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**VIA FEDERAL EXPRESS**

Arizona Corporation Commission
DOCKETED
FEB 25 2002
DOCKETED BY

Ms. Vickie Lasher
Arizona Corporation Commission
Legal Division
Docket Control
1200 West Washington
Phoenix, Arizona 85007-2996

Re: **In the Matter of the Generic Proceedings Concerning Electric Restructuring Issues, Docket No. E-00000A-02-0051**

Dear Ms. Lasher:

Enclosed for filing are the Comments of the Center for Energy and Economic Development ("CEED") in the above referenced proceeding. In CEED's Comments we reference two reports by Mills, McCarthy & Associates. Considering the voluminous nature of the two reports, we are not providing a copy of the reports to the persons listed on the service list. However, if a member of the service list would like a copy of either of the reports, we will gladly forward them upon request.

Finally, we have enclosed an additional copy which we ask that you stamp as having been filed and return it to us in the enclosed federal express envelope. Thank you for your assistance.

Sincerely,

Danèe Gaines

Enclosures

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**BEFORE THE ARIZONA CORPORATION COMMISSION**

| | | |
|---|---|---|
| **IN THE MATTER OF THE GENERIC PROCEEDINGS CONCERNING ELECTRIC RESTRUCTURING ISSUES** | ) ) ) | **DOCKET NO. E-00000A-02-0051** |

# COMMENTS OF THE CENTER FOR ENERGY AND ECONOMIC DEVELOPMENT

## I. Introduction

The Center for Energy and Economic Development (CEED) submits these Comments in response to the Procedural Order issued in the above-referenced docket on January 22, 2002. CEED is a non-profit organization formed by the nation's railroads, coal producing companies, a number of electric utilities and related organizations for the purpose of participating in state and regional regulatory proceedings affecting the utilization of coal by electric utilities. CEED's members include coal producing companies that sell coal to Arizona electric utilities and railroads that transport that coal.

As an initial matter, CEED takes no position as to whether or not the electric utility industry in Arizona should be restructured. CEED's view is that, if restructuring occurs, it should be fuel and resource neutral. In other words, restructuring should be accomplished in a way that does not favor any one method of generation over any other nor any one type of fuel for generation over any other. All types of electric generation should compete on a level playing field.

Our comments focus on the issues raised in Commissioner Spitzer's January 22, 2002 letter to Commissioners Mundell and Irvin. Commissioner Spitzer's questions concern environmental impacts of a restructured industry as compared with the environmental impacts of the present regulated industry. In particular, Commissioner Spitzer raises questions concerning "older dirtier plants." Although not stated in Commissioner Spitzer's letter, existing coal-based generating stations are often included in the category of "older dirtier plants."

The purpose of CEED's comments is to highlight the fact that, whether the Arizona electric utility industry is restructured or not, substantial progress will continue to be made in meeting the nation's air quality goals. This progress has been made and will continue to be made because of the strict system of clean air regulation that the nation - - and Arizona - - has put in place. This system will operate regardless of the system of electric utility regulation that is implemented in Arizona. Whether or not older electric generating stations are retired, they will become subject to increasingly strict requirements. CEED recommends, therefore, that environmental considerations not be the driver as to this Commission's decisions on restructuring. Environmental improvement will take place in any event.

At the same time, it is important that Arizona not take action that will serve to increase electric rates. Low electric rates are obviously critical to the state's economy; repeats of the California disaster must be avoided. Low electric rates are also critical to continued environmental progress. As we will show below, low electric rates create the basis for the continued electrification of our economy. The continued electrification of our economy will lead to lower environmental impacts as electrotechnologies substitute for fossil fuel-fired technologies. Thus, the state should avoid short-sighted actions that promote higher cost electric generating resources. The state should adopt a policy of environmental progress through low cost, environmentally-regulated generation.

## II. The Nation and Arizona Have a Strict Set of Environmental Laws that Can Be Counted on to Create Continued Environmental Progress.

As the Commission analyzes the environmental impacts of restructuring , it is important that it have an understanding of the nation's environmental laws. The cornerstone of national air quality policy is the National Ambient Air Quality Standards (NAAQS). Congress has directed the United States Environmental Protection Agency (USEPA) to establish primary NAAQS for air pollutants at a level that USEPA determines, based on a review of all scientific evidence and allowing "an adequate margin of safety," are requisite to protect public health. 42 U.S.C. § 7409(b)(1). Congress has also directed USEPA to establish secondary NAAQS to protect the public welfare from any known or anticipated adverse effects associated with the presence of an air pollutant in the ambient air. 42 U.S.C. § 7409(b)(2). In promulgating the primary and secondary NAAQS, the USEPA uses an elaborate process of funding scientific research, reviewing scientific studies, having its work reviewed by independent experts, and then asking for public comment.

The pollutants regulated under the primary and secondary standards (sulfur dioxide, nitrogen dioxide, carbon monoxide, suspended particulates, ozone and lead) are called "criteria" pollutants – the name taken from the detailed criteria document that USEPA must prepare to establish these national standards. 42 U.S.C. § 7408. This document lists the health and social welfare effects of each pollutant. The relevant scientific literature is reviewed in this document in order to determine the lowest pollution levels that lead to health effects. This criteria document is reviewed by the Clean Air Scientific Advisory Committee (CASAC), a group of independent experts (generally from universities and research institutions). In addition, USEPA invites public comment on the proposed air quality standard and supporting literature. This process is elaborate and consumes thousands of professional days over several years. The primary standard is set not simply at a level which avoids health effects but at a much lower level to provide an adequate margin of safety.

The NAAQS are reviewed every five years in light of new scientific evidence and tightened if necessary. In July 1997, USEPA issued new regulations providing for a more restrictive ozone standard and for a new fine particle ($PM_{2.5}$) standard.

Pursuant to the Clean Air Act, state legislatures, including the Arizona legislature, have adopted state plans to implement, maintain and enforce the primary and secondary standards and related Clean Air Act requirements in each air quality control region of the state, and have established appropriate state agencies to carry this out. 42 U.S.C. § 7410. These State Implementation Plans (SIPs) establish requirements to bring state air quality into compliance with the USEPA NAAQS for regions of the state that are presently out of compliance, and they establish requirements to maintain air quality for regions of the state that are in compliance. State agencies are given authority to administer the SIPs, including permitting systems for major sources of air emissions.

All electric generating stations in Arizona are required to obtain such an air quality permit. These permits require that each plant meet specific limitations on emissions so that operation of the plant does not cause a violation of the NAAQS. Severe sanctions are authorized in the event that a plant violates its air quality permit.

New powerplants and existing powerplants that propose major modifications are subject to especially strict restrictions under USEPA's New Source Review (NSR) program. This program requires that any new or modified stations install "best available retrofit technology." It also requires sources that potentially create air quality impacts in a Class I area (generally a wilderness area or national park) are subject to review to ensure no impact to important air quality related values.

In addition to the system just described, the Clean Air Act imposes special requirements for the emissions of sulfur dioxide, an acid rain precursor, and nitrogen oxides, an ozone precursor. Title IV of the Act created a nationwide cap on emissions of sulfur dioxide. Any plant emitting sulfur dioxide must obtain emissions credits to ensure that the nationwide cap cannot be violated.

With respect to nitrogen oxides, the Clean Air Act established specific dates to bring ozone non-attainment areas into compliance, ranging from November 15, 1993 for "[m]arginal" areas to November 15, 2010 for "[e]xtreme" areas. 42 U.S.C. § 7511. The statute prescribes comprehensive regulation to protect against ozone non-attainment – envisioning controls not just over electric powerplants but rather over a wide range of sources and ozone precursors. 42 U.S.C. §§ 7511a, 7511b, 7511f. Congress also provided specific procedures for controlling interstate transport of ozone. 45 U.S.C. § 7511c. Congress has furthermore established an Acid Rain $NO_x$ Emission Reduction Program for coal-based electric utility units. 42 U.S.C. § 7651f. USEPA has promulgated rules setting $NO_x$ emission limits for a large number of utility powerplant units under this provision.

USEPA has also put in place regional haze regulations intended to ensure reasonable progress towards remedying existing, and preventing new, sources of visibility impairment in Class I areas. The Western Regional Air Partnership was established to create a West-wide approach to air quality issues. While CEED does not agree with the specifics of all of USEPA's actions in the regional haze area, there can be no question that substantial progress will be made to improving visibility conditions.

The nation's clean air regulations are creating substantial improvements in air quality. According to USEPA's August 2000 annual survey, *Latest Findings in Air Quality: 1999 Status and Trends*, aggregate emissions of the criteria pollutants have declined each year since 1970. In 1999, emission of the criteria pollutants were a full 31% below 1970 levels. This improvement occurred at a time when the U.S. population grew by 33% and economic output, measured by gross domestic product, increased by 147%. Emissions from coal-based electricity have decreased by one-third since 1970, while the use of coal for generating electricity has nearly tripled during the same period. It is estimated that, simply through continued implementation of existing regulations, emissions of major pollutants will be almost a full 50% lower in 2015 than they were in 1970.

It is likely, however, that emissions regulations will tighten in the future. Under President Bush's recently announced Clear Skies Initiative, sulfur dioxide emissions would be cut by 73% from the current cap of 11 million tons to a cap of 4.5 million tons in 2010 and 1.7 million tons in 2018; nitrogen oxide emissions would be cut by 67% from current emissions of 5 million tons to a cap of 2.1 million tons in 2008 and 1.7 million tons in 2018; and mercury emissions would be cut by 69% from current emissions of 48 tons to a cap of 26 tons in 2010 and 15 tons in 2018. Alternative proposals introduced in Congress would create additional reductions on a more expedited time frame.

In sum, as the Commission deliberates how to account for environmental issues in electric utility restructuring, it must bear in mind that there are strict environmental laws in place, that these laws are creating significant environmental improvement; and that this improvement will accelerate in the future. The emissions concerns raised by older powerplants are being, and will continue to be, addressed.

## III. Low-Cost Electricity is the Best Environmental Policy this Commission Could Adopt.

The best environmental policy with respect to electricity is to maintain low electric rates. Throughout the economy, electricity competes with other types of fuels, primarily fossil fuels, for use as energy inputs in commercial, manufacturing and industrial processes. As the price of electricity is reduced, electricity becomes more competitive with these other types of fuel. Lower cost electricity, therefore, will lead to the substitution of electricity for these other types of fuels.

As is now well-documented, electricity is much more efficient than other types of fuels in end use processes. *See, e.g.*, EPRI, "Electricity for Increasing Electric Efficiency," EPRI Journal, 1992. As a result, the use of electricity in homes, businesses and industries results in lower emissions than the use of competing fuels ***taking into consideration the emissions resulting from generation of the electricity***. Thus, the availability of low-cost electricity will likely lead to end users switching from fossil fuels to more efficient electricity with a net reduction in emissions.

It has been demonstrated that policies that reduce electric prices will result in lower overall emissions. According to one study that examined carbon dioxide emissions, in results that apply equally to any other kind of fossil fuel-related emissions:

- In 1991 for the first time in history, the industrial, commercial, residential (ICR) sectors which drive the economy consumed the major share (51%) of their fuel as electricity. By 2010, over 63% of the ICR energy will be consumed as electricity. In 1970 only 32% of all ICR energy consumption was in the form of electricity.

- In 1970 the ICR sectors spent about $150 billion to buy fuels, and $88 billion to buy electricity (1991$). By 1991 the pattern reversed: expenditures on fuels *dropped* to $112 billion, purchases of electricity rose to $180 billion. Electricity replaced fuel burning in the marketplace and supported a 60% growth in the nation's economy.

- Coal power plants provided 60% of the increased use of electricity since 1970, and are projected to supply over 50% of new electric demand over the next two decades.

- Despite rapidly rising coal use to support electric and economic growth, total U.S. $CO_2$ emissions have dropped from 4 pounds/$GNP in 1970, to about 2.7 pounds in 1991, and will fall below 2 pounds/$GNP by 2010.

- The association of reduced $CO_2$ emissions/$GNP and increasing coal consumption is not coincidental – it is causal. Reduced $CO_2$ emissions are a primary consequence of improved overall energy efficiency, and energy efficiency gains are a direct result of electrification. Since 1970, for every single kilowatt-hour of new demand there has been a *net* reduction in $CO_2$ emissions of 3.6 pounds.

The report went on to conclude that:

> The driving force behind improved $CO_2$ efficiency is revealed in examining the role of electrotechnologies. As the economy has switched to electric processes for pivotal productivity and economic benefits, electrotechnologies brought net reductions in $CO_2$ ranging from 0.5 lbs to 60 lbs of $CO_2$ per kwhr. The economical and ecologically beneficial use of kilowatts has been documented extensively. Examples are found in every aspect of the economy, ranging from cooking, materials processing and metals fabrication, ink and paint drying, to transportation and even solid waste recycling. These activities often involve burning fuels; using electrotechnologies instead eliminates $CO_2$ emissions associated with such burning. The net effect is fewer $CO_2$ emissions even taking into account emissions from a power plant needed to produce the electricity. $CO_2$ savings arise from the fact that electrotechnologies are more efficient than their fuel-burning equivalents.[1]

In sum, as Arizona's economy grows in the future, the key to controlling emissions is to implement policies that reduce the price of electricity. The key is to make sure that electricity is priced low enough so that at the point of use consumers are encouraged to utilize electricity as an energy source rather than to switch to other less efficient fuels. The Commission, therefore, should be careful as it considers restructuring not to take steps that will artificially increase rates and retard the environmentally beneficial electrification of the economy. The best environmental policy is low electric rates.

## IV. CONCLUSION

Environmental considerations should not influence the Commission's decisionmaking regarding restructuring. The nation's environmental regulations can be

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[1] See Mills, McCarthy & Associates, "Sustainable Development and Cheap Electricity," copy attached. In addition, we attach a copy of the Mills, McCarthy report "Does Price Matter?" demonstrating the benefits of low cost electricity throughout the economy.

counted on to provide continued environmental improvement. The Commission, however, should avoid actions that would increase electric rates and thereby unintentionally damage the environment.

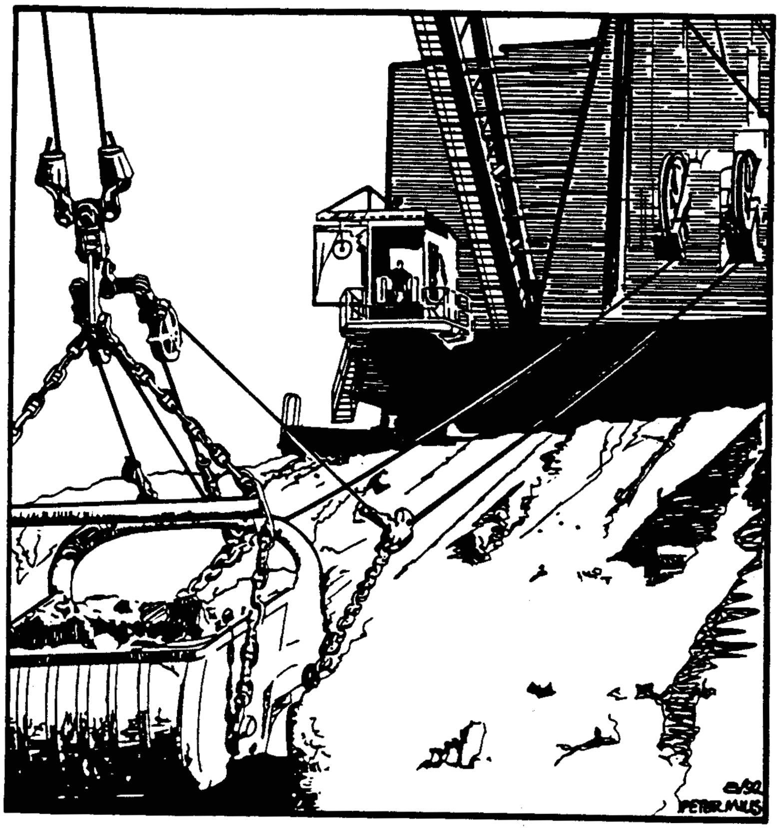
Dated: February 22, 2002

Respectfully submitted

Terry Ross
West Region Vice-President
Center for Energy and Economic Development

# Sustainable Development and Cheap Electricity

An Evaluation of the Impact of Lower Electricity Prices on the U. S. Economy
and
U. S. Carbon Dioxide Emissions



Prepared by:
Mills•McCarthy Associates
October, 1992

# SUSTAINABLE DEVELOPMENT AND CHEAP ELECTRICITY

**An Evaluation of the Impact of Lower Electricity Prices on the U. S. Economy and U. S. Carbon Dioxide Emissions**

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October, 1992

Note: *This analysis was performed under contract to Western Fuels Association, Inc. (WFA). The opinions and data presented do not necessarily represent the position(s) of WFA.*

# List of Figures & Tables

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# SUSTAINABLE DEVELOPMENT AND CHEAP ELECTRICITY


### *EXECUTIVE SUMMARY*

The economy and the environment increasingly appear to be in competition. This is most striking in the electricity sector where programs around the nation are discouraging or have discouraged electricity consumption ostensibly in order to improve energy efficiency and minimize environmental impacts. While there are sensible and economically viable programs to promote the more efficient use of electricity, such activities have all too often been mistakenly interpreted to mean that overall electric use should be discouraged.

Historical technical and economic evidence reviewed in this analysis shows that the overall effect of *declining electricity costs and rising electricity use is beneficial both for the economy and the environment.* This analysis reveals the fact that economic growth over the next two decades could be accelerated with low-cost electricity. And while the increased use of coal is inextricably linked to low-cost electricity, the remarkable efficiencies of the electricity-using technologies that will be replacing fuel-burning technologies in the marketplace more than offset emissions from coal-fired power plants -- so much so that one can expect substantial reductions in the emissions of carbon dioxide (the principal gas implicated in the global warming theory).

The economic and environmental importance of low-cost electricity is highlighted by the following facts which illustrate the transition to an economy dominated by electricity :

- *In 1991 for the first time in history, the industrial, commercial, residential (ICR) sectors which drive the economy consumed the major share (51%) of their fuel as electricity. By 2010, over 63% of the ICR energy will be consumed as electricity. In 1970 only 32% of all ICR energy consumption was in the form of electricity.*
- *In 1970 the ICR sectors spent about $150 billion to buy fuels, and $88 billion to buy electricity (1991$). By 1991 the pattern reversed: expenditures on fuels dropped to $112 billion, purchases of electricity rose to $180 billion. Electricity replaced fuel burning in the marketplace and supported a 60% growth in the nation's economy.*
- *Coal power plants provided 60% of the increased use of electricity since 1970, and are projected to supply over 50% of new electric demand over the next two decades.*
- *Despite rapidly rising coal use to support electric and economic growth, total U.S. $CO_2$ emissions have dropped from 4 pounds/$GNP in 1970, to about 2.7 pounds in 1991, and will fall below 2 pounds/$GNP by 2010.*
- *The association of reduced $CO_2$ emissions/$GNP and increasing coal consumption is not coincidental but causal. Reduced $CO_2$ emissions are a primary consequence of improved overall energy efficiency, and energy efficiency gains are a direct result of electrification. Since 1970, for every single kWhr of new demand there has been a net reduction in $CO_2$ emissions of 3.6 pounds.*

The driving force behind improved $CO_2$ efficiency is revealed in examining the role of electrotechnologies. As the economy

has switched to electric processes for pivotal productivity and economic benefits, electrotechnologies brought net reductions in $CO_2$ ranging from 0.5 lbs. to 60 lbs of $CO_2$ per kWhr. The economical and ecologically beneficial use of kilowatts has been documented extensively. Examples are found in every aspect of the economy, ranging from cooking, materials processing and metals fabrication, ink and paint drying, to transportation and even solid waste recycling. These activities often involve burning fuels; using electrotechnologies instead eliminates $CO_2$ emissions associated with such burning. The net effect is fewer $CO_2$ emissions even taking into account emissions from a power plant needed to produce the electricity. $CO_2$ savings arise form the fact that electrotechnologies are more efficient than their fuel-burning equivalents.

Lowering the price of electricity would stimulate a classic economic response of greater demand. It would also stimulate the use of new electrotechnologies in vast areas of industrial processing where price sensitivities are highest. This analysis finds that lowering electricity costs to an achievable national average of 5.9¢/kWhr (1991$) in 2010 instead of the projected 7.2¢/kWhr in 2010 (current average is 6.9¢/kWhr) would result in:

- *Over $1 trillion more economic activity in 2010: nearly $4000/yr more for every American citizen in that year.*
- *An accelerated introduction of hundreds of revolutionary, highly productive, energy efficient technologies, and therefore more jobs and greater U.S. competitiveness.*
- *A net reduction in U.S. $CO_2$ emissions of over 1.3 billion tons per year if half of all new electricity is coal-fired as now projected. (And nearly 1 billion tons net reduction in total U.S. $CO_2$ emissions even if all the new electricity were coal-fired).*

# 1 INTRODUCTION

The purpose of this report is to explore the issues underlying a growing tension between the need to stimulate economic development, and programs to improve the environment and energy efficiency. The tension between these two sets of goals is readily apparent in the electricity policy arena where utilities are frequently encouraged, or required, to avoid practices that promote the use of electricity.

The motives which underlie the trend towards avoiding electricity consumption seem, at first glance, indisputably correct. Minimizing electricity use reduces fuel consumption and the environmental impacts associated with power plants (notably coal). And minimizing electricity consumption, a.k.a. electricity efficiency, would appear to have the twofold economic benefit of enhancing savings in electricity purchases, and avoiding the costly and sometimes politically painful process of building new electric power plants.

The proposition that using less electricity means that less money is spent buying electricity, has superficial appeal. But measures that raise electricity prices to reduce demand have not demonstrated overall reductions in electricity bills or overall economic benefits. However, the realities of technology, progress and the marketplace are far more complex. It is possible, indeed likely, that fiscal and policy preoccupations with electricity efficiency are economically counter productive. The list of important electricity-using technologies is virtually limitless. Depressing their use—i.e., avoiding electricity consumption—would be economically myopic and hardly justify the meager savings in purchased electricity. The act of avoiding purchases of electricity cannot, on average, be a significant economic benefit. Total annual U.S. expenditures on electricity amounts to barely 4% of the national economy.[1] Electricity's relevance is not anchored in simple purchase costs, but in that it permits businesses, industries and home owners to do remarkable things—a basic fact often lost in the current debate.

Of course, building power plants has been a painful experience for some organizations. Many have learned how to do it better. Others will avoid doing so at all costs in the future, contracting the task out in a surrogate fashion via power purchase contracts. Some analysts and policy makers are taking the position that building power plants should be avoided *a priori*. For example, a recent Office of Management and Budget (OMB) memorandum takes the Bonneville Power Administration to task for a plan that creates the possibility of increased electric load.[2] The OMB's interpretation of the National Energy Strategy appears to be that increased electricity use is not consistent with economic growth and increased overall energy efficiency.

Surely the nation and the economy would be better served by policies that focus first on economic growth while at the same time preserving the environment and

[1] Calculation: approximately $5 trillion economy, 2.7 trillion kilowatt-hours purchased @ 7¢/kWhr avg. It is often noted that the cost of building power plants is an economic burden. This may be true, but it is irrelevant since all costs associated with building and operating power plants for a utility are ultimately included in the cost of the electricity provided; considering power plant financing as a separate economic problem is in effect a double counting of the economic impact of electric growth.

[2] *Inside Energy*, August 10, 1992, "OMB Hits DOE for Discouraging Gas Use."

improving energy efficiency—"sustainable development" with the emphasis on development. And, if it turns out that such economically-oriented policies result in a need for more power plants, why should this be considered bad?

The basic thrust of this report is that an ideologically agnostic electricity policy that promotes economic development will achieve energy efficiency and environmental goals *as a result of* increased demand for electricity.

# 2 BACKGROUND

Managing the use and alleged over-use of electricity is a central theme in many of the current energy and environmental manifestos. Pricing electricity "correctly"—i.e., increasing its price—thereby reducing electricity consumption is held out as a vital part of regulatory and utility policy in order to save energy and help the environment. Perhaps this philosophy has been best epitomized by one recent study's title: *"Stabilizing Electricity Production and Use: Barriers and Strategies."*[3]

The reason for this goal? Environmental activists appear to have figured something out that many policy makers and energy planners have not, or at least ignore: economic growth and electricity use are intimately linked. The logic chain that springs from this is clear:

People like economic growth, but—

- *Economic growth spurs electricity consumption;*
- *Electricity growth increases fuel use at power plants;*
- *The major share of electricity is made with coal;*
- *Coal emits more carbon dioxide than any other fuel.*

Thus with the environmental community's current pressure to address carbon dioxide emissions because of the global warming theory, the question of the day appears to be:

- *How does one decouple economic growth and electricity growth?"*

This is the wrong question. The correct questions are, first:

- *"How does one stimulate the economic growth associated with rising electricity consumption?"*

And, second, but importantly:

- *"What effect would economically driven electricity policies have on national energy efficiency and carbon dioxide emissions?"*[4]

While the answer to the second question is found later in this analysis, we here consider the answer to the first, since it is so readily apparent: lower the price of electricity. Lowering electricity prices is at the heart of a nascent revival of an old policy: state regulators supporting policies that provide electric rate discounts in order to stimulate depressed local economies.[5]

There is an implicit economic theory behind programs attempting to stimulate the economy via lower electric rates. The theory is not based on the straightforward

[3] American Council for An Energy Efficient Economy, 1992.

[4] In this analysis the environmental impact considered is carbon dioxide because of its prominence in the current debate, and because it in fact serves as a valid general surrogate for virtually all other emissions. With respect to sulfur dioxide emissions, the analysis assumes compliance with the Clean Air Act. We note that the opportunities grow daily for compliance at relatively low cost via low sulfur fuels, advanced combustion and scrubbing technologies.

[5] *Public Utilities Fortnightly*, August 1, 1992, "Electric Sales Growth and the Conservation Ethic;" the Connecticut DPUC has approved plans to stimulate electric demand and approved a "long-term economic development rate." The New Jersey Board of Regulatory Commissioners approved "economic recovery" programs which include industrial and commercial rate credits and even $500 payments to first-time home buyers.

impact of lower prices. Electricity discounts are *not* intended to stimulate the economy arising from the relatively modest funds made available from the savings in reduced electricity purchases. It is possible to confirm that such direct benefits are relatively small by calculating the effect of a hypothetical 1¢/kWhr subsidy on all of the nation's electricity consumption. This would generate purchase savings equal to about 0.5% of the total economy.[6]

The essential economic theory behind policies to lower electric rates is rooted in two basic principals, one obvious, the other less so: first, lowering the price of electricity (or any item) will result in increased consumption. Second, increased electricity use creates increased economic growth.

The first observation is an indisputable basic economic fact relating to elasticities of demand. In fact the inverse of this—increasing electricity prices to decrease consumption—is a core goal of many environmental organizations' energy plans.[7]

The second statement is less well recognized. Yet, nearly six years ago the National Academy of Sciences (NAS) reached a profoundly important conclusion in its study of electricity and the economy.[8]

"To foster increased productivity, policy should stimulate increased efficiency of electricity use, *promote* the implementation of *electrotechnologies* when they are economically justified, and seek to *lower* the real costs of electricity supply." (Emphasis added.)

The essential reasons for the NAS conclusion can be seen in the basic trends that have occurred over the decades following World War II (See FIGURE 1). The basic track of energy use, electricity and the GNP growth make it clear that electricity must play a role in the economy more important than that of a simple fuel.

The NAS reached another closely related conclusion. Productivity growth, the anchor of economic health and international competitiveness, *increased* most rapidly during periods of decreasing electricity prices. Increases in electricity prices have been an important factor in slowing U.S. productivity growth, the NAS concluded.[9]

And yet, many of those who express concern over the U.S. economy and U.S. competitiveness are the same ones who are promoting policies to increase the price of electricity. Policies to increase electricity prices are, however, masked under the rubric of ensuring that consumers pay for the "full" cost of electricity, or the so-called externality costs.

The most prominent environmental externality currently cited and debated is that of carbon dioxide ($CO_2$) emissions. This arises from the role of $CO_2$ as the primary contributor in the global warming theory. Policies and programs intended to address $CO_2$ emissions must confront an obvious relationship between electricity and the fuels needed to provide it. Coal has been the dominant source of electricity for decades (see FIGURE 2), and in fact coal use has now reached record levels, supplying nearly 55% of all the nation's electrical needs.

[6] This observation also suggests that claims that consumers benefit from more efficient electrical devices, in terms of avoided purchases of electricity, may be true but also largely irrelevant. Note also that the cost of purchasing electricity is a relatively small share of average household expenditures, and average business expenses as well. The exceptions are isolated primarily to low income households and a few notable industrial activities.

[7] *Stabilizing Electricity Production and Use*. p. 43; the plan to raise electricity prices is cloaked under the auspices of fully accounting for environmental externalities from power plants, and attaching a speculative cost to the various externalities. This approach to raising electricity prices creates a fundamental flaw, discussed later in this paper. The flaw: ignored are the environmental externalities arising from the use of electricity in the market.

[8] *Electricity in Economic Growth*, A Report Prepared by the Committee on Electricity in Economic Growth, Energy Engineering Board, Commission on Engineering and Technical Systems, National Research Council, National Academy Press, 1986, p xvi.

[9] *Electricity in Economic Growth*, p. xviii.

Because burning coal releases more carbon dioxide per unit of energy than does any other fuel, concerns over global warming make electricity consumption a prime target. According to many environmentalists, electricity growth must be slowed or stopped, else $CO_2$ emission will rise. The market must be sent the "right" signals—i.e., increase the price of electricity to discourage its use, and thereby reduce the consumption of coal.

A low $CO_2$ future, we are told, is only possible through policies that limit electricity use. The economic implications of such a path are ameliorated by the anemic logic of savings in electricity purchases and the overall benefits of a more efficient society. Does the historic record, however, substantiate the worry that rising electricity use necessarily contributes to poor overall energy efficiency and rising $CO_2$ emissions? The answer is "no", as we shall see in the following section.

