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June 27, 1996

VIA FEDERAL EXPRESS
Docket Control
Arizona Corporation Commission
1200 West Washington
Phoenix, Arizona 85007

Re: Docket No. U-0000-94-165

Dear Docket Control:

Enclosed for filing is an original and eleven (11) copies of the Comments of the Center for Energy and Economic Development ("CEED").

We have enclosed an additional copy to be "filed" stamped and returned to us in the self-addressed stamped envelope we have provided.

Thank You.

Sincerely,

Peter Glaser

Arizona Corporation Commission
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STATE OF ARIZONA

ARIZONA CORPORATION COMMISSION

Request for Comments on)
Electric Utility Restructuring) DOCKET NO. U-0000-94-165

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 Request for Comments on Electric Utility Restructuring issued by the Arizona Corporation Commission staff on February 22, 1996 and as modified on April 23, 1996.

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 staff's questions with respect to environmental quality in a restructured industry and efforts this Commission should make with respect to renewable resources.

II. Environmental Quality in a Restructured Industry

There is no reason environmental quality should or will suffer in a restructured industry and every reason to suppose that environmental quality will improve. Environmental quality will not suffer because the nation is governed by a stringent system of environmental laws and regulations which will, of course, continue to be in effect whether or not Arizona restructures the electric industry. Environmental quality will improve because the principal benefit of restructuring will be lower electric rates, which will increase the electrification of the American economy and reduce the emissions of pollutants into the air. We discuss both of these points in more detail below.

A. The Nation's Environmental Regulatory System Can and Should be Relied on by this Commission in a Restructured Electric Industry to Supply the Degree of Environmental Regulation Society Deems Necessary.

The cornerstone of national air quality policy is the National Ambient Air Quality Standards (NAAQS). Congress has directed the United States Environmental Policy 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 National Ambient Air Quality Standards 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, NO_2, carbon monoxide, suspended particulates, ozone and lead) are called "criteria" pollutants -- the name taken from the elaborate 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 detail, 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.

Congress has further controlled the emission of these pollutants, among other things, by requiring specific standards of performance for new stationary sources which apply to new utility power plants. 42 U.S.C. § 7411.

Pursuant to the Clean Air Act, state legislatures 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.

Any electric generating station in Arizona is required to obtain such an air quality permits. 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.

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 NO_2, an ozone precursor. The Act created a nationwide cap on emissions of sulfur dioxide. Any plant emitting sulfur dioxide must obtain emissions credits to assure that the nationwide cap cannot be violated. Retail competition, thus, cannot lead to an increase in sulfur dioxide emissions.

With respect to NO_2, 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 nonattainment -- 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 controlling interstate transport of ozone. 45 U.S.C. § 7511c. In addition to all of the above, Congress has established an Acid Rain NOx Emission Reduction Program from coal-fired electric utility units. 42 U.S.C. § 7651f.

USEPA has promulgated rules setting NOx emission limits for a large number of utility powerplant units, listed in 1990 by Congress at 42 U.S.C. § 7651c, Table A ("Phase I units"), and for certain other units which are dry bottom wall-fired and tangentially fired boilers ("Phase II, Group I"). 60 Fed. Reg. 18751 (Apr. 13, 1995). On January 19, 1996, USEPA proposed rules which would implement the second phase of the Acid Rain NOx

Reduction Program. 61 Fed. Reg. 1442-1480. In its January 19, 1996 proposed rule, USEPA states that it expects its April 13, 1995 regulation, by the year 2000, "to nationally reduce NOx emissions by an estimated 1.54 million tons per year." 61 Fed. Reg. 1442 (emphasis added).

In sum, the nation and Arizona already have in place a stringent system of air quality regulation which is designed to attain clean air throughout the nation. Under this system, no provider of electricity will be able to build new fossil generation unless the environmental regulators decree that the plant will operate in accordance with the nation's environmental laws. The Commission can and should rely on this system of environmental regulation as it determines whether and how to restructure the electric utility industry.

B. Low-Cost Electricity is the Best Environmental Policy.

The key environmental issue in connection with restructuring is likely to be the effect restructuring will have on air emissions. CEED strongly recommends that the Commission consider the impact restructuring will have on emissions both at the point where electricity is generated **and at the point where electricity is used**. Examining emissions only at the point of generation will yield incomplete and, we believe, inaccurate results as to the environmental impact of electric restructuring. Examining impacts on a "full fuel cycle" basis, in contrast, will lead to a more realistic assessment of those impacts.

In particular, the Commission must keep in mind that a key purpose of restructuring is to bring downward pressure on electric rates by increasing customer choice. Lower electric rates as a result of restructuring will likely result in increased consumption of electricity. Such increased electric consumption will lead to two impacts on air emissions. There will be increased emissions at the point where electricity is generated to the extent fossil-fueled generators supply all or part of the increased consumption. But there will also be a **reduction** in emissions at the point where electricity is used, as electricity is substituted for fossil fuels as an energy input in a variety of residential, commercial and manufacturing applications. The net effect will be a lowering of emissions.

An analysis of how electricity is used reveals why increased electric consumption will reduce emissions in Arizona. In the real world, 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 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.

The economic firm of Mills, McCarthy & Associates in its 1992 Report "Sustainable Development and Cheap Electricity" demonstrated that the key to reducing overall societal emissions is to maintain low electric prices. It found that policies that reduce electric prices will result in lower overall emissions. It concluded (pp. 1-2) as to CO_2 emissions, in results that apply equally to NO_x, SO_2 or any other kind of fossil fuel-related emission, that:

- 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 Mills, McCarthy 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.

The Mills, McCarthy report details a variety of uses of electrotechnologies in industrial and manufacturing processes that will result in increased efficiency and reduced emissions. A copy of the Mills, McCarthy report is 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.

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.

III. **Renewable Resources**

Staff inquires as to how restructuring can be devised so as to encourage renewable resources. The Commission needs to be careful, if it undertakes restructuring, not to undermine the main benefit of competition - low electric rates - with policies that increase rates because of a desire to subsidize renewable resources. CEED believes that, under any regulatory scenario, renewable resources are likely to play only a minor role in the nation's energy portfolio for the foreseeable future. The problem for renewable resources, and particularly solar resources, is that they are not economically competitive with traditional resources. In addition, it is unlikely, absent a major and unforeseen technological breakthrough, that renewables will ever be available as a significant source of baseload electric generation.

We attach a study by the firm of Resources Data International (RDI) entitled "Energy Choices in a Competitive Era", which points out some of the major difficulties of renewable generation. The RDI study makes the following key conclusions:

- Under current levels of tax incentives and regulatory support, renewable energy (excluding hydro technologies) is projected to grow from its current 2% of all U.S. electricity generation to 4% by 2010. <u>Such an increase in market share will occur at a cost of about $52 billion (in 1995 $) above today's competitive power alternatives.</u>

- With open and direct competition in electricity, generation from renewable energy could shrink to just 1% of U.S. electricity in 2010.

- Even with the imposition of exceptionally aggressive subsidies from public and private sectors, renewable energy would provide a maximum of just 11% of the nation's electricity by 2010. Such an ambitious increase would cost taxpayers, consumers and/or utilities about $203 billion (in 1995 $) in subsidies between now and 2010.

- All renewable resources have technological or logistical obstacles that limit their ability to produce and provide reliable electricity to the grid -- obstacles that cannot be overcome, even through the use of subsidies.

- Approximately 71% of non-hydro renewable generation serving the grid currently comes from combustion technologies -- not wind, solar or geothermal processes. <u>Outside California, nearly all existing renewable generation serving the grid comes from combustion technologies</u>.

- All electric generation technologies, including renewables, present adverse environmental impacts.

- Because renewables and natural gas occupy similar dispatch positions, gains in generation share by renewables will tend to displace growth in natural gas generation, and similarly, losses in renewables will tend to go to natural gas.

- Despite government incentives and private sector subsidies, renewable resources cannot replace fossil fuels in the nation's generation mix. <u>Coal will remain the baseload fuel of choice, supplying more than half of all electricity generation in 2010, even assuming aggressive subsidies for renewables</u>. (Emphasis in original.)

In sum, the prospects for renewables resources should not be a determining factor for the Commission as it decides whether and how to restructure the electric utility industry. At least for the foreseeable future, renewable resources will not represent a substantial part of the electricity generation mix no matter what action the Commission takes.

IV. Conclusion

As the Commission considers restructuring, it should not undertake policies that undermine the main benefit of increased competition - lower electric rates. The nation's environmental regulators should be relied on to supply the degree of desired environmental regulation; lower electric rates, in of itself, will increase environmental quality. In addition, the Commission should not undertake policies that increase rates in order to stimulate renewable resources.

Dated: June 27, 1996

SUSTAINABLE DEVELOPMENT
&
CHEAP ELECTRICITY

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

For:

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August 1992

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

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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.

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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.)

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SUSTAINABLE DEVELOPMENT & CHEAP ELECTRICITY

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 pre-occupations with electricity efficiency are economically counterproductive. 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.

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1 Calculation: approx. $5 trillion economy, 2.7 trillion kwhrs purchased @ avg. 7¢/kwhr. 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 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.

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,9 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 which focus first on economic growth while at the same time preserving the environment and 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.

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

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 is 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:

a) "How does one stimulate the economic growth associated with rising electricity consumption?"

And, secondarily, but importantly

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

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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

The answer to question b) is found later in this analysis. First we consider the answer to question a), since it is 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 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]

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"; 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 payers.

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 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.

The second statement is less well recognized. Yet, nearly six years ago the National Academy of Sciences 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 National Academy of Science's (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.

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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.

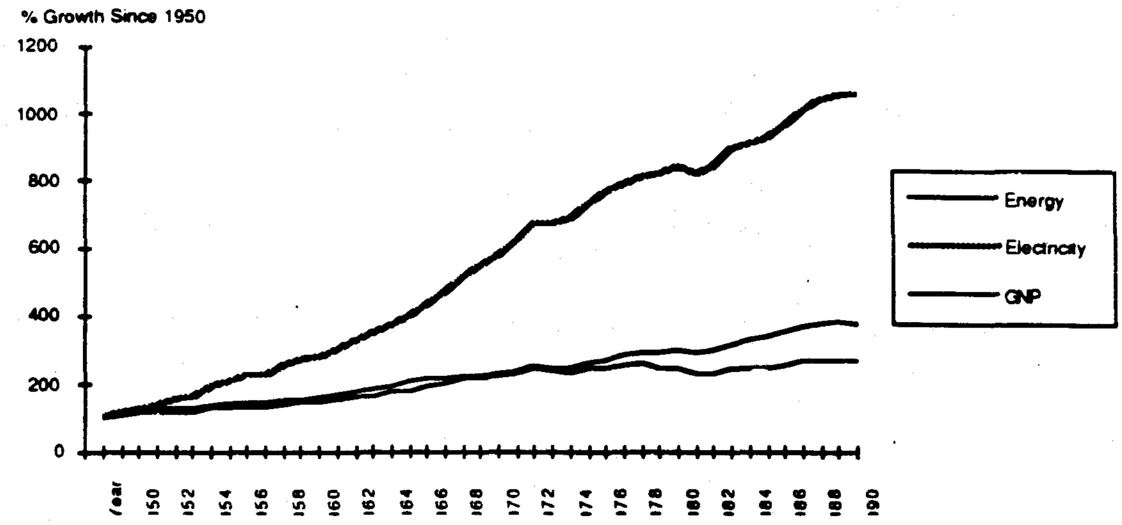
Because burning coal releases more carbon dioxide per unit of energy than does any other fuel, concerns over global warming make electricity consumption a prime target. According to many environmentalists, electricity growth must be slowed or stopped, else CO_2 emission will rise. The market must be 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 CO2 emissions? The answer is no, as we shall see in the following section.

§§§

Figure 1

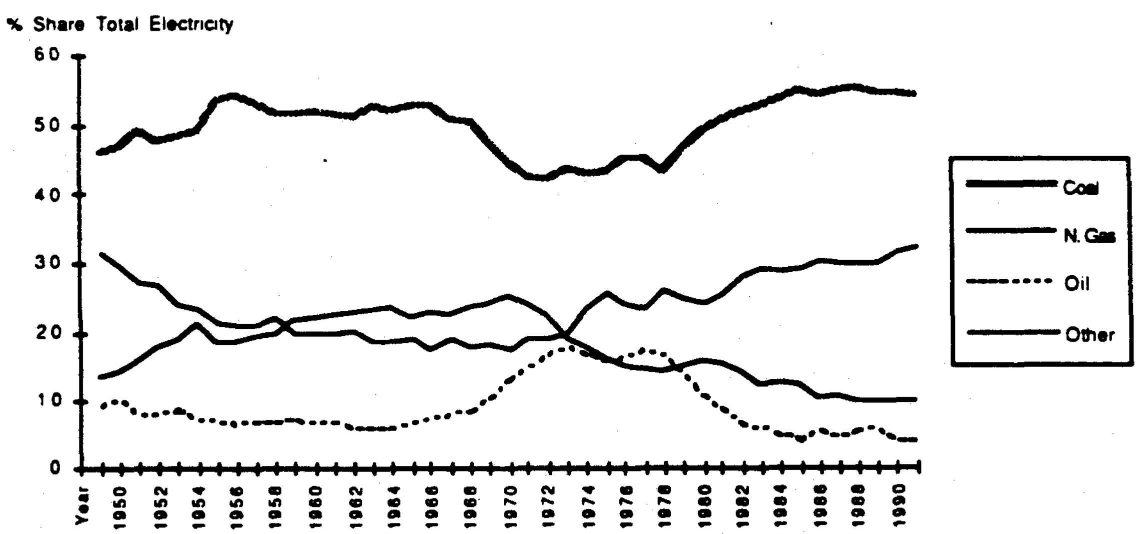
Energy, Electricity, and GNP Growth Since World War II([10])



GNP in constant $

Figure 2

Share of Total Electricity Generation([11])



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10 Data from Annual Energy Review, May 1991, Energy Information Administration.

11 Data from Annual Energy Review, May 1991, Energy Information Administration.

THE 20-YEAR TREND: COAL, ELECTRICITY, THE ECONOMY & CO2

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

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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.

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 its 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] Coal is also projected to be the source of at least 50% of all new electricity supply for the next two decades.[14]

Does rising electricity and coal use inevitably mean greater CO_2 emissions? Figure 4 suggest the answer is "no."

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.

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

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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 other all 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	1523
1991	1549	264	111	613	276	10.1	2823
1991-'70	+845	-109	-73	+591	+28	+9.1	+1291

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
1990	16.06	2.93	1.3	6.14	3.71	1523
2010	22.6	5.72	1.7	6.67	6.25	2823
2010-'90	+6.54	+2.8	+0.4	+0.5	+2.5	+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 CO2 emissions over the past 20 years.

use and decling CO_2/$GNP, summarized in Figure 5, is critical to considering future projections and policies.

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

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Figure 3

Electricity, Energy & GNP Growth

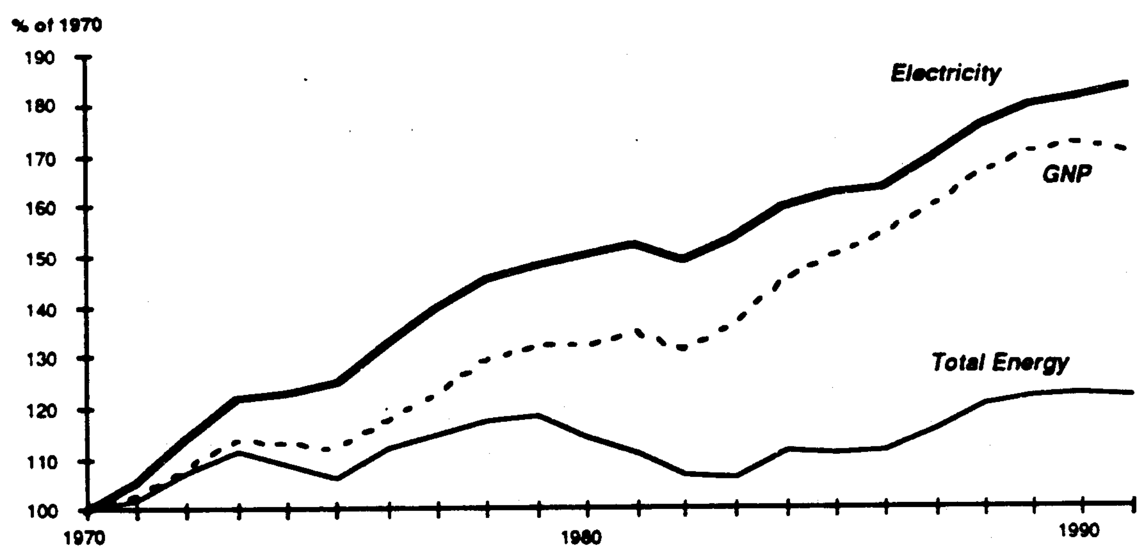


Figure 4

Coal Use, CO_2 Emissions, and CO_2 Efficiency

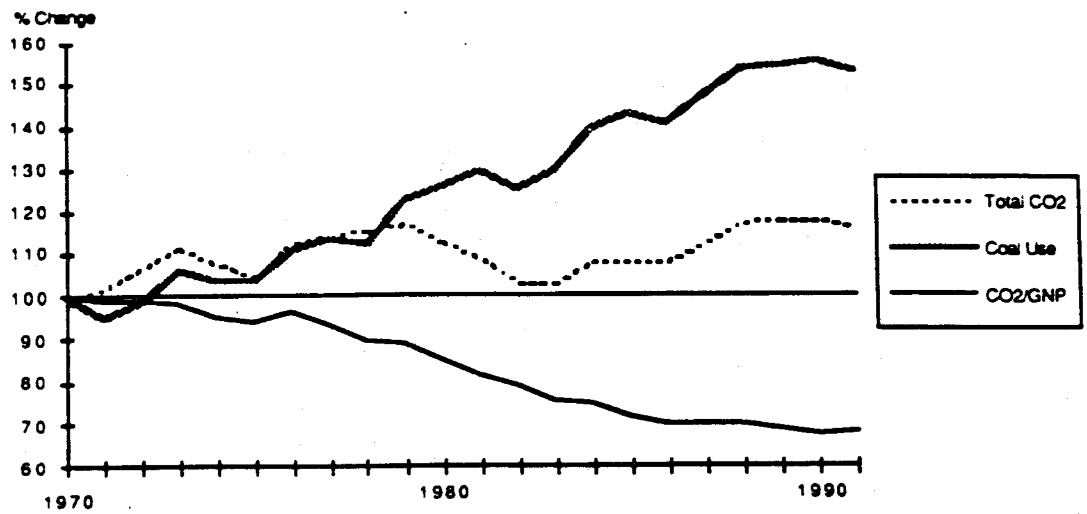
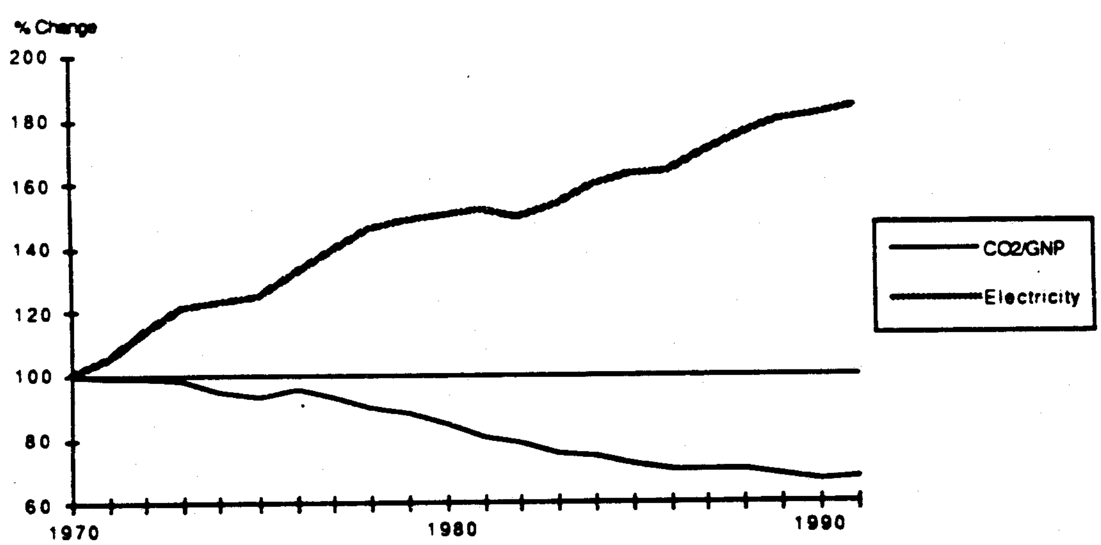


Figure 5

Electricity Consumption and CO_2 Efficiency



THE 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.

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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.

- 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.

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, ntaural 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 <u>dropped</u> 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.

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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 6

Fuel Use in the Industrial+Commercial+Industrial Sector

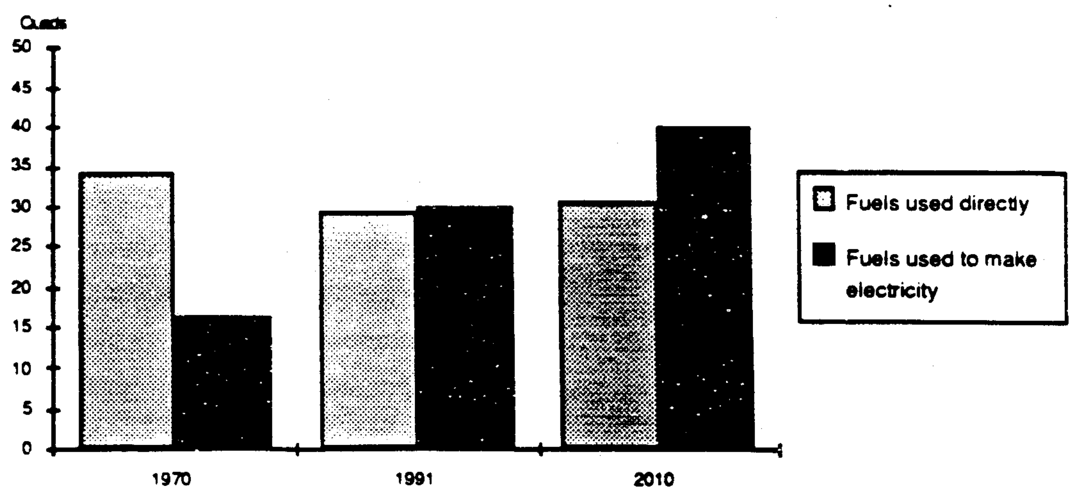


Figure 7

Trends in Industrial Sector Energy Consumption

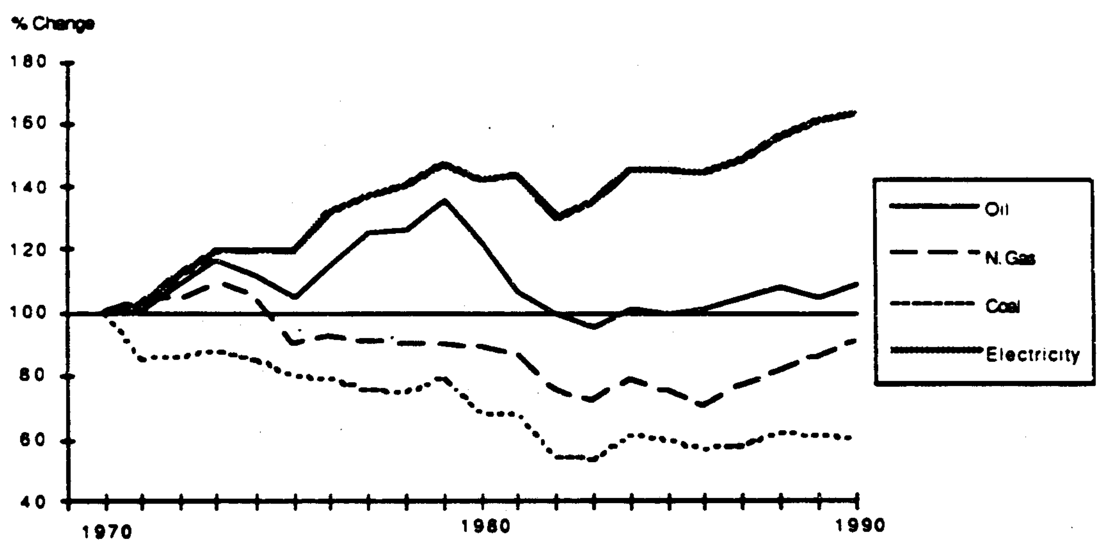
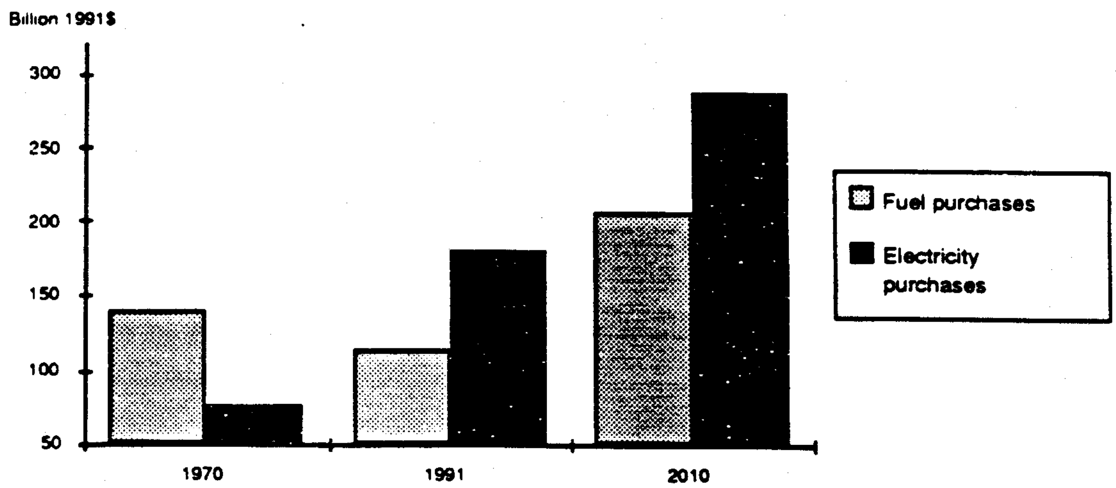


Figure 8

Fuel Purchases in the Industrial, Commercial, Residential Sectors



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. Yet, 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 <u>improve</u>, with a 23% energy/GNP ratio decline

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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 <u>Electric Power 1991: Projections Through 2010</u>, July 1991; base case projections through 2010.

