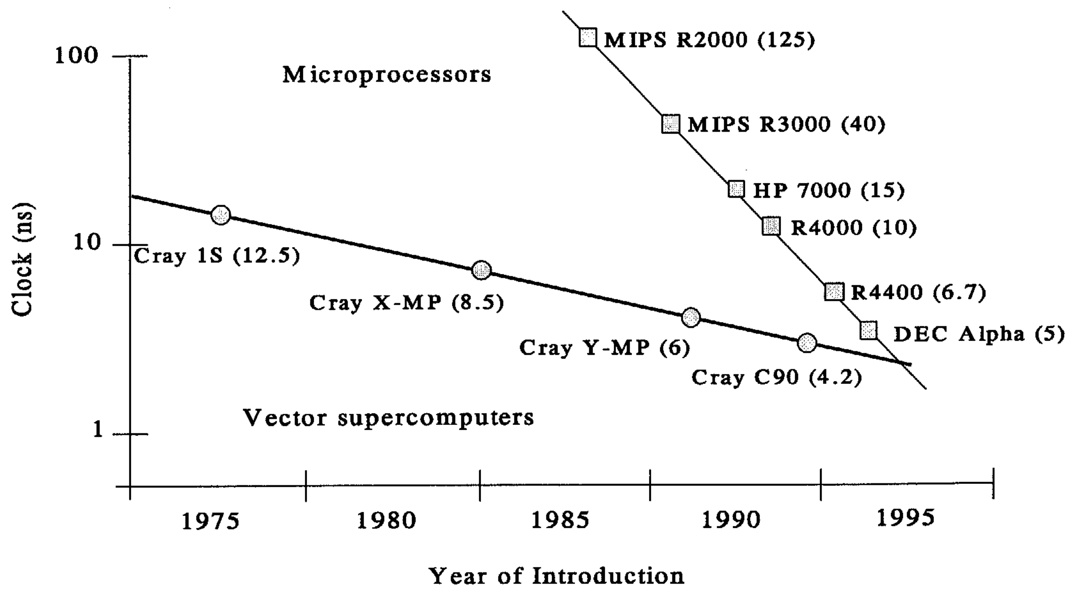


FIGURE 4

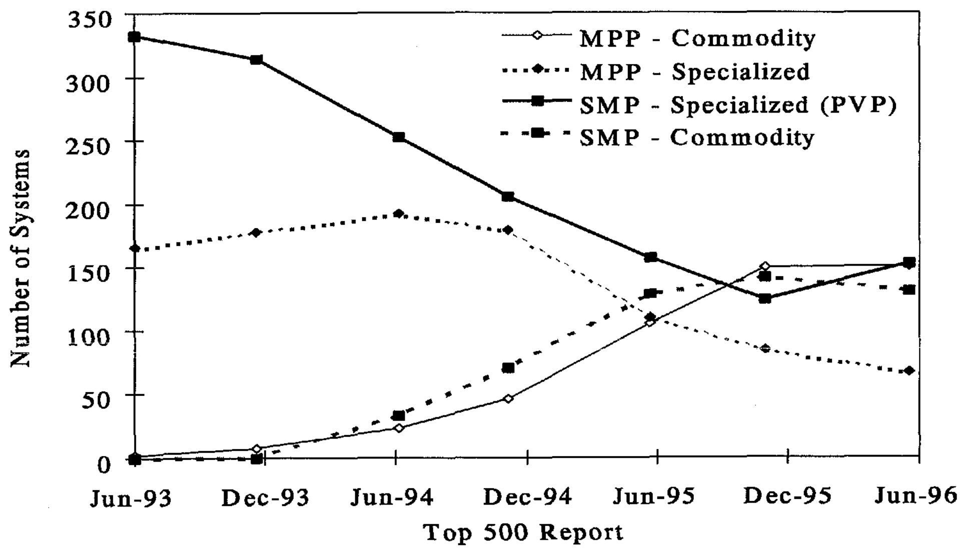
WHAT IS A SUPERCOMPUTER?



Adapted from Forest Baskett, SGI and SCS Vanguard

FIGURE 5

COMMODITY v. SPECIALIZED



THE STATUS OF ELECTRIC INDUSTRY RESTRUCTURING

Mathew Morey
Director, Economic Policy
Edison Electric Institute

The Edison Electric Institute (EEI) is an association of shareholder-owned electric companies. Its members generate approximately 79 percent and distribute 75 percent of all of the electricity generated by electric utilities in the United States. EEI provides a forum for individuals in the electric power industry to exchange ideas and experiences and to communicate with a variety of audiences. More importantly, EEI acts as a representative for the shareholder-owned electric power industry on subjects of public interest.

To provide an accurate picture of the operations of the shareholder-owned electric industry, EEI develops information resources and tools. On behalf of its members, EEI also initiates numerous surveys and studies that provide factual data on electric utility operations, regulations, sales and revenues, environmental practices, marketing opportunities and other topics.

The shareholder-owned segment of the electric industry is undergoing rapid changes in its regulation as the industry is opened to increased competition. At the same time, electricity is more important than ever in helping businesses and homeowners reduce their overall energy use, while significantly improving the environment. EEI is intimately involved in shaping both of these strategic areas of the industry and more specific information on these issues follows.

The following presentation explores current regulatory reform with a special focus on the impacts of competition in the Midwest marketplace.

TABLE 1

IMPETUS FOR ELECTRIC RESTRUCTURING

- Increasing competition in a global economy
- Technology change and low gas prices
- Trends in economics and politics: "Markets are superior to regulation"

TABLE 2

GUIDING PRINCIPLES

- All customers should benefit
- Past regulatory commitments should be honored
- State and regional approaches should be recognized and allowed to evolve
- Corporate structures should be determined by markets
- Subsidies, preferences or mandates that provide a competitive advantage or disadvantage should be eliminated
- Public goods should be supported by all system users

TABLE 3

PURPA AND EPAct

- PURPA (1978) provided the initial impetus to independent power:
  - Focus on energy efficiency
  - Mandatory utility purchases
- EPAct (1992) furthered whole competition:
  - Established a new category of independent generators (EWGs)
  - Gave FERC authority to order transmission access

TABLE 4

FERC ACTIONS IMPLEMENTING EPAct

- EWG Rule (2/93)
- Regional Transmission Group Policy Statement (6/93)
- Policy Statement on Good Faith Requests for Transmission Service
- Information Requirements Rule (3/93)
- Stranded Cost NOPR (6/94)
- Power Pooling NOI (10/94)
- Transmission Pricing Policy Statement (10/94)
- Open Access and Comparability NOPR (Mega-NOPR) (3/95)
- Electronic Bulletin Board Technical Conference and Request for Comments (3/95)
- Real Time Information Network (RIN) NOPR (12/95)
- Merger NOI (1/96)
- Final Rule on Open Access and Stranded Cost and Open Access Same-Time Information System (OASIS — formerly RIN) (Order Nos. 888 and 889) (4/96)
- Capacity Reservation Tariff (CRT) NOPR (4/96)

TABLE 5

ISSUES AT FERC

- Order No. 888:
  - Comparability and open access
  - Pricing of ancillary and transmission services
  - Stranded cost recovery
- Market Power:
  - Market-based rates
  - Horizontal market power
  - Functional unbundling
  - Independent System Operator
- Merger Policy

TABLE 6

FERC OBJECTIVES
ORDER NOS. 888 AND 889

- Promote robust wholesale competition
- Remedy undue discrimination in transmission
- Facilitate the transition through stranded cost recovery

TABLE 7

TRANSMISSION SERVICE UNDER ORDER NOS. 888 AND 889

- "Unbundled" transmission service provided under a single, *proforma* tariff
- Service and price "comparability" for provider and others
- Transmission availability and service requests via electronic information systems ("OASIS")
- Utility power marketing and transmission functions separated ("functional unbundling")
- Principles proposed for Independent System Operators

TABLE 8

FEDERAL/STATE JURISDICTION

- Service of delivering electric energy to end-users — States' jurisdiction
- Unbundled retail transmission in interstate commerce by public utilities — FERC jurisdiction
- FERC deference — To state regulators' knowledge of distribution facilities, consistent with seven-part test

TABLE 9

RECIPROCITY

- Required for non-public utilities using new tariffs
  - But only to provider
- Applicable to municipal systems, PMAs, co-ops using tariffs
  - But exempts distribution co-ops buying through G&T
- Applicable to non-public transmitting utility using marketer or intermediary to obtain access
- Non-public utility members of pools/RTGs must provide reciprocity to other members
- Non-public utility may request waiver

TABLE 10

FUNCTIONAL UNBUNDLING

- Provided separate rates for wholesale
  - Generation
  - Transmission
  - Ancillary services
- Use same tariff as others
  - New wholesale sales and purchases for transmission and ancillary services
- Rely on same electronic information network for transmission system information
- Implement non-discriminatory open access transmission
  - Otherwise use ISO or other measures

TABLE 11

MARKET-BASED RATES — NEW GENERATION

- FERC has required applicants to demonstrate following conditions:
  - No generation dominance
  - No transmission market power
  - No affiliate abuse or reciprocal dealing
  - Unable to erect barriers to entry
- Open access meets transmission market power test
- Market dominance standard dropped for *new* generation:
  - Entry is easy
  - New capacity markets are competitive
  - "New Capacity": Construction commenced on or after effective date of the rule
  - Demonstration could be required in light of specific evidence (e.g., proximity to transmission constraint)

TABLE 12

MARKET-BASED RATES — EXISTING GENERATION

- Market dominance standard still effective for sales from existing generation
  - Open access does not guarantee lack of market dominance
  - Case-by-case determinations continued

TABLE 13

STRANDED COST RECOVERY

- Provides for recovery of "legitimate, prudent, and verifiable" stranded costs
- Must demonstrate reasonable expectation of continuing service
- Obligation determined using a top-down "revenues lost" formula
- Collected from departing customers through an exit fee or transmission surcharge

TABLE 14

INDEPENDENT SYSTEMS OPERATORS (ISOs) — FUNCTIONS

- Control interconnected transmission within a region
- Ensure short-term reliability
- Relieve constraints; promote efficient trading

TABLE 15

ISO PRINCIPLES

- Provide non-discriminatory open access
- Single, unbundled, grid-wide tariff
- Fair and non-discriminatory governance
- Incentives for efficient operation
- No financial interest in economic performance by ISO or its employees
- Pricing policies promote efficient consumption and use
- Transmission system information made publicly available via electronic information network
- Coordinate with neighboring control areas
- Provide alternative dispute resolution

TABLE 16

FERC (NEAR) FUTURE DIRECTIONS

- Further transmission tariff revisions
- Transmission pricing
- Independent System Operators
- Market power: Merger policy, market-based pricing for existing generation and corporate structure
- Reliability/security
- Federal/state jurisdiction

TABLE 17

STATE ISSUES

• Reliability	• Renewables
• Taxes	• Environmental
• Universal service	• ISOs/power
• Consumer	• Pilot programs
• Utility	• Reciprocity
• Corporate	• Energy
• Stranded costs	• Continued

TABLE 18

PILOTS

- **Utility Initiated**
  - Central Illinois Light
  - Illinois Power
  - Orange and Rockland
  - Washington Water Power
  - Pennsylvania P&L
- **State Mandated**
  - New Hampshire
  - Massachusetts
    - Mass Electric Company
    - Commonwealth Electric Company
  - Michigan
    - Consumers Power
    - Detroit Edison

TABLE 19

DURATION AND LOAD

•	Central Illinois Light	2 Years	50 MW
		5 Years	25 MW
•	Illinois Power	3 Years	50 MW
•	New Hampshire	2 Years	50 MW
•	Massachusetts Electric	1 Year	200 million kWh
		1 Year	100 million kWh
•	Commonwealth Electric	15 Months	15 MW
•	Consumers Power	N/A	3-10 MW
•	Detroit Edison	N/A	N/A
•	Orange and Rockland	3 Years	40 MW
•	Washington Water Power	2 Years	1/3 of industrial customers
•	Pennsylvania Power & Light	18 Months	265 MW

TABLE 20

PILOTS: ELIGIBILITY

	Industrial	Commercial	Residential
• CILCO	8 Largest >10 MW	Open Access Sites	Open Access Sites
• IP	20 Largest >15 MW	N/A	N/A
• NH	3%	3%	3%
• MASS ELEC.	13	4 Sites	4 Sites
• CONSUMERS	Yes	N/A	N/A
• DET. ED.	Yes	N/A	N/A
• O&R	Yes	Yes	Yes
• WWP	Yes	N/A	N/A
• COMM. ELEC.	Yes	N/A	N/A
• PP&L	Yes	Yes	Yes

TABLE 21

PILOTS: RESULTS

- Suppliers learning how to market electricity
- Retail competition implementation issues being discovered
- Lots of competitors offering deep discounts; not about making money
- Not a precursor of future competitive markets
  - Excess capacity today
  - Pilots too simplistic, too narrowly focused
  - Ignore billing, metering cost and other issues

TABLE 22

ELECTRIC INDUSTRY OF TOMORROW

- Unbundled generation, transmission and distribution
- Generation
  - IPPs, power marketers, brokers, IOU generation affiliates
- Transmission
  - Transco, RTGs, ISOs
- Distribution
  - Disco, Esco

TABLE 23

ESCOs

- More than 30 formed by IOUs since 1992
  - Can sell competitors' energy
  - Can operate outside traditional service territory
  - Packages electric/gas with energy efficiency
- ESCO and Power Marketer
  - Can offer a customer A to Z energy service
  - Can modify customer load shape to fit energy availability profile
  - Can steer customer towards utility
  - Can operate anywhere

TABLE 24

DISCOs

- Owns and runs electric and/or gas distribution system
- Has customer service obligations
  - Metering
  - Billing
  - Hook-up
  - Trouble shooting
- Has primary reliability responsibility
- Heavily regulated, fixed territory

TABLE 25

PROSPECTIVE ACTIONS

- Congressman Schaefer (R-CO) comprehensive electricity legislation introduced July 11
- FERC Merger NOI — comments filed May 7
- FERC Capacity Reservation Open Access Transmission Tariff NOPR (CRT) — comments filed October 21
- Rehearing of Final Rules (Order Nos. 888 and 889) — filed May 24
- Transmission pricing at FERC
- Federal/state issues
- Market power issues

TABLE 26

KEY ISSUES FOR UTILITIES

- What is the strategy for growth?
  - Retail v. bulk power trading
  - Regional v. national focus
  - Domestic v. international scope
- What skills/capabilities are required?
- What mix of non-utility merger, acquisition and alliances are essential to remain competitive?

TABLE 27

BARRIERS

- FERC's transmission pricing policy
- FERC's merger policy
- OASIS implementation
- Market power
- Congressional actions
- Level playing field
- Reliability/security
- Environmental restrictions
- Limits on transmission system expansion
- Low-cost states' resistance to competition

TABLE 28

CONGRESSIONAL INITIATIVES
SENATOR JOHNSTON — S. 1526

- Prospective repeal of PURPA
- Requires state to adopt one of three choices:
  - Competitive wholesale procurement markets where anyone can bid — lowest bid consistent with offer and reliability wins;
  - Retail competition by 2002; or
  - An alternative plan that prevents undue discrimination in favor of utility's own generation
- Retail access required for all by 2010
- Provides for recovery of legitimate, prudently incurred, verifiable stranded costs — FERC as backstop

TABLE 29

CONGRESSIONAL INITIATIVES
REPRESENTATIVE SCHAEFER — H.R. 3790

- Requires unbundled service and retail choice for all customers by December 2000
- Power sales by distribution service providers will remain regulated pending achievement of "effective competition;" not so for other suppliers
- States only required to "consider" reliability, stranded costs recovery, universal service, "social programs"
- Postpones PURPA, PUHCA reform pending state determinations on market competitiveness

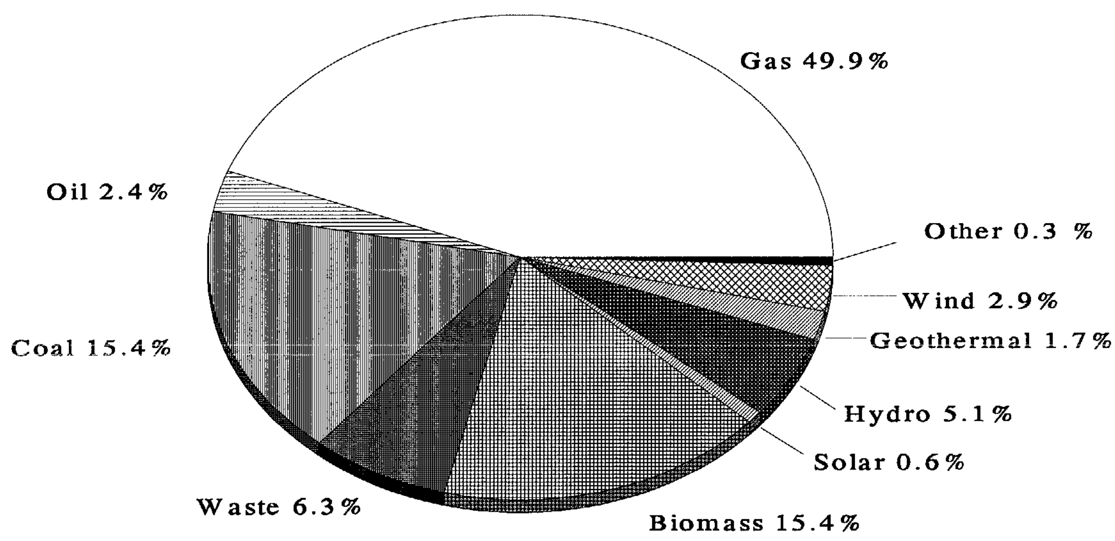
TABLE 30

CONGRESSIONAL INITIATIVES
REPRESENTATIVE TOM DeLAY — H.R. 4297

- Sets January 1, 1998 for customer choice
  - Covers IOUs, Co-ops, and Munis
- If customer fails to choose, state may initially assign
- If competitive rates are not in effect by January 1, 1998, FERC to set rates
- Prohibits any federal, state, or local "preference or protection from competition"
- Prohibits exit fees, subsidies, or other penalties
- PUHCA, PURPA relief conditioned on state finding of retail choice

FIGURE 1

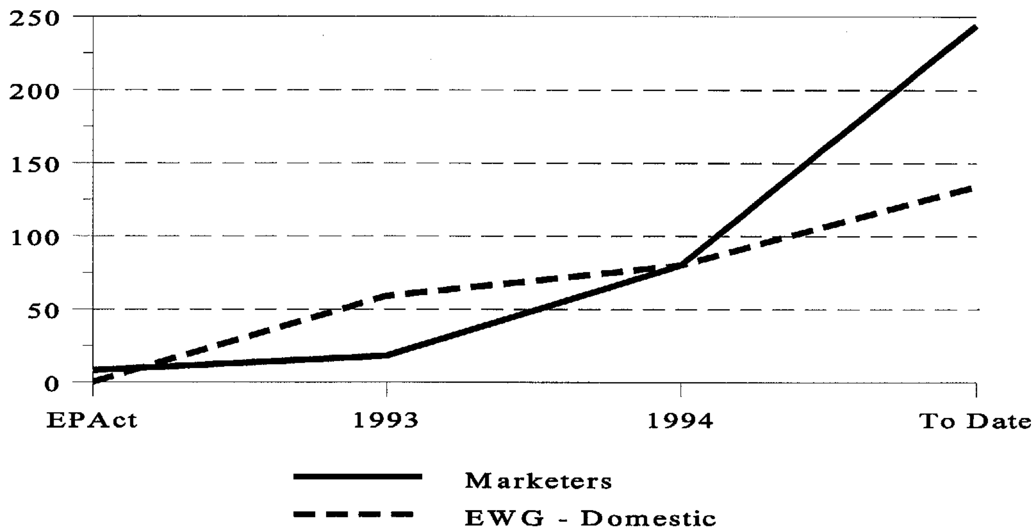
**NON-UTILITY CAPACITY
BY PRIMARY ENERGY SOURCE — 1994**



Source: Capacity and Generation of Non-Utility Sources of Energy, EEI

FIGURE 2

COMPETITIVE WHOLESALE MARKET DEVELOPMENTS
AS OF July 24, 1996



Source: EEI EPAct Briefing Service

FIGURE 3

POWER MARKETERS SALES FOR RESALE
(000's MWhs)

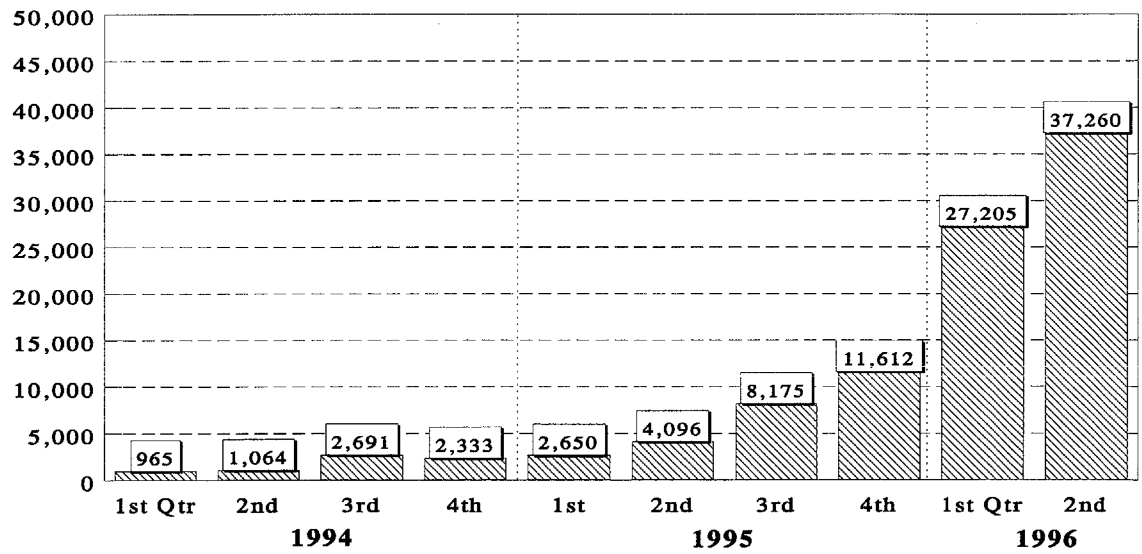
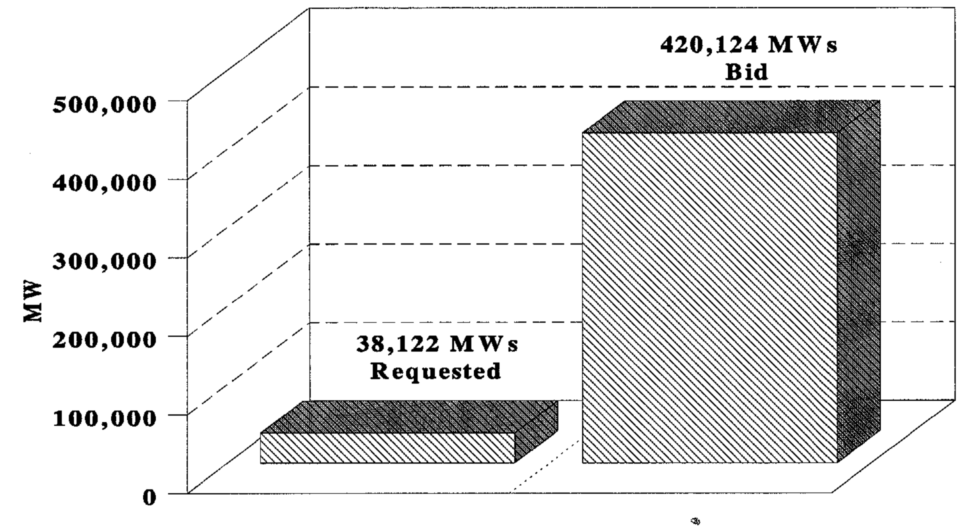


FIGURE 4

RESULTS OF STATE BIDDING PROGRAMS
11 MWs OFFERED FOR EACH MW REQUESTED — 1984 TO PRESENT



Source: Current Competition, Vol. 5, No. 8

FIGURE 5

CUMULATIVE CAPACITY ADDITIONS BY YEAR IN MWs

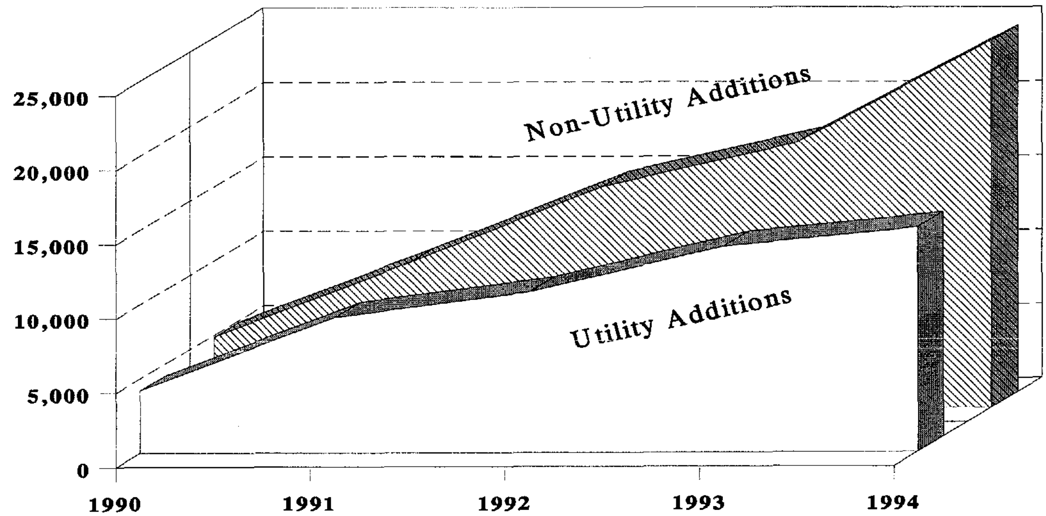
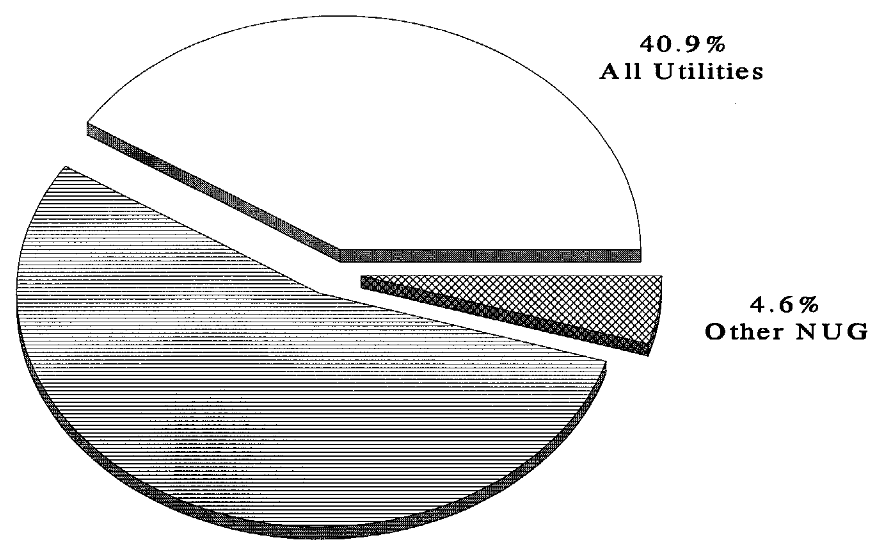


FIGURE 6

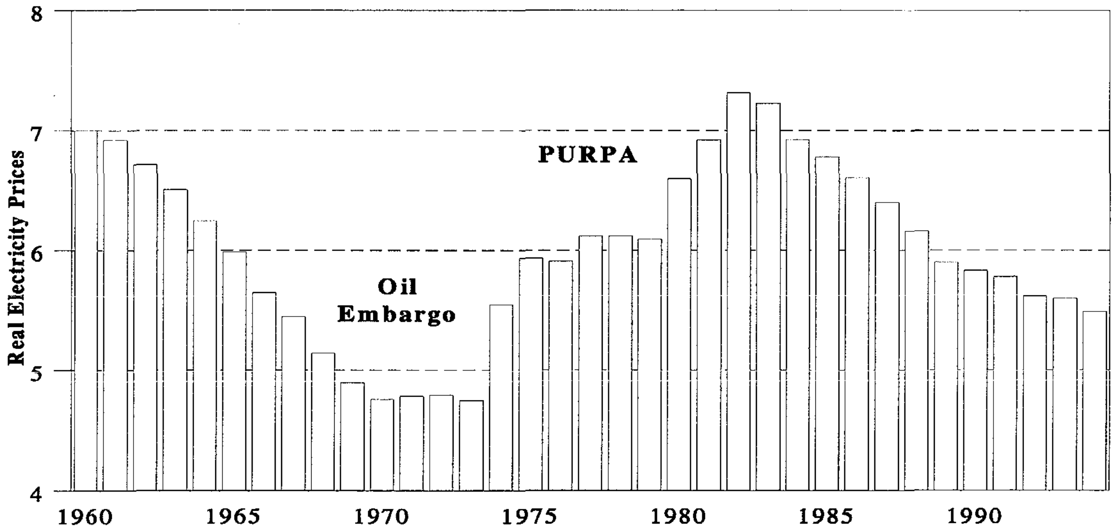
% OF NEW CAPACITY ADDITIONS — 1994 (MW)



Source: Capacity and Generation of Non-Utility Sources of Energy, EEI.

FIGURE 7

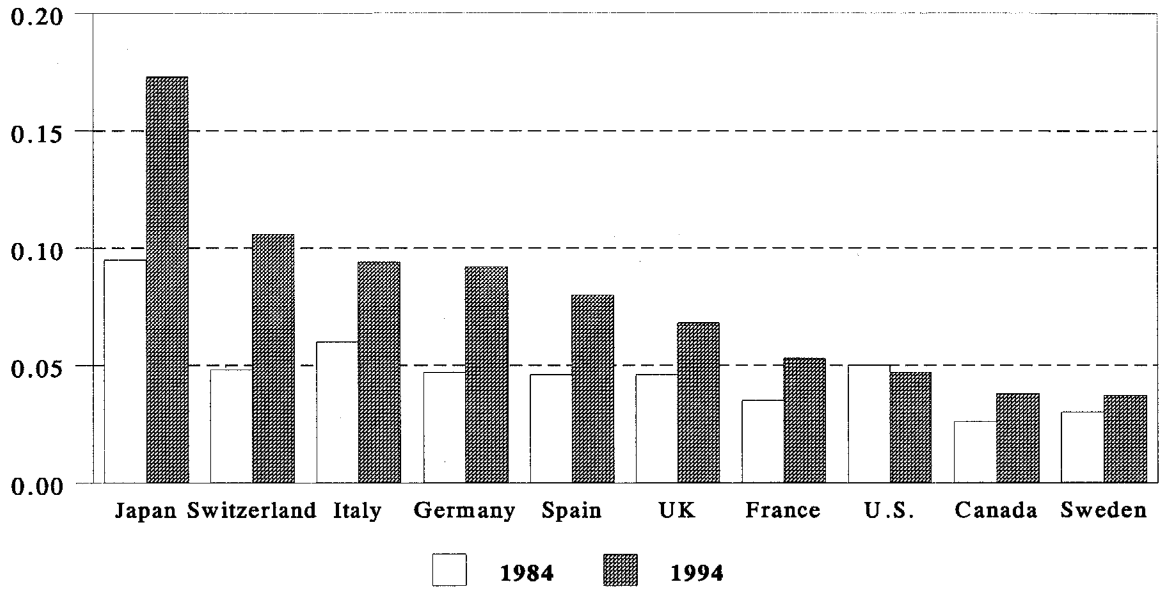
**REAL ELECTRICITY PRICES IN THE U.S.
1960-1994 IN CENTS/kWh**



Source: U.S. Energy Information Administration, Economic Indicators from the U.S. Department of Commerce

FIGURE 8

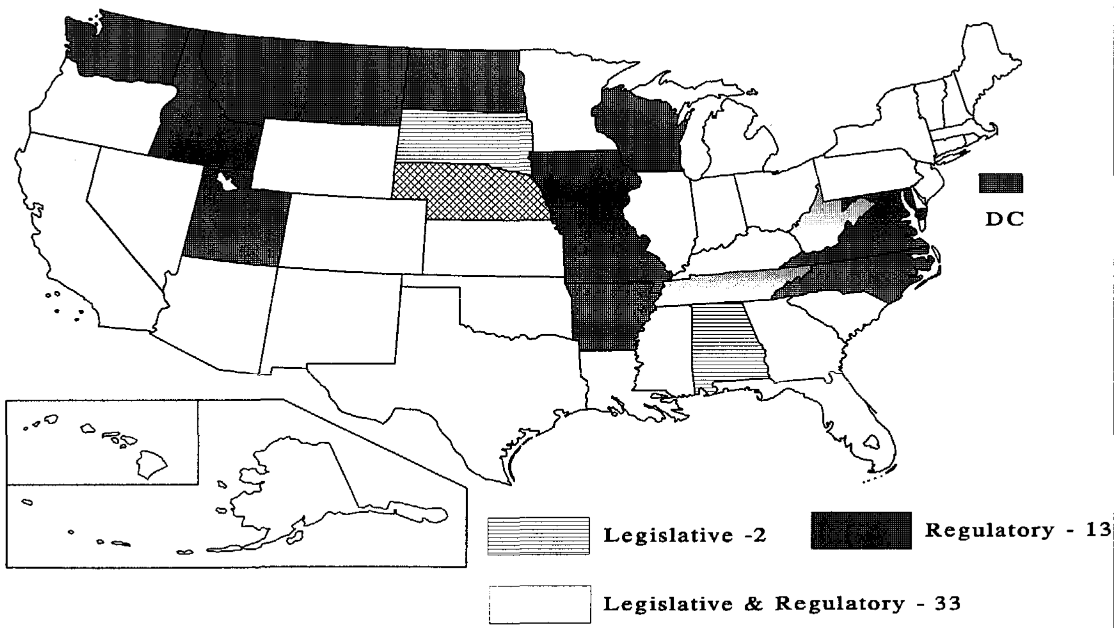
WORLDWIDE INDUSTRIAL ELECTRIC PRICES
CURRENT DOLLARS



Source: International Energy Agency Statistics, 1995

FIGURE 9

RETAIL MARKET DEVELOPMENTS
STATE ACTIVITIES ON RESTRUCTURING AND COMPETITION



Source: EEI Retail Wheeling & Restructuring Report; 9/96

FIGURE 10

RETAIL MARKET DEVELOPMENTS
AVERAGE REVENUE PER kWh — TOTAL INDUSTRY —1994

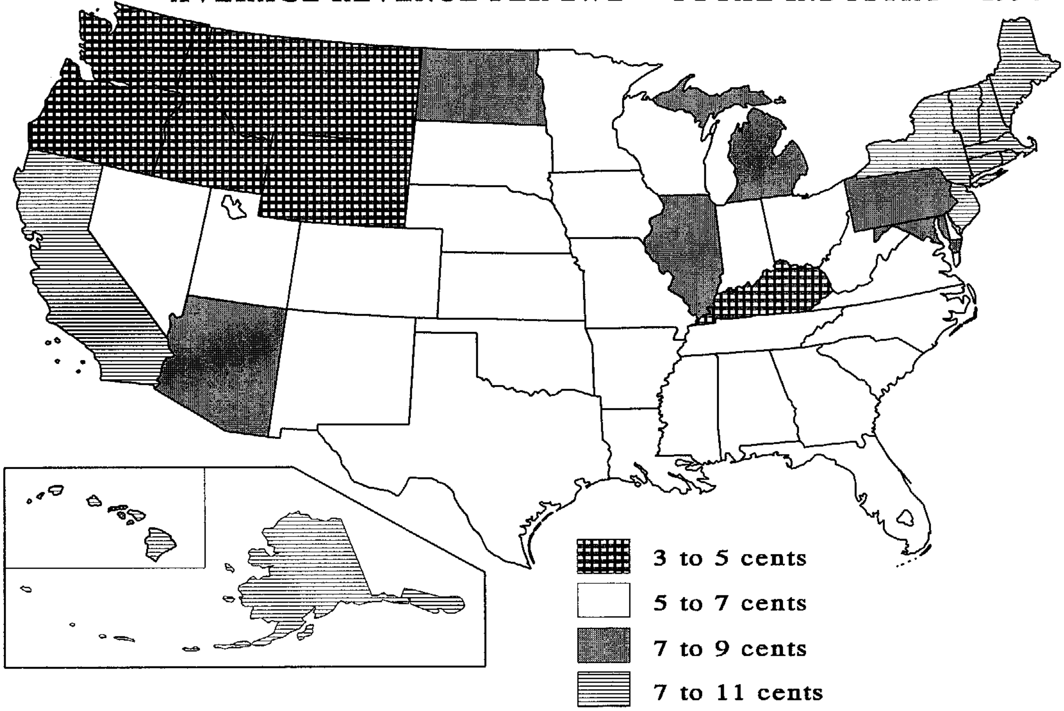


FIGURE 11

RETAIL MARKET DEVELOPMENTS
STATES IMPLEMENTING ELECTRICITY RESTRUCTURING

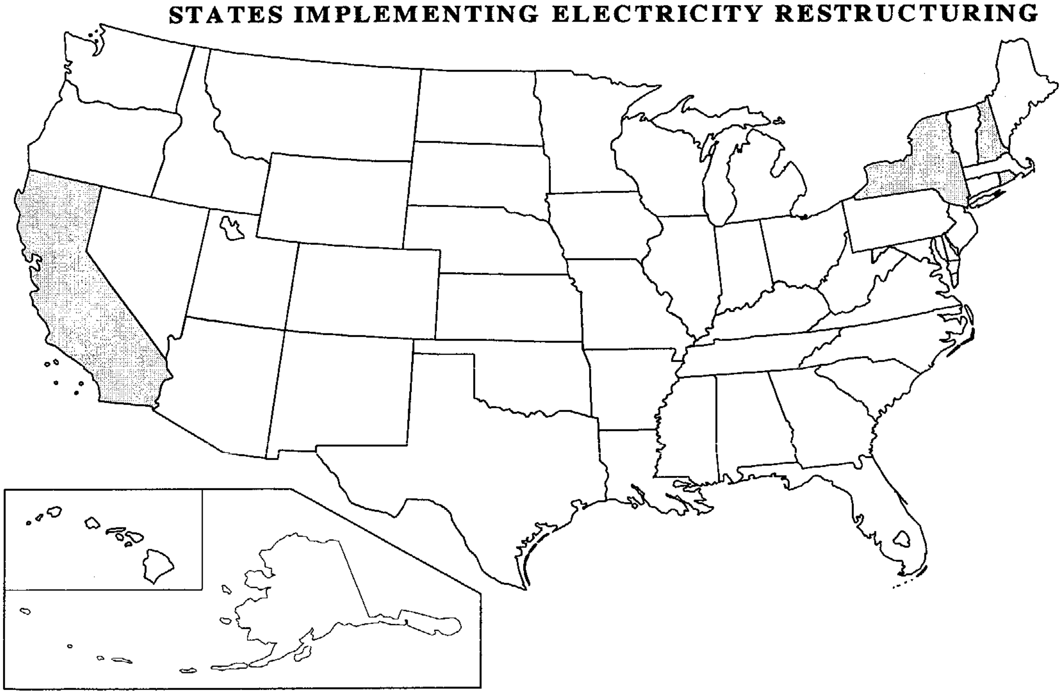


FIGURE 12

RETAIL MARKET DEVELOPMENTS
STATES WITH HIGH AVERAGE COSTS — 9-11 CENTS/KWh

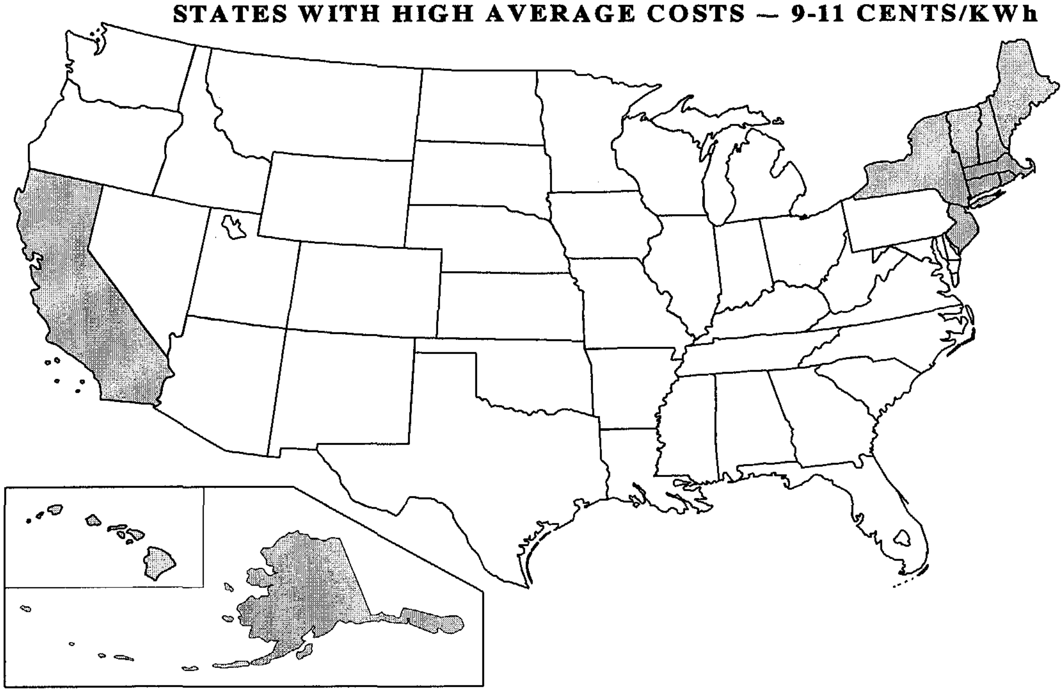


FIGURE 13

TOMORROW'S WIRES BUSINESS?