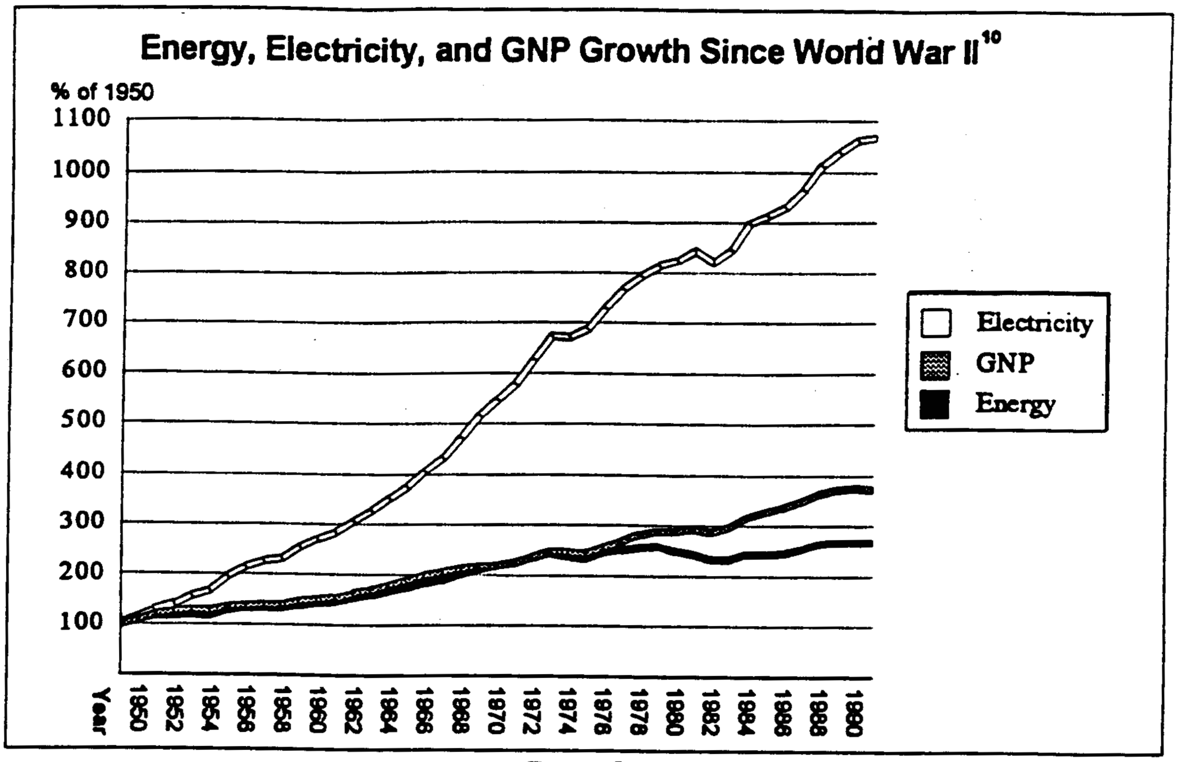


FIGURE 1

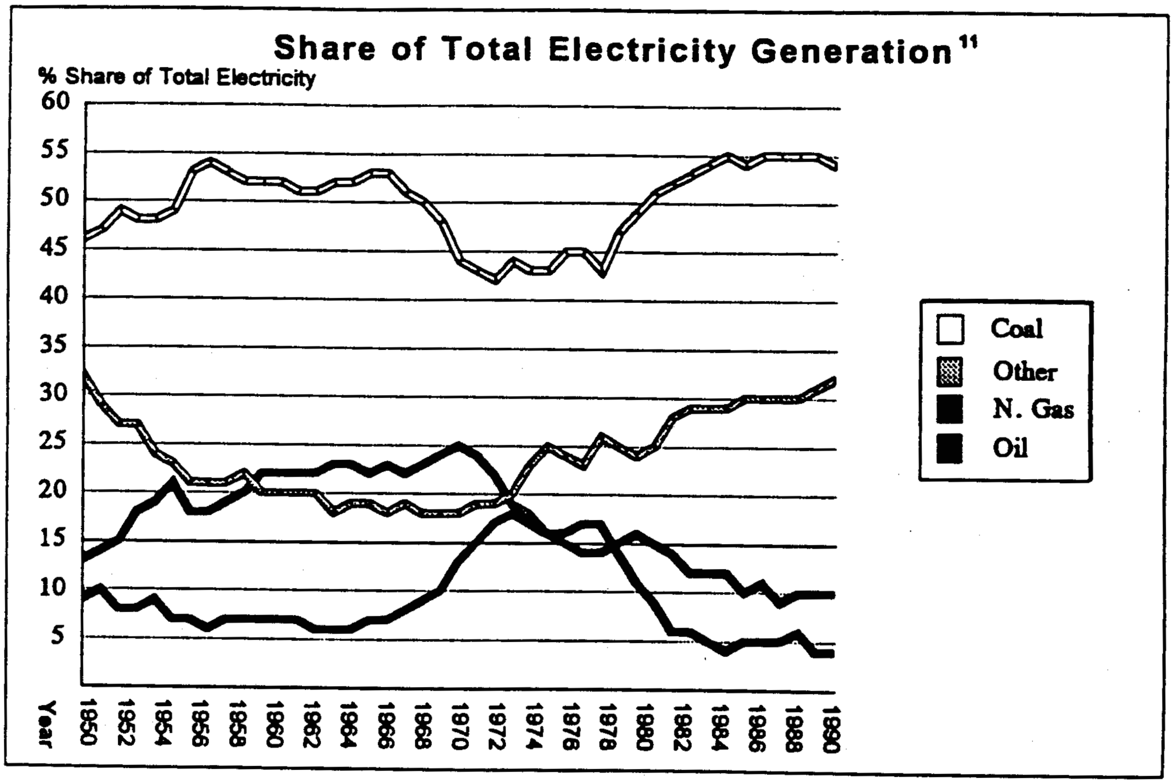


FIGURE 2

[10] Data from *Annual Energy Review*, May 1991, U. S. Energy Information Administration.

[11] *Ibid.*

# 3 THE 20-YEAR TREND

### *Coal, Electricity, The Economy And $CO_2$*

What does the future hold? It is the practice of many prognosticators to deal in two decade projections. This is a time period during which it is possible to anticipate at least the broad scope of trends. While intriguing information can be extracted from the long term trends illustrated in FIGURES 1 and 2, it is difficult to apply the lessons directly because so many unpredictable technical, social and political events can unfold over such a long period.

The two decade period is simply more manageable and reliable. It is also a period of time for which events in history retain significant relevance as predictors of future possibilities. Unfortunately, many prognosticators have been ignoring the lessons of the past two decades.

FIGURE 3 illustrates a now familiar historic trend in which one can see that electricity and GNP growth appear to be tightly correlated. Energy growth, on the other hand, is not strongly tied to GNP growth. FIGURE 3 is one of the basic indicators supporting the National Academy of Science's conclusions, cited earlier, regarding the importance of electricity to GNP growth.

The trends seen in FIGURE 3 suggest two questions that are the core issues explored in this analysis.

- *What economic effect would arise from a goal of lowering electricity prices—i.e., an aggressive national trend towards economic development rates?* [12]
- *What is the likely environmental effect, specifically the change in $CO_2$ emissions, of a policy to stimulate electricity growth, particularly considering the dominant role of coal-fired generation? As previously noted, reducing electricity prices will certainly increase demand. Setting aside the economic implications of such an event, this would appear to be in conflict with environmental goals.* FIGURE 3 *already suggests to some that electricity growth is "out of control." Increasing electricity consumption, rather than decreasing it, is something of great concern to those who believe that limiting coal consumption is an important carbon dioxide mitigation strategy.*

Regardless of one's views on the debate over global warming theory, it is clearly important to understand the role of coal given it is the dominant position in supplying the nation's electricity. Coal has supplied nearly 60% of all new electricity supply over the past two decades. [13]

[12] The point of this analysis is not to project future electricity prices, but to explore the implications of practices that would drive prices down.

[13] As the table below summarizes, over the past two decades, there has been a gross increase in generation of 1,473 billion kWhrs collectively from coal, nuclear, hydro and all other sources, offset by a net decrease of 182 billion kWhrs from natural gas and oil generation, yielding net growth in consumption of 1,291 billion kWhrs. Of all sources of supply that increased, coal accounted for 57%. Data from *Annual Energy Review*, May 1991

**Changes in Electricity Generation**
**(billion kWhrs)**

| | Coal | N. Gas | Oil | Nuclear | Hydro | Other | Total |
|---|---|---|---|---|---|---|---|
| 1970 | 704 | 373 | 184 | 22 | 248 | 1.0 | 1523 |
| 1991 | 1549 | 264 | 111 | 613 | 276 | 10.1 | 2823 |
| 1990-70 | +845 | -109 | -73 | +591 | +28 | +9.1 | +1291 |

Coal is also projected to be the source of at least 50% of all new electricity supply for the next two decades.[14] As FIGURE 4 shows, coal use has risen sharply, nearly 60%, over the past 20 years. Yet, total $CO_2$ emissions are barely 10% greater.[15] And emissions of $CO_2$/$GNP (measured in constant 1982$), perhaps the most important practical measurement, have actually declined over 35%. In other words, the U.S. economy has expanded and $CO_2$ efficiency has improved dramatically despite the fact that coal-fired electricity has been the primary fuel for economic growth.

Does rising electricity and coal use inevitably mean greater $CO_2$ emissions? FIGURE 4 suggests the answer is "no".

This 20-year record does not support projections of rising $CO_2$ emissions inevitably arising with a growing economy. The phenomenon that has driven the trend of rising electricity use and decinling $CO_2$/$GNP, summarized in FIGURE 5, is critical to considering future projections and policies.

Before exploring the specific factors creating this phenomenon, we explore first the economic implications and opportunities in the modern electrified economy.

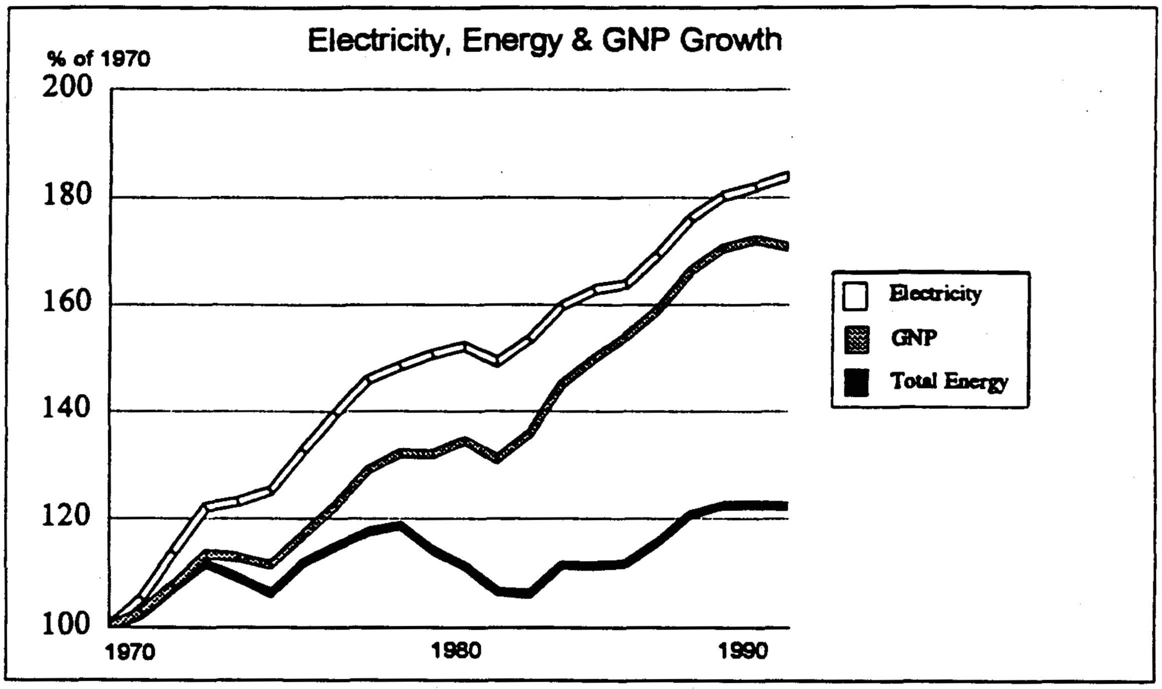


FIGURE 3

[14] From *Annual Outlook for U.S. Electric Power 1991: Projections Through 2010*, July 1991.

**Changes in Electricity Generation**
**(Quads)**

| | Coal | N. Gas | Oil | Nuclear | Hydro+Other | Total |
|---|---|---|---|---|---|---|
| 1970 | 16.06 | 2.93 | 1.3 | 6.14 | 3.71 | 1523.0 |
| 1991 | 22.60 | 5.72 | 1.7 | 6.67 | 6.25 | 2823.0 |
| 1991-70 | +6.54 | +2.80 | +0.4 | +0.50 | +2.50 | +12.8 |

[15] Other than the continued electrification of America, there have only been two large structural changes in the energy economy over the past 20 years: increased automobile efficiencies (CAFE), and nuclear power. As is shown later in this analysis, these two factors together, while significant, account for only 22% of the avoided increases in $CO_2$ emissions over the past 20 years.

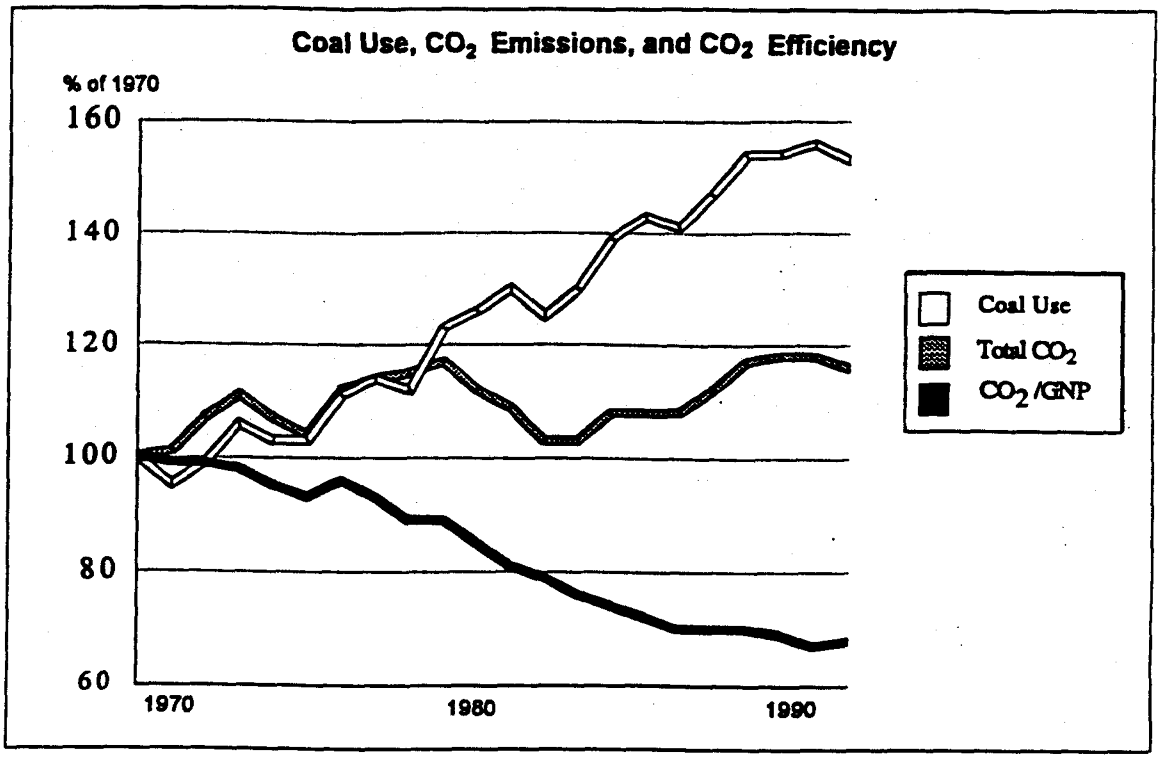


FIGURE 4

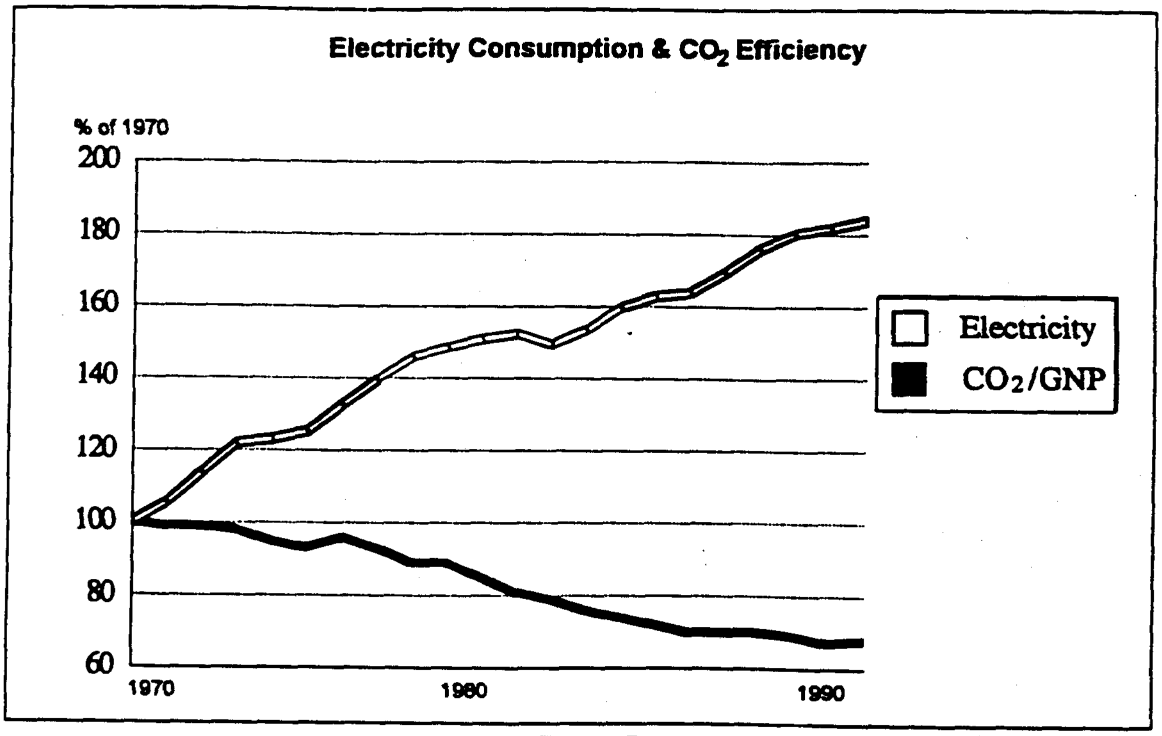


FIGURE 5

# 4 Transition to An Electricity-Dominated Economy

The economic opportunities and risks associated with electricity policy and pricing are more important today than at any time in history. This is because a critical transition has taken place during the past two decades.

As illustrated in FIGURE 6, for the first time in history, the sectors driving the economy—the industrial, commercial, residential (ICR) sectors—consumed the major share of their fuel in the form of electricity.[16] The crossover occurred in 1991 when 51% of all the primary energy consumed by the ICR sectors was used first by utilities to generate electricity.[17]

The transition to an electricity-dominated economy is not expected to reverse itself, even within the context of current conventional projections for electricity and energy growth. According to the Energy Information Administration, by 2010 over 63% of the total ICR energy will be consumed by utilities in order to provide electricity to businesses, homes and industry.[18] The speed of this transition is apparent in the fact that in 1970 only 32% of all ICR sector energy consumption was in the form of electricity. This transition demonstrates the dominance of technologies associated with producing and using electricity.

This transition contains a number of important implications. As the activities in the ICR sectors become increasingly dependent on electricity:

- *They become inherently less dependent on the availability of raw resources. A reliable electric supply can be achieved with a very broad array of primary fuels.*
- *They are more effectively insulated from basic fuel price swings. This arises from the fact that raw fuel constitutes only one share (ranging from 40% to 70%) of the total number of components contributing to the cost of electricity.*
- *They achieve greater flexibility in adopting new technologies because of the inherent flexibility of electricity. (Combustion-based technologies are inherently less flexible.)*
- *They can enjoy various environmental benefits due to the low or zero impact of electric-based technologies—in effect, environmental issues are transferred to the supplier of electricity. As a practical matter, this means in many cases that the environmental impact is removed from population centers, and is easier to monitor and manage at the central location of a power plant, rather than at thousands of dispersed locations.*

[16] This analysis does not incorporate the transportation sector for two reasons. First, transportation is largely un-electrified, and will likely remain so for the period considered in this analysis. Second, the combined industrial, commercial and residential sectors are collectively larger economically than is the transportation sector, and involve activities that are fundamental to future economic growth. The Census Bureau reports (*Statistical Abstract of the United States 1991*, Table 1019), for example, that about $1 trillion of outlays are associated with all passenger and freight transportation—significant, but only 20% of the total economy.

[17] Data from *Annual Energy Review*, May 1991.

[18] Data from *Annual Outlook for U.S. Electric Power 1991: Projections Through 2010*, July 1991.

The energy use trends over the past 20 years which have given rise to electricity's dominance can be seen in FIGURE 7. While FIGURE 7 illustrates the industrial sector portion of the ICR trends, it is typical of all three sectors—significant declines in the direct use of oil, natural gas and coal, accompanied by large growth in electricity use. This type of trend highlights the need to consider carefully electricity's critical role in supporting industrial economic health. The trends point to the need for caution in developing policies that explicitly, or implicitly, discourage electricity use.

One other way to reveal electricity's increasingly important role is in spending patterns, as illustrated in FIGURE 8. In 1970, the ICR sectors spent about $150 billion to buy fuels, and about $88 billion to buy electricity (in 1991$).[19] By 1991, the spending pattern had reversed. The ICR sectors' 1991 expenditures on fuels *dropped* to $112 billion, while purchases of electricity rose to $180 billion. By 2010, the disparity will grow even greater, with over $300 billion in electricity purchases for these sectors, and $200 billion for fuels.[20] This transition to an economy dominated by electricity use and price argues strongly for economic policies intended to minimize the cost of electricity.

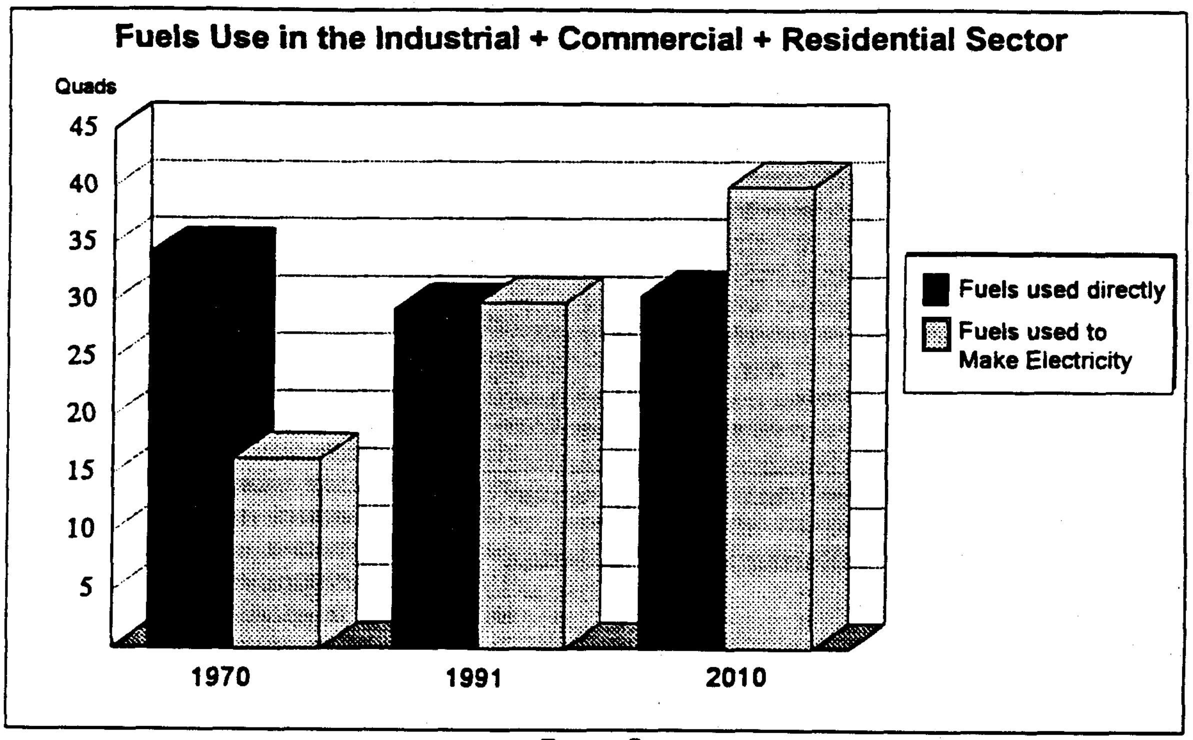


FIGURE 6

[19]Data from Annual *Energy Review*, May 1991.

[20]Data from *Annual Outlook for U.S. Electric Power 1991: Projections Through 2010*, July 1991.

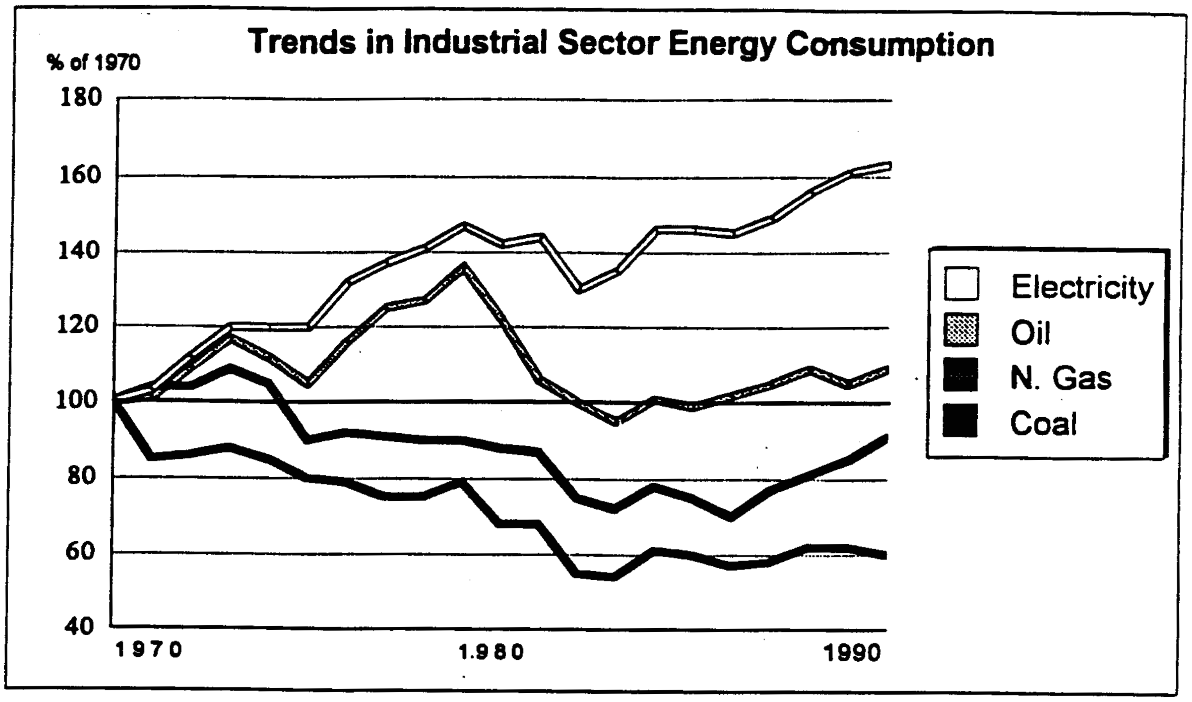


FIGURE 7

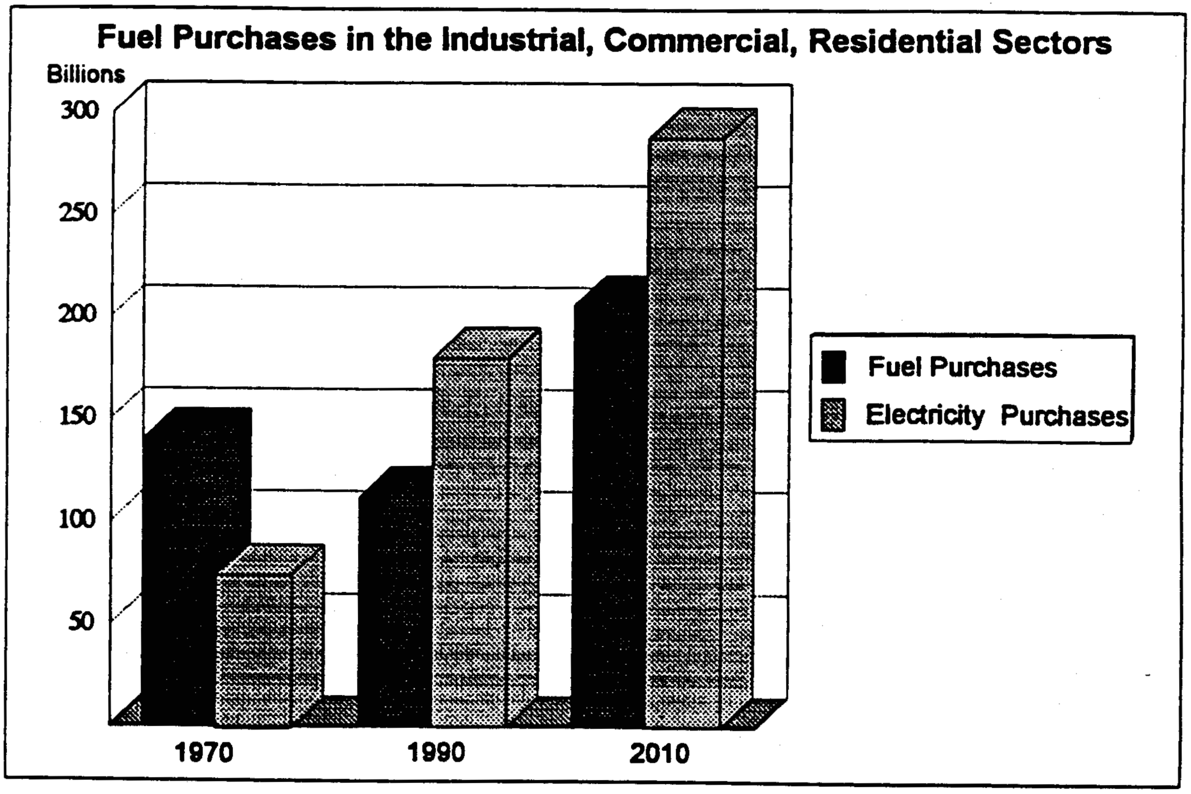


FIGURE 8

# 5 ECONOMIC POLICIES TO SUSTAIN OR PROMOTE DEVELOPMENT?

Electricity has now achieved a dominant role in the economy. Can economic growth be maintained while minimizing the electric sector's impact on the environment, especially $CO_2$ emissions?