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

In the next section of this report we consider the environmental aspects of development-oriented electricity pricing, specifically carbon dioxide 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 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 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]
(¢/kwhr)

	1990	2010
Capital	3.1	2.3
Operating & Maintenance	2.1	2.1
Fuel	1.8	2.9
Total	6.9	7.2

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 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

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 reason 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]

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

26 Electric Power 1991: Projections Through 2010, July 1991; base case projections through 2010: p. 13

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 accroding the The Wall Street Journal "stunning" (August 31, 1992) will continue to reinforce 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.

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 than 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 cost decline (as projected by EIA), along with no change in operation & 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
Operating & Maintenance	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

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.

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 straightforward 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 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 drive 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

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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 shakey 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.

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 price ratio of electricity to gas is about 3-to-1, simple electric resistance heating becomes economically competitive with gas heat.[36] 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 time as much heat as electricity consumed. Once consumers see increasing price advantage of electric heat, and come to believe that it will continue, the shift to electric heating will accelerate.[37]

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%.[38]
- Electricity holds 32% of the total residential energy market.
- 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

[36] The essential calculation here is not complex since it assumes roughly equal T&D costs, and thus assumes that once electricity is less than 1/3 the price in delivered BTU terms, the losses in electricity generation (about 3:1) make it cost-competitive at the end-use.

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

[38] 1992 Edition of the GRI Baseline Projection of U.S. Energy Supply and Demand to 2010, Gas Research Institute, April 1992, p. 26, 27.

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:

1) the average cost of electricity in 2010 resulting from all new supply being priced at no more than 5.5¢/kwhr
2) the elasticity of demand; i.e., how much more electricity will be consumed because of lower prices
3) the GNP/kwhr relationship; i.e., the effect on the GNP of increased overall use of electricity.[39]

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

1) 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[40] and price pressure from a low cost supplier (specifically coal) will

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[39] 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.

[40] 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. As 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.)

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 -- than the average cost of electricity from existing power plants would be expected to be lower in 2010 than it is today -- principally because of the declining cost of capital as the power plants age (amortize).

Table 4
Components of Electricity Prices from Existing Plants
(¢/kwhr)

	1990	EIA 2010[41]	Possible
Capital	3.1	2.3	2.3
Operating & Maintenance	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.[42] 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.[43]

2) 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.

EIA and others appear to take solace in providing tables illustrating that other organization's 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.

41 Electric Power 1991: Projections Through 2010, July 1991; base case through 2010: p. 13

42 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.

43 [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.]

There is an extensive body of research which has sought to accurately quantify demand elasticity of electricity.[44] 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*).[45]

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.[46]

3) 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.

Table 5
Ratio of Electricity/GNP Growth Rates[47]

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

44 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.

45 ibid a) p. 48, b) p. 361, 362.

46 Electric Power 1991: Projections Through 2010, July 1991; base case projection for 2010 of 4,117 billion kwhrs.

47 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.

Despite the history of stronger electricity/GNP connections, we use here instead a conservative linkage of 1.0, and assume further than current demand-side management programs are successful in weakening this linkage somewhat. Thus, 750 billion kwhrs of greater consumption would be associated with nearly $1 trillion greater GNP than currently projected for 2010 (in 1991$).[48] 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 electric cost drops 18% to 5.9¢/kwhr
  (arising from 5.5¢/kwhr benchmark for new supply)
- GNP grows
  + $1 trillion GNP over EIA base case
- Electric demand grows
  + 240 more power plants (@ 500 MW) over EIA base case of 300
- Total electricity purchases drop
  - $10 billion[49]

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48 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.

49 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 response to low cost marginal electricity prices of 5.5¢/kwhr.

Figure 9
Average National Electricity Price Trends

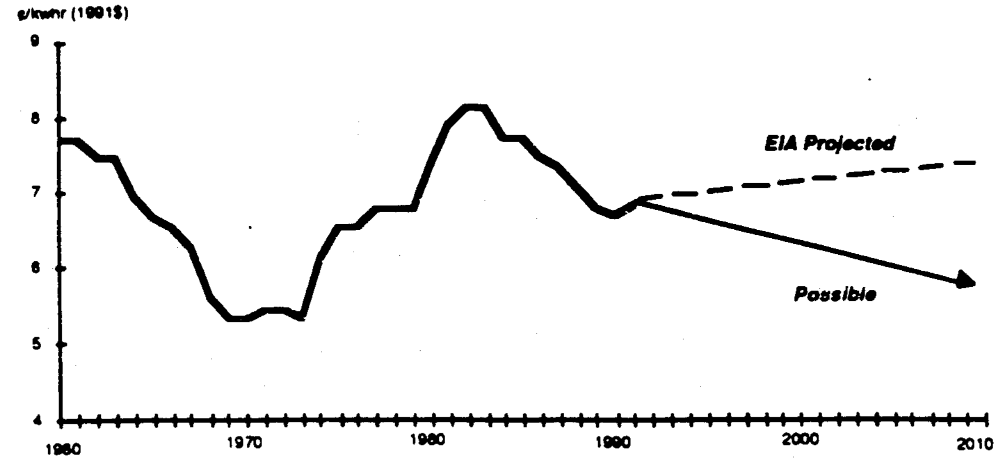


Figure 10
Industrial Sector Electric v. Gas Price Trend

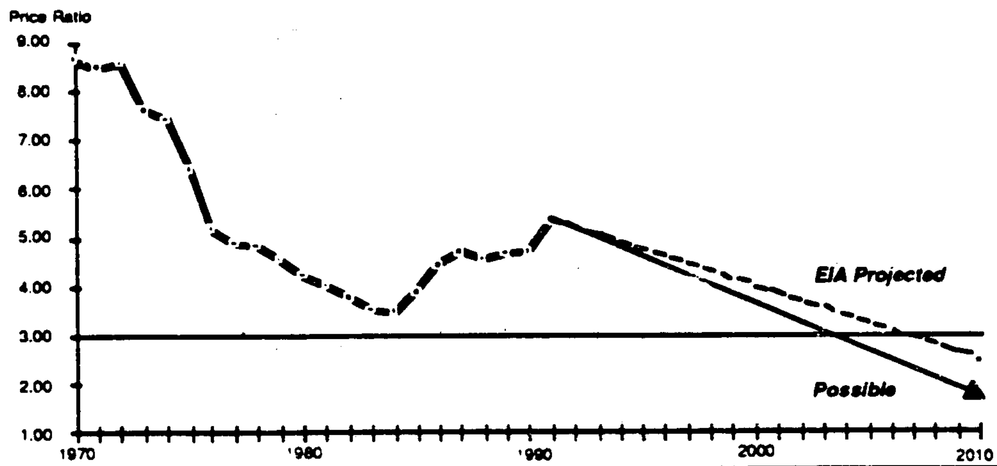
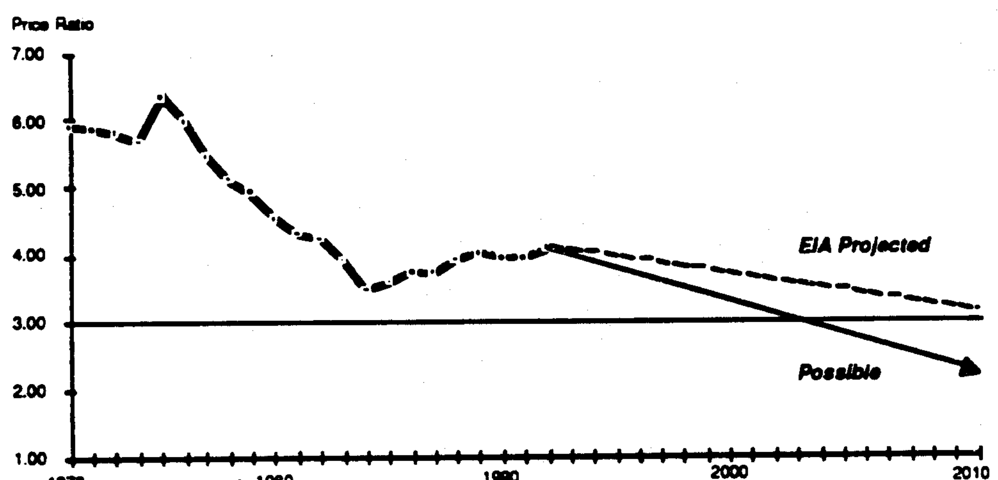


Figure 11
Residential Sector Electric v. Gas Price Trend



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.[50]

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)[51].

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 GNP
- Overall energy efficiency 23% better
- Growth in electricity demand requiring 300 power plants (@ 500 MW)
- Coal supplies 50% of new electricity demand

- CO2 emissions/GNP$ decline by 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?

50 Public Utilities Fortnightly, August 1, 1992, "Electric Sales Growth and the Conservation Ethic."

51 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.

According to the Electric Power Research Institute (EPRI), there are two powerful trends that will reduce CO_2 emissions over the next two decades.[52] 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 300 million tons/year. EPRI also estimates that increased use of electricity -- in their terms, "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 reduce 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 <u>improved</u> 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 (seeFigure 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

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52 <u>Saving Energy and Reducing CO2 with Electricity (Estimates of Potential)</u>, Electric Power Research Institute, CU-7440, September 1991.

documented.[53] 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, CO2 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 causal. Reduced CO2 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.[54]

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53 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 CO2 with Electricity (Estimates of Potential), Electric Power Research Institute, CU-7440, September 1991.

54 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 CO2. The increase in on-the-road fleet average fuel efficiency from about 14 mpg to over 21 mpg is responsible for reducing prospective CO2 emissions increases by about 400 million tons of CO2. (The calculation is performed by considering the additional fuel use and associated CO2 emissions if the 1990 fleet operated at the 1970 fuel efficiency.) Together, CAFE and nuclear power eliminated nearly 1 billion tons of CO2. If the U.S. economy operated in 1990 at the 1970 CO2 efficiency, there would be about 3.6 billion tons more CO2 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 CO2 emissions. Thus, electrification is held to be responsible for the remaining 2.6 billion tons of net CO2 reductions. Therefore, the 1.2 trillion kwhr growth in electric demand was associated with a 2.3 billion ton decline in CO2 emissions -- or about 3.6 lbs CO2/kwhr.

Figure 12
Electricity & Energy Efficiency Trends

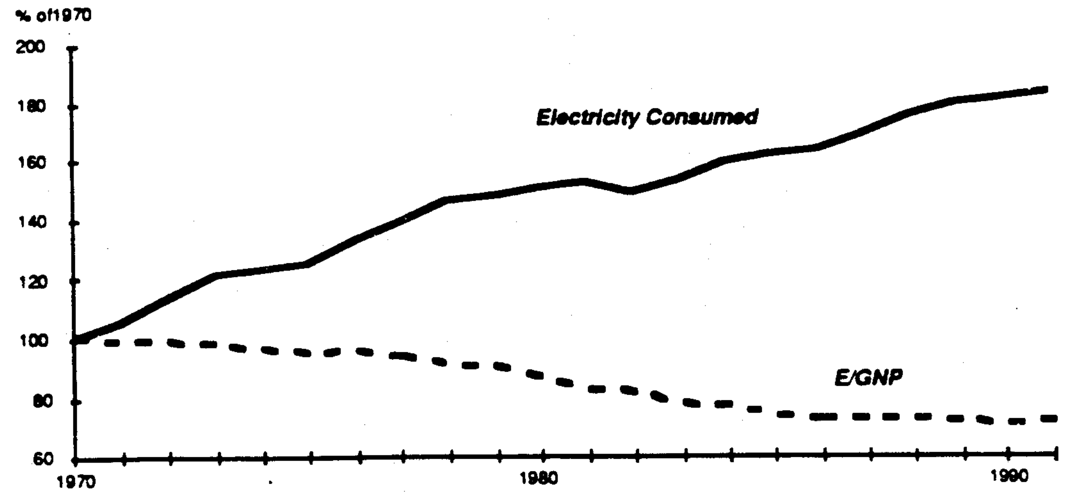


Figure 13
Marketplace Dependence on Fuels

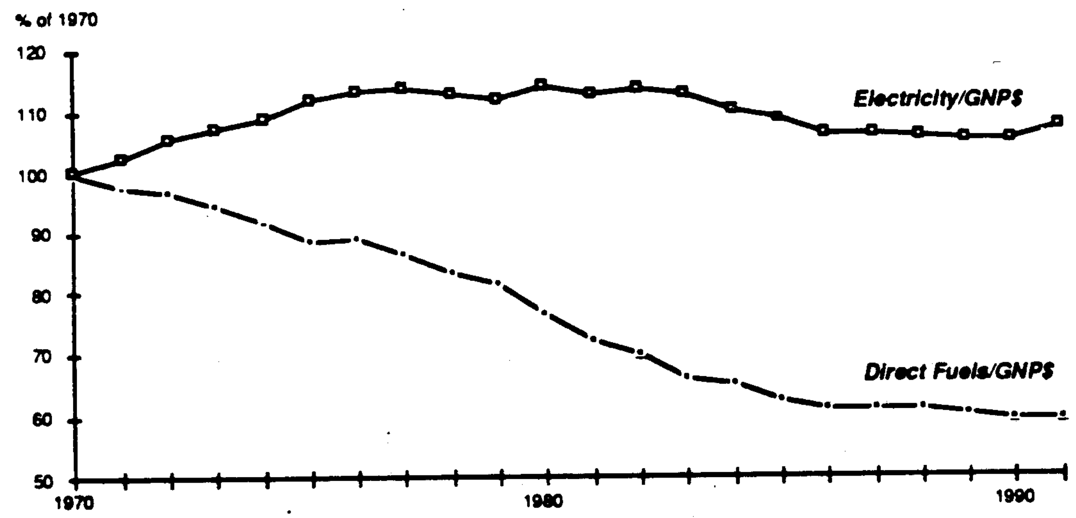


Figure 14
CO2 and CO2 Efficiency Trends[55]

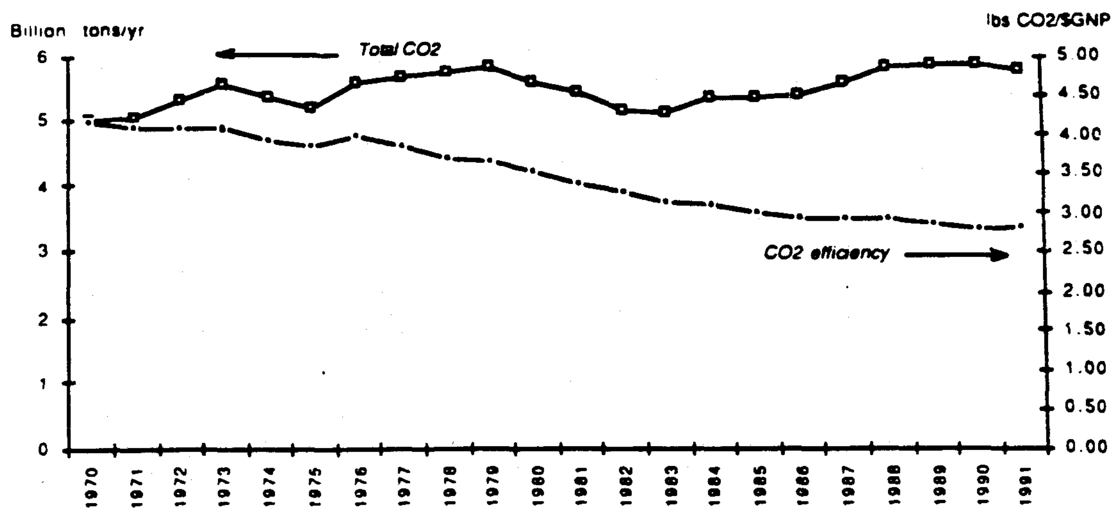
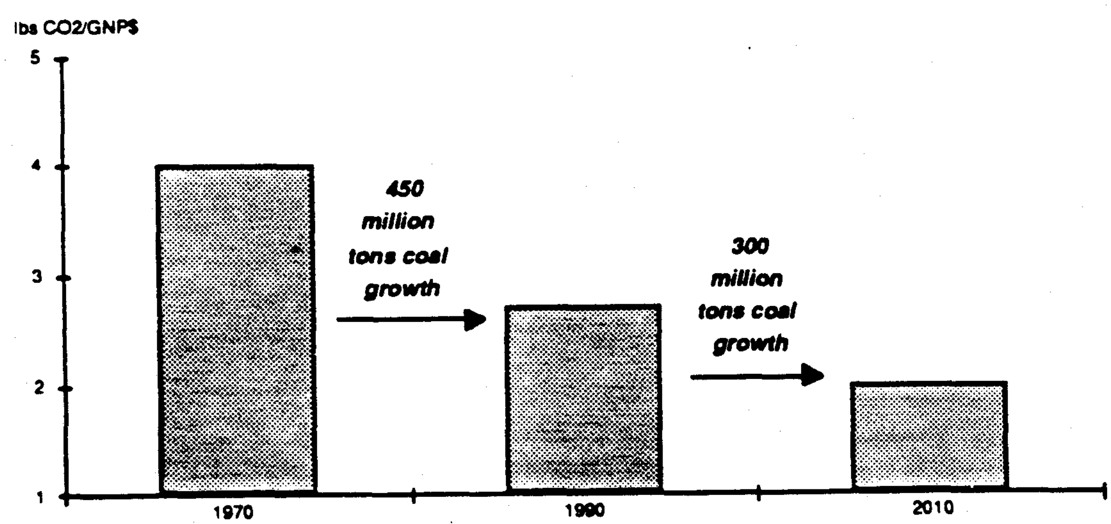


Figure 15
U.S. Carbon Dioxide Efficiency & Coal Use



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[55] Data from Monthly Energy Review, Energy Information Administration. Gross fuel consumption for each year used to determine annual CO2 emissions based on: coefficients for carbon dioxide 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

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 CO2 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 6 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.[56]

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.[57]

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

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[56] 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.

[57] The purpose of assuming that only coal is used for the required electricity is used 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 CO2 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 CO2 due to electrification.

- 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 situation. This phenomenon, which we term ecowatts in which economic and ecological benefits arise derive 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[58]

Activity	lbs CO_2 reduction/kwhr 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

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 macro analysis is consistent with an average of 2.5 lbs of CO_2 eliminated for every kwhr which can be derived from an EPRI evaluation of the future impact of 15 key residential, industrial and commercial electrotechnologies.[59]

[58] 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.

[59] Saving Energy and Reducing CO2 with Electricity (Estimates of Potential), Electric Power Research Institute, CU-7440, September 1991.

Table 9
National CO_2 Impact of Fuel Switching to Electrotechnologies[60]
YEAR 2010

End Use Technology	Increase Electricity Use (GWh)	Net Energy Savings (Quads)	Net CO2 Emission Reduction (Million tons)
Residential			
Heat Pumps	180,000	1.13	37
HP Water Htr.	86,000	0.69	27
Commercial			
Info 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 Htr.	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	0.04	7
UV/IR	14,000	0.14	6
Transportation			
Transit & Freight	24,000	0.12	10
Electric Vehicles	10,000	0.07	6
	------	----	---
Total	663,000	4.82-7.02	264-438

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, 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)[61]

> "Environmental externalities are a special class of externalities. Specifically, they are costs or benefits created by changes in the

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[60] ibid.

[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 12.

environment occasioned or exacerbated by decisions that do not take these costs or benefits into account."
(emphasis added)[62]

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.[63] 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 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.

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[62] 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.

[63] 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.

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 equip. costing $174,000
High-Freq. Resistance Welding of Tubes	Rejected tubes dropped from 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 costs, 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 equip.
Electric Fryers (commercial kitchens)	One-third the cooking energy, less waste heat in kitchen, 20% higher production capacity

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.[65] It makes no sense to suggest that utilities should be held accountable for some currently unregulated externality negatives at

[64] 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

[65] 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.

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 CO2 Impact of Increased Electrification of Selected Activities[66]

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, lawns and microwave garbage, UV drying inks on printing presses, 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 CO2/kwhr. EPRI data on 15 electrotechnologies provides for an average reduction of 2.5 lbs, and national trends over the past 20 years yield 3.6 lbs CO2/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

[66] 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.

revealed in EPRI projections. 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.[67]

(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 CO2 savingsof just below 1 billion tons/year.[68])

Table 12
Summary of the Impact of Lower Electricity Prices
(assumes 5.5¢/kwhr benchmark)

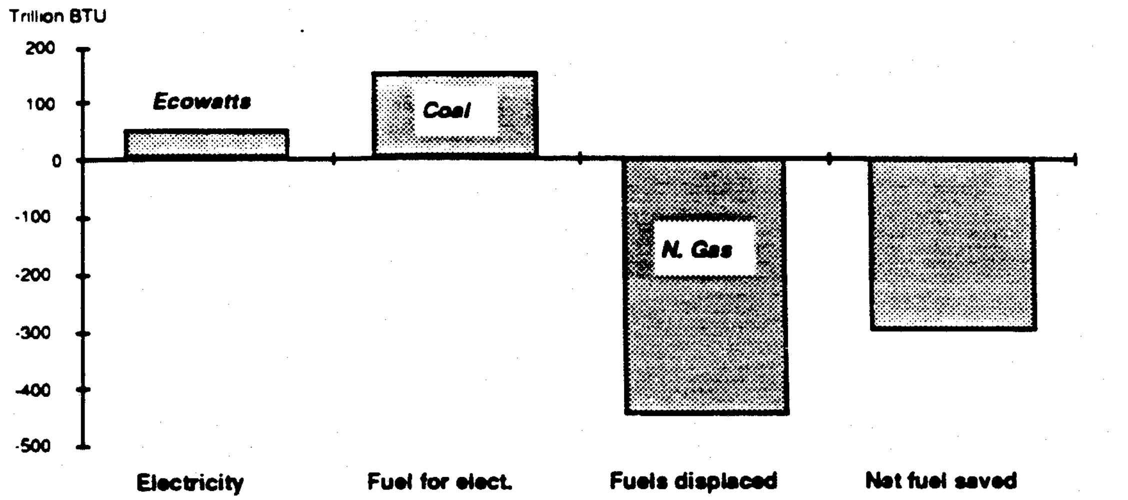
- GNP grows
  - + $1 trillion GNP over base case growth of $3 trillion
- Electric demand grows
  - + 240 more power plants (@ 500 MW) over EIA base case of 300
- Total CO_2 emissions drop 1.3 billion tons over EIA base case

§§§

[67] The average benefit is calculated earlier to be about 3.6 lbs CO2/kwhr

[68] The CO2 benefit assuming 100% coal-fired electricity on the margin is reduced to 2.6 lbs/kwhr.

Figure 16
Energy Implications of Increased Use of Five Industrial Electrotechnologies to AD 2000[69]



69 The 5 technologies evaluated in Figure 16 are: freeze concentration, industrial heat pumps, direct arc melting, plasma processing, and ultraviolet curing.

Does Price Matter ?

The Importance of Cheap Electricity for the Economy

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September 1994

Does Price Matter?

The Importance of Cheap Electricity
for the Economy

Executive Summary

Electricity is the single largest non-labor commodity input to the U.S. economy. Economic growth has been accompanied almost exclusively by increased use of electricity, not other energy forms or other commodities.

The current turmoil in the electric utility industry in which analysts and journalists talk increasingly of changes being brought about by "competition" begs a question. For what are businesses competing? The answer: to supply the large and growing market for electricity. The underlying driving force of competition is price. Regardless of the regulatory or legislative outcomes for utilities in the emerging competitive environment, issues surrounding the price of electricity will remain central. The reason that price matters to markets is that cheap electricity provides anti-inflationary pressure, accelerates the economy, boosts manufacturing productivity, improves job prospects and in general helps the economy more than any other single commodity.