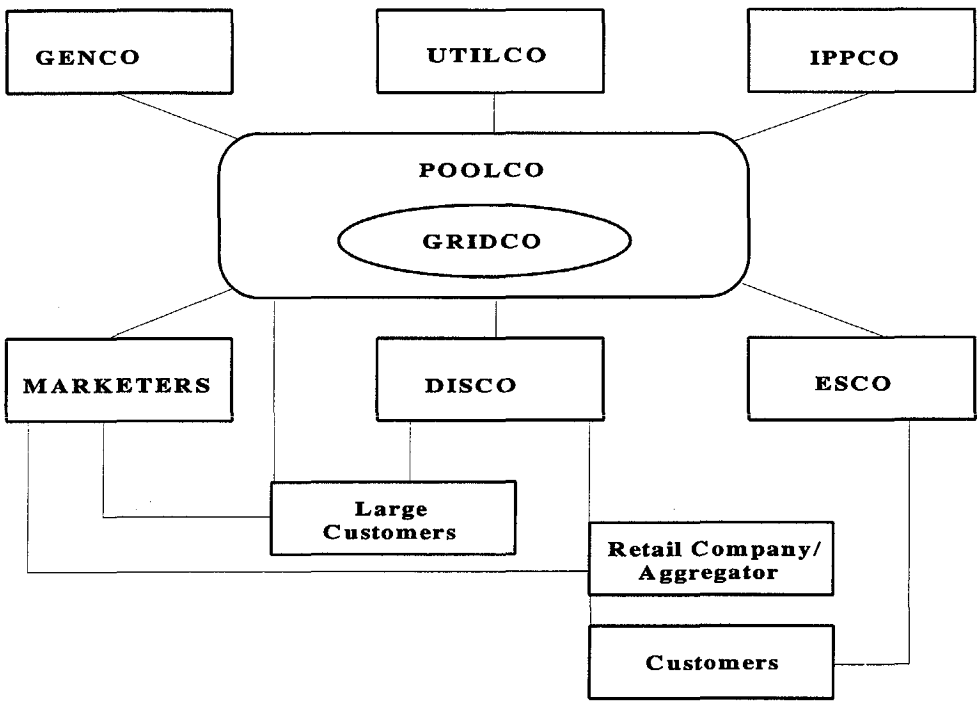
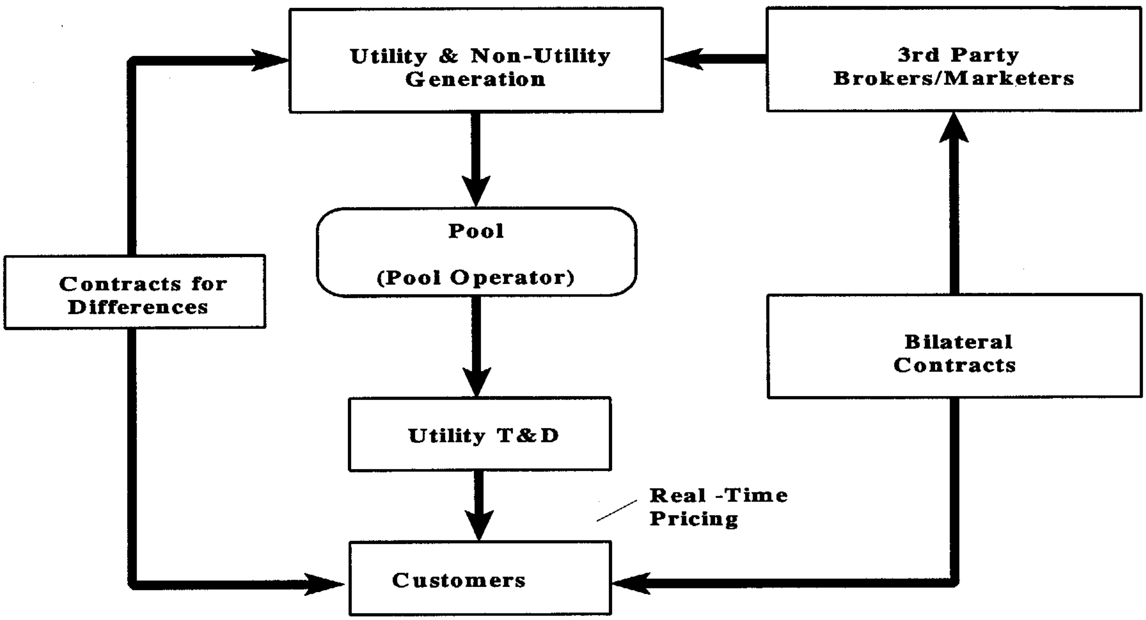


FIGURE 14

TOMORROW'S POWER MARKET?



Customers receive their energy from monopoly distribution system and may enter into a side contract with a third party to hedge the pool price.

ENERGY PRICES AND PUBLIC POLICY: BACK TO THE FUTURE ... NOT!

Thomas Bonenberger
Senior Regulatory Economic Analyst
Corporate Planning
Amoco Corporation

Many large-scale, mature industries in the United States will close the 20th century with radically different structures than those under which they developed. Commercial trucking, railroads, telecommunications, commercial air transportation, natural gas, and now electricity either look much different now than they did only a few years ago or will be different once their restructuring is complete. Of the examples cited, the notable event that facilitated such comprehensive restructurings has been an increasing reliance on market forces rather than regulation to discipline industries. Perhaps more important is the fact that increasing reliance on competitive markets is a global trend. Indeed, expanding globalization of information, markets, and finance and the opening of high growth economies to foreign investment are contributing to a global trend in thinking that robust markets, not rigid regulation, hold a significant key to achieving the aspirations of many peoples and countries. Competitive forces in an ever increasing global economy will become more fierce for individual companies which infers that there be a corresponding drive towards efficiency in the implementation of public policy goals.

Implementing change, certainly of the magnitude required to shift from regulation to markets, carries risks. Some may wonder if the proposed "cures" may be worse than the diagnosed "diseases" and be timid to move forward with reforms. In other words, *back to the future* may be the more prudent course of action. This paper takes the position that industrial restructurings such as those mentioned at the outset are generally appropriate and should be further implemented to completion. Transition to a market-based discipline of industries is sufficiently facilitated and/or complemented by marketing innovations, technological developments, and market-based risk management tools to alleviate concerns that markets may not work as advertised. Policy makers are encouraged to accommodate seasonal and regional energy price fluctuations without interdicting energy supply with the view that the marketplace will appropriately respond to such temporary phenomena. This position will be supported by reviewing the development, growth, and restructuring of the natural gas industry in the U.S.

TABLE 1

GLOBAL TRENDS

- Expanding Globalization: Information, Markets, Finance
- Opening Economies — High Growth Opportunities
- More Reliance on Competitive Markets to Discipline Industries
- Outward Focus v. Inward Focus
- Focus on Knowledge, Competencies
- Focus on Integration (through Alliances, etc.)
- Increasing Rate of Technological Development and Deployment
- Ends and Means Matter (Rogues v. True Value Builders)
- Growth v. Cost Cutting

Source: From comments by Daniel Yergin, President, Cambridge Energy Research Associates, USAEE/IAEE, N. America Conference, Boston, MA, October 28, 1996

TABLE 2

NATURAL GAS REGULATION PRIOR TO 1978

- The Natural Gas Act of 1938
-
  - FPC regulation of interstate transportation and sales for resale
  - NGA did not regulate wellhead price
  - NGA aimed at promoting the development of an interstate NG industry
    - Market risk — limited entry
    - Supply risk — line up 20 year supply contracts
    - Financial risk — shifted downstream to LDC's customers
  - Abundant NG supply from being a byproduct of oil drilling
- 1950s Court Decisions Establish Wellhead Price Regulation of Natural Gas
  - Phillips Petroleum Company v. Wisconsin, 1951
  - City of Detroit v. FPC, 1955
  - Dual Markets for Natural Gas Emerge
  - Use of "vintaging" established Two-Tier Pricing of Gas
- Natural Gas Shortages Result from FPC Regulation

TABLE 3

1970s NATURAL GAS SHORTAGES AND CURTAILMENTS

- Four-fold increase in consumption between 1950-1970
- Pipeline industry mature by 1970s — Most pipelines we have today were built by then
- Static, low prices failed to elicit sufficient exploration drilling
- 1968 — Consumption > Reserve Additions
- Moratoria on new gas hookups
- 1973 — U.S. natural gas production began to decline
- By 1974, curtailments for industrial customers in interstate markets were widespread
- Intrastate gas market prices rose in an attempt to balance supply and demand, but interstate gas market prices remained artificially low due to FPC cost-based pricing
- Some believe that the gas resource was almost exhausted
- Pipelines bid up supply contract terms since they could not raise price
- Low interstate gas price plus new environmental regulations increased demand for natural gas in residential and industrial markets

TABLE 4

GOVERNMENT RESPONSES TO THE NATURAL GAS SHORTAGES AND CURTAILMENTS OF THE 1970s

- FPC's use of historical average cost estimates necessarily put the ceiling prices out of synch with actual costs.
- Political debate over the degree and form of federal intervention in natural gas markets evolved in three states.
  - 1969-1973: Congress considered partial deregulation and structural reform of FPC procedures
  - 1974-1977: Momentum toward deregulation:
    - June 1974: FPC Opinion 699 — Set national price for "new gas" of $0.42/MCF plus annual escalation. Gas drilled prior to 1973 continued to be regulated on historical cost of service.
    - July 1976: FPC Opinion 770 — "New" gas prices raised to $1.42/MCF escalating at $0.04/year. 1973-1974 "vintaged priced (reversing Opinion 699).

TABLE 5

NATURAL GAS POLICY ACT: THE BEGINNING OF THE END OF NATURAL GAS PRICE REGULATION

- Congress passed the Natural Gas Policy Act in 1978 as part of the Carter National Energy Plan.
  - Series of price ceilings
  - Eliminated dual market — Effectively reversed the Phillips decision
  - Deregulated new gas and certain intrastate gas as of January 1, 1985 (half of gas effectually deregulated by that date)
- Emergence of gas bubble — 1980 recession caused drop in demand.
- Collision of past and present regulatory requirements prevented less costly gas from getting to the market (P/L reluctant to aggravate T or P contracts).

TABLE 6

SERIES OF FERC INITIATIVES SEARCH FOR THE RIGHT SOLUTION

- FERC permitted "special marketing programs" for industrial customers to get access to cheap spot market gas.
- FERC Order 380-May 1984 — Eliminated P/L minimum commodity bills so LDS shop for the cheapest gas.
- FERC Order 436-Oct 1985 — Established open access on a voluntary basis — not many takers.
- 1986 — Use of open access accelerated T or P — Liabilities mushroomed!
- Order 451-Jun 86 — Removed vintaging of "old gas" and set "old gas" ceiling at the highest price.
- Order 500 (interim) — Reaffirmed open access transportation, set policy regarding recovery of transition costs.
- Jul 89 — Natural Gas Wellhead Decontrol Act set some immediate decontrol and all by January 1, 1993.
- By 1991 — Only 16 percent of annual gas volumes were P/L sales.
- FERC 636 — Removed P/L as merchant of gas, unbundled transportation and storage services and set standards for services.

TABLE 7

MAJOR ASPECTS OF FERC 636

- Unbundling of Services
- Straight Fixed Variable (SFV) Rate Design
- Capacity Release
- Crediting of Interruptible Revenue
- Flexible Receipt and Delivery Points

TABLE 8

MARKET INNOVATIONS FACILITATE AND/OR COMPLEMENT RESTRUCTURING

- **New Technologies**
  - Reliable short-haul aircraft facilitated hub-and-spoke commercial air travel routing
  - Computer reservation systems helped to manage the explosion in classes of air fares
  - Facilitates better capital budgeting decisions
- **Market Intermediaries**
  - Travel agents — commercial air travel
  - Transportation brokers — trucking
  - Natural gas marketers, aggregaters, brokers
  - Emerging "energy brokers"
- **Financial Instruments**
  - NYMEX futures and options contracts

TABLE 9

NEW YORK MERCANTILE EXCHANGE (NYMEX) ENERGY FUTURES CONTRACTS

•	Heating Oil	1978
•	Leaded Gasoline	1981
•	Crude Oil	1983
•	Unleaded Gasoline	1984
•	Propane	1987
•	Natural Gas	1990
•	Electricity	1996

TABLE 10

IMPACT OF INDUSTRY RESTRUCTURING ON ENERGY PRICES

- Trend toward long run marginal cost
- Reflect regional market dynamics
- Increased volatility

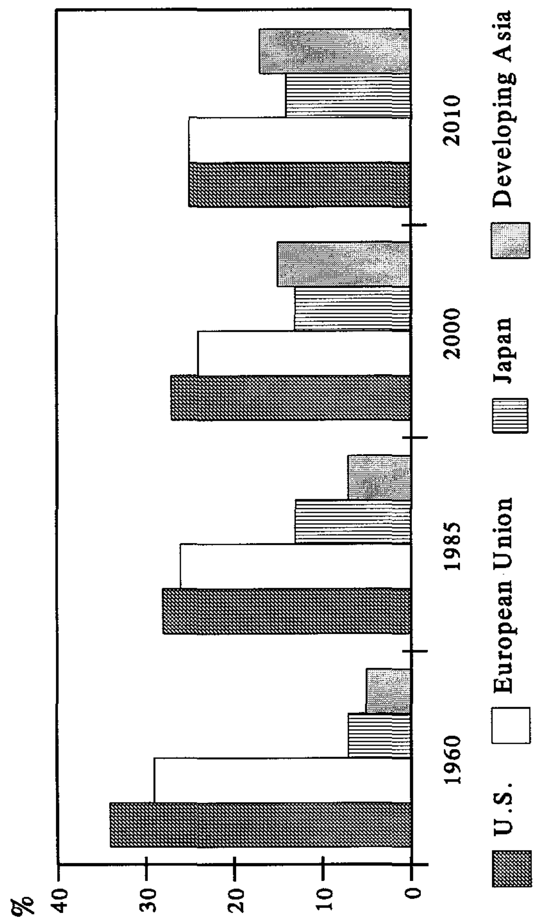
TABLE 11

STATUS OF NATURAL GAS INDUSTRY RESTRUCTURING

- **Need to Fine Tune Remaining Federal Issues:**
  - Capacity release
  - Market-based rates
  - Understand impacts of decreasing term lengths in gas nominations
  - Matching of rate profiles with load profiles
  - Enhanced services
  - Transaction cost impacts relative to level of unbundling
- **At the State Level:**
  - Unbundle services
  - Introduce competition and extend customer choice behind the city gate

FIGURE 1

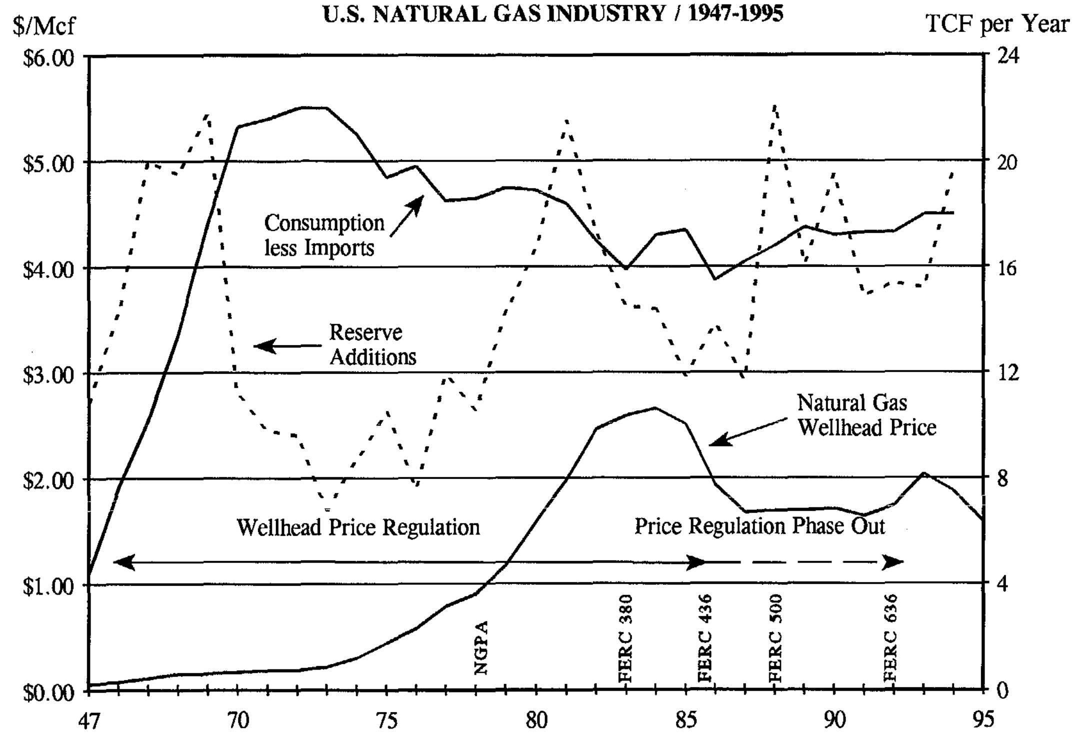
SHIFT IN ECONOMIC ACTIVITY
% SHARE OF WORLD GDP



Source: OECD

FIGURE 2

U.S. NATURAL GAS INDUSTRY / 1947-1995



Source: API - Basic Petroleum Data Book, September 1996.

FIGURE 3

REGIONAL NATURAL GAS PRICE DIFFERENTIALS
JANUARY 1995 v. JANUARY 1996

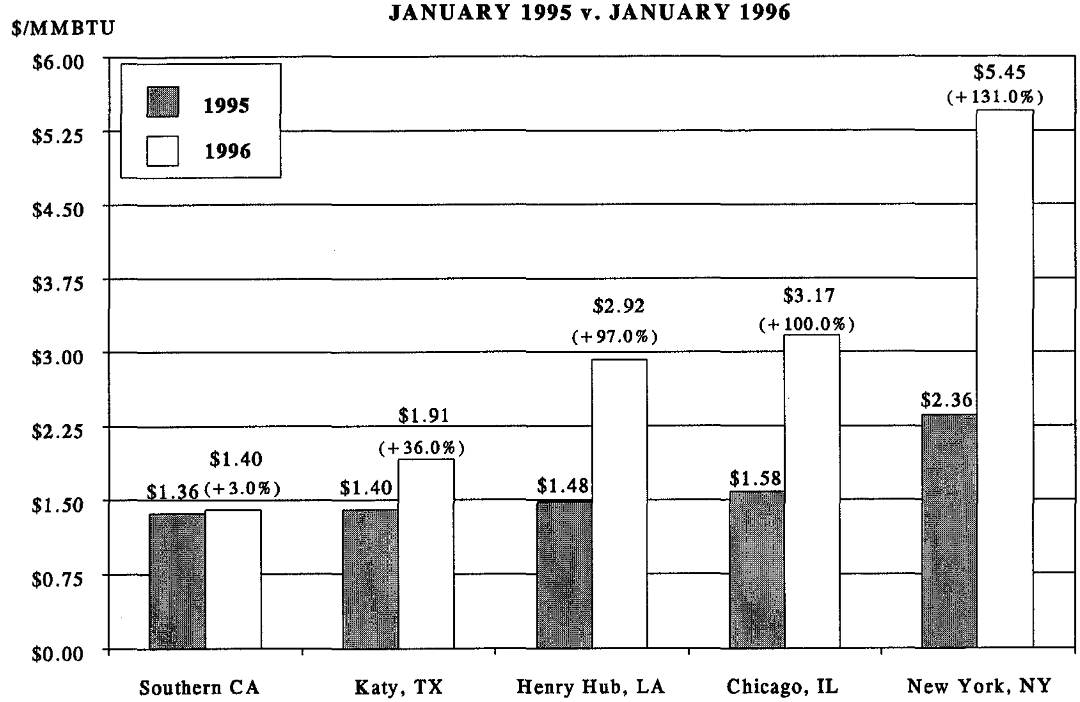


FIGURE 4

EVOLUTION OF GAS VALUE CHAIN

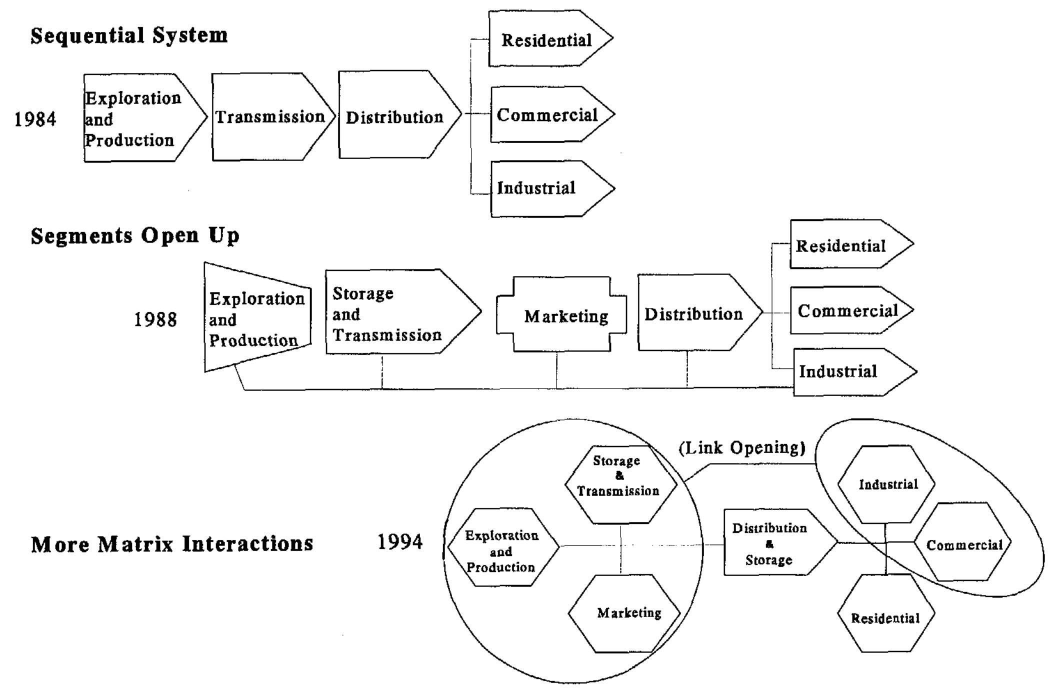
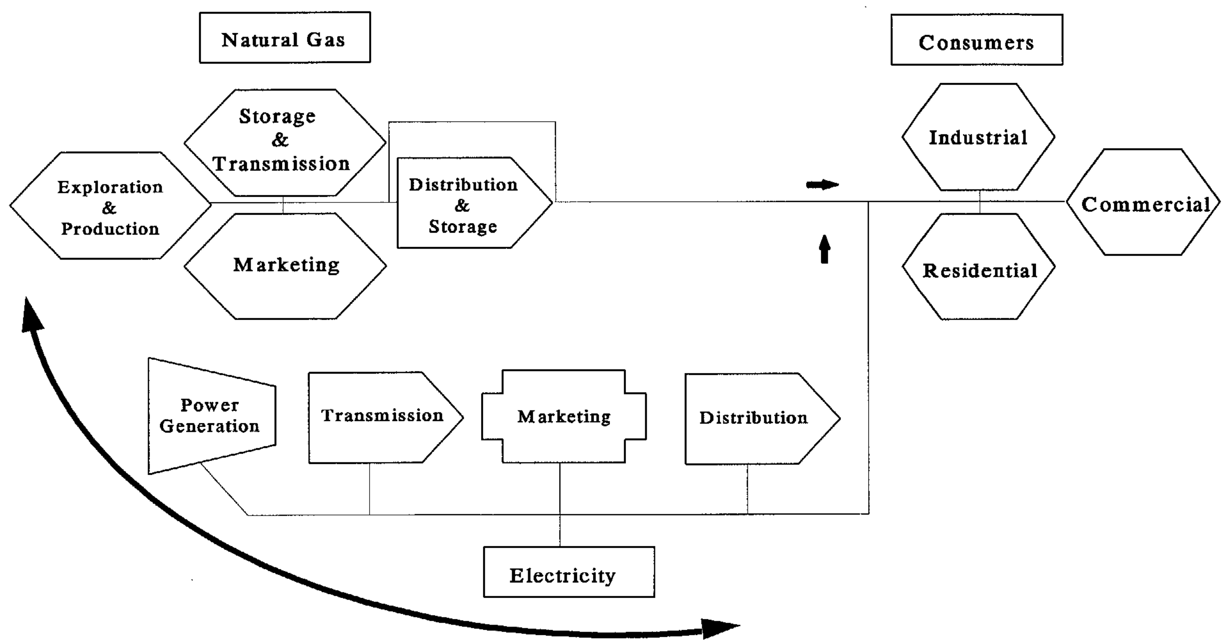


FIGURE 5

GAS AND ELECTRICITY VALUE CHAINS



Natural Gas and Electricity Value Chains are Evolving Towards Convergence

FIGURE 6

NATURAL GAS MARKET PRICES

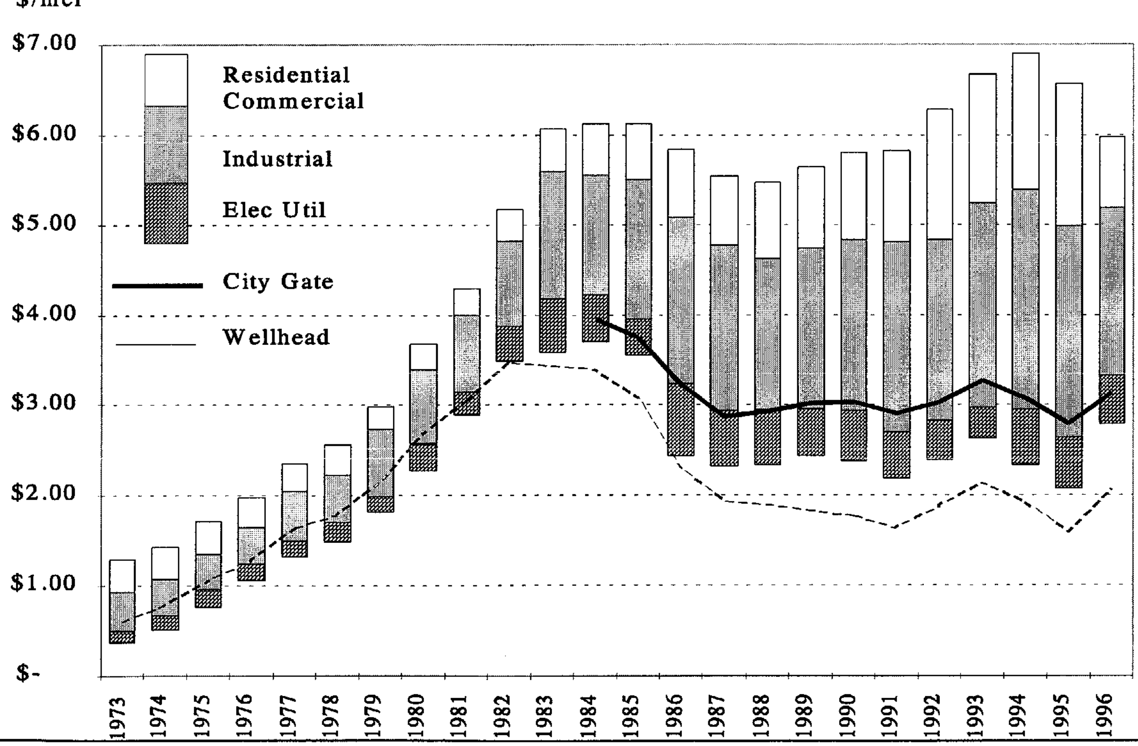


FIGURE 7

CONCLUSIONS & RECOMMENDATIONS

- Global trends matter
- Economics and technology matter
- Politics matter
- The long-run effects of policy designs must be considered
- Continue Forward Progress toward greater reliance on competitive market mechanisms
- Don't Go Back to the Future

SESSION II:

ENVIRONMENT AND THE MARKETPLACE

ENVIRONMENTAL CONTROLS: MARKET INCENTIVES V. DIRECT REGULATION

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INTRODUCTION

Cap-and-trade environmental markets, where the commodities are tradable pollution rights, are being introduced in several closely watched applications as a potentially more cost-effective way of cleaning up the environment than direct or command-and-control (CAC) regulation. In this study, we examine the evidence on control cost savings provided by price and transactions data from the first few years of activity in two markets designed to reduce atmospheric pollution. Some observers of both markets have argued that prices for tradable permits lower than expected, and transactions fewer than expected, are evidence that the markets are not achieving the hoped for savings.

We find, on the contrary, that observed prices point toward more flexible and improved pollution control choices and that the number of transactions has been steadily increasing as market incentives are incorporated into enterprise decisions. These new markets during their first few years are generating, according to our estimates, control cost savings in the neighborhood of one to two billion dollars annually. However, there is evidence that the markets have not yet reached their full potential. In the course of this study, we have found several obstacles to market performance that are worthy of attention by policy makers.

Potential Savings

The two cap-and-trade markets under review in this study are ACID RAIN SO_X, as established by Title IV of the Clean Air Act Amendments of 1990 (CAAA'90), and RECLAIM NO_X in the Los Angeles region, as enabled by the CAAA'90, and established by state and local legislation. RECLAIM stands for Regional Clean Air Incentive Market, managed by the South Coast Air Quality Management District (SCAQMD).

There were high hopes of significant savings from the introduction of these path-breaking markets. Estimates made prior to their initiation were surveyed by a group of experienced U.S. EPA researchers who found projections of savings that ranged from 0.7 to 1 billion dollars annually during the period 1995 through 1999 for ACID RAIN SO_X, an estimated 25 percent reduction from the costs of CAC regulation (Anderson, et al., 1997). Projections for RECLAIM NO_X were found to range around 0.5 billion dollars for the period 1994 through 1997, an estimated 57 percent reduction of costs of CAC control. Varied as the methods were to obtain these estimates, they all rested squarely on the incentives created by decentralizing the control decision.

There are differences between the markets, but there are striking similarities in the use of incentives to achieve savings that make a comparison of their performance timely and valuable in answering the questions of this study. In this endeavor, it will be important to compare key institutional features of the two markets that could affect their separate workings. It will be equally important to show how market incentives in both cases can lead to savings when compared with CAC regulation.

HOW CAP-AND-TRADE MARKETS CAN ACHIEVE SAVINGS

Static Cost-Effectiveness

Direct, centralized or CAC regulation can be inappropriate in industries or activities where many sources of emissions have varying marginal control costs. This is clearly the case in the two cap-and-trade markets (U.S. Government Accounting Office 1994, and SCAQMD 1996). To require each source to reduce in the same absolute or proportional amount by imposing technology or compliance option choices can cause excessive use of valuable resources and administrative effort. In contrast, allocating a given amount of tradable emission allowances or credits among sources allows those with lower costs to reduce emissions and sell tradable rights to those with higher costs, thus reducing the use of control resources, and administrative effort. No other regulatory scheme can allocate emission reductions among the sources more cost-effectively; a powerful argument for cap-and-trade markets when they work as expected (Montgomery, 1974).

Additional intertemporal cost-effectiveness opportunities are opened up if we think of compliance costs as discounted values over a stream of future control actions. By allowing sources to bank permits, or to trade or swap rights of future dates, the market provides ways to minimize the present value of control choice costs.

Dynamic Cost-Effectiveness

The market creates another incentive for emitters to search out and implement new control measures that further reduce costs. If successful, the innovator gains by selling additional permits. Although sometimes hard to detect and always difficult to forecast, these innovations could well be the most significant of all savings. We find evidence that they are playing an important role in both markets and help explain the lower than expected prices.

These ideas on cost effectiveness are illustrated in Figure 1, where the top line (aC_n) depicts an aggregate marginal cost curve. (All tables and figures appear at the end of this presentation). At each point command-and-control regulation requires of every source the same degree of reduction regardless of the emitter's marginal costs. The next lower line (bC_n) reveals an aggregate curve where, for each degree of aggregate reduction, the individual sources equate not emission reductions but marginal costs to an appropriate tax or tradable permit price. The lowest of all lines (dC_n) reveals how costs are further reduced as innovations are stimulated by market incentives.

Figure 1 also portrays the regulatory scene as environmental policy changes from CAC to a competitive cap-and-trade market. Emitters now have the flexibility to choose the least-cost combination of emissions and tradable right sale or acquisition, and to search out innovations in control which would continue to shift the cost curve downward, for example, to dC_n. Even if the cap were to be reduced to, say, $0C_1$, prices could continue to decline given a sufficiently high rate of innovation.

One way of measuring cost savings would be to compare the areas under the cost curves. That task is complicated by a number of issues, among them being problems of estimating and aggregating the micro-cost curves. We can make some inferences about these matters from our observations on the first few years of prices and transactions, but a more complete analysis awaits additional data and future research.

Underlying the cost curves of Figure 1 are several a priori reasons for expecting cap-and-trade markets to induce cost-saving behavior on the part of traders while at the same time achieving a public purpose. These have to do with the autonomy and anonymity of decision-making.

Autonomy of Decision-Making

The cap-and-trade market can assign particular decisions to the parties with the most complete information and appropriate motivation to make good choices. Management at the micro or decentralized level can make control decisions, under market incentives, based on detailed knowledge of the economic performance of particular control measures. Governments at the macro or centralized level can make their policy decisions on capping aggregate emissions based on their judgment of the public interest, and can establish fair and enforceable market guidelines.

Anonymity of Decision-Making

Allowing all kinds of traders to enter the market without apology for, or identification of their motivation, whether they are emitters, brokers, speculators, hedgers, environmental groups, or school children, contributes to market liquidity and efficiency. These benefits of market activity are frequently under appreciated, and sometimes improperly regulated. All that is required of traders is the willingness to abide by well constructed market rules.

A COMPARISON OF MAJOR RULES AND FEATURES OF THE CAP-AND-TRADE MARKETS

Cap-and-trade markets are a new environmental policy instrument that have features that contrast sharply with the limited tradable emission schemes introduced prior to 1990. They establish a right to emit that can be freely traded; require participation by covered emitters; set an aggregate cap on pollution or emissions; allocate pollution rights to individual emitters; and provide for recordation, monitoring, and enforcement. Both markets have these major defining features, but there are particular differences in how the features are elaborated. These differences should to be kept in mind when interpreting price and transactions data.

Tradable Pollution Rights, ACID RAIN Sulfur Dioxide (SO_2) Allowances

SO_2, the major SO_x component emitted largely from coal combustion, can contribute to the formation of tiny particulate matter in the air that can severely harm the lungs, and can diminish visibility. SO_2 also acts as a major precursor of acid rain, which by dry or wet precipitation, can increase acidity in lakes and can cause injury to some vegetation. As a means of control under the CAAA'90, major emitters, primarily electric utilities, are allocated current and future allowances (from 1995 through 2025). Each allowance is good for one ton of emissions on or after the year of its date. Allowances can be bought, sold, or banked beyond the year of date not only by utilities but by anyone entering the market. Each utility has thirty days at the end of the year, the "true-up" period, to turn back to the EPA properly dated allowances equal to emissions. Using the atmosphere as an airfill for SO_2 is consequently restricted and priced.

Tradable Pollution Rights, RECLAIM NO_x Trading Credits (RTCs)

NO_x, primarily NO_2 emitted largely from fossil fuel combustion, is a major precursor of low-level ozone which can impair lung function, damage some vegetation and materials, and limit visibility. Under the RECLAIM program, major stationary emitters of NO_2 are allocated dated RTCs, valid for twelve month periods, from 1994 through 2010. Each RTC is good for one pound of emissions. RTCs, of any vintage, can be bought or sold by emitters or anyone else entering the market. Unlike SO_2 allowances, they cannot be banked, the fear being that banking would cause emission spikes. Overlapping twelve month cycles for RTCs were designed to avoid price spiking at the reconciliation point in time. A properly dated RTC must be turned back to the SCAQMD for each pound emitted during a twelve month cycle. Using the atmosphere as an airfill for NO_2 is thus restricted and priced.

Coverage, Timing, and Geography of the Markets

Phase I of ACID RAIN SO_x, extending from 1995 to 1999 and covering large utilities east of the Mississippi River, allocated SO_2 emission allowances to 72 utilities for each of the 445 generating units that these utilities operate. Phase II, extending from the year 2000 to 2025 will cover large utilities wherever located. An additional 179 utilities are allocated allowances for each of the 700 generating units they operate (U.S. Government Accounting Office, 1994). Although acid rain clouds have regional significance with respect to harms, the market was made national in area in order to simplify trading. In RECLAIM NO_x, the market, launched in 1994, covered 270 companies with 351 facilities which emitted 10 tons or more of NO_x annually. Each facility was allocated RTCs for their cycle during the period 1994 through 2010, as we mentioned. The Los Angeles region is divided into coastal and inland areas with trading permitted from coastal to inland areas but not in the other direction due to prevailing winds.

The Aggregate Cap and the Individual Emitter Allocation

No features are more essential to this market incentive scheme than the determination of the aggregate cap and the allocation of the aggregate among sources. And no features are more subject to debate. Setting the cap gives the government a control measure over aggregate pollution, a big step forward from CAC regulation where frequently the rate of emission but not the aggregate is subject to control. However, setting the optimal cap, where presumably benefits equal costs, is a difficult issue to resolve to everyone's satisfaction (equivalent to deciding whether C_1 or C_2 is better in Figure 1).

In theory, once the cap is determined, the appropriate number of tradable rights could be auctioned off without affecting the cost-effective outcome of market incentives. Emitters have complained that if they have to pay for rights and also introduce control measures, they are being charged twice (auction revenues could be recycled in answer to this point). In any event, both markets under consideration allocated allowances and credits free of charge to secure the cooperation of emitters. The discussion did not end with free allocation, however. Allocations to generating units or facilities require some benchmark or baseline, again a potentially controversial decision. The distributional implications of allocating tradable rights worth substantial sums are clearly important to interest groups and rent seekers.

For ACID RAIN SO_X, the Phase I aggregate cap was set at about 8.7 million tons annually, a 20 percent reduction from the historical emissions benchmark of the average of 1985 to 1987. The Phase II cap was set at 8.95 million tons annually, a 50 percent reduction for the larger set of emitters. Allocations were made to individual generating units (a utility may control one or more units) by multiplying an emissions rate for SO_2 times the unit's benchmark heat input.

However, adjustments to this calculation were made during the legislative process. An extra 3.5 million allowances were provided for utilities choosing to add SO_2 scrubbers. A smaller amount of extra allowances were also provided because of past state regulations or unusual circumstances of the benchmark period (Joskow and Schmalensee, 1996). Such additional allocations can be carried forward under the banking right.

Finally, 2.8 percent of individual allocations were set aside for an annual public auction to assure new entrants in the electricity generation field of access to allowances.

For RECLAIM NO_X, the aggregate cap was reduced in a series of equal percentage cuts from 40,000 tons annually in 1994 to 10,000 tons in 2003, and constant thereafter. Allocations to individual facilities (an emitter could control one or more) were based on planned reductions under CAC regulation. That is, covered facilities received allocations of RTCs equal to what emissions would have been under the earlier planned CAC regulatory system. To secure cooperation from emitters, who had numerous complaints about their share, over-allocations were made during the first few years to ease the transition. Recall that RTCs are dated and cannot be used after expiration so that any excess of RTCs cannot be carried forward.

RECLAIM NO_X, while not providing for public auctions did not prohibit privately sponsored auctions, at least two of which have been established and become well publicized.

Monitoring, Recordation, and Enforcement

In the case of ACID RAIN SO_X, continuous emissions monitoring equipment appears to be providing accurate readings on emissions. The U.S. EPA has an allowance tracking system that operates much like a checking account for each utility's generating unit providing information on the location of allowances, but not on the prices of transactions. If emission limits are violated, the utility forfeits allowances to cover the excess and pays automatic fines well above the average cost of compliance.

In the case of RECLAIM NO_X, continuous emissions monitoring and fuel meters are used to verify emissions, but the technology appears to be less well established and tested than for SO_2 emissions. The SCAQMD must approve each trade and prepares publicly available reports on transactions and price data, and even on stated reasons for a transaction (Prager, et al., 1996). While penalties for facility emissions in excess of RTCs are specified, the District has preferred to work with emitters to correct problems.

In sum, the major differences appear to be that RECLAIM NO_X allocates tradable permits based on unit CAC projections, curtails banking, limits trading between two areas, and requires emitter reports on trades, whereas ACID RAIN SO_X allocates permits based on a unit's historical benchmark, allows banking, has no geographical restraints, requires recordation of allowances utilized at true-up time, and is applied to a heavily regulated industry. The similarities are important: Both programs create markets open to all traders, are based on a cap that decreases over time, allocate allowances or credits to individual units or facilities, and rely on decentralized control decisions that can respond to cost-minimizing incentives. With these differences and similarities in mind, we present data on the first few years of market activity.

PRICES & TRANSACTIONS IN THE CAP-AND-TRADE MARKETS

ACID RAIN SO_X

We consider first data from the annual public auction managed for the U.S. EPA by the Chicago Board of Trade. This auction, currently scheduled each spring, offers the 2.8 percent set-aside of SO_2 allowances in a discriminant-type market where bids are arrayed from high to low with successful buyers paying what they bid. Private offers, with reservation prices, may also be entered in the auction in which case low offers are matched with high bids, the latter price prevailing. The auction is of interest as it would appear to cut a quantitative window at one point of time into the more general ongoing SO_2 allowance market where private bilateral transactions are harder to trace.

Table 1 organizes the price and transactions data for the first four auctions, 1993 through 1996, as reported by the U.S. EPA. Allowances are sold for use in the current year or for use six or seven years ahead. The observed data have surprised many observers who were expecting higher prices and more bids and offers.

All publicly offered allowances have been sold, but almost none of those privately offered. The clearing prices reveal a strong downward trend after the second auction. The spread between the prices of current and future use allowances provides information on the time premium. Informed traders will have discounted future prices at least by the carrying costs over six or seven years. Given the tightening of the cap in Phase II, the small size of the time premium suggests that utilities are anticipating even lower prices perhaps due, in part, to reductions in control costs.