The notion of preserving the environment while encouraging economic growth has been given the label "sustainable development." Central to recommendations to achieve sustainable development is the idea that economic policies should be subsumed to environmental goals, while ensuring that there are "no losers." But, such an approach is more likely to ensure that there are no winners. As a practical matter, programs focused on avoiding problems are rarely as economically effective as programs focused on achieving results.[21]

The irony is that encouraging the link between the economy and electricity is by its very nature environmentally beneficial. Given the state of the American economy, and the increasing need for improving U.S. productivity and competitiveness, state and federal policies should be oriented towards development as a priority. Such an orientation, far from being bad for energy efficiency and thus bad for the environment, is good for both. The evidence is that economic growth can occur with electricity demand rising, along with improved energy efficiency.

The evidence is present for example in the current wisdom as illustrated by the projections of the Energy Information Administration (EIA). EIA projects, for example, that over the next 20 years:[22]

- *The economy will grow by over $3 trillion.*
- *The nation will require the additional electricity output of at least 300 new power plants (@ 500 MW).*[23]
- *Yet, energy efficiency will improve, with a 23% energy/GNP ratio decline.*

In the next section of this report we consider the environmental aspects of development-oriented electricity pricing, specifically $CO_2$ emissions. First, however, we will explore the implications of the basic question posed at the outset:

> *"How does one stimulate the economic growth associated with rising electricity consumption?"*

The answer? Provide the market with economic incentives to use more electricity; i.e., make it cheaper.

As FIGURE 9 shows, the trend of the past several decades is encouraging. In real, inflation-adjusted terms, electricity prices are lower today than they were 10 years ago.[24] However, that fact masks an important trend. Electricity prices were

[21] Obviously, this is not to say that environmental goals should not be given an important place in economic planning. However, plans which focus first on the economy, and subsequently seek to evaluate and mitigate environmental impacts are by definition more likely to be economically aggressive.

[22] *Electric Power 1991: Projections Through 2010*, July 1991; base case projections through 2010.

[23] Electricity consumption per $GNP is projected to decline by 5%.

[24] The notable exception to this is California, where 20 years ago the average cost of electricity was the same as the U.S. average, and where today it is 30% higher than the national average, and twice as high as the achievable lowest cost source of supply in Wyoming for example. Not only does California spend over $5

declining until the early 1970s, when they began to rise. FIGURE 9 shows the movement downward to a low of about 5.3¢/kWhr nationally in the early 1970s. Following the low period, a combination of increased fuel prices and escalating capital costs served to increase the cost of electricity to a peak of about 8.3¢/kWhr in 1980 and 1981. Since then, prices have been falling.

History suggests that electricity prices are not as low as they could go. Yet the current projections from many sources, typified by the EIA, provide for rising electricity prices. An examination of the essential components of EIA projections (see TABLE 1) reveals whether or not the projection of rising electricity prices is probable, or avoidable. Could economically aggressive policies promoting low cost electricity return electricity rates to historically low levels?

TABLE 1

***Components of Electricity Prices (EIA)*** [25]

| | 1990 | 2010 |
|---|---|---|
| **Capital** | 3.1 | 2.3 |
| **O & M** | 2.1 | 2.1 |
| **Fuel** | 1.8 | 2.1 |
| **Total** | 6.9 | 7.2 |

As TABLE 1 illustrates, EIA projects the capital cost component will decline over the coming two decades. This is expected in part because of the aging and thus amortization of the existing power plants, and in part because of the low-cost option of extending the life of older plants. This projection is also consistent with manufacturers having gained the necessary experience over the past two decades on how to build power plants efficiently in the new regulatory and political climate that emerged in the 1970s.

However, TABLE 1 shows that EIA expects utility fuel costs to rise. The fuel price components of this assumption are shown in TABLE 2.

TABLE 2

***Utility Fuel Costs (EIA)*** [26]

(1990$/million Btu)

| | 1990 | 2010 |
|---|---|---|
| **Coal** | 1.6 | 2.2 |
| **Natural Gas** | 2.9 | 6.2 |
| **Fuel Oil** | 3.0 | 5.4 |

There appears to be widespread agreement that natural gas prices will rise substantially in the coming decades.[27] The primary reasoning for rising natural gas prices would appear to be rooted in the economic tumult created by previous regulations (e.g., the now defunct Fuel Use Act, restricting gas use for electricity generation) and an overall situation where supply and demand have not begun to get into reasonable balance.[28] Also, projections show that the current low cost natural gas reserves will be depleted and are projected to be replaced by higher cost domestic and imported sources.[29]

billion annually more for electricity than if the state price reflected national averages, but more important has been the lost economic opportunity deriving from depressed growth associated with discouraging continuing productive electrification.

[25] *Electric Power 1991: Projections Through 2010*, July 1991; base case projections through 2010: p. 13

[26] *Ibid.*

[27] *1992 Edition of the GRI Baseline Projection of U.S. Energy Supply and Demand to 2010*, Gas Research Institute, April 1992.

[28] The sudden 16% rise in the nation's natural gas prices following Hurricane Andrew's disruption of gas flow from the Gulf of Mexico, was according to the *The Wall Street Journal*, "stunning" (August 31, 1992). This reinforces the marketplace perception that gas prices are volatile.

[29] *1992 Edition of the GRI Baseline Projection of U.S. Energy Supply and Demand to 2010*, Gas Research Institute, April 1992: 95% of current gas supply comes from low cost domestic sources. By 2010 58% will come from existing domestic sources, and the balance will come from substantially more expensive sources—20% from imports (including Alaska) and 21% from "advanced technology" sources.

The situation for coal is significantly different. Coal's dominant role in electricity generation has been largely unchanged for over five decades—establishing a long supply and demand history for economic stability. In addition, known, low-cost domestic coal reserves are well-defined.[30] Thus, overall, there is much less uncertainty about the future of coal prices, and indeed, considerable reason to doubt the EIA projection that coal prices will rise at all, much less the 1.4-fold projected.

The future of coal prices is the single most important factor determining the future of electricity prices. EIA projections show coal will supply just over 50% of all new electricity supply through 2010.[31] Despite EIA's price projection for rising oil prices, there is little evidence to support the contention that coal prices will rise too.[32] Long-term coal contracts are currently available for fuel prices of $1 to $1.50 per million Btu.[33] Coal is available to maintain or reduce utility delivered prices for the entire period of the 20-year projection considered here. In fact, the potential exists for electricity to be cheaper in 2010 than it is today, and return to costs comparable to those of 20 years ago.

TABLE 3 summarizes this possiblity. Capital costs decline (as projected by EIA), along with no change in operation and maintenance costs because these factors are significantly fixed by existing equipment, operations and requirements. But utility fuel costs, primarily coal, need not rise.

TABLE 3

***Possible Components of Lowest Cost Electricity***

(¢/kWhr)

| | Avg 1990 | 2010 possible |
|---|---|---|
| Capital | 3.1 | 2.3 |
| O & M | 2.1 | 2.1 |
| Fuel | 1.8 | 1.0 |
| Total | 6.9 | 5.4 |

Based on available coal-fired technology and coal resources, we take 5.5¢/kWhr as the benchmark price for delivering electricity over the next two decades. The availability of low-cost electricity will force competition among sources of supply ensuring the lowest cost of electricity for consumers. The first threshold test for new suppliers of electricity should be to meet or beat the lowest cost of supply.

The effect of reducing electricity prices will have one straight forward consequence. More electricity will be consumed. However, it is not the fact of greater electricity consumption that is important; it is the extent to which more electricity is consumed *productively* and *in place of fuel combustion* in the marketplace. The productive and environmental benefits of electric-based technologies are explored in the next section of this report. Here we explore the extent to which fuel switching—purchasing electricity instead of direct fuels, specifically natural gas—will be driven by

[30] The confidence with which coal prices can be projected also applies to implications arising from the Clean Air Act and sulfur dioxide emissions. Both reserves of low sulfur coal, as well as the technologies available for clean combustion are well established.

[31] Natural gas is projected to supply about 22% of all new supply.

[32] It has long been the case that coal and oil prices have become substantially disconnected—except under extreme circumstances where, for example, oil at >$40/bbl renders synfuels viable. Similarly, natural gas and oil prices have become substantially disconnected, as was demonstrated during Desert Storm where fluctuations in oil prices were unreflected in natural gas prices.

[33] Western Fuel Association membership price survey. See also WFA Technology Screening Analysis of coal combined cycle power plants.

lower electricity prices.[34] It is not the lower cost of electricity *per se* that would encourage fuel switching. The determinant is the comparative cost of electricity to natural gas prices in the marketplace.

The increased use of electricity in industry, for example, is strongly influenced by the ratio of electricity to gas prices. FIGURE 10 illustrates the two decade history and possible future of the electric/gas price ratio. FIGURE 10 shows that even if electric prices do not decline, and rather increase slightly as EIA projects, the price advantage of electricity over natural gas will grow rapidly. If electricity prices return to their historic levels, as proposed here, and gas prices continue their projected rise, the price advantage of electricity is accelerated.

For technology and fuel choices in industrial processes, it is not just the current price ratio that is important, but the expectation of the future price ratio that determines the viability of investment in new equipment—i.e., should the equipment or process be fuel-based (natural gas), or electricity-based. Given the expected trend for the electricity/natural gas price ratio, it is clear that the advantage of electricity will shortly be at record levels and is likely to stimulate a strong switch to electric processes on a price basis alone (regardless of other productive and structural advantages of electroprocesses).

Over 90% of all industrial electricity is used for electromechanical drives and electrolytic separation. Only a small fraction, under 1%, is used for other direct process applications.[35] Thus, there is a very large potential for increased electrification in the industrial sector. As the price advantage of electricity over gas reaches record levels (by 1999 under the low cost scenario here, and by 2004 under EIA projections), price factors alone will drive fuel switching to electric processes.

The same trend is developing, and can be accelerated in the residential sector. When the economic benefits of electric heat-pumps are considered (the only significant source of growth in the electric heating market), the cost benefits of electricity will become overwhelming. As FIGURE 11 illustrates, the price ratio is declining rapidly and will be below 3-to-1 within the decade. Existing heat pumps deliver at least three times as much heat as electricity consumed; new ground-source or so-called geothermal heat pumps deliver at least six times as much heat as electricity consumed. Once consumers see the increasing price advantage of electric heat, and come to believe that it will continue, the shift to electric heating will accelerate.[36]

The advent of highly efficient electric heat pumps, and a rapidly declining electric-to-gas price ratio, underlies the reason for the vigorous competition between the electric and gas industries in the residential market. The importance of this competition for both sectors can be seen in the following facts:

- *Natural gas accounts of the largest share of total residential energy use, at 45%.*[37]
- *Electricity holds 32% of the total residential energy market.*

[34] Considerable debate has erupted over fuel switching in the other direction; i.e., encouraging electric utilities to help consumers use natural gas instead of electricity. Here we do not explore the merits of such policies which are frequently based on shaky environmental justifications. Rather, we are concerned here with basic economic competitiveness issues. For a discussion regarding the merits of regulatory-directed fuel switching, rather than market-based fuel switching, see for example "Fuel Switching," Alfred Kahn, *Highlights from a National Meeting on Demand Side Management: Completing the Picture*, June 1992, Mills-McCarthy & Associates.

[35] "A Conceptual Basis for Productive Electricity Use in Manufacturing," Philip S. Schmidt, Proceedings of the Electricity Beyond 2000 Conference, Washington D.C., October 1, 1991.

[36] Of course, this is true only if market forces are permitted to operate freely.

[37] *1992 Edition of the GRI Baseline Projection of U.S. Energy Supply and Demand to 2010*, Gas Research Institute, April 1992, p. 26, 27.

- *Space heating consumes 65% of all residential energy consumption, with water heating about 15%.*

Quite obviously, capturing the residential heating market represents a significant economic issue.

There is little debate that lowering electricity prices, particularly in a climate of rising natural gas prices, will stimulate greater electricity use. Before turning in the next section to the environmental implications of such a trend, we continue here to explore the broad impact on the economy of reduced electric rates.

In order to evaluate the macro-economic effect of lower electricity prices, three basic inputs are required:

- *The average cost of electricity in 2010 resulting from all new supply being priced at no more than 5.5¢/kWhr;*
- *The elasticity of demand, i.e., how much more electricity will be consumed because of lower prices; and*
- *The GNP/kWhr relationship, i.e., the effect on the GNP of increased overall use of electricity.*[38]

The essential facts considered for each of the three inputs cited above are as follows:

*Average 2010 price of electricity.*

An estimate of a possible (rather than projected) year 2010 average cost of electricity can be arrived at by estimating two price components for supply in 2010; first, the cost of electricity from existing power plants, and second, the cost of electricity from new power plants.

Rather than assume fuel prices will rise, as projected by EIA, it is possible that existing trends[39] and price pressure from a low cost supplier (specifically coal) will exert a downward pressure on other fuels. It is just as likely that average fuel costs for utilities will be the same in 2010 as it is that they will be higher. In fact, as TABLE 4 summarizes, if fuel prices do not rise—a possibility demonstrated by events of the past 20 years—then the average cost of electricity from existing power plants would be expected to be lower in 2010 than it is today—

[38] It is not actually the consumption of electricity *per se* that increases the GNP. It is the greater use of productive electric-based technologies that boosts the economy. In other words, lower cost electricity fueling such productive processes as electric steel making, electro-chemical processing, and so on improve productivity, employment and profits.

[39] Perhaps the most important indicator of the failure of fuel price projections is the continued assumption that oil will be more expensive in the future than it is today. At a minimum, the Gulf War demonstrated that even during a major war in the world's prime oil basin there can be a price *decline*. This hardly points to price volatility. Indeed, the tremendous diversity in oil supply, increased reserves, delivery and exploration globally have significantly eroded world oil price sensitivity to local events. Note, for example, that in 1970 OPEC accounted for 51% of world oil production—peaking at 56% in 1973. By 1990, OPEC's share of world production dropped to 38%.

In addition, the literature of the past decade does not support the belief that world low-cost oil reserves are sufficiently low to tax supply any time in the coming two decades. Indeed, the opposite appears to be the case, wherein increased energy efficiency, and increased motivation of oil sellers for revenue are more likely to stimulate price competition and lower oil prices than they are the opposite. Insofar as the historic record is concerned, the price of oil (in constant 1988$) has averaged $11/bbl from 1890 to 1990, seldom varying outside of a price band of $7 to $17/bbl. Only for seven years between 1979 and 1986 did the price spike briefly, and some might say, fatally for OPEC considering the extent of world exploration stimulated by that event. (See p. 11, 1992 *International Petroleum Encyclopedia*.)

EIA and others appear to take solace in providing tables illustrating that other organizations' price projections are consistent with their own. It is entirely possible that this consistency is not an indicator of accuracy on any particular organization's part, but rather a demonstration of pack mentality. There was also a consensus on future electric and fuel prices reached in the early 1970s, and it was wrong.

principally because of the declining cost of capital as the power plants age (amortize).

TABLE 4

*Components of Electricity Prices from Existing Plants*[41]

(¢/kWhr)

| | 1990 | EIA 2010 | Possible |
|---|---|---|---|
| Capital | 3.1 | 2.3 | 2.3 |
| O & M | 2.1 | 2.1 | 2.1 |
| Fuel | *1.8* | 2.9 | *1.8* |
| Total | 6.9 | 7.2 | 6.2 |

In 2010, about 70% of all the required electricity for that year would be provided by those power plants that already exist. This electricity could be supplied for about 6.2¢/kWhr as summarized in TABLE 4.[41] The balance of the base-case for needed electricity in 2010 would come from new power plants. As previously discussed, this could be provided for an average cost of 5.5¢/kWhr.

The blended cost of electricity from old plants (those existing in 1990) and new plants would be a national average year 2010 cost of 5.9¢/kWhr.[42]

### *Elasticity of Demand for Electricity*

How much more electricity would be consumed in 2010 if the average price were an achievable 5.9¢/kWhr rather than the projected 7.2¢/kWhr?

There is an extensive body of research which has sought to accurately quantify demand elasticity of electricity.[43] The short-term and long-term elasticities are usually different. In this case, we are primarily concerned with long-term elasticities for which there appears to be a consensus value of -1.0. In other words, a 10% price decrease would produce a 10 percent consumption increase (and *vice versa*).[44]

A year 2010 price of 5.9¢/kWhr represents a long term price decline of 18%. This translates into an 18% increase in demand, or nearly 750 billion more kWhrs consumed in 2010 than currently projected.[45]

### *Electricity/GNP link*

What would be the macro-economic effect of 750 billion kWhrs greater electricity use?

The relationship between electricity and GNP has changed over the decades. TABLE 5 summarizes the broad trends. While there are clearly complex relationships between electric-based technologies and the industrial, commercial and residential sector use of those technologies, at the broadest level it is possible to observe the market economic response to using such electricity-based devices and processes.

[40] *Electric Power 1991: Projections Through 2010*, July 1991; base case through 2010: p. 12

[41] *Electric Power 1991: Projections Through 2010*, July 1991; base case projections through 2010: total 1990 generation of 2.8 trillion kWhrs from existing power plants would represent about 70% of the EIA year 2010 base-case supply of 4.1 trillion kWhrs.

[42] Note that as a minimum, such a price structure would create over $50 billion a year in savings on electricity purchases for the base demand projected. There would of course be additional expenditures required for the additional electricity purchases created by rising demand.

[43] See for example,

a) *Electricity in Economic Growth*, A Report Prepared by the Committee on Electricity in Economic Growth, Energy Engineering Board, Commission on Engineering and Technical Systems, National Research Council, National Academy Press, 1986, p xvi.

b) *Electricity in the American Economy: Agent of Technological Progress*, Schurr et al, Greenwood Press, 1990.

[44] *Ibid* a) p. 48, b) p. 361, 362.

[45] *Electric Power 1991: Projections Through 2010*, July 1991; base case projection for 2010 of 4,117 billion kWhrs.

TABLE 5

*Ratio of Electricity/GNP Growth Rates*[46]

| | Electricity/GNP Growth |
|---|---|
| 1947 - 1960 | 3.1 |
| 1960 - 1973 | 1.61 |
| 1973 - 1983 | 0.98 |
| 1983 - 1991 | 1.18 |

Despite the history of stronger electricity/GNP connections, we use here instead a conservative linkage of 1.0, and assume further that current demand-side management programs are successful in weakening this linkage somewhat. Thus, 750 billion kWhrs of greater consumption would be associated with nearly $1 trillion greater GNP than currently projected for 2010 (in 1991$).[47] This much additional electricity demand represents the output of about 240 electric power plants of 500 MW size. The overall economic issues are summarized in TABLE 6.

TABLE 6

***Summary of the Impact of Lower Electricity Prices in 2010***

- *Average 2010 drops 18% to 5.9¢/kWhr (arising from 5.5¢/kWhr benchmark for new supply).*
- *GNP grows $1 trillion over EIA base case;*
- *Electric demand grows 240 more power plants (@ 500 MW) over EIA base case of 300.*
- *Total electricity purchase costs drop by $10 billion.*[48]

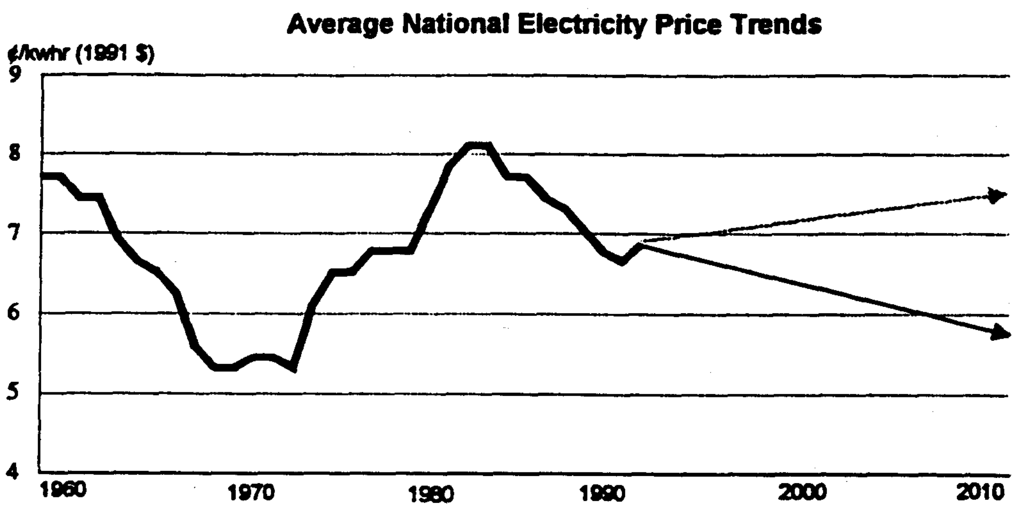


FIGURE 9

[46] *Electricity in Economic Growth*, A Report Prepared by the Committee on Electricity in Economic Growth, Energy Engineering Board, Commission on Engineering and Technical Systems, National Research Council, National Academy Press, 1986, p 50; and 1983- 1991 from EIA *Monthly Energy Review*.

[47] The current ratios suggest that the $5.6 trillion economy (1991$) is supported by about 2.8 trillion kWhrs, with an essentially 1:1 linkage; i.e., $2 of GNP for every kWhr of consumption. Because of the national trend towards multi-billion demand-side management programs (in which the economic requirement for electricity is reduced), we assume for the sake of argument that current DSM programs will be sufficiently successful to erode the electricity/GNP ratio by 25%; in other words, in 2010 about $1.50 of GNP will be associated with each kWhr of consumption.

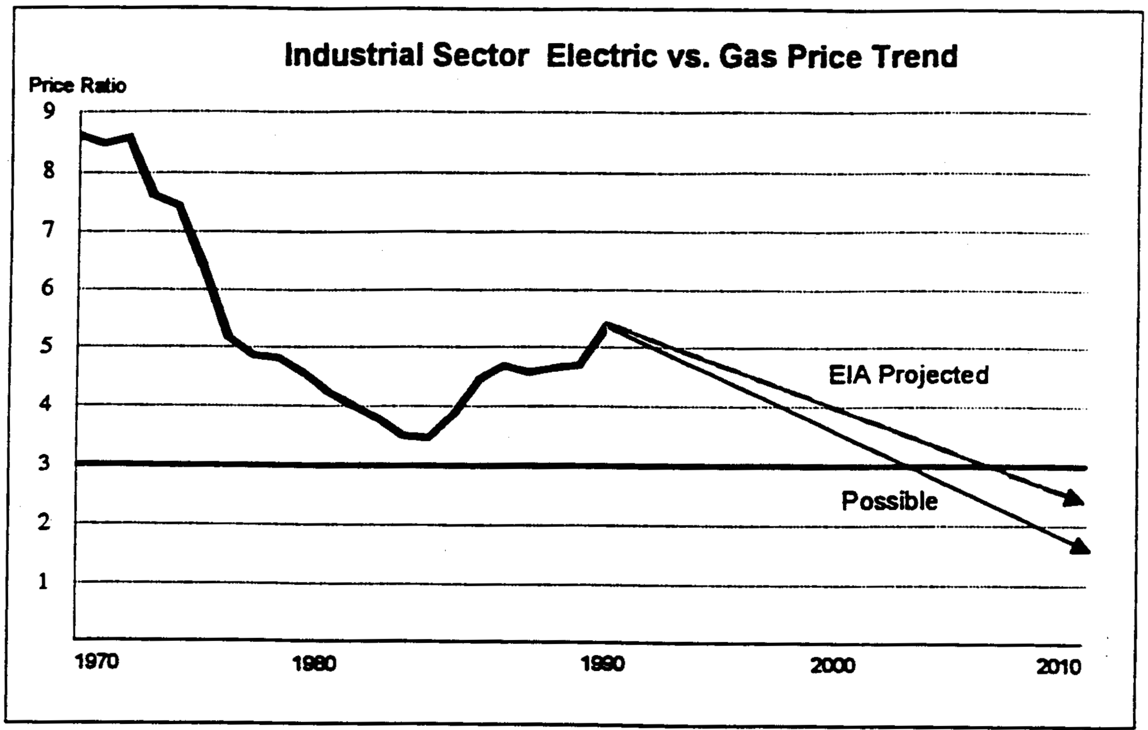


FIGURE 10

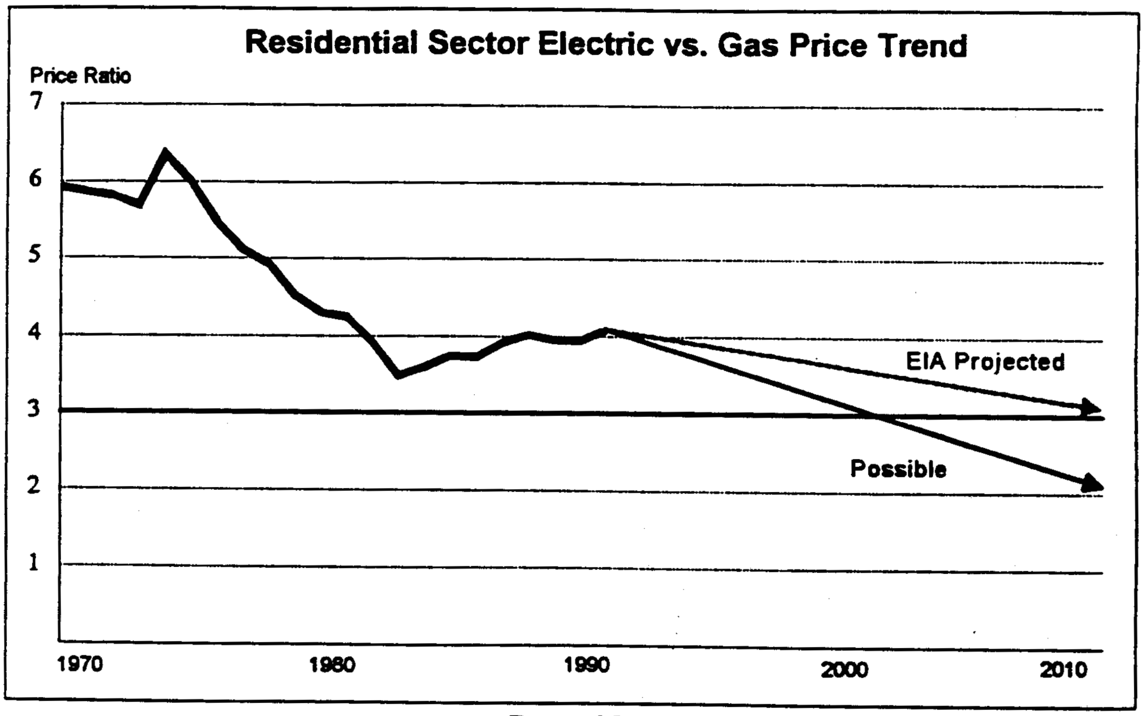


FIGURE 11

[44] Savings arise from $50 billion lower electricity purchase costs for 2010 base case consumption of 4.1 billion kWhrs, net of $40 billion to purchase additional 750 billion kWhrs created by elastic reposnse to low cost marginal prices of 5.5¢/kWhr.

# 6 WHAT PRICE ECONOMIC DEVELOPMENT

There can be little doubt that lower cost electricity would help stimulate a more productive economy. Such a reality is at the core of economic development rates that are increasingly seeing favor with state regulators because of depressed local economies.[49]

But if the extra 30% boost in the economy by 2010 requires 240 more 500 MW power plants than currently projected, what price would be paid in environmental terms? Specifically, what impact would such an event have on total U.S. $CO_2$ emissions? This would appear an important consideration with the current environmental focus on the global warming theory, since generating the 750 billion kWhrs from the 240 power plants would require an increase of nearly 300 million tons more coal per year than currently projected (assuming that all additional low-cost generation were coal-fired units).[50]

In short, would such a development-oriented policy be environmentally sustainable?

Before evaluating the net effect of increasing electric demand beyond that already anticipated, it is important to note the trends inherent in current projections. TABLE 7 summarizes some key data from current EIA projections.

TABLE 7

***Current EIA Projections***

- *GNP grows by $3 trillion*
- *U. S. energy efficiency 23% better*
- *Growth in electricity demand requiring 150,000 MW*
- *Coal supplies 50% of new electricity demand*
- *$CO_2$ emissions/GNP$ decline 25%*

The EIA projections contain the implicit recognition that electricity and coal use can rise along with improved energy and carbon dioxide efficiency. How so?

According to the Electric Power Research Institute (EPRI), there are two powerful trends that will reduce $CO_2$ emissions over the next two decades.[51] One is the improved efficiency with which electricity is used, via demand-side management (DSM) programs. The other arises from the improved overall energy efficiency arising from fuel switching in the marketplace from combustion-based processes to electroprocesses.

EPRI estimates that by 2010, the effect of DSM programs will be to reduce total U.S. $CO_2$ emissions by about 350 million tons/year. EPRI also estimates that increased use of electricity—in their terms,

[49] *Public Utilities Fortnightly*, August 1, 1992, "Electric Sales Growth and the Conservation Ethic."

[50] Given that current projects show coal providing 50% of all new generation, a policy encouraging more low-cost electricity would likely find coal supplying 50% to 75% of the new demand—especially given current price projections for natural gas. Here, 100% coal is suggested for illustration purposes.

[51] *Saving Energy and Reducing $CO_2$ with Electricity (Estimates of Potential)*, Electric Power Research Institute, CU-7440, September 1991.

"beneficial electrification"—will also reduce net $CO_2$ emissions, but by an amount of over 400 million tons/year by 2010.

In other words, electricity growth and increased coal consumption will be attended by reduced environmental impacts in the form of lower $CO_2$ emissions—"sustainable development."

The fact that increasing electricity use reduces overall $CO_2$ emissions runs counter to the current paradigm—increased electricity use is generally held to run counter to energy efficiency and environmental goals. But if the historic record doesn't support this contention, why should we believe projections that claim such an effect? The primary measure of environmental impacts, and in particular $CO_2$ emissions, is the trend in energy efficiency. See FIGURE 12.