The importance of the price of electricity is the central focus of this report for which the following two recommendations emerge:

A The 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 in favor in regulatory circles.

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

B The price of electricity should be explicitly included in the "basket" of commodities used to track and predict economic trends and in particular, inflation.

The defining facts contained in this report are:

The price of electricity is a more important economic factor than the price of oil.

- 90% of the U.S. Gross Domestic Product arises from the residential, commercial and industrial sectors which collectively use 99.9% of all electricity, and 34% of all oil.
- 10% of the economy arises from the transportation sector which uses 0.1% of all electricity, and 66% of all oil.

Cheap electricity is anti-inflationary, more so than cheap oil.

Analysts consider price changes in a basket of commodities as one of the critical leading indicators of inflation. Yet the traditional commodities basket does not include electricity despite an impending establishment of a formal commodities market for electricity. Each year, 300% more electricity is purchased than the second largest commodity, gasoline, and 600% more than the largest non-energy commodity, cattle. Including the price of electricity in the commodities "basket" provides a more realistic view of the basket as an inflationary indicator. Fractional changes in the basket's price index are watched closely for inflationary pressure. A two percentage point change in the commodity basket's price index would occur (with all other cost held constant) due to an increase in gasoline prices of about 30¢/gallon; or an increase in gold prices of about $300; an increase in soy of $2/bushel; or an increase of only 0.5¢/kWh.

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The price of electricity is trending rapidly down.

Competitive, resource, technology and market forces are all driving the price of electricity down more rapidly than conventional projections suggest. By 2010, the average cost of electricity is likely to be below 5¢ a kilowatt-hour compared to the conventional wisdom of over 7¢ (in 1994$).

Electrotechnologies play a central role in enhancing 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. Increased use of electrotechnologies is strongly correlated with increased productivity, more so than for any other fuel type or class of technologies. Electricity's share of manufacturing energy use grew nearly 20% compared to a 5% decline in natural gas share over the past decade.

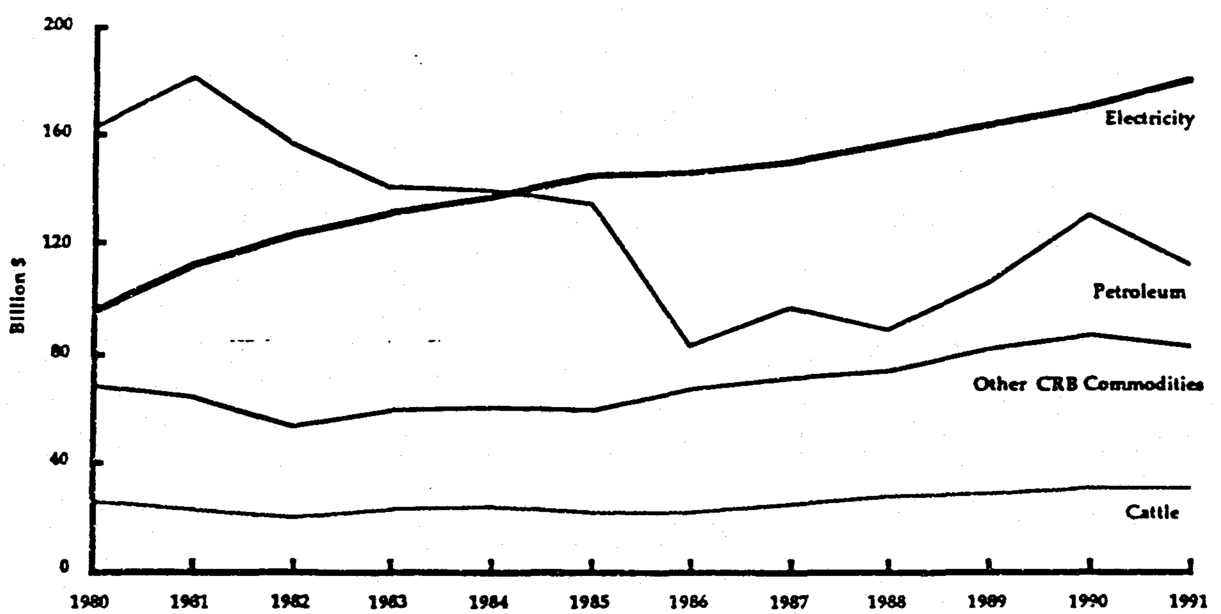
Consumers and businesses prefer cheap electricity.

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 ranking of states with the best and worst job prospects from Forbes magazine correlates strongly with the price of electricity. The 12 states with the lowest priced electricity include seven of the states with the best job prospects. Similarly the 12 states with the highest priced electricity include 11 of the states with the worst job prospects.

Cheap electricity is consistent with environmental and social goals

Energy efficiency and alternative energy programs, regardless of their other merits, should be held to a standard of declining electricity rates. In addition, declining rates stimulate greater use of electric technologies, which also typically reduce total fuel-cycle energy use and environmental emissions.

Total Purchases of Commodities



Petroleum 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.[1]

Introduction

"It's the economy...stupid"

Slogan from the 1992 Clinton/Gore campaign headquarters.

Brief:
The forces of competition and the economy's demand for electric technologies are increasingly at odds with traditional views of the electric sector and in particular with environmental programs which are intended to raise the cost of electricity.

The economy of the 21st century will be dominated by technological changes in the fields of biotechnology, information technology, and electric technology. Of these three broad areas of technological change, considerable attention has been afforded by the media and analysts to the first two. Substantially less analytic attention has been focused on electric technologies. A common view is that the electric revolution is one that took place during the first half of the 20th century, and is now over. That revolution which was stimulated by such electric technologies as motors, lights, air conditioners, and refrigerators has brought more profound changes to all aspects of modern life than any other single factor.

The rapid growth in the use of then new electric technologies brought about an attendant rapid growth in the generation and consumption of electricity – a ten-fold increase in the first 50 years of the 20th century. While it may be less obvious to casual observers, in part because of the impression that innovation in electric technology has largely ended, electricity consumption has continued and continues to grow at a pace which can only suggest that more electrotechnologies are being used every day. Demand for electricity has increased about 70% in the past two decades. A second electric revolution is underway, and while less visible to consumers, it is no less dramatic for its effect on manufacturing productivity. The revolutionary impact of electrotechnologies is in significant measure growing because of the natural integration with electronic control systems and information technologies.

This analysis is focused not so much on the technologies that use electricity and thus drive consumption trends, but on the importance and role of the price of electricity that fuels those technologies. In particular, this analysis is focused on the question:

"Does the price of a kilowatt-hour matter?"

The question is prompted by the existence and advancement of 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 cause electric rates to increase (not to mention such straightforward techniques as special fees and taxes). Initiatives have included subsidizing alternative energy and conservation programs. Relatively recently added to the portfolio of cost-increasing initiatives is the idea of externality "adders" wherein consumers are charged for emissions remaining after power plants have fully met state and federal regulations. These cost-increasing activities are in conflict with the forces driving electric prices down, especially technology progress and competition. A recent New York Times front page story is one of the early signs that the popular media, rather than those "in the trade" are beginning to pay serious attention to the impact of these competing forces.

"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.[2]

Wall Street activities provide ample evidence that tension exists between price-increasing and price-decreasing forces and that its consequences are considered serious regarding the viability of electric utilities. The first half of 1994 saw electric 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 in the battle for markets 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.[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 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]

While Wall Street worries about and reacts to the investment implications of these trends, as this report shows, the nation's economy and consumers in general, the fundamental overall impact of forces that exert a downward pressure on the price of electricity are good. A few analysts have taken note of this fact.

"Amid all the gloom, it is possible to lose sight of the fact that no one is forecasting a drop in electricity consumption. Wall Street sometimes becomes obsessed with one side of an investment story. When that happens, it is often wise to buck the consensus. Now appears to be such a time."

New York Times, Business, May 1994.[5]

This report describes an analysis intended to reveal the role of 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.[6]) This report does not evaluate the details nor take a position on the merits of proposals for retail wheeling. Instead, we explore the marketplace's powerful interest in low cost electricity that is the underlying driving force for such proposals and that will have a continuing effect on the utility business regardless of specific regulatory outcomes.[7] This report is organized in the following fashion.

1 Overall indicators of the role of electricity in economic growth.
2 Indicators of the role of electricity in manufacturing and competitiveness.
3 Indicators of the importance of the price of electricity.
4 Projections for the future price of electricity.
5 Implications of cheaper electricity.

Part 1 - Overall Indicators of Electricity's Role in the Economy

Brief:
Historic evidence shows that the consumption of electricity is strongly correlated with a growing economy, a trend that it is likely to continue. The strength of this linkage underscores the importance of the price of electricity.

As figure 1 shows, over the past two decades the consumption of electricity – not total energy – has grown nearly 70% in close conjunction with the growth in the economy (measured as Gross Domestic Product, GDP).

This increase cannot be accounted for simply by the expansion of the population or number of households associated with a somewhat greater use of existing electrotechnologies. The U.S. population has grown about 18%, and the total number of households about 40% over the same two-decade period.[8] Electric use has grown about 70%. Indeed, the demand associated with existing electric technologies (the ones which spawned the electric revolution of the first half of this century) would be expected to lag behind the simple growth in the use of those technologies because of normal continued improvements in electric efficiency of those devices and appliances.

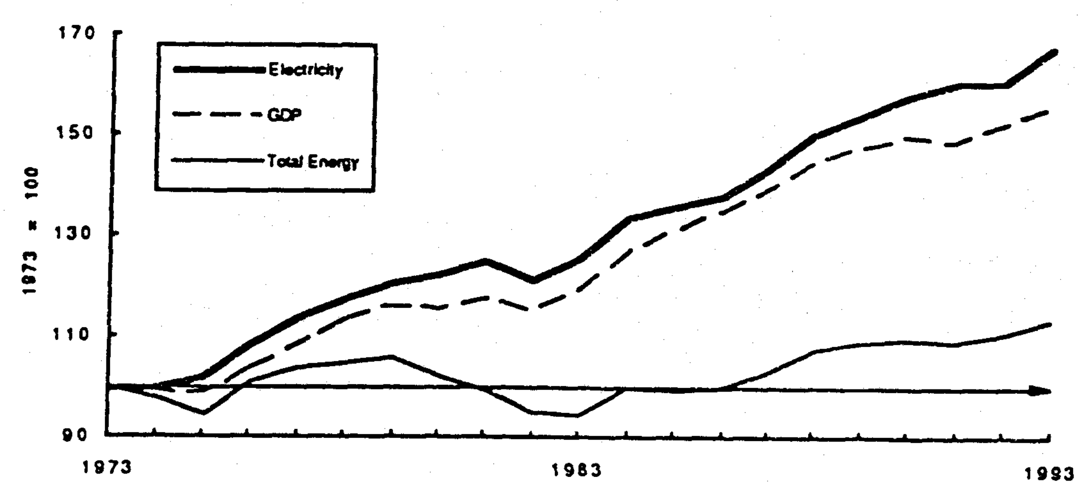
As a matter of historical fact, the use of electricity – which is fundamentally a surrogate measure of the increased use of electrotechnologies – has grown with and synergistically fed the growth in the economy and importantly, the growth in industrial output. Total industrial output grew 77% between 1973 and 1993. This has lead to a profoundly important transition. The components of the marketplace that use electricity – i.e., all parts excluding transportation, which is to say the industrial, commercial and residential sectors – now use more energy in the form of electricity than in the form of direct combustible fuels.

This transition to an electricity-dominated economy means that the supply, reliability and price of electricity as an input to the economy are now more important than at any previous time.

A more accurate picture of the role of electric technologies in the market place is seen when fuel used in transportation is excluded. At the national level, historic trends in transportation technology and fuel use have virtually nothing to do with the electric sector.[9] Only 0.1% of all transportation energy is in the form of electricity.[10] Over 97% of all transportation energy is in the form of oil.

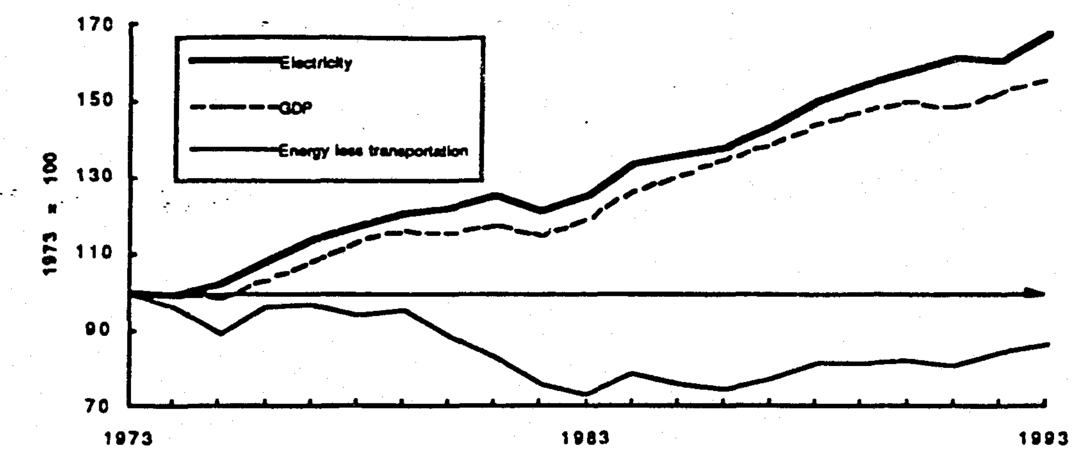
Thus, including the use of transportation energy in trends will serve to hide what is really happening in the parts of the economy where electricity is actually used. In addition, while the transportation sector supports most aspects of the economy in some fashion, it represents less than 10% of the GDP.[11] Primary economic issues are associated with the non-transportation part of the economy, the part of the economy that uses electricity.

Figure 1 U.S. Trends: 1973 - 1993



Data from DOE/EIA Annual Energy Review, June 1993

Figure 2 U.S. Trends Excluding Transportation: 1973 - 1993



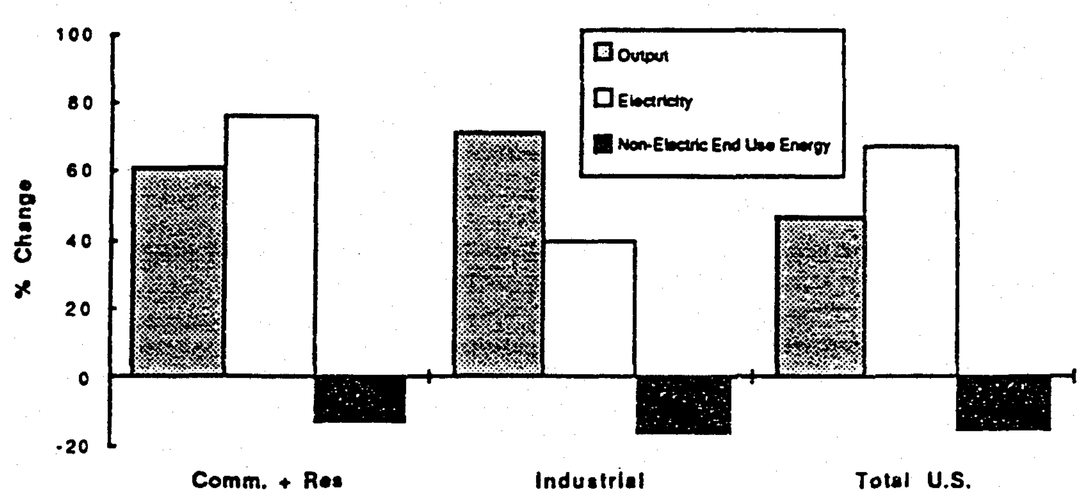
Data from DOE/EIA Annual Energy Review, June 1993

As shown in figure 2, between 1973 and 1993, the marketplace consumption of combustible fuels (*excluding* those used in transportation) declined by 12%. 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.[13]

Figure 2 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.[14]

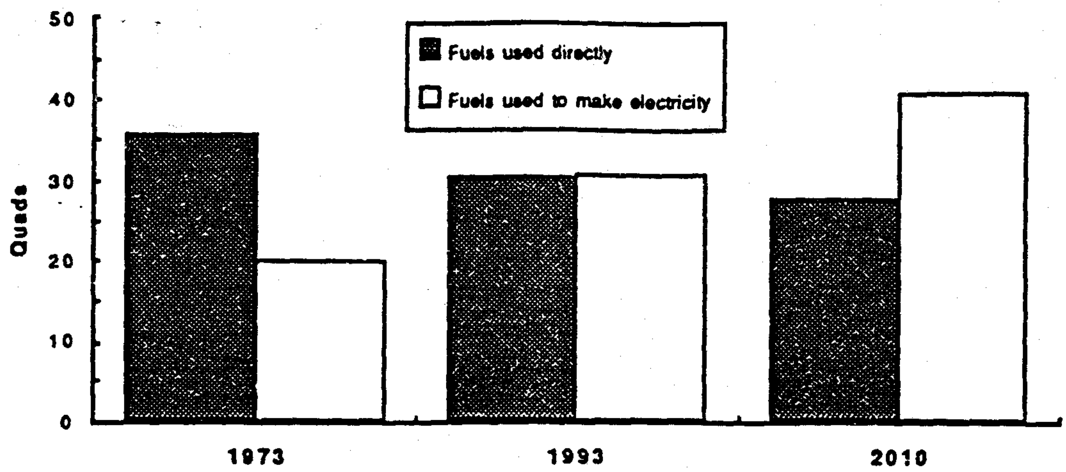
These trends can be summarized in a different way, as shown in figure 3. Growth in the economy and the industrial, commercial and residential activities has been primarily supported by growth in the use of electricity since there has been an actual decline in the direct use of combustible fuels. The commercial and residential parts of the economy have grown 60% since 1973: electricity use is up almost 80% and direct combustible fuel use down 15%. The industrial sector has grown 70% since 1973 with an associated 45% growth in electricity use and 12% decline in direct combustible fuel use.[15]

Figure 3 Changes in the Economy vs Consumption of Fuels & Electricity 1973 - 1993



Data from Statistical Abstract of the United States, ...[12]

Figure 4 Industrial+Commercial+Residential Sector Fuel Use



Data from DOE/EIA Annual Energy Review, June 1993; DOE/EIA Annual Energy Outlook 1994, Jan. 1994

The historical data unequivocally show that electricity has been displacing the use of fuels in the market place. Since electricity growth is a surrogate measure of the increased market use of electrotechnologies, this points to the importance of identifying and understanding those technologies -- and to the importance of the price of electricity which drives those technologies.

The sectors driving the economy -- the industrial, commercial, and residential (ICR) sectors -- have evolved from a primary dependence on combustible fuels to a primary dependence on energy in the form of electricity (see figure 4). The ICR sectors now consume 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] In 1993, over 53% of all the primary energy consumed by the ICR sectors was used first by utilities to generate electricity.

The transition to an electricity-dominated economy is expected to continue and accelerate. According to the Energy Information Administration (EIA), by 2010 nearly 60% 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 1973 only 32% of all ICR sector energy consumption was in the form of electricity. This transition demonstrates the increasing importance of the availability and price of electricity as an input to the economy.

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 80% 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.[19]

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]
*-- 80% of non-transportation energy growth is for electricity

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 shows current conventional wisdom for the future).

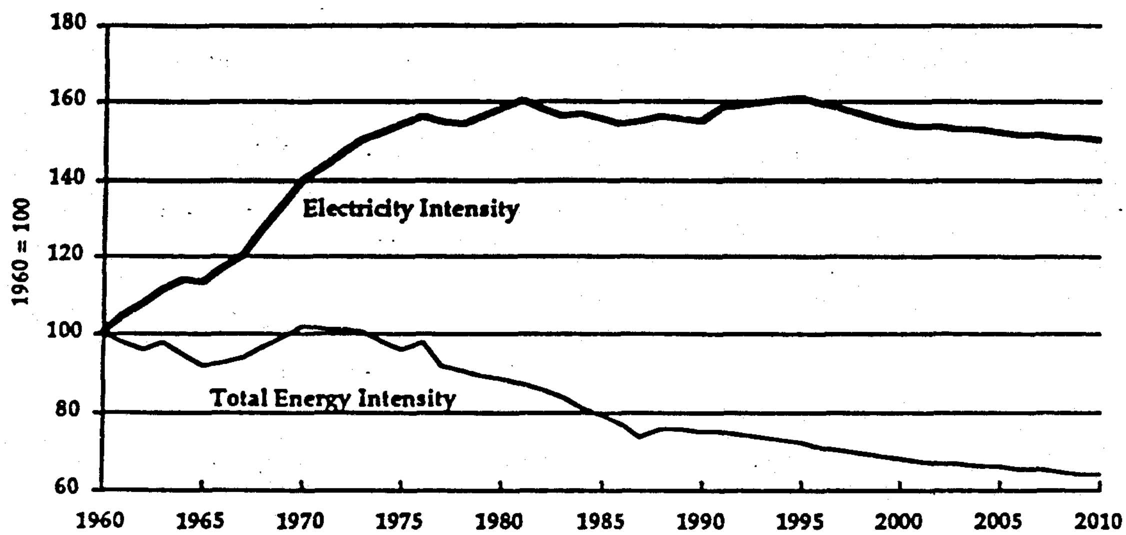
The total energy required to support a dollar of GDP has been dropping as is projected to continue to drop. The economy is becoming more energy efficient, and thus increasingly less dependent on the cost of fuel as an input. At the same time, the economy has become more dependent on electricity in terms of kwhrs consumed per dollar of GDP. This means that the cost of electricity as an input has become increasingly important over the past several decades.[20]

The bottom line:
All of the evidence summarized in this section pertaining to the importance of electricity, and thus the price of electricity, can be summarized in one over-riding set of data:

- 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.[21]

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. The activities associated with industrial, commercial and residential sectors form the major share of the economy and are clearly more dependent on electricity as an input than they are on oil. Given this reality, one can only conclude that the preoccupation with the price of oil as an economic indicator, and the virtual blindness to electricity's price is a carry-over from decades ago when oil was in fact a larger determinant, and electricity much less significant.

Figure 5 **Total Energy and Electricity Intensity per $GDP**



Data From EEI Electricity Futures Project

Part 2 - Electricity, Productivity & Competitiveness

Brief:
Technologies that use electricity — electrotechnologies — are the dominant form of new and emerging technologies that are driving a continuing growth in U.S. manufacturing productivity.

Productivity growth has always been a primary determinant of economic health. With improvements in productivity, unit costs of products can decline even as wages and benefits increase. This combination of outcomes allows people to 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 improvements in productivity.

Numerous factors, among them organizational changes, positively impact productivity. Nonetheless, the use of new technologies is one of the most important, and may in fact be <u>the</u> most important factor driving improvements in productivity. 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 Admin. technology & economic plan[22]

Economists typically measure technology progress in the form of investment in new machinery and equipment. Studies consistently show that machinery and equipment investment has a strong association with economic growth. Lawrence Summers and a colleague found in a recent analysis that between 1960-1985, 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 factors showed as strong an association with economic growth.[23]

The relevant issue for this analysis is the extent of the role of <u>electric</u> technologies in equipment investment, and therefore electricity and its price. In what remains one of the most comprehensive explorations to date of the role of electricity in the economy, the National Academy of Sciences (NAS) reached the following principal conclusion.

> *"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, <u>promote the implementation of electric technologies</u> when they are economically justified, and seek to <u>lower the real costs of electricity</u> supply by removing any regulatory impediments and developing promising technologies to provide electricity. [emphasis added]*[24]

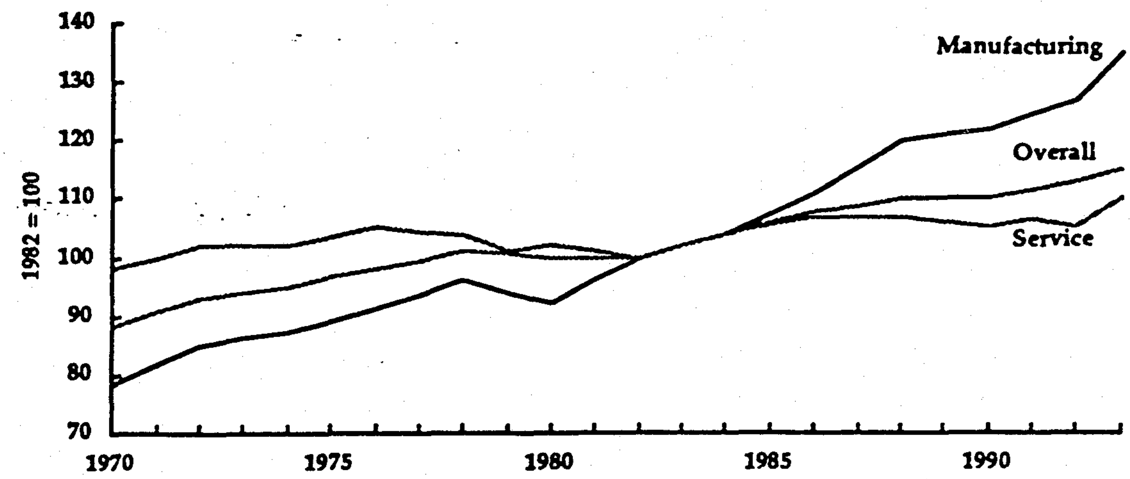
In previous studies we have focused on the structural and mechanical reasons that particular electrotechnologies yield such clear benefits that the NAS so strongly and clearly recommended a "promotion" of electric technologies.[25] In this analysis, we are focused on the NAS recommendation that productivity can be accelerated by policies seeking to *lower the cost* of electricity. It is a simple economic maxim that reducing the price of a commodity will lead to increased consumption. The increased use of electricity is almost exclusively associated with increased use of electricity-consuming equipment.[26]

Since declining electric rates will stimulate increased use of electrotechnologies, it will also increase modernization — wherein technical progress is invariably productivity-enhancing over time. The National Academy of Sciences 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 electricity stimulates productivity growth in 23 of the 35 industries and dampens productivity growth in only 12.[27] These two findings are causally linked since electricity is only useful as a means to operate the productivity enhancing equipment.