Perhaps the biggest surprises of Table 1 are the low and declining prices of spot allowances and the apparently small number of utilities participating in the auction. Figure 2 provides information on the pre-auction expectations of allowance prices. The direct sale price for allowances was set at $1,500 at the time of the act, to be indexed for inflation. A later estimate of marginal control costs by the U.S. EPA was $750 a ton, which provides an indicator of the allowance price when the market is in equilibrium. A utility survey at about the same time revealed a range of estimated marginal control costs with an expected value of about $600. An econometric study by the Electric Power Research Institute placed the average marginal control cost for major regions at about $700, although the variation among regions was substantial. While these numbers may be based on varying conceptions of costs, auction prices are far below these and most other prior estimates (U.S. GAO 1994).

The auction provides only a narrow window on the broader market; but, there is evidence that auction prices, although perhaps subject to some bias due to the type of auction, are close to and even lead private bilateral transaction prices taking place elsewhere throughout the year (Joskow, et al., 1996). If these prices are reflective of marginal costs, as we interpret them, then significant events are taking place at the utility level in controlling SO_2 emissions at costs well below the expected level.

Transactions activity presents more of a problem for analysis because the auction may represent only a small share of total trading. Few utilities have been the apparent buyers in the auction, although several utilities have purchased the major share of allowances among them being Illinois Power, Carolina Power and Light, and Duke Power. As mentioned, privately offered allowances on the auction have not sold well because reservation prices were higher than bids, perhaps not surprising given the earlier expectations of high control costs.

The U.S. EPA allowance tracking system in the general market appears to confirm the suspicion that some utilities are not actively trading allowances. After several years of activity, fewer than 12 percent of the 31,000,000 recorded allowances transferred were inter-utility; that is, were trades between independent utilities. The great majority were transfers among generating units owned by a utility (Burtraw, 1997). It would appear that a number of utilities were, as part of their compliance activity, not trading allowances, but were transferring them among units or banking them for future use (Rose, 1997).

The apparent lack of trading could be taken to mean that the market is not working well in equating marginal costs across emitters. The apparent pattern of low prices could be taken to mean that the market is working well in stimulating cost-saving control measures. The data present a paradox that calls for resolution.

RECLAIM NO_x

Figure 3 organizes price and transactions data as reported by the SCAQMD through 1995. The price per ton of NO_2, read on the right hand side of the figure, rises in step with the reduction in cap through 2004, as might be expected. While the trajectory is plausible in view of the declining cap, both the low starting price and ending constant prices are noteworthy. The former may be largely due to the large initial over-allocations. The SCAQMD writes that it expects that the over-allocation of dated RTCs to be fully worked off by 1997-1998. Figure 3 does reveal an acceleration of the price path for credits of vintage beyond that point of time. The program is up for sunset review in 2004 which may explain constant prices after that date.

Figure 3 also reveals that transactions between independent companies, for a reported price, were relatively small percentages of allocated RTCs. RTCs of future date may be bought or sold enabling emitters to anticipate requirements by building an intertemporal portfolio, but little trading of this nature has been reported. These transactions data require a more detailed analysis which we shall turn to shortly; but, as in the case of SO_2, they would appear to be an indication that the RECLAIM NO_x market is yet to work at full capacity.

Figure 4 organizes expected and reported prices for the years 1994 through 1999. As in the case of the SO_2 allowance market, the difference between the two is striking. The expected prices were estimated by economists using a sophisticated quantitative model that allowed emitters to choose the least-cost combination of particular control technologies (Johnson and Pekelney, 1996). These estimates, generated prior to the initiation date of the market, have turned out to be much higher than reported RTC prices. Both markets have revealed tradable right prices below expected values due, in our interpretation, to market incentives stimulating reduced control costs. Before defending this interpretation, we make use of these allowance and credit prices to prepare revised estimates of savings realized to date.

THE EXTENT OF SAVINGS: INTERPRETING PRICES & TRANSACTIONS DATA

Savings Estimates

The first estimates are based on the assumption that the markets are at competitive equilibrium, an assumption that we examine critically in the next section. The method is straightforward — we need estimates of the reduction in emissions multiplied times the difference in market-based compared with CAC control costs.

For ACID RAIN SO_X, Phase I emissions have been running well below those of 1990 and below required reductions (Burtraw 1996, Figure 2). Actual emissions in 1995 and 1996, during which period electricity output increased, were about 3.4 million tons below the allowable 8.7 million. Auction allowance prices that cleared the market were $130 per ton in 1995 and $66 per ton in 1996 (taken from Table 1) at the clearing level, which provides our estimate of short-run equilibrium marginal control costs under market incentives. Using the forecasts of control costs in Figure 2 as CAC marginal values, and drawing on anecdotal estimates drawn from other sources to give a spread in this uncertain area, we obtain the ingredients for estimating the difference between marginal costs under incentives and under CAC, and for estimating a range of savings as follows:

Savings Estimates: Acid Rain SO_X

Year	Emission Reduction	Mcc Difference	Estimated Annual Savings ($ Billions)
1995	3.4	$170 to 570	0.6 to 1.9
1996	3.4	$230 to 630	0.8 to 2.1

Notes: Emission reductions are in millions of tons of SO_2. Mcc equals marginal control costs. The highest estimates for CAC values are from Figure 2, and the lowest ($300 per ton) are from Rose (1977). The market incentive values are from Table 1.

These are short-run marginal cost differences applicable to Phase I. Savings based on marginal control costs differences may be too high if we use Figure 1 as a guide. The difference in the height of the triangles multiplied by the reduction in emissions overstates the savings. Furthermore, linear cost curves were chosen to simplify the exposition not to correspond to reality. To be conservative, we divide the savings by half obtaining estimates of 0.3 to .95 billion dollars for 1995 and 0.4 to 1.05 billion in 1996. These conservative savings estimates could range up to 25 percent of CAC costs for these two years, and are not far from those of the Government Accounting Office (1994).

For RECLAIM NO_X, we start with the savings estimates based on the model simulations by Johnson and Pekelney (1996, p. 281) comparing RTC price with CAC regulation incremental costs. These estimates of compliance cost savings were obtained by model simulations of RTC prices determined in a market compared with engineering type calculations of CAC costs for the years 1994 through 1999. For example, these savings due to market incentives were calculated to be $98 million for 1995 and $47 million for 1996 (in 1987 dollars). We have set aside 1994 as an outlier start-up year.

However, the Johnson and Pekelney simulated RTC prices turned out to be much higher than actual RTC prices reported by emitters to the SCAQMD for the vintage years 1994 through 1999 (Figure 4). Their savings estimates are too low if reported RTC prices rather than simulated prices reflect marginal costs.

Before revising the Johnson and Pekelney savings estimates, we must deal with the impact on reported prices brought about by the over-allocation of RTCs during the first year or two of RECLAIM. That is, we need to find some way of calculating what reported prices would have been without the over-allocation. Reported prices in 1997 and 1998 are likely much closer to defensible estimates of costs, and provide a statistical way around our problem. The 1997 vintage reported price, at which time the overhang will have been reduced, is close to the 1995 Johnson and Pekelney simulated RTC value for that year. We are prepared to use it as a surrogate for what the 1995 reported price would have been without the over-allocation. Since the 1997 vintage reported price and 1995 simulated price are close, we are prepared to defend the savings estimate for 1995 as not needing much adjustment. The same cannot be said for 1996.

The 1998 vintage reported price, at which time the overhang ought to be eliminated, is only seven percent of the Johnson and Pekelney simulated value for 1996. No reasonable adjustments can bring them into alignment. Our conclusions are that their 1996 simulated market price is much too high and therefore their savings estimate, market incentive over CAC, for that year is too low. Reinforcing this conclusion is the fact that the 1998 cap is below that of 1996. Taking a conservative position, we double the Johnson and Pekelney savings estimates for 1996, obtaining a total of $94 million.

Our revisions, increasing the savings estimates over what had been expected, are in the correct direction even though surrounded by generous confidence intervals. For 1995, cap-and-trade market costs were 12 percent of what CAC costs would have been as estimated by Johnson and Pekelney. For 1996, cap-and-trade market costs were 31 percent of what CAC costs would have been by our estimates.

Our conclusion is that significant savings are being realized in both ACID RAIN SO_X and RECLAIM NO_X markets compared with what CAC costs would have been.

However, this conclusion rests squarely on the assumptions that observed prices for tradable pollution rights in both markets correspond to marginal control costs and that reported transactions are sufficient to equalize marginal control costs across all emitters. We are prepared to defend these assumptions as reasonable, but they have been challenged and require a more thorough defense.

ARE MARKET IMPERFECTIONS AFFECTING PRICE & TRANSACTIONS DATA?

In the case of acid rain SO_X, concerns have been expressed that the layers of regulation on utilities impede market activity, that utilities exhibit inertia and anxiety about public relations, that the design of the auction market is flawed, and that large transactions costs deter trading. In the case of RECLAIM NO_X, concerns include over-allocation of RTCs during the first years, denial of banking, large transactions costs, and excessive reporting requirements. These possible imperfections, if significant, could limit the use of prices as indicators of marginal control costs.

Is Trading Activity Sufficient to Assure Price Discovery?

In reply to the concern that the amount of trading activity is insufficient in both markets, we note that active trading is not a requirement for attaining savings in all circumstances. If emitters were to have identical cost functions, and if pollution rights were distributed equally among them, then cost-effectiveness could be obtained with no trading (although in this special and unlikely case cap-and-trade markets would have no advantage over CAC regimes).

However, the case of equal cost functions is far from the situation in either market. A Government Accounting Office study found wide variations in estimated incremental control costs among utilities covered by ACID RAIN SO_X; some utilities having ten to twenty times the costs of others (GAO, 1994, Figure 2.3 and Appendix Figure I.1). The variety of industries covered by RECLAIM NO_X — ranging from oil and petroleum extraction and products, to stone, clay and glass, and then to electricity, gas, and sanitary services — also militates against this idea.

A more plausible case occurs if tradable pollution rights were allocated to emitters in proportion to their marginal control costs. Low cost emitters having few rights would use control measures, and high cost emitters having more rights would return them to the government rather than use control measures; that is, a cost-minimization allocation obviates the need for numerous, if any, trades.

There is some research and evidence on this allocation issue. A detailed study of the ACID RAIN SO_X locations concludes that the final distribution showed some correlation with cost estimates aggregated by state (Joskow and Schmalensee, 1996), but considerable variation remained at the generating unit level (GAO, 1994). While it is difficult to see how allocations based on benchmark emissions rates, plus the numerous adjustments for special circumstances, would have resulted in a perfect cost-minimization distribution, it is equally difficult to argue that every utility must engage in numerous trades to equate marginal costs.

No comparable studies of the relation of marginal costs to the RECLAIM NO_X location of RTCs to facilities appear to be available. RTCs were to be allocated at a facility-specific rate equivalent to the average allowable emissions that would have been achieved under the SCAQMD's plan to implement future CAC regulations (Johnson and Pekelney, p 281). It is not inconceivable that emitters with high costs received more RTCs than the average; however, the tendency of CAC regulation to apply the same measures to all sources regardless of costs works against any close correspondence to a cost-minimization allocation. Again, the incentive to trade under this allocation rule may have been less, at least in the first years, than under alternative distributions.

Despite doubts, we are unable to reject the possibility that high cost emitters tended to get larger allocations than low cost; that is, a distribution with some correspondence to cost-minimization did occur in both markets. This possibility would help explain both the apparent small number of trades and the savings compared with CAC regulation. However, the number of transactions by itself is not the only, or perhaps even, the important question. Rather, we ask: Are emitters using high cost control measures instead of reducing costs by acquiring allowances or RTCs? Investigating this question leads to the other concerns about the markets.

Are Market Participants Taking Full Advantage of Trading?

Some observers have found the layers of regulations on the electric utility industry as a reason for their reluctance to engage in trading in the ACID RAIN SO_X market. The lack or vagueness of appropriate rules and guidelines issued by public utility commissions, by the Federal Energy Regulatory Commission, and even by the Internal Revenue Service have been seen as impediments to utilities taking advantage of the new incentives (Rose, 1997). The treatment of expenditures for tradable rights as capital or current expenses, the question of trading gains or losses accruing to shareholders or ratepayers, and the tax implications of capital gains for traded rights initially allocated free of charge, are all among the regulatory issues that require clarification if trading is to be facilitated. Lack of regulatory clarification may explain why some utilities with high marginal costs are not active bidders in the auction markets (GAO 1994).

A recent study has challenged this view by examining trading activity by state. Considering data on trades between independent parties occurring within a state, Bailey (1996) concludes that activity has not been limited to states with the most complete regulatory rulings, and that regulation has been developed as utilities have entered the market. A limitation of the study is that the analysis was based on the existence of a trade within the states but not on the volume of trades.

Utilities have been active in transferring their allowances among their own generating units. These transfers are not subject to the same regulatory scrutiny as inter-utility or brokered trades and have made up 85 percent of the 26 million U.S. EPA recorded exchanges of allowances through 1995. There are two implications of note in these data: First, the potential savings in control costs by intra-utility reallocation could be very significant; and second, a rational reallocation of allowances within the utility requires some imputation of allowance price. The best source for that imputation is a credible market price.

Are Prices of Tradable Pollution Rights Credible?

The public auctions of SO_2 allowances taking place every spring have been acclaimed as a means for price discovery and for promotion of liquidity. The credibility of this price information (see Table 1) has been questioned on the grounds that the discriminant market nature of the auction leads to strategic bids and offers that produce a price below the desired equilibrium value. A study by Joskow et al (1996) finds some evidence of this bias in the first year of the auction, but finds, for later years, that the prices are tracked very well by other price information from brokers in the larger, continuing market. Offer prices have, in the auction market, been too high limiting sales rather than too low. Bid prices have narrowed in range over the four auctions indicating that buyers are well informed about prices in the outside market. There is little evidence of bias.

The SCAQMD publishes data on reported RTC prices over the various vintage years. These prices also correspond with the price ranges reported in the private auction markets (reported in a personal communication from Robin Langdon, Manager of Cantor Fitzgerald's Clean Air Auction). The admitted large initial over-allocation of RTCS — but not over-emission of NO_X — during the first several years coupled with the denial of banking strongly suggests that the low prices of 1994 and 1995, at least, be equated with over supply and not with costs (SCAQMD 1996, Figure 3.1, p. 025). However, reported prices for RTCs of later year vintage reflecting the tightening of the cap are, in our view, serious candidates for marginal cost estimation.

Both markets appear to be the arena for competitive broker activity with a resulting downward pressure on transaction expenses for trader search, price discovery, and negotiation.

Anecdotal reports on utility reluctance to enter the market because the act of purchasing pollution rights might be misinterpreted by the public, and reports that the

SCAQMD's requirements for recording trades inhibit market participants are both hard to evaluate, but could be expected to be impediments if they exist, that diminish over time.

These emerging cap-and-trade markets appear to be going through a transitional period in terms of government over-regulation and (some) emitter reluctance to take full advantage of the new opportunities. However, our analysis indicates that they are performing well for new institutions. In sum, we find that a great deal of trading may not be necessary for tradable right prices to be reasonable approximations to equilibrium values, and for a significant number of emitters to equate their costs to these prices by trading. The active reallocation of rights within the emitters' jurisdiction points toward an appreciation of their value. The close relationship of auction to privately determined allowance prices, and reported to privately determined RTC prices, is evidence of active markets. To conclude otherwise, in our view, risks arguing that emitters persist in passing up profitable trading opportunities.

Our interpretation of the data is that prices lower than expected are not so much an indication of imperfections in the market, but more a result of introducing new cost-saving measures. In fact, having cleared a path through the underbrush of concerns about market malfunctioning, this study leads to the question we consider of great importance: What kinds of new control choices have been stimulated by incentives at the emitter level that have led to lower prices of tradable rights, and consequently savings?

HOW ARE DECENTRALIZED CONTROL CHOICES LEADING TO STATIC & DYNAMIC COST-EFFECTIVENESS?

While both utilities generating electricity and the enterprises covered by RECLAIM use highly capital intensive production methods, and would appear to be locked into emission control procedures, there exist cost-effective short-run options for altering production inputs or for introducing control measures that can reduce emissions per unit of output. Furthermore, there is taking place what we discern to be innovations in perfecting these options and measures even in the short-run. Market stimulation of these new arrangements is an important factor in explaining the low prices of allowances and credits and, consequently, in achieving cost-effective control of pollution.

In looking beyond the immediate short-run, more fundamental innovations appear on the horizon that further reduce the SO_X and NO_X emission content per unit of output. The most telling criticism of CAC regulation is that it impedes progress on these fronts in two ways: It does not create incentives for choosing least-cost arrangements and innovative methods, and it can actually inhibit such progress.

A detailed investigation into the research and development expenditures underway in these innovative areas is highly desirable, and likely to reveal that the markets have actively stimulated the search for and introduction of new control measures. Our endeavor to scout this important research area draws on numerous conversations with utility staff and observers, and on surveys of possible innovations, for example, Blasing, et al. (1996).

ACID RAIN SO_X

We can detect signs of what is going on in the immediate short-run affecting emissions. They include the increased use of low sulfur coal, altered power purchasing arrangements, changes in the share in output of two or more generating units, and the optimization of intertemporal emission levels. Many of these options and measures have been known for some time, but under market incentives, something new is being added.

Railroad deregulation has acted to reduce the rates of hauling western low sulfur coal and expanding the latter's market area. This reduction in transportation costs, so important in the coal industry, was underway prior to 1990 (Ellerman and Montero, 1996). What is new under cap-and-trade market incentives is the improved train arrangements (longer trains, for example) and innovative actions of the low sulfur coal industry in extracting and marketing their product, including the packaging of allowances with coal sales.

Utilities that once thought blending low with high sulfur coal would be expensive or impossible, have found ways of doing just that in light of the altered relative prices. It is reported that the problem of waste generation, which has in the past been aggravated by the use of low sulfur coal, is being dealt with in innovative ways.

There are stories of new power purchasing arrangements that enable utilities to deliver power with lower emissions content. Utilities with generating units that use different fuels or fuel mixes have shifted allowances among these units so as to generate kilowatt hours with reduced emissions content. Choosing an intertemporal mix of units, in part by scheduling repair and maintenance activities, to meet emissions goals has become part of the compliance plan.

An indication that utilities are giving thought to innovative intertemporal emissions planning can be seen in such allowance swaps as Allegheny Power's transfer of 1996 and 1997 allowances to Duke Power for 1995 allowances in return. Brokers report developing allowance derivatives that look much like future and option contracts. Competition among brokers appears to be leading to decreases in transactions costs for such risk reallocation instruments (Colton, 1997).

More options become available when horizons beyond the immediate short-run are considered. Utility managers who once were concerned that the CAAA'90 would force expensive scrubbing with conventional fuel gas desulfurization technologies have found the future much less bleak. As coal will continue for some time to be a major energy source for electricity, there exist repowering and retrofitting technologies under development that can make high sulfur coal more benign. The economic performance of these technologies remains to be determined, but the incentives are in place to create a competition based on cost-effectiveness. Forecasts that oil and gas would likely not increase as an energy source for electricity much beyond their present 15 percent share seem now to be an underestimate. Innovations in gas and oil generating units appear promising.

For some time, the energy efficiency of generation has been improving at a rate close to one percent per year, which means less SO_X emission per kilowatt hour delivered. Some of the best gas turbines achieve a 50 percent efficiency rating currently, far above the industry average. There is much room for continued improvement, and market incentives serve to help this rate, along in cost-effective ways.

Another significant trend is the decarbonization of the energy supply. Carbon contributes to blackened lungs and air pollution as it is a surrogate for sulfur and heavy metals that attach to it in fossil fuels. Decarbonization has occurred over time as the importance of different fuels has changed. The story is told in the carbon intensity of fuels in tons per kilowatt year: wood being .84, coal .73, oil .55, gas .44, and ultimately hydrogen at very low values. The direction of the trend is apparent, and appears to be accelerated by market incentives. Not that fuel cells are right around the corner, but interest in the required research and development activities has been stimulated.

RECLAIM NO_X

NO_X emissions arise in a number of industries, including electricity generation, which also have a variety of short-run and long-run options that can alter the ratio of emissions to inputs or output. Innovations in these control measures can also be discerned.

The short-run control options include a variety of combustion controls, several types of catalytic converters, seasonal gas use, altered power purchasing arrangements, and alternate emissions reduction schemes. Again it is possible to detect not only use of existing short-run options, but also innovative ways in exploiting them. CAC regulation with its emphasis on the rate rather than the volume of emissions for a given technology would be unlikely to stimulate the decentralized variety of arrangements underway in the Los Angeles region.

Utilities covered by RECLAIM have increased their purchase of power from outside the region. Given the prevailing winds, NO_X emissions generated from outside power sources are unlikely to be transported to heavily populated areas. Low NO_X burners are important control devices attached to boilers and furnaces. The rate of improvement of these burners has reportedly increased under market incentives. Catalytic reduction is expensive, but selective catalytic reduction appears to be the most promising option under development. The copper oxide process is attracting more attention.

Under the RECLAIM program, stationary NO_X emitters can claim emission reductions credit by designing programs to scrap high emitting vehicles, two-stroke lawn mowers, and old fashioned outboard motors for boats. The cost of these options in terms of dollars per ton reduced, based on the first few efforts, seems very cost-effective. These options provide one way to bring the important mobile and area sources of emissions under the market incentive framework. The SCAQMD staff reports calls from inventors who have new ideas and want to be put in touch with emitters. Such calls rarely occurred under CAC regulation.

CONCLUSIONS

We do not agree with the view that transactions are too few and prices too low in these cap-and-trade markets to signify much success in achieving savings. Rather, prices for tradable pollution rights demonstrate the cost-effectiveness of cap-and-trade markets at work: They reflect the flexibility of control options being implemented as emitters make full use of their information on control choices. They are low because cost-effective options exist in both markets that are now being utilized. Having surveyed some of these options in this study, we are the first to admit that there is much more to be learned about this process.

This is not to argue that the markets have reached their full potential. We are inclined to assign less weight to such often cited reasons for this performance as newness of the market or lack of information on market operations; incentives have a way of overcoming such impediments. Public response to trading appears to have turned favorable as additional information has been provided on the social gains of trading.

Our comparative study leads us to assign more weight to removing certain impediments to improved market performance. For ACID RAIN SO_X, the clarification of PUC and FERC regulations affecting utility behavior in the market would in no way be inconsistent with other regulatory goals and would contribute to market efficiency. Given the initial reluctance of some utilities to support the cap-and-trade market program, the increasing level of trading activity is a positive sign of the sway of market incentives. The relatively successful accomplishments of the first few years should bring the last of the resisters into an active role.

The annual public auctions might be scheduled at a time closer to the "true-up" period to make transactions more relevant to the time of annual settlement. The development of standard futures and options contracts may be feasible as market activity continues to increase. Such a development would contribute to cost-effectiveness by reallocating risks to more willing takers.

Our comparative study would indicate, for RECLAIM NO_X, that the close supervision of the SCAQMD over transactions reporting may become an impediment once emitters have gained experience. Any thought among emitters that this new-fangled mechanism would be blown away with the first change of the political wind must grow more unrealistic as RECLAIM continues in existence. The District has taken the right tack by working with the apparently 14 percent of emitters who have exceeded their limits. Inexperience and the difficulties of measurement of NO_X emissions, a difficulty that is being addressed, are the most likely explanations of this problem during the first years. The prohibition of banking could be revisited once the over-allocation of RTCs has disappeared from the scene. Although reinstating a form of banking may be difficult, it would facilitate more rational intertemporal choices in a program with a continually declining cap.

Despite the imperfections in the markets, we believe the most defensible appraisal of their early performance is that prices have become better indicators of marginal control costs over time, and that emitters entering the market have brought their marginal control costs into correspondence with prices. Cost-saving transfer of rights among units or facilities — intra-enterprise decisions — are making their contribution. All these market activities add up to significant savings. If the maximum potential savings are not being achieved as yet, it is a reasonable bet that hesitant emitters, spending more on compliance than they have to, will become more aware that there are profitable opportunities for trading in the cap-and-trade market.

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TABLE 1

QUANTITY AND PRICES OF SO_2 ALLOWANCES TRADED AT ANNUAL AUCTION (1 TON = 1 ALLOWANCE)

Date of Auction or Bid (Spring)	Year Allowance First Usable	Number of Allowances Publicly Offered (tons)[a]	Number of Allowances Privately Offered (tons)	Number of Privately Offered Allowances Sold (tons)	Number of Bids: Total	Number of Bids: Successful	Clearing Price ($/ton)
Phase I							
1993	1995	50,000	95,010	10	106	36	131.00
1994	1995	50,000	58,001	0	103	17	150.00
1995	1995	50,000	8,306	600	89	26	130.00
1996	1996	150,000	8,000	0	139	47	66.05
Phase II							
1993	2000	100,000	30,500	0	65	30	122.00
1994	2000	25,000	50,000	400	70	10	140.00
1994	2001	100,000	47,000	800	111	19	140.00
1995	2001	25,000	7,000	400	24	9	128.00
1995	2002	100,000	7,000	400	37	17	126.00
1996	2002	25,000	7,000	0	34	9	64.14
1996	2003	100,000	7,000	0	92	25	63.01

Source: Annual CBOT Reports

[a] All publicly offered allowances were sold for all years.

FIGURE 1

MARKET INCENTIVE AND CAC CONTROL COSTS COMPARED

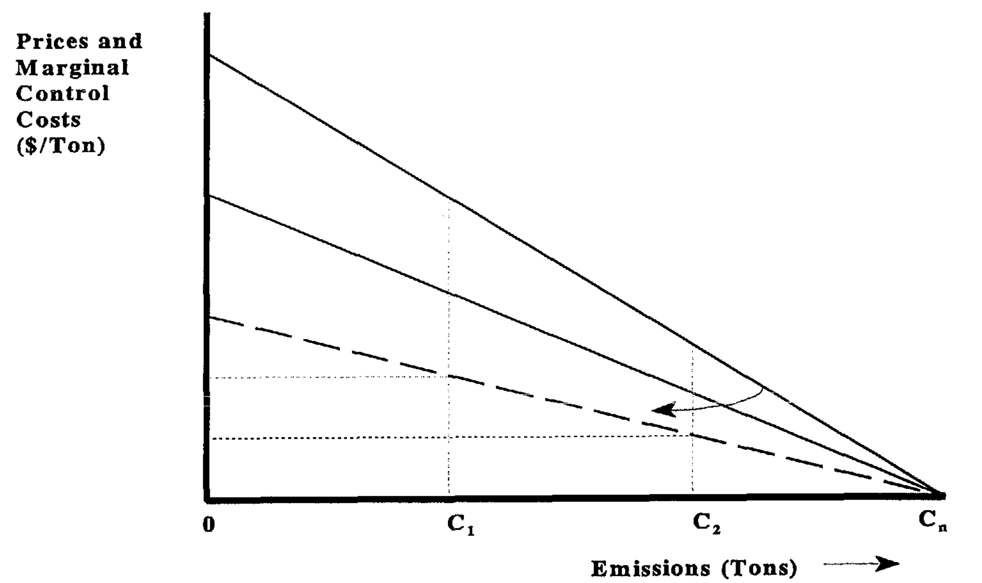
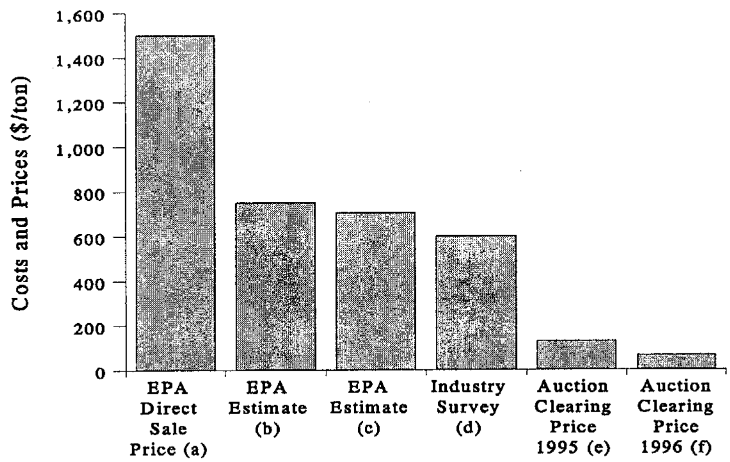


FIGURE 2

ESTIMATED ABATEMENT COSTS AND AUCTION PRICES OF SO_2 ALLOWANCE



a The Clean Air Act requires EPA to offer allowances for direct sale at $1,500, indexed to inflation

b EPA estimated the incremental cost of allowances to be approximately one-half of the direct sale price when trading began

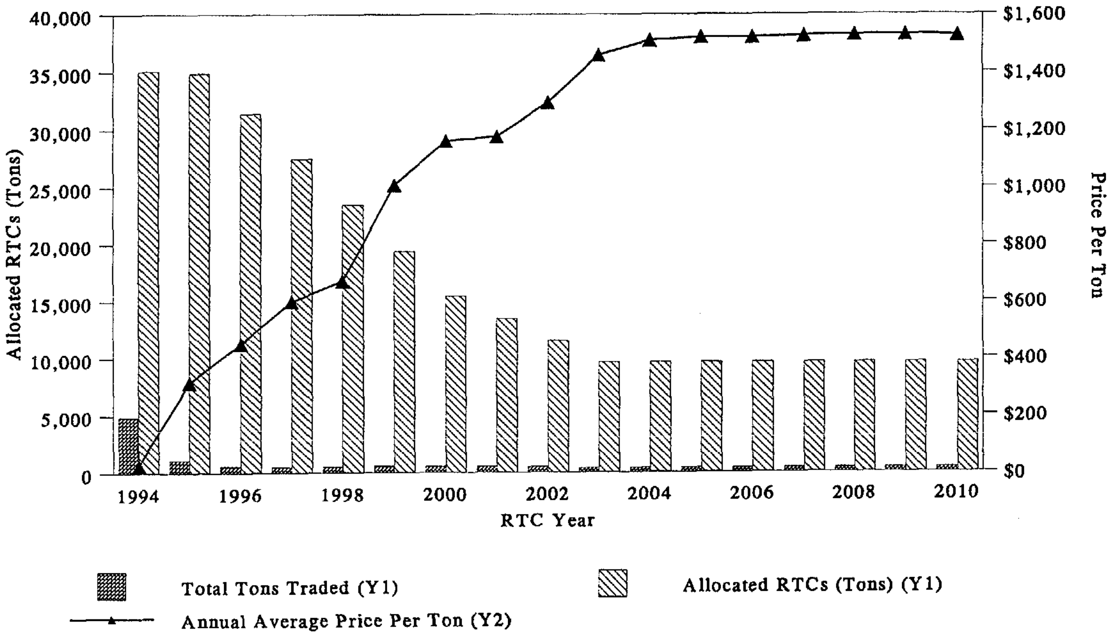
c Integrated Analysis of Fuel, Technology, and Allowance Markets: Electric Utility Responses to the Clean Air Act Amendments of 1990, Electric Power Institute (EPRI), TR-12510 (Aug. 1993). Shown here is the average of regional marginal costs

d AERX Survey of Utilities

e & f Annual U.S. EPA and CBOT Reports

FIGURE 3

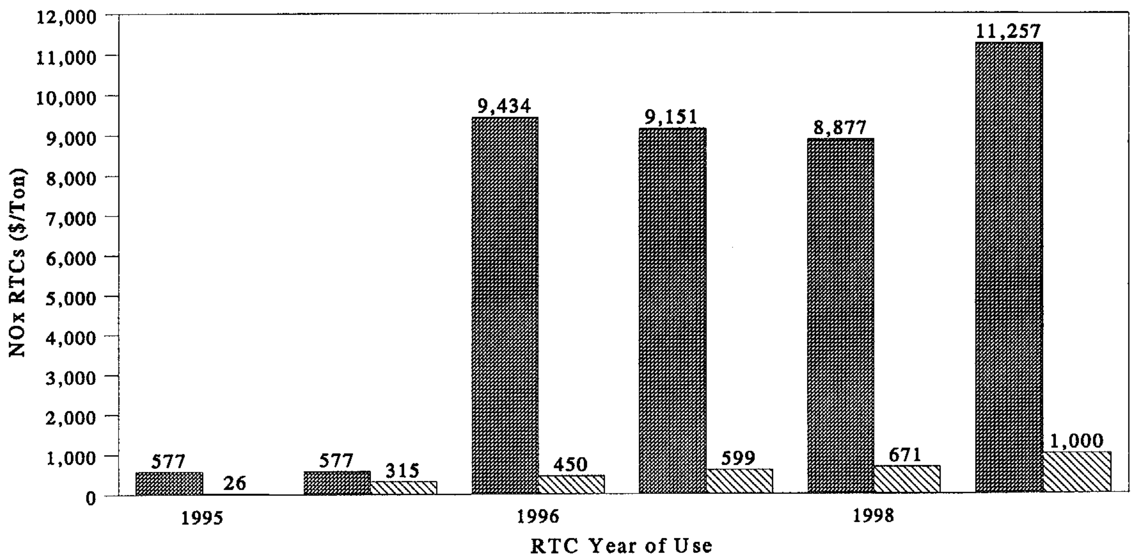
ANNUAL AVERAGE NO_x RTC PRICES, ALLOCATED RTCs, AND TRADED RTCs



Source: SCAQMD, 1996 Tables 4.4 and 4.7

FIGURE 4

PROJECTED AND REALIZED RTC PRICES



Source: SCAQMD, 1996 Tables 4.4 and 4.7

THE SO_2 TRADING PROGRAM AS A METAPHOR FOR A COMPETITIVE ELECTRIC INDUSTRY

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Philip O'Connor is a national utility consultant providing strategies for development of competitive services in a deregulated utility environment. The following tables highlight the key points of his presentation which focused on competitive market impacts of SO_2 emissions trading.

TABLE 1

KEY PRINCIPLES OF SO_2 TRADING

- Solved "stranded cost" and subsidy problem by allocating tradable allowances on the basis of past emission levels.
- Gave credit for recent compliance expenditures.
- Redirected focus from value of emission to value of reduction.
- Avoided playing technology favorites.
- Provided long-term certainty for the system — Life of allowances open-ended.

TABLE 2

KEY RESULTS OF THE SO_2 TRADING PROGRAM

- SO_2 reductions ahead of schedule.
- Compliance costs only 1/20th of worst predictions.
- Coal market rationalized — Cost differences between western and eastern coals wiped out so far.
- Has set the stage for NO_x and other trading programs.

TABLE 3

KEY IMPLICATIONS FOR A COMPETITIVE ELECTRIC INDUSTRY

- SO_2 program has not distorted electric market by seriously disadvantaging some competitors.
- Compliance flexibility has helped to avoid stranded cost add-ons.
- Consistent with movement to incremental cost and real-time pricing of electricity — Each kilowatt hour will incorporate its environmental cost.
- Trading template provides a perfect fix for any regional pollution transfer (NO_x) from electric competition.

TABLE 4

SO_2 TRADING AS A METAPHOR FOR COMPETITION IN THE ELECTRIC INDUSTRY

SO_2	ELECTRICITY
• No restrictions on ownership and control of SO_2 allowances.	• No restriction on control of kilowatt hours or other products.
• Technology and fuel neutral.	• "Least cost" planning, regulated DSM and technology favoritism obsolete.
• Program initiation smoothed by allocating allowances based on past emissions and compliance expenditures.	• Stranded cost compensation and sharing will be a threshold question to initiate prompt retail access.

ILLINOIS TASK FORCE ON GLOBAL CLIMATE CHANGE

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THE CLIMATE CHANGE PHENOMENON

Scientific evidence indicates that average global temperatures increased by 0.5 to 1.1° during the 20th century. Atmospheric concentrations of greenhouse gases rose 30 percent. Theoretically, these two events are related through the operation of a natural process known as the greenhouse effect.

The presence of a greenhouse effect is essentially undisputed. Gases in the atmosphere, such as water vapor, carbon dioxide, methane, nitrous oxide and other trace gases, are relatively transparent to incoming shortwave solar radiation. As a result, the sun's energy passes through the atmosphere to the earth's surface where some of it is absorbed. The heated earth emits part of its stored energy or heat into the atmosphere as long-wave terrestrial radiation. The greenhouse gases, opaque to long-wave radiation, trap radiant energy and reflect it back to earth enhancing the warming of its surface.

While the empirical evidence for human-induced climate change is not unequivocal, many involved scientists believe that the earth's climate will warm by several degrees over the next few decades. Science is unable to predict the rate or magnitude of local or regional temperature or precipitation patterns at this time. Predicting changes in the variability of climate and weather patterns is also beyond present capabilities. The only certainty is that the climate has shifted and fluctuated over the decades and centuries in the past and that it will remain unstable.

THE ILLINOIS TASK FORCE ON GLOBAL CLIMATE CHANGE

The Illinois Task Force on Global Climate Change was authorized by HJR 84 in 1991 "to monitor national policy and to study and make recommendations for state policies and programs regarding climate change." The task force is composed of state legislators, state agency directors and private citizens representing business, agriculture, academic and scientific institutions, and environmental organizations.

After a series of meetings, the group concluded that Illinois should respond to the potential for climate change to protect its interests on two fronts. First, the future of the state's essential natural resources and weather-sensitive human activities could be negatively affected by climate change if nothing is done. And second, the future health of the state's economy could be negatively affected by federal climate policies if Illinois is not involved in their development. The task force set out a series of policy recommendations for global climate change policy in *A Climate Change Action Plan for Illinois* in July 1994.

The task force was re-authorized by the General Assembly (HJR 124) in July 1994. In light of continued pressures for action and potential costs of postponing action, task force members began developing strategies for implementing their earlier recommendations.

ILLINOIS' RESPONSE TO CLIMATE CHANGE: EXECUTIVE SUMMARY[1]

As a result of the Berlin Mandate, international pressures are growing for more stringent federal greenhouse gas emissions measures. By 1997, industrialized countries are expected to develop a strategy to reduce greenhouse gas emissions below their 1990 levels after 2000. Given an abundance of coal reserves and heavy reliance on nuclear facilities, Illinois could be placed at a competitive disadvantage should federal mandates be adopted to achieve stabilization of greenhouse emissions without the state's input. To meet national climate change goals and demonstrate that mandates are unnecessary, Illinois should implement programs to reduce emissions, adapt to climate variations, and strengthen research on and public awareness of climate change.

A Climate Change Action Plan for Illinois (1994) recommended a set of responses to climate change. Since its publication, the Illinois Task Force on Global Climate Change has moved forward to implement the state plan and launch climate change strategies in the areas of national policy development, emissions reduction, research and education, and adaptation. The purpose of this report is to document progress

[1]Illinois Response to Climate Change; Report of the Task Force on Global Climate Change, Illinois Department of Natural Resources. IDNR/EEA-96-01.

in these areas and to identify additional specific actions that will be undertaken to implement the state action plan.

ACTION PLAN PROGRESS

The Task Force on Global Climate Change has developed greenhouse gas inventories and identified numerous effective, socially beneficial and cost-effective programs for reducing greenhouse gas emissions in the atmosphere. Energy efficiency measures, forestry programs and joint implementation projects (cooperating with others outside the state to achieve emission reductions) have all demonstrated promise for Illinois. The promotion and widespread adoption of these activities within the state is needed to demonstrate the effectiveness of voluntary measures in achieving significant emissions reductions.

Illinois is moving ahead on climate monitoring, impact research, and education. A Climate Change Center was designated as a clearinghouse for climate research and benchmark weather stations were established to monitor climate changes. In addition, several long-term projects have been established to disseminate information about global climate change and its effects on Illinois. These activities will require continuing support to build a foundation for dealing with extreme weather events and potential global warming. Climate related adaptation needs are also being addressed in Illinois. Conservation 2000 contains provisions to study state water laws to determine what can be done to alleviate crises during extreme weather events. Other initiatives are underway to deal with floodplains and infrastructure.

Illinois is a climate change leader among the states. It is among the first to inventory greenhouse gases, develop a state plan and implement climate change mitigation pilot projects. The Illinois Task Force on Global Climate Change has provided input into the national climate change action plan and its implementation, voluntary emissions and emissions reduction reporting, and joint implementation guidelines. Because the state has been active, Illinois is now considered an authority among states on climate change policy and has credibility in the national climate change policy debate.

Much progress has been made on implementing *A Climate Change Action Plan for Illinois*. However, the process is incomplete. More work is needed in national policy development, emissions reduction, research and education, and adaptation.

NATIONAL POLICY DEVELOPMENT

National and international climate change policy are still in a developmental stage. Informed participation could mean the difference between policies that are beneficial and those that are detrimental to Illinois. To protect Illinois interests while meeting national goals, the state should continue to:

- Track national and international climate change policy,
- Help shape the national climate change policy agenda, and
- Advocate a "nuclear-conscious" emissions baseline and alternative fuel initiatives.

The Illinois Task Force on Global Change tracks policy development and makes recommendations to state and national policy-makers as needed. To assure that this work continues, the task force should be re-authorized and the climate change program at the Department of Natural Resources continued. This working group, representing diverse interests affected by climate change, can continue to provide input as new issues arise and oversee implementation of the state's climate change action plan. Contacts have been initiated with federal government agencies to create an awareness of Illinois' unique nuclear profile, exert pressure for a level playing field and protect Illinois interests in the shaping of the national climate change policy agenda.

EMISSIONS REDUCTION

Illinois and other states can serve as independent laboratories to demonstrate that meaningful reductions can be achieved through voluntary initiatives. Illinois must embrace options that reduce emissions to meet national goals while serving the interests of Illinois. In an effort to implement the climate change action plan, the task force has begun to identify and launch cost-effective mitigation measures.

Economic analyses have shown that conserving energy is the most cost-effective way of reducing emissions and that forestation and forest management are practical means of removing carbon from the atmosphere. State and private energy efficiency and forestation activities are being inventoried and several programs launched to strengthen state efforts to reduce atmospheric greenhouse gases. New programs include expansion of the DNR tree seeding distribution program through private contributions to the Conservation Foundation and the capture of methane for energy production under the Landfill Methane Outreach Program. These activities are effective in reducing atmospheric concentrations of greenhouse gases and have other social benefits beyond their climate effect — reducing pollution, enhancing environmental quality, saving energy, increasing energy independence and improving public health. Illinois has also explored innovative projects such as developing a feasibility study for the repair of leaking gas pipelines in China to reduce atmospheric greenhouse gas emissions. This international joint implementation project was found to be a cost-effective means of reducing greenhouse gas emissions.