The historic record shows increased electricity consumption is correlated with *improved* overall energy efficiency—decreasing total energy needed per $GNP. As encouraging as this broad measure is, it understates the market realities. It is the efficiency with which markets use fuel or electricity that is a more direct indication of trends (see FIGURE 13).

As FIGURE 13 illustrates, the use of fuels per unit of GNP in the market has plummeted over the past two decades—in other words the environmental impact of the marketplace has declined. At the same time, there has been no significant change in the amount of electricity required per unit of GNP.

The historic record shows that energy efficiency actually gets better when electricity use goes up. Although this phenomenon is frequently ignored, it has been extensively documented.[52] The idea that using more electricity—more kilowatts—can confer economic and ecological benefits can be given the term "ecowatts."

FIGURE 14 illustrates the implication of these recent energy efficiency trends in terms of total U.S. $CO_2$ emissions: the overall emissions of $CO_2$ from the U.S. economy have remained remarkably unchanged for the past two decades. And, the most important measure of $CO_2$ impacts, $CO_2$ emissions per unit of economic activity—$CO_2$/GNP$—has been declining.

The debate over $CO_2$ emissions has drawn attention to the role of coal in the energy mix, but typically without recognizing the impact of coal-fired electricity on the economy *and* on $CO_2$ emissions reductions. As FIGURE 14 illustrates, the record shows that $CO_2$ emissions have dropped from 4 lbs/$GNP in 1970, to about 2.7 lbs in 1991. Current projects show that this rate will continue to decline to about 2 lbs/$GNP by 2010. Yet, for the two decades since 1970, coal use grew by almost 450 million tons/year, and is projected to grow another 300 million tons/year over the next two decades. (See FIGURE 15.)

The association of reduced $CO_2$ emissions/$GNP and increasing coal consumption is not coincidental—it is

[52] See for example:

*Ecowatts: The Clean Switch*, April 1991, Science Concepts, Inc.

*Electricity and Industrial Productivity: A Technical and Economic Perspective*, P. Schmidt, Pergamon Press, 1984.

*Carbon Dioxide Reduction Through Electrification of the Industrial and Transportation Sectors*, Edison Electric Institute, Energy Research Group, 1989.

*Saving Energy and Reducing $CO_2$ with Electricity (Estimates of Potential)*, Electric Power Research Institute, CU-7440, September 1991.

causal. Reduced $CO_2$ emissions are a primary consequence of improved energy efficiency, and energy efficiency gains are a direct result of electrification. Since 1970, every kilowatt-hour of new demand has been associated with a *net* reduction in $CO_2$ emissions of 3.6 lbs.[53]

[53] Two factors are commonly held as significant reasons for reductions in U.S. carbon dioxide emissions per unit of GNP: (1) increased use of nuclear power, and( 2) automobile CAFE (gas mileage) regulations.

Other than electrification, these two factors are the only other substantial structural changes in the energy economy over the past two decades. Since 1970, the increased use of nuclear power has displaced fossil fuels (based on existing and probable fuel mixes) with a total value of about 440 million tons of $CO_2$. The increase in on-the-road fleet average fuel efficiency from about 14 mpg to over 21 mpg is responsible for reducing prospective $CO_2$ emissions increases by about 400 million tons of $CO_2$. (The calculation is performed by considering the additional fuel use and associated $CO_2$ emissions if the 1990 fleet operated at the 1970 fuel efficiency.) Together, CAFE and nuclear power eliminated nearly 1 billion tons of $CO_2$. If the U.S. economy operated in 1990 at the 1970 $CO_2$ efficiency, there would be about 3.6 billion tons more $CO_2$ emitted. For the sake of conservative estimations, it is assumed that the aggregate effect of other small factors over the past two decades has been equal to the impact of CAFE standards, or nuclear power—i.e., 10% of the net declining $CO_2$ emissions. Thus, electrification is held to be responsible for the remaining 2.6 billion tons of net $CO_2$ reductions. Therefore, the 1.2 trillion kWhr growth in electric demand was associated with a 2.3 billion ton decline in $CO_2$ emissions—or about 3.6 lbs $CO_2$/kWhr.

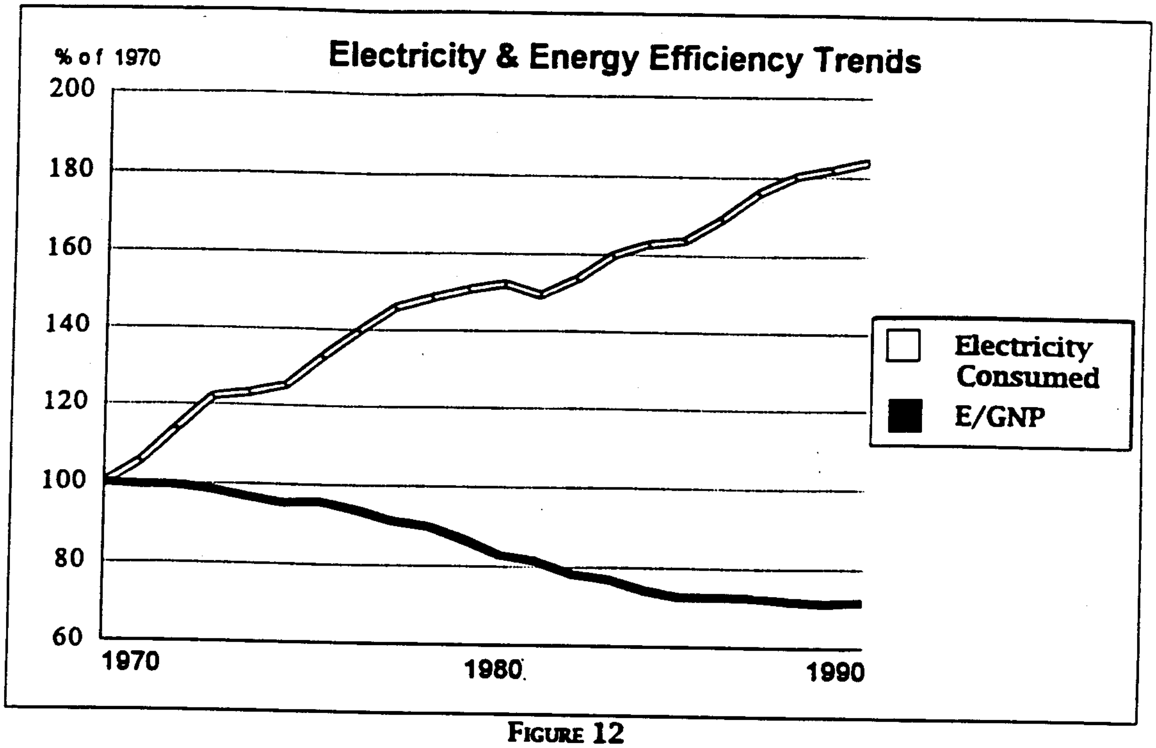


FIGURE 12

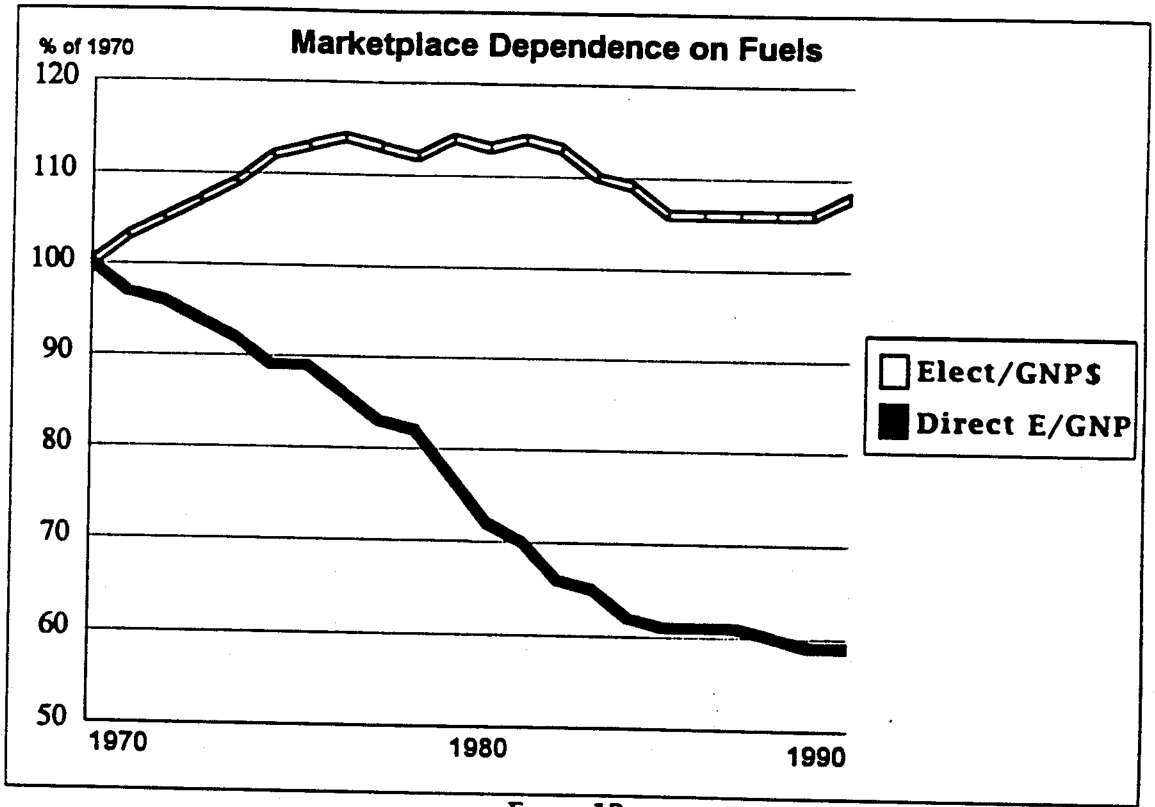


FIGURE 13

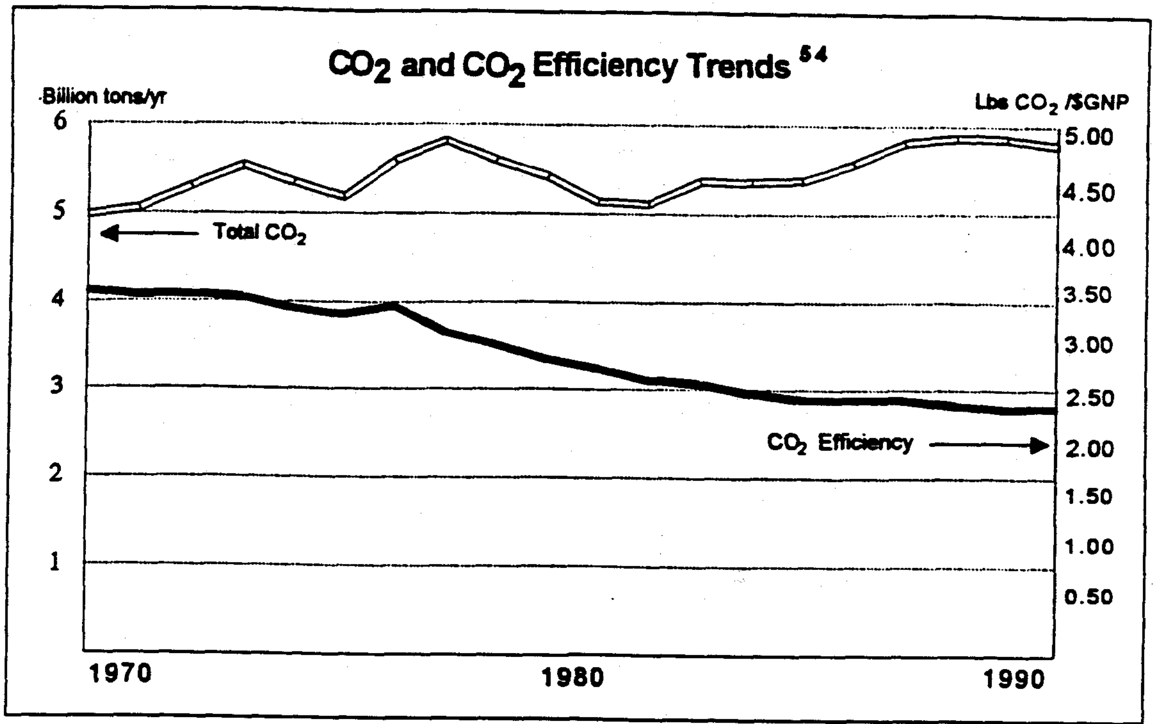


FIGURE 14

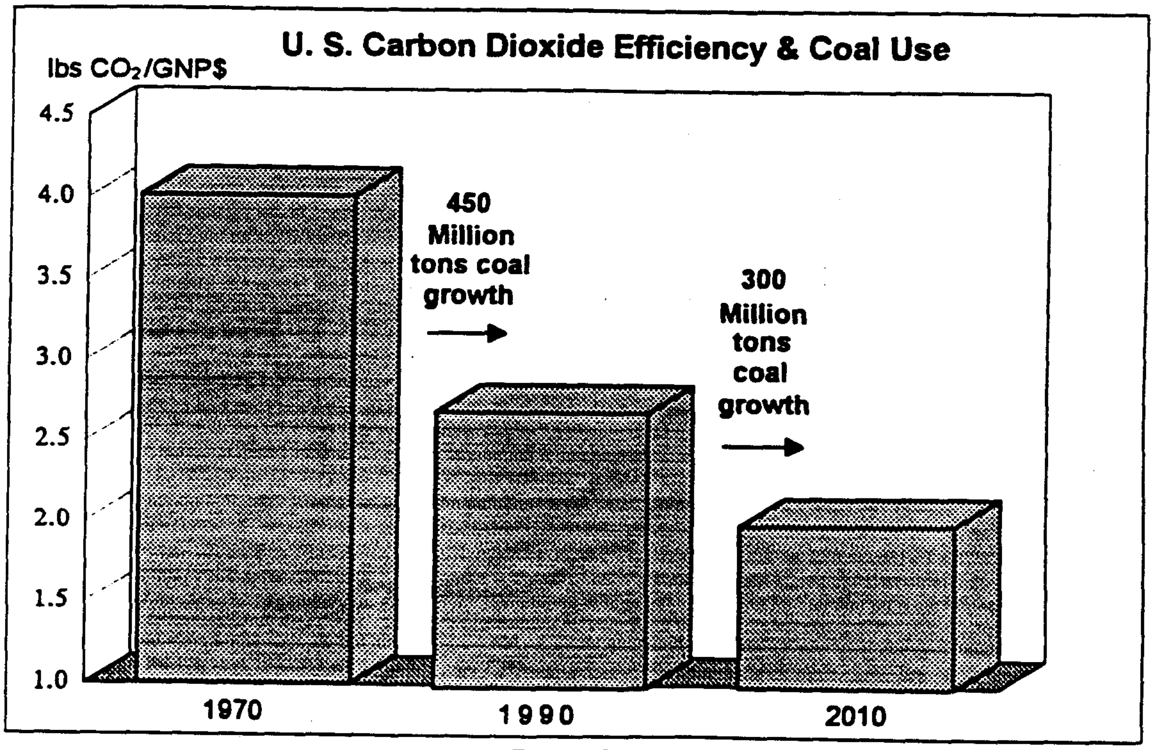


FIGURE 15

[54] Data from *Monthly Energy Review*, Energy Information Administration. Gross fuel consumption for each year used to determine annual CO2 emissions based on: coefficients for $CO_2$ production from fuel combustion: $1.1x10^{-4}$ lbs $CO_2$/Btu of natural gas burned; $1.7x10^{-4}$ lbs $CO_2$/Btu of oil burned; $2.2x10^{-4}$ lbs $CO_2$/Btu of coal burned.

# 7 Technological Underpinnings

### *Externality Benefits Of Electricity*

The suggestion that there is a direct causal relationship between increased electricity use, in particular increased coal consumption, and decreased $CO_2$ emissions may appear at first heretical.

FIGURE 16 provides some perspective on this phenomenon, as calculated by the Electric Power Research Institute (EPRI). FIGURE 16 illustrates the estimated energy impact of the enhanced use of *only* five industrial electrification technologies over the next decade alone. In this scenario, industrial electricity consumption would rise by 17 billion kWhrs/year by AD 2000 (equal to the output of six large coal-fired power plants) directly because of the greater use of the five electrotechnologies. At the same time overall energy use, including that needed to generate the electricity, would decline by about 60%, the energy equivalent of 53 million barrels of oil per year, because the electrotechnologies are so efficient compared to the fuel processes displaced.[55]

The net energy balance shown in FIGURE 16 is based on the replacement of *direct* fuel combustion with electricity, including the energy to make the electricity. (Not included, but virtually always evident, are such energy benefits as reduced material waste and reduced energy required in maintenance, associated infrastructure and shipping.) From the environmental perspective, even if all the electricity needed to support the additional use of those five technologies were produced by coal-fired power plants, and only natural gas were displaced in the market, there would be a net *reduction* in $CO_2$ emissions of 10 million tons/yr.[56]

The nature of the technologies considered in the calculations for FIGURE 16 points to two other important issues:

- *Cheap electricity would stimulate the use of these new highly productive technologies, accelerating turnover of new equipment, directing valuable industrial financial resources towards equipment changes that are fundamentally productive—but that nonetheless save energy*
- *Regional, or "breathing zone," environmental impacts typically go to zero; that is emissions at the point-of-use are eliminated (typically in congested urban zones).*

The energy and $CO_2$ savings summarized in FIGURE 16 do not represent a unique

[55] *End-Use Energy Efficiency*, EPRI, January 1991 p. 8; primary energy requirement for electric generation of 0.175 Q, net fossil fuel savings of 0.253 Q; assumes 500 MW coal plant, 65% CF.

[56] The purpose of assuming that only coal is used for the required electricity is for two reasons. First, if the phenomenon works with coal, it eliminates any justification for arbitrarily focusing on fuel type for electric growth insofar as $CO_2$ impacts are concerned. Secondly, the price of electricity is a significant factor in determining how much, if any, fuel switching will occur in the market. It is obvious that using natural gas to supply the electricity would provide a greater net reduction in CO2 than using coal-fired power plants. However, this observation, while theoretically valid, is functionally irrelevant. As a practical matter, the price of electricity will determine the viability of many industrial electrotechnologies (as discussed earlier). Over the long run, the use of more expensive natural gas will result in more expensive electricity, thereby eliminating the market incentive to use the electricity—and eliminating any potential for net reductions in $CO_2$ due to electrification.

situation. This phenomenon, which we term ecowatts in which economic and ecological benefits arise by switching from fuels to electricity-based technologies can be illustrated for a remarkably long list of technologies. TABLE 8 shows some examples from a disparate range of representative electrotechnologies. Here net $CO_2$ emissions have been calculated for every extra kWhr used in a fuel switching situation—i.e. emissions eliminated by the electrotechnology replacing a fuel technology net of the emissions associated with the electric power plant.

TABLE 8

***$CO_2$ Impact per kWhr of Fuel Switching to Electrotechnologies***[57]

| Activity | lbs CO2 reduction/kW use |
|---|---|
| Fax document | 63 |
| Dry paint | 13 |
| Cook meat | 12 |
| Foundry sand | 3 |
| Make steel | 2 |
| Mow lawn | 2 |
| Heat home | 0.7 |
| Concentrate milk | 0.8 |

TABLE 9

***National $CO_2$ Impact of Fuel Switching to Electrotechnologies***[60]
***Year 2010***

| End Use Technology | Increase Electricity Use (GWh) | Net Energry Savings (Quads) | Net $CO_2$ Emission Reduction (Million tons) |
|---|---|---|---|
| Residential | | | |
| Heat Pumps | 180,000 | 1.13 | 37 |
| HP Water Heater | 86,000 | 0.69 | 27 |
| Commercial | | | |
| Information Technology | 95,000 | .95 - 2.85 | 75 - 217 |
| Heat Pumps | 133,000 | 0.83 | 31 |
| Chillers (with HP) | 10,000 | 0.05 | 2 |
| HP Water Heater | 16,000 | 0.13 | 5 |
| Induction Griddle | 8,000 | 0.02 | 0 |
| Industrial | | | |
| Freeze Concentration | 16,000 | 0.35 | 18 |
| Heat Pumps | 2,000 | 0.01 | 0 |
| Induction Heating | 34,000 | (.1) - .1 | (4) - 17 |
| Arc Melting | 23,000 | .39 - .48 | 46 - 56 |
| Plasma Processing | 12,000 | 0.14 | 6 |
| UV/IR | 14,000 | 0.14 | 6 |
| Transportation | | | |
| Transit & Freight | 24,000 | 0.12 | 10 |
| Electric Vehicles | 10,000 | 0.07 | 6 |
| Total | 63,000 | .82 - 7.02 | 64 - 438 |

[57] *Rebuttal Testimony Regarding Testimony of Land and Water Fund of the Rockies*, Mark P. Mills, Public Utilities Commission of the State of Colorado, Docket 91M-642-EG, April 10, 1992.

As TABLE 8 shows, the range of impacts can be very broad. As it turns out, 3.6 lbs is the average amount of $CO_2$ eliminated for every kWhr used over past 20 years. This macroanalysis is consistent with the range of $CO_2$ reductions shown in TABLE 8 for a selected 15 residential, industrial and commercial electrotechnologies.[58] $CO_2$ is a prominent feature in the current debate over externalities—environmental impacts that are external to current regulated impacts. However, it is rarely the case that these externalities are properly accounted for, even though the basic definition of an externality is acknowledged. For example:

> "An externality is a real cost or *benefit* which is not considered in the cost/benefit analysis associated with a given decision." (Emphasis added.)[60]

> "Environmental externalities are a special class of externalities. Specifically, they are costs or *benefits* created by changes in the environment *occasioned* or exacerbated by decisions that do not take these costs or *benefits* into account." (Emphasis added.)[61]

Regardless of such definitions, the desire to include externalities in electricity costs has focused almost exclusively on the environmental *costs* associated with generating electricity. The externality benefits have been largely ignored.

It has been a basic reality of the electrification of modern society that the buyers of electricity are interested in using electricity for benefits other than the simple energy-equivalent value of kilowatt-hours; i.e., buyers are interested in benefits *external* to the purchase price of a kilowatt-hour. This is readily apparent in the types of technologies itemized in TABLES 8 and 9.

Up until now, external benefits of electricity have been the exclusive concern of the buyer of kilowatt-hours. In fact, remarkably little attention has been paid to the profound productivity, environmental and energy benefits of the electrification of society.[62] TABLE 10 lists just a few of the kinds of benefits which accrue to users of a few commercial and industrial electrotechnologies. The TABLE illustrates

TABLE 10

***Economic & Environmental Externality Benefits of Selected Manufacturing Electrotechnologies***[64]

| Electrotechnology Application | Sampling of Externality Benefits |
|---|---|
| Electrochemical machining | Rejected pieces dropped from 1% to 0% saving $16,000/yr on equipment costing $174,000 |
| High-Frequency Resistance Welding of Tubes | Rejected tubes dropped deom 20% to 5% with productivity and throughput increased |
| UV Curing of Labels | Several thousand feet of stock saved per day and varnish cost dropped three-fold |
| Microwave Curing Rubber | Material savings of 5%, 30% floor space savings 30% drop labor cost, 100% elimination of scrap |
| Plasma Steel Cutting | Scrap rate dropped from 20% to 10%; fewer rejects, higher throughput. |
| Shortwave Infrared Curing | 25% drop in paint cost, 99% recovery overspray 40-fold drop in floor space, 50% energy cost |
| Electrical Discharge Machining | Greater accuracy, scrap rate dropped from 10 - 20% to 0.5% more reliable equipment |
| Electric Fryers (commercial kitchens) | One-third the cooking energy, less waste heat in kitchen, 20% higher production capacity |

[58] *Saving Energy and Reducing $CO_2$ with Electricity (Estimates of Potential)*, EPRI, CU-7440, September 1991.

[59] *Ibid.*

benefits that translate into improved productivity and lowered costs—but many of the benefits also have environmental implications in the form of reduced waste and scrap.

There is a remarkably wide range of important externality benefits that are not necessarily environmental, or may have indirect environmental consequences. These externalities accrue to the purchaser of kilowatt-hours, such as improved convenience (via microwave ovens for example), or reduced environmental compliance costs (via zero-emissions electrotechnologies replacing fuel-based processes), or reduced work place hazards, or greater productivity, or reduced landfill needs.[64] It makes no sense to suggest that utilities should be held accountable for some currently unregulated externality negatives at the power plant and not permit the same utilities to take credit for currently undocumented externality positives in the marketplace.

Returning to the focus of this analysis, the $CO_2$ environmental externality, it will be important for policies to recognize the magnitude of the benefits from increased electrification. The overall effect of electrifying more and more processes can be dramatic. TABLE 11 provides an indication of the magnitude of the impact of a small, but representative list of such technologies.

TABLE 11

***Overall $CO_2$ Impact of Increased Electrification of Selected Activities***[65]

| Increase Electrification to 50% of all activity | $CO_2$ reduction (million tons/yr) |
|---|---|
| Make Steel | 90 |
| Concentrate Milk | 60 |
| Cook Meat | 30 |
| Heat Home | 30 |
| Foundry Sand | 6 |
| Mow Lawn | 1 |
| Total | 217 |

Research shows literally hundreds of electrotechnologies for industrial, commercial and residential use: foundries, lawn care, reduction and recycling of garabage, drying inks and paints, computer-driven and electrochemically supported automated metal parts production.

For the purposes of this analysis, however, the only benefit of direct interest is the net reductions in $CO_2$ emissions that would likely arise from increasing electricity consumption beyond that already expected.

As was shown in TABLE 7, the range of net $CO_2$ reductions per kWhr of demand is broad—from 0.5 lbs to over 60 lbs $CO_2$/kWhr. EPRI data on 15 electrotechnologies provides for an average reduction of 1.3 lbs, and national trends over the past 20 years yield 3.6 lbs

[60] *Testimony of Land and Water Fund of the Rockies*, Shepard Buchanan, Public Utilities Commission of the State of Colorado, Docket 91M-642-EG, p 2, line 12.

[61] *Testimony of Land and Water Fund of the Rockies*, Shepard Buchanan, Public Utilities Commission of the State of Colorado, Docket 91M-642-EG, p 2, line 17.

[62] A particularly good exploration of this phenomenon can be found in *Electricity in the American Economy*, Sam H. Schurr, Calvin C. Burwell, Warren D. Devine, New York, Greenwood Press, 1990.

[63] *Rebuttal Testimony Regarding Testimony of Land and Water Fund of the Rockies*, Mark P. Mills, Public Utilities Commission of the State of Colorado, Docket 91M-642-EG, April 10, 1992: Data from Center for Materials Fabrication

[64] An electricity-driven infrared drying process can be used to reclaim and recycle sand at foundries. The nation's foundries currently have an annual disposal and land fill need of over 3 million tons of contaminated sand. There are also a wide range of electricity-based processes (for shredding, de-zincing, etc.) that can be employed to separate and recycle solid waste thus reducing municipal landfill requirements.

[65] *Rebuttal Testimony Regarding Testimony of Land and Water Fund of the Rockies*, Mark P. Mills, Public Utilities Commission of State of Colorado, Docket 91M-642-EG, April 10, 1992.

$CO_2$/kWhr of electricity consumption. In the calculations here, the national trend is expected to weaken slightly, but continue to yield externality benefits at least as great as that over the past two decades. In other words, an increased use of almost 750 billion kWhrs would result in a net decline in $CO_2$ emissions of nearly 1.3 billion tons—this assumes that 50% of all the additional electricity is coal-fired.[66]

As a matter of interest, the net effect of 100% coal for all the marginal growth in 750 billion kWhrs would be to reduce the benefit to a net $CO_2$ savings of just below 1 billion tons/year.[67]

Historical technical and economic evidence reviewed in this analysis shows that the overall effect of *declining electricity costs and rising electricity use is beneficial both for the economy and the environment.* This analysis reveals the fact that economic growth over the next two decades could be accelerated with low-cost electricity. And while the increased use of coal is inextricably linked to low-cost electricity, the remarkable efficiencies of the electricity-using technologies that will be replacing fuel-burning technologies in the marketplace more than offset emissions from coal-fired power plants—so much so that one can expect substantial reductions in the emissions of carbon dioxide (the principal gas implicated in the global warming theory.)

TABLE 12

***Summary of the Impact of Lower Electricity Prices***

(assumes 5.5¢/kWhr benchmark)

- *GNP grows $1 trillion over base case growth of $3 trillion.*
- *Electric demand grows, requiring 240 more power plants (@ 500 MW) over EIA base case of 300.*
- *Total $CO_2$ emissions drop 1.3 billion tons over EIA base case.*

[66] The average benefit is calculated earlier to be about 3.6 lbs $CO_2$/kWhr.

[67] The $CO_2$ benefit assuming 100% coal-fired electricity on the margin is reduced to 2.6 lbs/kWhr.

[68] The five technologies evaluated in FIGURE 16 are: freeze concentration, industrial heat pumps, direct arc melting, plasma processing, and ultraviolet curing.