Other analyses have reached the same conclusion about these linkages.

> *"...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."*[28]

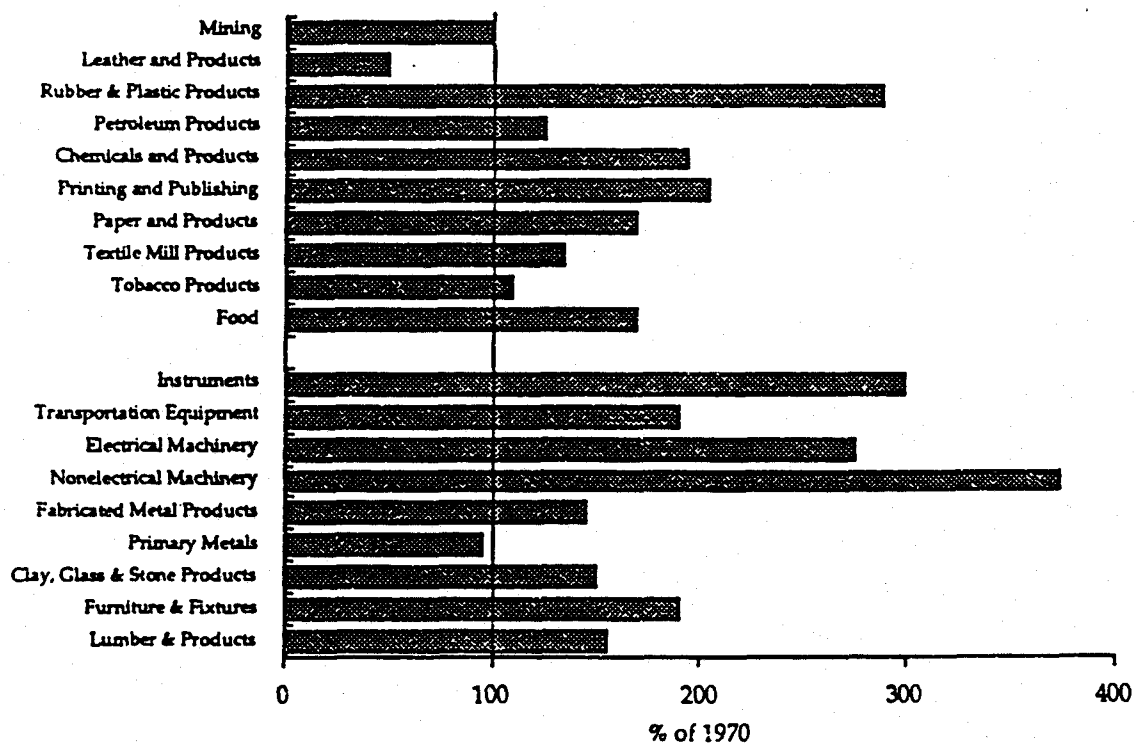
Figure 6 Productivity Growth



Source: Fortune

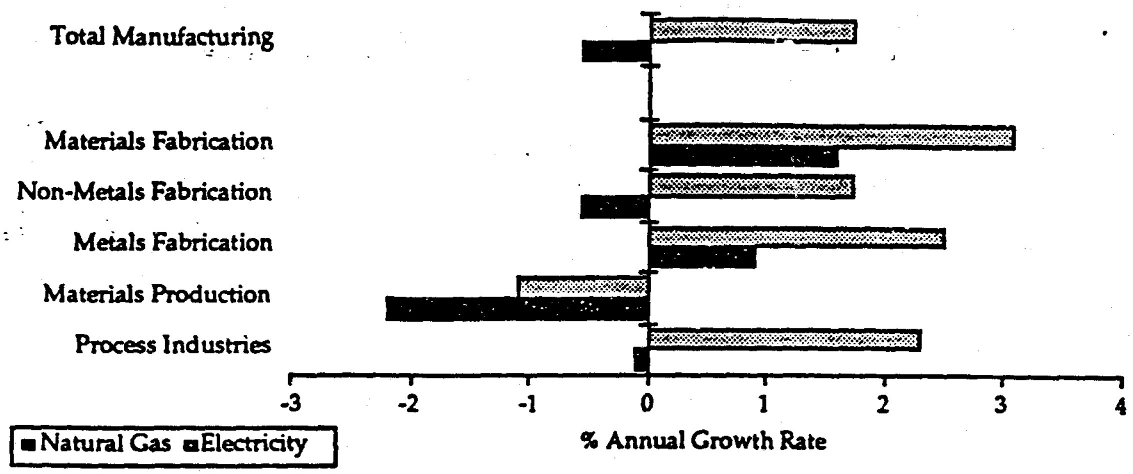
Far from being solely of historical interest, the importance of new equipment's role in productivity is, if anything, becoming more important. The current economic expansion is concentrated more heavily in equipment investments than any other economic recovery in recent history. Equipment purchases have accounted for over 30% of the economic growth in this recovery compared to a more usual 10% to 15%. Not surprisingly then, 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 the labor hours.[29] The combined effect of economic growth coming from increased productivity and no significant growth in labor hours is strongly anti-inflationary.

Figure 7 Changes in Manufacturing Output 1970 - 1990



Data from Statistical Abstract, table 1252; adjusted for inflation

Figure 8 Annual Growth Rates in Manufacturing Fuel Use 1980 - 1990



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

There is ample anecdotal evidence that manufacturing firms feel more competitive, too. One national survey of manufacturing firms found:

> *"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."*[30]

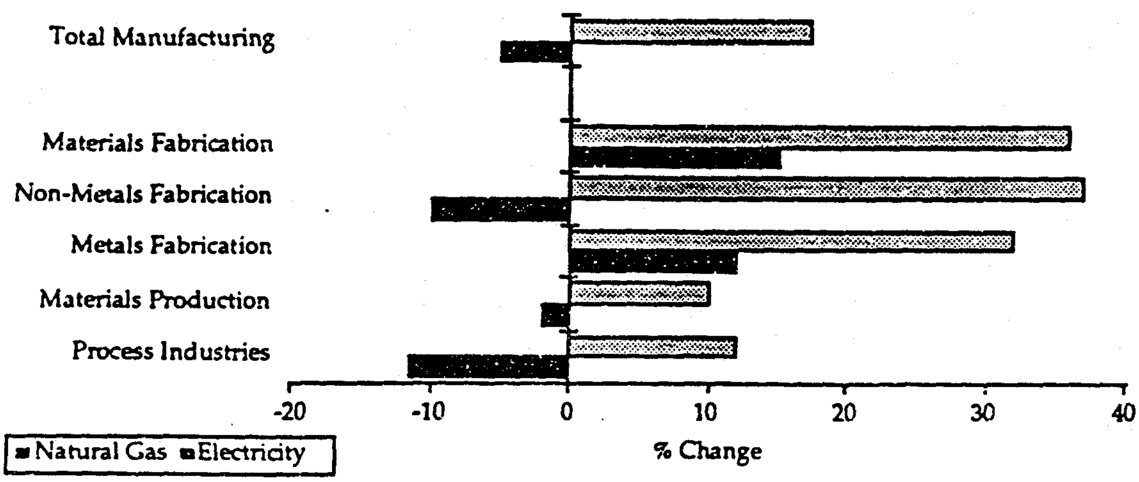
In what amounts to a stealth revolution, manufacturing productivity growth has taken off over the past decade as businesses have adapted to new technologies (see figure 6).

Most analysts have focused on the widespread adoption of information technologies as presages of productivity growth. In manufacturing, it is the flexibility, speed of response, and natural adaptation to and use of microprocessors that biases new manufacturing processing towards an integration of electric and information technologies.[31]

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).

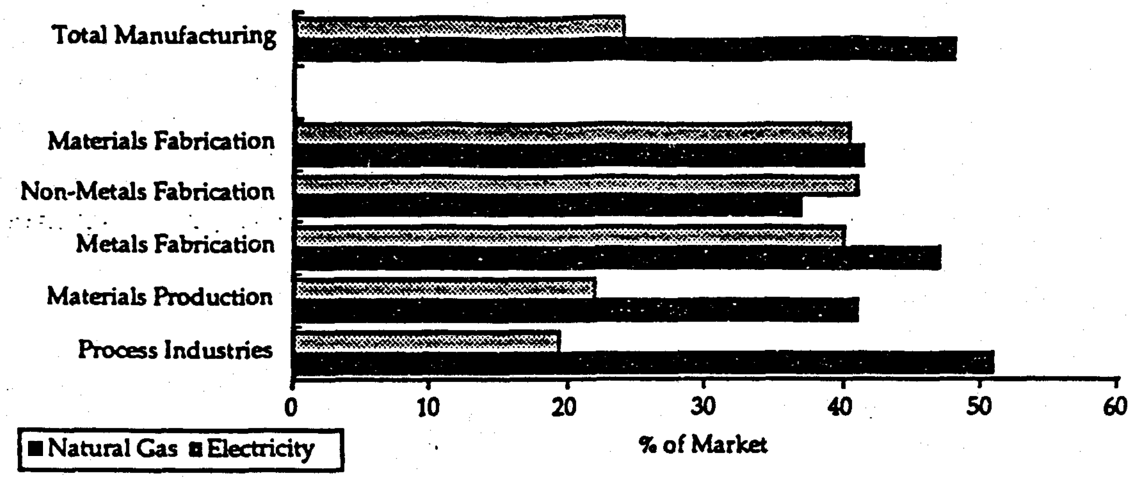
There are two ways to directly observe the increased use of productive technologies attributable principally to electrotechnologies. One is to identify and itemize specific technologies. Some work has been undertaken in this direction.[32] The second is to document the relative share of electric and natural gas use in various industries, since the fuel use is largely a surrogate measure of the choice of equipment.

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



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

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



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

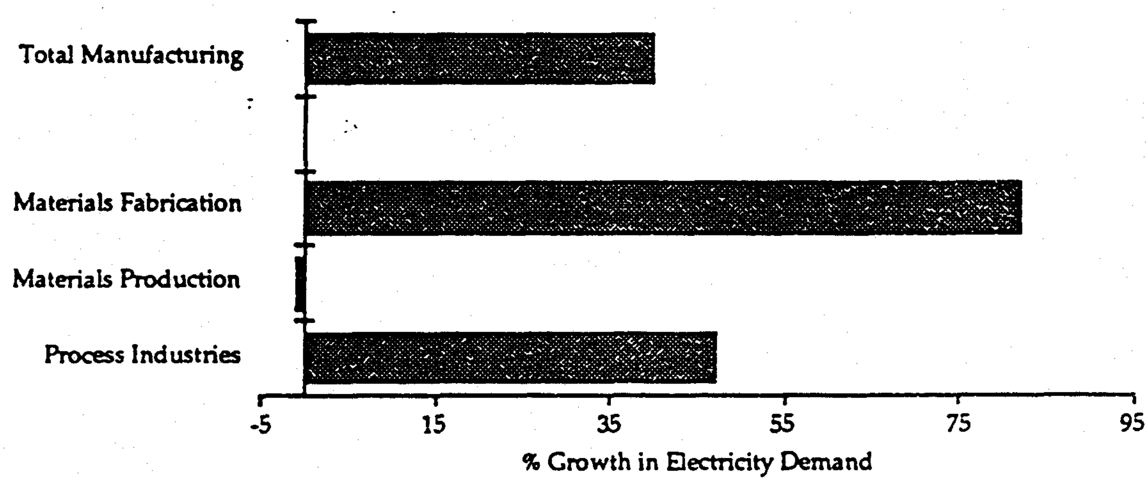
The use of electricity in manufacturing has been growing at nearly 2 percent per year, while the use of natural gas has been declining by about 1 percent per year since 1980. Figure 8 shows that the disparity holds across the various types of manufacturing. Even where natural gas use has been increasing, such as in materials fabrication, the use of electricity has been growing twice as fast.[33]

Figure 9 illustrates the inevitable result of the rising electric use in conjunction with declining fuel-combustion use in manufacturing. In the decade 1980 - 1990, electricity increased its marketshare in manufacturing by 20 percent, while natural gas declined overall by nearly 5 percent. Again, even where natural gas gained market share in a specific manufacturing sector such as metal fabrication, electricity gained an even greater share. This result arises from marketplace choices in the types of equipment purchased and used.

Despite the clear preference of the manufacturing sector for electricity in terms of the changes in market share, natural gas is still the dominant fuel used in manufacturing. As shown in figure 10, natural gas has 48% of total manufacturing fuel use compared to electricity's 24%. This suggests that there remains significant opportunities for investment in new electric technologies, and in all likelihood, 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 are the most unelectrified, with over 50% of market share taken by natural gas, and electricity capturing under 20%. Process industries account for 61% of

Figure 11 Projected Growth in Manufacturing Electricity Consumption by 2010



Data from Electrotechnology Reference Guide, EPRI TR-101021, table 3-2 manufacturing sector energy consumption.[34] Electricity is gaining ground in that sector, with significant implications for electric demand and fuel competition.[35] Electric price is a more important determinant in process industries than in the other manufacturing sectors.

It is not only the absolute increase in the use of electricity, but the increased share of electricity that points to a growing electrotechnology dominance in manufacturing. Sectoral shifts or overall equipment efficiency improvements may mitigate electric consumption growth, but cannot not 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 provides insight as to the importance of electrotechnologies to businesses.[36] Detailed survey responses from 335 firms provided the KSU researchers with a statistically valid sampling of the state's manufacturing activities. The study found about 40% of Kansas manufacturers use some type of electrotechnology and a "high percentage" were interested in learning more about electrotechnologies.

This transition towards an increasingly electricity-dominated manufacturing sector contains a number of important implications. With increasing electrification, marketplace activities:

- Become less dependent on raw resources; electricity can be generated with a very broad variety of fuels.
- 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.
- Achieve greater flexibility in adopting new technologies because of the inherent flexibility of electricity.
- Enjoy various environmental benefits due to the low or zero impact of electric-based technologies – in effect, environmental issues a: : 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 a central location.

Other analyses have documented the energy efficiency and environmental improvements associated with increased use of electrotechnologies.[37]

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

> *"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."*[38]

There are hundreds of electrotechnologies.[39] The types of benefits arising from some representative electrotechnologies are summarized briefly in table 2. And an analysis of patent data suggests that a large share, probably over 40%, of all future manufacturing innovation is associated with emerging electrotechnologies.[40]

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[41]
Asphalt recycling, microwave	Saves Los Angeles over $1.5 million/year[42]
Clothes drying, microwave	Substantially lower operating cost than conventional clothes drying[43]
Commercial dishwashing, ultrasonic	Eliminated heating 500,000 gallons of pre-rinse water[44]
Cooling tower ozonation	Operating costs were reduced by almost $90,000/year[45]
Copper processing, electrowinning	Costs are 39% lower when compared to conventional methods[46]
Corona discharge	Lower cost to treat 3000 CFM air with <100 ppmv VOC[47]
Dairy processing, freeze concentration	A typical dairy can save $100,000 annually using freeze concentration[48]
Deburring, electrochemical machining	Production rates have resulted in annual savings of $90,500[49]
Electrical discharge machining	Scrap rate for dies reduced from 10-20% down to 5%[50]
Electrochemical machining	Rejected pieces dropped from 1% to 0% saving $16,000/yr on equipment[51]
Electromagnetic forming	Rejection rate dropped from 10% down to 2%[52]
Electroreactivated carbon	Eliminates trucking of spent carbon to reactivation site[53]
Hardening, flux field concentrator	Energy savings of 42% due to flux field concentrator[54]
Label curing, ultraviolet	Several thousand ft of stock saved per day and varnish cost dropped 3-fold[55]
Laser cutting systems	Total cost per part reduced from $172 down to $42[56]
Lumber processing, microwave	Old growth hardwood trees spared, 30% stronger than natural timber[57]
Metal cutting, plasma	Scrap rate dropped from 20% to 10%; fewer rejects, higher throughput[58]
Microwave curing of rubber	Savings of 5% material, 30% floor space, 30% in labor cost, 100% in scrap[59]
Paint spraying, supercritical CO_2	Improved transfer efficiency from 40% to 70%, reduces VOC use[60]
Paint stripping, flashlamp	Aircraft paint stripping cost reduced 4-fold, toxic chemical use eliminated[61]
Painting, electrostatic	Transfer rates of 65% vs 15-40% with conventional methods[62]
Powdered metal coating curing, IR	Case study cost per light pole dropped from $1.56 down to $0.86[63]
Pressurized water cutting	Reduces waste, downtime for sharpening blades eliminated[64]
Short wave infrared curing	25% drop in paint costs, 99% recovery overspray for 50% energy cost savings[65]
Toxic waste vitrification	Eliminates cost of shipping contaminated soil to disposal site[66]
Through heating, resistance	Cost per ton of steel reduced from $34.80 for gas down to $33.80[67]
UV setting of offset inks	Less expensive heat source, better heat transfer, 100% solid inks eliminated VOCs[68]
UV/EB Curing	Less flash-off, smaller ovens, higher line speeds due to reduced drying time[69]
Wastewater treatment, UV	Eliminates transportation of waste to treatment site[70]
Welding tube, resistance	Increased throughput with a rejection rate drop from 20% to 5%[71]
Zinc recovery from galvanized steel	9 million BOE, $256 million in zinc imports saved recovering 60% of scrap[72]

Part 3 - Does price matter?

Brief:
Consumers and businesses feel very strongly about the price of electricity. Evidence of the importance of price, not to give short shrift to public and political reaction to utility rate increases, is found in Wall Street. Wall Street analysts strongly favor utilities that can compete successfully as low-cost providers.

In April 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 popular and trade press.[73] The CPUC was by no means first in proposing to adopt policies that would move regulated electric monopolies towards a competitive environment.[74] The CPUC proposals nonetheless included the first proposed schedule to implement the plan and thus galvanized much of the debate that was already underway.[75]

The central goals contained in the CPUC proposals:
- 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.[76] 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.[77]

Since much utility policy ends up being laced with various environmental, social and technical ideologies, Wall Street analysts arguably provide an ideologically agnostic view of utility policies. For example, a Prudential Securities evaluation of utilities identifies the following key competitiveness indicators:[78]
- how cheaply a utility generates power
- whether or not cheaper nearby competitors exist
- dependence on industrial customers
- 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 regions correlate strongly with the availability of low-cost electricity predominantly provided by coal-fired generation.[79]

In a similar evaluation, Daniel Scotto, managing director at Donaldson, Luffkin & Janrette 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 tend to be those that compete on price. That Wall Street analysts consider that coal-fired utilities can compete on price is merely a reflection of the precipitous drop in the costs of controlling emissions from coal combustion with new technologies. In addition, with long-term, low-cost and stable supplies, coal looks tough to beat on price.

The Wall Street vote for utilities that can supply cheap electricity is a direct reflection of the marketplace's hunger for cheap electricity. For example, a recent survey of commercial and industrial customers found:[80]
- 38% would switch electricity suppliers for a 5% rate reduction
- 53% would switch for a 10% rate reduction.

Such survey results are, for quite obvious reasons, at the heart of the controversy. This also underscores the far-reaching complexities associated with proposals to encourage greater competition for electricity markets.

The business market is not substantially different, in terms of price sensitivity, than the residential market. A similar survey of residential customers found that for a 5% rate reduction, the share of customers that would switch to another utility would be:[81]

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

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.[82]

The residential customer's concern with price should send a clear signal to electric utility planners. And for those who believe, despite all market evidence to the contrary, that people will feel good about paying more for a product (e.g. a kilowatt-hour) because of environmental/conservation programs, consider the results of a national Roper survey. When people are asked to rank factors as determinants in making purchasing decisions, the survey found that people rate the following factors as important:[83]

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

Many utilities are, of course, responding and have long responded to customer concerns over price. Over 20 states have allowed utilities to offer special low rates to large industrial customers who might otherwise seek lower-cost self-generation.[84] The implications of a deregulated and competitive environment make the stakes higher. American Electric Power is, for example, implementing a trial program to permit residential customers to have more control over costs through real-time variable electric rates with their Transtext system. The system permits a customer-controlled, three-tiered rate structure reflecting the cost and availability of power during different times of day and different seasons. A customer can, for example, select different air conditioning temperature set points for different prices of electricity.[85]

The key to such a control system, and others similar to it across the country, is the use of real-time communications and control systems – i.e., an information "superhighway" linking utilities and their customers. The value of such a capability for improving electrical service and lowering costs has lead to utilities being one of the major players in installing fiber optic links to residences. Beyond the implications for utilities to engage in the sale or collaboration of other information services, 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.[86]

While understandable self-interest in preserving one's own money is an obvious driving force for sensitivity to electric rates, more is at stake. 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 importance of electric rates.

For example, in a contretemps between Governor Cuomo's office and Forbes magazine, it was instructive to see how prominently electric rates played in a debate over the attractiveness of New York State to businesses. Forbes blasted state policies as being anti-business growth. In identifying eight central points of contention with Forbes over its claim that New York was a business disaster, New York State Director of Economic Development cited electric rates as the number two item (workers' compensation was the 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."* [87]

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 correlates remarkably with electric rates (although that was not the intent of the survey). Forbes established an index to rate future job prospects by state based on six key indicators: 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 be a more accurate predictor of economic health. Nonetheless, the electricity price correlation between states with good and bad job prospects is remarkably strong.

Forbes predicted strong job growth in 23 of the 50 states.[88] 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 Rates	Highest Rates
Idaho	Alaska
Louisiana	California
Nevada	Connecticut
Oregon	Delaware
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 prospect
** not ranked as state with worst job prospect

Electric Rates & Inflation

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."* [90]

While no one doubts the importance of keeping inflation under control, inflation is notoriously difficult to predict and has all of the earmarks of soothsayers reading entrails.

> *"I get a feel for what I think is going on based on the information..." Fed governor in a New York Times interview.*[91] *[emphasis added]*

With inflation, the difference between cause and effect is not only unclear but there is also a feedback loop. Because of the arcane nature of the factors driving inflation, it is clear that perceptions matter almost as much (perhaps more) than substance. In simplest terms, as dollars chase commodities, a typical market response is for prices to rise. The chase heats up if there is a perception that prices may rise -- which increases prices and heats up the chase, and so on.[92] This dynamic seems uncomfortably dependent on perceptions. If recent New York Times interviews with Fed officials is any indication, perceptions matter.

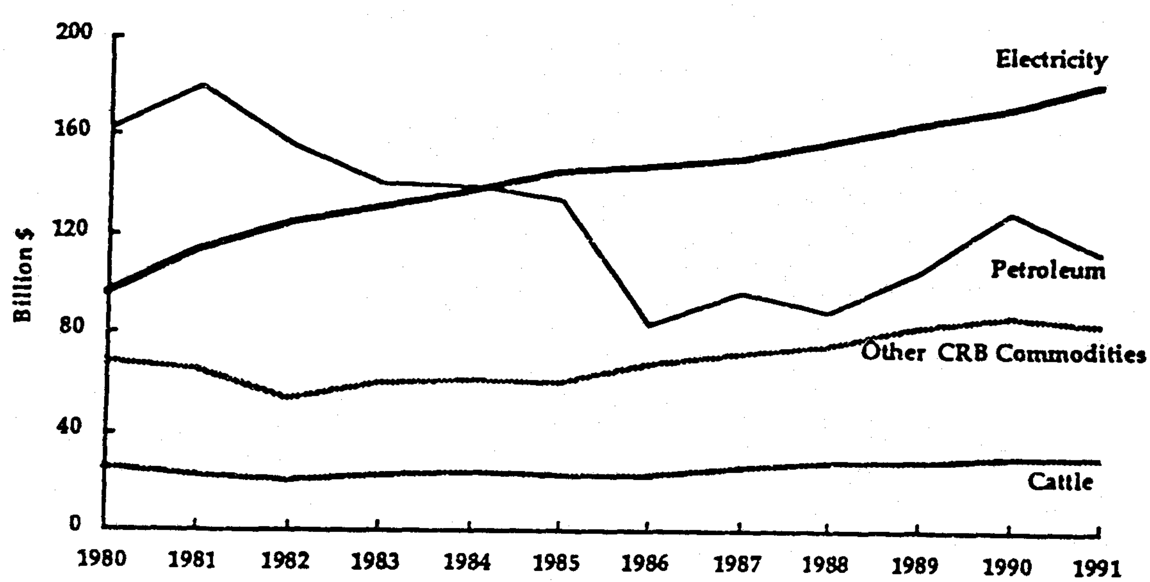
> *"Fed officials said they were putting greater weight on the economic indicators ranging from the price of gold and the output of factories to personal anecdotes. They are also paying more attention to human psychology: notably investors' expectations of inflation, an area that has long exasperated economists who use computer models to predict inflation."*.[93] *[emphasis added]*

Inflation indicators commonly watched by analysts are: commodity prices, manufacturing capacity utilization, and housing prices.[94] Of these three broad indicators, both commodity prices and manufacturing capacity have direct, but largely ignored, links to electricity, and the price of electricity.