RESEARCH AND EDUCATION

The science of climate change remains uncertain, and the federal research agenda continues to focus on uncertainties. Little support is provided for policy-relevant research concerning the economic, social and environmental impacts of change, the development of adaptation techniques or mitigation measures. Conflicting views of climate change are disseminated through the mass media. Efforts are being made to:

- Develop a capacity to measure climate change indicators,
- Develop and implement a state climate change research agenda,
- Maintain and enhance Illinois-relevant research, and
- Strengthen climate change education.

During 1995, several benchmark weather stations have been designated to monitor climate change indicators. The Illinois climate network and private weather stations were put to use in climate monitoring. In 1996 scientists, policy-makers and state agency staff convened a conference as a first step in developing a state climate research agenda. The State Water Survey and the Department of Natural Resources urged the federal government to fund more policy relevant climate change research. And, to counteract the conflicting views of climate change in the media, several climate change education programs are being initiated. Project Environmental Literacy 2000 is designed to make environmental issues, including climate change, a part of grade and high school science education. Project Plan-It provides teaching materials, class projects and teaching plans for specific environmental issues.

ADAPTATION

Some actions are needed whether or not global warming becomes a reality. Recent events revealed that Illinois is not prepared to deal with water resource crises precipitated by weather extremes. Furthermore, Illinois could be vulnerable to climate change in other ways. Changes in floodplain designations, modifications in infrastructure planning, and research into new crop strains could put the state in a better position to deal with climate extremes. Steps are being taken to:

- Strengthen Illinois water laws to protect water quantity and quality, and
- Plan for adaptation.

The Conservation 2000 legislation passed in 1995 provided funding for a review of Illinois water laws and the laws of other states to determine what they do in times of crisis. The study is to be completed in 1996, and legislation will be prepared to modify the water laws. Floodplain remapping has commenced as a part of the National Flood Insurance Program. In 1996 DNR determined whether construction rules that take climate change into account have been developed elsewhere and review their applicability to Illinois. In addition, areas with particular vulnerability to climate change have been identified; these include the Chicago Metropolitan Area, the Illinois River Basin and the Great Lakes Basin.

TABLE 1

ILLINOIS CLIMATE CHANGE TASK FORCE

- Created by the Illinois General Assembly in 1992; housed in Department of Natural Resources
- Monitors national policy and studies and recommends state climate change policies and programs
- Inventory of greenhouse gas emissions to establish a baseline and inform the task force
- Recommendations for state climate change policy
    - A Climate Change Action Plan for Illinois, June 1994
- Reports on implementation progress
    - The Illinois Response to Climate Change, January 1996

TABLE 2

ILLINOIS INVENTORY OF GREENHOUSE GAS EMISSIONS AND SINKS — 1990 HIGHLIGHTS

- Inventory Methods
  - States Workbook/EPA Funding
  - DNR Database Availability
- Results
  - Emissions Levels
  - Distribution
  - Projections to 2000
- Inventory Use
- Updates

TABLE 3

A CLIMATE CHANGE ACTION PLAN FOR ILLINOIS — 1994 POLICY PRINCIPLES

- Scientifically Sound
  - Reduce uncertainty about magnitude, timing and potential impact
  - Increase effectiveness
  - DNR database availability
- Cost Effective
  - Reduce economic costs
  - Take into account environmental benefits and social effects
- Promote International Cooperation
  - Act in concert with others for global solution to global problem

TABLE 4

THE ILLINOIS RESPONSE TO CLIMATE CHANGE — 1996 HIGHLIGHTS

- National Policy Development
  - Tracking national and international climate change policy
  - Helping shape national policy agenda
- Emission Reduction
  - Identifying and launching cost-effective mitigation measures
- Research and Education
  - Developing capacity to measure climate change indicators
  - Maintaining and enhancing Illinois relevant research
  - Strengthen climate change education
- Adaptation
  - Strengthening water laws
  - Planning for adaptation

FIGURE 1

ILLINOIS GREENHOUSE GASES
CHANGES IN GREENHOUSE GAS EMISSIONS 1990 — 1994

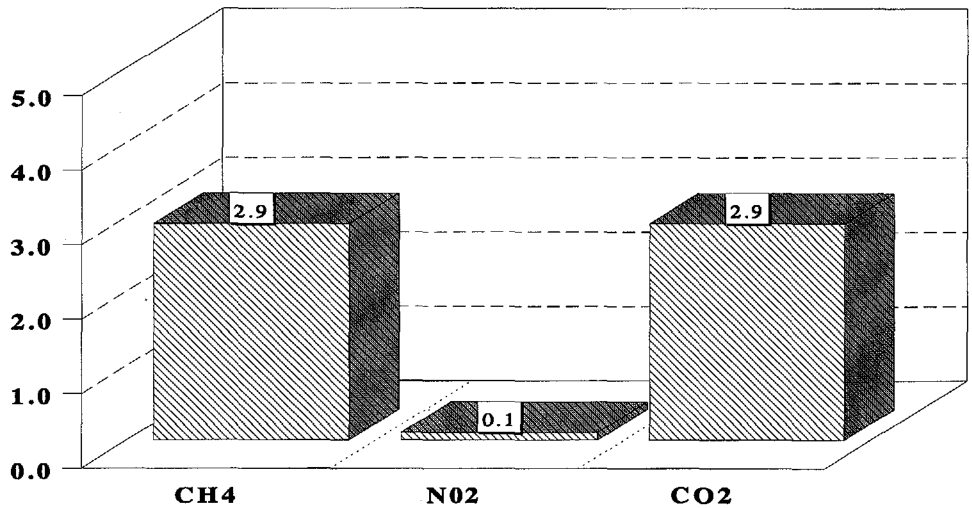


FIGURE 2

CONTRIBUTION TO GREENHOUSE EFFECT BY SECTOR, 1994

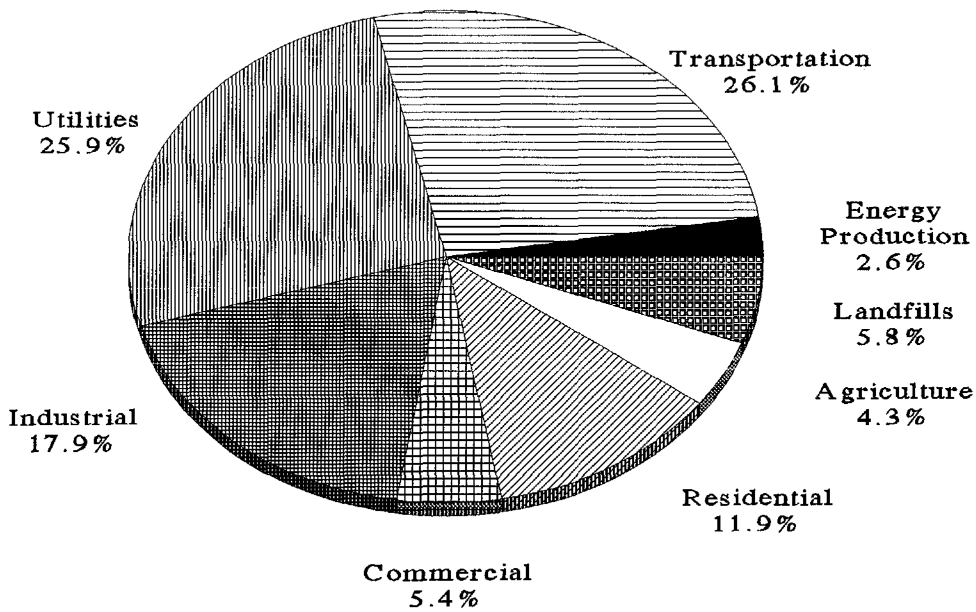


FIGURE 3

ILLINOIS SHARE OF U.S. EMISSIONS, 1994

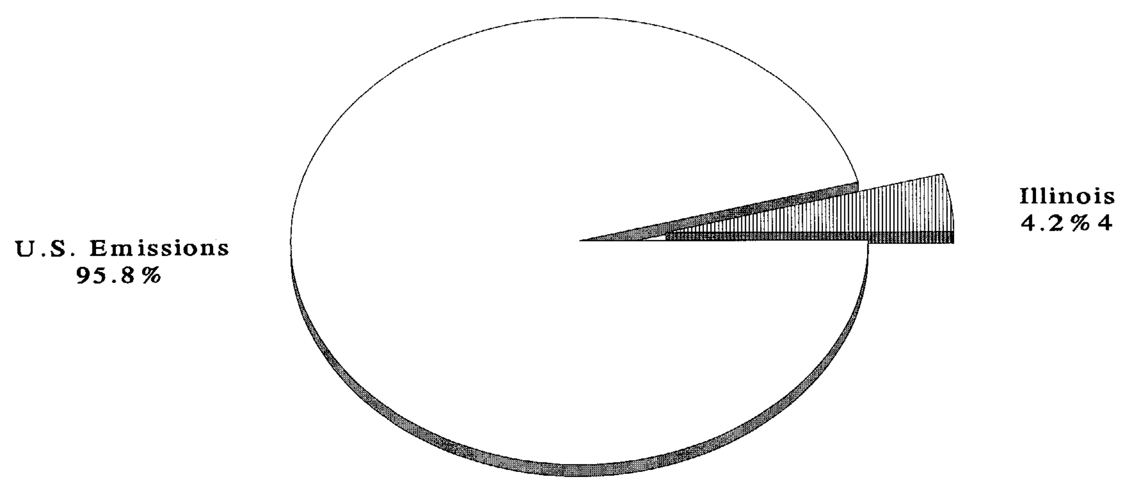


FIGURE 4

ILLINOIS GREENHOUSE EMISSIONS IN CO2 EQUIVALENT
1970-2000

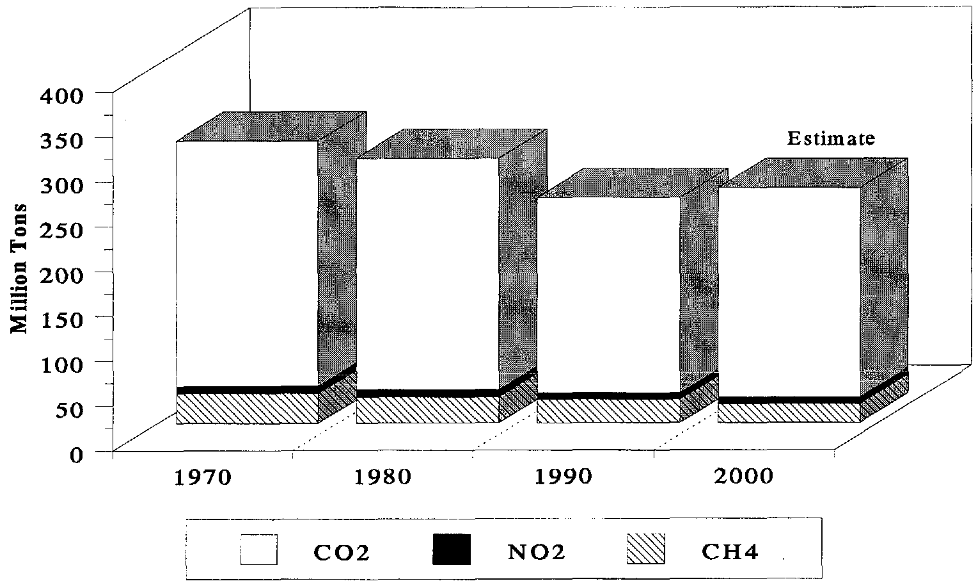


FIGURE 5

ILLINOIS GREENHOUSE GAS EMISSIONS IN CO2 EQUIVALENT
1990, 1992 and 1994

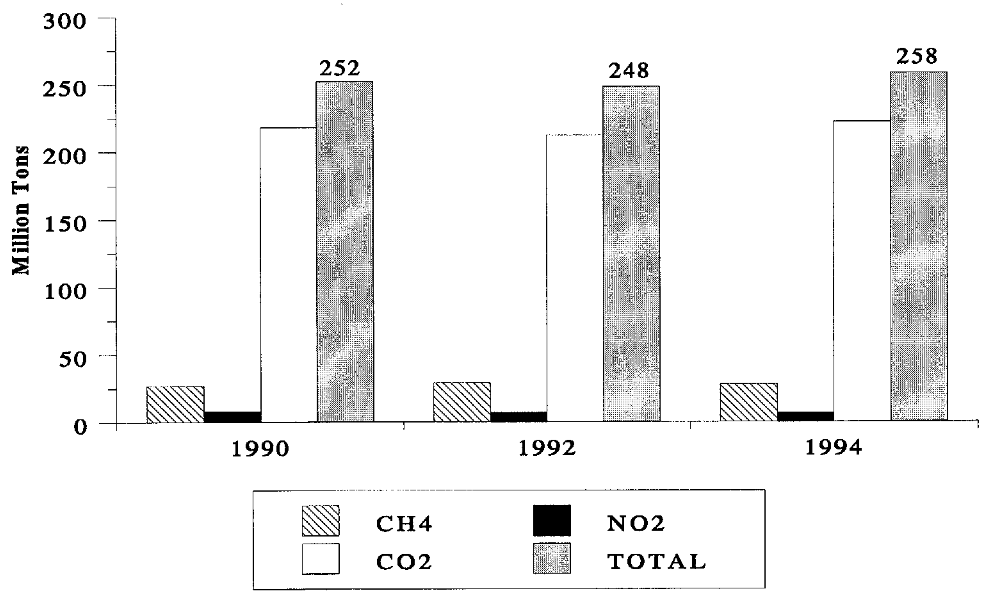
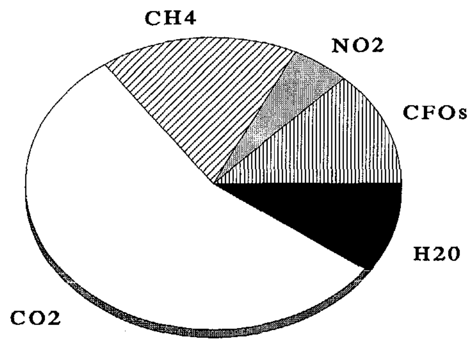


FIGURE 6

ILLINOIS CLIMATE CHANGE PROGRAM

Global Greenhouse Gases



GHGs — Sources & Sinks

Sources		**Sinks**
CO2	fossil fuels	forests
	cement production	ocean
	deforestation	crops
	transportation	soils
CH4	rice paddies	
	domestic animals	
	landfills	
	natural gas leakage	
	biomass burning	
	wetland	
	coal mining	
NO2	fertilization	
	fossil fuel &	
	biomass combusiton	
	domestic animals	
	transportattion	
CFCs	refrigerants	
	industrial solvents	
	fire retardants	
H2O	evaporation	

SESSION III:

TRANSPORTATION AND THE MARKETPLACE

TRANSPORTATION AND THE MARKETPLACE

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INTRODUCTION

Ever since the end of the second World War there has been a steady increase in the number of private vehicles in the United States. In the Chicago six-county metropolitan area, even after many decades of growth in registered passenger vehicles it shows no sign of subsiding. Registered vehicles grew by over 800,000 vehicles in the 1980s; by contrast the population increased by just over 150,000 during the same time. This ratio of growth in automobiles versus population (five to one) is remarkable especially when compared with other metropolitan areas. While most, not all, metropolitan areas had a larger growth in cars than people, the size of the ratio is unusual. This large ratio has certainly contributed to overall increases in travel, congestion and energy use.

The objective of this report is to examine how and why this has occurred and what we might expect in the near future to address the growing traffic problems and energy use. Specifically the focus is on energy use by household vehicles as well as other forms of passenger travel rather than freight traffic during the last several decades.

CHANGES IN REAL PRICES OF GASOLINE

While it is common knowledge that the real cost of gasoline has declined during this century, it is useful to start from this perspective. Other than the spike experienced in the late 1970s and early 1980s, there has been a long-term decline in the principal transportation energy source (Figure 1). (All tables and figures follow this presentation). The spike in the 1970s likely contributed to the long-term decrease in prices, as exploration and discovery heralded in a new era of plentiful petroleum at modest costs. Prices have only recently begun to rise but this may be a short-term phenomenon.

Declining gasoline prices have made possible decreasing real costs per mile of travel and increasing numbers of passenger cars. Part of this decline in prices can be attributed to the fixed nature of gasoline taxes at the pump and the reluctance of governmental bodies to increase these taxes (local, state and federal). Concurrently many other nations have raised their gasoline taxes resulting in substantial increases in their gasoline prices, thereby strengthening the demand for energy efficient vehicles and curtailing the demand for energy. This has dampened the rising demand for gasoline at a time in which new discoveries have been boosting supplies.

EFFECTS OF POPULATION TRENDS ON ENERGY USE

The history of Chicago is characterized by continued improvements in the transportation system facilitating longer commutes, more travel and an increasingly larger metropolitan region. The declining prices seen on Figure 1 have contributed to these trends, but this is also driving up the demand for gasoline. As metropolitan regions grow in size so does the demand for travel.

The conventional wisdom is that recently the increase in passenger cars (in the 1960s) triggered the decentralization of urban activities. In the Chicago area, however, population has been decentralizing away from the downtown area for nearly the entire century (Table 1). The area within two miles of the center of Chicago (State and Madison Streets) reached its peak population near the turn of the century. Throughout the first half of this century the population of this area declined, and the new growth areas moved farther and farther out. The two-to-four mile donut reached its maximum population around 1910 to 1920 while the six-to-eight mile donut grew until the 1950s. This decentralization process has reflected changing and improved means of transportation. Over the 100 year span of Table 1, new means of transportation provided more comfortable ways to travel greater distances.

Currently the principle population growth is in the distant suburbs located over thirty miles from downtown Chicago (Figure 2). As was true earlier, the periphery is growing and the core area is declining in population. Not only is the City of Chicago losing population, but so are the majority of inner suburbs.

While this process is creating a vast metropolitan region, it should be noted that despite the population losses in the city and inner suburbs, the number of private vehicles in these declining areas is actually increasing. As a result the number of vehicles per person and the number of vehicles per household are increasing. In the 1980s City of Chicago households registered an 11 percent increase in the average number of private vehicles per household, larger than the percentage gain in any of the suburban counties. By contrast the percentage increase was only 2.4 in suburban Cook, 3.3 in DuPage County and a suburban high of 6.6 in Will County. These numbers suggest that not only are the suburbs dominated by automobiles, but the city is increasingly becoming more automobile oriented.

The rapidly decentralizing population has also contributed to a metropolitan area with still a rather densely populated core but also surprisingly low-density suburbs. In comparing suburban densities, Chicago ranks only twelfth among the 35 largest urbanized areas in the nation (Table 2). It is surprising that Chicago ranks so low but the lack of topographic constraints have allowed the region to grow outward, and as the area grows, each additional mile-donut area measured from the Chicago CBD encompasses a larger and larger territory. This has led to these exceptionally low densities. The surrounding satellite cities of Joliet, Aurora, Elgin and Waukegan initially drew suburban growth in their directions but there is now considerable urban expansion beyond these cities.

Perhaps most surprising is that Los Angeles houses the most densely populated suburbs in the nation. The pronounced mountains on the east and the ocean on the west have produced a legendary basin renowned for car traffic, smog and urban sprawl, but these reputations were earned in the past and "sprawl" is not a word that still applies to metropolitan Los Angeles; poor air quality still does. The limitation on the amount of land make even the smallest suburban Los Angeles land parcels rather expensive. The resulting small lots provide the area with moderately high densities. The inability of the urban areas to expand territorial, due to topographic constraints, seems to characterize many urban areas in California and Florida. The New York metropolitan area, ranked eighth, has the densest suburbs outside these two states.

In the Chicago area the low densities and the dispersal of population and jobs has yielded sharp contrasts in transportation energy use. Comparing the average commutes in the zero to two mile donut to those in neighborhoods in and near low-density suburbs such as Schaumburg, Hanover Park and Bolingbrook, suburban commuters typically consume ten times more energy in travel. Distances are commonly much greater and commuters frequently drive alone. Conversely, residents of the urban core frequently walk or use public transit systems which are characterized by very high load levels and therefore are very energy efficient.

Effects of Population Decentralization on Mode Use

Outside California and Florida, the prevailing tendency is the continued evolution of metropolitan areas into extensive territories of dispersed activities. Increasingly, urban activities are taking place beyond the core where the public transit system is best able to provide alternatives to automobile use. Considerable attention is now focused on building transit friendly and walking friendly neighborhoods (urban villages). This is a response to the precipitous declines in commuting by public transit and on foot during the last thirty years (Figure 3) brought about by the decentralization phenomenon. In 1960 transit and walking each accounted for over ten percent of the commuters, but by 1990 the two modes together accounted for less than ten percent. Many found themselves, perhaps by choice, in neighborhoods not well served by transit and with few practical walking destinations.

Even working at home has noticeably declined, although there was a slight increase between 1980 and 1990. Despite all the rhetoric regarding telecommuting, its effect on commuting has been minor. Recently studies have focused on the reluctance of companies to initiate telecommuting programs and why workers are reluctant to work at home, concerned about missing opportunities available only in the office. It is evident that the three traditionally energy efficient modes — transit, walk and work-at-home — have all declined with the changing form of urban America.

Within the Chicago area the picture is somewhat mixed. Commensurate with national trends, in the last fifteen years CTA bus use has declined 43 percent (Figure 4). This is partially attributed to a decline in the number of residents and jobs in its primary service area. Conversely Pace bus use, servicing the growing suburbs, has remained largely unchanged during the same period while both the two rail systems servicing the downtown have had only small declines during the same period. The shifts in mode use largely reflect the changing activity levels within their principal market areas. Typically, the low population densities and scattered job sites are not readily served by conventional public transit, and the recent trends toward continued population decentralization have not helped the transit providers.

Also the movement of jobs from Chicago to the suburbs has negatively affected transit patronage. In the 1980s the City of Chicago had a net decrease of 82,000 jobs while suburban Cook increased by 181,00 and DuPage County by 237,000.

Part of the declining use of public transit in the Chicago area can also be attributed to the relative costs of transit and gasoline. In the 1970s, when the United States experienced several energy shocks (declines in the availability of foreign sources), gasoline prices rose and through governmental policies transit costs declined (Figure 5). The 1980s were characterized by the opposite trends. Subsidies to transit declined, and with the emergence of many new suppliers of petroleum, gasoline prices declined.

TRENDS IN TRANSPORTATION ENERGY USE

Domestic Production and Transportation Energy Use

The changes in urban form and travel behavior have contributed to an increasing demand for petroleum. While there has not been a dramatic increase due to new efficiencies in our rolling stock, what is of concern is our dependence upon foreign sources to meet this demand. Figure 6 illustrates how the United States has become more dependent upon foreign petroleum. The greatest increase can be seen since 1985 when domestic production was almost sufficient to provide for at least transportation petroleum use. By then public recollection of the energy shocks of the 1970s was fading and the popularity of larger, less energy-efficient private vehicles rose.

Trends in Energy Use by Mode

The general public is responsive to declining gasoline prices and is either not concerned about or aware of the growing dependence of the United States on foreign sources of petroleum. A large number of consumers are opting for light trucks over passenger cars (Figure 7). Much of the increase in energy use can be traced to these vehicles (sports utility vehicles and vans). They are typically large vehicles which are far less energy efficient than passenger cars. They are safer than small vehicles and they provide good traction off the road and in heavy snow. Energy use is secondary to purchasers of these vehicles.

Energy use by these vehicles increased in the early 1970s but then remained stable for a five-year period from 1978 to 1982 (inclusive) when energy supplies were uncertain and prices were increasing. There was another plateau ten years later, but as a whole, there has been a substantial increase in energy use by these vehicles. From 1970 to 1994 there has been a threefold increase.

By contrast energy use by passengers vehicles (excluding light trucks) has changed very little in the last fifteen years and only slightly more since 1970. The increase in the number of vehicles is offset by the improvements in energy use. It even declined immediately after the second petroleum shock in 1977.

Also, while not obvious from Figure 7, the energy use by buses has almost doubled during this period. This is more apparent in the next section.

Trends in Energy Use per Vehicle Mile

Per mile passenger vehicle energy use has shown a noticeable decrease since 1970 attributable to a significant effort to make vehicles more energy efficient. Corporate Average Fuel Efficiency (CAFE) standards have stimulated producers to manufacture more energy efficient vehicles, and since 1980, the Gas Guzzler Tax has had an effect on consumers. The tax increased steadily until 1991 when all Gas Guzzler Tax levels were doubled from the previous change in 1986 and reached a maximum of $7,700 for vehicles obtaining less than 12.5 miles per gallon. The lowest tax, $1,000, was assessed on vehicles in the 22 to 22.5 mpg range; none on vehicles with better fuel economy. The taxes have remained at the 1991 level.

Consumers' and manufacturers' responses can seen in the total revenue generated by this tax. In its first year it generated only approximately $1 million but reached a high of $176 million in 1986 when the levels increased substantially. From 1986 to 1990, before they were doubled in 1991, the total revenue decreased from $176 to $103 million. In 1992 it jumped to $134 million but it is clear that since current revenue totals are less than the 1986 level, the tax has accomplished its desired effect of decreasing the number of new energy inefficient vehicles.

Figure 8 shows that while there has been substantial progress in passenger vehicle fuel efficiency, there has actually been the reverse in intracity bus and little change in school buses. Since buses have been recognized for years to be energy efficient, there has not been the focus on making them more energy efficient. Much of the decline in energy efficiency can be attributed to heavier buses. More buses now have air conditioning units, lifts, passenger counting devices, kneeling mechanisms (allowing the bus to lower the front end permitting easier entry) and so on. Consequently from the early 1970s when the average bus mile consumed just over three times the energy of an average private vehicle's mile, the factor has risen to approximately eight.

It is critical to recognize, however, that these data come from different sources and direct comparisons between modes are not necessarily very accurate. Nevertheless, the data reflect long-term trends which cannot be ignored and deserve further study.

Trends in Energy Use per Passenger Mile

The consequence of these trends is that passenger vehicles are now a comparatively efficient means of transporting people. The energy use per passenger mile has steadily decreased for passenger vehicles while it has unfortunately increased for both intracity bus and for rail transit. In 1970 the energy use per passenger mile was more than twice as high as it was for automobile use. There has been a steady increase in energy use per passenger mile for both bus and rail, and since automobiles became more and more energy efficient particularly near the end of the 1970s, the relationship has now reversed. Moreover, this did not occur just yesterday but these data suggest that automobiles caught up with buses in 1990. It has now been true for more than half a decade. Again a cautionary note needs to be raised — comparisons between modes reflecting different data sources should not be interpreted too precisely.

This reversal is mainly due to declining low load factors on public transit as well as increases in energy use per vehicle mile (heavier buses). It should be noted, however, that these relationships hold for national averages and not necessarily to any given metropolitan area. Certainly conditions vary from city to city, and transit clearly has greater energy saving potential over passenger automobiles. Since it frequently runs with relatively low passenger levels, during the off-peak period and on back-hauls during the peak period, nationally it has lost its competitive edge in energy use. In cities like New York and Chicago, where load factors are high, it is unlikely that this relationship holds. Public transit can become more energy efficient as load factors improve. Ironically, technological improvements coupled with governmental policies have undermined energy efficiency measures.

FUTURE DIRECTIONS

There are typically two concerns regarding the performance of a transportation system: congestion and pollution. Both of these concerns relate to the amount and type of fuel used and they are examined briefly in this section.

Intelligent Transportation Systems

Since the large-scale expansion of our highway system is likely a thing of the past, methods need to be devised to more fully use the existing roadway capacity. This effort, through the use of modern technology, is called Intelligent Transportation Systems (ITS). ITS applies to both public transportation systems as well as private vehicles. In the private vehicular market, route guidance systems are currently available to direct a driver to a requested destination minimizing travel distance. Since many drivers add to roadway congestion by searching for a destination or using an inefficient route, ITS can decrease the use of highways. Dynamic route guidance, such as the ADVANCE project in metropolitan Chicago (the largest dynamic route guidance study to date conducted jointly by Illinois Department of Transportation, Motorola, University of Illinois at Chicago and Northwestern University), was designed to direct a driver around congested areas, not only to minimize travel time but also potentially fuel use. The technology in this study proved to perform well, and it may well be available on a large-scale basis in the near future. Some applications already are.

More efficient use and monitoring of buses is also being developed in ITS. The study by Pace in west suburban Chicago permits bus drivers to change traffic signals (signal preemption) affording buses priority over other traffic. This makes buses more efficient and potentially more attractive to riders while being more energy efficient. Similarly in the city, the Chicago Transit Authority is equipping buses with Global Positioning Systems (GPS) so that fleet managers have accurate information about the locations of their buses and they can respond more quickly to problems.

There are dozens of other examples of ITS such as demand coordinated traffic signals to improve traffic flow and incident detection methods to quickly inform traffic officers about traffic delays. The object is to make better use of existing highways, thereby having beneficial effects of both travel time and energy consumption.

Energy Sources and Air Quality

Since air quality affects everyone, there has been considerable attention focused on the role of the transportation sector in problem areas. While mobile sources of pollutants have been decreasing for several years, poor air quality persists in many urban areas. Also while there have been declines in most pollutants, ozone remains a problem. Los Angeles is a severe ozone non-attainment area and numerous other metropolitan regions have been designated as ozone non-attainment areas. Not all governmental policies have been successful. The Employee Commute Option (ECO) program, requiring expanded car pooling or other forms of ride sharing, proved to be unpopular and was withdrawn.

Conversely technology has been responsive. Highway vehicles emitted 31 percent less carbon monoxide in 1994 than in 1970 even with substantial increased travel. Nitrogen oxides are up by two percent during the same period but they, too, have declined from 1980. The greatest gains were made in curtailing volatile organic compounds (VOCs). Nationally, the amount of VOC emissions by highway vehicles decreased from 13.0 million short tons in 1970 to 6.3 million short tons in 1994. Decreases were also registered for emissions of particular matter.

In places like Los Angeles, the number of Stage One air quality alerts have declined from over 100 days in the mid 1970s to 14 in 1995 and only seven in 1996. While health concerns regarding mobile sources of pollutants continue, progress is being made.

TABLE 1

POPULATION IN THE CITY OF CHICAGO BY DISTANCE FROM THE LOOP 1860-1956

Year	0 - 2	2 - 4	4 - 6	6 - 8	8 +
1860	80	32	—	—	—
1870	175	105	19	—	—
1880	230	215	55	3	—
1890	325	490	165	80	40
1900	350	700	270	210	95
1910	360	715	620	290	200
1920	275	715	851	500	360
1930	221	663	962	822	708
1940	198	634	968	854	743
1950	221	673	981	866	880
1956	217	645	925	863	970

Source: Chicago Area Transportation Study, 1959

TABLE 2

LARGEST URBANIZED AREAS RANKED BY SUBURBAN DENSITY, 1990

	Urbanized Area	Central City Density	Suburban Density
1.	Los Angeles	7,426	5,009
2.	Miami	10,071	4,386
3.	San Jose	4,566	3,873
4.	Ft. Lauderdale	4,656	3,604
5.	Sacramento	3,835	3,288
6.	San Francisco/Oakland	10,500	3,185
7.	San Diego	3,933	3,034
8.	New York	23,705	3,027
—	— —	—	—
12.	Chicago	12,252	2,906

Source: Calculated by the author from Census data.

FIGURE 1

PRICE OF REGULAR GASOLINE

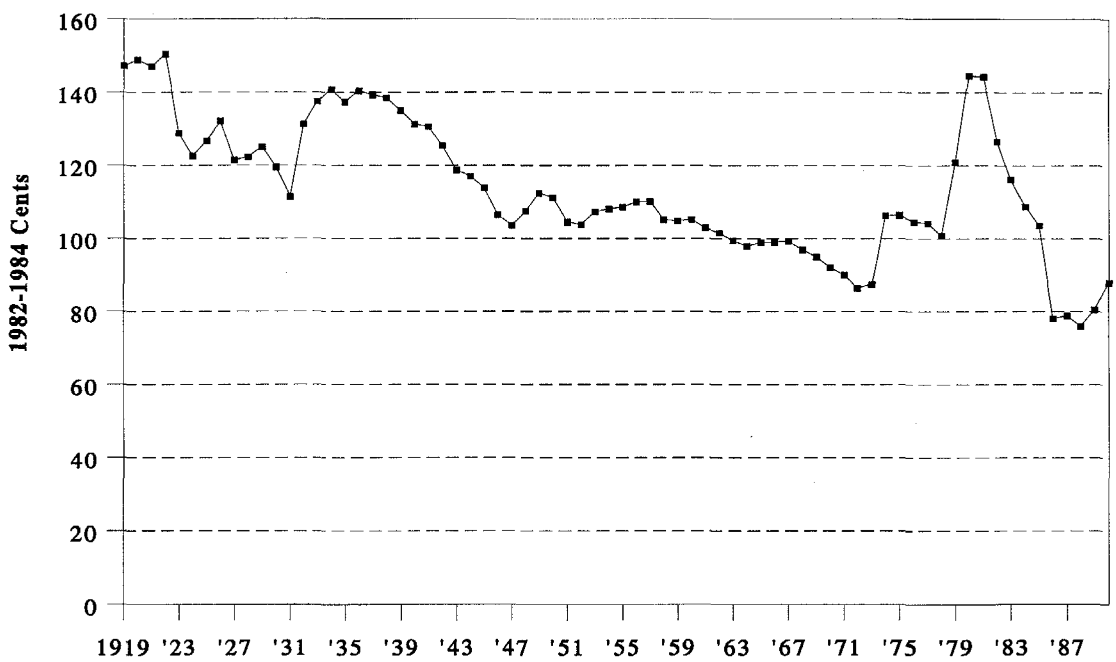
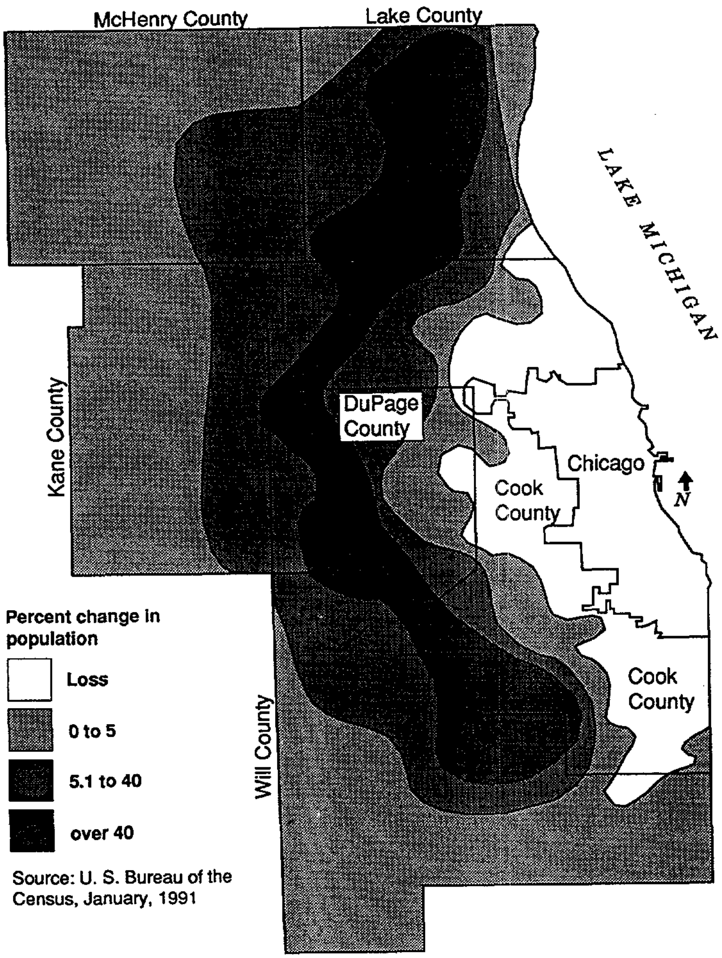


FIGURE 2

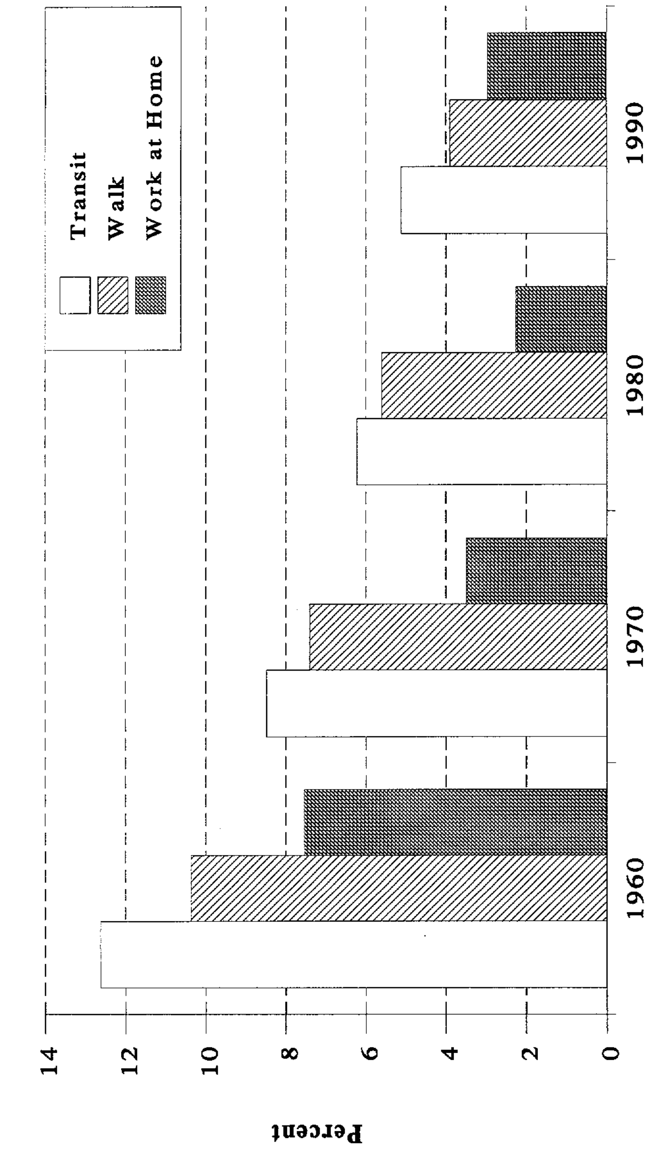
CHANGE IN POPULATION, 1980-1990
NORTHEASTERN ILLINOIS



Cartography Laboratory, Anthropology Department, UIC

FIGURE 3

TRENDS IN COMMUTING



Source: U.S. Bureau of the Census

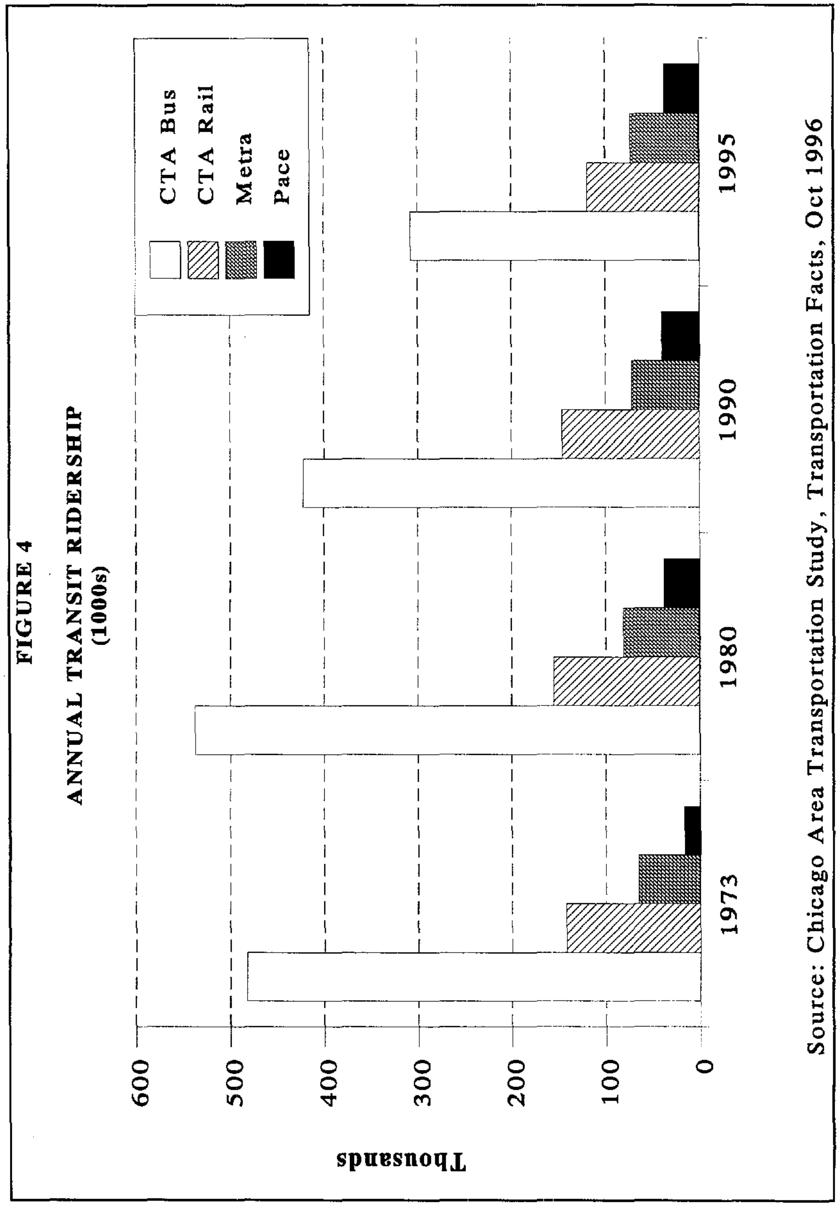
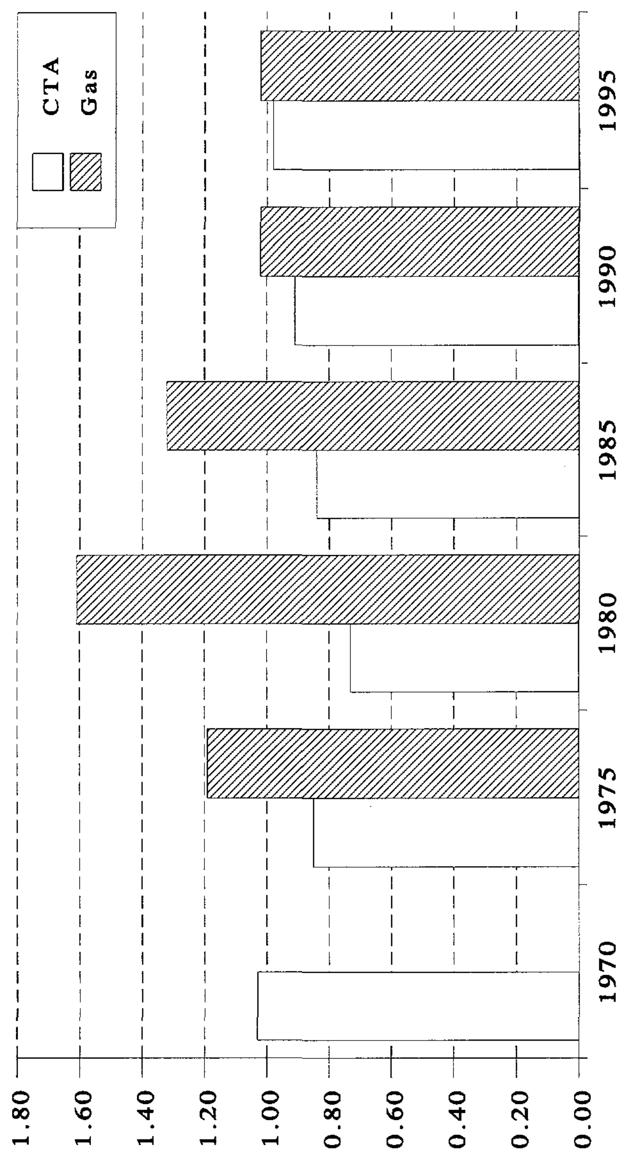