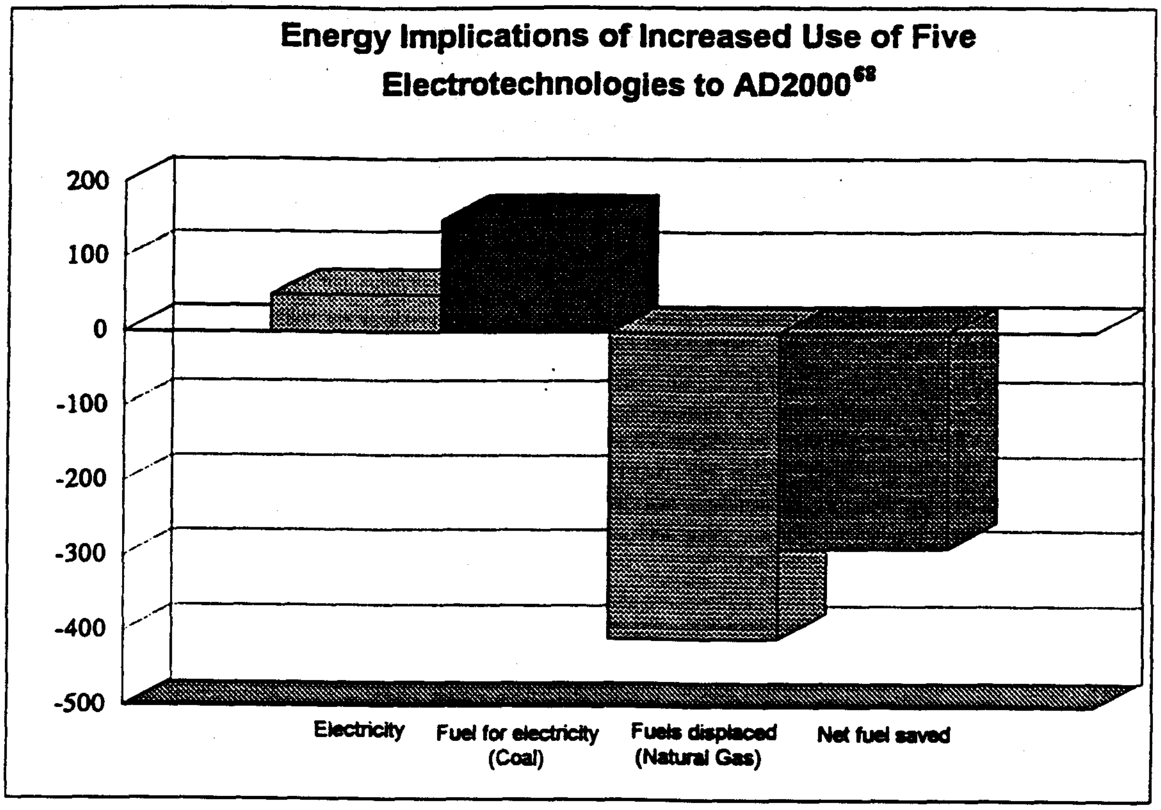
Energy Implications of Increased Use of Five
Electrotechnologies to AD2000[68]
200
100
0
-100
-200
-300
-400
-500
Electricity
Fuel for electricity (Coal)
Fuels displaced (Natural Gas)
Net fuel saved

FIGURE 16

**WESTERN FUELS ASSOCIATION INC.**
*The National Fuel Supply Cooperative*

Magruder Building
1625 M St, NW
Washington, DC 20036-3264
Telephone (202) 463-6580

# THE IMPORTANCE OF CHEAP ELECTRICITY FOR THE ECONOMY

# DOES PRICE MATTER?

## The Importance of Cheap Electricity for the Economy

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January 1995
*(Second version. Revised from September 1994.)*

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Figures



Tables

# EXECUTIVE SUMMARY

*The United States economy has become increasingly electrified. Over the past two decades, electricity consumption has soared nearly 70% in close conjunction with economic growth. The residential, commercial and industrial sectors of the economy (which account for 90% of the U.S. Gross Domestic Product) collectively use 99.9% of all electricity. In contrast these same sectors account for only 34% of all oil consumption. Our economy today is much more dependent on electricity than it is oil.*

Economists and policymakers often overlook the significance of electricity's role in America's economic life. Consider the fact that although electricity is the single largest non-labor commodity input to the U.S. economy, it is not included in the traditional commodities basket. Analysts watch price changes in this basket (or index) of goods in order to track and predict inflation and other economic trends. Each year 300% more electricity is purchased than the second largest commodity, gasoline, and 600% more than the largest non-energy commodity, cattle, and 2000% more than another "bellwether" commodity, soy. As a consequence, the inflationary impact caused by an increase in the nation's average electric rate of one-half cent per kilowatt-hour is comparable to increasing the price of gasoline by 30 cents per gallon, or increasing the price of gold by $300 per ounce, or increasing the cost of soy by $2 per bushel. But only the much smaller changes in these other commodities make headlines in the mainstream press. Fluctuations in the price of electricity are noted, if at all, only in trade journals, and the implications of such fluctuations are generally ignored.

When electricity prices are properly tracked, we find that competition, resource technology and market forces have all been driving costs down more rapidly than conventional projections indicate. By 2010 the price of electricity is likely to be below 5¢ per kilowatt-hour rather than the 7¢ presently projected. There are several important implications for the U.S. economy in these relatively low electricity prices:

1) Low cost electricity has an anti-inflationary effect. Given the significance of electricity as a commodity and given that prices are trending downward, electricity's inclusion in the commodities index would have a moderating effect on overall trends.

2) Low cost electricity promotes increased use of electrotechnologies which, in turn, enhance productivity. U.S. manufacturing productivity and competitiveness is in resurgence due to three primary factors, of which only two are widely acknowledged: organizational changes, increased use of information technology, and increased use of electrotechnologies. This latter phenomenon is strongly correlated with increased productivity. Electricity's share of manufacturing energy use has grown nearly 20% over the past decade while the natural gas share has declined 5%. Manufacturing productivity has grown 35% over the same ten year period.

3) Consumers and businesses prefer low cost electricity. Surveys, market behavior, and economic indicators show that the price of electricity is vitally important and that consumers and markets are making increasingly price-driven decisions. A *Forbes* magazine ranking of states with the best and worst job prospects correlates strongly with the price of electricity. The 12 states with the lowest priced electricity include seven with the best job prospects. The 12 states with the highest priced

electricity include 11 of the states with the worst.

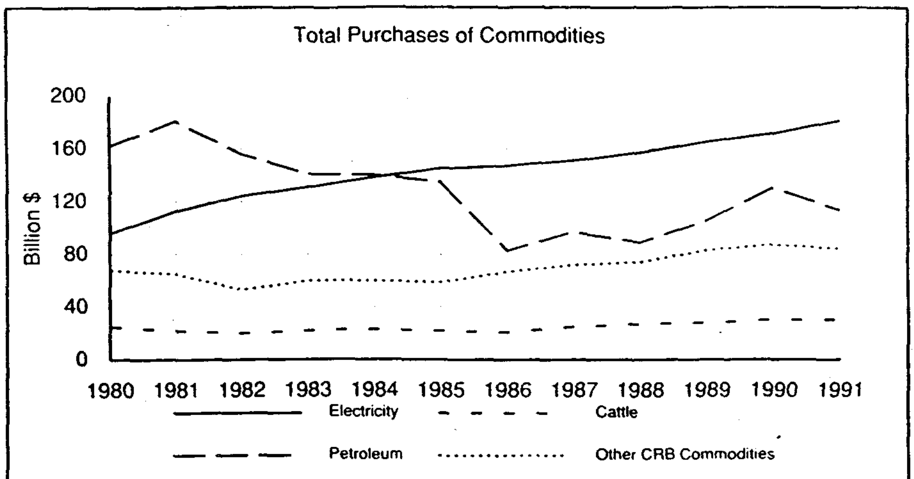
4) Low-cost electricity allows the U.S. to achieve environmental and social goals without slowing down its economy. Energy efficiency and alternative energy programs, regardless of their other merits, should be held to a standard of declining electricity rates. Declining rates will stimulate greater use of electric technologies, which typically reduce total fuel-cycle energy use and environmental emissions.

In light of the above,

- The price of electricity should be explicitly included in the "basket" of commodities used to track and predict economic trends and inflation, in particular. Failure to do so provides a false picture of the health of the economy.

- Pursuit of cheap electricity should be a central part of national and state economic development goals and should take precedence over other goals and objectives currently favored in regulatory circles.

[This recommendation mirrors one made by the National Academy of Sciences in its 1986 study "Electricity in Economic Growth."]




Petroluem includes crude oil, unleaded gasoline and heating oil. Other CRB commodities include hogs, pork bellies, gold, silver, platinum, coffee, cocoa, sugar, cotton, copper, lumber, corn, wheat, and soybeans.

# Introduction

*"It's the economy...stupid"*

Slogan at 1992 Clinton/Gore campaign headquarters.

The hot new topic in the once staid and still (for now) largely monopolistic, electric utility industry is "competition." Just as deregulation in the telecommunications, trucking, rail, airline and natural gas industries brought confusion, opportunity, and turmoil, increasing competitive pressures and the mere anticipation of deregulation is already having the same effect in the electric utility sector. Increased competition is also having the same effect on electricity prices as it has had on every other economic sector: prices are starting to drop. In some cases, regulators are contributing to this effect. In others, regulators have supported efforts to raise prices artificially.

The pressure on utilities to become more competitive — i.e., to lower prices — comes at a time when many activists and utility commissions continue to advance prescriptive regulatory policies which have the effect of raising electricity rates. As a vast regulated monopoly system, electric utilities have been subject to all manner of initiatives that have caused electric rates to increase. Subsidizing alternative energy and conservation programs, not to mention such straightforward techniques as imposing special fees and taxes, exemplify such initiatives. A relatively recent addition to the portfolio of cost-increasing initiatives is the idea of environmental externality "adders," wherein consumers are charged for emissions remaining after power plants have fully met state and federal environmental regulations. These cost-increasing activities are in conflict with the forces driving electric prices down, especially technology progress and competition.[1]

The California Public Utility Commission (CPUC) set the tone for the debate over deregulation in the electric sector earlier this year when it issued a preliminary plan to open up California's wholesale and retail electric markets to competition. The explicitly expressed goal of the CPUC plan was to find a way to drive down electric rates. Regardless of (or perhaps because of) the irony of this action by the same Commission that has endorsed or required programs leading California to have among the highest rates in the nation, the California initiative is being watched closely everywhere, especially on Wall Street. The impending, some would say de facto, deregulation of the electric utility industry is now widely recognized.

**"The electric utility industry, one of the last monopolies in the American economy, is bracing for competition, a change that is likely to eventually lower rates across the country. Companies are scrambling to prepare by cutting their costs, diversifying and looking for partners."**

*New York Times,* August 1994.

The attendant concern and confusion are already evident in investor response to electric utilities. The first half of 1994 saw utility stocks drop 262 points, or 7.65%. Over the same period the Dow Jones Industrial average dropped just 11 points, or 0.3%. This market behavior reflects confusion about who the winners will be in meeting the market demand for cheap electricity. Investor-owned and independent power producers, as well as electric-only and electric-plus-gas utilities, experienced comparable declines in their stock values at a time when demand for their product continues unabated.[3]

**"The average electric utility stock has fallen [with] losses in the past 8 months by more than 30 percent. To put that performance in perspective, if the Dow Jones industrials had done as badly as the Dow utilities since last fall, the Dow would now be about 2,540. There would be talk about recession and national crises, and no doubt Congress would be busy looking for villains to blame for the fall.... The fear now is as the electric utility industry is deregulated, new competitors will sell power for less to prime industrial and commercial customers. That will force price cuts, lower profit margins and smaller dividends."**

*New York Times,* May 1994.[4]

There is little doubt that, from a Wall Street perspective, the price of electricity matters. But this perspective is merely a reflection of an implicit acceptance of the importance of electricity, and thus its price, to the overall economy.

This analysis explores the tension between the forces that can raise or lower electric rates, and specifically highlights the role played by the price of electricity in the U.S. economy. (Previous analyses have evaluated the beneficial role of increased use of electricity and electric technologies on energy consumption and the environment.[5]) This report examines this dynamic from six perspectives.

1 The role of electricity in economic growth.

2 The role of electricity in manufacturing and competitiveness.

3 The importance of the price of electricity.

4 Electricity & Inflation.

5 Projections for the future price of electricity.

6 Implications of cheaper electricity.

PART ONE

# Overall Indicators of Electricity's Role in the Economy

**BRIEF**

*Too often, depictions of U.S. energy use lump together transportation energy and electric sector data. Such presentations obscure the role of electricity in the economy. When data concerning electricity are considered separately, two crucial facts emerge: 1) The economy has become much more energy efficient than is generally recognized, and 2) The core of the economy is growing increasingly dependent on electricity. Trend #1 is substantially a consequence of trend #2.*

Over the past two decades, U.S. population has grown about 18% and the total number of households, about 40%.[1] Despite increased efficiency of electric appliances, electricity use in the United States has grown by about 70%. How to account for this phenomenon?

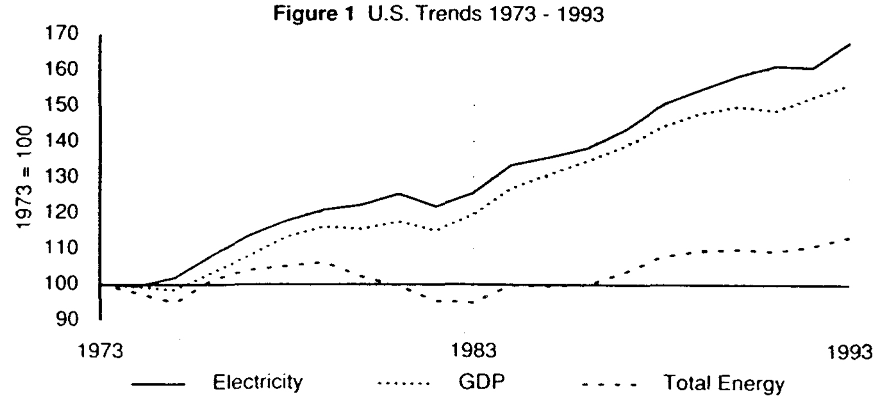
As Figure 1 shows, over the past two decades, growth in electricity consumption — not total energy consumed — is in close conjunction with economic growth (measured as Gross Domestic Product, GDP).

As a matter of historical fact, the use of electricity — which is fundamentally a surrogate measure of the increased use of electrotechnologies — has grown with, and synergistically fed, growth in the economy and growth in industrial output. Total industrial output grew 77% between 1973 and 1993. This led to a profoundly important transition. The components of the marketplace that use electricity — i.e., the industrial, commercial and residential sectors (ICR) — now consume more of their energy in the form of electricity than as direct combustible fuels.[2] The crossover occurred in 1991 when, for the first time, more than 50% of all the primary energy used in the ICR sectors was first consumed by utilities to generate electricity.[3] By 1993, that figure grew to 53%. The speed of the transition is apparent in the fact that in 1973 only 32% of ICR sector energy consumption was in the form of electricity. (See Figure 2 on page 4.)

This transition to an electricity-dominated economy is big news. It is largely unheralded. At the very least it means that the supply, reliability, and price of electricity as an input to the economy are now more important than at any previous time. One reason this trend is overlooked is that policymakers typically lump together energy consumption statistics from transportation with all other sectors.

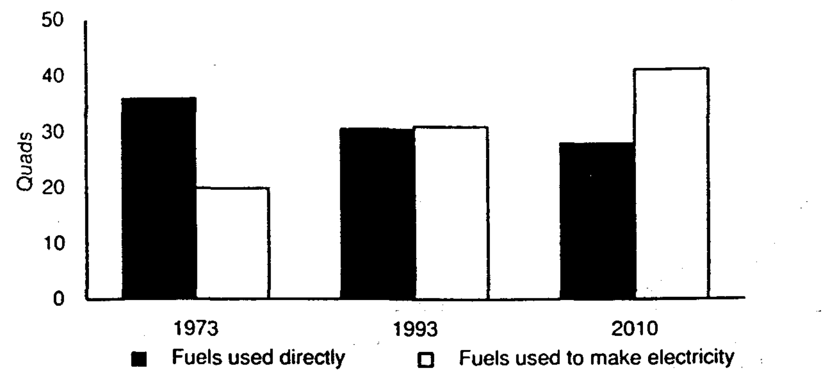
An accurate picture of the role of electric technologies in the market-

**Figure 1** U.S. Trends 1973 - 1993




Data from DOE/EIA Annual Energy Review, June 1994

**Figure 2** Industrial + Commercial + Residential Fuel Use




Data from DOE/EIA Annual Energy Review, June 1994; DOE/EIA Annual Energy Outlook 1994, Jan. 1994

place can only be seen when fuel used in transportation is called out of the rest of the data depicting national energy use patterns. At the national level, historic trends in transportation technology and fuel use have virtually nothing to do with the electric sector.[4]

- 90% of the economy uses 99.9% of all electricity and 34% of all oil consumed.

- 10% of the economy uses 0.1 % of all electricity and 66% of all oil consumed.[5]

The 10% of the economy that does not use electricity is the transportation sector which, according to Department of Commerce data, accounts for less than 10% of the nation's GDP. Activities associated with the industrial, commercial and residential sectors form the major share of the economy and are clearly more dependent on electricity than they are on oil. One can only conclude that preoccupation with the price of oil as an economic indicator, and virtual blindness toward electricity's price, is a carry-over from a time decades ago when oil was a larger determinant and electricity much less significant.

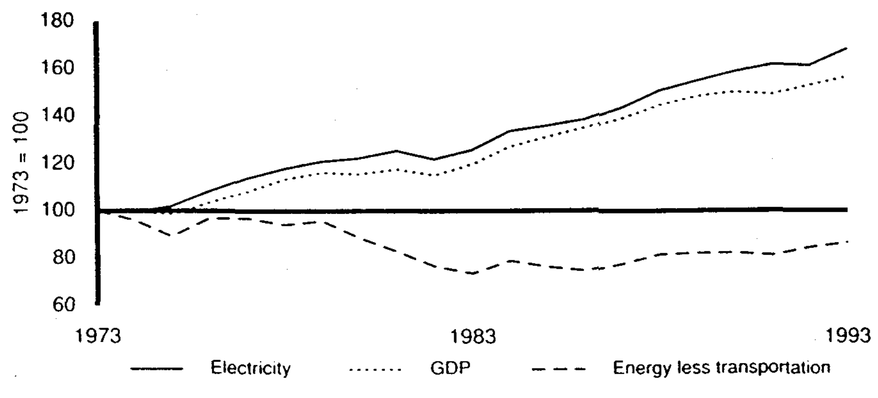
Including transportation fuel in energy use trends masks what is happening in the parts of the economy dependent upon electricity. As shown in Figure 3, marketplace consumption of combustible fuels (excluding transportation) declined by 12% between 1973 and 1993. Juxtaposed against the fact that marketplace electricity use has grown 70% with the economy's 56% growth, one can only conclude that, overall, electrotechnologies are displacing fuel-based technologies.[6]

Figure 3 also illustrates the fact that there has been a 30% improvement in overall national energy efficiency with respect to all non-transportation activities. In 1973, $58 of non-transportation GDP was supported by a million non-transportation Btus. By 1993, the same million non-transportation Btus supported $75 of GDP.[7]

These trends can be summarized in a different way, as shown in Figure 4.[8] Economic growth and industrial, commercial and residential activities have been primarily supported by increased use of electricity. Direct use of combustible fuels actually declined. The commercial and residential sectors of the economy have grown 60% since 1973 along with 80% growth in electricity use and a 15% drop in direct combustible fuel use. The industrial sector has grown 70% since 1973, with an associated 45% growth in electricity use and 12% decline in direct combustible fuel use.[9]

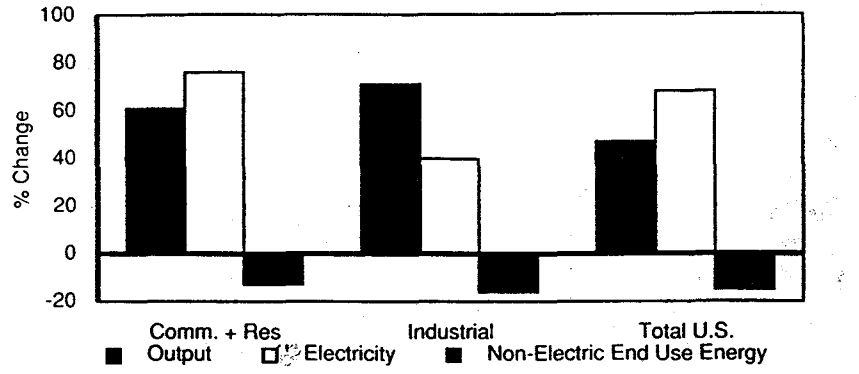
Historical data show, unequivocally, that electricity has been displacing the use of fuels in the marketplace. This transition to an electricity-dominated economy is expected to continue and accelerate. According to the Energy Information Administration (EIA), by 2010 nearly 60% of total ICR energy will be consumed by utilities in order to provide electricity to businesses, homes and industry.[10]

**Figure 3** U.S. Trends Excluding Transportation 1973-1993




Data from DOE/EIA Annual Energy Review, June 1994

Figure 4 Changes in the Economy vs. Consumption of Fuels & Electricity 1973 - 1993




Data from Statistical Abstract of the United States

Since electricity growth is a surrogate measure of increased market use of electrotechnologies, this points to the importance of identifying and understanding these technologies — and to the importance of the price of electricity which drives their use.

| Table 1 Growth in Total U.S. Energy Consumption 1993 - 2010 | |
|---|---|
| 56% | electricity generation* |
| 27% | transportation |
| 17% | all other applications |

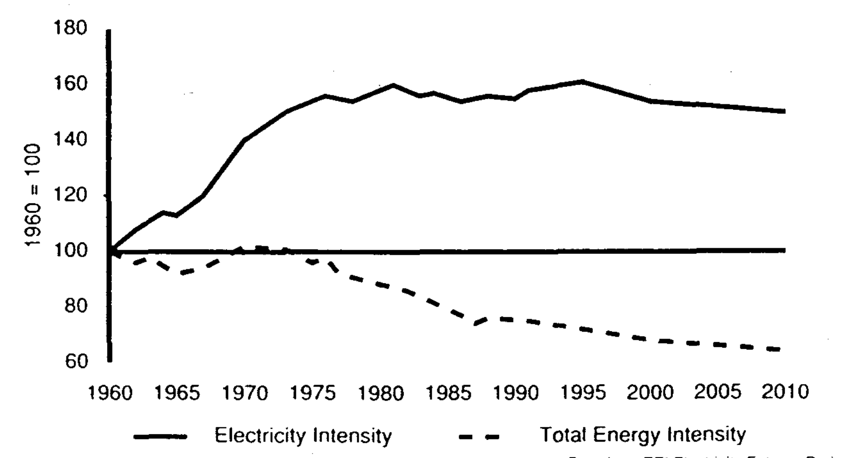
*[Source: GRI 1994 Baseline Projections]*
*- *70% of non-transportation energy growth is for electricity*

The continuation of electricity as the fuel-of-choice in the marketplace is supported by projections from the Gas Research Institute (GRI). According to GRI data, summarized in Table 1, over 70% of all growth in non-transportation energy demand through 2010 will be filled by electricity. This means that both the gas industry and electric utilities expect their single largest new source of revenue to come from the same place: customer use of electrotechnologies.[11]

In broad terms, it is possible to measure the economy's changing dependence on any commodity by tracking the quantity required to support an inflation-adjusted dollar of Gross Domestic Product (GDP). Figure 5 illustrates the historic trend (and depicts conventional wisdom as to the future).

The total energy required to support a dollar of GDP has been dropping and is projected to drop further. The economy is becoming more energy efficient and thus increasingly less dependent on the cost of fuel as an input. At the same time, the economy has become more dependent on electricity in terms of kilowatt-hours consumed per dollar of GDP. This means that the cost of electricity as an economic input has become increasingly important over the past several decades.[12]

Figure 5 Total Energy and Electricity Intensity per $GDP




Data from EEI Electricity Futures Project

PART TWO

# Electricity, Productivity & Competitiveness

BRIEF

*U.S. manufacturing productivity has been growing steadily, primarily because of new and emerging technologies. Predominant among them are electrotechnologies — technologies that use electricity.*

In what amounts to a stealth revolution, manufacturing productivity growth has taken off over the past decade as businesses have adapted new technologies (see Figure 6). Not only has the economy become more productive, but in virtually every category of the manufacturing economy, real output has been rising (see Figure 7). There is ample anecdotal evidence that manufacturing firms feel more competitive, too. According to one national survey of manufacturing firms:

**"Fully 90% of the survey respondents believe they are doing a better job of meeting the competition than they were just five years ago. Ninety-five percent agree that they have improved product quality significantly."[18]**

The importance of this trend cannot be overstated. Productivity growth has always been a primary determinant of economic health. Improvements in productivity allow wages to increase even as unit costs of products decline. This combination of outcomes is a "win-win"; people earn more while the cost of goods drops. Accordingly, federal and state policies cannot be usefully formulated without understanding what factors permit and indeed encourage these developments.

Of course numerous factors enhance productivity; however, the use of new technologies is one of the most significant, and may in fact be the most significant driving force. Politicians of all stripes have long touted technological innovation in this regard. For example:

**"Technology is the engine of economic growth. In the United States, technological advance has been responsible for as much as two-thirds of productivity growth since the Depression."**

Clinton Administration
Technology for America's Growth[1]

Typically, though, analysts focus almost exclusively on the widespread adoption of information technologies as predicates to productivity growth. But this is only part of the story. In manufacturing, it is the flexibility,

**Figure 6** Productivity Growth

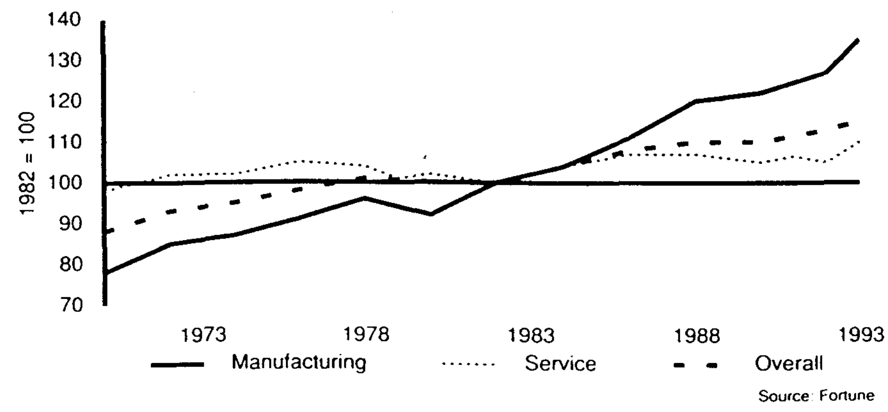
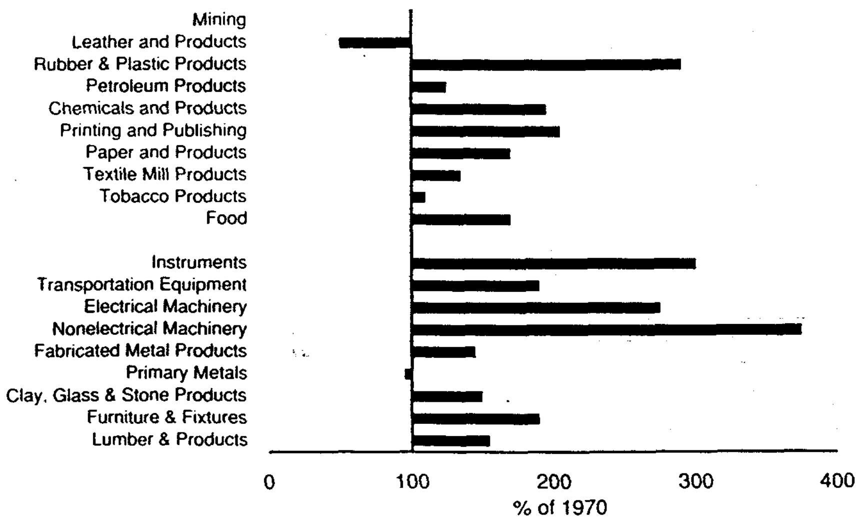


**Figure 7** Changes In Manufacturing Output 1970-1990




Data from Statistical Abstract, table 1252; adjusted for inflation

speed of response, and natural adaptation to and use of microprocessors that biases new manufacturing processing towards an integration of information and electric technologies.[3]

Studies consistently show that machinery and equipment investment have a strong association with economic growth — to the extent that economists typically use investment in this area as a measure of technology progress. Lawrence Summers and a colleague found in a recent analysis that, between 1960 and 1985, each extra percent of GDP invested in equipment was associated with an increase in GDP growth of one third of a percentage point per year. No other investment factor is as strongly correlated with economic growth.[4]

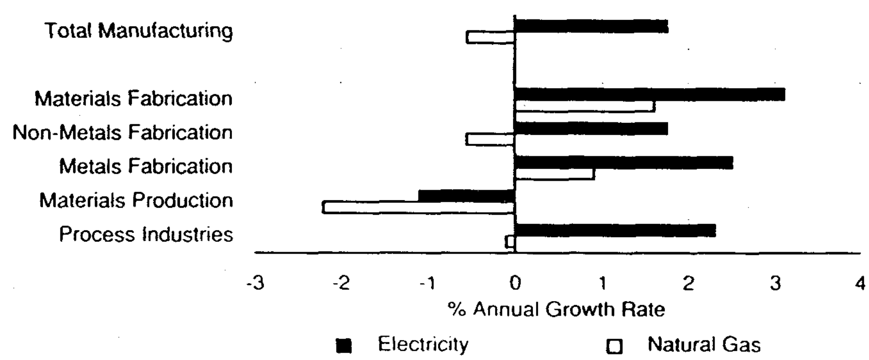
Investment in new equipment is now the primary driving force in the U.S. economy and, more important, in the current economic recovery than in any other economic recovery in recent history. Equipment purchases have accounted for over 30% of the current economic recovery compared to the more usual 10% to 15%. Over 90% of the economy's growth so far in this recovery is attributable to a surge in productivity rather than to an increase in labor hours.[5] The combined effect — economic growth stemming from increased productivity with no significant growth in labor hours — is strongly anti-inflationary.

But how to document the increase in productivity attributable to electrotechnologies?[6] The most straightforward method is to view the relative share of electric and natural gas use in various industries, since fuel use is largely a surrogate measure of the choice of equipment. The use of electricity in manufacturing has been growing at nearly 2 percent per year while the use of natural gas has been declining by about 1 percent per year since 1980. Figure 8 shows that this disparity holds all across the manufacturing sector. Even in areas where natural gas use has been increasing (such as materials fabrication) the use of electricity has been growing twice as fast.[7]

Figure 9 on page 8 illustrates the inevitable result of rising electric use in conjunction with declining fuel-combustion use in manufacturing. In the decade of 1980 to 1990, electricity increased its market share in manufacturing by 20% while overall natural gas declined by nearly 5%. Again, even where natural gas gained market share in a specific manufacturing sector such as materials fabrication, electricity gained an even greater share.