Traditionally, when manufacturing capacity reaches 82.5% utilization, economists see the pressure on demand chasing the capacity to provide goods as inflationary. In early 1994, manufacturing capacity utilization reached 83.5%, although most analysts did not see inflationary pressures commensurate with this traditional signal.[95] The reasons may well be rooted in the failure to account for technology progress, and thus modify the capacity "trigger point" accordingly.

It is almost certainly the case that manufacturers are today able to operate at higher utilization levels than in the past without comparable strains on their ability to meet demand and thus the related impacts on price. Manufacturers can operate at higher utilization levels than previously because of the increased productivity of manufacturing operations, and in particular the

Figure 12 Total Commodity Purchases[89]



extensive use of advanced technologies, 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.

The other principal inflationary leading indicator is the change in price of the commodities basket. Here too electricity has a large role. Of the commodities tracked and reported, oil is the one that captures media attention most frequently and therefore helps feed the perception-reality feedback loop. Oil price changes generate prominent media coverage with explicit links to inflation. Typically:

> *"Drop in Oil Prices is Likely to Benefit Consumers by Keeping Inflation Low,"* Wall Street Journal, *December 1, 1993.*

Despite the fascination with oil (and its unquestioned importance in the transportation sector and international markets), the evidence nonetheless suggests strongly that it is not a pre-eminent inflationary indicator. The absolute price of oil did not significantly change manufacturing costs when oil prices increased 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. [96]

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 (i.e., 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 needed in the form of electricity -- not combustible fuels,

Table 4 - CRB Index List of Commodities

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

whether oil or natural gas. Why then is electricity not included in the commodities basket? The answer may be, in part, that the traditional basket was created in the 1950s when electricity was a comparatively small commodity.

The Commodity Research Bureau's index of futures prices incorporates 21 goods, including oil, gasoline and heating oil.[97]

Trends in overall commodities prices are, almost as much as oil prices, monitored for their predictive effect on inflation.

> *"If commodity prices are on the upswing, can inflation be far behind? That's one of the key questions bugging 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 [98]

Even single non-oil commodities are watched 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 [99]

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.[100] Figure 12 shows the trends in total purchases. Clearly electricity is the predominant commodity, even though it is not in any basket. 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 its share of the total basket is rising.

Given the substantial role that electricity plays in the overall economy, in productivity growth, and the price sensitivity of the market to electric prices, and now the commodity on which more money is spent than any other, the obvious question to ask is:

> *What happens to the price index of the commodities basket if electricity is made part of the equation?*

Figure 13

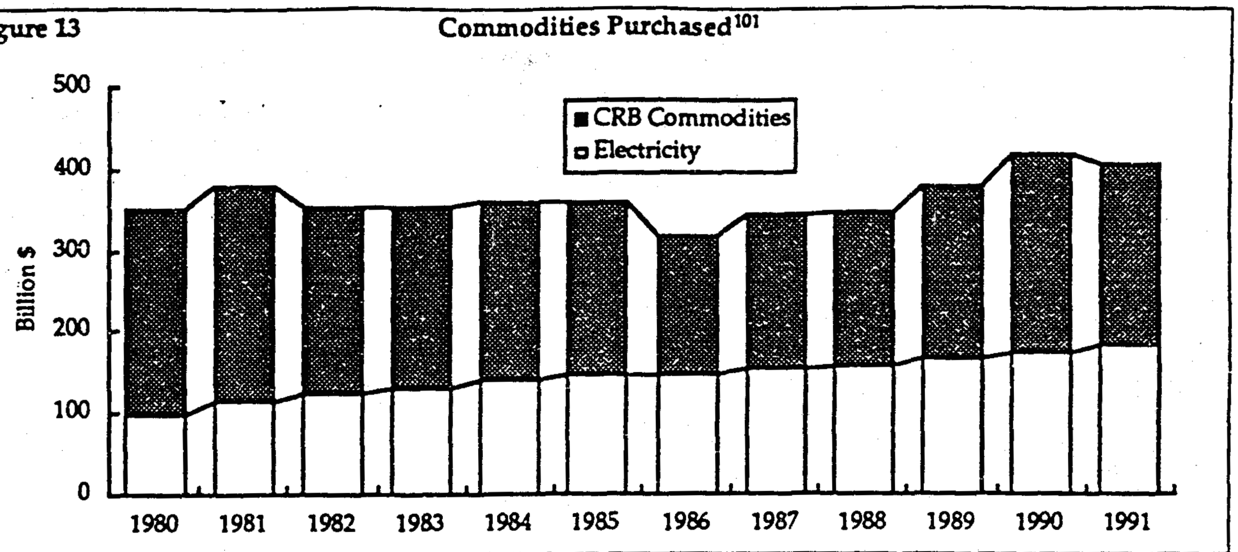


Table 5 - 1991 Commodities Purchased[102]

Commodity	Billion $
Electricity*	181
Natural Gas*	70
Unleaded Gasoline	58
Crude oil	50
Cattle	30
Corn	18
Soybean	11
Pork B	10
Sugar	7
Coffee	7
Heating Oil	7
wheat	6
Lumber	6
Cotton	5
Hogs	5
Copper	4
Gold	3
Cocoa	1
Silver	<1
Platinum	<1

* not included in the CRB 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.

The commodity basket price index is substantially altered by the inclusion of electricity as a commodity, as shown in figure 14. 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 the large quantity of stable electric prices may be playing a hidden moderating role. Including electricity in the commodities basket would quench the inflationary heat caused by increased prices in other commodities.[103] Some perspective on the impact of electricity in the market basket can be acquired by looking at broad impacts or price changes.

The large effect small changes in electric prices have on the economy can be demonstrated in two ways. Both the change in the total amount of money spent purchasing all of the commodities in the basket as well as the change in the weighted price index of the basket can be calculated for a change in price of a single commodity in the basket. The basket used for these comparisons includes electricity, and the price index for the entire basket is modified accordingly.[104] Table 6 shows the effect of doubling in the price of a number of commodities.

Table 6 - Impact of Commodity Price Changes

Double price of Commodity	% increase in cost of total basket	% point increase in basket price index
Electricity	44	32
Gasoline	14	4
Soy	3	5
Gold	1	3

Doubling the price of electricity, an 'accomplishment' that has been effected in a few states, would 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%, compared to doubling the price of gasoline which would raise the cost of buying all commodities collectively by only 14%. Similarly, the price index of the basket, the harbinger of inflation, is moved 5 points by doubling soy prices, but 32 points by doubling electricity prices.

Another way to illustrate the relative importance of these representative commodities is shown in table 7 where the inverse of the logic used in table 6 is presented. Table 7 shows the price changes required in the commodities that would lead to the same overall impact on the basket.

Table 7 - Relative Importance of Commodities

A 10% increase in the total cost of purchasing commodities would arise from a:
23% rise in electric prices, or a 71% rise in gasoline prices, or a 367% rise in soy prices, or a 1200% rise in gold prices.

A 2% point rise in the commodities price index would arise from a:
6% rise in electric prices, or a 46% rise in gasoline prices, or a 37% rise in soy prices, or a 73% rise in gold prices.

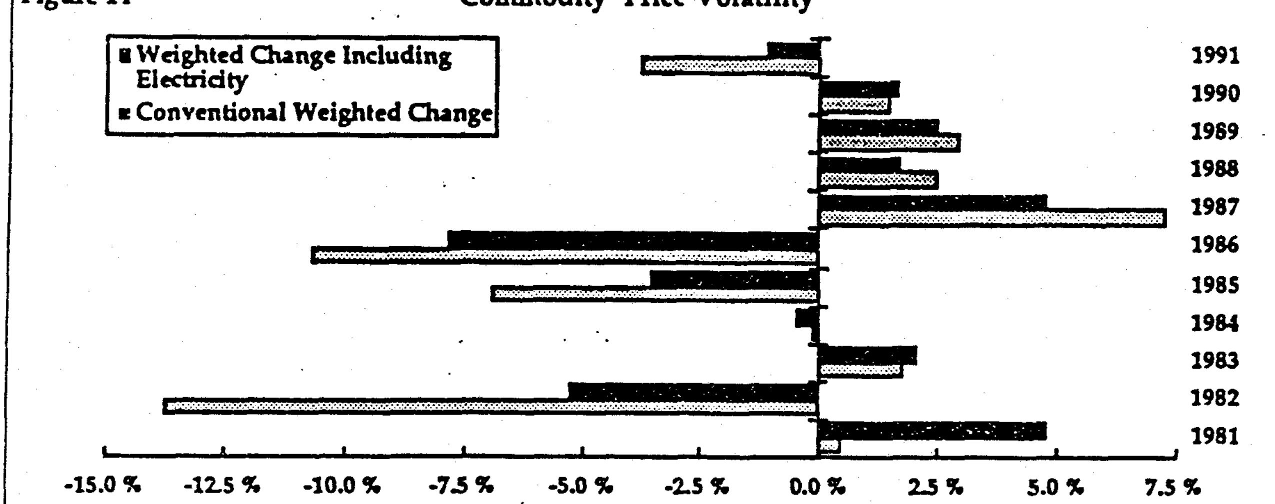
To a significant extent, utility trading in wholesale markets already treats electricity as a commodity. For example, Consolidated Edison Co. of NY has established a Megawatt-Hour Store using an on-line computer system for enhancing exchanges of power. Con Ed already buys over half of its electricity in the bulk power market. According to Con Ed, volume trading provides a competitive edge and the computerized trading saved its customers $18 million in the first five months of 1994 compared to same period during the previous year on 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, the most important of which is demand from electric customers and thus electricity trading frequently must take place 24 hours a day. Currently, Con Ed trades focus on hourly, daily, weekly and monthly deals.[105]

There are signs that electricity's role 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.[106] While the trading will likely be limited to only some markets initially, probably the West, it seems likely to expand. Even before trading expands from the West, the price declines that will almost certainly be created by the competition will directly affect the nation's commodities basket. Around 20% of the nations electricity is sold in the western region.[107] If competition drives prices in the West down by an average of 20%, it would reduce the national average price of electricity by about 3%. This 3% reduction of national electricity cost would reduce the price index by about 1.2 percentage points, and reduce the total cost of commodities purchased by an amount equal to reducing the cost of gasoline 11%, or reducing the cost of gold by 179%.

As electricity is increasingly recognized as the commodity that it is, and, as the markets become increasingly competitive and fractionated, prices will vary dramatically and inclusion of electric prices in the commodities basket will be vital.

The macro-economic importance of cheap electricity's moderating force on inflation can be simply illustrated. Inflation has the effect of eroding people's savings. Every percentage point increase in inflation permanently robs at least (does not include cost value of real assets such as land) $30 billion each year from the nation's savings accounts.[108]

Figure 14 Commodity Price Volatility[109]



Part 4 - Where is the price of electricity going?

Brief:
Economic and competitive forces are increasingly competing with social forces in the electric area. The former forces drove electric prices down. The latter drove prices up. Trends point to the likelihood that the cost of electricity will drop dramatically over the next 20 years.

Social goals, exercised through the transmission line, tend to raise electric rates. Economic and technology forces over time tend to lower electric rates. According to Business Week:

> *"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."*[110]

This observation from Business Week underscores 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. The states in which mandated conservation programs and renewable energy projects have been most aggressively required by public service commissions also tend to be the same states that have the highest electric rates: California, Maine, and New York, for example.

Maine provides an instructive example of the bizarre circumstances that have come to surround the economics of electricity. Maine is a state that has been battered by an economic downturn, and 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 on this rate reduction, which could save Maine businesses tens of thousands of dollars? The staff wants to treat it as a rate increase, requiring expensive, elaborate filings and, if history is any guide, interminable and costly delays."*[111]

They were right. Over two years later, in a July 20, 1994 filing with the state commission, Bangor Hydro continues its attempt to provide competitive, i.e., cheaper, electricity. They propose to be allowed to have the flexibly to lower rates any time they need to help businesses and meet competition -- but under the proposal the utility would not be able to raise rates without going through traditional rate procedures.

Maine's opponents of cheap electricity and proponents of DSM and alternative energy admit that electric rates have increased because of the programs they have advocated.[112] But the advocates of high-priced electricity claim that the subsidized renewable energy projects have provided direct and "indirect" employment, and:

> *"The biggest gain is the significantly reduced carbon dioxide emissions."*

Setting aside the arguably irrelevant value of the "biggest gain" (and ignoring the implied cost of this "gain"), and setting aside the possibility that the policies actually increased carbon dioxide emissions,[113] 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 other states/regions resulting in loss of competitiveness, lost sales, and an attendant reduction in demand for inputs from the state, reducing wages etc. The second effect is a decline in consumer purchasing power.

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

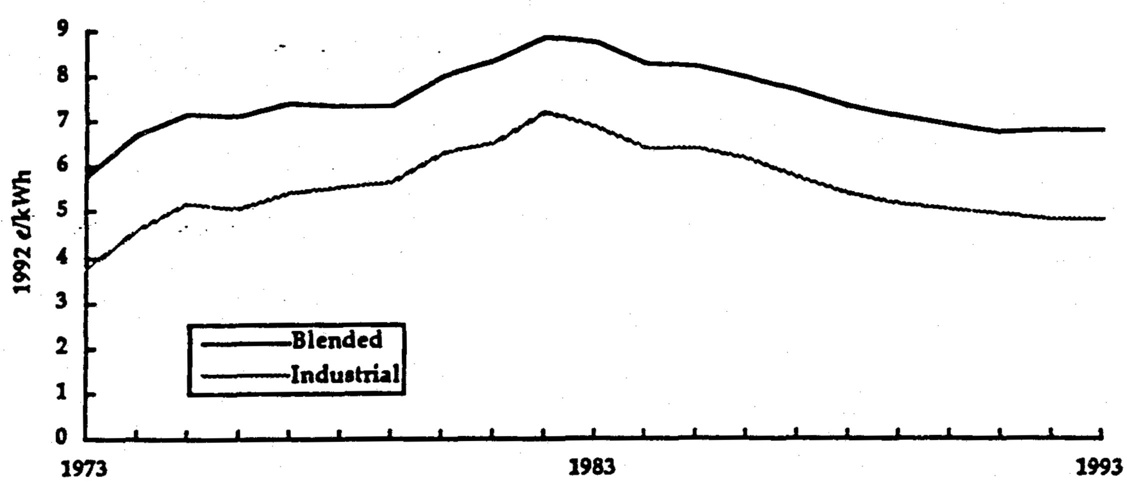
> *"Using an econometric model a 10% increase in electric costs for the state lead to a 0.23% drop in employment, 0.27% drop in output GSP, 0.19% drop in personal income; reduction of over 1,700 jobs in employment, $75 million in output and $68 million in personal income."*[114]

Maine actually experienced a 30% increase in electric costs relative to the rest of the region and nation.

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 20 years ago.

One might argue that the trend illustrated in figure 15 means that on average the social and economic forces

Figure 15 Historic Cost of Electricity



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 tensions between the forces of social engineering and competition are going to be more powerfully engaged than in the past. Ascertaining which forces will likely dominate requires an examination of the components of those forces.

There are three main components to the social engineering agenda:

- Demand Side Management (DSM) to reduce electricity use
- Environmental externalities to "capture" unregulated environmental impacts
- Alternative energy to replace conventional fuel and power sources.

Each of these components of the social engineering has aspects that are laudable, achievable, and cost-effective. It is the zealous pursuit of these programs that creates economic problems. Here we very briefly review the economic aspects of these three components.

Demand Side Management (DSM)

An entire industry and academic discipline has arisen on the subject of DSM. We make no attempt here to dwell on this subject except to note the basic thrust of this aspect of social engineering. The underlying logic of DSM programs is that there are often cheaper ways to save electricity than to make 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 to minimize capital requirements.

Table 8

Capital Assets Required per Dollar of Revenue[115]	
Electric Utilities	$3.03
Mining	$1.74
Communications	$1.09
Railroads	$1.68
All Manufacturing	$0.92
Retail Trade	$0.52

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, as a minimum as a wise aspect of customer service. However, as the 'cream' in DSM is taken away, programs are chasing increasingly expensive avoided costs and can be oversold (overselling is generally unintentional, either because of an inadequate appreciation of a market's response, or a failure to account for full-program costs.)

A review of the Bonneville Power Authority's DSM program, for example, revealed typical BPA DSM programs cost rising from an original level in the 4 to 5¢/kwhr range to 7 -11¢/kwhr.[116] Such costs do not compare favorably to a 4¢/kwhr or lower costs of purchasing or generating power in the Western region.

The super-efficient home refrigerator is a pre-eminent example of overselling a DSM technology. Technologies clearly exist that can make even the currently most efficient home refrigerator significantly more efficient. Advocates frequently advocate that utilities should directly subsidize homeowners' purchase of such equipment. A recent issue of Consumer Reports evaluated the field of home refrigerators, and also undertook a test and evaluation of the "world's most efficient refrigerator" delivering a withering criticism of it on all counts: energy savings, economic viability, practicality and sensibility.[117]

As public utility commissions increase scrutiny on DSM programs, many utilities are backing off of earlier, overly ambitious commitments primarily because they are too expensive; i.e., they tend to raise electric rates.

Environmental Externalities

The concept underlying environmental externalities is simple: even when power plants fully meet federal and state environmental regulations, they still emit some pollutants. These pollutants are "external" to the regulatory process, but nonetheless, it is argued, have both an environmental and financial cost to society. The solution? Normally, if the scientific evidence supported an environmental impact, regulations would be tightened up to reduce the emissions. However, when this is not possible (because of the weakness of the evidence), environmentalists propose to 'guesstimate' the residual cost associated with these externalities and then add them to the cost of the electricity.[118] Typically, these quantification's of externalities leads to penalties per ton of emissions of $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 regulated emission since it is a benign gas and not a pollutant unlike the other pollutants which are regulated).[119] The net overall effect of these penalties will increase the cost of electricity from power plants with more externalities and thereby discourage their use; i.e., sending the "right" price signal to the market. Typically, these penalties can add 10% to 15% to electricity rates.[120] In many cases the externality penalty has the potential to increase rates from low-cost coal-fired power plants up to 4¢/kwhr.[121]

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-de-jour. This has the effect of promulgating a silly idea.[122]

The fundamental problem with this theory 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 of the electricity. The external environmental impacts of using an electrotechnology are just as real as the environmental impacts of making the electricity to operate the electrotechnology. A vast array of electrotechnologies are used for there fundamental economic benefits, but because of the inherent efficiency of their operation, they also eliminate more emissions than are created at the power plant. Electric vehicles are the most familiar example of this phenomenon.

In order to determine the actual net environmental externality of electricity, residual emissions from the power plant must be offset by the emissions eliminated in the marketplace. When this type of correct full fuel-cycle calculation is undertaken, one typically finds that there is a net decline in environmental impacts associated with most electrotechnologies. Put another way: increased electrification typically decreases environmental impacts, taking into account power plants. This fact has been extensively reviewed in other analyses.[123]

Table 9 summarizes the results of typical externality calculations for some representative electrotechnologies. The reduction in CO_2 and NOx are shown taking into account national average fuel use at the power plant. The energy savings are shown as a percentage reduction in the total fuel-cycle compared to the fuel-based alternative to the electrotechnology, and the emissions reductions are shown in pounds of emissions eliminated for every 1,000 kwhrs of electricity used to operate the respective electrotechnologies instead of the non-electric alternative. Electric Power Research Institute calculations shows that by 2010, the increased use of 15 representative electrotechnologies will of course increase electric demand, but will also lead to a net reduction in total fuel-cycle energy use of hundreds of millions of barrels of oil equivalent per year.[124]

Nonetheless, advocates of environmental externalities are not proposing to undertake proper full fuel-cycle evaluations. Instead, they are focused on penalizing electricity users for the environmental impacts of power plants without giving 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 resulted in a power plant emitting one ton of NOx each year, but the technology being operated by the end-user eliminated two tons of NOx per year, the end-user should be paid $1,000, not penalized $1,000 for the electricity used.[125]

Table 9 - Examples of Fuel-Cycle Savings From Electrotechnologies[126]

Technology	Energy Savings	Reduction to 1000 kWh lbs CO2	lbs NOx
Automobile, electric	36%	1,260	2.9
Canoe, electric	49%	1,970	0.6
Car warmer, electric	91%	18,170	18.8
Clothes drying, heat pump	70%	2,560	1.8
Clothes drying, microwave	35%	470	0.0
Cold vaportization	63%	1,850	2.2
Commercial cooling	40%	620	56.9
Commercial laundry, ozone	31%	350	0.5
Copper melting	37%	520	0.7
Dairy processing, MVR	76%	3,700	4.4
Dishwashing, ultrasonic	98%	56,940	47.1
Electric airport shuttle	63%	1,860	46.3
Electric mill	46%	820	1.0
Electric moped	68%	3,940	7.8
Electroreactivated carbon bed	85%	9,600	21.8
Farm chore tractor	10%	510	18.0
Farm pump	22%	790	15.9
Fax	93%	24,410	31.9
FlashBake cooking	86%	6,920	5.4
Forging, direct resistance	22%	160	0.3
Forging, induction	16%	40	0.1
Freeze concentration, dairy	45%	790	1.0
Freeze concentration, sugar	66%	2,090	2.5
Freeze concentration, water	14%	290	0.1
Garbage disposer	68%	3,880	48.4
Gas-line compressor	50%	1,020	1.3
Glass bottles	31%	350	0.5
Grill, electric	75%	4,090	4.6
Heat pump, geothermal	60%	1,660	1.1
Heated floortiles	67%	2,270	1.5
Ion blast air cleaning	59%	1,540	0.9
Irrigation pump	33%	1,140	13.1
Kitchen fax	20%	23,380	30.6
Ladle preheating, electric resistance	60%	1,610	2.0
Lawn leaf mulching, electric vacuum	82%	8,040	20.8
Magazine ink drying, UV	58%	1,470	1.8
Medical waste, electron beam	96%	39,030	381.6
Medical waste, Medaway-1	64%	3,330	43.2
Medical waste, microwave	68%	3,850	48.1
Maglev train	75%	5,360	7.2
Microwave oven	91%	11,410	9.1
Mower, cordless electric	69%	4,170	10.7
Noise cancellation muffler	99%	352,270	1626.5
Outdoor lighting vs. gas light	90%	11,210	9.0
Paint curing, infrared	88%	8,690	10.2
Paint spraying, supercritical CO2	85%	8,810	31.7
Parboiling rice, microwave	44%	830	1.1
Pasta drying, microwave	94%	19,930	23.3
Powdered coating curing, IR	57%	1,380	1.7
Powdered coating curing, UV	65%	2,230	2.6
Powdered plastic coating curing, IR	64%	1,940	2.4
Pressure washing, electric	98%	100,910	278.8
Riding lawn mower	25%	880	7.8
Sand reclamation, IR	7%	250	5.2
Silk-screen curing, ultraviolet	90%	10,980	12.6
Telecommuting	71%	4,550	3.4
Trash compactor	97%	53,740	420.3
Wastewater treatment, RO	31%	350	0.5
Water heater, heat pump	32%	370	0.2
Water-jet paint stripping	69%	2,680	29.1
Welding of tube, resistance	28%	280	0.4
Yarn drying, radio frequency	16%	40	0.1

Renewables

Environmentalists and the media have had a long love affair with renewable energy. The campaign for renewable energy is being resurrected almost verbatim from the failed programs of the late 1970s and early 1980s. Typical of the observations:

> *"Large amounts of renewable energy...are available for generating electricity" "most utility planners fail to recognize the substantial economic benefits of adding renewable energy to their resource mix."*[127]

Central to the support for renewable energy technologies is the idea that the so-called non-renewables (coal, oil, natural gas, primarily) are running out and we had better hurry and replace them.

Dire warnings of an impending oil shortage with attendant escalating prices is the first refuge of all advocates of expensive alternatives. Claims for a sustained oil shortage within the foreseeable future are simply not supportable by facts (more about this later). The literature of prognosticators is littered with oil shortage warnings. For example:

> *"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 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, claim advocates, alternative energy will eventually become cheaper. Statements of this kind (see the example below) are virtually identical to those made 20 years ago.