FIGURE 4
ANNUAL TRANSIT RIDERSHIP
(1000s)
Thousands
600
500
400
300
200
100
0
1973
1980
1990
1995
CTA Bus
CTA Rail
Metra
Pace
Source: Chicago Area Transportation Study, Transportation Facts, Oct 1996

FIGURE 5

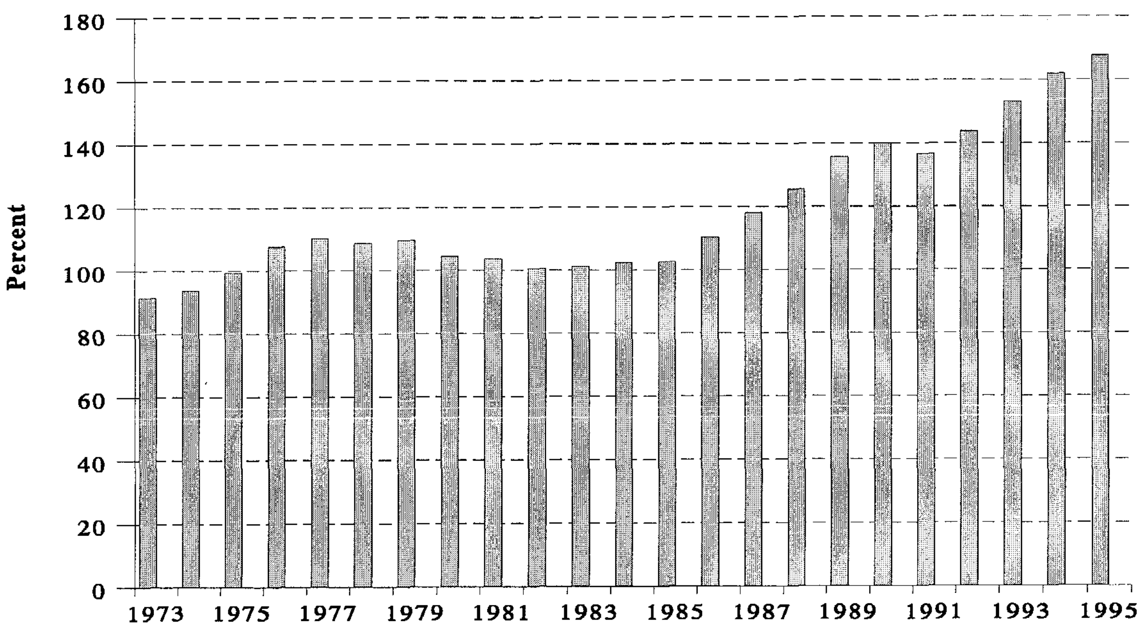
CTA BASE FARE AND AVERAGE COOK COUNTY COST OF A GALLON OF GASOLINE
(1982-1984 DOLLARS)



Source: CATS, Transportation Facts, Oct 1996

FIGURE 6

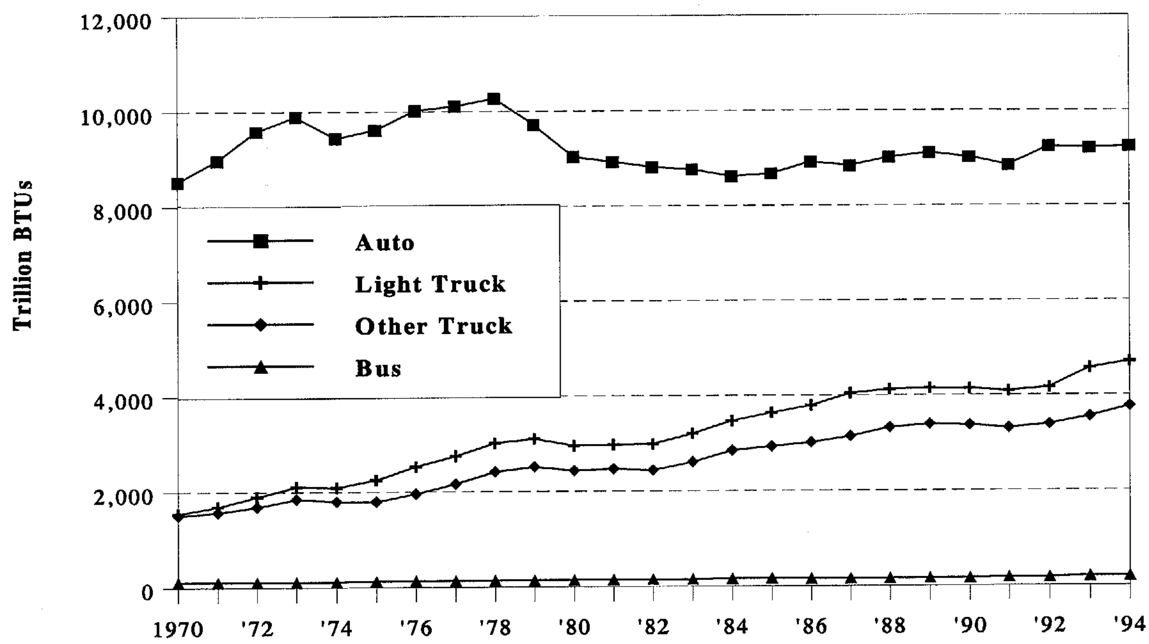
TRANSPORTATION PETROLEUM USE AS A PERCENTAGE OF DOMESTIC PRODUCTION



Source: Transportation Energy Data Book: Edition 16, Oak Ridge National Laboratory

FIGURE 7

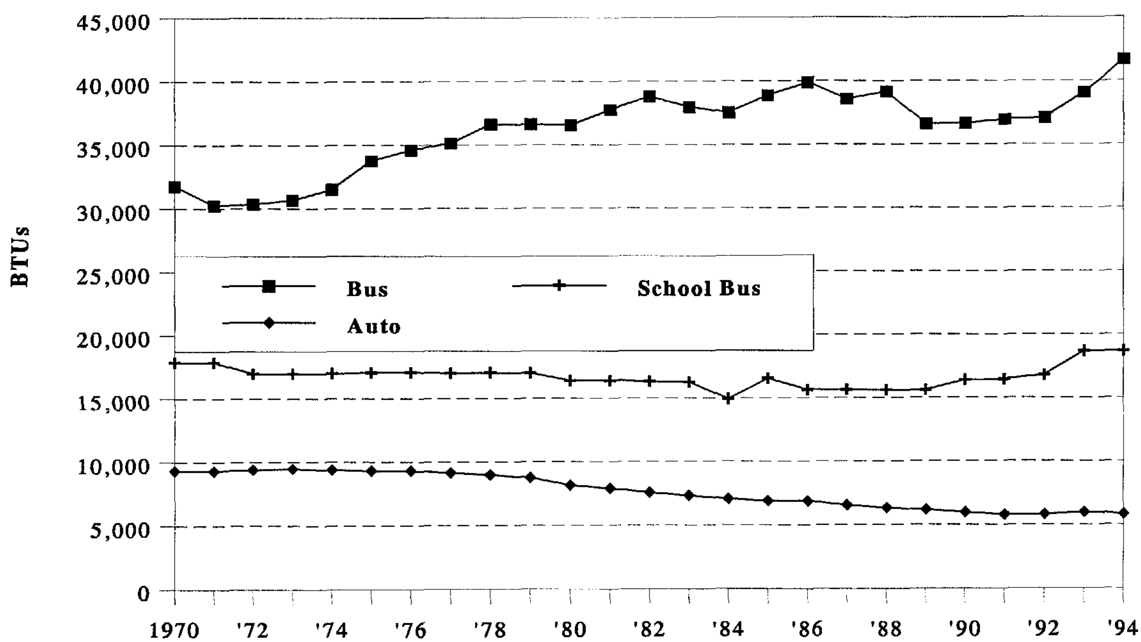
TRANSPORTATION ENERGY CONSUMPTION
1970-1994



Source: Transportation Energy Data Book, Edition 16, ORNL

FIGURE 8

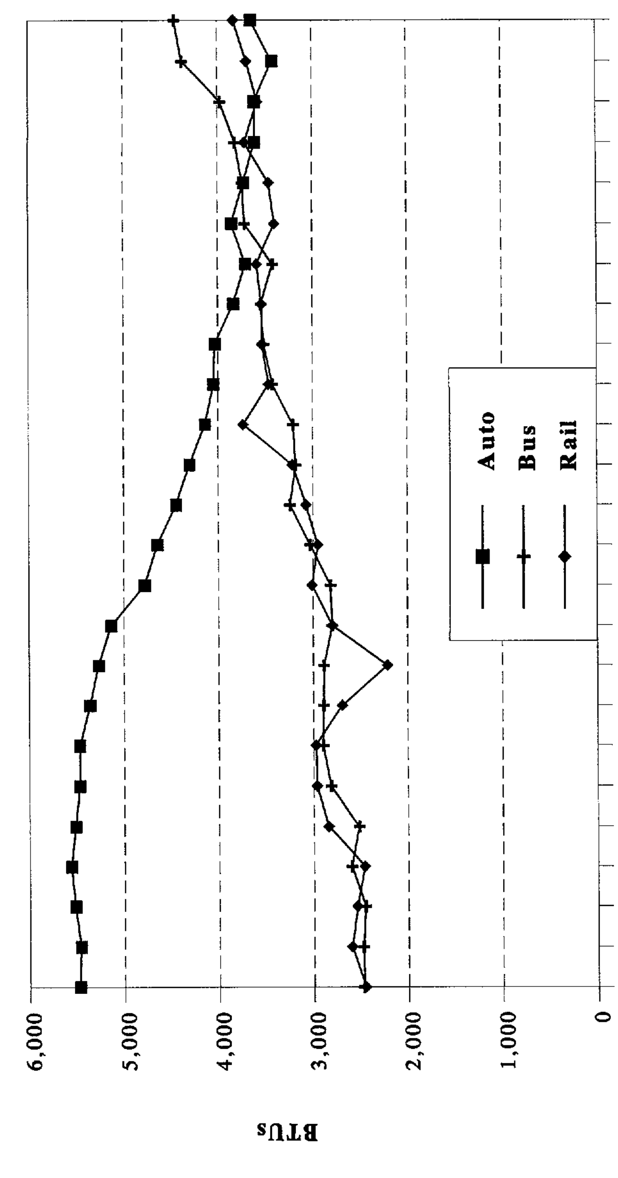
ENERGY USE PER VEHICLE MILE



Source: Transportation Energy Data Book, Edition 16, ORNL

FIGURE 9

BTUs PER PASSENGER MILE



Source: Transportation Energy Data Book, Edition 16, ORNL

ENERGY EFFICIENCY IN PASSENGER TRANSPORTATION: WHAT THE FUTURE MAY HOLD

Stephen Plotkin
Staff Scientist
Argonne National Laboratory

Mr. Plotkin is a specialist in advanced automotive technology. For many years, he directed studies of transportation fuels and oil and gas resources for the Congressional Office of Technology Assessment. In this presentation, Mr. Plotkin called upon these experiences to project future impacts of energy efficiency in passenger transportation.

Mr. Plotkin focused his comments on three major points:

- The first was the fact the U.S. continues to see an expansion of the transportation sector resulting in further dependency on imported oil.

- The second point targeted freight trucks and air fleets as holding great potential for increased energy efficiency.

- Finally, he identified the light duty vehicle as the only technology option for a major increase in efficiency for the transportation sector.

The following tables and figures highlight the above observations.

TABLE 1

SUMMARY — THE FUTURE OF U.S. TRANSPORT ENERGY IN A FREE ECONOMY

- Continued growth and oil dependency
- Key targets for energy use reduction:
  - Light-duty vehicles
  - Freight trucks
  - Air travel
- Few viable, **major** options for reduction
- Light-duty vehicles — The technology option:
  - Past is future: New technology, stagnant fuel economy is a likely scenario
  - The 50 + mpg family car will likely be available — **If** we really want it — But do we?
  - Be careful about interpreting claims about "supercars"
  - Alternative fuels — Need a breakthrough or a crisis

TABLE 2

WHAT ARE OUR OPTIONS?

- Change vehicle technology
- Invest in mass transit
- Change urban design
- Change travel behavior: Telecommuting, carpooling, etc.
- **Note: The above options are not independent from each other**

TABLE 3

REALISM VERSUS IDEALISM

- There are successful examples of better urban design, mass transit increases, behavioral change
- **But the trends nationwide are in the opposite direction — Cities spread out, carpooling disappears, mass transit serves a shrinking piece of the transportation pie**

TABLE 4

RECENT TECHNOLOGY CHANGE IN THE U.S. FLEET

- Engine improvements — Penetration of 4-valve overhead cam designs, huge improvements in pushrod engines
- Transmissions — 4 speed with lockup
- Better tires and aerodynamics
- Improved body design — Materials, supercomputer design
- Universal fleet use of port fuel injection
- **Result: Same fuel economy as before!**

TABLE 5

EACH EFFICIENCY TECHNOLOGY COULD BE USED FOR SOMETHING ELSE

- Advanced materials, supercomputer optimized design — Increase body stiffness, increase size
- Drivetrain improvements (more efficient transmissions, increased engine specific power) — Better performance with same engine displacement
- Aero and tire improvements — Don't reduce power, take most of the benefits in increased performance

TABLE 6

HOW TO REDUCE VEHICLE FUEL USE

- Reduce loads on the vehicle:
  - Inertial
  - Aerodynamic
  - Rolling resistance
- Increase drivetrain efficiency (increase energy delivered to the wheels from each gallon of fuel):
  - Engine (pumping losses, friction, idling losses)
  - Other — Transmission, accessories
- Capture braking energy

TABLE 7

YEAR 2015 FAMILY CAR (CONVENTIONAL DRIVETRAIN)

- Optimized aluminum body (2,300 lbs.)
- Continuously variable transmission
- Drag coefficient: 0.25
- Advanced low drag tires
- D.I.S.C. engine
  - Fuel economy: 53 mpg
  - Added cost: $1,500 (est.)

TABLE 8

WHAT ABOUT HYBRID POWERTRAINS?

- Combined electric drivetrain with engine (gasoline, diesel, turbine, fuel cell)
- Electric storage — Battery, flywheel, ultracapacitor, etc.
- Engine generates electricity, may or may not drive the wheels also (parallel v. series hybrid)
- Electric motor drives the wheels
- Regenerative braking via the motor
- Advantages:
  - Regenerative braking
  - Smaller engine, mostly kept within efficient operating mode
- Disadvantages:
- - Potential for increased weight
  - Electrical losses
- **DOE is aiming at 2X fuel economy from a hybrid; OTA thought it wouldn't be easy to get 25-30 percent**

TABLE 9

YEAR 2015 FAMILY CAR: HYBRID DRIVETRAIN

- Same engine, materials, tires, aero technology as conventional (50 + mpg)
- High power hybrid battery:
  - 65 mpg, $4,600
- Ultracapacitor or flywheel
  - 70 + mpg, $7,000 +
- Fuel cell
  - 80 mpg, $??????

TABLE 10

PERFORMANCE CLAIMS — HOW TO AVOID COMPARING APPLES AND ORANGES

- Claims about tractive forces — Aerodynamics, mass, rolling resistance
- Requirements:
  - Acceleration
  - Gradeability
  - Grid dependent/independent
  - Repeatability
  - Performance in all electric mode
  - Performance at full load
- Component efficiencies

TABLE 11

CONCLUSIONS

• Technology prospects:	Optimistic
• Cost prospects:	Uncertain
• Incentives for fuel efficiency:	Poor
• Ongoing programs:	Good
• Prospects for better fuel economy:	Not so good
• At best:	On-road fleet will improve slowly

FIGURE 1

TRANSPORTATION ENERGY USE IS GOING UP

Projected Transportation Energy Consumption

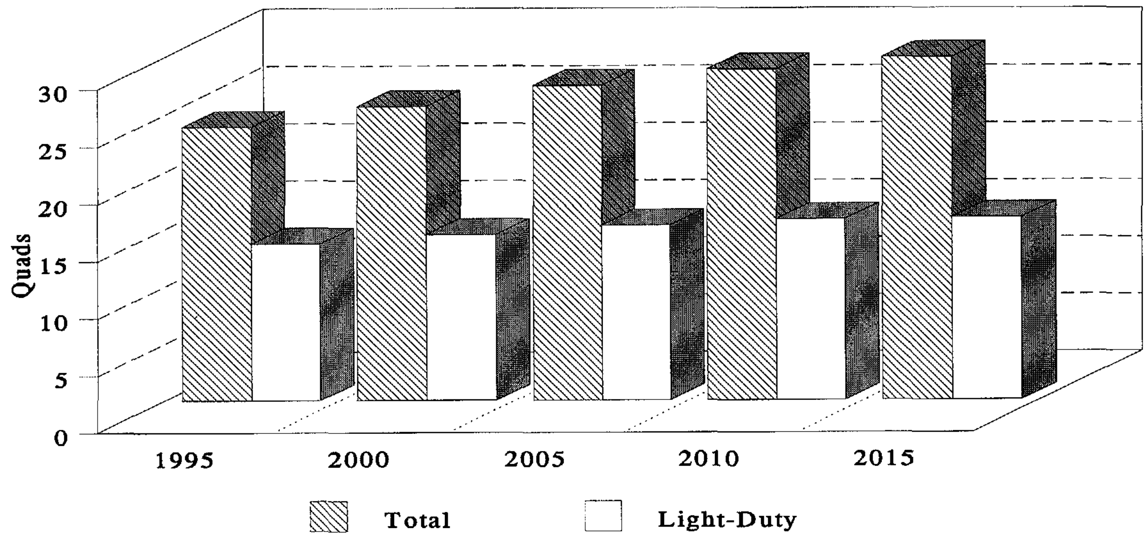


FIGURE 2

1995 TRANSPORTATION ENERGY USE, 24 QUADS

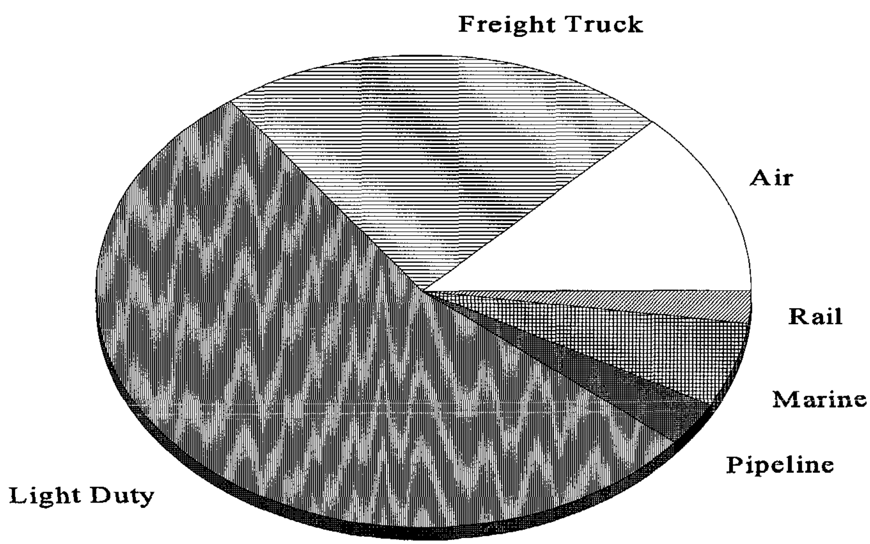


FIGURE 3

PASSENGER MILES BY MODE, 1994

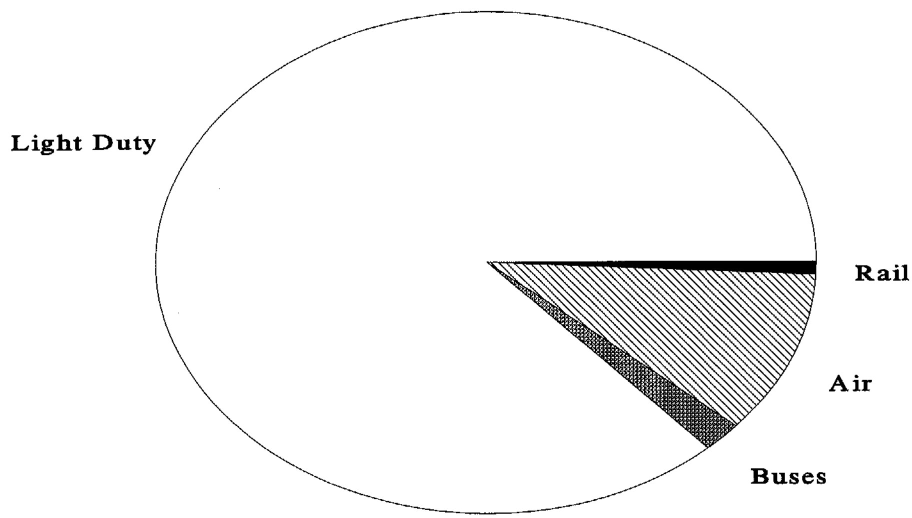
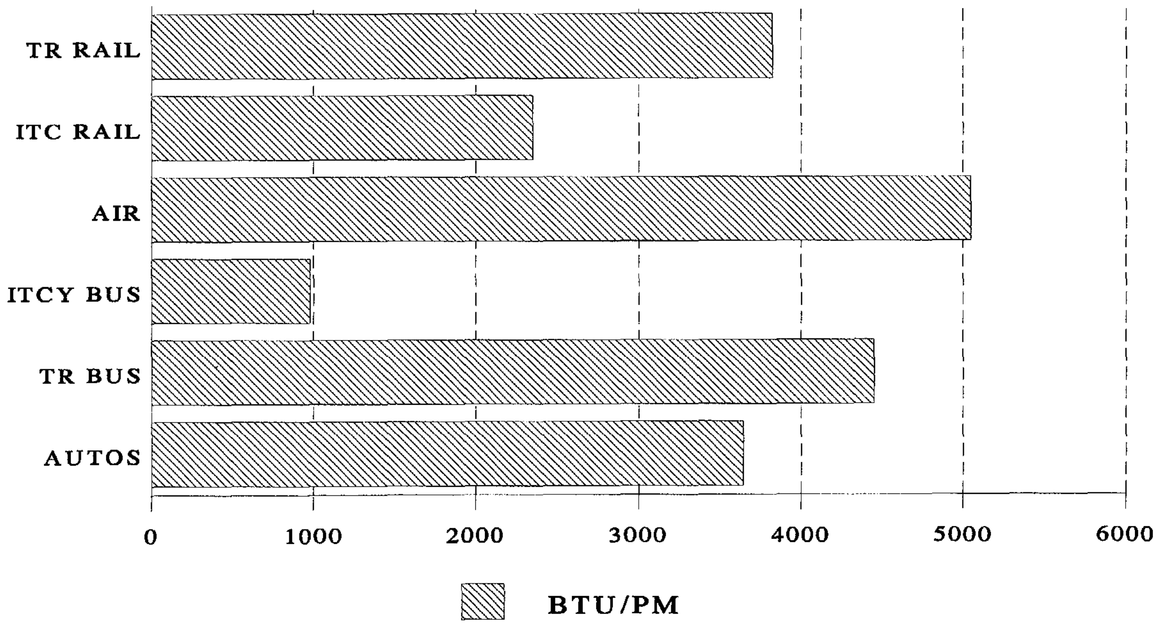


FIGURE 4

MODAL EFFICIENCY, BTU/PASSENGER MILE



OUTLOOK FOR ALTERNATIVE TRANSPORTATION FUELS

David E. Gushee
Senior Program Manager
EA Engineering, Science and Technology

The transportation sector currently accounts for about two-thirds of U.S. petroleum use. It is over 97 percent dependent on petroleum. With about half of all our petroleum being imported, all the gasoline used in the U.S. today is in effect made from imported oil. Every additional mile driven leads directly to more imports of oil. This dependence on imported oil for transportation makes the U.S. economy and its citizens vulnerable to perturbations in the world oil market. Unlike other energy-using sectors of our economy, the transportation sector has essentially no ability to switch fuels and no way in the short term to soften the impact of oil shortages other than to drive less.

Titles III, IV, V, and VI of the Energy Policy Act of 1992 (EPACT) are Congress' major responses to this vulnerability of the transportation sector. This part of EPACT sets, as a first approximation, goals of 10 percent displacement of light duty vehicle fuel use by 2000 and 30 percent by 2010 with non-petroleum fuels. It requires that the federal vehicle fleet, state vehicle fleets, and vehicle fleets of alternative fuel providers increasingly turn to alternative fuels for their light duty vehicles so that, by 2002, most of their vehicles will be able to use and do use alternative fuels. EPACT also asks the U.S. Department of Energy (DOE) to study the pros and cons of the 10 percent and 30 percent goals, to set different goals if its studies so indicate, to issue a rule requiring that private fleets also turn to alternative fuels for their vehicles, and to take other steps as appropriate to move motorists increasingly toward alternative fuels.

It is now four years since EPACT was passed. Some progress has been made, but the 10 percent and 30 percent goals are receding further and further into improbability.

EPACT establishes the premise that the government should lead, and the rest of us will follow that example. The federal fleet now has about 30,000 alternative fuel vehicles (AFVs) in its fleet, as shown in Table 1. (All tables appear at the end of this presentation). However, in response to pressures forcing the federal deficit down, Congress is no longer appropriating funds to cover the incremental costs of these vehicles for the agencies acquiring them. The outlook for future years, therefore, is not clear. There is a Presidential Executive Order in preparation that would require that the agencies make up the cost differences from other agency funds. However, that order has been over a year in the making and its details are very controversial. Among the issues are whether an equal amount of money should be spent on vehicles for each fuel or whether there should be equal numbers of vehicles, in which case natural gas and electric vehicles get a lot more money spent on them than alcohol fuel vehicles would get. Another issue is how the incremental costs should be distributed; that is, should comparable conventional vehicles and AFVs be carried on the books at the same costs or should the incremental costs be shown directly?

DOE has issued its rulemaking for state and fuel provider fleets, requiring that, starting in model year 1997, they begin to purchase AFVs and to use alternative fuels.[1] These programs require that 90 percent of new vehicles acquired by fuel providers be alternatively fueled by 2000 and 75 percent of new vehicles acquired by state fleets be alternatively fueled by 2001.

DOE has published an Advance Notice of Proposed Rulemaking,[2] the first step in a process to determine whether or not an AFV mandate for private and local government fleets is necessary to meet the EPACT goal of 30 percent displacement by 2010, whether the goal is practicable and achievable, and whether EPACT's other conditions of vehicle and fuel availability are met.

DOE has also set up a Clean Cities Program, a mechanism for achieving voluntary commitments from vehicle suppliers, fuel providers, and fleet purchasers to get alternative fuel vehicles into those cities and to assure that supplies of the alternative fuels are available to meet the needs of the vehicles. The number of Clean Cities is now approaching 50; Chicago is one of these. In these programs over 1,000 stakeholders are participating, with plans to operate some 30,000 AFVs within the next several years. Unfortunately, it is not clear how many of these plans will become alternative fuel vehicles in place; there is some evidence that the plans are not true commitments.

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[1]61 FR 10622, March 14, 1996.

[2]61 FR 41032, August 7, 1996.

DOE has carried out one extensive modeling study so far to determine whether or not the 10 percent/30 percent goals are technically and economically achievable. The report from that study[3] shows that, according to the DOE model used,[4] the country would show a small net positive benefit from having displaced with alternative fuels 30 percent of the gasoline that would otherwise have been used by light duty vehicles in 2010.

That study did not estimate the costs of getting to the 30 percent level nor did it identify and evaluate the costs of the transitions required of the vehicle and fuels industries and of the refueling infrastructure. DOE is in the final stages of putting together a new model[5] to identify transition pathways and to estimate transition costs. It expects to have this model up and running by some time in 1997.

DOE is also in the final stages of its first technical and policy analysis required by Section 506 of EPACT. This report is to evaluate progress toward achieving the EPACT goals, the actual and potential role of replacement fuels and alternative fuels and alternative fuel vehicles in significantly reducing U.S. reliance on imported oil, and the actual and potential availability of various domestic replacement fuels and alternative fuel vehicles. The report is in final clearance at DOE and is expected to be published before the end of this year.

This analysis undoubtedly will show that it is highly unlikely that alternative fuel use will grow anywhere near to the 30 percent level by 2010, unless something drastic happens to relative fuel prices or unless Congress decides to give DOE additional authorities, or possibly both. Given current trajectories, currently authorized programs will lead to displacement of about 200,000 barrels per day of motor fuel, or about three percent of the projected 2010 demand for light duty vehicle fuel. Current vehicle offerings, vehicle populations, and fuel use are shown in Tables 2, 3, and 4.

These data show that by far propane (LPG) has the lion's share of AFVs on the road today and that its share has not depended on the provisions of EPACT.

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[3]"Market Potential and Impacts of Alternative Fuel Use in Light Duty Vehicles: A 2000/2010 Analysis." Technical Report Fourteen in the DOE Office of Policy series, "Costs and Benefits of Flexible and Alternative Fuel Vehicle Us in the U.S. Transportation Sector." Report DOE/PO-0042, January 1996.

[4]The Alternative Fuels Trade Model (AFTM), developed at Oak Ridge National Laboratory.

[5]The Transition to Alternative Fuel Vehicles Model (TAFVM), also being developed at Oak Ridge.

The key observation to be drawn from Table 3 is that, aside from propane (LPG), only compressed natural gas is consumed in any meaningful quantities. Note also that the 1996 amount consumed for CNG, according to EIA is twice the amount consumed in 1994. Based on what is known about the limited number of new CNG vehicles entering the fleet in 1995 and 1996 from both the OEMs and through conversions, there is a good chance that this number will be revised downward by EIA in its next report.

On the basis of experience in many other countries which have tried various forms of alternative fuel stimulation programs, spillover from fleets into the motoring public in general is highly unlikely. In every case, major economic incentives have been necessary even for penetration into fleet markets. In Canada, New Zealand, the Netherlands, Brazil, and Italy, for example, the price of the alternative fuel has been set well below the prices of gasoline and diesel fuel — in most cases by 60 cents per gallon or more. This was easily done in those countries, because gasoline and diesel prices have been very high compared to American prices — \$3 to \$5 per gallon — as a result of tax policy. As a result, even the "subsidized" price of the alternative fuel generated considerable tax revenues for the taxing authority. Further, these countries also found it necessary to subsidize the incremental cost of the alternative fuel vehicle through tax incentives and found it helpful to subsidize the construction of the service station network.

Although it is not possible to aggregate the value of the various tax incentives precisely, I estimate that in most of these countries, each alternative fuel vehicle purchaser received a total subsidy over the life of the car of around \$3,000 for an LPG car and about \$5,000 for a CNG car. Brazil's experience in subsidizing ethanol has been comparable. Further, these subsidies never stimulated the vehicle or fuel markets enough for economies of scale to take over and render the subsidies no longer necessary. And further still, these countries have found it very difficult — and eventually impossible — to maintain the subsidies over time, when international tensions have eased but domestic budget pressures have not.

A study by Argonne National Laboratory[6] estimated that the current mandates could lead to as many as five million AFVs by 2010 and that the discretionary private fleet rulemaking could double that. I have estimated[7] that those programs would lead to many fewer, less than one million for the federal, state, and fuel provider mandates, and up to about 1.5 million for the private fleet mandate, should it eventually be promulgated.

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[6]"Estimates of Alternative Fuel Vehicle Use from Federal, State, and Local Programs," by Margaret Singh.

[7]"Impact of Highway Fuel Taxes on Alternative Fuel Vehicle Economics," by David E. Gushee, Congressional Research Service. Report CRS 94-247, March 16, 1994.

DOE estimates that, to reach a 30 percent displacement goal by 2010, AFV sales would have to reach 30-40 percent of new vehicle sales by the year 2000 and stay in that range through 2010. Since the alternative fuel vehicle/alternative fuel systems are today not economic except for special cases, incentives similar to those used in other countries, if not even more, would be necessary since those countries never achieved penetration into the private fleet market at the levels sought under EPACT. The incentives available in the U.S. today are:

1. A deduction from adjusted gross income of up to $2,000 for a car (higher for heavier vehicles). This is worth about $600 for an individual, less than $100 for a business already able to depreciate the car as a business property.

2. An incentive of a deduction of up to $100,000 for the incremental cost of a refueling facility. As with a business vehicle, this amounts to an accelerated depreciation schedule.

3. Similar incentives in various states.

4. For an electric vehicle a deduction from income tax of up to $4,000, combined with similar state and local incentives. In Los Angeles, the South Coast Air Quality Management District is offering a tax incentive of $5,000 for the first few thousand electric vehicles purchased. Since an electric car is currently priced at about twice the cost of a comparable conventional car, these incentives bring the cost down, but not to a comparable level.

On the disincentive side, vehicle costs are higher for an AFV than for the conventional vehicle. An LPG car costs about $2,000 more, a CNG car about $3,500 to $5,000 more, a methanol or ethanol car less than $1,000 more. Although Ford is currently offering its methanol AFV at a discount from the comparable conventional car and its LNG truck at half the range for an equal price and at a comparable range for about $2,000 more, this cannot continue indefinitely.

Natural gas and propane cost less at the factory gate, so to speak, than gasoline or diesel fuel. Methanol currently costs slightly more; ethanol a lot more. By the time distribution costs, retail station markups, and other preparation costs are added, much if not all of the intrinsic price advantage is gone. Then, federal and state taxes must be added. And here, U.S. tax policy works strongly against the alternative fuels, except for compressed natural gas. All of the alternative fuels except CNG are taxed per liquid gallon, and all contain much less energy per gallon than gasoline or diesel fuel. Thus, the tax per gasoline equivalent gallon is greater than that for gasoline. state taxes for the most part work in the same direction, as can be seen in Table 5.

The Natural Gas Vehicle Coalition tells me that CNG is available at refueling stations in many parts of the country for about 30 cents per gallon less than gasoline, including federal and state taxes on both fuels. Assuming that the natural gas vehicle costs $3,000 more than the comparable gasoline vehicle, it will take 10,000 gasoline equivalent gallons of CNG to recover the vehicle incremental cost. For a payback period of four years, that is 2,500 gallons per year or for a vehicle getting 20 miles per gallon, 50,000 miles per year. Only a few percent of American vehicles travel that many miles per year, and this estimate already includes the favorable tax treatment for CNG. LNG, methanol, and propane do not have that advantage. Instead, they are disadvantaged as shown in Table 5.

In sum, the outlook is for minimal penetration of alternative fuels, despite the presence of EPACT mandates, DOE programs, and tax incentives at both the federal and state levels. The Department of Energy is busily engaged in a search for additional programs to recommend to Congress that it be given authority to carry out to add thrust to the now-modest drive under EPACT toward AFVs. It is at the same time, through its ANOPR, asking for comments on whether the 30 percent goal in EPACT should be modified, and if so, how. DOE has not signaled which course of action — asking for more authority or reducing the goal — it might take, nor has it indicated when it might reach such a decision. Meanwhile, the alternative fuels industries are lobbying both the Administration and Congress to do something about the counter-productivity of the federal highway tax structure. Bill Archer, Chairman of the House Ways and Means Committee, has set up a task force to receive proposals and to study their implications. That does not necessarily mean that the 105th Congress will do anything on the issue, as oil import dependence is not one of the burning passions of the day.

TABLE 1

FEDERAL ALTERNATIVE FUEL VEHICLE ACQUISITIONS

FY	CNG		M-85		E-85		LPG		EV		TOTAL
	Qty	%[1]	Qty	%[1]	Qty	%[1]	Qty	%[1]	Qty	%[1]	
91	104	37.6	70	25.3	0	0.0	103	37.1	0	0.0	277
92	799[2]	7.1	2,520	90.5	25	0.9	7	0.3	35	1.2	2,786*
93	2,273	42.0	2,974	54.8	89	1.6	13	0.2	78	1.4	5,427*
94	4,446	53.4	3,727	44.8	25	0.3	106	1.3	17	0.2	8,321*
95[3]	4,276	87.4	366	7.5	250	5.1	0	0.0	0	0.0	4,892
Totals through FY 95	**11,298**	**52.0**	**9,657**	**44.5**	**389**	**1.8**	**229**	**1.1**	**130**	**0.6**	**21,703**
Planned FY 96 Acquisitions											
96	6,142	77.3	0	0.0	1,352	17.0	100	1.3	350	4.4	7,944
Totals through FY 96	**17,440**	**58.8**	**9,657**	**32.6**	**1,741**	**5.9**	**329**	**1.1**	**480**	**1.6**	**29,647**

*Exceeded requirements of the Energy Policy Act of 1992.

Notes

[1]Percentage of annual AFV acquisition. May not add to 100% due to rounding.
[2]Includes 600 Compressed Natural Gas General Motors (GM) pickups recalled by GM.
[3]FY 95 quantities are based on preliminary acquisition data obtained from federal agencies.

TABLE 2

ALTERNATIVE FUEL VEHICLES IN USE IN THE UNITED STATES

Fuel	1992	1993	1994	1995	1996 (Est)	Annual Growth Rate
LPG	221,000	269,000	264,000	272,000	279,000	6%/Yr
CNG	23,191	32,714	41,227	65,489	84,319	38%/Yr
LNG	90	299	399	482	563	58%/Yr
Methanol M85	4,850	10,263	15,484	20,170	22,284	46%/Yr
Methanol M100	404	414	415	413	411	0.4%/Yr
Ethanol E85	172	441	605	894	*	*
Ethanol E95	38	27	33	32	33	-3%/Yr
Electricity	1,725	1,847	2,238	2,350	2,460	9%/Yr
Fuel Unknown	0	140	0	0	0	
Non-LPG Subtotal	30,470	46,145	60,401	90,190	142,294	47%/Yr
Total	**251,470**	**315,145**	**324,401**	**362,190**	**421,294**	**14%/Yr**

Source: Energy Information Administration, "Alternatives to Traditional Transportation fuels 1994." dated January 1996.

*EIA's number in this table assumed availability of E85 pickup trucks from GM, subsequently delayed.

TABLE 3

CONSUMPTION OF ALTERNATIVE FUELS IN THE UNITED STATES

(Thousands of Gasoline Equivalent Gallons)

Fuel	1992			1994			1996		
	Light Duty	Heavy Duty	**Total**	Light Duty	Heavy Duty	**Total**	Light Duty	Heavy Duty	**Total**
LPG	141,042	67,100	**208,142**	167,300	81,250	**248,550**	177,200	85,930	**263,130**
CNG	10,477	6,345	**16,823**	15,490	8,670	**24,160**	28,949	19,280	**48,230**
LNG	*	583	**585**	0	2,320	**2,320**	0	3,150	**3,150**
M85	607	461	**1,069**	2,290	50	**2,340**	3,490	50	**3,540**
M100	13	2,534	**2,547**	0	3,190	**3,190**	0	3,160	**3,160**
E85	20	1	**21**	80	0	**80**	1,030	0	**1,030**
E95	3	82	**85**	0	140	**140**	0	140	**140**
Electricity	226	148	**374**	280	150	**430**	311	280	**590**
Total	152,388	77,254	**229,646**	185,440	95,770	**281,210**	210,979	111,990	**322,970**

Source: Energy Information Administration, "Alternatives to Traditional Transportation Fuels 1994," dated January 1996.

*Less than 500 gasoline equivalent gallons.