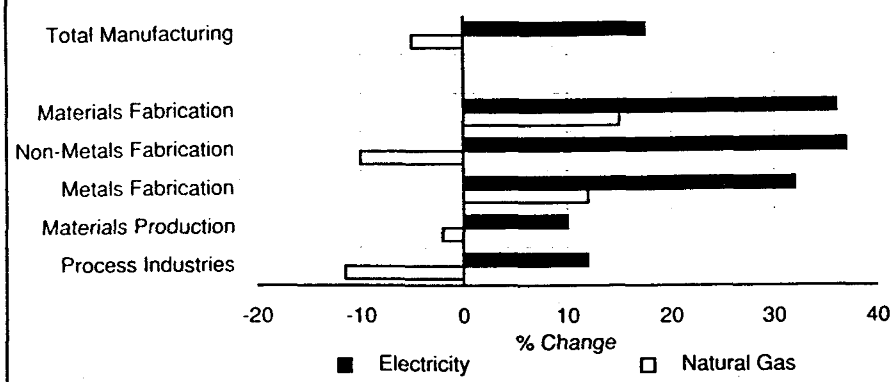
Despite the manufacturing sector's growing preference for electricity as seen in the above trends, natural gas is still the dominant fuel used in manufacturing. As shown in Figure 10 on page 8, natural gas comprises 48% of total manufacturing fuel use compared to electricity's 24%. This shows that significant opportunities for investment in new

**Figure 8** Annual Growth Rates In manufacturing Fuel Use 1980-1990




Data from Electrotechnology Reference Guide, EPRI TR-101021, table 2-6

**Figure 9** Change in Market Share for Fuels in the Manufacturing Sector 1980-1990




Data from Electrotechnology Reference Guide. EPRI TR-101021. table 2-6

**"Our first and most important conclusion is that electricity plays a very important role in productivity growth.**

**"To foster increased productivity, policy should stimulate increased efficiency of electricity use, promote the implementation of electric technologies when they are economically justified, and seek to lower the real costs of electricity supply by removing any regulatory impediments and developing promising technologies to provide electricity." [emphasis added][11]**

electric technologies remain, with attendant improvements in productivity and economic growth.

As is shown in Figure 11, electricity is projected to continue to capture market share. Process industries, which account for 61% of manufacturing sector energy consumption, are the least electrified. Natural gas has over 50% of market share.[8] Electricity has captured under 20% of the market share here but is gaining ground with significant implications for electric demand and fuel competition.[9] The price of electricity is a more important determinant in process industries than in other manufacturing sectors.

It is not only the absolute increase in the use of electricity, but also the increased share of electricity, that points to the growing dominance of electrotechnologies in manufacturing. Sectoral shifts or overall equipment efficiency improvements may reduce electric consumption growth, but cannot fully account for the phenomenon observed in the data presented here.

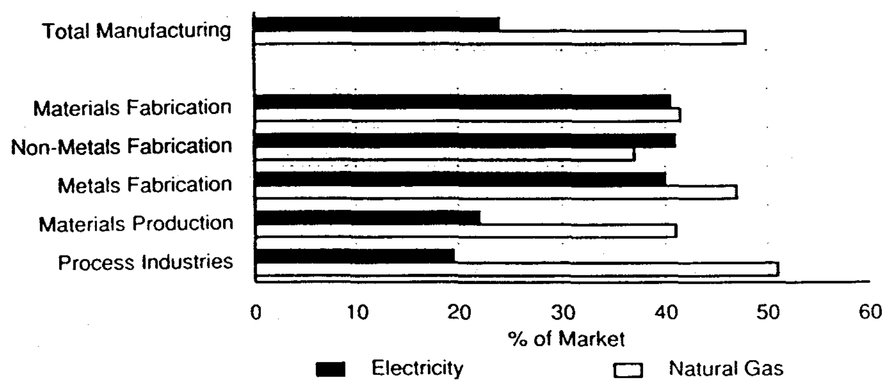
A survey of manufacturing firms undertaken by the Kansas Electric Utility Energy Research Program underscores the importance of electrotechnologies to businesses.[10] Detailed responses from 335 firms provided the Kansas researchers with a statistically valid sampling of the state's manufacturing activities. The study found that about 40% of Kansas manufacturers use electrotechnologies and a high percentage were interested in learning more about them.

The overall trend showing increased productivity related to increased use of electrotechnologies, as measured by increased electricity use, was documented earlier in this report. In what remains to date one of the most comprehensive explorations of the role of electricity in the economy, the National Academy of Sciences (NAS) asserts:

In previous studies we focused on the structural and mechanical reasons that particular electrotechnologies yield such clear benefits that the NAS could so strongly and clearly recommend a promotion of electric technologies.[12] The relevant conclusion in this analysis relates to the NAS recommendation that productivity can be accelerated by policies seeking to lower the cost of electricity.[13]

The NAS's analysis found that technology advancement caused electricity use to increase for 23 of the 35 industries included in their study. The NAS study also found that a decline in the price of electric-

**Figure 10** Total Market Share for Fuels in the Manufacturing Sector 1980-1990




Data from Electrotechnology Reference Guide. EPRI TR-101021. table 2-5 ity stimulates productivity growth in 23 of the 35 industries, and dampens productivity growth in only 12.[14]

Other analyses have reached similar conclusions about this linkage.

**"...long-term growth in capital (i.e., plant and equipment) has been associated with much steeper increases in electric than in non-electric energy. Since changes in plant and equipment are the main vehicle for achieving technological improvements, electricity's very high rate of growth relative to capital signifies that technological progress in manufacturing over the course of the twentieth century has shown a strong affinity for energy in the form of electricity."**[15]

The transition toward an increasingly electricity-dominated manufacturing sector contains a number of important implications:

- Manufacturing becomes less dependent on raw resources because electricity can be generated with a very broad variety of fuels.

- Manufacturers are effectively insulated from fuel price swings because fuel constitutes only one share (ranging from 40% to 70%) of the total number of components contributing to the cost of electricity.

- Industry achieves greater flexibility in adopting new technologies because of the inherent flexibility of electricity.

- Manufacturers enjoy various environmental benefits due to the low or zero environmental impact of electric-based technologies. In effect, environmental issues are transferred to the supplier of electricity. As a practical matter, this means that environmental impacts are often removed from population centers and made easier to monitor and manage at a central location.

Other analyses document the energy efficiency and environmental improvements associated with increased use of electrotechnologies.[16]

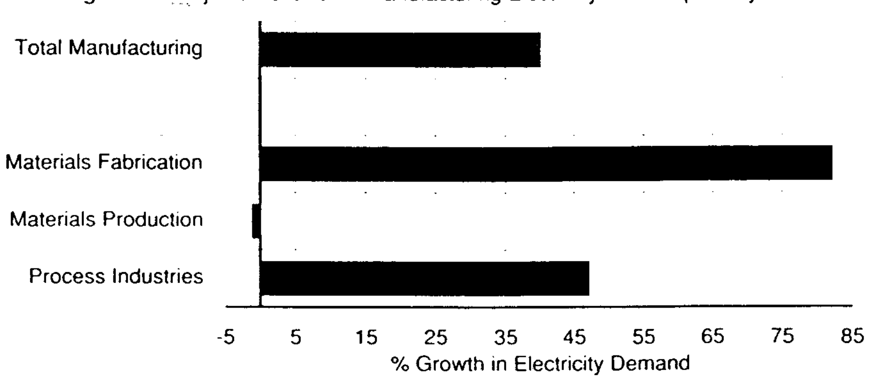
A recent U.S. Department of Commerce study on manufacturing technologies both supports the conclusion that electric technologies dominate advanced/productive technologies and validates the energy efficiency benefits. In a survey of advanced manufacturing technologies in over 6,000 manufacturing plants (taken as de facto indicators of greater productivity), the Commerce study concludes:

**"The increased application of these technologies may act to decrease overall energy demand while at the same time increasing electricity demand."**

**"Plants which utilize higher numbers of advanced technologies are less energy intensive and rely more heavily on electricity as a fuel source; use less energy per unit of output, but consume a higher proportion of electricity; plants over 30 years old are the most energy intensive and rely most heavily on non-electricity."**[17]

There are hundreds of electrotechnologies.[18] The benefits arising from some representative electrotechnologies are summarized in Table 2 on page 10. An analysis of patent data suggests that a large share, probably over 40%, of all future manufacturing innovation is associated with emerging electrotechnologies.[19]

**Figure 11** Projected Growth in Manufacturing Electricity Consumption by 2010




Data fron Electrotechnology Reference Guide, EPRI TR-101021v, table 3-2

**Table 2 Examples of Electrotechnology Production & Economic Benefits**

| Electrotechnology | Economic Benefit: Case study example |
|---|---|
| Aluminum melting, resistance | Metal losses dropped from 12 % for gas fired to under 2% for electric[20] |
| Asphalt recycling, microwave | Saves Los Angeles over $1.5 million/year[21] |
| Clothes drying, microwave | Substantially lower operating cost than conventional clothes drying[22] |
| Commercial dish washing, ultrasonic | Eliminated heating 500,000 gallons of pre-rinse water[23] |
| Cooling tower ozonation | Operating costs were reduced by almost $90,000/year[24] |
| Copper processing, electrowinning | Costs are 39% lower when compared to conventional methods[25] |
| Corona discharge | Lower cost to treat 3000 CFM air with <100 ppm VOC[26] |
| Dairy processing, freeze concentration | A typical dairy can save $100,000 annually using freeze concentration[27] |
| Deburring, electrochemical machining | Production rates have resulted in annual savings of $90,500[28] |
| Electrical discharge machining | Scrap rate for dies reduced from 10-20% to 5%[29] |
| Electrochemical machining | Rejected pieces dropped from 1% to 0% saving $16,000/yr on equipment[30] |
| Electromagnetic forming | Rejection rate dropped from 10% to 2%[31] |
| Electroreactivated carbon | Eliminates trucking of spent carbon to reactivation site[32] |
| Hardening, flux field concentrator | Energy savings of 42% due to flux field concentrator[33] |
| Label curing, ultraviolet | Several thousand feet of stock saved per day and varnish cost dropped 3-fold[34] |
| Laser cutting systems | Total cost per part reduced from $172 to $42[35] |
| Lumber processing, microwave | Old growth hardwood trees spared, 30% stronger than natural timber[36] |
| Metal cutting, plasma | Scrap rate dropped from 20% to 10%; fewer rejects, higher throughput[37] |
| Microwave curing of rubber | Savings of 5% material, 30% floor space, 30% in labor cost, 100% in scrap[38] |
| Paint spraying, supercritical $CO_2$ | Improved transfer efficiency from 40% to 70%, reduces VOC use[39] |
| Paint stripping, flash lamp | Aircraft paint stripping cost reduced 4-fold, toxic chemical use eliminated[40] |
| Painting, electrostatic | Transfer rates of 65% vs 15-40% with conventional methods[41] |
| Powdered metal coating curing, infrared | Case study cost per light pole dropped from $1.56 down to $0.86[42] |
| Pressurized water cutting | Reduces waste, downtime for sharpening blades eliminated[43] |
| Short wave infrared curing | 25% drop in paint costs, 99% recovery of over spray for 50% energy cost savings[44] |
| Toxic waste vitrification | Eliminates cost of shipping contaminated soil to disposal site[45] |
| Through heating, resistance | Cost per ton of steel reduced from $34.80 for gas to $33.80[46] |
| Ultraviolet (UV) setting of offset inks | Less expensive heat source, better heat transfer, 100% solid inks eliminated VOCs[47] |
| UV/Electron Beam(EB) Curing | Less flash-off, smaller ovens, higher line speeds due to reduced drying time[48] |
| Waste water treatment, UV | Eliminates transportation of waste to treatment site[49] |
| Welding tube, resistance | Increased throughput with a rejection rate drop from 20% to 5%[50] |
| Zinc recovery from galvanized steel | 9 million BOE, $256 million in zinc imports saved recovering 60% of scrap[51] |

PART THREE

# Does Price Matter ?

BRIEF

*Consumers and businesses feel very strongly about the price of electricity. Evidence of the importance of price is underscored by the fact that Wall Street analysts strongly favor utilities that can compete successfully as low-cost providers.*

Imagine a scenario in which homeowners receive solicitations from alternative suppliers of electricity, just as they do now for alternative providers of long distance telephone services. Imagine these solicitations offered discounts, cheaper electricity. Many utilities are imagining (and many are worrying) about just such a scenario. Many industrial customers are already selecting electricity suppliers on this basis. The concept is euphemistically known as "wheeling" — residential or wholesale wheeling, depending on the ultimate customer. It is a concept that has powerful and non-trivial implications for all electric utilities and their customers. It is a concept that is fundamentally driven by the market's desire for cheap electricity.

Under this scenario, would consumers switch to a lower-cost provider?

A recent survey of commercial and industrial customers found that:[1]

- 38% would switch electricity suppliers for a 5% rate reduction;
- 53% would switch for a 10% rate reduction.

The residential market is not substantially different in terms of price sensitivity. A similar survey of residential customers found that for a 5% rate reduction, the share of customers that would switch to another utility breaks down as follows:[2]

- 49% if their current rates were "very high,"
- 41% if their current rates were "a little high,"
- 27% if their current rates were "low."[3]

The residential customer's concern with price sends a clear signal to electric utilities. For those who believe, despite all market evidence to the contrary, that people don't mind paying more for a product (e.g. a kilowatt-hour) because of non-price benefits such as environmental/conservation programs, consider the results of a national Roper survey: When people are asked to rank factors as determinants in making purchasing decisions, here is what they consider in order of importance:[4]

- 82% past experience with brand
- 64% price
- 47% quality reputation
- 26% well known/well advertised
- 18% environmental record.

While price is of critical importance when it is perceived to be substantially out of line with expectations (which is the case in many states and regions), the Roper survey shows that people do respond to other non-price benefits that utilities can positively influence if they want to retain customers (or in a non-competitive environment, simply keep them happy), notably "past experience" and having a "quality reputation." While both of these represent soft benchmark criteria, programs to influence such criteria are not soft and are amenable to other measurement or performance benchmarks. Such programs include activities related to power quality, outage rates, new technology deployment, economic development and public service.

But at the core, the fact remains that if a utility is not perceived as providing low-cost electricity, customers will be unhappy and, in a competitive environment, they will leave. Responding to pressure for cheaper electricity, regulators across the nation are debating, and even putting into place, trial programs to test the effects of competition and learn how to fairly manage a transition to a more competitive environment.

In April of this year, the California Public Utilities Commission (CPUC) completed a 14-month study on the effects of an increasingly competitive environment for electric utilities and the direction utility regulatory policy should take. Issuance of the CPUC proposals catalyzed strong reactions across the country in both the popular and trade press.[5] The CPUC was by no means first to propose adopting policies that would move regulated electric monopolies towards a competitive environment.[6] It was, however, the first to include a proposed schedule to implement the plan and thus galvanize much of the debate that was already underway.[7]

The central goals contained in the CPUC proposals are:

- create downward pressure on rates;
- assist investor-owned utilities to compete in increasingly competitive markets;
- reduce administrative burdens of the present regulatory regime;
- reform utility regulations to reflect increasing competition.

Utilities are well aware of the importance of low rates.[8] Typical of many reactions is that of Pacific Gas & Electric Co. which, in preparing for stiffer competition, recently announced that it will continue its 19-month freeze on retail electric rates through 1995.[9]

Economic competitiveness often takes a back seat to various environmental and social agendas when utility policy is formulated.[10] Wall Street analysts, however, take a strictly hard-nosed economic view of the industry and implicitly reflect consumer preferences. For example, a Prudential Securities evaluation of utilities identifies the following key competitiveness indicators:[11]

- how cheaply a utility generates power;
- whether or not cheaper nearby competitors exist;
- dependence on industrial customers;
- the utility's record in forging favorable, i.e., low, rate agreements with big customers.

The utilities that best meet these criteria, according to the same analysis, tend to be in the South, Southwest and West. Not coincidentally, these are the same regions where low-cost electricity predominantly provided by coal-fired generation is most often available.[12]

In a similar evaluation, Daniel Scotto, managing director at Donaldson Luffkin & Jenrette reached the following conclusion:

**"Because of the demand [for low-cost power] by big corporate users ... the [utility] winners are likely to be plain-vanilla, coal-based electric utilities."**

The best utilities, according to Wall Street analysts, tend to be those that compete on price. The fact that coal-fired utilities can compete on this basis reflects the low cost of coal as a fuel and the precipitous drop in the costs of controlling emissions from coal combustion. In addition, with long-term, low-cost, stable supplies, coal looks tough to beat on price.

Of course, many utilities understand and respond to customers' price concerns. Over 20 states allow utilities to offer special low rates to large industrial customers who might otherwise seek lower-cost self-generation.[13] Since the stakes are even higher in a de-regulated and competitive environment, utilities are trying other innovative programs. For example, American Electric Power is implementing a trial program to permit residential customers to have more control over costs through real-time variable electric rates. AEP's Transtext system features a customer-controlled, three-tiered rate structure reflecting the cost and availability of power during different times of day and different seasons. Customers can select the temperature of their homes based on real-time information about how much it costs for various temperatures at different times of the day.[14]

The key to such control systems is the use of real-time communications — i.e., information "super-highways" linking utilities and their customers. The necessity of this capability for improving electrical service and lowering costs has required utilities to pioneer the use of fiber optic cables to residences. This trend highlights the linkage between end-use electric technologies and information technologies. Indeed, increased flexibility and control over costs from such real-time information systems also serves to accelerate the market use of electrotechnologies.[15]

Accommodating their customers' desire to keep their electricity bills as low as possible has an added benefit for utilities. Electric rates can set a tone for and directly impact business and job prospects in a region or state. Both anecdotal and statistical evidence support the notion that electric rates have a key impact on business decisions.

For example, in a recent contretemps between the New York Governor's office and *Forbes* magazine over the attractiveness of New York State to businesses, electric rates received prominent play. *Forbes* blasted state policies as being inimical to business growth. In identifying eight central points of contention with *Forbes* over its claim that New York was scaring away business, the New York State Director of Economic Development cited electric rates as the number two item (workers' compensation was first) and attempted to cast a positive light on New York's high-cost electricity. His claim:

**"According to the EEI, the highest rates charged by NYSE&G for industrial customers works out to about 11.5 cents per kwhr (as of last July 1) for a very small user; more typical would be about 8.8 cents. Comparable rates charged by [Pennsylvania utility] PP&L range from 7.7 to 9.9 cents."** [16]

New York State's defensiveness over high electric rates is well placed. A *Forbes* 1994 survey of the states with the best and worst job prospects is highly correlated with electric rates (although that was not the intent of the survey). *Forbes* used six key indicators to rate state job prospects: tax structure, cost of energy, cost of labor, impact of defense cuts, and Clinton health care proposals and export markets. (As the data earlier in this report illustrates, the cost of electricity rather than the cost of "energy" would have been a more accurate predictor of economic health.) Nonetheless, the way in which electricity prices correlate with job prospects in the various states is still remarkable.

*Forbes* predicted strong job growth in 23 of the 50 states.[17] (Table 3.) The 12 states with the lowest electric rates included seven states with the best job prospects. Inversely, we found that the 12 states with the highest electric rates included 11 states with the worst job prospects.

**Table 3 - Job Prospects & Electric Rates**

| Lowest Electric Rates | Highest Electric Rates |
|---|---|
| Idaho | Alaska |
| Louisiana | California |
| Nevada | Connecticut |
| Oregon | [illegible] |
| South Carolina | Hawaii |
| Tennessee | Illinois |
| Wyoming | Massachusetts |
| Kentucky* | New Hampshire |
| Montana* | New Jersey |
| Nebraska* | New York |
| Washington* | Rhode Island |
| West Virginia* | Arizona |

* *not ranked as state with best job prospects*

** *not ranked as state with worst job prospects*

PART FOUR

# Electricity and Inflation

BRIEF

*Electricity is already treated as a commodity at the wholesale level. Repeating a trend that developed just before the natural gas industry was deregulated, a commodities market is forming to formally recognize and facilitate the trading of kilowatt-hours. Analysts who read the entrails of the relationship between commodity price and inflation are still ignoring electricity — the biggest commodity in the country — and are now lagging behind reality.*

Rising inflation is one of the most feared and damaging trends in any economy.

**"Inflation steals our savings, upsets economic calculation, punishes bond holders, and bails out debtors."**

The price of commodities is considered one of the key indicators of inflationary trends. Of the commodities tracked and reported, oil is the one that captures media attention most frequently and therefore helps feed a perception/reality feedback loop (i.e., if people are afraid that prices will rise, they often buy now to avoid rising prices, thereby stimulating the demand that causes a price rise). Oil price changes often generate media commentary on the subject of inflation. A typical headline:

**"Drop in Oil Prices is Likely to Benefit Consumers by Keeping Inflation Low,"**

*Wall Street Journal*, December 1, 1993.

Despite fascination with oil (and its unquestioned importance in the transportation sector and international markets), evidence nonetheless suggests strongly that oil is not a pre-eminent inflationary indicator. The biggest single commodity is electricity and it more directly impacts the economy than does oil — but it is not in the "basket" of commodities used to track inflationary trends.

Consider: 90% of the economy uses 99.9% of the electricity (as reviewed earlier). Three times as much money is spent on electricity compared to oil in those economic markets excluding transportation, which accounts for 10% of the economy and 66% of oil consumption. Put another way, the 90% of the economy that uses electricity obtains 53% of all the energy it needs in the form of electricity — not from combustible fuels, either oil or natural gas. So why isn't electricity included in the commodities basket? The answer may be, in part, that the basket was created in the 1950s when electricity was a comparatively small commodity. Demand for oil has increased 2.5-fold since 1950; electric demand has grown 10-fold.

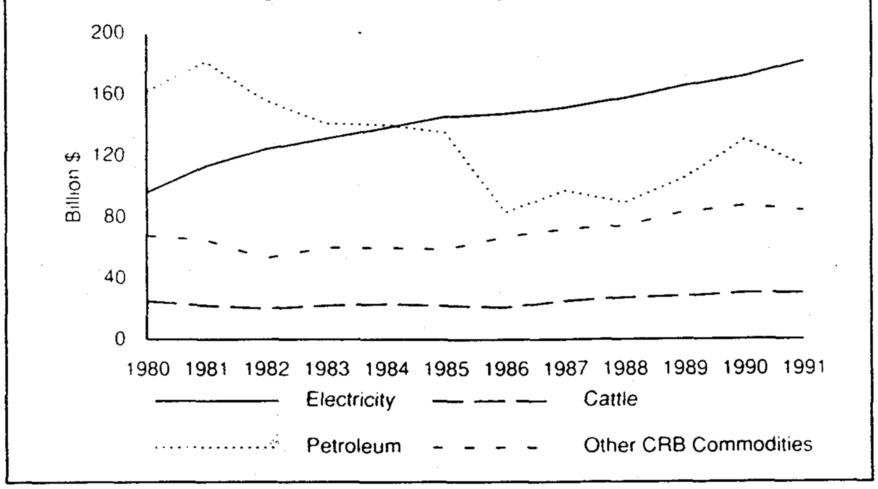
**Table 4 - CRB Index List of Commodities**

| | |
|---|---|
| Meats | cattle, hogs, bellies |
| Metals | gold, silver, platinum |
| Imports | coffee, cocoa, sugar |
| Misc. | orange juice |
| Industrials | crude oil, cotton, copper, unleaded gas, heating oil, lumber |
| Grains | corn, wheat, soybeans, soybean oil, soybean meal |

Trends in overall commodities prices are monitored for their predictive effect on inflation almost as much as oil prices are monitored. The Commodity Research Bureau's index of futures prices incorporates 21 goods, including oil, gasoline and heating oil. (Table 4.)

**"If commodity prices are on the upswing, can inflation be far behind? That's one of the key questions bugging**

Figure 12 Total Commodity Purchases




**financial markets and America's Federal Reserve these days. So far this year, the Commodity Research Bureau's spot price index of industrial raw materials has risen a hefty 12.7%."**

*Business Week*[4]

Even single non-oil commodities are tracked as important indicators of inflationary trends.

**"Inflation-watchers take note: August is the critical month for determining how big the soy crop will be. That's significant because the Commodity Research Bureau's Index of 21 major commodities — an important barometer of inflation — is heavily influenced by price changes in soybeans."**

*Barron's*

Soybeans, but not electricity!

Table 5 itemizes the amount of money the nation spends on the various commodities included in the "basket," with electricity and natural gas added to the list for comparison.[6] Figure 12 shows the trends in total purchases. Over three times as much money is spent on electricity as the largest commodity in the current basket (gasoline); and six times as much is spent on electricity as on the largest non-energy commodity (cattle). Clearly, electricity is the predominant commodity, even though it is not in any basket.[7]

Figure 13 aggregates the total amount of money spent each year on these selected commodities. As the data show, the inclusion of electricity not only substantially changes the total amount of money spent on commodities, but (were it included) its share of the total basket would be rising. A little over a decade ago, electricity accounted for about 30% of the total amount of money spent on commodities in the basket (again, assuming electricity is included in the basket). Just ten years later, electricity accounted for almost 50% of the total basket of commodity purchases.[8]

**Table 5**
**1991 Commodities Purchased** [11]

| COMMODITY | BILLION $ |
|---|---|
| Electricity* | 181 |
| Natural Gas* | 70 |
| Unleaded Gasoline | 58 |
| Crude oil | 50 |
| Cattle | 30 |
| Corn | 18 |
| Soybean | 11 |
| Pork Bellies | 10 |
| Sugar | 7 |
| Coffee | 7 |
| Heating Oil | 7 |
| wheat | 6 |
| Lumber | 6 |
| Cotton | 5 |
| Hogs | 5 |
| Copper | 4 |
| Gold | 3 |
| Cocoa | 1 |

* *not included in the CRB basket*

Commodity prices are of course not the only inflation indicators commonly watched by analysts. Two other important ones are manufacturing capacity utilization and housing prices.[9] Of these two, broad manufacturing capacity also has a direct, but largely ignored, link to electricity and, thus, its price.

Figure 13 Commodities Purchased

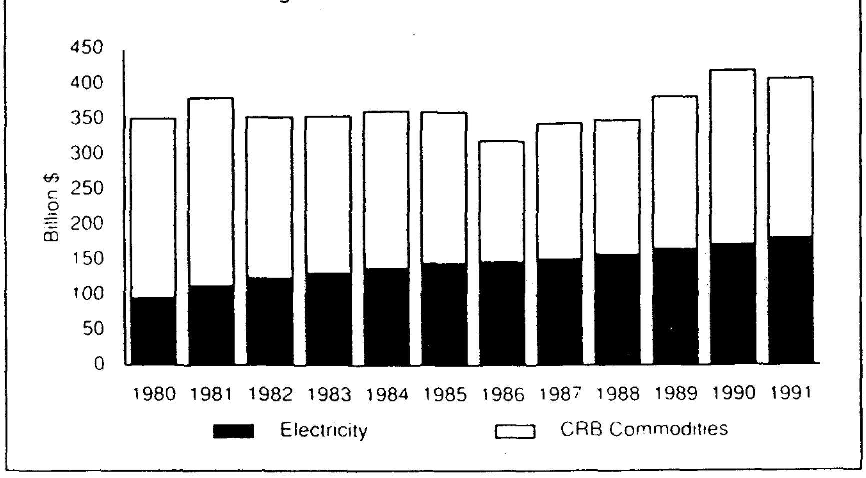


**Table 6 - Impact of Commodity Price Changes**

| Double Price of Commodity | % Increase in Cost of Total Basket |
|---|---|
| Electricity | 44 |
| Gasoline | 14 |
| Soy | 3 |
| Gold | 1 |

Economists generally believe that when manufacturing capacity reaches 82.5% utilization, the pressure of demand on the capacity to provide goods leads to inflationary pressure. In early 1994, manufacturing capacity utilization reached 83.5%, but the traditional inflationary signals did not follow, according to most analysts.[10] The reason may well be rooted in the failure of traditional theory to account for technology progress, which has probably modified the capacity "trigger point."

**Table 7 - Relative Importance of Commodities**

A 10% INCREASE IN THE TOTAL COST OF PURCHASING COMMODITIES WOULD ARISE FROM A:

- 23% rise in electric price
  [1.5¢/kwhr increase over the 6.8¢/kwhr base]
- 71% rise in gasoline prices
  [47¢/gallon increase over the 67¢/gal. base]*
- 367% rise in soy prices
  [$20/bushel increase over the $5.58/bushel base]
- 1200% rise in gold prices
  [$5,300/ounce increase over the $441/ounce base]

A 2% POINT RISE IN THE COMMODITIES PRICE INDEX WOULD ARISE FROM A:

- 6% rise in electric prices
  [0.4¢/kwhr increase over the 6.8¢/kwhr base]
- 46% rise in gasoline prices
  [32¢/gallon increase over the 67¢/gal. base]
- 37% rise in soy prices
  [$2/bushel increase over the $5.58/bushel base]
- 73% rise in gold prices
  [$322/ounce increase over the $441/ounce base]

** Base gasoline price is post refinery price; excludes taxes and distribution, retail costs and profits*

Manufacturers today are able to operate at higher utilization levels than in the past without comparable strains on their ability to meet demand. They can do so because of the increased productivity of manufacturing operations and, in particular, the extensive use of advanced technologies, especially information technology (not to mention such adaptations as just-in-time inventories which are, in turn, made possible by new technologies). As previously discussed, it is the increased use of electrotechnologies, and in particular their integration with information technologies, that is central to the quiet revolution in manufacturing productivity and its salutary impact on prices.

Given the substantial role that electricity plays in the overall economy and in productivity growth, the price sensitivity of the market to electric prices, and the fact that more money is now spent on this commodity than any other, the obvious question to ask is: What is the inflation-predicting effect of adding electricity to the price index of the commodities basket?

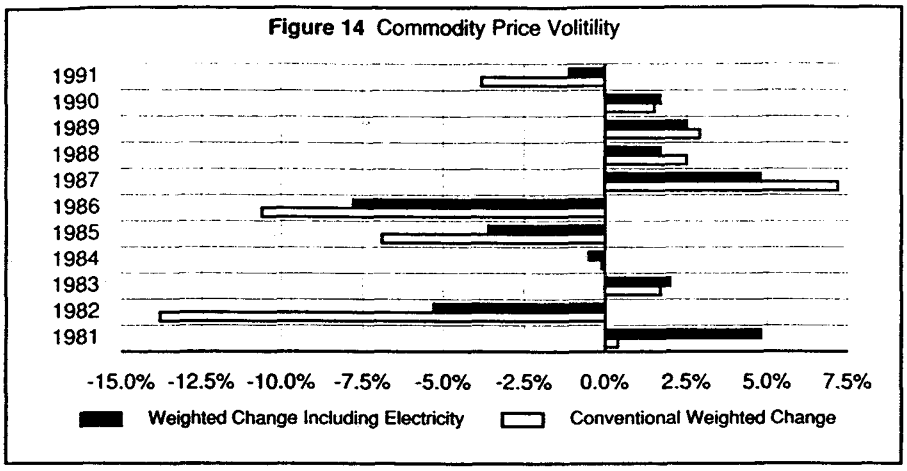
The CRB commodity basket price index is an unweighted index designed to indicate overall price pressures associated with commodities. Relatively small changes in the index are believed to have a large multiplier effect on inflationary trends in the economy.