> *"Most of the renewables are still infant technologies with big cost disadvantages."*[128]

The renewable advocate's approach: what if prices for gas, coal, oil rise? Investing in renewables (which they admit are more expensive "for now") will provide a hedge against this vigorously proclaimed inevitability of rising prices for conventional energy.[129] 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 (something that renewable advocates work vigorously to ensure through use of externality theory), then using renewables now will 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 SOx emissions would cost over $2000/ton; however, the actual cost of compliance 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.[130]

> *"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."*[131]

Economic Forces

It is possible to divide into three areas the principal economic forces driving down the price of electricity:

- competition
- technology
- raw fuel inputs

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

Competition

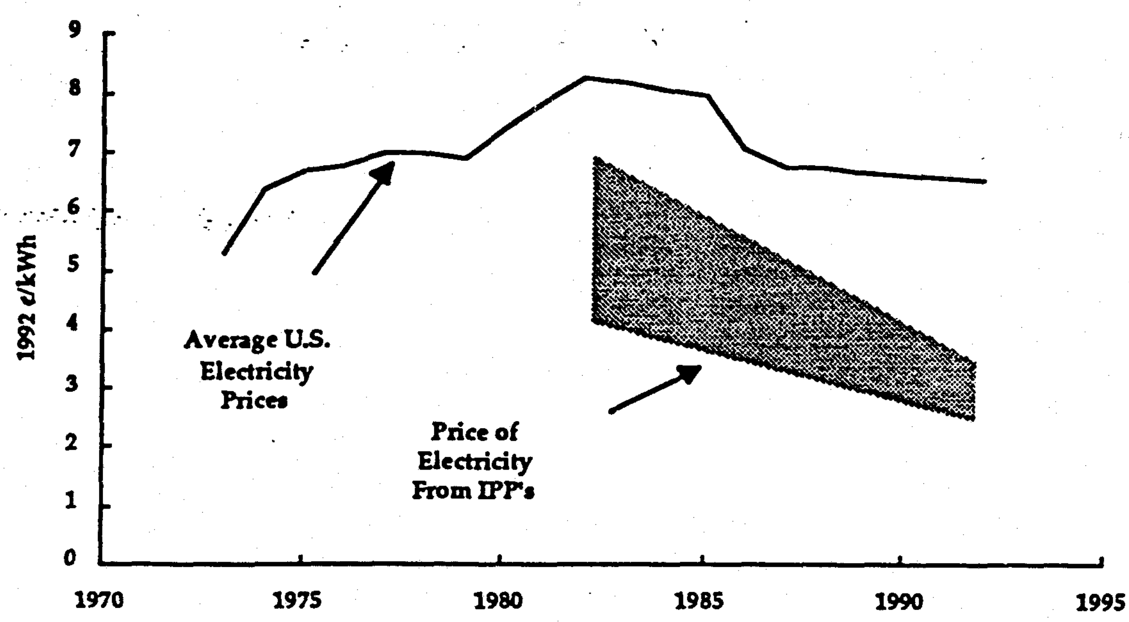
The demand for electricity has increased for the past two decades, and is projected by virtually all analysts (including those that are trying to avoid demand) to increase for the next two decades. Increasing demand for a product increases competition to provide the product, especially in an increasingly competitive market. The typical net effect of this 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. Over time, economic forces will drive electric rates to those low levels.

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 Bangor Hydro of Maine is having (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, which resulted in that facility leaving 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 have a tremendous incentive in a competitive market to price power just above incremental costs, otherwise 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.

The nation's existing coal plants operate at just under 60% capacity factor. Operating these power plants at full capability of 75% capacity factor would provide over 450 billion more kwhr of supply, equivalent to 140 new 500 MW generating plants.[132] The marginal cost of this additional electricity will be substantially less than 3¢/kwhr, and may be as low as 1.5¢/kwhr.

Figure 16 U.S. Electric Prices[133]



Repowering old power plants is another less obvious category of additional, cheap power that has been largely ignored until very recently.[134] 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.[135] Far from being retired, 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 cheapest. For example, at the end of last year San Diego Gas & Electric rejected 15 IPP bids to proceed instead with a repowering of one of their existing older power plants because it was a substantially cheaper option.[136]

Competition to provide electricity is increasing and is coming not just from Independent Power Producers (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 directly derivative experience. If revenue growth is inadequate in the local service territory, clearly seeking new revenue from a core activity – 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 above. 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 the cost of the entire system down.[137]
Long time successful IPP CEO and prognosticator Roger Sand succinctly observed:

> *"If today's low prices persist, the economics of lower-cost power will likely overwhelm the regulatory stem now in place."*[138]

If overwhelmed, and the economic gloves come off, 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 pressures to raise their electric costs as it will put them at a substantial disadvantage vis-a-vis competitors for their customers regardless of the specific regulatory outcome.

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 electricity delivered to customers goes down.

Coal-fired generation is the technology which typically involves the most extensive materials handling combined with rigorous env.ronmental regulations. Yet progress in new types of highly efficient and squeaky clean combustion technologies makes it clear that advanced coal-fired electricity will meet and exceed all environmental regulations while delivering electricity for 4 to 5¢/kwhr.[139] 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 already exist to allow coal-fired power plants to match the low emissions characteristics of natural gas generation.[140] This will continue to lead to competitive responses from the technologies for natural gas fired (and even oil-fired) generation.

A wide panoply of technologies beyond the generating plant 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 are permitting more efficient integration and dispatch of power sources, which again has the effect of 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 the cost of electricity which occurred for decades following the advent of the electric age. This view confuses technology progress with scale economics. In many cases there have been economies from scaling up power plants, and these economies remain largely real. Even IPP providers which started with small power plants, are moving increasingly to large power plants, because of economies of scale. But technology progress has been the underlying factor in driving down the costs of technology to generate and deliver electricity. No serious student of technology doubts that this progress is continuing.

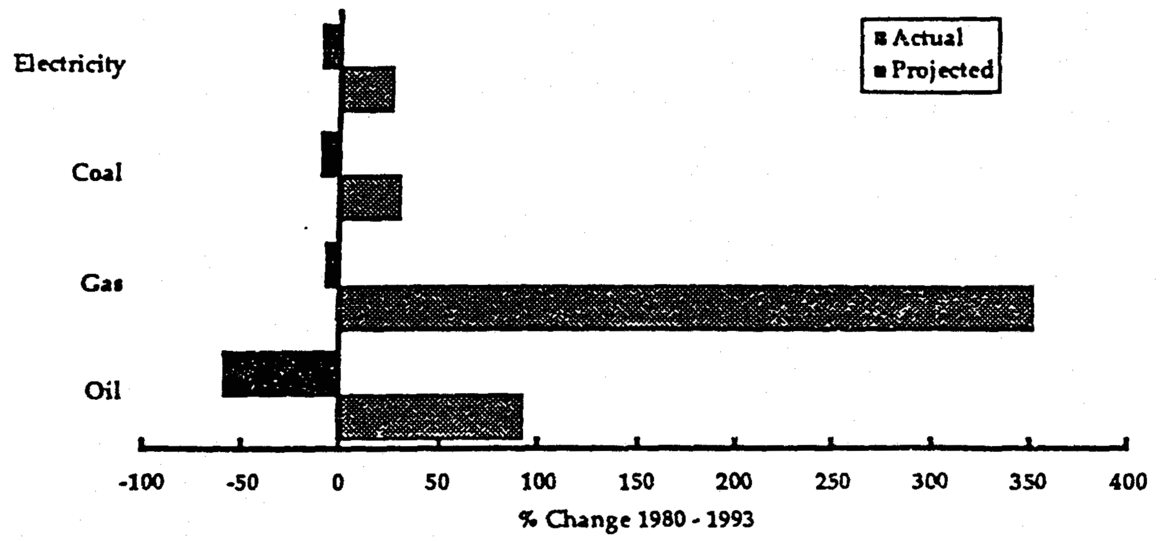
Basic Fuel Resource

The trump card for every advocate of non-combustion technologies is to point to projections showing rising projected fuel costs for oil, gas and coal. Buy the more expensive alternative now, we are told, to protect against future fuel price rises. The problem is that there is no historical record to support the belief that fuel prices will rise, nor is there any current evidence to support such a trend. Fuel price escalation's are simply a fiction.[141]

Figure 17 illustrates a typical phenomenon -- although one largely missed since prognostications of a decade ago are typically forgotten by the time the same analysts' predictions are trotted out ten years later.

Figure 17 shows the U.S. Department of Energy's 1980 projected 1990 price increases for oil, coal, natural gas and electricity. DOE projections both then and now generally reflect the conventional wisdom of other prognosticators, and further DOE projections are those most commonly used by all analysts. As the figure shows, not only were the projections of a decade ago

Figure 17 DOE 1980 Price Projections to 1990 vs Actual Changes



wrong, 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.[142]).

Oil price projections are frequently viewed as the bell-weather indicator of where energy prices in general are trending. This preoccupation with oil prices arise 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 price escalation), and in part because of the almost immediate affect oil prices have on homeowners' transportation budgets.

According to current DOE projections, oil prices are trending up.[143] 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.[144] All indications are that major oil producers can continue to make a profit at $15/bbl.[145] 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 (eg., new oil exploration, the use of supercomputers and even satellites, new extraction technology such as horizontal drilling, etc.). Today oil can be found readily for about $3/bbl in finding costs.[146] 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 remained at that level for 50 years.[147]

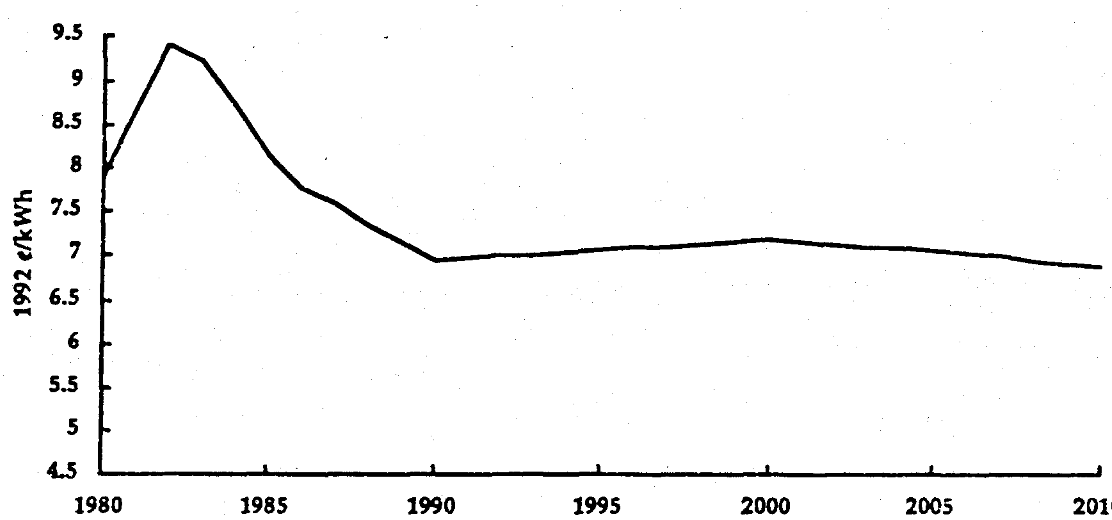
Even without considering the historical, ultimately a price ceiling for oil is established by the cost of delivering OPEC natural gas to markets. Over time, the market cannot sustain a price for oil that is greater than the cost of delivering OPEC natural gas to world markets via LNG tanker. Natural gas can be used in many of the applications where oil is used now. 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.[148]

In the electric generation business coal prices are the principal determinant of the cost of delivered energy since 55% of all electricity is coal-fired, and this dependence will still be the same 20 years from now. Coal prices are projected to be stable and decline in real terms over the next two decades.[149]

All things considered then, what is the trend for the price of electricity? Figure 18 illustrates today's conventional wisdom.[150]

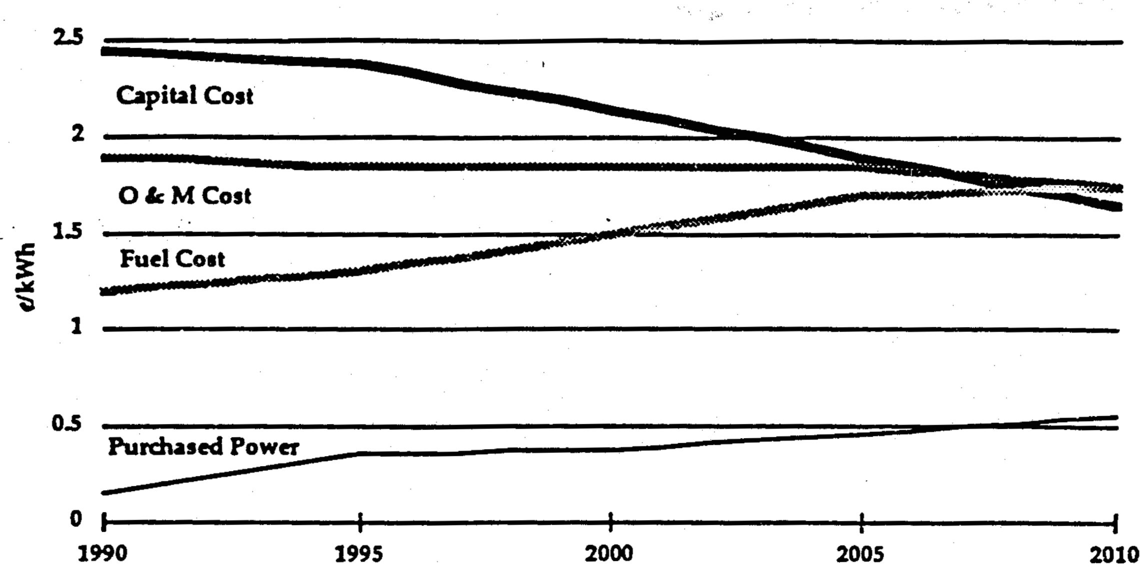
Some comfort may be extracted from figure 18 in that electric rates are not projected to rise over the next 20 years. But given the evidence summarized in this analysis, there are substantial reasons to believe that a declining trend would be preferable. To ascertain if the conventional projection is 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).[151]

Figure 18 Electric Cost Trend & Projection



Source: EEI Futures Project

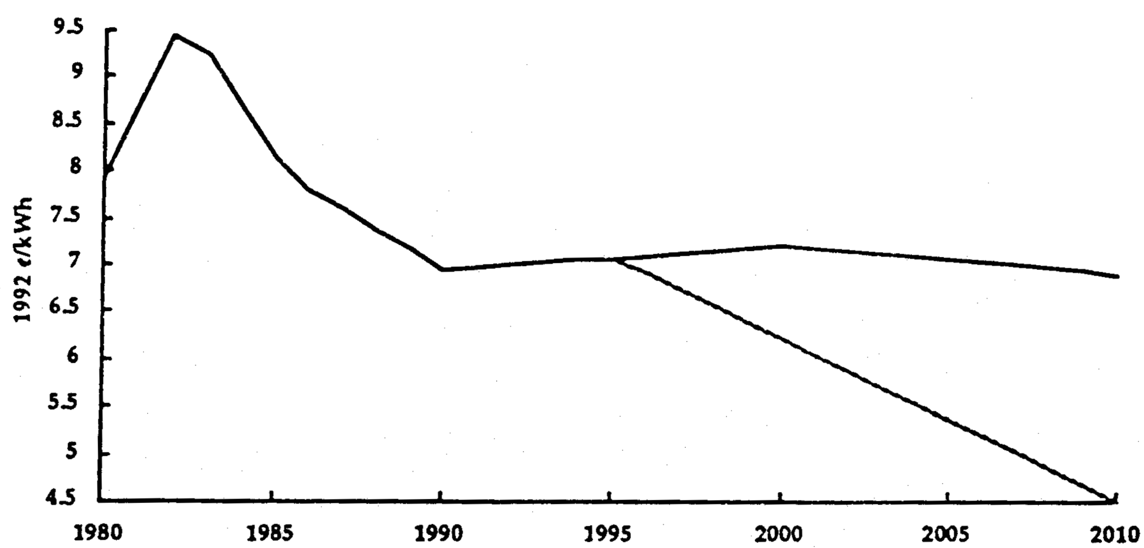
Figure 19 Components of Electric Price Projection



Based on the evidence reviewed here, the projections illustrated above seem reasonable for two of the four components. There is no doubt that capital costs to build and O&M costs to operate power plants are declining. However, there is no evidence to support the belief that fuel and IPP purchases will increase in cost over the next 20 years. In fact, the evidence reviewed here support a view that these two inputs will decline.

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

Figure 20 Modified Electric Price Projection



Part 5 - Implications & Recommendations

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

- 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 towards electricity
- new technologies increase competitiveness
- cheap electricity is anti-inflationary

Can alternative energy and DSM programs survive in a competitive price environment? The pursuit of DSM and alternative energy programs should continue. But such programs should be held to a standard of meeting or beating declining, not increasing, electricity costs. Any DSM or alternative energy program that can compete on price will, by definition, deliver high value to both utilities and to customers. Not only will the economy be afforded the benefit of additional cheap electricity, but all of the putative benefits of such programs will be genuinely achieved cost-effectively. Clearly, many DSM and alternative energy programs cannot meet this standard.[152]

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 also achievable through increased electrification. And, 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 maximal benefit to society.

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References and Notes

1 Not included in the graph, but included in the complete CRB basket are soybean oil, soyb n meal and orange juice. The soybean value used in the data in the graph represents over 85% of the total soybean market.

2 "Electric Utilities Brace for an End to Monopolies," New York Times, Monday, August 8, 1994.

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

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

5 "Electric Panic Creates bargains for the Brave," Market Watch, New York Times, May 15, 1994.

6 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.

7 "The Electric Utility Industry in Transition," Leonard Hyman, Fortnightly, September 1, 1994.

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

9 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.

10 Monthly Energy Review, November 1993, DOE/EIA, p. 33; total transportation energy use of 22.4 quads of which electricity (including generation) accounts for 0.044 quads.

11 Statistical Abstract of the United States, U.S. Depertment of Commerce, 1993; table 647.

12 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.

13 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.

14 Annual Energy Review, DOE/EIA, 1993.

15 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.)

16 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 Btu 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 used 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.

17 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.

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

19 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.

20 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.

21 Annual Energy Review, DOE/EIA, 1993.

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

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

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

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

26 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 on examination for the residential sector. 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 weighed 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.

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

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

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

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

31 The Productivity Payoff Arrives," Fortune, June 27, 1994.

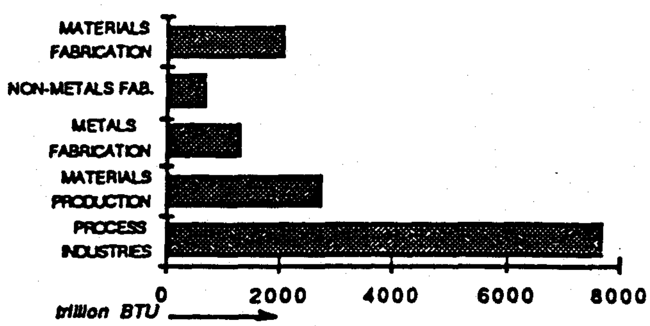
The productivity revolution in manufacturing technologies is having a positive impact in rural, not just, urban areas. Over 80% of the 513 manufacturing rural counties experienced net population growth. This is in contrast to the previously trend towards virtually all rural counties loosing population. Note that the classification "manufacturing" is the second largest class of rural counties, exceed only by rural "farming" at 520. "The Rural Rebound," American Demographics, May 1994.

32 See 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.

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

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

Manufacturing Sector Fuel Consumption - 1990



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

35 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.

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

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

38 "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.

39 A listing of over 200 is contained in CLEANER Economy

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

41 EPRI Center for Materials Fabrication-086

42 EPRI TechApplication No. 2, 1992

43 CLEANER Economy Technical Background

44 CLEANER Economy Technical Background

45 EPRI TechApplication No. 3,19992

46 EPRI CMP-061

47 CLEANER Economy Technical Background

48 EPRI

49 EPRI TechApplication Vol. 1, No. 10, 1987

50 EPRI TechApplication Vol. 1, No. 9, 1987

51 EPRI Center for Materials Fabrication

52 EPRI TechApplication Vol. 1, No. 8, 1987

53 CLEANER Economy Technical Background

54 EPRI TechApplication vol. 1, No. 11, 1987

55 EPRI Center for Materials Fabrication

56 EPRI TechApplication Vol. 1, No. 6, 1987

57 Wall Street Journal February 26, 1993

58 EPRI Center for Materials Fabrication

59 EPRI Center for Materials Fabrication

60 CLEANER Economy Technical Background

61 ElectroTechnology Report, February 1993

62 CLEANER Economy Technical Background

63 EPRI Center for Materials Fabrication

64 CLEANER Economy Technical Background

65 EPRI Center for Materials Fabrication

66 CLEANER Economy Technical Background

67 EPRI TechApplication Vol. 1, No. 19, 1987

68 CLEANER Economy Technical Background

69 CLEANER Economy Technical Background

70 CLEANER Economy Technical Background

71 EPRI Center for Materials Fabrication

72 Popular Science, May 1992

73 "Political Alliances and the Struggle Over Competition," Fortnightly, September 1, 1994.

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

75 "California Pushes Restricting, Retail Wheeling," Fortnightly, May 15, 1994.

76 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.

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

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

79 It is important to note that one of the correlators is also an implicit price issue, i.e., a utilities record in establishing favorable long-term agreements with large customers. In many cases such agreements can be successfully forged 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.

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

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

82 "American Spending," American Demographics Desk Reference No. 5

83 "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.

84 "Managed Competition," Independent Energy, September, 1994.

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

86 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.

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

88 "The fight for jobs," Forbes, January 31, 1994.

117 "The world's most efficient refrigerator?" Consumer Reports, February 1994.

Consumer Reports tested the Sun Frost super-efficient refrigerator noting is "astounding" $3015 price, about $2000 more than conventional refrigerators. The testers observed that "it is so massive that it might not fit in an existing niche. It has no rollers or leveling legs, so you have to use some effort to muscle it into position. The heavily insulated door needs 3.5 inches more side clearance than an ordinary model. ... the refrigerator section is very short, very small, and very low ... when we measured total gross volume, we found the Sun Frost to be 16 rather than 19 cubic feet."

As to energy efficiency : "To justify its energy use claims, Sun Frost appears to use standards that are quite different from those issued by the U.S. Department of Energy and followed by the rest of the industry ... Sun Frost reported 374 kWh per year ... our tests 495 kWh/yr." In addition, the temperature in the Sun Frost 'freezer' was a "balmy 23^{o}" while *Consumer Reports* notes "we've long used 0^{o} as our benchmark." When the Sun Frost was cranked down to reach as close to 0^{o} as it could achieve, the unit used 710 kwhr/yr compared to larger conventional freezer model's use of 825 kwhr/yr. This 115 kwhr/yr saving at 7¢/kwhr yields annual savings of $8.05 and a payback for the additional capital cost of 248 years.

118 The idea of "contingent valuation" is another externality approach to environmental protection that is not reviewed here, but that is already costing businesses money and is unquestionably goofier than most current approaches to externalities. Here's how it works: If conventional sources of funds collected from corporations for environmental damage in the form of direct clean-up costs and regulatory fines aren't sufficiently "just" (read "punitive"), there is the new fuzzy category called contingent valuation. A cross section of individuals are polled to see what they say a particular natural resource is worth to them personally, say a seal in Alaska, a whooping crane in Texas, or a slightly different looking sunset in Maine. The results of the poll are used to assess additional economic fines on corporations.

Zvi Griliches, Harvard economist, has observed that "Asking a housewife in Raleigh what a seal is worth to her in Alaska doesn't strike me as sensible." ("Fresh Ammo for the Eco-Cops," Business Week, November 29, 1993). Nonetheless, New York State regulators have collected $12 million over the past five years from contingent valuation judgments. The total toll collected by Federal and state regulators already exceeds $175 million (October 18, 1993 Justice Dept. Report)

119 "Minnesota Prices Externalities," Fortnightly, May 1, 1994.

120 "Emerging Externalities," E. Palola, Independent Energy, November 1992.

121 "A Mixed Bag," M. Brower et. al., Fortnightly, May 1, 1994.

122 15 "Methods of Valuing Environmental Externalities," P. Chernick, E. Caverhill, Electricity Journal, March 1991.

123 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.

124 "Saving Energy and Reducing CO_2 with Electricity, Electrical Power Research Institute, September 1991.

125 By far a simpler means to achieve this environmental and economic benefit would be to permit utilities to sell cheap electricity and provide appropriate rate discounts to end-users of electrotechnologies that have substantial environmental benefits. It is in principal feasible to trade the emissions "credits" that are associated with electrotechnologies, and that such trades could be engineered or facilitated by electric utilities.

126 Details on calculations and case studies for the examples in the table can be found in A CLEANER Economy, Mills•McCarthy & Associates Inc.

127 "A Mixed Bag," M. Brower et. al., Fortnightly, May 1, 1994.

128 "The Sun shines brighter on alternative energy," Business Week, November 8, 1993

129 Ibid

130 Even the mere act of regulating utilities (their rates, as opposed to health and safety issues) causes rates to increase. See for example: "Estimating the Financial Cost of Utility Regulation" Charles Studness, Fortnightly, November 1, 1993: "Under effective competition, average electric rates charged all utility customers would be reduced by 1.06 cents, from 6.58 to 5.52 cents per kilowatt-hour, which would produce savings of $24.4 billion for customers, based on 1992 usage." And: "Yet as large as those potential savings are, they do not include the benefits that competition would provide in spurring technological advances and broadening the range of customer choice."