TABLE 4

HISTORY OF AFV VEHICLE MODEL AVAILABILITY

Year	CNG Pass. Car	CNG Light Truck	M85 Pass. Car	M85 Light Truck	LPG Truck	E85 Pass. Car	E85 Light Truck	EV Pass. Car	EV Light Truck
1985			Ford Crown Victoria		Ford F600/F700				
1990					Ford F600/F700				
1991			Ford Taurus Chev. Lumina		Ford F600/F700				
1992		Dodge Vans Chev. PU[1] Trucks	Dodge Spirit	Ford Vans	Ford F600/F700	Chev. Lumina			
1993		Dodge Vans	Ford Taurus Chev. Lumina Dodge Spirit		Ford F600/F700	Chev. Lumina Ford Taurus			
1994		Dodge FS[2] & Mini Vans	Ford Taurus Dodge Spirit		Ford F600/F700	Ford Taurus			

TABLE 4 (Continued)

HISTORY OF AFV VEHICLE MODEL AVAILABILITY

Year	CNG Pass. Car	CNG Light Truck	M85 Pass Car	M85 Light Truck	LPG Truck	E85 Pass. Car	E85 Light Truck	EV Pass. Car	EV Light Truck
1995		Dodge FS & Mini Vans Dakota PU Ford PU & Vans[3]	Ford Taurus Dodge Intrepid		Ford F600/F700	Ford Taurus			
1996	Ford Crown Victoria	Dodge FS & Mini Vans Dakota PU Ford PU & Vans[3]	Ford Taurus		Ford F600/F700; Bifuel Pickup	Ford Taurus			Ford Ranger Chrysler Minivan
1997	Ford Crown Victoria & Bifuel Contour	Ford PU & Vans	Ford Taurus	NS[4]	NS	Ford Taurus GM Lumina[5]	GM S-10[5]	GM EV1 Honda EV	Ford Ranger GM S-10 Chrysler Minivan Toyota RAV4

TABLE 4 (Continued)

HISTORY OF AFV VEHICLE MODEL AVAILABILITY

Year	CNG Pass. Car	CNG Light Truck	M85 Pass. Car	M85 Light Truck	LPG Truck	E85 Pass. Car	E85 Light Truck	EV Pass. Car	EV Light Truck
1998	Honda Civic	NS	NS	NS	NS	NS	GM S-10	GM EV1 Honda EV	Ford Ranger GM S-10 Chrysler Minivan Toyota RAV4

[1]Pickup

[2]Full-size

[3]Bifuel vehicles

[4]Not yet specified

[5]Planned

TABLE 5

EFFECT OF TAX POLICY AND ENERGY DENSITY ON TOTAL FEDERAL AND STATE HIGHWAY TAX USING ARIZONA AS AN EXAMPLE

(Cents per Gasoline Gallon Equivalent)

Fuel	Federal Tax	State Tax	Total
Gasoline	18.4	18.0	36.4
Methanol	23.0	36.0	59.0
Ethanol	19.7	27.2	46.9
LNG	28.2	27.6	55.8
Propane	24.9	24.4	49.3
CNG	5.6	1.0	6.6

Sources: U.S. Tax Code and Arizona Department of Commerce, adjusted for energy content by CRS.

TRANSPORTATION ENERGY TRENDS AND ISSUES THROUGH 2030

John M. DeCicco
Director
American Council for an Energy-Efficient Economy

ABSTRACT

Controlling transportation energy use looms as a serious challenge for the United States in the 21st century. Demand for transportation services is steadily growing, driven by increasing population, economic activity, and incomes. Few forces presently constrain growth in travel by the energy-intensive modes of automobile, truck, and air transportation. In contrast to other sectors of the economy, transportation energy efficiency improvements are nearly stagnant. Efficiency increases are now absent in highway modes; aircraft efficiency is improving, but not enough to offset rising air travel. Transportation is also the most oil-dependent sector of the economy as well as the country's most rapidly growing source of greenhouse gas emissions.

A conservative forecast indicates U.S. transportation energy consumption rising from 23 Quads in 1990 to roughly 36 Quads by 2030; less conservative assumptions push the total to 43 Quads by 2030. Yet opportunities exist for efficiency improvements to counter a substantial portion of this growth. The most promising options are technological, with potential long-term efficiency improvements of threefold for light vehicles, twofold for aircraft, and 65 percent for heavy trucks. Combined with system efficiency changes to help limit growth of the energy-intensive modes, transportation energy use might be cut to 19 Quads by 2030. Pursuing cost-effective strategies to move the system toward such reduced energy intensiveness would be clearly valuable for the economy and environment. This paper examines these trends and options, and offers suggestions for policies that could lead to reductions in transportation energy use and its associated problems such as greenhouse gas emissions and oil dependence risks.

INTRODUCTION

Transportation energy use raises a variety of public concerns, ranging from security issues associated with oil import dependence to environmental problems such as air pollution and greenhouse gas emissions. Until the "energy crises" of the 1970s energy use in transportation, as in other sectors of the U.S. economy, essentially grew in step with population and economic activity. The oil shocks of 1973 to 1974 and 1979 to 1980 broke that link through market responses to fuel shortages, price hikes, and public policies (such as car and light truck fuel economy standards) established in response to the crisis. From 1972 to 1992, U.S. transportation energy use grew at an average rate of only 1.1 percent/year, in spite of economic growth averaging 2.7 percent/year over that period (Greene and Fan 1994). However, since 1992, the efficiency improvements induced over a decade ago have been played out, and transportation energy use is again growing steadily with population and economy activity. The sector remains highly petroleum dependent and now accounts for 67 percent of U.S. petroleum use, up from a 51 percent share in 1973 (Davis and McFarlin 1996). Transportation fuel use also generates large amounts of air pollution (see Table 1). (All tables and figures follow this presentation). Transportation directly accounts for 32 percent of U.S. carbon emissions from energy use; the share is larger if the upstream emissions involved in producing transportation fuels are counted. However, transportation measures account for only 12 percent — eight of the 66 million metric tons (MTc/year) — of energy sector reductions projected under the first U.S. Climate Change Action Plan (CCAP 1993). The need to control greenhouse gas emissions (which are mostly carbon from fossil fuels) to allay risks of climate disruption poses an immense challenge to the U.S. transportation energy system, and the carbon implications of energy use are highlighted throughout this discussion.

In spite of the public concerns surrounding transportation energy use, the economic motivations for addressing it are quite weak. Recent politics have been unsuited for proactive interventions that might significantly alter the country's transportation energy picture. The expected effects of policies that have been put in place, such as alternative fuel initiatives and the "supercar" R&D effort, will be next to negligible for the foreseeable future. Past experience indicates the need for a crisis, or at least the perception of one, to induce meaningful action. The public does have robust environmental concerns. This sensibility is reflected in the strengthening of air pollution control measures — one transportation energy related arena where progress continues. Most existing pollution reduction targets can be achieved through further refinement of the existing auto and oil-based system, valiant efforts to promote electric vehicles notwithstanding. Environmental concerns have yet to result in significant measures for controlling greenhouse gas emissions, which would pose a more fundamental challenge to the existing transportation energy system. The auto and oil industries, among the largest and most politically powerful in the country, appear quite content with the status quo, "letting the market work" as they like to put it. Indeed, oil prices have been at historic lows, aside from fluctuations which, though they may attract much attention, are relatively small when viewed in a broader context. Risks of future oil supply disruptions surely exist, but are not reflected in prices and have largely faded from public awareness. A dilemma for the nation is how to prudently pursue options for improving transportation efficiency and diversifying its energy supply in the face of low oil prices.

The depth of the dilemma can be seen by examining the current structure of transportation energy use in the country. A look at the past 20 years of energy use, broken down by major transportation mode, helps reveal both the inertia in the system, which resists efforts at change, as well as where past progress has been made, which can help guide measures likely to succeed in the future. Ultimately, transforming the transportation energy system to ameliorate its problems (energy security concerns, economic risks, and environmental impacts) is a matter of making strategic investments leading to greater efficiencies, both of vehicles and the system as a whole, and to more sustainable energy resources. The scale of the system is far too large for these to be public investments alone, although public investments in more efficient infrastructure are essential. Since market forces are incapable of addressing what are fundamentally non-market concerns, private investments will need public guidance. Examining current trends in transportation energy use reveals the greatest challenges and suggests strategies for pointing the system towards solutions to the concerns that now overshadow the U.S. transportation energy future. The discussion given here is drawn largely from analyses now underway by the author and colleagues as part of an cross-sectoral energy and climate strategy study for the United States (ACEEE et al., forthcoming).

TRANSPORTATION ENERGY USE TRENDS

Figure 1 places transportation energy use in the context of overall U.S. energy consumption, in which it represents a 28 percent share. About 36 percent of U.S. energy consumption is through electricity use, which is mainly distributed over the industrial and buildings (residential and commercial) sectors. Transportation today uses only a negligible amount of electricity. What transportation does consume is oil. The U.S. transportation fuel consumption rate corresponds to two gallons per day of petroleum products per capita (Greene 1996). Current transportation energy consumption is 23 Quads (1015 Btu/year). Of this consumption, 97 percent is petroleum products, amounting to 11 Mbd (million barrels per day). Figure 2 breaks down the sector's energy use by mode. Light vehicles (cars and light trucks) account for the largest portion at 58 percent. Freight trucks (medium and heavy duty) account for 15 percent and aircraft for nine percent. Other modes have smaller shares and — except for international shipping — smaller growth rates than the dominant modes of light duty vehicles, freight trucks, and aircraft. All of these modes rely nearly exclusively on petroleum fuels; the sector's relatively small amounts of natural gas and electricity are used mainly in pipelines.

A more revealing view is provided by the cross-tabulation in Table 2, which shows sources of energy-related carbon emissions by end-use sector and fuel type. Total emissions in 1990 amounted to 1,338 million tonnes (MTc/year) on a carbon-mass basis (corresponding to 4.9 billion tonnes of CO_2). As noted earlier, transport's share is 32 percent and it is concentrated in oil use. At 422 MTc/year, transportation oil use is the single largest contributor to U.S. fossil carbon emissions, exceeding even the 409 MTc/year from coal used for electricity generation. Transportation carbon emissions also exhibit the fastest growth rate. Based on Department of Energy (DOE) projections, carbon emissions from transport will grow at 1.3 percent/year over 1995-2010, compared to 0.6 percent/year growth in carbon emissions from electricity generation and 0.2 percent/year growth from industrial energy use. Figure 3 shows expected near-term growth in carbon emissions relative to the 1990 level among U.S. energy end-use sectors; transportation is clearly the "sore thumb."

The project on which this paper is based used the DOE Energy Information Administration (EIA) National Energy Modeling System (NEMS). Projections through 2010 are based on a 1995 version of NEMS, as used to prepare the 1995 Annual Energy Outlook (EIA 1995), but with updated (slightly lower) oil and gas price assumptions. Oil prices are most relevant for transportation and only a modest price increase, averaging 0.9 percent/year 1995-2010, is assumed. This rate implies gasoline rising from a 1995 price of \$1.18/gallon to just \$1.35/gallon (1995\$) by 2010. Economic (GDP) growth is assumed to average two percent/year over the period. For extrapolations beyond 2010, various sources as cited below were used to build spreadsheet models for light vehicles, freight trucks, and air; long-term trends for the other modes were drawn from EIA (1991). Figure 4 summarizes the resulting long-term projection. Overall, under the given assumptions, U.S. transportation energy use will increase by 60 percent over the 1990 level by 2030, reaching roughly 36 Quads compared to 22.5 Quads in 1990. Sector energy use grew at an average rate of 1.8 percent/year over the two decades 1970-90. The projections shown imply average growth rates of 1.3 percent/year for 1990-2010 and 1.1 percent/year for 2010-2030. DOE's projections have tended to understate transportation energy use growth (due to assumptions of lower growth in highway travel and higher rates of efficiency improvement than recently observed). Assumptions more in line with recent trends imply roughly 11 percent higher growth by 2010 and 20 percent higher growth by 2030, compared to the projections of Figure 4. In such a case, 2030 transportation energy use would reach about 43 Quads, 90 percent higher than the 1990 level.

OPPORTUNITIES FOR CHANGE

The projections given here indicate the enormous challenge associated with transportation energy use. The issue with respect to greenhouse gas emissions is particularly pronounced. The United States, like other nations, largely relies on fossil fuels for energy, and transportation relies nearly exclusively on oil. Nevertheless, advances in technology and alternative approaches infrastructure planning offer hope that the U.S. transportation system can evolve toward lower energy intensity and lower greenhouse gas emissions (DeCicco, et al. 1993). The problems faced in attempting to transform transportation are collective problems — market failures, tragedies of the commons, inheritances of past public investments that poorly meet the needs of the future. Required will be collective solutions that can guide the market toward investments in higher efficiency, renewable fuels, and a greater diversity of transportation choices. Identifying strategies to achieve such solutions is a major question facing policy makers, who must reconcile diverse interests in crafting public policies that can be perceived as cost-effective and win political support. The following discussion examines options for developing such strategies based on the dominant modes — light vehicles, freight trucks, and commercial aircraft. The analysis of potential energy savings is based on preliminary results from ACEEE, et al. (forthcoming).

Cars and Light Trucks

Cars and light trucks comprise the largest portion of transportation energy use and they have received the most attention to date. The principal policy which has had a measurable impact on the sector is the Corporate Average Fuel Economy (CAFE) standards enacted in 1975. These standards have not been significantly strengthened since they reached their highest Congressionally mandated level in 1985. Nevertheless, they still constrain the fleet to an average fuel economy higher than what would be likely in their absence. CAFE standards are one of the major energy policy success stories of the past several decades. Greene (1990) estimates that they are responsible for at least three-quarters of the fuel savings obtained through light vehicle efficiency increases since 1978 when the standards first took effect. However, the new fleet average MPG has not significantly increased since 1982; the combined car and light truck average has been 25 ± 1 mpg for the past 14 model years (see Figure 5). No further efficiency gains are to be had from the retirement of older vehicles. On the other hand, ongoing increases in the amount of driving, which doubled in the past two decades, have now overtaken the vehicle efficiency increases. As a result, the past few years have seen record car and light truck gasoline consumption, which is expected to increase for the foreseeable future unless new steps are taken to induce efficiency improvements. Of course, attention should also be paid to controlling the amount of driving; that aspect of a transportation strategy is noted further below.

Technology for improving vehicle efficiency has greatly advanced over the past decade and the feasibility of further improvements is well established (DeCicco and Ross 1993, 1994). Nevertheless, the subject has long been a contentious area of public policy. Disagreements involve how much improvement can be made over a given time frame. Many technologies that can improve fuel economy can also be applied to enhance other vehicle attributes, such as performance and luxury, as has been observed in recent years with the absence of market signals or regulatory direction pointing toward higher efficiency. The general public prefers efficiency standards to higher gasoline taxes. The automobile industry stridently opposes stronger CAFE standards and takes the position that, if public concerns dictate control of fuel consumption, a modestly higher gasoline tax is their preferred approach. In fact, transportation fuel demand is relatively inelastic and the existing CAFE constraint implies that a certain tax hike threshold must be passed before the market is likely to be moved by higher fuel prices (DeCicco and Gordon 1995). Ideally, a combination of regulatory and incentive approaches is likely to be the best way to motivate higher fuel economy.

To estimate the energy savings from higher fuel economy if policies were enacted to pursue it, we drawn on DeCicco and Ross (1993), who estimated potential near-term (roughly ten-year lead time) improvements at three levels of technical certainty. The higher levels involve greater technical risk in the sense that widespread use of the technology improvements may be more difficult within a ten-year time horizon. As summarized in Table 3, these estimates are for new car fleet averages of 39 mpg to 51 mpg (41 percent to 82 percent higher than the 1990 average of 28 mpg). Proportional degrees of efficiency improvement are applicable to light trucks, which now average 21 mpg. Cost estimation is difficult because of the limited information that is publicly available. The incremental cost estimates shown in Table 3 were based on a review of previously published information covering potential technology changes that are cost-effective in terms of fuel saved over the life of a car. A cost-effectiveness index is the Cost of Conserved Energy (CCE), derived from the ratio of incremental technology cost to fuel savings over the life of an improved vehicle. An efficiency level is cost-effective if its marginal CCE is less than the future cost of gasoline expected over the life of the improved vehicles. For example, achieving the mid-range (Level 2) estimate of 45 mpg is estimated to cost an average of $690 per car and be cost-effective (from an aggregate consumer perspective) at an avoided fuel cost of $1.48/gallon. This cost is higher than the DOE's expected gasoline price in 2005-2010. However, if even modest values of gasoline consumption externalities are added, this level would be cost-effective.

For post-2010, potential efficiency improvements can be linked to attainment of the tripled fuel economy research goal adopted by the government/industry Partnership for a New Generation of Vehicles (PNGV 1994). This effort plans to have pre-production prototypes ready by 2003-2005. Allowing for one to two years of testing followed by three to four years to tool up for initial mass production suggests that super-efficient vehicles could be introduced into at least one market segment by roughly 2010. Allowing another 20 years for the technology to diffuse to all other car and light truck segments suggests that a tripled new fleet average — 75 mpg vs. today's 25 mpg — could be attainable by 2030. Although the technologies needed for such high fuel economy levels appear costly at present (OTA 1995), the industry's R&D goals include affordability and cost-effectiveness in terms of fuel savings. Other researchers project that fuel cell vehicles having such efficiency levels could be competitive with gasoline vehicles on a life-cycle cost basis early in the next century (DeLuchi 1992; Williams, et al. 1995). Lovins (1995) identifies the possibility of dramatically higher efficiency levels through a radical "ultralight" approach to car design, which could yield tenfold or higher fuel economy levels. Clearly, such breakthroughs would greatly change the transportation energy picture and may well be necessary to achieve sharp curtailments of greenhouse gas emissions.

We adopt the PNGV goal as more conservatively indicative of a long-term (circa 2030) potential. Figure 5 summarizes the recent history of U.S. car and light truck fuel economy along with indications of both near- and long-term potential fuel economy levels. For the purpose of projecting potential transportation sector energy savings, we adopt a linear fuel economy improvement trajectory starting at 25 mpg in 1997 and reaching 75 mpg by 2030. Such a path falls in the mid-range of the DeCicco and Ross estimates for the near-term and reaches the PNGV goal in the long-term. If the new fleet fuel economy triples by 2030, the on-road stock will have improved by a factor of 2.7 over the 1990 level. The result would be a 63 percent cut in light vehicle fuel consumption (other factors, such as the amount of driving, held equal). Thus, instead of light vehicles using roughly 20 Quads in 2030 (as indicated in Figure 4), their consumption could be potentially cut to 7.5 Quads. Even without shifting to renewable fuels, this energy savings would result in a substantial carbon emissions reduction compared to the trend we are already on. Combined with fuel diversification and measures to cut the amount of driving, we can be reasonably optimistic about greatly alleviating at least the light vehicle aspects of the U.S. transportation energy concerns.

Realizing even modest vehicle efficiency improvements will require concerted public policy guidance which is now lacking. Without market or regulatory incentives, there is no guarantee that R&D efforts such as PNGV will yield technologies advances that are deployed so as to yield higher fleet average fuel economy. Strengthened CAFE standards would be a sensible and very cost-effective starting point. (Standards could also be converted to a marketable permit system for fleetwide fuel consumption or CO_2 emissions, which could provide greater flexibility as a "market-based" approach to regulation). However, a standards-setting process is inherently conservative, so standards alone may not be extended high enough to bring advanced, PNGV-type technologies into production. Establishing a financial incentive, such as an extended gas-guzzler tax used to fund rebates for vehicles more efficient than average ("feebates"), would be a valuable complement to CAFE standards and provide a long-term signal that could help spur greater technical advances. Extending initial market creation efforts, such as fleet programs, to coordinate bulk purchases of more efficient vehicles is another approach worth exploring. A policy package combining strengthened CAFE standards with market incentive and market creation programs for efficient vehicles was recommended in Majority Report (1995), which this author endorsed.

Freight

Trucking accounts for the second largest share of transportation energy use and shows steady growth. However, structural and operational changes in the trucking industry plus serious data limitations complicate the analysis of freight truck energy use. From 1960-1990, heavy truck energy use tripled, an increase rate only recently rivaled by air, and freight truck efficiency in ton/miles per Btu decreased over much of that period, even during the steep fuel price increases of 1973 to 1982 (Mintz and Vyas 1993). NEMS-based projections are for freight truck energy use to increase at an average rate of 1.6 percent/year through 2010, with truck efficiency improving slowly (0.4 percent/year). Such an improvement rate would exceed what has been observed to date. According to EIA's aggregation of freight truck classes (small, medium, large), small (under 10,000 lb GVW) trucks account for 29 percent of freight truck energy use. To estimate potential efficiency improvements, small trucks can be treated separately from medium and large trucks, since small freight trucks have engineering characteristics more similar to passenger vehicles than to heavy load-hauling vehicles.

Small freight trucks, such as those used in urban delivery applications, are likely to be able to incorporate many if not all of the technology improvements being developed for light duty passenger vehicles. However, a technology assessment particular to small freight trucks is not available, so we extrapolate from those used for light duty passenger vehicles. As noted above, PNGV technologies are intended to triple light vehicle fuel economy. Given the lack of assessment work that has been done, we assume a more modest target of doubling the 1995 fuel economy for the small freight truck fleet by 2025. The long-term target is for new vehicles; using a stock turnover model implies a 70 percent improvement in small freight truck efficiency by 2025.

For large and medium freight trucks, the published assessments and research targets imply a more limited potential for efficiency improvement. Estimates of technical potential have only been made for the heavier classes of large trucks, but we will assume these provide a good guide to the potential for all medium and large trucks. Duleep (1996) projects that, optimistically, given current and expected technology trends, new heavy truck fuel economy can continue to improve at 1.2 percent/year per year, yielding a 33 percent fuel economy improvement over current levels by

2015. Sachs, et al. (1992) identified a higher fleetwide potential, for a 65 percent fuel economy improvement, from advanced technologies and higher penetrations of other technologies. We assume this level of improvement a long-term target achievable in new trucks by 2025. Accounting for stock turnover implies a 1.3 percent/year improvement rate. Freight truck energy use would then be cut by about 34 percent by 2030, from a baseline projection of 5.3 Quads down to 3.5 Quads. In addition to steady support for R&D leading to engine improvements, an aggressive and well-marketed commercialization and technology incentive program would probably have to be established to realize improvements like these in the on-road truck stock. Further policy analysis and program development efforts are needed to identify what types of measures would be workable and effective for improving freight truck energy efficiency.

Intermodal Shipping

Efficiency can also be improved by increasing the use of intermodal freight shipping, in which a portion of truck highway travel is substituted with rail. Given goods and shipping routes for which it is suitable, rail is an inherently efficient mode of freight transport and, as noted below, the railroads have continued to improve their energy efficiency. Intermodal shipping has been a rapidly growing segment of the freight sector in recent years; it still covers only a small portion of total freight and considerable growth potential remains. AEC (1991) projected a long-term potential shift of 12 percent based on estimates of the amounts of major commodity aggregations that could not be shifted from truck to rail. We also adopt this 12 percent as a 2030 estimate of the amount of baseline truck ton-miles that could be shifted to rail through either mode substitution or increased intermodalism. Adjusting for the increased rail traffic, including longer route circuity, yields an estimate of roughly 0.6 Quads of energy savings from greater use of intermodal shipping.

Other Freight Modes

In contrast to trucking, rail efficiency has shown steady increases in efficiency (measured in ton-miles per Btu) over the past several decades. Rail freight energy intensity dropped from 706 Btu/ton-mile in 1972 to 399 Btu/ton-mile in 1992, an average intensity decrease rate of 2.8 percent/year (Greene and Fan 1994). According to Cataldi (1996), the railroad industry is actively modernizing and making technology improvements for competitive and economic reasons, and ongoing efficiency improvement is likely to occur as a side benefit. Lacking published assessments of future rail efficiency gains, we assume that progress continues at one-half the past rate of energy intensity reduction. The result is a 1.4 percent/year decline in rail freight energy intensity through our scenario horizon. For waterborne and pipeline freight, potential efficiency improvements can be based on the "very high conservation" case projections of EIA (1991), which were also adopted in AEC (1991). The NEMS baseline is for nearly negligible improvements (0.06

percent/year 1995-2015) in the ton-miles per Btu efficiency of domestic water shipping. However, diesel technology improvements similar to those being pursued for heavy trucks and rails would also be applicable to ships. Improvements in other aspects of design and operation are also likely to be feasible. The EIA (1991) projections are for a 20 percent decrease in energy intensity by 2030 compared to the 1990 level, or an average rate of 0.64 percent/year, for water and pipeline freight efficiency improvement.

Commercial Aircraft

Air travel is the third largest subsector of transportation energy use and GHG emissions and it has been rapidly growing. U.S. air passenger miles travelled (PMT) grew at an average rate of 6.1 percent/year from 1972 to 1992 (Davis and McFarlin 1996). Because it is so energy intensive and the industry strives to reduce fuel costs, air travel has also shown the greatest efficiency improvements of any mode. Its energy intensity dropped by more than half, from 9.2 kBtu/PM in 1972 to 4.3 kBtu/PM by 1992 (Greene and Fan 1994). Thus, air travel energy use increased only 50 percent even though PMT more than tripled over this period. About 74 percent of this historical efficiency improvement came from technology changes and the rest came from operational changes (higher load factors). In the future, load factors can be increased somewhat further while the opportunities for ongoing technology improvements are substantial. NEMS baseline projections of personal air travel show an average annual increase rate of 4 percent/year for 1992 to 2010. The baseline efficiency increase rate is much slower, 0.7 percent/year, for a 14 percent improvement by 2010 and a continuation of this rate is assumed through 2030. The net increase in base case air energy use and GHG emissions is 43 percent from 1990 to 2010. Steady growth is anticipated farther into the future, so that energy use for air travel in 2030 is 81 percent higher than the 1990 level, as reflected in Figure 4. These projections pertain to domestic air traffic; international travel is expected to have even higher growth rates.

Because of the large growth in air travel, the resulting airport congestion, and anticipated limits in new airport construction, investments in high-speed rail (HSR) are attractive for a number of regions in the country. Options for HSR intercity passenger service include various forms of fast steel-wheel trains, such as the French Train de Grande Vitesse (TGV), as well as magnetic levitation (Maglev) vehicles. HSR could be competitive with air (on both energy cost and travel time) at distances of roughly 600 miles or less, which account for about one-third of domestic air travel. AEC (1991, C-28) presented a scenario assuming a phase-in of HSR such that one-half of the shorter trips are shifted from air to HSR by 2030. Adopting such a scenario would cut overall air travel by about 15 percent by 2030.

Greene (1995) identified significant opportunities for air travel efficiency improvement, largely technological. Under an optimistic scenario, aircraft efficiency could increase from a 1995 level of 51 seat-miles per gallon (SM/gal) to 86 SM/gal by 2015 (accounting for stock turnover). Interpolating this 2.8 percent/year increase rate for 2010, and assuming load factor increase to 67 percent, energy intensity could be reduced to 2.6 kBtu/PM by 2010. This case entails a 57 percent efficiency improvement over the 1990 level, compared to 14 percent in the baseline by 2010. Since NEMS lacks a fuel-price or technology-policy sensitive model of aircraft efficiency, we adjusted the NEMS results for a higher level of efficiency improvement. Combining operational improvements with Greene's optimistic technical efficiency improvements indicates that aircraft efficiency can essentially double by 2030. Incorporating shifts to high-speed rail, energy use for air travel could be cut by 38 percent compared to the baseline projection for 2030. As for freight trucking, further analysis is needed to determine what role public policy might play in accelerating air transport efficiency improvements beyond those likely to occur through market forces alone.

Intermodalism

While advances in vehicle and fuels technologies are surely necessary for a more sustainable transportation system, such "tech fixes" do not address all public concerns regarding the system and may not be sufficient to achieve the large greenhouse gas emissions likely to be needed over the long run. The past two decades reveal how failing to address system efficiency can greatly reduce energy savings. Vehicle efficiency improvements yielded a gross savings of 6.6 Quads in U.S. passenger surface transportation from 1972 to 1992; however, decreases in vehicle occupancy had the effect of increasing consumption by 3.7 Quads, reducing the net savings by more than half (Greene and Fan 1994). Thus, while pursuing better vehicle technology is clearly critical, system efficiency must also be improved. Approaches include providing a richer set of travel and accessibility choices, through smarter planning of land use and transportation infrastructure investments, and reforming price signals to eliminate or counterbalance the current subsidies of energy intensive modes such as cars, trucks, and aircraft. A key to system efficiency is "intermodalism," that is, combining transportation modes in ways that provide better access than relying on a dominant mode such as highway travel. This approach was acknowledged in the title of the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), what was once known as the "highway bill."

It is beyond the scope of this essay to discuss the range of options and strategies for intermodal efficiency. The ACEEE, et al. study on which this paper is based reviews recent assessments of the scope for transportation system efficiency improvements and synthesizes them into estimates of possible reductions in nationwide vehicle miles of travel (VMT). It is likely that concerted efforts to reduce VMT would occur only in areas facing air quality constraints. Based on 1993 status, 22 U.S. metropolitan regions fall into this category, accounting for 21 percent of national VMT. Examining the constrained areas' VMT reduction plans yields an average VMT reduction of 20 percent by 2010, which translates to a nationwide reduction of 5.4 percent in 2010 due to regional VMT reduction efforts. For the longer term, one can also incorporate effects from changes in land use as might be induced by location-efficient mortgages, transit-oriented development, and other measures to decrease auto dependence. Discussion of and impact estimates for such strategies were given in Majority Report (1995). Applying them to the VMT baseline based on NEMS yields combined effects (excluding fuel taxes or VMT fee-based pricing policies) amounting to an 18.6 percent cut of VMT by 2030.

Pricing Reforms

Changing the price signals, particularly for energy use and travel demand, will be an important part of a long-run strategy to improve transportation efficiency. From a climate protection perspective, a tax-shifting strategy to establish an economy-wide carbon tax is appropriate. The ACEEE, et al. study adopts a carbon tax of $25/ton ($CO_2$-mass basis, corresponding to $92/ton of carbon) which would, for example, raise the price of gasoline by $0.22/gal. Offsets for such a tax could involve shifting state and local road subsidies and other hidden, fixed, or indirectly paid costs of driving to fuel taxes or VMT-based fees. Such shifts are also justifiable as sector-specific pricing reforms which would serve to improve the economic efficiency of the transportation system. Other approaches could involve raising the federal gasoline tax and then expanding and tailoring transportation trust fund allocations to provide appropriate state compensation. Another promising approach is "pay-at-the-pump" insurance. In terms of policy mechanics, shifting to a gasoline tax has the advantage of an existing mechanism and framework for revenue redistribution. Looking ahead, "smart" technologies might also be used to implement various innovative means of road use pricing or insurance premium charging. For example, vehicles could carry a device which reads an electronically encoded debit card that could be used for multiple purposes, from fuel purchase or toll collection to insurance collection. Any such tax shifting approach raises equity issues that must be forthrightly acknowledged and carefully mitigated. It will not be easy to win broad political support unless the public can be convinced that they will see a true burden shift rather than a net tax increase.

Renewable Fuels

Shifting to lower carbon fuels, produced from renewable feedstocks, is another strategy that will be important for addressing both oil dependence and greenhouse gas emissions concerns. Our analysis of such options has not yet progressed as far as the analysis of energy efficiency opportunities. Much research has been done on the topic of alternative transportation fuels, but no clear consensus has emerged about which fuels or combinations of fuels are most likely to succeed. As a preliminary analysis for alternative fuels, we developed a plausible trajectory of decreasing carbon intensity (e.g., in grams of carbon per Btu of fuel supplied) for delivered transportation fuel sectorwide, based on a review of studies of various low-carbon fuel options. Little fuel switching is expected to occur before 2010. The trajectory results in a decrease of roughly three percent by 2010 and 17 percent by 2030 relative to the 1990 level (which was essentially all petroleum, at 19.2 gC/kBtu). Such a shift could be accomplished by some combination of renewably produced biofuels (methanol or ethanol) or hydrogen, along with some natural gas. We did not consider electric vehicle use beyond that which has been mandated in California, New York, and Massachusetts. Further analysis is needed to examine particular choices among these options and transition paths by which they might be accomplished. Currently, extensive research, demonstration, and niche-market deployment efforts are being tried for alternative fuels, not all of which are that much less carbon-intensive than gasoline. A more concerted strategy, including broader incentives to favor low-carbon fuels, is likely to be needed to achieve significant shifts away from petroleum fuels.

CONCLUSION

Like other aspects of economies which affect natural resources and the environment, transportation energy use is confronting an issue of sustainability, namely, the extent to which current impacts might jeopardize the needs of future generations. The U.S. transportation system is 97 percent dependent on petroleum, nearly half of which is imported. The sector is responsible for nearly a third of the country's carbon emissions and it generates substantial shares of several serious air pollutants. The security, economic, and environmental risks associated with these energy-related impacts strongly suggest that the current transportation system may not be sustainable. This look at current trends indicates that energy use by each of the major energy-intensive transportation modes is growing steadily. Transportation energy use, which was 22.5 Quads in 1990, could reach 36 to 43 Quads by 2030. Figure 6 summarizes these trends in terms of carbon emissions. The range of baseline projections indicates growth by 2030 of 60 percent to 90 percent above the 1990 level.

A variety of opportunities exists for efficiency improvements to offset growth in transportation energy use. The most promising options are technological. Potential long-term (circa 2030) efficiency improvements appear to be 200 percent for light vehicles, 100 percent for aircraft, and 65 percent for heavy trucks. Combined with system efficiency changes to help limit growth of the energy-intensive modes, transportation energy use might be cut by nearly 50 percent below the baseline for 2030, or as much as 20 percent below the 1990 level. The assumed shifts to renewable fuels would compound the efficiency effects to yield a 57 percent reduction below the 2030 baseline projection of transportation carbon emissions, as shown by the lower curve of Figure 6. Pursuing cost-effective strategies to move the system toward reduced energy intensiveness would be clearly valuable for the economy and environment. However, achieving such reductions in energy use and emissions will be a public policy challenge, requiring renewed efforts to increase car and light truck fuel economy as well as the development of new initiative to spur efficiency increases for freight and air transport. Complementary efforts to improve system efficiency through better planning and to orient the overall system to lower energy and carbon intensity through pricing reforms would also contribute, as can expanded programs to foster a switch to renewable fuels. A crucial question is whether the political will can be mustered to proactively redirect the U.S. transportation energy system towards greater sustainability, or whether a new crisis must arise before serious steps can be taken.

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TABLE 1

TRANSPORTATION SECTOR SHARES OF ENERGY USE AND ENERGY RELATED EMISSIONS IN THE UNITED STATES (1992)

	Quantity	Share of National Total
Energy Consumption	23 x 10^{15} Btu/yr.	28%
Petroleum Consumption	11 Mbbl/day	67%
CO Emissions	63 MT/yr.	80%
No_X Emissions	9.4 MT/yr.	45%
VOC Emissions	7.5 MT/yr.	36%
Carbon Emissions	432 MT_C/yr.	32%

TABLE 2

U.S. CARBON EMISSIONS BY SECTOR AND PRIMARY FUEL, 1990

	Million Metric Tons of Carbon per Yr.						Electricity Consumption	
	Direct Fossil Fuel Use			Indirect		End-Use	TWh/	
Sector	*Gas*	*Oil*	*Coal*	*Electric*	*Totals*	*Share*	*yr.*	*Share*
Electricity	41.2	26.8	408.8	—	476.8	—		
Commercial	38.7	18.1	2.3	147.5	206.6	15.4%	839	30.9%
Residential	65.0	24.0	1.6	162.4	253.0	18.9%	924	34.1%
Transport	9.9	422.3	0.0	0.7	432.9	32.4%	4	0.1%
Industrial	119.6	91.9	67.8	166.3	445.6	33.3%	946	34.9%
Totals	274.4	583.1	480.5	—	1338.0	100.0%	2713	100.0%
Fuel Shares	20.5%	43.6%	35.9%					

Source: Derived from DOE/EIA Annual Energy Outlook 1994, Tables A8 and A17.

TABLE 3

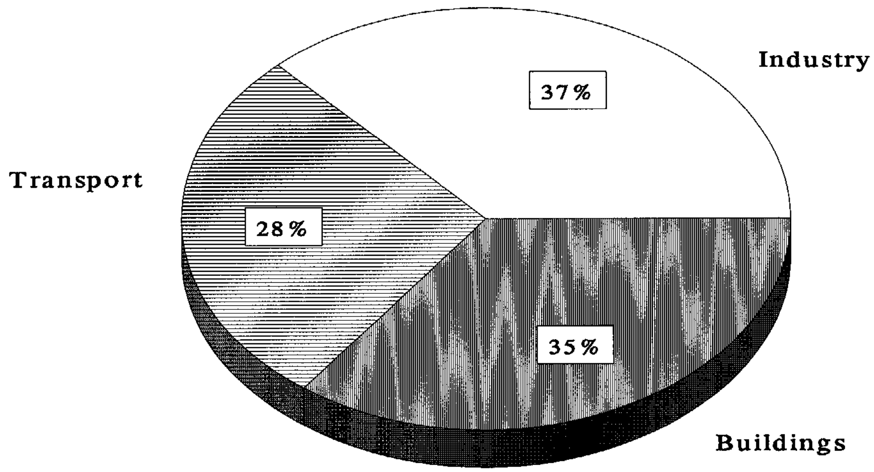
POTENTIAL NEW CAR FLEET AVERAGE FUEL ECONOMY AND COST ESTIMATES

Technology Certainty:	**Level 1**	**Level 2**	**Level 3**
Achievable New Car Fuel Economy (MPG)	39	45	51
Improvement over 1990 New Fleet	41%	60%	82%
Average Added Cost per Vehicle (1995 $)	560	690	820
Average Cost of Conserved Energy ($/gallon)	0.51	0.50	0.50
Marginal Cost of Conserved Energy ($/gallon)	1.46	1.48	1.62

Source: DeCicco and Ross (1993), updated to 1995 $ using 4 percent cumulative inflation from 1993-1995. Fuel economy values are EPA composite 55 percent city, 45 percent highway unadjusted test ratings. Cost-effectiveness estimates are based on a 5 percent real discount rate and 12 year, 10,000 miles per year vehicle life.

FIGURE 1

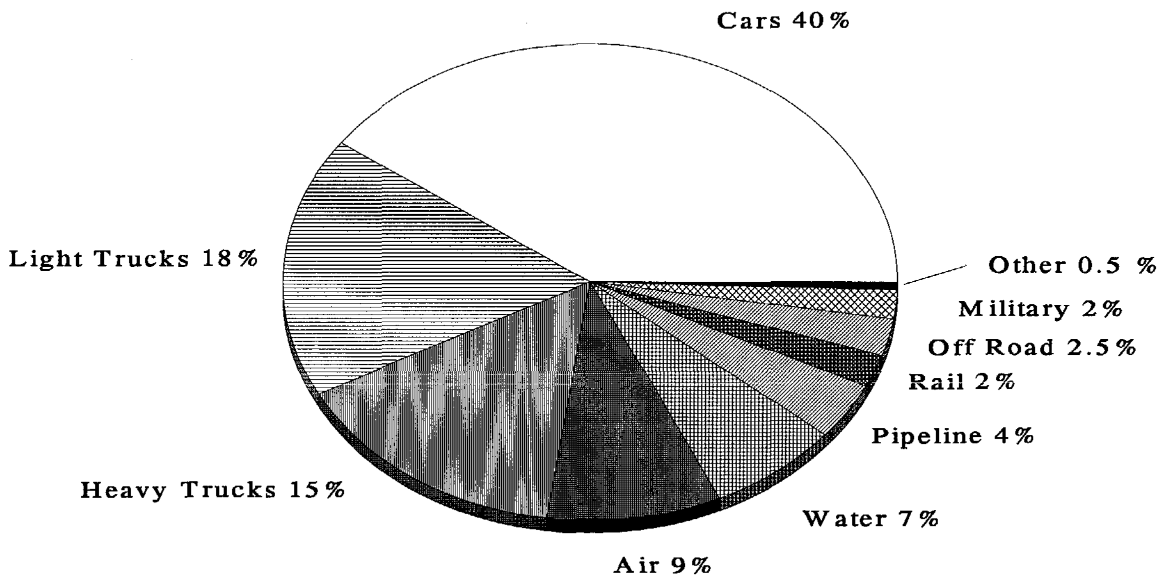
U.S. PRIMARY ENERGY CONSUMPTION BY MAJOR END USE ESTIMATES FOR 1990: 81.3 QUADS/YR. TOTAL



Source: ORNL Transportation Energy Data Book, ed. 6, Table 2.9

FIGURE 2

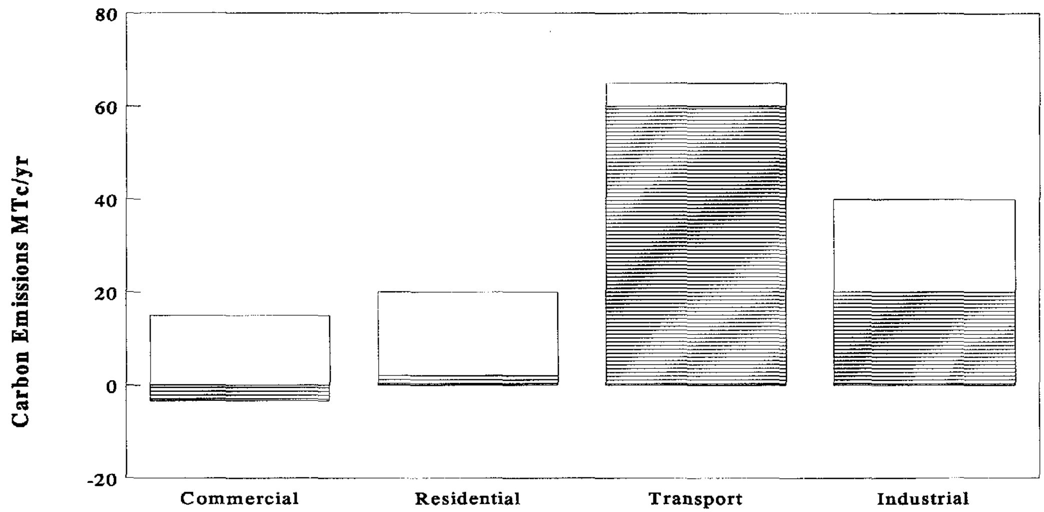
SHARES OF U.S. TRANSPORTATION ENERGY USE BY MODE, 1992
SECTOR TOTAL: QUADS (10.9 Mbbl/DAY OIL EQUIVALENT)



Source: ORNL Transportation Energy Data Book, ed. 14, Table 2.7

FIGURE 3

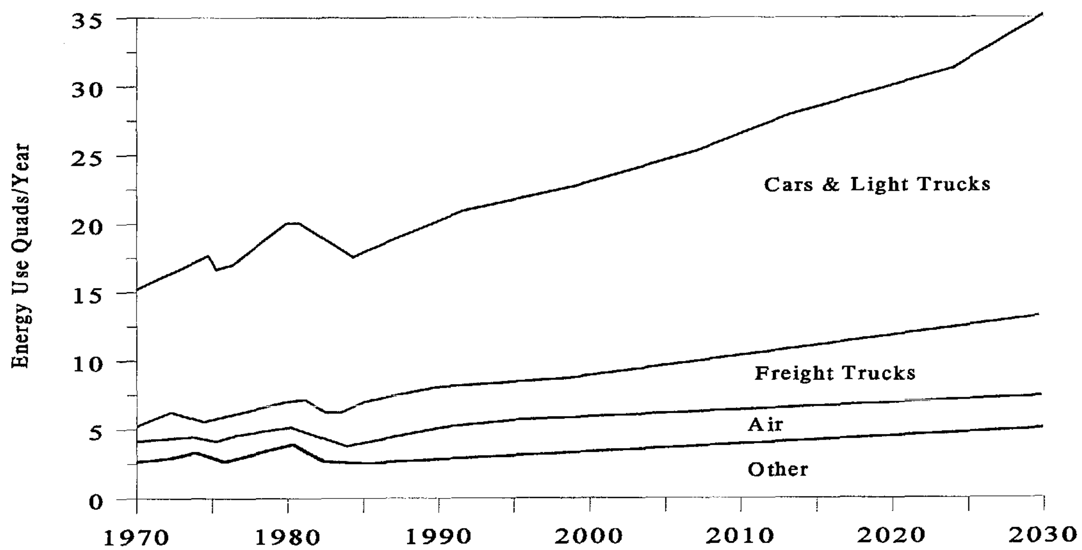
U.S. CARBON EMISSIONS GROWTH OVER 1990 LEVEL BY 2000 WITH CUTS PROJECTED BY THE CCAP, FOR ENERGY END USE SECTORS



Top of bar shows growth project by Annual Energy Outlook (EIA 1995). White area is cut projected by Climate Change Action Plan (CCAP 1993). Lined area is the growth remaining.