As a part of this analysis, we undertook the development of a preliminary commodity basket index that includes electricity, modeled on the CRB index. The commodity basket price index is substantially altered by the inclusion of electricity as a commodity, as shown in Figure 14.[12] The inclusion of electricity in the price index alters the change in the index by over 3 percentage points in 7 of the 10 years from 1980 to 1990.

So far in 1994, the traditional commodities price index has been rising, without an apparent commensurate inflationary response. While there are numerous factors influencing inflation, it seems very likely that stable electric prices may be having a hidden moderating effect. Including electricity in the commodities basket would quench the inflationary heat caused by increased prices in other commodities and give analysts a more accurate picture of U.S. economic health.[13] Additional perspective on the implications of electricity in the market basket can be acquired by looking at broad impacts or price changes.

Small fluctuations in electric prices can have a large effect on the economy. This effect can be measured by calculating: 1) the change in the total amount of money spent purchasing all of the commodities in the basket, and 2) the change in the weighted price index of the basket after the price of a single commodity in the basket has been altered.[14] Table 6 shows the effect on the over all basket of a doubling in the price of a number of commodities. In each case, the target commodity's price is doubled while all other commodity prices are held constant.

Doubling the price of electricity, accomplished by a few states in recent years, can be seen to have a




dramatically larger impact on the economy than doubling the price of any other commodity. The total cost of the commodities basket would increase by 44% if electricity prices doubled, compared to 14% if the price of gasoline were doubled. Similarly, the price index of the basket — the harbinger of inflation — is moved 5 points by doubling soy prices, but moved 32 points by doubling electricity prices.

Another way to illustrate the relative importance of these representative commodities is shown in Table 7 on page 16. Here, the inverse of the logic used in Table 6 is demonstrated by showing what price changes would be required in the commodities in order to have the same overall impact on the basket as equivalent changes in the price of electricity.

The percentage changes can be viewed in terms of the absolute change in the price of each commodity. Thus, an 0.4¢/kwhr (a 4-mill) increase in national electricity prices has an inflationary impact comparable to raising the price of gasoline 30¢ a gallon, or soy by $2/bushel (from the base level of $5.58 in the model) and gold by $300/ounce (from the model's baseline price of $440/ounce). There are environmental programs that have been proposed or which are already in place in many states that would raise electricity prices substantially more than 1¢/kwhr (100-mills).

The obvious leverage that electricity has as a commodity, combined with the fact that many utilities are already treating kilowatt-hours this way, provides both a motivation and a base of experience to advance a broader and more formal treatment and recognition of electricity in general commodities markets.

For example, Consolidated Edison Co. of New York has established a Megawatt-Hour Store using an online computer system to facilitate exchanges of power. ConEd already buys over half of its electricity in the bulk power market. According to ConEd, volume trading provides a competitive edge. Computerized trading saved its customers $18 million in the first five months of 1994 compared to the same period during the previous year using the old system. Con Ed's overall trading in electricity was $200 million in 1993 and is up 20% this year. There are, of course, practical differences between trading electricity and wheat. Perhaps the most significant is that demand from electric customers, and consequently electricity trading, frequently must take place 24 hours a day. Currently, Con Ed trades focus on hourly, daily, weekly and monthly deals.[15]

There are signs that electricity's significance as a commodity is beginning to be recognized. The New York Mercantile Exchange, the world's leading market for energy-related commodity trading, plans to introduce electricity futures contracts in 1995. The model? Natural gas deregulation.[16] While trading is likely to be limited to only a few markets initially (probably in the West) the practice is expected to expand. Even before that happens, the price declines that will almost certainly be created by such competition will directly affect the nation's commodities basket. Around 20% of the nation's electricity is sold in western states.[17] If competition in this region drives prices down by an average of 20%, the national average price of electricity will drop by about 3%. This 3% average reduction in the national cost of electricity would reduce the commodities price index by about 1.2 percentage points. To have a similar effect on the total cost of commodities purchased, the price of gasoline would have to fall by 11%, or gold prices would have to fall 179%.

As electricity is increasingly recognized as a commodity, and as electricity markets become increasingly competitive and fractionated, prices will vary dramatically. Including electric prices in the commodities basket will become vital.

At the macro-economic level, cheap electricity's moderating effect on inflation can be illustrated simply. Inflation has the effect of eroding people's savings. Every percentage point increase in inflation permanently robs at least $30 billion each year from the nation's savings accounts (the value of real assets, such as land, not included).[18]

While no one doubts the importance of keeping inflation under control, inflation is notoriously difficult to predict and seems uncomfortably dependent on perceptions. If recent *New York Times* interviews with Federal Reserve officials is any indication, perception matters almost as much as fact.

**"Fed officials said they were putting greater weight on the economic indicators ranging from the price of gold and the output of factories to personal anecdotes. They are also paying more attention to human psychology: notably investors' expectations of inflation, an area that has long exasperated economists who use computer models to predict inflation.".[19] [emphasis added]**

One would have to conclude that today's analysts do not perceive that the price of electricity matters — a fact implicit in electricity's absence from the commodities basket. Consumers, on the other hand, have an innately different perception regarding the importance of the price of electricity (as explored in the previous section), a perception more in line with the facts outlined here. One hopes that in the evolving competitive market for electricity, economic analysts will begin to perceive and formally recognize electricity's role in the economy.

PART FIVE

# Where Is the Price of Electricity Going?

BRIEF

*Where is the price of electricity going? Down. In the electricity sector, marketplace forces and various ideological agendas are often in open conflict. The former tend to drive prices down while the latter drive them up. But the move toward a competitive marketplace for kilowatt-hours portends dramatic decreases in electricity prices over the next 20 years.*

The states in which mandated conservation and renewable energy programs have been most aggressively promoted by public service commissions also tend to be the same states that have the highest electric rates. California, Maine, and New York are good examples.

Maine provides an instructive example of the sometimes bizarre field of utility economics. Battered by an economic downturn, Maine has seen its electric rates soar from among the lowest in the nation to among the highest. Bangor Hydro, one of the state's utilities, has been engaged in a two-year battle to lower electric rates. Two years ago, an editorial in the Bangor, Maine, paper observed:

**"The latest word out of Augusta [the state capital] on this rate reduction, which could save Maine businesses tens of thousands of dollars? The [PUC] staff wants to treat it as a rate increase, requiring expensive, elaborate filings and, if history is any guide, interminable and costly delays."[1]**

With that last observation, the local press had it right. Over two years later, in a July 20, 1994 filing with the state commission, Bangor Hydro continued its push for permission to provide competitive, i.e., cheaper, electricity. They want the flexibly to lower rates when necessary in order to boost businesses and meet competition — although they are not asking that they be able to raise rates without going through traditional rate procedures. Yet, this win-win proposition has aroused a hailstorm of opposition.

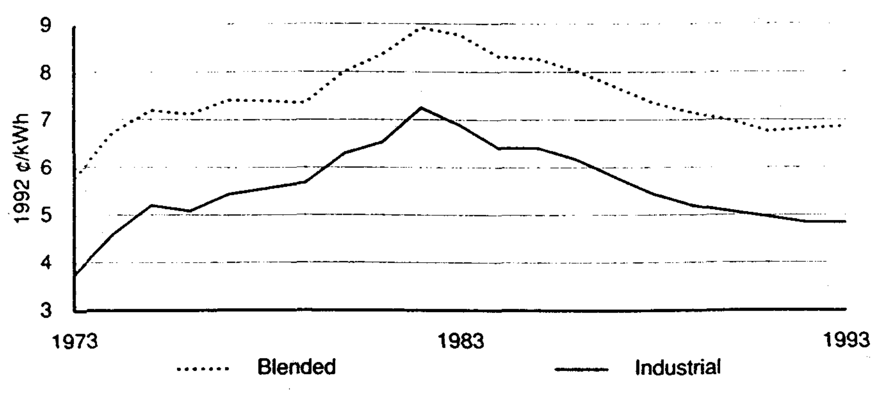
Opponents of cheap electricity admit that electric rates in Maine have increased because of the Demand Side Management (DSM) and alternative energy programs they have advocated.[2] They claim, however, that higher prices are off-set by two benefits: 1) subsidized renewable energy projects provide direct and indirect employment, and 2) the programs have significantly reduced carbon dioxide emissions. They tout this latter contribution as most significant.

Setting aside the dubious $CO_2$ claim (and ignoring the implied cost of this "contribution") and setting aside the possibility that the alternative policies actually may have increased carbon dioxide emissions,[3] the real issue is the extent to which high-priced electricity has harmed the State of Maine. High and rising electricity costs affect a state's economy in two ways: production costs in the commercial and industrial sector rise relative to those of other states/regions, thereby eroding competitiveness with an attendant loss of sales, indirect employment, and wages etc.; second, there is a decline in consumer purchasing power.

A comprehensive study of the effect of higher electric rates in Maine found that:

**"Using an econometric model [we found] a 10% increase in electric costs for the state led to a 0.23% drop in employment, 0.27% drop in output GSP [gross state product], 0.19% drop in**

Figure 15 Historic Cost of Electricity




laudable, achievable, and cost-effective. But, when they are pursued in an over-zealous fashion, economic problems often follow.

**personal income; reduction of over 1,700 jobs in employment, $75 million in output and $68 million in personal income."[4]**

The 10% increase in electric costs posited in the above analysis was actually far too conservative. Maine actually experienced a 30% increase relative to the rest of the region and nation. The impact on the state was probably far more severe than the effects described above.

The difficulty facing Bangor Hydro, as it tries to respond to an increasingly competitive environment, typifies the problems besetting other utilities. They are still mired in a regulatory environment ruled by an old paradigm and wedded to obsolete goals.

**"Environmentalists ... have effectively used the regulatory system to goad utilities into adopting energy-efficiency programs and into buying power from renewable sources. But if retail competition is allowed, the lowest-priced supplier would win. Environmentalists say that's short-sighted and ignores the public benefits of lower consumption and diverse supply sources."[5]**

This observation from *Business Week* underscores the reason why so many environmentalists are anxious to create a system in which environmental externalities, among other things, can be used as yet another tool to increase electricity costs.

Where, then, are electric rates trending? As Figure 15 illustrates, the national average price of electricity is about the same today (in inflation adjusted terms) as it was 20 years ago.

One might argue that the trend illustrated in Figure 15 means that, on average, social and economic forces have balanced each other out to the public's benefit. Or, one could argue that today's average electric rates could have been much lower than they are. The tension between the forces of social engineering and economic competitiveness are going to be more powerfully engaged than in the past. Ascertaining which forces will likely dominate requires an examination of their respective components in order to reach a conclusion about the likely direction of electricity prices.

### Social Engineering

A variety of programs fall under the category of social engineering: Demand Side Management (DSM), environmental externalities, and alternatives to conventional energy sources. Each has aspects that are laudable, achievable, and cost-effective.

### Demand Side Management (DSM)

Often touted as "win-win," DSM has a broad range of adherents. The underlying logic is that it is cheaper to save electricity than to produce it. Given that electric utilities are the most heavily capitalized businesses in the nation (see Table 8), utility management should be, and frequently is, receptive to ways that minimize capital requirements.

DSM programs that are fundamentally cost-effective (i.e., those that unequivocally cost substantially less than generating additional power) make sense for utilities to pursue, both as a wise aspect of customer service and for mutual financial benefit. The most obvious area in which DSM programs provide mutual benefit is in the replacement of old, inefficient lights and motors with new, more efficient ones. While there is considerable debate over the extent of "free riders" — i.e., customers who take a utility's money to upgrade lighting efficiency when they would have upgraded them anyway — the evidence suggests that there are many cases in which utility-subsidized efficiency programs achieve benefits that otherwise would have been passed over.

Table 8 - Capital Assets Required per Dollar of Revenue

| | |
|---|---|
| Electric Utilities | $3.03 |
| Mining | $1.74 |
| Communications | $1.09 |
| Railroads | $1.68 |
| All Manufacturing | $0.92 |
| Retail Trade | $0.52 |

However, as the "cream" in DSM is fully exploited, i.e., the obvious and easy "fixes" are made where there are large efficiency differences between old and new equipment, the programs begin to chase increasingly expensive opportunities. The challenge then becomes one of correctly evaluating the benefits and costs of program management, verification, and administrative overhead, to name a few. In addition, real costs need to be compared with realistic estimates of avoided costs. Avoided cost is the cost of electricity that one will not have to use for some period of time into the future — a period of time over which the economic cost of the efficiency program is supposed to be recovered. The temptation to oversell begins to appear. If one is trying to justify increasingly expensive efficiency measures, one might be biased toward projecting a higher future avoided cost, or to inadequately account for market resistance (the adoption rate) to a new technology, or fail to account for full-program costs.

A review of the Bonneville Power Administration's DSM program, for example, revealed that their program's cost rose from the original level of a 4 to 5¢/kwhr range to 7 -11¢/kwhr.[7] These latter costs do not compare favorably to the 4¢/kwhr or lower "avoided" costs of purchasing or generating power in the Western region.

A significant risk for DSM advocates is that they become so preoccupied with seeking the most electric-efficient technologies that they disconnect from marketplace realities, and in so doing, disconnect from realistic goals and costs. An example of this extremism is the promotion of a super-efficient home refrigerator. Technologies exist that can make even today's most efficient home refrigerator significantly more efficient. Many DSM proponents advocate that utilities directly subsidize homeowners' purchases of such equipment. A recent issue of Consumer Reports evaluated the field of home refrigerators, including the "world's most efficient refrigerator." They delivered a withering criticism of it on all counts: energy savings, economic viability, and practicality.[8] The additional cost to purchase the "world's most efficient refrigerator" would take an owner nearly two centuries to recover in terms of reduced electric bills.

Closer scrutiny of DSM programs by public utility commissions have led many utilities to back off of earlier, overly ambitious commitments primarily because such programs tend to raise electric rates.

**Environmental Externalities**

The concept underlying environmental externalities is simple: even power plants that fully meet federal and state environmental regulations still emit some pollutants. There are also some emissions that are not pollutants and are thus not regulated, but for which claims are made concerning environmental impacts, specifically carbon dioxide with its ostensible contribution to global climate change. These emissions are "external" to the regulatory process, but nonetheless, some argue, they have both an environmental and financial cost to society. The solution? Normally, if there is a measurable or documentable environmental impact, regulations are tightened to reduce the emissions. However, when hard data cannot be obtained because the evidence is weak or non-existent, environmentalists propose that the residual cost associated with these externalities be "guesstimated" and then added to the cost of the electricity.[9] Typically, these quantifications of externalities lead to penalties that can be calculated per ton of emissions. Typical guesstimates include: $0 - $300 for sulfur oxides, $68 - $1600 for nitrogen oxides, $1200 for volatile organic compounds, $1200 for particulates and $6-$15 for carbon dioxide (this last of course is not a "pollutant" nor a regulated emission).[10] The net overall effect of these penalties is to increase the cost of electricity from power plants where these externalities are incorporated and thereby discourage the power plants' use. According to advocates, this has the effect of sending the "right" price signal to the market. Typically, these penalties can add 10% to 15% to electricity rates.[11] In many cases the externality penalty has the potential to increase rates from low-cost coal-fired power plants up to 4¢/kwhr.[12] In Minnesota this approach to raising electricity costs has been enacted by statute. It is also in-place in various regulatory forms in states such as Massachusetts, Vermont and Nevada, and is being promoted or explored in many others such as Florida and Kansas.

To support their theories, which perforce require imaginative stretches, many externality proponents use "proof by association" as a typical justification: i.e., they list other states where externalities have been implemented to justify doing it in the state *du jour*. This has the effect of promulgating a silly idea.[13]

The fundamental problem with the externality approach is the failure of its advocates to understand it. Environmental externalities associated with a kilowatt-hour exist both at the power plant and at the point-of-use. The external environmental impact of using an electrotechnology is just as real as the environmental impact of making the electricity to operate the electrotechnology. A vast array of electrotechnologies are used for their fundamental economic benefits. But because of the inherent efficiency of their operation, they eliminate more emissions than are created at the power plant. Electric vehicles are the most familiar example of this phenomenon, which can also be seen in hundreds of other electrotechnologies.

In order to measure electricity's environmental externality on a correct net basis, residual emissions from the power plant must be offset by the emissions eliminated in the marketplace. When a full fuel-cycle calculation of this kind is undertaken, one typically finds that there is a net decline in environmental impacts associated with most electrotechnologies. Put another way: increased electrification on average decreases environmental impacts, taking into account the power plants. This fact has been extensively reviewed in other analyses.[14]

Table 9 summarizes the results of typical externality calculations for some representative electrotechnologies. The reduction in energy use, carbon dioxide emissions, and nitrogen oxide emissions are shown taking into account national average fuel use at the power plant. The energy savings are shown as a percentage reduction achieved by the electric technology. The energy savings are calculated by taking into account energy used at the power plant. The fact that there are net savings, counting the power plant inefficiencies, arises from the efficiency advantages of the electric technology at the point of use.

The emissions reductions shown in Table 9 are in pounds of emissions eliminated for every 1,000 kwhr of electricity used to operate the respective electrotechnologies instead of their non-electric alternative. Again, the emissions take into account power plant emissions, since the electric technologies themselves typically emit nothing at the point of use.

The data in Table 9 illustrate significant individual benefits. When all of the opportunities for energy savings from electrification are added together, the total benefits are quite large. For example, Electric Power Research Institute calculations shows that by 2010, the increased use of 15 representative electrotechnologies will lead to a reduction in total energy use equivalent to hundreds of millions of barrels of oil per year.[15]

Nonetheless, despite the fact that substituting electrotechnologies for fuel-burning technologies has clear energy and environmental benefits, advocates of environmental externalities are not proposing to undertake evaluations that credit such opportunities.[16] Instead, they focus on penalizing electricity users for the environmental impacts associated with power plants and don't give credit for end-use environmental benefits. Should externality theory be properly applied, it would, on average, have the inverse effect of that intended by its advocates: users of electricity would be paid (not penalized) for using electrotechnologies. If a ton of NOx has a value of $1,000 and a specific electrotechnology used by a business results in a power plant emitting one ton of NOx each year, but the technology applied by that end-user eliminates two tons of NOx per year, the end-user should be paid $1,000, not penalized $1,000 for the electricity used.[17]

### Alternative Energy

Environmentalists and the media have had a long love affair with alternative, or renewable, energy. Today's campaign for renewable energy is being resurrected almost verbatim from the failed programs of the late 1970s and early 1980s. Still being heard is the largely irrelevant claim first made 20 years ago that there is lots of unrealized potential out there in untapped energy.[19] Clearly, the potential is irrelevant if the cost is too high; and it is. Central to the support for renewable energy technologies is the idea that the so-called non-renewables (coal, oil, and natural gas, primarily) are running out and we had better hurry and replace them.

All advocates of expensive alternatives love to sound dire warnings of impending oil shortages with attendant escalating prices. Claims for a sustained oil shortage within the foreseeable future, however, are simply not supported by facts (more about this later). The literature of prognostication is littered with oil shortage warnings. They even started warning about oil shortages 50 years ago:

**"The recent decline in the rate of discovery of new petroleum fields in this country has given rise to the question of what we can do to meet the demand.... Great Britain, Germany, and Japan are making synthetic oil and gasoline. Now is the time to conduct a rigorous research program so that methods will be available to supply necessary liquid fuels from American coals when the petroleum supply begins to fall."**

From the February 1944 *Scientific American*, re-published February 1994

Current advocates would substitute the phrase "renewable energy" for the phrase "American coals" in the above quote, but the idea is not much different. The impending oil shortfalls of 50 years ago (and of 20 years ago) have not materialized, nor have any sustained price escalations, to justify

## Table 9 Examples of Fuel-Cycle Savings From Electrotechnologies[18]

| Technology | Energy Savings | [redacted] | [redacted]n per 1000 kWh lbs NOx |
|---|---|---|---|
| Automobile, electric | 36% | [redacted] | 2.9 |
| Canoe, electric | 49% | | 0.6 |
| Car warmer, electric | 91% | | 18.8 |
| Clothes drying, heat pump | 70% | | 1.8 |
| Clothes drying, microwave | 35% | | 0.0 |
| Cold vaporization | 63% | | 2.2 |
| Commercial cooling | 40% | | 56.9 |
| Commercial laundry, ozone | 31% | | 0.5 |
| Copper melting | 37% | | 0.7 |
| Dairy processing, mechanical vapor recompression | 76% | | 4.4 |
| Dish washing, ultrasonic | 98% | | 47.1 |
| Electric airport shuttle | 63% | | 46.3 |
| Electric mill | 46% | | 1.0 |
| Electric moped | 68% | | 7.8 |
| Electroreactivated carbon bed | 85% | | 21.8 |
| Farm chore tractor | 10% | | 18.0 |
| Farm pump | 22% | | 15.9 |
| Fax | 93% | | 31.9 |
| FlashBake cooking | 86% | | 5.4 |
| Forging, direct resistance | 22% | | 0.3 |
| Forging, induction | 16% | | 0.1 |
| Freeze concentration, dairy | 45% | | 1.0 |
| Freeze concentration, sugar | 66% | | 2.5 |
| Freeze concentration, water | 14% | | 0.1 |
| Garbage disposal | 68% | | 48.4 |
| Gas-line compressor | 50% | | 1.3 |
| Glass bottles | 31% | | 0.5 |
| Grill, electric | 75% | | 4.6 |
| Heat pump, geothermal | 60% | | 1.1 |
| Heated floor tiles | 67% | | 1.5 |
| Ion blast air cleaning | 59% | | 0.9 |
| Irrigation pump | 33% | | 13.1 |
| Kitchen fax | 20% | | 30.6 |
| Ladle preheating, electric resistance | 60% | | 2.0 |
| Lawn leaf mulching, electric vacuum | 82% | | 20.8 |
| Magazine ink drying, UV | 58% | | 1.8 |
| Medical waste, electron beam | 96% | | 381.6 |
| Medical waste, Medaway-1 | 64% | | 43.2 |
| Medical waste, microwave | 68% | | 48.1 |
| Maglev train | 75% | | 7.2 |
| Microwave oven | 91% | | 9.1 |
| Mower, cordless electric | 69% | | 10.7 |
| Noise cancellation muffler | 99% | | 1,626.5 |
| Outdoor lighting vs. gas light | 90% | | 9.0 |
| Paint curing, infrared | 88% | | 10.2 |
| Paint spraying, supercritical $CO_2$ | 85% | | 31.7 |
| Parboiling rice, microwave | 46% | | 1.1 |
| Pasta drying, microwave | 94% | | 23.3 |
| Powdered coating curing, IR | 57% | | 1.7 |
| Powdered coating curing, UV | 65% | | 2.6 |
| Powdered plastic coating curing, IR | 64% | | 2.4 |
| Pressure washing, electric | 98% | | 278.8 |
| Riding lawn mower | 25% | | 7.8 |
| Sand reclamation, IR | 7% | | 5.2 |
| Silk-screen curing, ultraviolet | 90% | | 12.6 |
| Telecommuting | 71% | | 3.4 |
| Trash compactor | 97% | | 420.3 |
| Waste water treatment, RO | 31% | | 0.5 |
| Water heater, heat pump | 32% | | 0.2 |
| Water-jet paint stripping | 69% | | 29.1 |
| Welding of tube, resistance | 28% | | 0.4 |
| Yarn drying, radio frequency | 16% | | 0.1 |

supporting more expensive alternatives. The key here, of course, is cost. Alternative energy that is cheaper than conventional energy would have no difficulty competing for market share.

But, advocates claim, alternative energy technologies are in their infancy and suffer from cost disadvantages which will disappear over time.[20] Statements of this kind are virtually identical to those made 20 years ago — a rather long infancy.

The renewable advocates' approach: what *if* prices for gas, coal, and oil rise? Investing in renewables (which they admit are more expensive "for now") will provide a hedge against the vigorously proclaimed inevitability of rising prices for conventional energy.[21] Setting aside the fact that the states which bought this argument in the 1980s are now paying for it (literally) because all other forms of power are still much cheaper than renewables, the advocates' argument fails the obvious logic test: what if the price of the competing conventional energy sources declines? What is the total downside financial risk then? Simple evaluations reveal downside risks substantially larger than upside benefits.

Alternative energy advocates have another "what if" construct: what if environmental regulations become stricter (an outcome that renewable advocates work vigorously to ensure)? Wouldn't a renewable energy program provide a hedge against such an economic calamity? Once again, this argument requires a full financial exploration, the type of financial risk/benefit calculation businesses and homeowners regularly undertake. What if environmental regulations become less difficult to meet, whether through regulatory relaxation or technology progress? For example, early in the acid rain debate many feared (hoped?) that cutting sulfur oxide emissions would cost over $2000/ton; however, the actual cost of compliance today is about $400/ton and falling rapidly.

The net effect of mandating the use of renewable energy is simply to raise the cost of electricity.[22]

**"Those Altamont windmills produce power for 7 to 10 cents a kilowatt-hour, compared with 4 cents or less for conventional fossil fuel plants. Kenetech would be out of business were it not for tax breaks and federal and state mandates that have forced people to buy its products.... The mandated business with Kenetech amounts to a hidden tax that helps raise PG&E's rates 50% above the national average."[23]**

### Economic Forces

On the other side of the equation in determining future electricity prices are those three principal factors that make up the economic forces:

- competition
- technology
- raw fuel inputs

Unlike the social forces reviewed above, all of these economic factors have the effect of exerting downward pressure on electricity prices. Again, for purposes of arriving at an understanding of the overall trends, the following summarizes an extensive body of research in each area.

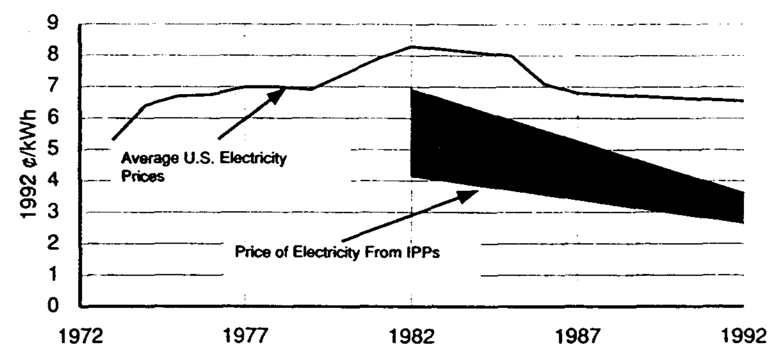
### Competition

The demand for electricity has increased for the past two decades and is projected by virtually all analysts (including those who are trying to dampen demand) to increase for the next two decades. Enhanced demand for a product increases competition to provide the product, especially in a competitive market. The typical net effect of rising competition is declining prices. The central driving force in the competitive electricity market is the fact that new generating facilities can produce low-cost power. Figure 16 illustrates how the cost of electricity from new independent power producers compares to the current average cost.[24] As Figure 16 shows, new power plants are producing power not only below the current cost, but also for a declining cost. Over time, economic forces will drive electric rates toward the lowest cost producer.

As ever less expensive sources of electricity become available, customers seeking cost benefits (large industrial customers, for example) will increasingly put pressure on their traditional suppliers for rate concessions. Utilities facing these choices almost always accommodate their customers or at least attempt to do so. In some cases, regulators do not give them the latitude. The difficulty experienced by Bangor Hydro (discussed earlier in this report) in lowering rates is not atypical. The New York Power Authority was not permitted to lower rates to meet-or-beat the cost of cogeneration from a large General Motors facility. In consequence, that facility left the system — with the attendant revenue loss to the utility. The reality is that it is usually more expensive to replace a lost customer than to keep an existing one. Utilities in competitive markets have a tremendous incentive to price power just above incremental costs. If they do not, existing power plants become underutilized thereby raising the cost of power to remaining customers.

In addition to the declining cost of new "green field" construction, utilities have at their disposal two large reservoirs of untapped cheap electricity: underutilized coal-fired power plants and yet-to-be-refurbished older fossil-fuel power plants.

Figure 16 U.S. Wholesale Electric Prices




The nation's existing coal plants operate at just under 60% capacity factor. Operating these power plants at a full capability (75% capacity factor) would provide over 450 billion more kwhr of supply, equivalent to 140 new 500 megawatts (MW) generating plants.[25] The marginal cost of this additional electricity will be substantially less than 3¢/kwhr, perhaps as low as 1.5¢/kwhr.

Repowering old power plants is a less obvious category of additional, cheap power that has been largely ignored until recently.[26] Over 3,000 MW of repowering is already proposed. About 20% of the existing coal-fired capacity and 50% of oil and gas capacity are over 35 years old, representing a total of 100,000 MW of generation.[27] Many of these power plants can be refurbished and "tuned up" to produce even more power than their original design. This option is frequently the least expensive way for a utility to meet power needs. For example, at the end of last year, San Diego Gas & Electric rejected 15 IPP (independent power producer) bids, deciding instead to repower one of their existing old power plants because it was a substantially cheaper option.[28]

Competition to provide electricity is increasing. It is coming not just from IPPs competing with utilities, but also from traditional utilities functioning as IPPs in the backyards of other utilities. For many utilities, it is a basic maxim that new sources of revenue should come first from areas in which they have direct or derivative experience. If revenue growth is inadequate in the local service territory, seeking new revenue from a core activity — i.e., supplying electricity as an IPP or wholesaling it in someone else's service territory — is an obvious option.

The effect of competition is dramatically demonstrated in Figure 16. Here the national average cost of electricity is compared to the range of costs from IPP projects in those years. The low and downward trend of electricity available from IPPs will, over time, pull down the cost of the entire system.[29] Long-time successful IPP CEO and prognosticator Roger Sant succinctly observes:

**"If today's low prices persist, the economics of lower-cost power will likely overwhelm the regulatory system now in place."[30]**

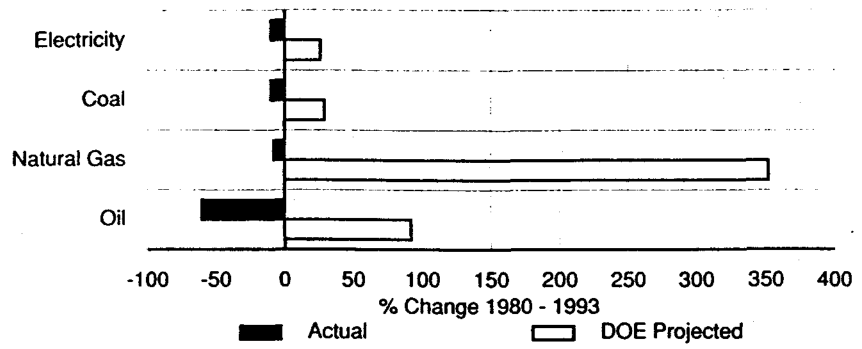
In this case, the competition will be fierce and prices are likely to plummet. The decline in the price of electricity is good for the economy and for customers, but it will create substantial stresses and turmoil in the electric utility business. This reality suggests that utilities should be wary of initiatives that have the effect of raising electricity prices. Such initiatives will put them at a substantial disadvantage with competitors for their customers.