131 "Mandate power," N. Munk, Forbes, August 1, 1994.

132 Data from NERC; calculations based on increasing CF

133 "Competitive Generation is Here," R. Sant, Electricity Journal, Aug/Sept. 1993.

134 "Repowering...A Ready Source of New Capacity," Energy Engineering, Vol 91, no. 1, 1994.

135 "Repowering," Special Report, Electrical World, March 1994.

136 "Repowering," Special Report, Electrical World, March 1994.

137 The disparity between IPP and traditional generation costs prompts questions about the reasons for the disparity in the first place, especially in cases where the IPP is operated by the same traditional utilities and people. Quite obviously, one major difference is the financial burden of social and regulatory issues that are attached to utility rates. The rapid rise in dependence on independent power is forcing a more realistic examination of the benefits of programs and taxes burdening the cost of a kilowatt-hour.

138 "Competitive Generation is Here," R. Sant, Electricity Journal, Aug/Sept. 1993

139 "Zero Emission from Coal by 2010?" RER Report, Fall 1991.

140 Virtually zero SOx emissions are already feasible. And, ABB has announced combustion technology that takes coal-fired NOx levels down to those of gas burners. (See for example, "Nix on NOx," Popular Science, July 1994.)

141 For a more extensive discussion, and statistical illustration of long-term trends showing declining historic resource prices -- even as consumption rises, see "The Reserve of Extracted Resources: The Historical Data," Julian Simon, to-be-published Non-Renewable Resources.

142 "Energy in transition" J. Holdren, Sept. 1990, Scientific American.

143 DOE projections encompass a base or reference case as well as a high and low range, including a low price projection of about $20/bbl by 2010. However, the reference case, which is the one typically used by other analysts and by states for purposes of planning, is for prices to reach nearly $30/bbl by 2010.

144 International Petroleum Encyclopedia, 1993, p. 11; only 1978 through 1984 did prices exceed this price band; the exploration boom and subsequent price collapse was stimulated by the brief escalation in oil prices beyond $25/bbl.

145 "History is full of giants that failed to adapt," Forbes, February 28, 1994.

146 Ibid; this is the reported cost for Royal Dutch Shell. Some majors still spend up to $9/bbl in finding costs.

147 International Petroleum Encyclopedia, also, "The Reserve of Extracted Resources: The Historical Data," Julian Simon, to-be-published Non-Renewable Resources.

148 "Analyzing the prospects for OPEC Countries' natural gas exports to Europe," H. Dahmani, OPEC Bulletin, October 1993.

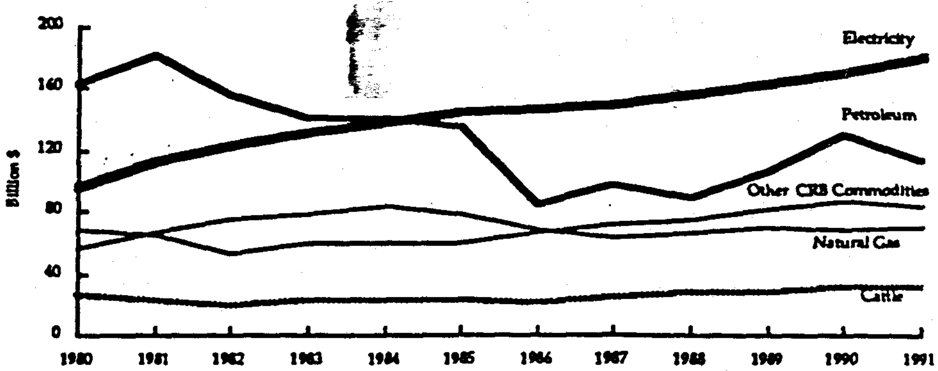
149 "Fuel Choice for New Electric Generating Capacity into he Next Century: Coal or Natural Gas" CEED, May 1994.

150 Electricity Futures Project, Edison Electric Institute, 1994

151 Ibid

152 Niagara Mohawk, for example, a leader in DSM programs is revamping its programs, and substantially reducing its DSM budget. Past DSM programs have been "successful in increasing net social welfare, but have had adverse impact on prices." The utility, like many others, would like to move away from cross subsidies. "Niagara Mohawk Changes Direction on Demand Side," The Quad Report, August 1994. Instead, the utility will pursue market-oriented DSM; i.e., programs that can make money on their merits.

89 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.



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

91 "Fed relying on Intuition In Rate Policy," K. Bradsher, Business Day, New York Times, February 28, 1994.

92 This started to happen to oil prices with the Gulf War, but then collapsed almost immediately as speculators perceived (correctly) that even a full scale war in the Middle East would not immediately or permanently impact oil supply and thus price.

93 "Fed relying on Intuition In Rate Policy," K. Bradsher, Business Day, New York Times, February 27, 1994.

94 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.

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

96 "The tail doesn't wag the dog," T. Mack, Forbes, January 31, 1994.

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

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

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

100 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.

101 Figure 13 was compiled using electricity consumption and price data from DOE/EIA Annual Energy Review. CRB commodities are based on department of commerce physical market price and consumption data.

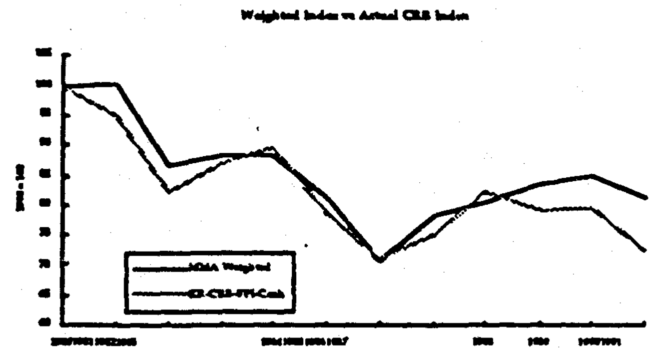
102

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	4,918	7,763	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

103 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.

104 The graph below 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 but this time using the weighted model developed for this report. As the graph shows, the two weighting systems, using the same commodities, produce similar results. We developed a model for this report in order to easily include electricity; the purpose of the graph below is to show that the model used produces largely the same results as the CRB model, when applied to the same commodities.



105 "The megawatt-hour store" Regional Report, Electrical World, August 1994.

106 "Another monopoly bites the dust," Forbes, May 23, 1994.

107 State Energy Data Report Consumption Estimates, DOE/EIA-0214; WSSC States include: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Wyoming, Washington

	Million kWh				
Region	1986	1987	1988	1989	1990
WSSC	432,886	4,495,96	474,796	488,485	505,593
REST	1,946,819	2,019,770	2,114,726	2,169,543	2,217,666
US	2,379,705	2,469,366	2,589,522	2,658,028	2,723,259
% WSSC of Total	18%	18%	18%	18%	19%

108 Statistical Abstract of the United States, U.S. Department of Commerce, 1993; Table 683: total private savings of $890 billion; Money Magazine, Sept 1994, p. 74: $2.1 trillion in mutual funds held in U.S.. These savings figures underestimate total real savings.

109 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.

110 "Shock Treatment for California Utilities?" Business Week, May 9, 1994

111 April 17, 1992 Editorial, Bangor Daily News

112 "Energy Choices Revisited: An Examination of the Costs and Benefits of Maine's Energy Policy," Mainewatch Institute, February 1994.

Mainwatch claims that while Maine's average electricity rate rose to 9.05¢ by 1992 compared to a national average of 6.84, when considered in 1987 constant dollars Maine electric costs dropped 3% from 1980 to 1992. They conveniently ignore that the national cost of electricity dropped almost four times as much over the same period (in the same 1987$ terms). In other words, Maine energy policies caused Maine's electricity to become vastly less competitive compared to what happened elsewhere and could have happened in Maine.

113 Actual net carbon dioxide emissions cannot be calculated without accounting for the lost opportunities for carbon dioxide reductions associated with greater electrification. Both historic evidence, and technology-specific calculations show that the average impact of electrification is to leave total carbon dioxide emissions unchanged, or slightly declining. Maine's policies not only discouraged efficient electrification through punitive pricing, but also through active discouragement of its utilities from marketing. Maine was by no means unique in this fashion.

114 "Electricity costs and the Maine economy: Review and prospects," Maine Policy Review, News & Commentary, C. Colgan, U. of S. Maine.

115 Electricity Futures Project, Edison Electric Institute, 1994

116 "What Does a Negawatt Really Cost? Further Thoughts and Evidence," P. Joskow, D. Marron, The Electricity Journal, July 1993.

Energy Choices in a Competitive Era

The Role of Renewable and Traditional Energy Resources in America's Electric Generation Mix

PREPARED FOR
Center for Energy and Economic Development

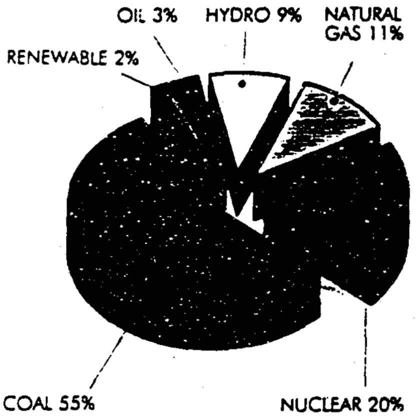
PREPARED BY
Resource Data International, Inc.

Energy Choices in a Competitive Era

IN 1994, U.S. ELECTRIC UTILITIES GENERATED 3 trillion kilowatt hours of electricity from a mix of energy resources, including nuclear power, hydroelectric, coal, natural gas, oil, and emerging renewable technologies such as solar, geothermal, biomass, and wind. For the country as a whole, coal-fired power plants accounted for 55% of all utility and non-utility electricity generated, with nuclear power contributing 20%, natural gas 11%, hydroelectric 9%, and oil 3%. Non-hydro renewable energy sources, including biomass, municipal solid waste, landfill gas, solar, wind, and geothermal, accounted for 2%.

As the country moves forward, demand for electricity is projected to grow at a rate of 1.5% per year. New generating capacity must continually be added to the nation's fleet of power plants and choices must be made about which technologies to employ. At the same time, the electric utility industry is undergoing a profound period of change and uncertainty as the result of the Clean Air Act Amendments of 1990 (CAAA) and the Energy Policy Act of 1992 (EPAct). While the CAAA are affecting generation and fuel choices, EPAct is heralding in an unprecedented level of competition and affecting the very ability of some utilities to survive.

U.S. GENERATION MIX, 1994
(BASED ON UTILITY AND NON-UTILITY GENERATION)



SOURCE: RDI 1995

This increasing emphasis on competition, in combination with the lowest fossil fuel prices in decades, is driving utilities and non-utility generation developers to choose traditional technologies for their capacity additions. For example, about 7,300 megawatts of new coal capacity are currently under construction or planned by utilities.

Meanwhile, the number of renewable energy plants under development has slowed dramatically and large portions of the renewable energy industry face economic failure as 1980s vintage power sales agreements based on high oil prices that were never realized begin to terminate, especially in California. Solar thermal, biomass, and geothermal will be the hardest hit, although some wind projects will also face difficulty. The national implications are apparent given that over 90% of the nation's solar, geothermal, and wind capacity is installed in California.

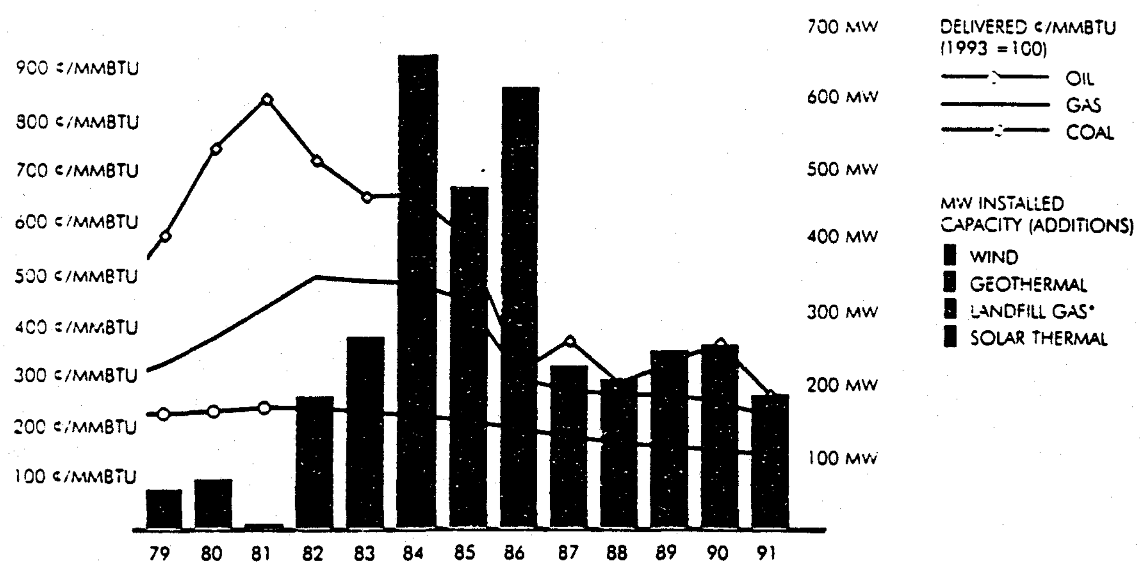
In response to the Public Utility Regulatory Act of 1978 (PURPA) and to the dramatic upsurge in oil and natural gas prices in the late 1970s and early 1980s, the renewables industry grew rapidly, with capacity additions peaking in the mid 1980s. However, as these new units were coming on line, oil and gas prices fell precipitously, resulting in a radical drop in renewable capacity additions by the early 1990s.

FUTURE GENERATION MIX SCENARIOS

Against this backdrop, public support for renewable resources persists for energy security and perceived environmental reasons. While the EPAct created barriers for further growth (and even re-licensing) of hydroelectric projects, it provides investment and production tax incentives for electricity generated from wind, geothermal, solar, and some types of biomass. This study examines the costs, capabilities, and feasibility of the various renewable energy technologies (excluding hydro), as well as state-of-the-art coal and natural gas technologies, and projects the future U.S. generation mix under three scenarios: (1) Base Case; (2) Full and Open Competition; and (3) Subsidy Intensification.

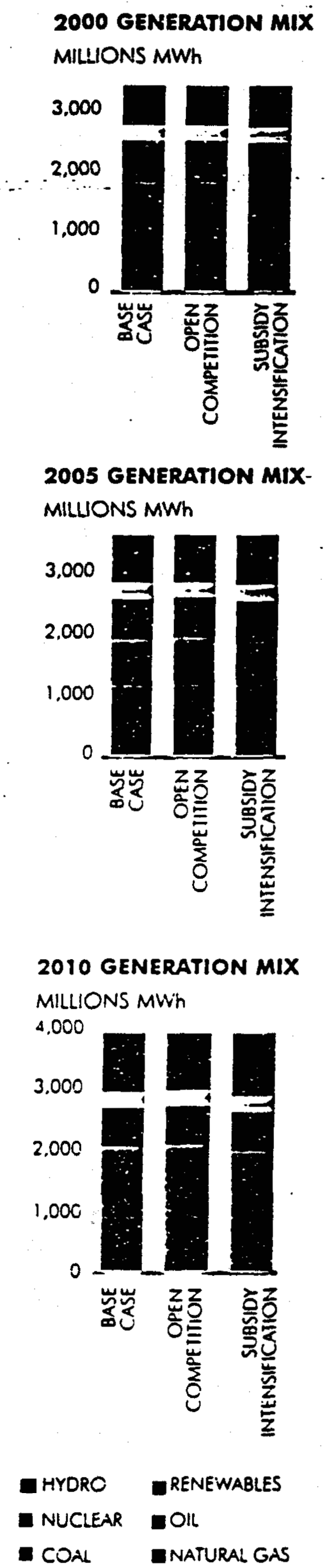
The results of this analysis show renewable technologies providing just under 3% of the U.S. generation mix by the year 2000 and about 4% by 2010, according to the Base Case

RENEWABLE CAPACITY ADDITIONS VS. DELIVERED FUEL PRICES
1979-1991



*BASED ON NUMBER OF PROJECTS PER YEAR AND MEAN CAPACITY OF 4 MEGAWATTS.
DATA NOT AVAILABLE FOR BIOMASS AND MUNICIPAL SOLID WASTE.
SOURCE: RDI POWERDAT 1995, AWEA 1995, GAA 1992, GEOTHERMAL SOCIETY 1992, SAND91-7014.

ELECTRIC GENERATION FORECAST UNDER THREE SCENARIOS



SOURCE: RDI 1995

scenario. Coal continues to drive the electric generation sector as the foundation of the country's baseload capacity at 54% and 53%, respectively.

Because renewable energy projects are not cost competitive, a Full and Open Competition scenario predicts a dramatic reduction of non-waste derived renewable energy generation by the year 2000, resulting in economic failure under 1980s vintage contracts in California and the inability of proposed new plants to win power sales agreements or secure financing. Waste-derived renewables continue to operate and grow only as an alternative to the costs of landfilling, open burning, and other waste disposal options.

However, the most telling results occur under a Subsidy Intensification scenario which posits a 50% subsidization of renewables production costs -- bringing average levelized costs in line with today's most competitive power alternatives. Even with this level of subsidization, electric generation from renewables garners only a 4% share of generation by 2000 and 11% by 2010. At the end of the forecast period, coal maintains its key role as the baseload fuel of choice at 51% of the mix, although natural gas falls to 11%, down from 18% under the Base Case scenario.

Therein lies an important finding of this study–that renewable energy sources stand to gain at the expense of natural gas more than any other competing technology. The reasons are many, but include the following: 1) renewables and natural gas play similar roles in the dispatch order; 2) renewables and natural gas will compete directly for small to mid-sized generation additions; and 3) coal will garner over half of all new generation, first through increased capacity utilization at existing plants and then through the construction of additional baseload projects which provide reliability and economies of scale.

TECHNOLOGY REVIEW

Contrary to popular belief, electric generation technologies are not always interchangeable, since they exhibit important distinctions between capability, resource availability, locational feasibility, and cost. Even within the category of renewable energy technologies, important differences persist. Demarcations exist between technologies that are combustion and

LANDFILL GAS (LFG)

In addition to direct combustion, garbage can also serve as an alternative energy source in a gaseous form. Once a landfill becomes compacted and all aerobic bacteria (i.e., those requiring oxygen) disappear, anaerobic bacteria begin to proliferate. Over the course of anywhere from 10 to 100 years these bacteria produce quantities of methane and carbon dioxide (CO_2) gases, in addition to other trace elements, that must be vented and either flared-off or released into the atmosphere. Recognizing a potential resource, a number of landfills now recover these landfill gases (LFG) for electricity generation or resale into gas markets. In 1991, fully two-thirds of all recovery projects generated electricity from 377 megawatts of capacity.

BIOMASS

Installed U.S. generating capacity based on biomass fuels stood at 7,415 megawatts in 1992, with more than 81% of that figure consisting of non-utility generation from wood and lumber industry residues. In fact, biomass is the largest of all grid-connected renewable energy sources, representing almost half of all installed U.S. renewable capacity (not including traditional hydroelectric). In many senses, biomass is hardly exotic or even an "emerging" technology. Biomass boilers are not very different from coal boilers, and the idea of burning agricultural waste is not new.

What is radical, however, is the concept of cultivating energy crops, and even energy forests, for the primary purpose of fueling boilers. Although the Energy Policy Act of 1992 (EPAct) provides a 1.5¢ per kilowatt hour production tax credit to the technology, costs remain high and there are currently no plants in commercial operation. Siting difficulties and land requirements add to high costs in preventing development. One estimate holds that 12% of the country's farmland would be required to provide 10% of the nation's electricity from such power plants.

MUNICIPAL SOLID WASTE (MSW)

The Environmental Protection Agency (EPA) defines municipal solid waste (MSW) as residential and non-process industrial wastes, excluding industrial process wastes, hazardous wastes, municipal sludge, and construction or demolition waste. The United States generates over 200 million tons of MSW every year, with 84% of that volume consisting of organic material and 16% consisting of inorganic material, such as glass and metals. Residential waste accounts for between 55% and 65% of annual volume. Just less than two-thirds of all MSW is disposed of in landfills, with approximately 20% recycled and more than 17% incinerated.

While some parts of the public support MSW as an alternative to landfills, others decry the environmental impacts of incinerating garbage. Indeed, emissions of heavy metals and other toxic elements are much higher from the 2,300 megawatts of existing MSW plants than from any other combustion technology. Nevertheless, stricter EPA landfill regulations are increasing the cost of landfills with the effect of comparatively improving MSW economics.

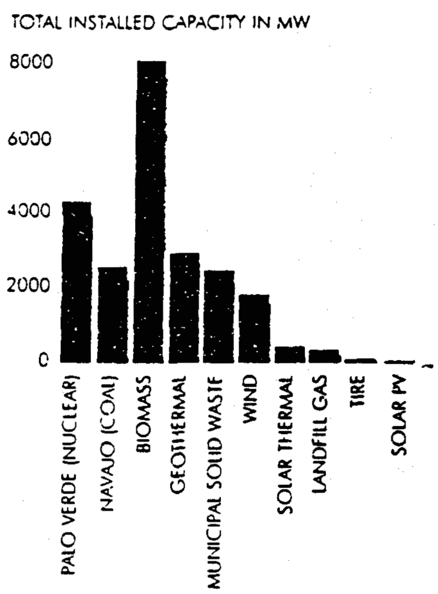
non-combustion, waste-derived and naturally occurring, intermittent and continuous, and land intensive and non intensive. However, the renewable energy technologies considered in this study have all developed to the point of commercial application.

CAPABILITY

The essence of an electric generation technology may be summed up in a characterization of its capability. Capability in this study is defined as the ability to generate electricity based on generating capacity and availability. In other words, capability determines the extent to which a utility can rely on the technology to meet electricity demand.

At the most basic level, generating capacity determines the amount of electricity that a plant can generate at any one time. Renewables vary in this regard from micro wind, solar, and landfill gas sites of less than one megawatt to about 150 megawatts for the largest biomass, solar, and geothermal plants. New wind farms are also generally limited to 150 megawatts or less, although the largest farm in the world, Tehachapi in California, exceeds 600 megawatts. Limitations on size result from both technological optimization and limitation of the available energy resources. By comparison, U.S. coal plants average 706 megawatts and range to over 3,000 megawatts.

U.S. INSTALLED RENEWABLE ENERGY CAPACITY VS. CAPACITY OF ONE NUCLEAR & ONE COAL-FIRED PLANT



SOURCE: RDI 1995

The ability of a utility to draw on generating capacity depends on the availability of the plant. Combustion technologies, such as coal, natural gas, biomass, municipal solid waste (MSW), and landfill gas (LFG), in addition to the non-combustion geothermal and nuclear technologies, present a high level of availability dependent only on planned and unplanned maintenance outages.

One indicator of availability is a plant's capacity utilization rate, which is a percentage of actual annual generation versus annual potential generation based on capacity. In this regard, new coal plants typically achieve capacity utilization in the range of 75-85% due to consistent fuel supply and relatively high availability, while LFG plants fare much worse as the result of unplanned outages that may average 51 weeks. Biomass agricultural waste plants may also experience somewhat lower capacity factors due to the seasonality of certain fuel stocks. Non-combustion technologies such as hydroelectric, solar, and

NON-COMBUSTION TECHNOLOGY OVERVIEW

WIND POWER

The United States is the world's largest producer of electricity generated from wind turbines, with installed capacity totaling 1,725 megawatts as of 1995. Although more than 90% of that capacity is located in California, utilities in six other states currently operate pilot projects. The further spread of wind power is limited geographically because the vast majority of the country's major wind systems are located in California and the Great Plains. Other limiting factors include the intermittent nature of wind, which results in a typical annual capacity utilization of 30%, and the land area required for siting wind farms. Avian mortality has also been cited as a problem, with preliminary studies finding hundreds of red tail hawks and dozens of golden eagles killed in turbine blades every year at just one wind farm in California.

SOLAR THERMAL

There are three well-developed solar-thermal technologies available today that can transfer solar energy into turbine-based electrical generation, including parabolic trough, parabolic dish and central receiver. All of these technologies rely on four system components: receiver, collector, converter, and transport/storage. Like wind, solar thermal technologies provide intermittent availability and are limited by resource availability to the Southwest and California. Although 354 megawatts of capacity are operating in California today, unfavorable energy market economics make development of new projects unlikely through the end of the century.

SOLAR PHOTOVOLTAIC

In 1994, over 400 utility sponsored Photovoltaic (Pv) sites produced close to 14 megawatts of capacity for the grid. While most of these utility projects are very small (less than 0.001 megawatts) and non-cost-effective in comparison to traditional generating technologies, industry specialists feel that Pv economics may someday be pushed over the threshold into market viability. This optimism is driven by the increasing production of consumer Pv cells (e.g., those used in watches and calculators) and a growing demand for stand-alone Pv systems in developing countries.