FIGURE 4

TRENDS IN U.S. TRANSPORTATION ENERGY CONSUMPTION BY MAJOR MODE HISTORIAL STATISTICS THROUGH 1990 AND PROJECTIONS TO 2030



Sources: 1970-1990 statistics from ORNL Transportation Energy Data Book, ed. 14, Table 2.10
1995-2010 scaled from 1990 values based on NEMS projections using AEO'95 model
2010-2030 author's extrapolations drawn from various sources

FIGURE 5

NEW CAR AND LIGHT TRUCK FUEL ECONOMY: HISTORY, NEAR-TERM POTENTIAL, AND LONG-TERM GOAL FOR REACHING TRIPLED MPG BY 2030

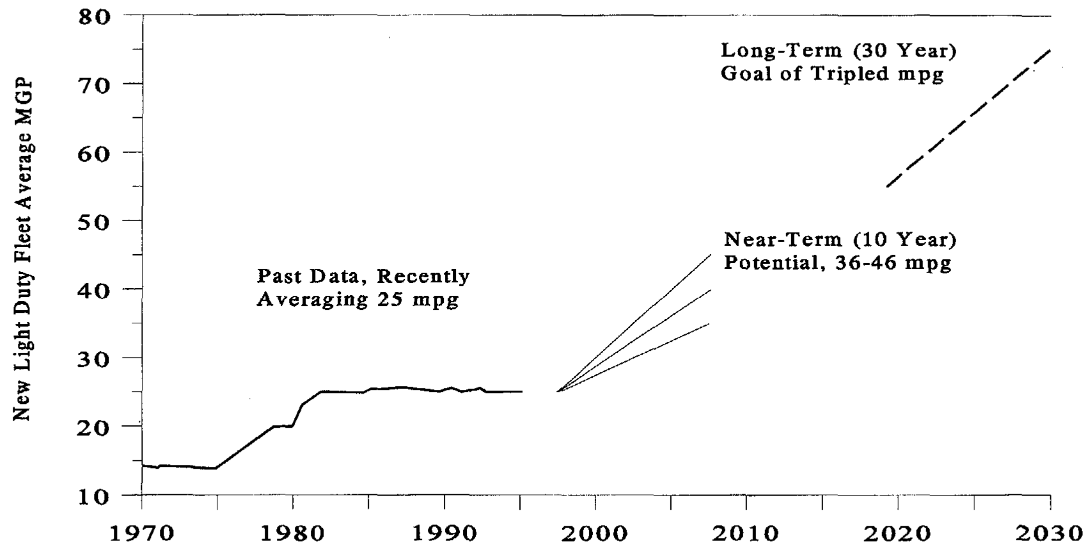
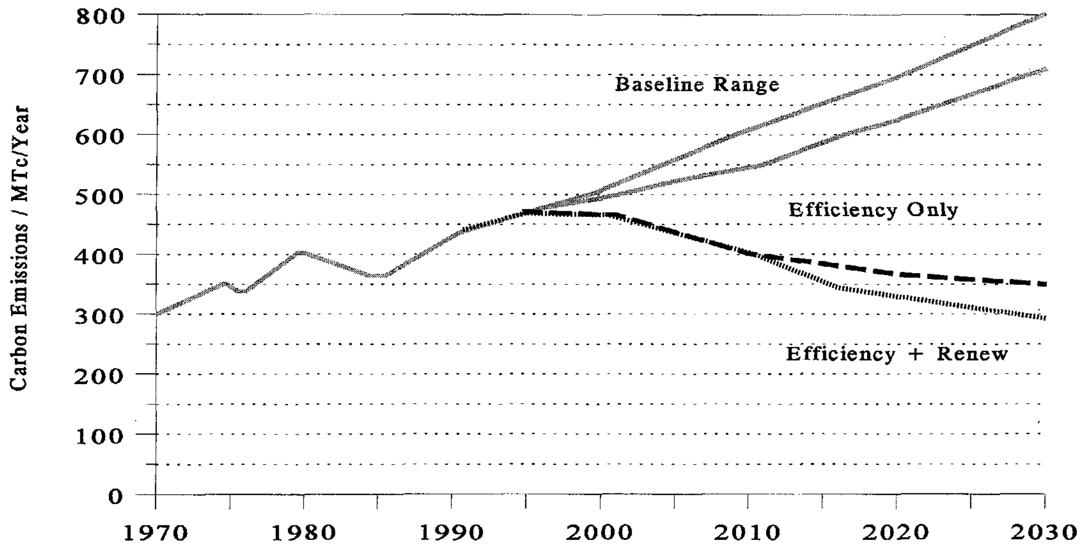


FIGURE 6

CARBON EMISSIONS FROM TRANSPORTATION ENERGY CONSUMPTION IN THE U.S.: BASELINE PROJECTIONS AND POTENTIAL REDUCTIONS FROM EFFICIENCY AND RENEWABLES



SESSION IV:

ENERGY EFFICIENCY, CONSERVATION, AND THE MARKETPLACE

ENERGY-EFFICIENT BUILDINGS: DOES THE MARKETPLACE WORK?

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For a variety of reasons, U.S. households, businesses, manufacturers, and government agencies all fail to take full advantage of cost-effective, energy-efficiency opportunities. Despite a growing environmental ethic among Americans and a concern for energy independence, consumers in this country are underinvesting in technologies, products, and practices that would cut their energy bills. The result is a large untapped potential for improving energy productivity, economic competitiveness, environmental quality, and energy security. The thesis of this paper is that the marketplace for energy efficiency, in general, is not operating perfectly, and the marketplace for energy-efficient buildings, in particular, is flawed.

The reasons for underinvestments in cost-effective, energy efficiency are numerous and complicated. They also vary from sector to sector: the principal causes of energy inefficiencies in agriculture, manufacturing, and transportation are not the same as the causes of inefficiencies in homes and office buildings, although there are some similarities. One of the reasons for these differences is that the structure of the marketplace for delivering new technologies and products in each sector differs.

Each of the sectors is also distinct in terms of the primary societal benefits from improved energy efficiencies. Improving the efficiency of transportation is essential to improving air quality and making the economy less dependent on imported oil. Improving the efficiency of the industrial sector is essential to economic competitiveness and pollution prevention. Energy-efficiency improvements in the buildings sector is critical to reducing greenhouse gas emissions, since most of the energy consumed in buildings comes from the burning of fossil fuels.

This paper therefore begins by describing energy use and energy trends in the U.S. buildings sector. Characteristics of the marketplace for delivering energy efficiency technologies and products are then described in detail, arguing that this marketplace structure significantly inhibits rapid efficiency improvements. Next, several specific barriers to energy efficiency in the buildings sector are described. In the course of describing these barriers, a selection of government programs and policies are described, including public R&D investments and market transformation programs. These programs exemplify the types of public-private partnerships that have helped stimulate investments in efficiency improvements in buildings. The evidence presented suggests that the marketplace, in partnership with government efforts, has resulted in impressive efficiency gains, but that ongoing public-private partnerships are critical to closing the efficiency gap.

ENERGY USE AND ENERGY TRENDS IN U.S. BUILDINGS

The gains in energy productivity achieved by the U.S. in the two decades following the 1973-1974 Arab oil embargo represent one of the great economic success stories of this century. The extent that the U.S. economy improved its energy productivity can be quantified by examining the relationship between total energy consumption and gross domestic product (GDP). In 1970, 19.6 thousand Btu of energy were consumed for each (1992) dollar of GDP. By 1995, the energy intensity of the economy had dropped to 13.4 thousand Btu of energy per (1992) dollar of GDP (EIA, 1996, p. 17). DOE estimates that the country is saving $150 to $200 billion annually as a result of these improvements.

The last quarter century has also shown increases in energy efficiency in the buildings sector. In 1970, residential and commercial buildings consumed 21.7 quads of primary energy (33 percent of total U.S. energy consumption). By 1995, the buildings sector consumed 32.1 quads of primary energy (35 percent of total U.S. energy consumption) (EIA, July 1996, p. 39). Over the same 25 years, however, the number of U.S. households increased, the square footage of commercial buildings increased, and the level of energy services provided in buildings increased.

In residential buildings, improvements in energy efficiency are illustrated by examining energy consumption per household. Between 1978 and 1980 (when data were first available from EIA's Residential Energy Consumption Survey), annual energy consumption per household ranged from 114 to 138 million Btu. Between 1990 and 1993 (the most recent years of available data), annual energy consumption per household ranged from 98 to 104 million Btu (EIA, July 1996, p. 55). (Ranges of years are provided, because these energy consumption estimates are not adjusted to account for variations in weather. The high levels of consumption in 1978 and 1979 were due, in part, to severe winters).

Similarly, in commercial buildings, energy-efficiency improvements are documented by examining energy consumption per square foot of commercial building space. Between 1979 and 1983 (when data were first available from EIA's Nonresidential Buildings Energy Consumption Survey), annual energy consumption per square foot ranged from 98 to 115 million Btu. Between 1989 and 1992 (the most recent years of available data), annual energy consumption per square foot ranged from 81 to 92 million Btu (EIA, July 1996, p. 77).

Over the same period that the energy consumed per household and per square foot has declined, the energy services provided in buildings has increased. For instance, the growth in air-conditioning over the past few decades, particularly in the South, has been significant. In 1960, fewer than two percent of U.S. homes had central air-conditioning (Courville, 1995, p. 10); by 1993 this number had grown to 43.5 percent, and another 26.6 percent had room air-conditioning (EIA, June 1995, Table 3.16b). Similarly, commercial buildings have seen a tremendous growth in "plug loads" due to the increased use of computers. Thus, efficiency improvements in such uses as heating, lighting, and refrigeration are overshadowed, in part, by the increased energy consumed by air-conditioning, computing, and other relatively new services.

It is therefore useful to examine the energy required to perform individual functions within buildings. Household refrigeration, for instance, has seen significant efficiency improvements. In 1972, the average household refrigerator in the U.S. consumed nearly 2,000 kWh per year. Today, new refrigerators consume less than 600 kWh/year, and it is anticipated that a kWh-a-day refrigerator will be available by the year 2000. Similarly, the energy used to light a square foot of commercial building space has decreased significantly, and this has resulted in secondary energy savings due to reduced cooling loads. These improvements have been enabled by DOE-supported R&D, demonstration programs, appliance labelling, and federal energy standards.

In considering the potential for future energy efficiency improvements, it is useful to examine the residential and commercial sectors independently, the energy they consume for each major end use, the life expectancy of existing structures, and the pace of new construction. It is also helpful to keep in mind the types of fuels consumed in buildings: in 1995, buildings accounted for 66 percent of the nation's electricity consumption and 45 percent of natural gas use, but only six percent of petroleum (EIA, July 1996, p. 39).

In the residential sector, owner-occupied, single-family residences account for a majority (61 percent) of energy use (EIA, June 1995, Table 3.5; EIA, Oct-b 1995, Table 5.2; EIA, Oct-d 1995, Figure 3.4). In terms of energy end-uses, space heating is the most important, accounting for about 37 percent. Other end-uses include water heating (14 percent); air-conditioning (nine percent); refrigerators and freezers (ten percent); lighting (eight percent); and other appliances and purposes (the remaining 22 percent). This last miscellaneous category (which includes waterbeds, home entertainment systems, and computers) has been growing the fastest in recent years.

In the commercial sector, food and health care are the most energy-intensive establishments, accounting for 12 percent and 11 percent of sectoral energy use, respectively — even though they represent only 6.0 percent and 4.7 percent of total floorspace (Zwack and Kinsey 1995, Tables 1.2.2; EIA Oct-a 1995, Tables 3.2, 3.4). Lighting predominates commercial sector primary energy use at 26 percent; space heating is the next most dominant use at 17 percent, followed by air-conditioning and ventilation at approximately seven percent each (Zwack and Kinsey, 1995, Table 1.3.2).

For policy purposes, it is important to distinguish new from existing buildings. Although new construction can more easily incorporate new, energy-saving technologies, new buildings amount to only two to three percent of the existing building stock in any given year (EIA, June 1995, Table 3.2a). Nearly 90 percent of the residential buildings that existed in 1990 will still exist in 2010, and approximately half of the 1990 stock will still be standing in 2030. About 80 percent of the 1985 commercial building stock is expected to still exist in 2010 (Courville, 1995, p. 37). As a result, retrofitting structures and upgrading the efficiency of their heating, ventilation, and air-conditioning systems offer the opportunity for significant increases in energy efficiency.

THE EFFICIENCY GAP

The Energy Information Administration (EIA) forecasts that 36.6 quads of energy will be consumed in buildings in the year 2010 (EIA, Jan. 1996, Table A2). This is 7.7 quads higher than a "best practice" scenario, developed by Lawrence Berkeley National Laboratory. The best practice scenario indicates the energy that would be consumed by the buildings sector if the most cost-effective, energy-efficiency technologies available during this period, most of which is already currently developed, were incorporated into new construction and building retrofits (Koomey, 1995). The 7.7-quad difference would save consumers almost $50 billion annually and would result in 118 million metric tons of avoided carbon emissions in the year 2010.

Many of the causes of this efficiency gap are rooted in the fragmented and decentralized nature of the building sector (See Figure 1). (All tables and figures appear at the end of this presentation). Figure 2 portrays the roles of the many different types of organizations that affect energy-related purchase and building operation decisions.

On the consumption side, the nation's 97 million households and the managers of nearly five million commercial buildings make up the largest group of energy decision-makers in the U.S. economy. Their decisions of how to use energy to produce heat, light, and other services are typically made without information about the cost of energy for each service. In some cases, basic information about how well energy is being used by a particular piece of equipment or in a particular building is missing as well. Repetition of energy purchases aids predictability, but uncertainty about concomitant energy consumption commonly remains.

The market for energy-efficiency in buildings is further fragmented by the existence of several thousand different state and local building code specifications. These code variations fragment the demand for building materials and equipment and thereby prevent economies of scale in the production and purchase of goods and services.

On the production side, buildings are the largest handmade objects in the economy. While there has been an increase in the use of factory-assembled components, standardization and mass production remains limited, and manufactured housing represents only seven percent of the housing stock. Regional differences in climate, energy prices, and building style traditions complicate standardization in buildings.

The building construction sector, especially the residential component, is dominated by small and medium-sized firms. The largest residential builder in the United States accounts for less than one percent of the market for new homes. Seventy-five percent of all residential construction firms build fewer than 25 homes per year.

Small commercial buildings (under 50,000 square feet) account for only 52 percent of commercial floorspace, but more than 95 percent of total commercial buildings (EIA, April 1995, Table 3.1). Small construction companies account for a large share of small commercial building construction.

Numerous decision-makers are involved in the construction and renovation of both residential and commercial (small and large) structures. An estimated 125,000 architects are involved in the design of buildings today, and only a small number of these are employed by large design firms. The design of many large commercial buildings typically involves an architect for the building envelope and mechanical engineers for the heating, ventilation, and air-conditioning (HVAC) system, a division of responsibilities that can result in energy-efficient approaches to envelope design that do not capitalize on opportunities for smaller HVAC equipment. The retrofit and home repair business is similarly dominated by very small firms, typically having fewer than ten employees (OTA, 1992, pp. 76, 78).

Manufacturers and product distributors also exert profound influences on the use of energy in buildings by controlling the supply of building products and materials. Their selection of products to manufacture and their choice of geographic markets for product distribution determines the availability and ease of access to high efficiency options.

The realty, financial, and insurance industries are very much a part of the buildings sector market and can influence energy decisions. The realty industry is considerably decentralized, though recent trends in national franchising of local offices may afford the opportunity for improving information dissemination through realty channels. The federal refinancing agencies, Fanny Mae and Freddie Mac, offer additional informational advantages by virtue of their central location in the market. Both are now supporting energy-efficient residential mortgages; realtors and the several layers of bankers must be involved for this transaction to take place. The insurance industry also may become powerful advocates of energy-efficient, environmentally-friendly buildings, in response to the increased property damage liabilities they could suffer as the result of global warming.

Finally, energy suppliers and energy service companies represent two additional players that have been instrumental in motivating and enabling energy-efficiency improvements in buildings. Demand-side management programs operated by electric and gas utility companies have offered rebates, low-interest loans, and direct installation programs that have led to the accelerated market penetration of many energy-efficient building products such as low-flow showerheads, compact fluorescent lamps, and attic insulation. However, these programs have been designed by individual utility companies, each with their own unique goals and resources, thereby further contributing to geographic variability in the supply and demand for energy-efficient building products and services. The following discussion illustrates additional ways that the fragmented nature of the buildings industry creates barriers to improved energy efficiency.

BARRIERS TO IMPROVING ENERGY EFFICIENCY

Barriers to achieving the full potential for cost-effective, energy-efficient improvements can be divided into two types: structural and behavioral (Table 1). Structural barriers result from the actions of many public- and private-sector organizations and are primarily beyond the control of the individual end-user. Behavioral barriers, on the other hand, result from characteristics of the end-user's decision-making, although they may also reflect structural constraints. As each of these seven barriers is discussed, it will become clear that there is a great deal of interdependency. The following discussions also highlight some of the public policies that have been used to address these barriers and thereby promote energy-efficiency investments in buildings. See Brown and Jones (1996) for a more thorough discussion of policy options.

The prices that consumers pay for fuels do not reflect the full environmental and social costs of fuels production, conversion, transportation, and use. For example, the cost of global warming is not now reflected in the price of fossil fuels or electricity. Similarly, the national security and foreign balance-of-payments implications of oil imports are not incorporated in fuel oil and gasoline prices. Fuel prices would rise significantly if they were to reflect their full social costs, and with higher fuel prices, investments in energy-efficient technologies would be more cost-effective.

Declining and uncertain fuel prices are a barrier to investment in both the manufacture and purchase of energy-efficient systems. Oil prices have been the most volatile; they were four times higher in 1981 than in 1972. But the price of natural gas and electricity have fluctuated, too. After decades of falling real prices, electricity prices increased by 50 percent between the early 1970s and 1982. Then the price trajectory reversed course, and electricity prices have declined steadily since then. How can consumers make rational decisions about new buildings and heating systems, when future energy prices are so uncertain?

This market structure is highly competitive, but it discourages private R&D, on both individual components and the interactive performance of components in whole buildings. As a result, the building and construction industries spend only 1.7 percent of revenues on R&D, compared with 3.5 percent for the overall U.S. economy (*Business Week*, 1995). Some R&D on equipment is undertaken by appliance and HVAC companies and on materials by chemical companies, but their R&D generally does not extend to interactive performance with other components of the building. These characteristics also retard the market entry and penetration of new energy-efficient technologies. In addition, industry restructuring has caused a downturn in electric utility R&D.

Coordinating R&D efforts among federal and state agencies, the private sector, academia, and the national laboratories is often cited as being vital to leveraging scarce resources, reducing duplication of effort, and dealing comprehensively with energy challenges. Reports by the Office of Technology Assessment, the Building Energy Efficiency Program Review Group, and the Secretary of Energy Advisory Board conclude that federal R&D programs play a critical role in financially supporting and coordinating buildings research among the various participants (OTA, 1991; OTA, 1992; BEEPR, 1992; SEAB, 1995, Annex 2, p. 143).

Some indication of the cost-effectiveness of R&D in the buildings sector can be gleaned from the experiences to date with DOE's buildings R&D programs. From fiscal year 1975 through fiscal year 1994, DOE spent a total of about $5.7 billion on energy-efficiency R&D and related deployment programs, measured in constant 1992 dollars (Sissine, 1995). No more than $2 billion of this was spent on the buildings sector. Detailed case studies are now available that document the impacts of this research. Geller and McGaraghan (1996), for instance, have documented the benefits of low-emissivity windows, electronic ballasts, and high-efficiency supermarket refrigeration systems — three of the most successful technologies to which the DOE program contributed. In all three cases, DOE worked in partnership with private companies to develop, refine, and demonstrate innovative energy-efficiency measures. The combined DOE costs of these projects have been approximately $24 million.

The primary energy savings from use of these three technologies reached about 250 trillion Btu per year as of 1995 (including about 18 billion kWh per year of electricity saving). The value of this energy savings is about $1.5 billion per year based on current energy prices. Overall, consumers should realize net economic savings of around $10 billion over the lifetime of the low-E windows, electronic ballasts, and high-efficiency supermarket refrigeration systems produced and sold in the United States through 1995 (Geller and McGaraghan, 1996, p. 28-29).

Thus, the value of the energy saved by three technologies, alone, far exceeds the investment made by DOE in their development and also exceeds the cost to the taxpayers of the entire energy-efficiency R&D budget of DOE's Office of Building Technology, State and Community Programs (BTS) over the past two decades.

LIMITED ACCESS TO CAPITAL

Research by Hausman (1979), Gately (1980), Meier and Whittier (1983), and DeCanio (1993) indicates that capital costs, or "first costs," are a barrier to energy-efficiency investments in the buildings sector. The tradeoff between larger initial outlays and lower subsequent expenditures is a typical problem in cost-benefit analysis. At high interest, or discount rates, energy savings in the future are worth less than they are with low interest rates. Market interest rates in the United States are relatively low now, ranging from six to ten percent for secured loans, but many analyses have indicated that both firms and households frequently use much higher discount rates in their evaluation of energy-saving appliances and equipment.

The question of why consumers' apparent discount rates for purchase of energy-efficient building equipment is higher than might be explained by typical commercial loan rates has been a matter of some debate. Explanations most often involve additional discounts for performance and energy price risks, transactions or "hidden" costs not included in the purchase price, consumer dislike for some of the products' attributes, and the lack of specific information on performance and price described above. Awerbuch and Deehan (1995) conclude that, at least for residential fuel switching, performance and other risks are sufficient to explain situations in which apparently cost-effective choices are not undertaken.

DOE's Weatherization Assistance Program for low-income households illustrates one successful type of public-private partnership that can help overcome the problem of capital availability. Since 1976, DOE's Weatherization Assistance Program has provided financial subsidies to reduce the burden of high heating and cooling costs on low-income families by improving the energy efficiency of their homes. Local weatherization agencies provide and install conservation measures, and state agencies and DOE regional offices provide the link between the local implementers and DOE headquarters. Some five million dwellings have been weatherized to date with DOE funds and resources leveraged from other federal agencies, state programs, gas and electric utilities, and nonprofit organizations.

A national evaluation of the Weatherization Assistance Program in 1989 indicated that the energy used by participants for space heating prior to weatherization was reduced by 18.2 percent as a result of their participation. Over the estimated 20-year lifetime of the installed weatherization measures, net savings from program expenditures in 1989 are projected to be 69.7 trillion Btu. At a cost of $1,550 (in 1989 dollars) per weatherized home, the value of the energy saved results in a benefit-cost ratio of 1.1 (Brown, et al. 1994). Many other evaluations of low-income residential energy-efficiency programs have found them to have benefit-cost ratios between 1.0 and 2.0, depending on the range of benefits in addition to energy-savings that are included and the sophistication with which energy saving measures are selected (Pigg, et al. 1995; Gunel, et al. 1995).

Performance contracting can also help overcome the barrier of capital availability. Energy service companies (ESCOs) have been offering energy-efficiency improvements in the United States through energy-savings performance (ESP) contracting for roughly a decade, focusing on commercial and public buildings (Hansen, 1993). Several contracting options have been developed, but the key feature of ESP contracting is that the ESCO receives part of the building energy cost savings for installing and managing new, more energy-efficient equipment.

The Housing and Community Development Act of 1987 gave Public Housing Authorities and Indian Housing Authorities greater flexibility to enter into energy performance contracts, and rules implementing these authorizations were completed by September 1991 (DOE and HUD, n.d., pp. 1B2). Federal agencies, through fiscal year 1993, awarded ESP contracts for 16 major facilities (DOE, Dec. 1995, pp. 24B26). Executive Order 12902 calls for increased federal use of innovative financing mechanisms, including ESP contracting, for energy-efficiency improvements. Because public buildings in the United States account for 25 percent of energy use by commercial buildings and 22 percent of floorspace (EIA, 1995, April, Table 3.2), governments have an excellent opportunity to exercise some direct influence over the markets for energy-efficient and alternative energy through performance contracting.

Energy-efficient mortgages (EEMs) and loans (EELs) can also ameliorate the problem of limited access to capital. The creation of an accurate and widely accepted Home Energy Rating System (HERS) is necessary to create a market for EEMs and EELS, since they are able to convey to lenders and borrowers the information necessary to value energy-efficiency features in new and retrofitted homes, thereby providing a means for builders to "sell" energy-efficiency upgrades to a home, helping to ameliorate the pressure to minimize first costs. Collins, et al. (1994, pp. 50B51) estimate annual energy savings for each EEM would be approximately 14 percent of home energy use. In the used housing market, the HERS could assist in capitalizing the value of energy retrofits, and the EEM can allow the borrower to add the cost of energy-efficiency improvements to the mortgage, providing the longer term, lower interest rate and the tax benefits of mortgage financing.

The availability of new energy-conserving technologies is often restricted to particular geographic areas. For example, in the early 1990s, compact fluorescent lamps were generally available only in those areas where demand-side management programs of electric utilities offered incentives to promote their purchase. Similarly, the purchase of heat-pump water heaters and ground-coupled heat pumps has been handicapped by limited access to equipment suppliers, installers, and repair technicians (Brown, Berry, and Goel, 1991; Technical Marketing Associates, Inc., 1988). The problem of access is exacerbated in the case of heating equipment and appliances, because they are often bought on an emergency basis, thereby limiting choices to available stock. A survey of 639 consumers who had recently replaced their gas furnaces, estimated that in one-third of the cases, the old furnace was not functioning (Cantor and Trumble 1988). Because high-efficiency furnaces represent a more costly inventory, dealers tend to prefer to sell them on special order. Thus, a potential barrier to the selection of high-efficiency furnaces by emergency buyers is the lack of available units in the stock maintained by dealers.

At the federal level, anecdotal evidence from the personal computing industry suggests that procurement initiatives, in coordination with energy rating programs, can affect the product lines of manufacturers. The General Services Administration purchases ten percent of all the office equipment sold in the U.S., which makes it the largest single buyer of computer equipment in the world (Dandridge, et al., 1994, p. 736). Executive Order 12845 of October 1993 required the federal government to purchase only EPA Energy Star computing equipment in circumstances involving no cost differential or sacrifice in performance. Energy Star personal computers can reduce total PC electricity consumption by 60 to 70 percent through the use of power management capabilities. Because the federal government is a large consumer of computing equipment, individual manufacturers found it necessary to add these power management capabilities to maintain sales. By August 1994, more than 300 computer and monitor manufacturers representing more than 80 percent of U.S. sales, and more than 45 printer manufacturers accounting for some 90 percent of U.S. sales, were producing Energy Star PCs, monitors, and printers (EPA, 1994, p. 11).

At the state level, procurement initiatives also look promising. For example, a host of New York purchasing agencies in conjunction with local utilities are coordinating their procurement of small, energy-efficient refrigerators. This initiative involves numerous partners: the Consortium of Energy Efficiency (CEE), the New York Power Authority (NYPA), the New York Housing Authority, DOE, the Department of Housing and Urban Development (HUD), and manufacturers. It seeks to bring to the market more than 50,000 superefficient apartment-sized refrigerators. In this initiative, NYPA is acting as a purchasing agent for the large number of refrigerators that the Housing Authority buys each year. In turn, HUD has agreed to let the Housing Authority pay back the money invested by NYPA with the money saved through lower electricity bills. DOE's Technology Introduction Partnership provided support to CEE to help design the project (Tatsutani 1995). DOE directly provided technical and procurement assistance to NYPA, will monitor and validate the energy savings of the refrigerators for release of HUD performance contracting funds to NYPA, and will recruit additional buyers for the 1997 refrigerator purchase.

Coordinated building retrofits at the local scale are providing economies of scale in the dispersed retrofit market. Transaction costs — the costs of each building owner/manager searching for the best options, assessing available market information, contracting for improvements, and so forth — can be reduced through coordinated efforts. Because the costs of local building improvements depend heavily on what is regularly stocked in an area, a coordinated retrofit effort can create the level of demand necessary to introduce new products and services to local markets. DOE's Rebuild America is an example of a program designed to combine federal energy-efficiency expertise with local buying power and government coordination to generate these new markets. Its partnerships with the U.S. Conference of Mayors, among other organizations have used federal funds to leverage substantial investments in building retrofits (DOE, Dec. 1995, p. 6).

ATTITUDES TOWARD ENERGY EFFICIENCY

Some recent federal and state programs may help motivate consumers to translate their supportive attitudes into concrete actions by providing a "seal of approval" for purchasing products that exceed a specified energy efficiency threshold. EPA's Green Lights Program is an example. It offers acknowledgement as well as information and technical assistance to commercial building operators for lighting retrofits, which they agree to undertake with their own funding where profitable opportunities are identified. In 1993, five percent of all commercial floorspace in the United States were participating in the Green Lights Program (Clinton and Gore 1993, Action Descriptions, p. 2).

INFORMATION GAPS AND PERCEIVED RISKS

Acceptance of advanced energy efficiency technologies is also hindered by lack of credible information on their technical and economic performance. People can easily learn what the capital cost is for an energy-efficient system, but the long-term savings in operating costs are much more uncertain. Risk aversion coupled with uncertainties about performance are strong barriers to customer participation in utility demand-side management programs and raise the implicit discount rates used by consumers in valuing alternative investments. Information gaps concerning the technical and economic performance of advanced energy technologies can also affect the decision-making of investors, manufacturers, distributors, and regulators.

Standardized methods for estimating the energy usage of building equipment and materials have been used in the U.S. since the late 1970s to provide consumers — including builders, architects, and others involved in building decisions — information about relative energy performance. Product labels and rating systems have been easiest to develop where usage patterns (that is, the demand for the energy service provided) are most similar throughout the U.S. (for refrigerators, for instance) and most difficult or controversial in cases where usage patterns vary the most (such as for overall building performance). Changes in consumer purchasing decisions ultimately depend on how well the information is presented, and whether potential cost savings are significant enough to be factored into the product decision.

Labels and rating systems are generic and do not tell consumers about their individual demands for energy services or how their own consumption patterns compare with others. Such individualized analysis are difficult for customers to conduct, but are easy and relatively inexpensive for utilities to provide. Kempton (1995) estimates that a small utility investment in enhanced billing, on the order of 2 to 25 cents per customer per year, can produce a large customer benefit.

Three pieces of information appear to be most valuable to consumers:

- Energy usage histories (for example, month-by-month comparisons of the current year with the past year) with adjustments for weather and price fluctuations,

- Comparisons to the usage of other customers in the same neighborhood or with similar-sized residences, and

- Calculations of change in energy use before and after investment in a new appliance or home improvement.

A study of 54 all-electric residential customers of Jersey Central Power & Light suggested that comparisons are what most customers really desire — comparisons with one's own past usage and with that of one's neighbors (Kempton, 1995). Where evaluations have been conducted, the additional information provided by enhanced bills generally has been found to be highly cost-effective (for example, with measured energy savings of up to 13 percent) (Kempton, 1995, p. 7). These positive findings are reinforced by other studies that have shown that consumers will reduce their energy consumption when provided with detailed information about their levels of energy use (Farhar, 1992). The experiences of three utilities that have provided annual reports of billing data to their customers suggest a favorable benefit-cost ratio. In general, the amount that customers indicate they are willing to pay for annual reports (an extra dollar or two per year) far exceeds the cost of providing the information (at about 30 cents per customer) (Kempton, 1995, p. 17).

Sutherland (1991) argues that, if consumers really wanted energy efficiency, a market for information and expert advice would arise. In fact, elements of such a market are emerging as evidenced by the development of home energy rating systems and the enhanced billing programs described above.

MISPLACED INCENTIVES

The misalignment of incentives is a barrier to many types of energy-efficiency investments in buildings (DeCanio, 1993; Howarth and Andersson, 1993; Fisher and Rothkop, 1989). One type of misalignment occurs when consumers must use the energy technologies selected by others. This involvement of intermediaries (e.g., builders, architects, and engineers) leads to an overemphasis on first costs rather than life-cycle costs. A second type of misalignment results when consumers are not charged specifically for the amount of energy they consume, but rather pay some standardized portion of an aggregated bill. This situation provides little motivation for the individual consumer to conserve energy.

Most residential construction is built prior to the identification of a buyer who could specify the materials and equipment to be used, so the builder is, in effect, building the house for a banker, whose criteria for selling a loan include keeping the ratio of monthly payment to monthly income of prospective buyers low enough to make the loan a reasonable risk. Thus, the builder is motivated to keep the cost of the house as low as possible. The buyer does have an interest in keeping future operating costs low, but has limited ability to identify the performance characteristics of the materials the builder used. In fact, even knowledge of, for example, the R-value of wall insulation may be insufficient to forecast its performance because the performance of the insulation depends on details of construction practices. The result is lower energy efficiency than the market would deliver if misplaced incentives could be eliminated, and if perfect information about energy efficiencies were available. Tenant-landlord relationships can also cause misplaced incentives, particularly in master-metered buildings where the rent paid by tenants does not reflect their individual levels of energy use (Fisher and Rothkop, 1989).

Commercial buildings suffer from similar misplaced incentives vis-a-vis builders versus owners, and renters versus landlords. DeCanio (1993) contends that building energy investments in large corporations also tend to suffer from inattention attributable to the same genre of incentive problem:

- Rational actions on the parts of individual employees in the corporation frequently do not generate the same result that rational choices on the part of a single individual would produce, and

- Cost-effective building energy investment opportunities remain unused.

Building codes have been successfully employed to address problems of misaligned incentives. Building codes in the United States principally cover new construction. In particular, they specify a minimum performance for different building components (such as walls and ceilings), but allow tradeoffs among these components, effectively placing a floor on the energy efficiency of building heating and cooling, but one that can be lower in some areas and higher in others. Rather than being required and controlled at the federal level, building codes are imposed at the state and local levels, with enforcement entirely under the jurisdiction of the issuing government.

At the state level, the Council of American Building Officials published model energy codes (MECs) in 1992 and 1995. At present, about ten states have adopted building codes that meet the requirements of the 1992 MEC and several are considering upgrading to the 1995 MEC. (In contrast, about an equal number of states currently use building codes that reflect technological capabilities of the early 1970s). The Alliance to Save Energy estimates that the ten states that have already adopted MEC standards will reduce CO_2 emissions by 556,000 tons per year (equivalent to 51,500 tons of carbon, or 0.002 percent of the residential sector's emissions in 1994).

The Bonneville Power Administration implemented a successful building code program in the Pacific Northwest in the mid 1980s that provided incentives to local jurisdictions for adopting an enhanced code; it also provided incentives to builders for constructing homes under the code. A study of houses built in Bonneville's service area suggests that those built to meet the code used an average of about eight percent less electricity per year than did houses not built according to the new code. With a recommended ceiling on the cost of saving energy of 56 mills per kWh, Bonneville's model code was deemed cost-effective to the region, with a cost of savings estimated to be 44 mills per kWh (Brown, 1993).

Support for building codes within the buildings industry has been varied, and certainly not comprehensive. Builders worry principally about the potential for increased first costs to price new homes too far above existing homes (which are not now covered by codes in most areas). They are also concerned about the potential for codes to require technologies that prove unreliable in performance over the longer term. Cost-effectiveness is a constant issue. Are standards set so high as to leave compliance costs greater than the benefits? These concerns are being addressed by various public-private partnerships, paving the way for the accelerated adoption of model energy codes in the future.

CONCLUSIONS

The data on energy use and energy trends presented at the start of this paper suggests that the marketplace, in partnership with government efforts, has resulted in impressive efficiency gains in the buildings sector. However, a large efficiency gap remains, and ongoing public-private partnerships are essential to closing it. While there are numerous barriers to improving the energy efficiency of buildings in this country, many public-private partnerships have been implemented that hold the potential for overcoming them in the future. In addition to the critical need for continuing public support for R&D, voluntary market transformation programs show great potential for stimulating further efficiency gains.

The creation of markets where none currently exist or where they are especially weak can permit consumers to signal their demands more effectively. In the buildings sector — characterized by a plethora of participants, from architects and engineers, to realtors and bankers, to owners and renters — voluntary programs can create and transform markets by providing coordination among private-sector participants, among different levels of government, and between public and private entities. These programs appear to be most effective when they combine policies and incentives to achieve the goals of multiple stakeholders. Examples discussed in this paper include the development of home energy ratings combined with incentive mortgages, the use of Energy Star labels for PCs combined with large federal purchases, and the coordination of local buying power with energy-efficiency expertise to create new markets for commercial retrofits. Other policy mechanisms for the buildings sector are discussed in a recent DOE report describing policies and measures for reducing energy-related greenhouse gas emissions (U.S. Department of Energy, 1996, Chapter 3).

The marketplace has resulted in impressive efficiency gains. With further government support for R&D and with well designed market transformation programs, the efficiency gap can be narrowed further.

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TABLE 1

BARRIERS TO IMPROVING ENERGY EFFICIENCY IN THE U.S.