### Technology Progress

Competition is one of the sustaining forces that advances technology. The technology of electricity generation, transmission, and distribution is advancing at a rapid pace. Power plants and associated systems are increasingly efficient, more reliable, and easier to maintain. These advances all have in common one outcome: the cost of providing electricity to customers goes down.

Coal-fired generation is the technology which typically involves the most extensive materials handling, hence it is laden with rigorous environmental regulations. Yet progress in the development of highly efficient and squeaky clean combustion technologies ensures that state-of-the-art coal-fired electricity will meet and exceed all environmental regulations while still delivering electricity for 4 to 5¢/kwhr.[31] Because of the abundance of coal as a resource, this economic reality sets a de facto ceiling on competition for much of the country. Cost-effective technologies which allow coal-fired power plants to match the low emissions characteristics of natural gas generation already exist.[32] These innovations will lead to competitive responses from the natural-gas-fired (and even oil-fired) generat-

**Figure 17** DOE 1980 Price Projections to 1990 vs Actual Changes




ing technologies.

Beyond the generation side, a wide panoply of technologies are emerging that will directly reduce the cost of electricity to consumers. Advances in high-powered solid state devices will soon make it possible to reduce by over 10% losses in transmission switching. High temperature superconductors will not only reduce transmission costs, but also generation and end-use technology costs. Advances in control systems permit more efficient integration and dispatch of power sources, again reducing the ultimate cost to consumers.

It has been claimed that there are no more "economies of scale" left in the electric business to support the drop in electricity prices which occurred for decades following the advent of the Electric Age. This view confuses technology progress with scale economics. Economies do result from scaling up power plants. Independent power producers that started with small power plants, in recent years have moved increasingly to large power plants because of this economic reality. But technology progress has been the big factor in driving down the costs of technology to generate and deliver electricity. No serious student of technology doubts that this progress will continue.

**Raw Fuel Resource**

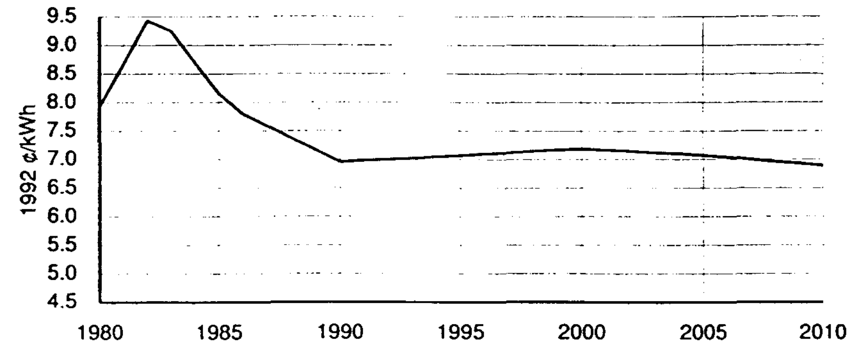
The trump card for every advocate of non-combustion technologies is to point to projections showing rising fuel costs for oil, gas and coal. Buy the more expensive alternative now, they urge, to protect against future fuel price rises. The problem is that there is no historical record that supports the belief that fuel prices will rise; nor is there any current evidence to support such a trend.[33]

Figure 17 illustrates a typical phenomenon — largely missed because prognostications of a decade ago are often forgotten by the time the same analysts' predictions are trotted out ten years later. Figure 17 shows the projections made in 1980 for 1990 prices of oil, coal, natural gas and electricity. These projections come from U.S. Department of Energy 1980 documents. DOE projections both then and now generally reflect the conventional wisdom of other prognosticators. Furthermore, DOE projections are those most commonly used by all analysts. As the figure shows, not only were the projections of a decade ago off, they were dramatically wrong. All prices were projected to rise significantly by 1990. None did. Compared to ten years ago, coal is cheaper today. Compared to 20 years ago, coal is about same price.[34]

Oil price projections are frequently viewed as the bellwether of where energy prices in general are trending. This preoccupation with oil prices arises in part because of the magnitude of the international oil trade, in part for psychological reasons (perhaps rooted in the shock of the 1973 oil embargo and attendant short-lived price escalation), and in part because of the almost immediate effect oil prices have on consumers' transportation budgets.

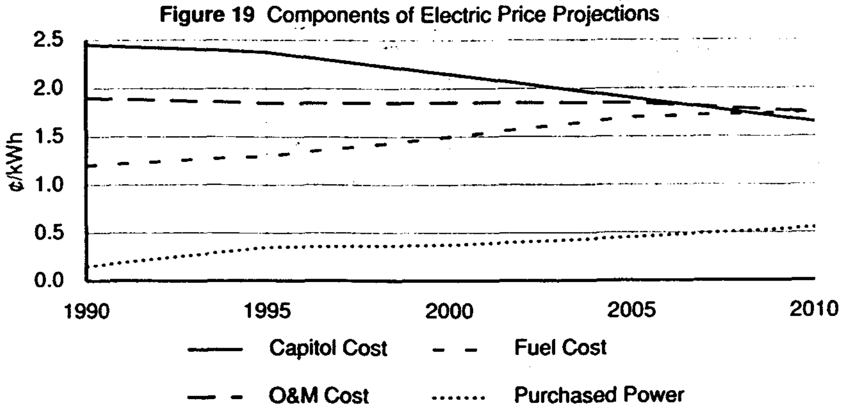
According to current DOE projections, oil prices are trending up.[35] By 2010, DOE's "reference case" projects that oil will reach about $30/bbl in today's dollars. It is instructive to note that oil prices (in constant 1988$) have stayed between $6 and $16/bbl for all but five years over the past century.[36] All indications are

**Figure 18** Electric Cost Trends & Projections




Source: EEI Futures Project

Figure 19 Components of Electric Price Projections




that major oil producers can continue to make a profit at $15/bbl.[37] When the price of oil finally rose over $25/bbl for several years in the late 1970s, energy competition was so intense that the price rapidly collapsed (e.g., new oil exploration, the use of supercomputers and even satellites, and new extraction technology such as horizontal drilling quickly eliminated the shortfall, etc.). Today oil can be found readily for about $3/bbl in finding costs.[38] On top of that, the proved reserves of oil — i.e., the amount proven to be available at current prices — have typically been sufficient for 10 to 15 years of consumption, and have been projected to be adequate for 10 to 15 years every year for the past 50 years.[39]

Historical data aside, ultimately a price ceiling for oil is set by the cost of OPEC natural gas. Over time, the market cannot sustain a price for oil that is greater than the cost of delivering OPEC natural gas to world markets via liquid natural gas tanker. Natural gas can be substituted for oil in many applications. That price "kicks in" at around $20 to $25/bbl. Here OPEC is in a strong position to supply that fuel with 40% of the world's proven natural gas reserves, an amount 10 times greater than U.S. reserves.[40]

Coal prices are the principal determinant of the cost of delivered energy in the electric generation business because 55% of all electricity is coal-fired. This level of dependence will continue for at least the next 20 years. Coal prices are projected to be stable and decline in real terms over that period.[41]

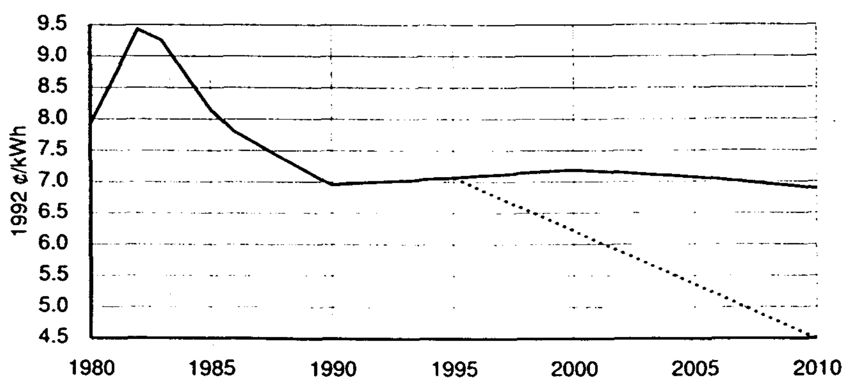
### The Price Trend

All things considered then, what is the trend for the price of electricity? Figure 18 illustrates today's conventional wisdom.[42] Some comfort may be extracted from Figure 18 in that electric rates are not projected to rise over the next 20 years. But given the evidence summarized in this analysis, there are substantial reasons to believe that a declining trend would be preferable. To ascertain if the current projection is likely, the components of the projection need to be evaluated. Figure 19 shows the projected trends for the inputs that make up the final cost of electricity: capital, operations and maintenance (O&M), fuel, and purchases from IPPs (excluding taxes and related fees).[43]

Based on the evidence reviewed here, the projections illustrated in Figure 19 seem reasonable for two of the four components. There is no doubt that capital costs and operational costs are declining. There is no evidence, however, to support the belief that fuel and IPP purchases will increase in cost over the next 20 years, as is currently projected. In fact, the evidence reviewed here supports a view that these two inputs will decline.

Figure 20 shows what the aggregated price projection for electricity looks like when all of the inputs are put together correctly, which is to say they trend downward in cost. The nation's average cost of a kwhr is likely to be below 5¢ by 2010.

Figure 20 Modified Electric Price Projections



PART SIX

# Implications & Recommendations

The purpose of this topical report has been to address the question, "Does Price Matter?" The evidence shows:

- people and businesses prefer cheap electricity
- electricity is the primary energy input to the economy
- competitive forces drive prices down
- technology progress drives prices down
- new end-use technologies are biased toward electricity
- new technologies increase competitiveness
- cheap electricity is anti-inflationary

Can alternative energy and DSM programs survive in a competitive environment? Yes, but only if they compete on price. Such programs should be held to a standard of meeting or beating declining, not increasing, electricity costs. In that case, such programs will deliver high value to both utilities and customers. Not only will the economy be afforded the benefit of cheap electricity, but the putative benefits of such programs will be achieved in a genuinely cost-effective manner. Many DSM and alternative energy programs cannot meet this standard, nor has this standard been applied to them.[1]

In any case, as discussed in this report and extensively documented elsewhere, the energy efficiency and environmental benefits which are the ostensible motivation for DSM and alternative energy programs are achievable through increased electrification. Increased electrification is most readily stimulated by reduced prices of electricity. In such a framework, the energy efficiency/environmental gains are not just "least cost", but are achieved at a maximum benefit to society.

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3 "Utility Stocks Head South," Financial News, *Public Utilities Fortnightly*, August 1, 1994.

4 "Electric Panic Creates Bargains for the Brave," Market Watch, *New York Times*, May 15, 1994.

5 A CLEANER Economy, Mills•McCarthy & Associates, Inc., June 1993; Electrotechnologies & Externalities, Mills•McCarthy & Associates, Inc., October 1993; Ecowatts: The Clean Switch, Science Concepts, Inc., April 1991; The Potential for Carbon Dioxide Reduction Through Electrification of the Commercial Sector, Energy Research Group, Inc., May 1991.

PART ONE

1 Statistical Abstract of the United States, U.S. Department of Commerce, 1993; table 2 and table 65.

2 The marketplace use of electricity is measured here as the total amount of primary energy required to make electricity. This properly accounts for society's use of energy, since it is the energy needed to make electricity that is relevant both from an environmental and from an economic perspective. Some analyses mistakenly count end-use electricity in simple Btu-equivalent terms; i.e., a kilowatt-hour is equivalent or 3413 Btus, and will in fact yield 3413 Btus if used to simply provide heat. This measure is misleading on two counts. First, most electricity is not used to provide heat. More importantly, it is the 10,000 Btus of energy needed to make electricity that is relevant. When a process that uses direct fuel is displaced by electricity, the energy exchange involves the use of fuels at a power plant. In all of the calculations and data in this report, we count the fuel used at the power plant.

3 Annual Energy Review, DOE/EIA, 1993: The primary energy required to generate the electricity consumed is credited to the end-use sectors consuming that electricity, even though that primary energy is consumed remotely at power plants.

4 The more substantial electrification of the transportation sector in the future, however, is a distinct possibility and a trend that will confer energy and environmental benefits comparable to those already achieved in electrifying the non-transportation aspects of the economy. For more information on the total energy and $CO_2$ implications of electric vehicles, see CLEANER Transportation, Mills•McCarthy & Associates, Inc., September 1993.

5 Annual Energy Review, DOE/EIA, 1993.

6 Annual Energy Review, DOE/EIA, 1993; Statistical Abstract of the United States 1993, U.S. Department of Commerce, 1973: table 31, table 69, table 1260.

7 Annual Energy Review, DOE/EIA, 1993.

8 Data from Statistical Abstract of the United States, U.S. Census Bureau Department of Commerce, and DOE/EIA Annual Energy Review. Commercial output is measured as the growth in the service sector; residential "output" is measured as the total growth in the residential housing stock.

9 Over 60% of the additional electricity supplied over the past two decades has been provided by coal-fired power plants. It is interesting to note that one national survey found that 81% of respondents failed to identify coal as a significant new source of electricity since 1973. (From "Ten Lessons from Research in 1993," A. Bisconti, USCEA, December 30, 1993.)

10 Annual Energy Outlook, DOE/EIA, January 1994.

11 1994 Policy Implications of the GRI Baseline Projection of U.S. Energy Supply and Demand to 2010. The GRI data also shows that gas-for-electricity generation accounts for 53% of projected total growth in natural gas consumption by 2010 (split about equally between utility and cogeneration sales); 17% for industrial processes, 12% for commercial activities, 12% for transportation and 5% in the residential market.

12 The projection for electric intensity to remain largely unchanged for the next 20 years is based substantially on the presumption that DSM programs will more than off-set the increased use of electricity associated with new electric technologies. This, the conventional wisdom, requires the unlikely assumption that DSM programs will not only survive but grow in an increasingly competitive environment, and further that there are not many new opportunities for electrification.

PART TWO

1 "The Global Challenge for American Manufacturers," K. Chilton, April 1994, Center for the Study of American Business.

2 Technology for America's Economic Growth, A New Direction to Build Economic Strength, President Clinton, Vice President Gore, February 22, 1993, p. 7.

3 The Productivity Payoff Arrives," *Fortune*, June 27, 1994. The productivity revolution in manufacturing technologies is having a positive impact in rural, not just urban, areas. Over 80% of the 513 manufacturing rural counties experienced net population growth. This is in contrast to the previously trend towards virtually all rural counties losing population. Note that the classification "manufacturing" is

the second largest class of rural counties, exceeded only by rural "farming" at 520. "The Rural Rebound," *American Demographics*, May 1994.

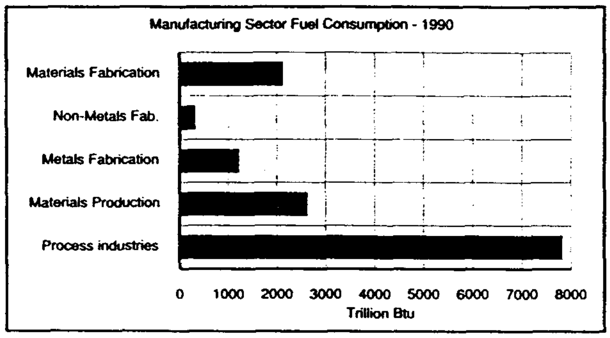
4 "Equipment Investment and Economic Growth," J. Bradford De Long, Lawrence Summers, *Quarterly Journal of Economics*, May 1991.

5 "Thus U.S. Recovery Could Give Inflation The Slip," Economic Trends, *Business Week*, July 25, 1994.

6 One method is to itemize, evaluate and document the productivity enhancements visible in specific equipment, for example: Electrotechnologies and Manufacturing Productivity, TECH Resources; Electricity in Industry, Schmidt Electrotechnology Reference Guide, Revision 2, EPRI TR-101021, August 1992. Electricity in the American Economy, Agent of Technological Progress, Schurr et. al., Greenwood Press, 1990.

7 Electrotechnology Reference Guide, Revision 2, EPRI-101021, February 1992.

8 Ibid, table 2-5; 7713 trillion BTUs in the process sector compared to 12,537 in total manufacturing.




Data from Electrotechnology Reference Guide, EPRI TR-101021, table 2-5

9 EPRI data includes non-purchased fuels for electricity generation, and gas feedstocks, but not other forms of non-purchased fuels. In other analyses looking at energy intensity of manufacturing, non-purchased fuels and structural shifts in the manufacturing sector were found to be important in assisting to explain declining energy intensities. See "Energy Efficiency in the Manufacturing Sector," Monthly Energy Review, DOE/EIA, December 1992. The focus here, however, is on absolute and relative changes in the use of electricity and the purchase of natural gas, rather than the overall energy intensities.

10 Marketing/End Users for Electrotechnology in Kansas Industries, Kansas Electric Utilities Research Program, Kansas State University, May 1993.

11 Electricity in Economic Growth, National Research Council, National Academy of Sciences, 1986.

12 "Electrotechnologies: Keys to a healthy economy, clean environment," Tools for Tomorrow, *Electrical World*, June 1994.

13 Much rhetoric emerging from activists specifically promoting increased electric rates and opposing cheap electricity presumes that consumers will somehow squander electricity if it is made too cheap or, in more sophisticated terms, "markets need to be sent the right price signals." This presumption is nothing less than ludicrous for businesses, and equally so for the residential sector on examination. The "don't turn the lights off, electricity's cheap" effect by and large just doesn't exist. It is true, however, that many equipment purchase decisions may be weighted in favor of electricity-using technologies as the price of electricity drops and is perceived to be likely to continue to drop. This is especially true for the process industries which are largely unelectrified.

A typical, but by no means isolated example, of the belief that energy prices need to be higher was articled by Secretary of Energy Hazel O'Leary who observed last year that "cheap is not always best" (NCC Energy News, Winter 1994 newsletter, Association of Energy Engineers, National Capital Chapter Fourth Annual Energy Conservation Forum, October 21, 1993). The Secretary evidently "saw less need to muck around" to accomplish U.S. efficiency goals if energy prices were higher.

14 Electricity in Economic Growth, National Academy of Sciences, National Research Council, 1986.

15 Electricity in the American Economy, Agent of Technological Progress, Schurr et. al., Greenwood Press, 1990.

16 CLEANER Economy, Mills•McCarthy & Associates, Inc., June 1993.

17 "Energy Intensity, Electricity Consumption, and Advanced Manufacturing Technology Usage," M. Doms, T. Dunne, July 1993, Center for Economic Studies, U.S. Dept. of Commerce, Economics and Statistics Administration.

18 A listing of over 200 is contained in CLEANER Economy, ibid.

19 America's Innovative Strength & Electrotechnologies, Mills•McCarthy & Associates, Inc., March 1993.

20 EPRI Center for Materials Fabrication-086

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1 "Customers are happy, but how loyal are they?" *Electrical World*, March 1993.

2 "Reliability, power cost top long list of commercial/industrial concerns," Power Marketing, *Electrical World*, April 1993.

3 This strong residential sensitivity to the cost of electricity is in significant measure a consequence of the share of a household's budget that is occupied by utility costs. For example, for families in the lowest 20% income bracket, a household's total utility bills are about equal to total mortgage, taxes, and maintenance expenses. Even for the households in the top 20% income bracket, utility bills are still nearly one-third of combined mortgage, taxes, and maintenance "American Spending," American Demographics Desk Reference No. 5

4 "Shade of Green," American Demographics, March 1994.
The survey provides some insight for strategies for customer retention even when a utility is not able too provide the lowest price. The first rated factor, "past experience" is clearly related to a positive past experience wherein there are many other services and programs in which a utility can establish a positive relationship with its customers. Also the third rated factor "quality reputation" with respect to utilities also provides an opportunity to provide value added in the form of quality, in all the forms that it can be measured and perceived by customers.

5 "Political Alliances and the Struggle Over Competition," *Public Utilities Fortnightly*, September 1, 1994.

6 "The Coming Electric Wal-Mart," J. Drzemiecki, P. Augustini, *Public Utilities Fortnightly*, July 15, 1993.

7 "California Pushes Restricting, Retail Wheeling," *Public Utilities Fortnightly*, May 15, 1994.

8 In some cases this awareness appears to have been subsumed to enthusiasm for certain DSM and alternative energy programs that have the effect of increasing rates. Regardless of the political attractiveness, and occasional political necessity, in caving to pressure to implement non-cost-effective programs, it is rarely in either the customer's or utility's best interests over the long term to support programs that increase electric rates.

9 "Pacific Gas Extends Retail-Rate Freeze On Electricity Use," *Wall Street Journal*, August, 3, 1994.

10 In fact, for a truly breathtaking approach to "quantifying" environmental risks — an activity of special interest to utility activists, so that they can accordingly raise the cost of electricity generated from their least favorite sources of electricity — see the new California Environmental Protection Agency study on environmental risk in which a new criteria is created called "peace of mind." For example, risks associated with greenhouse gases (since there are no scientifically quantifiable risks, or even agreed upon facts regarding global warming theory) are deemed a hazard to social welfare because of their potential for harm in such areas a "mental health, trust of governing institutions, access to reliable information, personal security, and personal relationships." See "California Report Sets Standard for Comparing Risks," *Science*, 14 October, 1994.

11 "Is it time to bail out of utilities? Not a chance." *WSJ Smart Money*, January 1994

12 It is important to note that one of the correlators is also an implicit price issue, i.e., a utility's record in establishing favorable long-term agreements with large customers. In many cases such agreements can be forged successfully on the basis of a 'basket' of economic issues, not just direct price but also price stability, quality of supply, reliability, etc., as well as related services.

13 "Managed Competition," *Independent Energy*, September, 1994.

14 "Real-Time Variable Electric Rates are Coming," *Energy Design Update*, June 1994.

15 In some senses this is an unintended and ironic consequence since many advocates of such real-time pricing point to these systems as means to reduce electricity consumption, not just reduce electricity costs. Customers, on the other hand, see such systems as ways to reduce overall costs, not just electricity costs. The flexibility and control over costs afforded by such real-time information links could in fact lead to more net demand for electricity (from the electrotechnologies) than reductions from more efficient use of those technologies originally targeted by the real-time pricing programs.

16 "New York State to Forbes: We're not that bad," *Forbes*, March 28, 1994.

17 "The fight for jobs," *Forbes*, January 31, 1994.

## PART FOUR

1 "Inflation, Confiscation, and Gold," Tom Bethell, *American Spectator*, September 1994.

2 "The tail doesn't wag the dog," T. Mack, *Forbes*, January 31, 1994. The absolute price of oil did not significantly change manufacturing costs when oil prices increased during the price run-ups of 1973/4 and 1979/80, and cannot directly account for inflationary trends in the past. In one study of 24 industries that use large amounts of energy, their performance and costs of product did not significantly suffer when oil prices rose in the past.

3 "Commodity Prices Spell Inflation Danger," *Fortune*, June 27, 1994.)

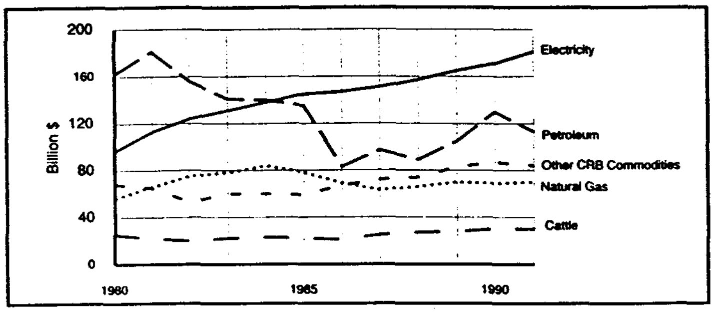
4 "Inflation Detectives Are Rounding up the Wrong Suspects" Economic Trends, *Business Week*, August 8, 1994.

5 "Bean-Counting" *Barron's*, August 8, 1994.

6 Natural gas is included on this list for comparison, and also included later in the modified commodities price index model. The analysis shows that natural gas, while arguably also a significant commodity, has neither the magnitude nor the moderating effect comparable to electricity.

7 The graph below duplicates the data shown in Figure 12, with the addition of natural gas in the series. Natural gas is clearly a significant commodity, and its inclusion will have some effect on the commodities basket — but not one equal in magnitude to that of electricity. As the purpose in this report is to gauge electricity's impact, we have not included natural gas in any of the calculations.

8 Figure 13 was compiled using electricity consumption and




price data from DOE/EIA Annual Energy Review. CRB commodities are based on U.S. Department of Commerce physical market price and consumption data.

9 There are of course other indicators. For example, economic guru Geoffrey Moore has developed an inflation index employing industrial material prices, import prices, percent of purchasing managers reporting slower deliveries or higher prices, and total debt. See "Sentinel on the inflation watch," *Forbes*, September 12, 1994.

10 "Inflation Watch: Distant Early Warnings," *SmartMoney*, March 1994.

11 (See table at foot of this page)

12 In order to arrive at a justified weighting for the commodities in the basket the following method was employed. First, commodity prices were normalized to 1980 where 1980 prices = 100. Then these normalized prices were factored by how many 1980 1$ quantities were represented in the basket. A 1980 1$ quantity is equivalent to how much of a commodity could be purchased in 1980 for 1$. These values were then factored a second time for value added effect to the general population. This value was then factored by the population for a per capita based value. These values were then added to obtain the desired index.

13 Complete data is not available to calculate the "quenching" effect for 1994, but data from previous years undertaken in this analysis makes it clear that here would be a substantial effect.

14 The graph on page 33 illustrates the annual changes in the CRB's weighted price index for the commodities tracked in the traditional CRB, compared to the same basket of commodities this time using the weighted model developed for

## Commodities Purchased 1980-1991

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 255,435 | 267,467 | 229,032 | 222,559 | 222,932 | 215,484 | 172,003 | 193,281 | 190,504 | 215,921 | 247,209 | 226,339 |
| Soybean | 6,351 | 7,108 | 7,387 | 7,986 | 8,859 | 9,473 | 10,012 | 10,648 | 11,494 | 10,948 | 11,055 | 11,087 |
| Corn | 6,918 | 7,743 | 8,047 | 8,699 | 9,650 | 10,318 | 10,906 | 11,599 | 12,520 | 17,759 | 18,090 | 17,716 |
| wheat | 3,725 | 4,169 | 4,332 | 4,684 | 5,196 | 5,555 | 5,872 | 6,245 | 6,741 | 7,578 | 7,141 | 5,943 |
| Cotton | 2,312 | 2,587 | 2,689 | 2,907 | 3,225 | 3,448 | 3,644 | 3,876 | 4,184 | 3,877 | 4,992 | 4,908 |
| Cattle | 25,147 | 21,810 | 19,626 | 22,422 | 22,977 | 21,534 | 21,356 | 24,746 | 27,040 | 27,939 | 30,138 | 30,098 |
| Hogs | 3,769 | 4,750 | 4,274 | 4,883 | 3,334 | 4,058 | 3,640 | 4,687 | 4,134 | 3,680 | 4,256 | 4,654 |
| Pork B | 8,003 | 8,686 | 7,816 | 8,929 | 8,563 | 7,999 | 8,652 | 9,400 | 8,261 | 8,377 | 10,294 | 10,075 |
| Lumber | 6,003 | 4,687 | 2,082 | 2,607 | 3,141 | 2,539 | 3,811 | 5,315 | 5,804 | 7,589 | 7,616 | 6,765 |
| Sugar | 9,375 | 8,537 | 7,070 | 7,121 | 6,983 | 5,772 | 5,257 | 5,443 | 5,770 | 6,355 | 6,917 | 6,873 |
| Cocoa | 920 | 1,014 | 1,054 | 1,139 | 1,264 | 1,351 | 1,123 | 1,194 | 1,003 | 991 | 1,094 | 1,092 |
| Coffee | 16,594 | 13,513 | 6,264 | 8,188 | 7,569 | 6,229 | 8,077 | 6,302 | 7,021 | 7,474 | 7,479 | 6,831 |
| Copper | 2,667 | 1,224 | 1,272 | 1,375 | 1,525 | 1,631 | 3,515 | 3,739 | 4,035 | 4,324 | 4,311 | 3,931 |
| Gold | 594 | 579 | 601 | 650 | 721 | 771 | 2,658 | 2,826 | 3,051 | 3,269 | 3,650 | 3,386 |
| Platinum | 12 | 13 | 14 | 15 | 17 | 18 | 19 | 20 | 21 | 23 | 27 | 21 |
| Silver | 732 | 342 | 268 | 418 | 330 | 266 | 315 | 429 | 432 | 389 | 361 | 263 |
| Crude oil | 79,464 | 87,826 | 71,843 | 64,821 | 66,294 | 61,765 | 35,901 | 44,637 | 38,071 | 47,566 | 58,865 | 49,561 |
| Gasoline | 76,308 | 85,085 | 77,079 | 69,590 | 66,605 | 66,374 | 43,212 | 47,731 | 46,776 | 52,751 | 64,701 | 57,525 |
| Heating Oil | 6,541 | 7,794 | 7,314 | 6,124 | 6,680 | 6,384 | 4,035 | 4,445 | 4,148 | 5,033 | 6,222 | 5,609 |
| Electricity | 95,713 | 112,664 | 123,914 | 130,952 | 137,777 | 144,844 | 146,757 | 150,944 | 156,748 | 164,650 | 171,357 | 181,001 |
| Natural gas | 55,675 | 65,832 | 74,577 | 78,152 | 83,891 | 78,333 | 68,970 | 62,726 | 65,906 | 70,003 | 68,957 | 69,591 |

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*The National Fuel Supply Cooperative*

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<u>CERTIFICATE OF SERVICE</u>

I, hereby, certify that on this 25th day of February, 2002, I served one true and accurate copy of the foregoing Comments of the Center for Energy and Economic Development upon the following individuals by first-class mail, postage prepaid.

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