Nevertheless, costs currently remain high for central generation from Pv technologies. The most promising area for the technology lies in remote applications, where the cost of installing or upgrading distribution lines or substations may be more expensive than installing a Pv generator at a new demand center. In addition to economic limitations, solar Pv is limited by intermittent availability.

GEOTHERMAL

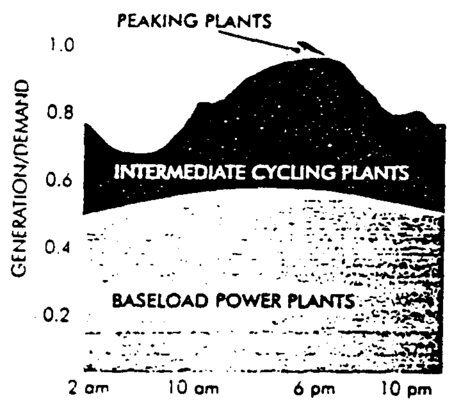
Four geothermal technologies are commercially available today: Dry Steam, Single Flash, Double Flash, and Binary Cycle. Dry Steam extracts naturally occurring steam from a well and runs it directly through a turbine. Flash plants pull hot water from a well into a separator tank where lower pressure allows a portion of the water to "flash" into steam and run through a turbine. Binary Cycle technologies run hydrothermal fluids in one loop and a power fluid (isobutane or ammonia) in another. These two loops align in a heat exchanger where the power fluid is vaporized and then run through a turbine.

Geothermal plants have proven a high availability, reaching annual capacity utilization beyond 90%. However, as with the other naturally occurring renewable energy sources, geothermal is limited by resource availability. California, Nevada, Utah, and Oregon possess almost all economically recoverable U.S. geothermal reserves, although pockets exist in other western states. Of the 2,700 megawatts of U.S. operating capacity, 90% are located wind depend on natural forces to provide their energy and therefore experience lower levels of availability. Hydroelectric generation takes place primarily in the Spring when water is plentiful, while lower levels of generation occur in the Fall and Winter when water is more scarce. To some extent, utilities can control availability by storing water in reservoirs. Conversely, storage technologies for solar and wind generation are not yet commercially available. Utilities employ intermittent wind and solar generation according to seasonal and even daily statistical probabilities, but cannot predict availability with absolute certainty. Capacity utilization for these technologies falls below 30%.

DISPATCHABILITY

The ability to control and draw on capacity to meet different levels of demand is central to electric utility economics. Throughout the day, utilities experience a relatively constant level of demand called "baseload" and a moderately fluctuating level called "intermediate." Sharp spikes in demand are called "peaks" and can occur when a large number of customers demand power simultaneously. A typical demand peak, for example, occurs when everyone turns on their air conditioners on a hot summer afternoon.

A TYPICAL DISPATCH PROFILE



SOURCE: RDI 1995

Utilities dispatch power plants at these different levels according to capability and cost. Plants assigned to baseload must be capable of continuously providing large amounts of electricity at a low operating cost, while plants assigned to intermediate load must be able to handle moderate fluctuations and are allowed a somewhat higher operating cost. Peaking plants must provide generation on very short notice, with less emphasis placed on cost. Therefore, coal and nuclear plants have historically served as baseload plants, not only because of their size, reliability, and low operating costs, but also because these technologies work best when operated at a continuously high level. Natural gas and oil serve as peaking units because of their higher variable costs and ability to increase generation quickly. Intermediate units consist primarily of larger gas plants with lower variable costs, as well as some older coal plants with moderate operating costs.

While renewable combustion technologies and geothermal may fit into this scheme, a special niche must be found for intermittent technologies. Solar and wind can neither be relied upon to provide large amounts of continuous generation for baseload nor can they be called upon to provide immediate generation for peaking. To adapt to these resources, utilities use intermediate or peaking generation to fill-in periods of low solar or wind generation. In a similar vein, some biomass plants provide generation seasonally, displacing traditional baseload or intermediate capacity when agricultural waste fuelstocks are plentiful.

Hydroelectric acts in the same way, with large displacements of coal and nuclear generation occurring in the Spring. Yet, this seasonal displacement of coal and nuclear plants is supported by the extremely low production costs of hydroelectric, while higher costs for solar, wind, and biomass generation provide little justification.

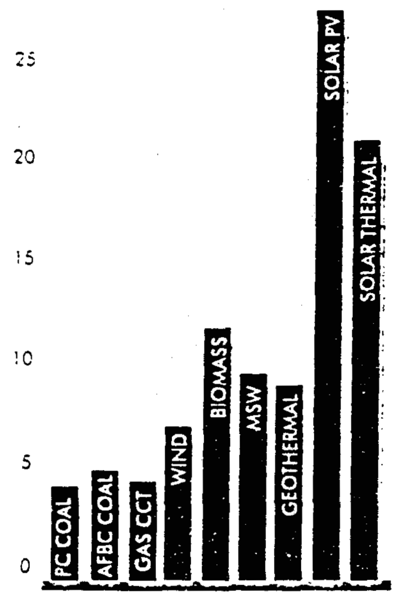
ECONOMICS

Production costs work in concert with capability to determine a plant's position in the dispatch order. If available, the least cost plants run first and the highest cost plants run last. This study compared the levelized production costs of the various renewable technologies, as well as coal and natural gas, to determine the competitive positioning of the technologies capable of providing new generating capacity.

There are three key factors that enter into the calculation of the levelized costs for each competing technology: 1) the cost of constructing and running the plant; 2) the projected cost of the fuel; and 3) the capacity utilization rate. RDI relied on EPRI's 1993 Technical Assessment Guide (TAG), in addition to vendor interviews, to determine the most likely plant designs and capital costs available today. For the cost of fossil fuels, RDI relied on its most recent regional fuel price forecasts as published in its *1995 Outlook for Coal and Competing Fuels*. Capacity utilization for fossil and combustion-based renewables plants is based upon the assumption that new plants will operate at the high end of the capacity currently attained by the newest state-of-the-art power plants for each technology. The following is a list of designs and operating parameters used in the base case cost analysis for each technology.

In order to compare the economics of various generating technologies, it is necessary to spread the capital cost over the plant's life and to add to this the projected ongoing operating and maintenance costs such as fuel and labor. In the chart below, the renewables subsidies provided by the EPAct have been factored into the levelized costs of these technologies, thus lowering their effective production costs.

LEVELIZED PRODUCTION COST COMPARISON, BASE CASE SCENARIO
(¢/KWH IN 1993 DOLLARS)



SOURCE RDI 1995

TRADITIONAL TECHNOLOGIES

- Pulverized coal (PC) plant with wet flue gas desulfurization located in the Southeast. One 400 megawatt unit burning bituminous coal, with an annual capacity utilization of 80%.

- Atmospheric fluidized bed combustion (AFBC) coal plant located anywhere in the U.S. One 200 megawatt unit burning bituminous coal, with an annual capacity utilization of 70%.

- Natural gas combined cycle turbine (CCT) unit located anywhere in the U.S. Capacity of 225 megawatts running at a 65% annual capacity utilization.

RENEWABLE TECHNOLOGIES

- Wind variable speed 0.2 megawatt turbine located in a Class 4 wind regime. Technology is based on the NREL Concept 1 with control electronics and advanced design airfoils placed on a 50 meter tower. Annual capacity utilization assumed at 29%.

- Biomass fluidized bed combustor burning wood and located in the West. One 50 megawatt unit operating at an annual capacity utilization of 70%.

- Waste-to-energy (WTE) MSW mass burn plant located in the West. 40 megawatts operating at an annual capacity utilization of 70%.

- Geothermal double flash plant located in the West. 1 to 25 megawatt unit operating at an annual capacity utilization of 90%.

- Solar flat plate Pv located in the West. 50 megawatt capacity.

- Solar thermal parabolic trough located in the West. 80 megawatt capacity operating at a 40% capacity utilization.

Sensitivities were examined for financing assumptions, regionality and capacity factors. In the end, the analysis found that coal technologies are consistently the least-cost generating option. With delivered fuel prices declining by 40% to 50% in real terms between 1983 and 1993 and coal-fired boiler capital costs following a similar magnitude of decline, coal has been able to outpace the gains made by renewable technologies and natural gas. At a levelized production cost of 3.3¢ to 4.4¢ per kilowatt hour under various discount rate assumptions, state-of-the-art coal PC boilers lead the list of new generating options, followed by AFBC coal plants at 3.9¢ to 5.2¢ per kilowatt hour. Natural gas CCT ranges in cost under these scenarios from 4.1¢ to 4.5¢. Renewables (including their subsidies) with the most promise include geothermal units with levelized costs ranging from 6.4¢ to 8.9¢ per kilowatt hour, wind at 5.2¢ to 8.7¢, and MSW from 6.9¢ to 11.9¢.

Cost estimates also varied regionally, with pulverized coal under the Base Case discount rate assumptions ranging from 4.2¢ per kilowatt hour in New England to 3.9¢ per kilowatt hour in the the South Atlantic. Natural gas combined cycle plants range from 5.0¢ in the South Atlantic region to 4.0¢ in the West South Central, and biomass from residue ranges from 9.3¢ in New England to 8.3¢ in the South Atlantic. In the end, a general analysis of the costs and capabilities of each energy resource may serve to educate, but a final decision about energy choices cannot be made without assessing the specific resources and projects in question.

With delivered fuel prices declining by 40% to 50% in real terms from 1983 to 1993 and coal-fired boiler capital costs following a similar magnitude of decline, coal has been able to outpace the gains made by renewable technologies and natural gas.

In order to assess the costs associated with the anticipated growth in renewable electricity generation–that is, electricity generated for the grid–the study examined the implications of both the Base Case and the Subsidy Intensification scenarios:

The **Base Case scenario** projects that total non-hydro generation from renewables will grow from 73 billion kilowatt hours (BkWh) in 1995 to 180 BkWh in 2010. At today's differential between the levelized cost of the most competitive generation and the projected mix of renewables, the cumulative "above market" cost of this generation between 1995 and 2010 will be $52 billion (1995$).

The **Subsidy Intensification scenario** posits a 50% subsidization of renewable energy. Under this extremely aggressive scenario, renewables generation grows from 75 BkWh in 1995 to 450 BkWh in 2010. For comparison, this level of generation is roughly one-fourth of today's coal-fired generation, three-fourths of today's nuclear generation or 110% of today's gas generation. Using current levelized costs as a basis of comparison, to achieve this level of generation the cumulative subsidies would total $203 billion (1995$) between now and 2010.

Different regions of the United States are endowed with different energy resources. However, while coal, oil, and natural gas can be transported both physically and economically to other parts of the country, renewables generally cannot.

LOCATION

Different regions of the United States are endowed with different energy resources. The West enjoys ample solar radiation, wind, and geothermal resources, while the East enjoys abundant biomass resources. Natural gas and oil are concentrated in the Gulf of Mexico and Alaska, and coal reserves are situated in the Appalachians in the East, the Illinois Basin in the Midwest, and the various coal basins of the Mountain region and Southwest. However, while coal, oil, and natural gas can be transported both physically and economically to other parts of the country, renewables generally cannot.

The fact that 90% of the nation's current solar, wind, and geothermal generation resides in California is no surprise when looking at a map of where those resources are located. In fact, the potential for harnessing any of these resources outside of California and other parts of the West is limited or non-existent. While utilities in Vermont, New York, Minnesota, and Colorado may be planning wind demonstration projects, the capacity additions that they might realize will be relatively insignificant and pale beside the wind farms of California.

REGIONAL LEVELIZED COSTS, BASE CASE SCENARIO
¢/KWH

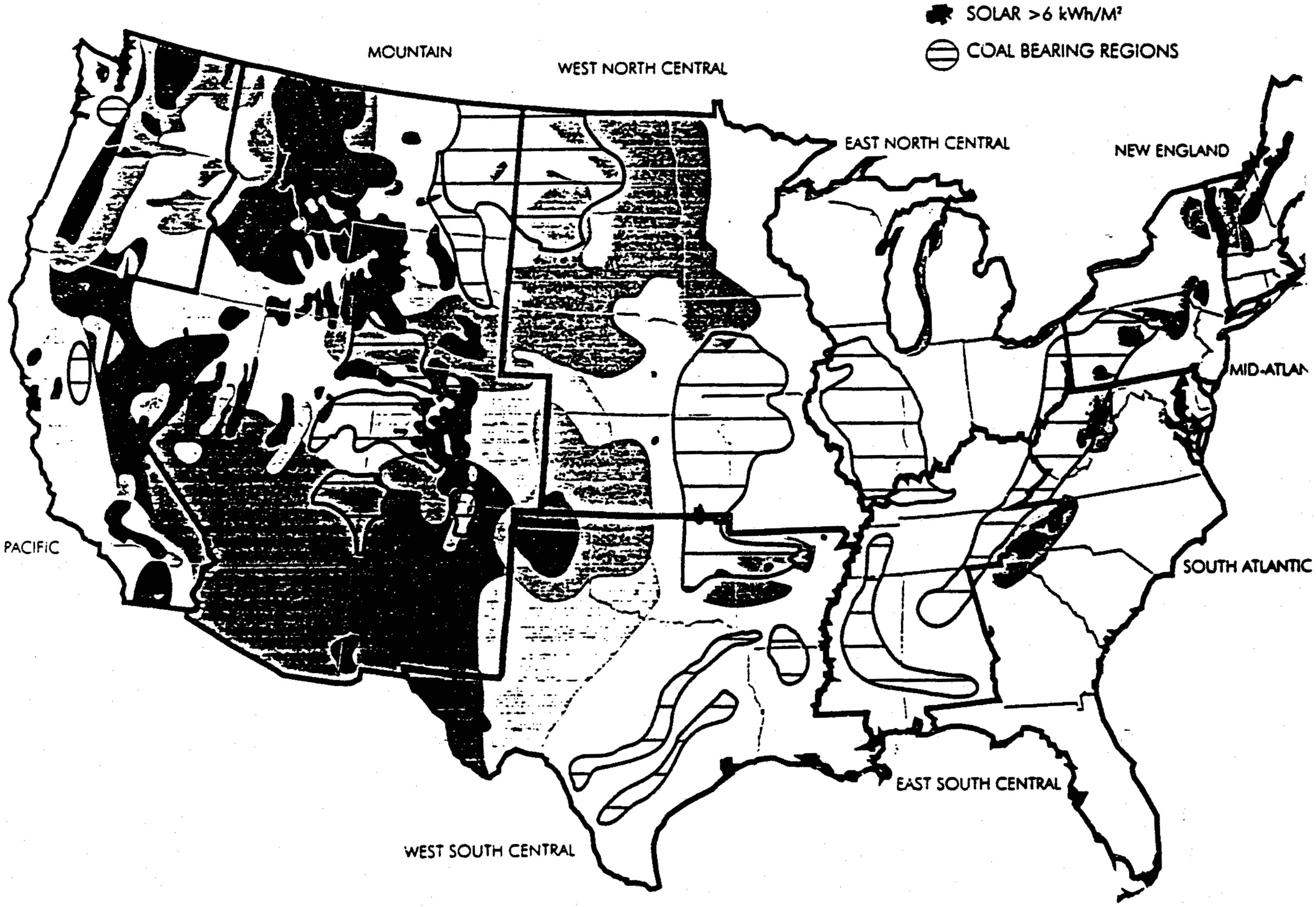
	SOUTH ATLANTIC	EAST NORTH CENTRAL	EAST SOUTH CENTRAL	MIDDLE ATLANTIC	MOUNTAIN	NEW ENGLAND	PACIFIC	WEST NORTH CENTRAL	WEST SOUTH CENTRAL	AVERAGE
Pulverized Bituminous Coal	3.9			4.1		4.2				4.1
Pulverized Subbituminous Coal		3.8	3.6.		3.5		4.0	3.5	4.0	3.7
Atmospheric Fluidized-Bed Combustion-Circulating	4.6	4.5	4.3	5.0	4.2	5.1	4.7	4.2	4.7	4.6
Natural Gas Combustion Turbine/ Combined Cycle	5.0	4.3	4.4	4.3	4.0	4.5	4.1	4.0	4.0	4.3
Wind-Variable Speed Turbine-Wind Class 4	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Wind-Variable Speed Turbine-Wind Class 5	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Wood-Fired Fluidized Bed Combustion-Residue	8.3	8.7	8.5	9.3	9.0	9.3	9.0	8.7	8.5	8.8
Wood-Fired Fluidized Bed Combustion-Energy Crop	11.5	11.8	11.7	12.5	12.2	12.5	12.2	11.8	11.7	11.8
Municipal Solid Waste-Mass Burning	8.5	9.3	9.0	10.6	10.0	10.6	10.0	9.3	9.0	9.3
Geothermal-Double Flash					9.2		9.2			9.2
Geothermal-Binary Cycle					8.0		8.0			8.0
Photovoltaic Central Station Flat Plate	28.7	31.6	32.8	42.4	19.6	38.4	24.5	24.1	23.5	27.4
Solar Thermal-Parabolic Trough					22.59		21.87		20.22	21.0

Similarly, low levels of rainfall in the West prevent agricultural and lumber industries from reaching the scale of such industries in the Southeast, Midwest, Upper Midwest, and Pacific Coast, and the low heat content of biomass fuelstocks generally prevents their economic transport beyond 50 miles. As a result, biomass generating technologies are limited in the West. The same follows for MSW and LFG generating technologies, which must be located near a metropolitan area or landfill. By comparison, coal is distributed to 47 of the 50 states for conversion into electricity.

A more specific locational issue relating to renewable energy is the fact that non-waste resources (i.e., solar, wind, and geothermal) tend to be located in remote areas. This presents a problem in terms of access to the transmission and distribution system, also called the "grid." The grid takes electricity generated at the plant and carries it to demand areas. Along the way, some electricity is lost on the lines, and these so-called

U.S. NON-COMBUSTION RENEWABLE ENERGY RESOURCES AND COAL RESERV

- WIND CLASS 4
- WIND CLASS 5
- WIND CLASS 6+
- GEOTHERMAL >90°C
- SOLAR 5-6 kWh/M²
- SOLAR >6 kWh/M²
- COAL BEARING REGIONS

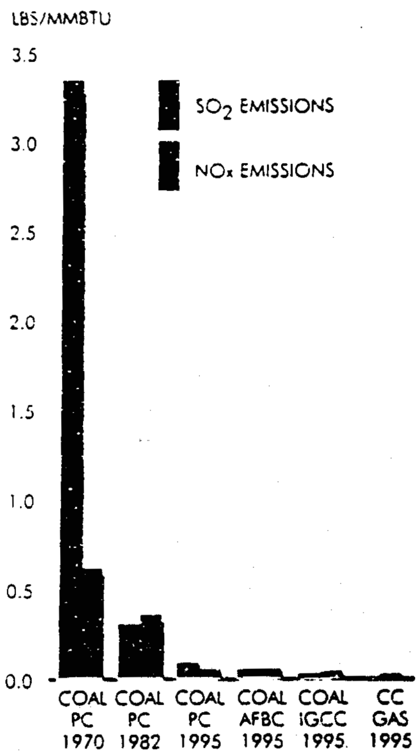


In 1995, state-of-the-art pulverized coal (PC) and fluidized bed combustion (AFBC) coal technologies present only 1-3% of emissions of earlier designs and compare favorably to integrated gasification and natural gas combined cycle turbines. All coal plants meet or exceed federal and state environmental regulations.

"line losses" increase with distance and the load on the grid. This fact, plus the considerable expense of building new transmission lines ($600,000 to $1 million per mile), severely impedes the construction of any power plant at a remote site unless it enjoys adequate economies of scale. Most renewable energy power plant projects do not exhibit such economies.

Finally, the large areas required by some renewable technologies also serve to further limit location. To supply just 10% of the nation's electricity demand with biomass generation, the U.S. would be required to plant more than 12% of all farmland with energy crops, such as hybrid poplars. For wind, one estimate calculates that 25 square miles would be required for a 50 megawatt farm. Likewise, solar thermal projects require roughly one-third square mile for each megawatt of produced electricity. Geothermal plants, however, require very little land, but are often located in wilderness areas.

COMPARISON OF EMISSIONS FROM VINTAGE COAL & GAS TECHNOLOGIES



SOURCE: PACE, STANLEY AND DALE SOPOCY, "DEVELOPMENT OF AN ECONOMICAL ADVANCED PULVERIZED COAL UTILITY PLANT COMMERCIAL DESIGN"

ENVIRONMENTAL IMPACTS

The Public Utility Regulatory Policy Act (PURPA) of 1978 is largely credited with creating the current U.S. renewable energy industry. However, PURPA originally intended to diversify the national generation mix for reasons of energy security, while renewable technologies are being pursued today because of their perceived environmental benefits.

Wind, solar, and geothermal present little, if any, emissions, and biomass, MSW, and LFG provide an alternative to landfills and open air burning of waste. Nevertheless, all energy technologies present environmental impacts. Wind, for example, consumes no fuel or water and gives off no emissions. However, it does present visual and noise pollution and kills a significant number of birds, particularly raptors, that fly into turbine blades. Solar Pv also consumes no fuel or water, but the Pv manufacturing process can involve hazardous chemicals that must be disposed of. Likewise, geothermal binary system plants create no emissions, although flash designs release hydrochloric acid and potentially hazardous hydrogen sulfides.

Combustion technologies cover a range of environmental impacts depending on the fuel combusted. The combustion of agricultural waste tends to be relatively benign, given that agricultural prunings and lumber residues would otherwise be

States adopting externalities are also imposing a cost on the public by increasing the local cost of electricity. Under the deregulation provisions of EPAct, industrial and large commercial electricity customers will be able to shop outside the state for cheaper electricity, while residential ratepayers will not. In short, advocates for renewable energy technologies are increasingly heading to public policy forums as they fail to make their case in the open market.

With delivered fuel prices declining by 40% to 50% in real terms from 1983 to 1993 and coal-fired boiler capital costs following a similar magnitude of decline, coal has been able to outpace the gains made by renewable technologies and natural gas.

CONCLUSION

On the whole, renewable energy technologies have demonstrated a limited commercial ability to produce electricity, some with environmental impacts that balance positively against waste disposal alternatives. Certain technologies in certain situations can hold their own in today's competitive marketplace. In most cases, however, the lower costs of traditional generating technologies have outpaced the gains made by renewables, and some sectors of the renewables industry face contraction rather than expansion.

This study demonstrates the capabilities and limitations of renewable energy technologies and provides a measure of reasonable expectation for their continued application. All represent niche technologies that can work in specific situations, while none offer a means to replace traditional generating technologies under current market conditions. Solar and wind do not have the capability to replace baseload coal plants, and biomass does not have the capacity. Few renewable technologies are economically competitive.

Meanwhile, reductions in hydroelectric capacity, due to new reservoir management regulations, and nuclear capacity, because of plant retirements, leave coal as the primary baseload energy resource capable of meeting the nation's growing energy demand. In that regard, continued favorable economics and dramatically improving environmental controls promise to reinforce coal as the fuel of choice, especially for baseload generation, well into the twenty-first century.

burned in an uncontrolled environment, and the same may be said of LFG which combusts methane gases that would otherwise have been flared or released into the atmosphere. MSW, on the other hand, generates toxic air emissions that would qualify as hazardous for other combustion technologies. Coal-fired power plants, which also employ combustion technologies, comply with a myriad of environmental regulations covering water, land, and air use. The most conspicuous of these is the Clean Air Act of 1970 and its amendments in 1977 and 1990. That legislation requires all new coal plants to employ smokestack technology that currently removes up to 95% or more of all sulfur dioxide (SO_2) emissions and provides limits on the emissions of SO_2 and nitrogen oxide (NO_X) from all existing plants. Largely as the result of these laws, SO_2 emissions in 1993 were lower than those in 1971, despite a doubling of coal-fired electricity generation over that period. When the CAAA take full effect in the year 2000, SO_2 emissions will be reduced by 62% and NO_X emissions by 33% from the levels generated by utilities in 1980.

Renewable energy advocates are increasingly heading to public policy forums as they fail to make their case in the open market. Southern California Edison calculated a cost of $560 million that would result from the state's latest round of renewable energy mandates (which were subsequently ruled out by the FERC).

PUBLIC POLICY SUPPORT

Acknowledging capability, dispatchability, economic, and location limitations, state and federal legislatures and regulatory bodies continue to support renewable energy technologies, partly as a measure of prudence in developing the energy resources of their region, but mostly because of their environmental appeal. Proponents cite the public benefits from the development of wind, solar, and geothermal resources, as well as the controlled combustion of agricultural and lumber waste in place of open burn.

However, such support comes at a cost. The California Biomass Energy Alliance, anticipating certain economic failure of its industry in an era of increasing competition, has proposed a 25¢ per month surcharge on ratepayers that the California Public Utilities Commission may consider in order to subsidize biomass plants. Southern California Edison calculated a cost of $560 million that would result from the state's latest round of renewable energy mandates (which were subsequently ruled out by the Federal Energy Regulatory Commission). In addition, EPAct provides a 1.5¢ per kilowatt tax credit to wind and certain biomass technologies, as well as a 10% investment tax credit.