- Distorted and uncertain fuel prices
- Insufficient R&D
- Limited access to capital
- Supply infrastructure limitations
- Behavioral barriers: Obstacles that reflect characteristics of the individual's decision-making attitudes toward energy efficiency
  - Information gaps and perceived risk
  - Misplaced incentives

FIGURE 1

ENERGY USE IN RESIDENTIAL AND COMMERCIAL

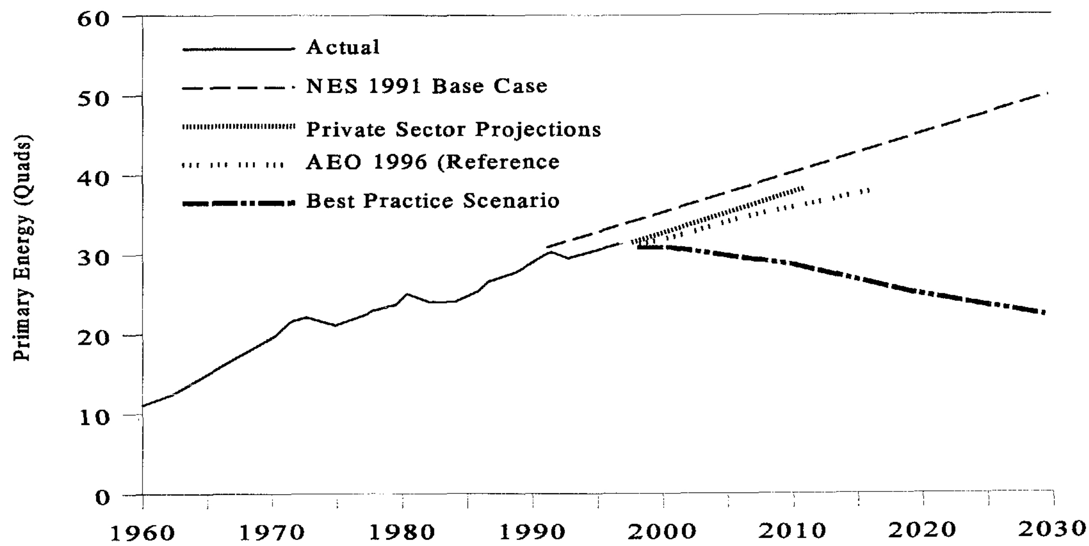


FIGURE 2

THE NUMEROUS TYPES OF ORGANIZATIONS INFLUENCING ENERGY USE IN BUILDINGS

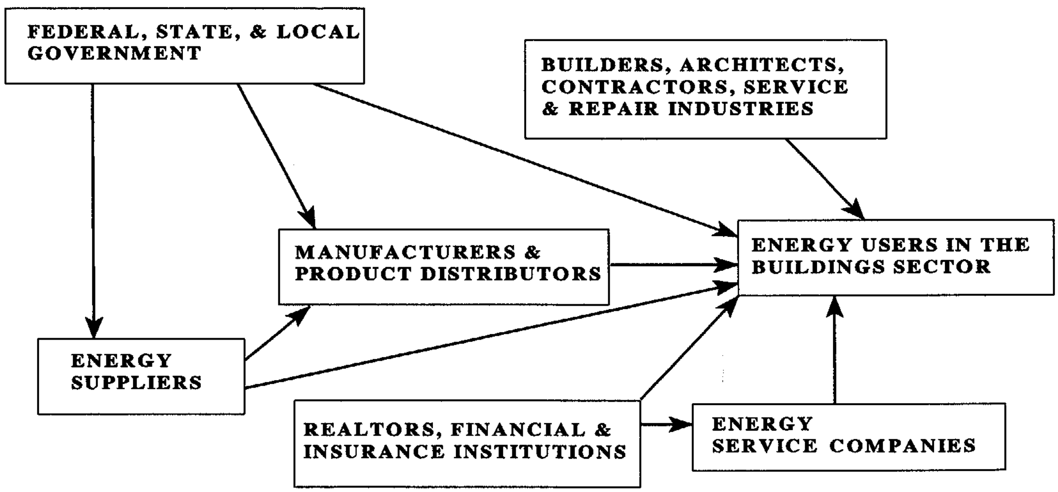


FIGURE 3

DECLINING AND UNCERTAIN FUEL PRICES ARE A BARRIER TO ENERGY EFFICIENCY INVESTMENTS / INSUFFICIENT R&D

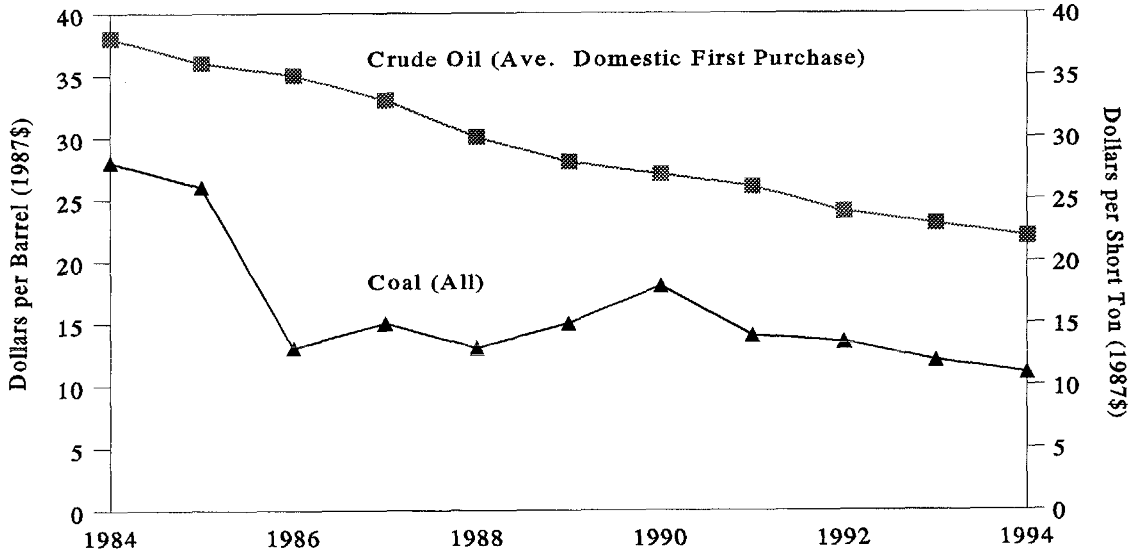
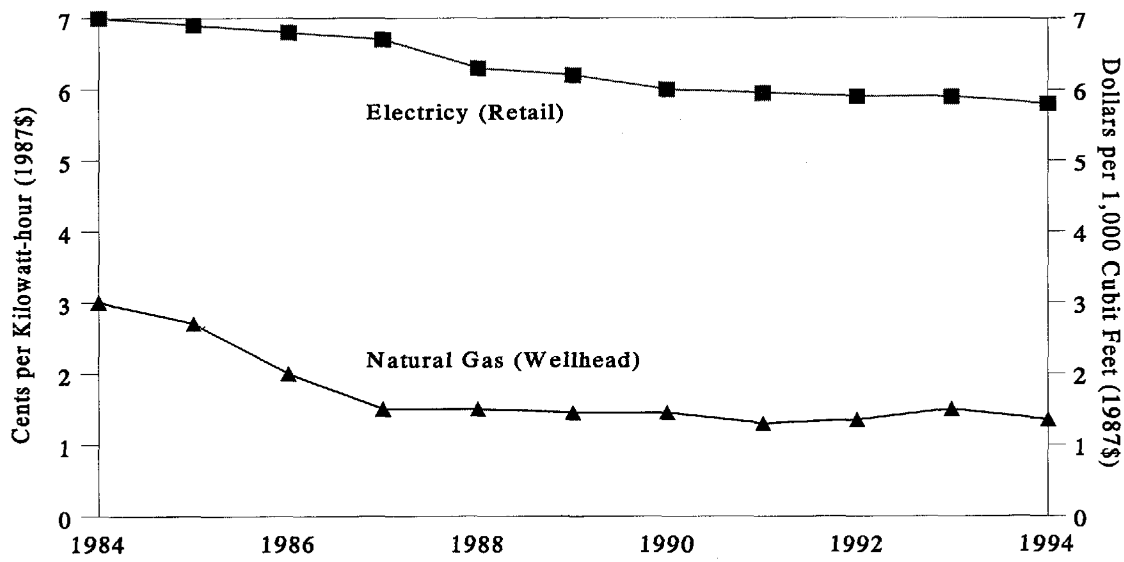


FIGURE 4

DECLINING AND UNCERTAIN FUEL PRICES ARE A BARRIER TO ENERGY EFFICIENCY INVESTMENTS / INSUFFICIENT R&D



RENEWABLE ENERGY RESOURCES IN A RESTRUCTURED ELECTRIC INDUSTRY

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TABLE 1

OUTLINE

- Renewable technologies:
  - Types
  - Attributes
  - Characteristics
  - Installed capacity and energy output
  - Costs
- Current/past policies
- Current/developing market
- Prospects for renewables

TABLE 2

RENEWABLE ENERGY ATTRIBUTES

- Environmental benefits
- Sustainable resources
- Resource diversity
- Economic benefits
- Modularity/flexibility
- Public support

TABLE 3

CHARACTERIZING RENEWABLE ENERGY

- Differences
  - Types: electricity, thermal, fuels
  - Applications: central v. distributed v. end-use
  - Base load v. as available
  - Regional variations
- Commonalities
  - Diffuse resources
  - Capital intensive
  - Cost certainty

TABLE 4

U.S. NON-HYDRO RENEWABLE ELECTRIC CAPACITY AND GENERATION — 1994

Energy Source	Capacity (MW)	Generation (bil kWh)
Wood/Wood Waste	6,523	37.1
Agricultural Waste	649	3.1
Municipal Solid Waste	2,379	13.8
Landfill Gas	486	2.8
Utility Biomass	516	2.0
Wind	1,853	3.5
Solar	389	0.8
Geothermal	1,084	9.4
Utility Geothermal	1,747	7.0
Total Renewables	**15,626**	**79.5**

TABLE 5

CRITICAL FACTORS IN PAST RENEWABLES DEVELOPMENT

- Non-utility development
  - Utility power purchase contracts
  - Transmission access and availability
  - Federal and state tax incentives
  - Special financing opportunities
  - Addressing other societal needs
  - Cooperative effort among all parties
- Utility development
  - Favorable economics
  - RD&D
  - Regulatory treatment

TABLE 6

PAST POLICY RESPONSES TO MARKET IMPEDIMENTS

- Cost
  - RD&D
- Capital requirements
  - Financial incentives
- Valuation
  - Integrated resource planning (IRP)
- Market Power
  - PURPA

TABLE 7

FINANCIAL INCENTIVES

- Federal examples
  - 10 percent energy tax credit for solar and geothermal projects
  - 10 year, 1.5¢/kWh production tax credit for power from wind and "closed-loop" biomass projects
  - 10 year, 1.5¢/kWh production payment to public utilities for power from solar, wind, biomass and geothermal projects
- State examples
  - Tax credits
  - Tax exemptions
  - Manufacturing incentives
  - Utility incentives

TABLE 8

THE ESSENCE OF IRP: RESOURCE VALUATION

- Integrated resource planning tells you what a resource is worth
- Traditional planning
  - Cost = Capital + Fuel + O&M
- Integrated resource planning
  - Value = F (Cost & Non-Cost Attributes)
    - Non-cost attributes = Environmental impacts, in-state economic impacts, fuel diversity, modularity/flexibility, distributed benefits

TABLE 9

THE PUBLIC UTILITY REGULATORY POLICIES ACT OF 1978

- Explicit recognition of diversity and security values
- Created a market for renewable electric projects
- Proved the commercial viability of renewable electric technologies
- Resulted in over 10,000 MW of renewables power

TABLE 10

THE IMPORTANCE OF STATE POLICIES

- PURPA-related policies have been a key driver in renewables development
  - Eight states account for more than 2/3 of past development (CA=40%)
- Those states with no policies have seen little, if any, renewables development

TABLE 11

THE CURRENT ELECTRIC MARKET FOR RENEWABLES

- Low market prices
- Excess capacity
- Competition
- Capital investment avoidance
- Potential strandable assets
- Short-term focus on cost cutting and customer retention

TABLE 12

KEY IMPEDIMENTS TO GREATER RENEWABLE ENERGY DEVELOPMENT

- Renewables are more expensive today than traditional energy sources
- Renewables tend to be capital intensive and have higher front-end costs
- Many of the non-cost values of renewables do not get adequately reflected in market decisions
- Concentrated market power in the energy economy

TABLE 13

THE NEW MARKET CONTEXT FOR RENEWABLES

- PURPA is less relevant as a vehicle for requiring utilities to purchase renewable QF power
- Renewables are still successful today where they make good business sense
  - *Competitive with other sources in various applications*
  - Risk reduction strategy (diversity/flexibility/environment)
  - Response to customer demand
- New policies must be compatible with a more competitive market environment

TABLE 14

COMPETITIVE MARKET PRINCIPLES

- Large number of sellers and buyers
- Buyers and sellers are price takers
- Homogeneous product
- Ease of entry and exit
- Buyers have perfect information

TABLE 15

CRITICAL FACTORS FOR FUTURE RENEWABLES DEVELOPMENT

- The future success of renewables will depend on:
  - Continuing technology improvement
  - Recognition of values
  - Access to markets
  - Response to customer preferences
  - Supportive policies

TABLE 16

ADDRESSING MARKET FAILURES

- Policies will still be required to address electricity market failures, particularly during the transition period
- Policy options include:
  - Renewables portfolio standards
  - System benefits charges
  - Green marketing

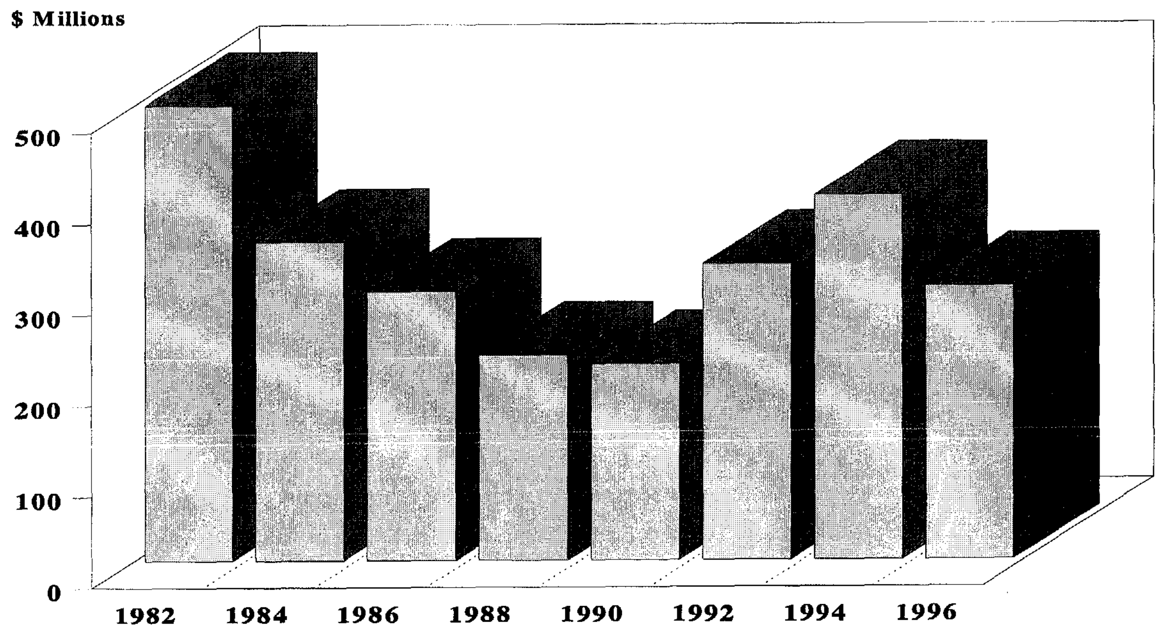
TABLE 17

RENEWABLE ENERGY POLICIES

- Portfolio standard
  - Requires every electricity supplier to provide a minimum percentage of its supply from renewables
- System benefits charge
  - Collects a standard fee from all electricity customers to fund renewables development
- Both policy approaches establish a minimum public obligation to fund renewables development

FIGURE 1

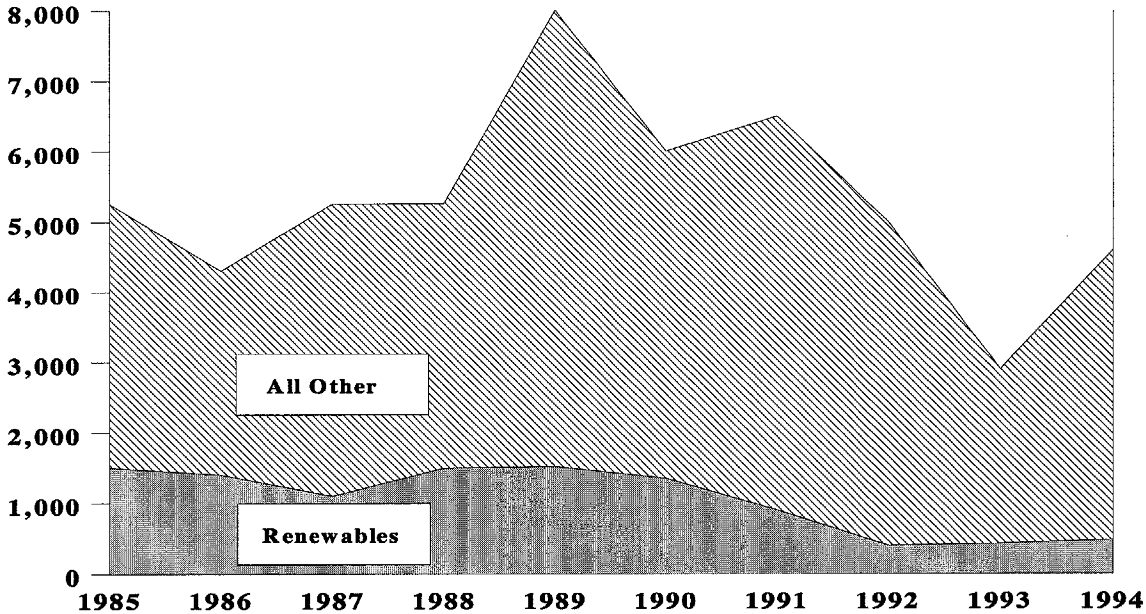
THE FEDERAL RENEWABLES R&D BUDGET



Source: Congressional Research Service

FIGURE 2

RECENT TRENDS IN NUG CAPACITY ADDITIONS
(IN MEGAWATTS)



Source: Edison Electric Institute

ETHANOL FROM BIOMASS: A STATUS REPORT

Robert Walker
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SWAN Biomass is a new company formed by Amoco Ethanol Development Corporation and Stone & Webster Industrial Development. Its mission is to commercialize primarily by providing and licensing Amoco's low-cost process for converting biomass to ethanol for fuel and industrial use. The process uses raw material from many sources, including waste from agriculture and the forest products industry.

BACKGROUND

Amoco has been monitoring the evolution of the technology for the production of ethanol from biomass from lignocellulosic (non-grain) feedstocks for almost 15 years. Substantial worldwide efforts by the scientific community gradually reduced the cost of ethanol from these feedstocks by the late 1980s to a point of commercial feasibility. Amoco increased its spending and accumulated rights to and further refined leading-edge conversion technology. In certain locations the technology can be expected to produce ethanol from lignocellulosic biomass at a cost lower than that using corn as a feedstock. The ultimate goal of the program is to be able to manufacture ethanol profitably from biomass without the need for a price subsidy.

Each of the two parent companies brings a particular expertise to the new company, with Amoco providing the base technology for biomass conversion and Stone & Webster the capability to provide prospective customers with process design packages.

The growth of the market for fuel ethanol has been spurred by environmentally based legislation and Executive action. These legislative and administrative statements reflect a more comprehensive public sentiment concerning clean air as well as sustainable growth. Other elements of this sentiment include a commitment to recycling and waste disposal restrictions, concern over the impact of fossil fuels on global warming, increased support for national self-reliance in fuels supply and increased awareness of the need to create jobs and stimulate economic development.

MARKETS

There are two potential markets for SWAN's biomass-to-ethanol technology. The first is a product market, which will initially be dominated by the use of ethanol as a fuel oxygenate and octane additive because of the subsidies provided for this use. In this market, ethanol competes with other additives, most notably MTBE, and with alternative refinery techniques to raise octane levels in finished gasoline.

The other initial market will be determined by the various feedstocks the process can be adjusted to convert. The earliest uses will be for reducing or eliminating waste streams in the areas of agriculture, forest product and municipal waste. These markets are feedstock-specific and may grow as the technology is refined to include the processing of crops grown specifically for energy production.

SWAN is forming local alliances with private and public sector stockholders selected from a number of defined groups: agribusiness firms, waste management firms, engineering and construction firms, forest product firms, fuel refiners and marketers, federal governments, state governments, municipal governments, power companies, and process development firms.

TECHNOLOGY

The current SWAN process for converting lignocellulosic biomass to ethanol is similar in approach to that used in corn-based ethanol facilities. The differences include the following:

- Pretreatment of lignocellulosic biomass is generally more severe than corn steeping or grinding since the cellulose and hemicellulose sugar polymers are more difficult to break apart than starch, the sugar polymer found in corn.

- The enzymes used to break cellulose and hemicellulose into sugars are different from those used to break the starch found in corn into sugars.

- The hydrolysis of sugar polymers into single sugar units and their subsequent fermentation to ethanol is done in the same vessels. Conventional practice in a corn-to-ethanol facility is to conduct these two operations in separate vessels.

- Unless the specific feedstock contains protein, the solid residue from the conversion of lignocellulosic feeds to ethanol is lignin. This material can be separated out at several places in the process and used as a low-sulfur boiler fuel.

CONCLUSIONS

The foundation of a broad new industry based on the conversion of renewable biomass to fuels and chemicals has been established. Market needs have been identified, and the technology to serve those needs has been developed. The major risks, both market and technical, have been identified and are assessed as being manageable. The industry will likely require the formation of local alliances that combine the competencies of two or more parties. The first local alliances were formalized in late 1995, with commercial activity starting in 1996.

TABLE 1

OVERVIEW

- Breakthrough technology for ethanol manufacture is emerging:
  - Ethanol cost of \$0.60 - \$0.90/gallon in market niches
  - Potential of niches may add to 20+ billion gallons/year
  - Process designed for low environmental impact
  - Ethanol and power production can be synergistic
  - Energy crops feasible in future
- SWAN Biomass Company was formed to accelerate commercialization of biomass-to-ethanol technology:
  - SWAN sells studies, process design packages, and licenses to build and operate plants
  - SWAN can conduct multiple concurrent projects

TABLE 1 (Con't)

OVERVIEW

- SWAN technology includes a combination of:
  - NREL biomass-to-ethanol technology (CRADA)
  - Purchased and proprietary pretreatment
  - Purchased low cost enzyme technology
  - Advanced yeasts (Purdue)
  - Heritage in biomass conversion, power production
  - Reservoir of engineering disciplines, talent
  - Strength in management of concurrent projects
- DOE funding critical to past success:
  - NREL CRADA (scale-up, integration)
  - CPBR support (Purdue yeast)

TABLE 2
POTENTIAL FEEDSTOCKS

- Rice straw, hulls
- Corn fiber
- Wheat straw, midds
- Other field wastes
- Sugar cane bagasse
- Forest, lumber mill waste
- Other farm wastes
- Other agriculture processing wastes
- Orchard prunings, processing wastes
- Waste paper, paper mill wastes
- Energy crops
- Feedstock preparation, biomass-to-power plants

TABLE 3

IMPACT OF FEEDSTOCK FLEXIBILITY

- Several concurrent projects probable
- Use of multiple feedstocks provides user options:
  - For year-round feedstock supply
  - To gain economies of scale
- Proliferation of demonstrated applications likely
- Potential for significant rural job creation, economic development

TABLE 4

COMMERCIALIZATION STATUS

- SWAN now is generating revenue
- First site-specific studies done — Others in process
- Corn fiber scale-up studies at NREL finished
- Scale-up studies for other feedstocks planned
- First license expected: 1997
- Several alliances formed — Critical for many projects

TABLE 5

STAKEHOLDER ALLIANCE FORMATION

- Common project alliance profile
  - Local private industry
  - Local government
  - SWAN
  - Other industrial participants
  - Public interest groups
- Stakeholders for early projects
  - Financial risk mitigation role
    - State government
    - Federal government
  - Technical risk mitigation role
    - NREL, other national laboratories
    - State technical community

TABLE 6

GRIDLEY RICE STRAW PROJECT

- Field burning of rice straw being stopped
  - Health risk — Very fine silica particles in smoke
  - SWAN technology chosen as solution
- Other critical factors
  - Reduce rural unemployment
  - Increase rural economic activity
  - Save failing power plants
- Input from many groups needed for success
- Support to date has been outstanding

TABLE 7

CASE STUDY — ETHANOL FROM CORN FIBER

- Corn fiber is solid "waste" of corn refining
  - Sold as animal feed
  - Market price set by protein content
  - No value for carbohydrates
- SWAN process converts corn fiber carbohydrates
  - Protein content recovered
  - Feed test validation in progress
  - Animal feed drying cost reduction likely
- Net result — Increased availability of low cost ethanol
  - U.S. potential for additional 300 million gallons/year
  - Cost of $0.60-$0.80 with 15 percent ROI
  - Process guarantees available this summer

TABLE 8

SUMMARY

- Future exciting for ethanol manufacture
- Variety of biomass feedstocks can now be used
- Long-term potential to profitably make more ethanol
- Multiple concurrent design projects possible
- Initial construction project announcements in 1997
- Increased job creations — Economic growth expected

FIGURE 1

ETHANOL/POWER BENEFITS

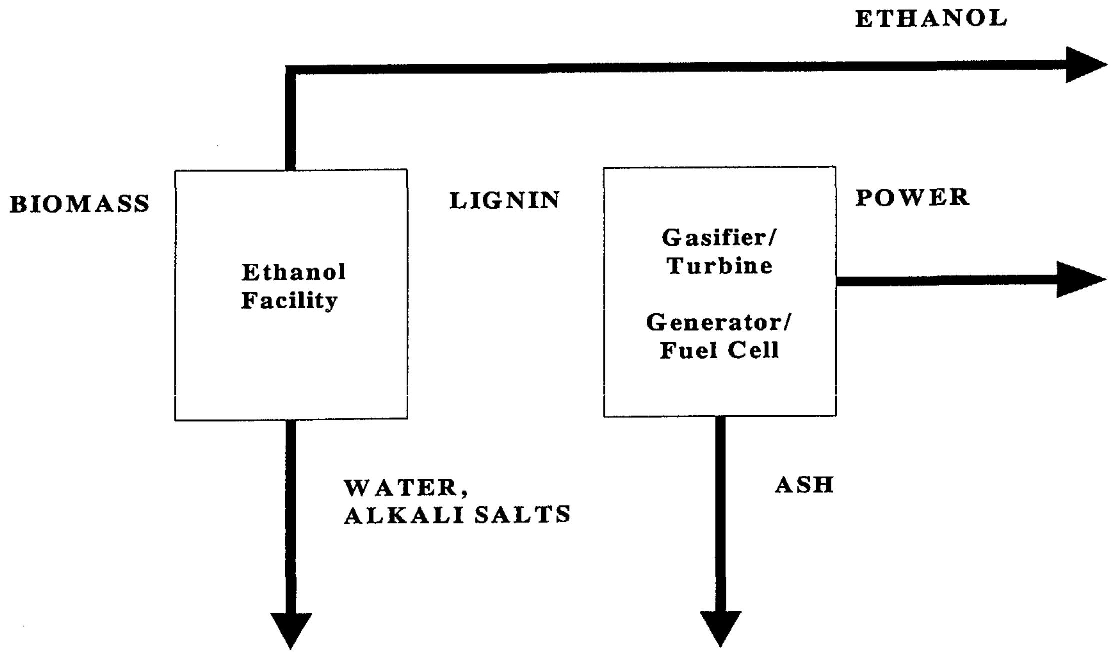


FIGURE 2

BIOMASS-BASED ETHANOL
POTENTIAL U.S. SUPPLY

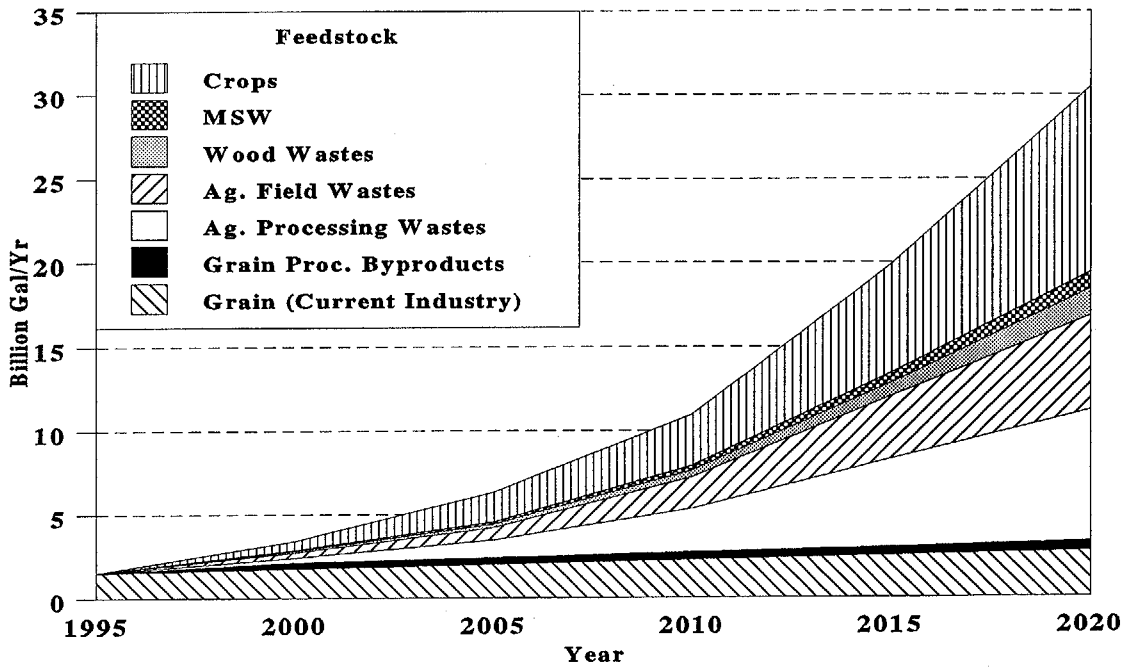


FIGURE 3

BIOMASS-BASED ETHANOL POTENTIAL INDUSTRY EMPLOYMENT LEVELS

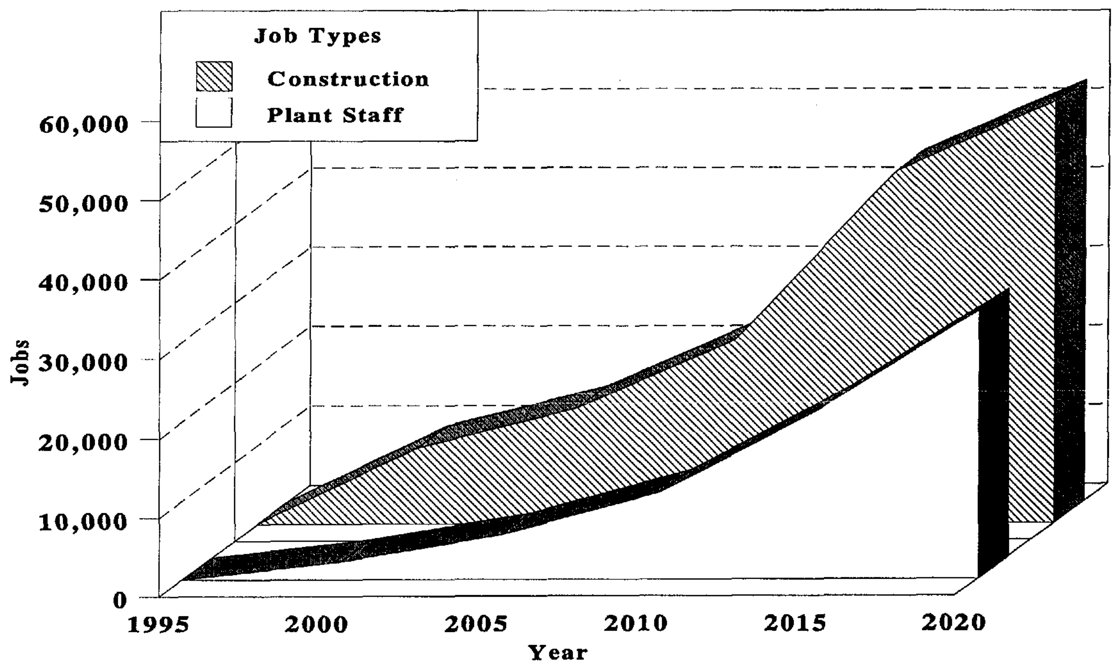


FIGURE 4

BIOMASS-BASED ETHANOL
POTENTIAL INDUSTRY ECONOMIC IMPACT

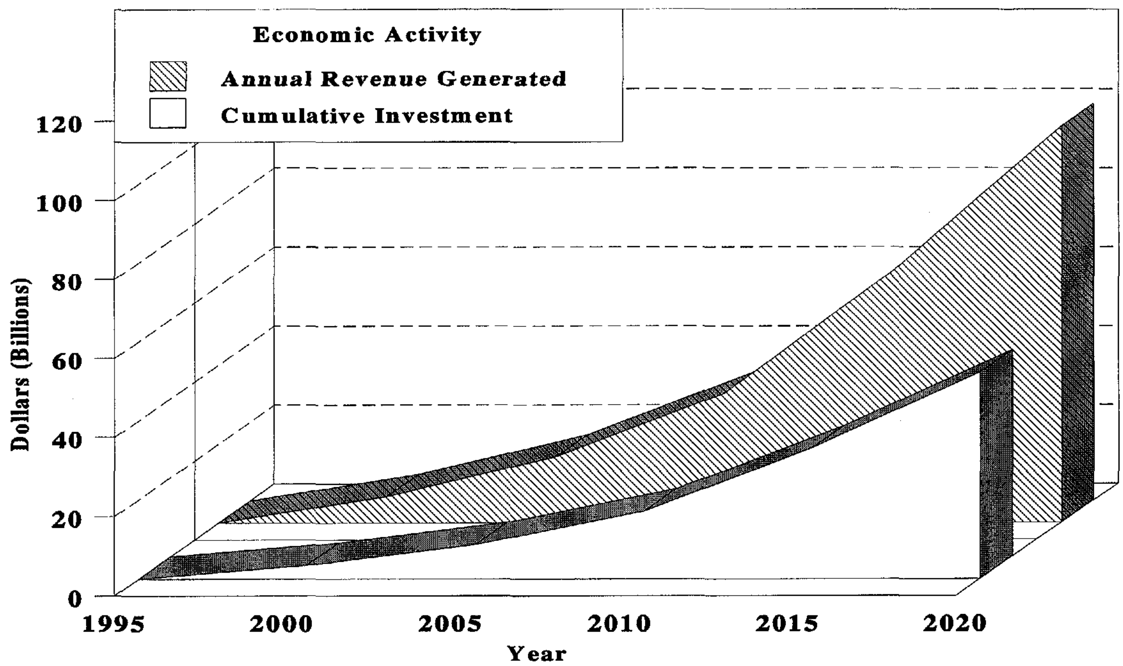


FIGURE 5

WASTE-BASED ETHANOL
POTENTIAL U.S. SUPPLY

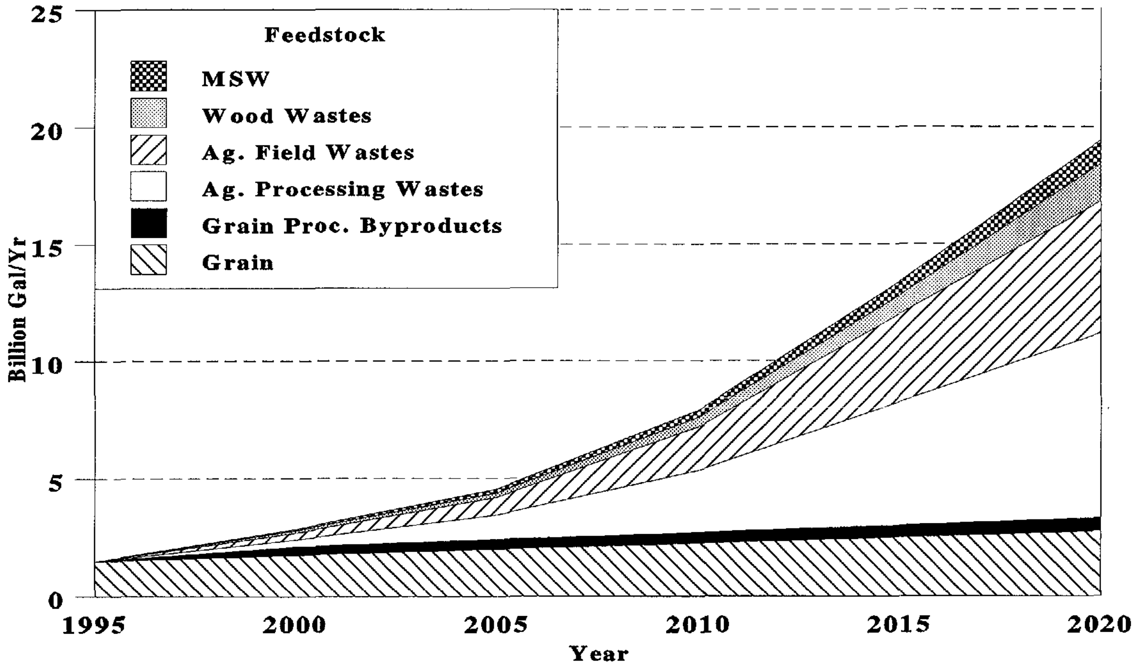


FIGURE 6

SWAN BIOMASS-TO-ETHANOL

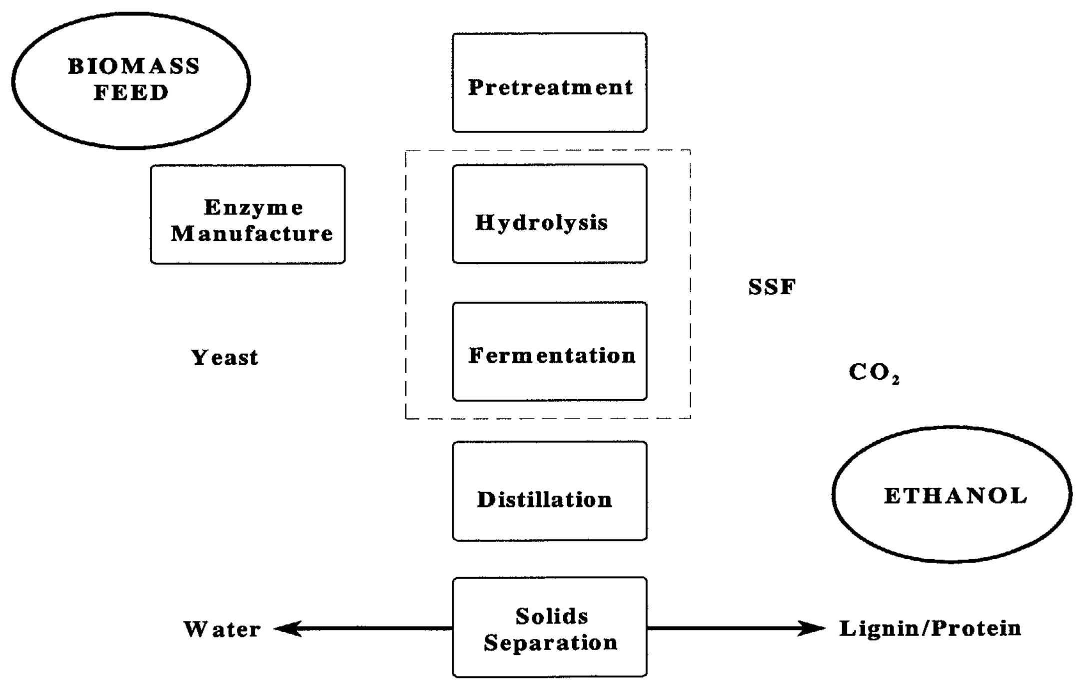


FIGURE 7

TECHNOLOGY MARKET OVERVIEW

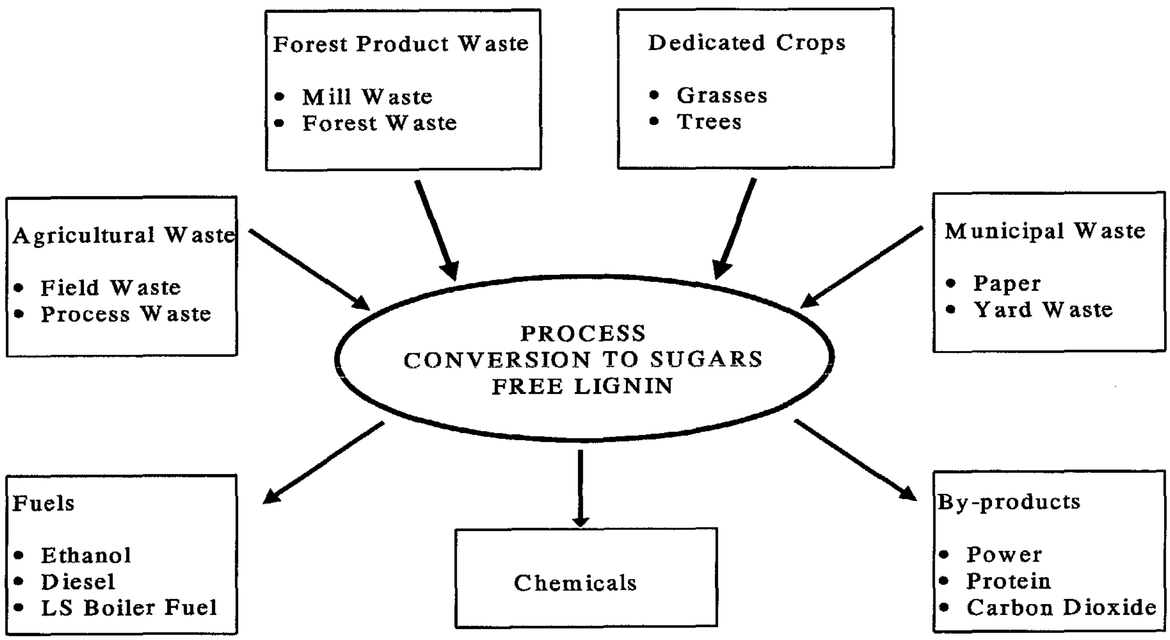
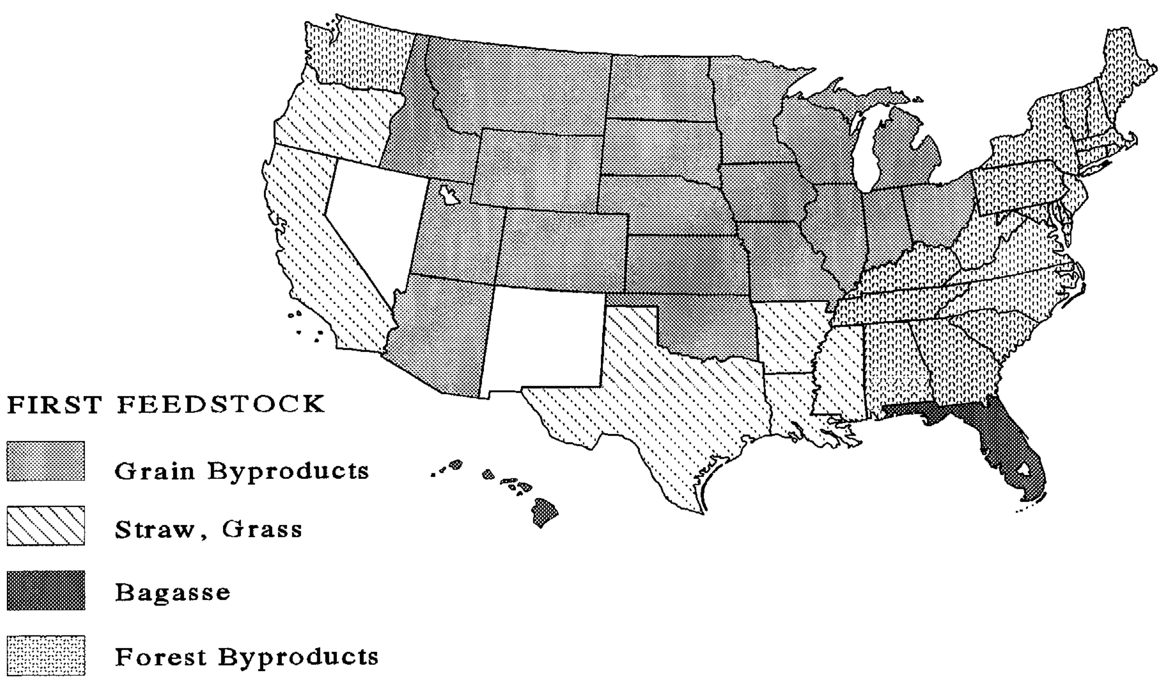


FIGURE 8

DISTRIBUTION OF POTENTIAL APPLICATIONS



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