COMPETITIVE ENTERPRISE INSTITUTE

ENVIRONMENTAL
STUDIES PROGRAM

GETTING IT WRONG:

ENERGY FORECASTS AND THE END-OF-TECHNOLOGY MINDSET

MARK P. MILLS

(Reprinted)
July 1999
ISSN: 1085-9075

GETTING IT WRONG:

ENERGY FORECASTS AND THE END-OF-TECHNOLOGY MINDSET

Mark P. Mills

EXECUTIVE SUMMARY

Just two decades ago, every environmental organization and a bevy of widely quoted energy experts predicted, nay practically promised, a bleak future by the late 1990s. They believed universally in an inevitable and rapid decline in the availability of fossil fuels that would create soaring energy prices with attendant economic and social disruption. Many intellectuals immersed themselves in studies, policy forums and conferences devoted to solving the looming problem of limited resources, especially fossil fuels, and limits to economic growth itself. The predictions emerged from a flood of "peer reviewed" studies, from computer models and technology evaluations. This pattern should sound familiar. Today, it is mirrored in language and prescriptions associated with adherents of the theory of human-induced global warming .

The track record of techno-forecasts arising from the "energy crisis" of the 1970s is instructive and relevant to today's global-warming debate, for it reveals much about how these soothsayers view technology change, compared to the actual nature of change in energy-related technologies. Two decades ago, the rich body of exhaustive and often "peer-reviewed" studies of energy options for leading the nation away from fossil fuels yielded a common theme. Underlying all these prognostications were assumptions about the prospects for technology solving the energy "crisis." How did the predictions fare?

Two things were clear to environmentalists and alternative energy advocates 20 years ago: Oil was disappearing, and electric demand would not, indeed should not, continue to grow. These self-appointed energy experts and environmentalists mounted furious campaigns calling for urgent federal and state funding for alternative energy programs.

The energy forecasts of these relatively recent days-gone-by were characterized by a breath-taking confidence on the part of environmentalists in their technology visions. A review of a large sample of the reports, studies and articles from two decades ago reveals that virtually all of the media, policy and regulatory community bought into a view of the near future (our present) that was utterly wrong. A representative sample of forecasts includes:

1981 "Conservative estimates project a price of $80 a barrel, even if peace is restored to the Persian Gulf and an uncertain stability maintained."
"Energy: A special report in the public interest," *National Geographic*, February *1981*.

1980 "It is now *abundantly clear* that the world has entered a period of chronic energy shortages that will continue until mankind has learned to harness energy from renewable sources."
Energy Strategy, Union of Concerned Scientists, *1980*.

1984 "We see electricity demand ratcheting downward over the medium and long term. ... The long-run supply curve for electricity is as flat as the Kansas horizon."
Amory Lovins, interviewed in *Business Week*, July 23, *1984*.

1980 "Because saturation levels for most major appliances are achieved, only minor increases in electricity consumption [will] occur." *Energy Strategy*, Union of Concerned Scientists, *1980*.

With regard to these few, but representative, examples of the record: Rather than escalating to over $100 (in $1998) as forecast, oil prices today remain about the same as the 100-year-long average price of about $17 a barrel. Far from experiencing "chronic" shortages, the world is awash in conventional energy. Renewable sources, excluding large-scale hydro — largely reviled by the environmental community — still account for under 1 percent of U.S. energy supply. As for the flat "supply curve" for electricity growth, in the years since the 1984 Lovins' forecast, electricity use has grown 40 percent. The market's appetite for electricity grew enough to require the additional output of 350 power plants, each in the $500 million scale. As for the Union of Concerned Scientists' 1980 forecast for flat growth in electric demand, actual demand soared 70 percent from the date of their assertion.

The record, as reflected in myriad reports, articles, and studies makes it clear that the bold energy forecasts cited above were typical of those put forward two decades ago when the last energy debate was in full swing. These forecasts were part of a pervasive culture of energy prognostication that led to the implementation of billions of dollars in federal and state research, development, tax incentives and regulatory programs to ensure that adequate "alternative" energy sources would be available. What followed in the two decades since these forecasts and programs was a 75 percent rise in the GDP made possible by traditional fossil fuels that supplied 65 percent of all net new energy, with nuclear power accounting for virtually all of the balance.

Without apology, and perhaps in part because of the absence of any mechanism for accountability, the same old crowd is at it again. Environmentalists and self-anointed energy experts were wrong 20 years ago. What credibility do such organizations and individuals have in making similar, often identical, energy technology forecasts today? Based on the record, the answer should be — none. The reason for the past and current failure of environmental energy forecasters can be found in their inability or unwillingness to understand technology progress in general and, more broadly, a paucity of imagination combined with a deep inherent pessimism regarding the technology innovations of industry.

If energy technology forecasting were a mutual fund established 20 years ago, it would have been bankrupt long ago and abandoned, rendered impotent by the power of market forces. But because energy forecasts directed at influencing federal and state policies entail the use of taxpayers' money, there is no "natural" market force for accountability. Clearly, being politically correct in energy forecasts means never having to say you're sorry, even if you are wrong. We imperil the nation's economic and energy future by ignoring the lessons of history, and basing policy on energy and economic forecasts made today by the same community of "experts" offering the same flawed nostrums as 20 years ago.

GETTING IT WRONG:

ENERGY FORECASTS AND THE END-OF-TECHNOLOGY MINDSET

Mark P. Mills

INTRODUCTION

The U.S. and the world's economies are inextricably anchored in the use of abundant and low-cost fossil fuels. Today the economies of the world use the energy equivalent of 60 billion barrels of oil a year. Fossil fuels supply almost 90 percent of all of that energy; oil alone supplies 25 billion barrels of the world's energy. And fossil fuels have provided 86 percent of the growth in energy supply over the past two decades. All this occurred as the average cost of fossil fuels collapsed over 40 percent from the brief peaks reached following the ill-advised OPEC oil embargo of 1973.

The reality of the magnitude and importance of fossil fuels appears to annoy environmentalists at some fundamental level. Two decades ago every environmental organization confidently forecast the end of the age of fossil fuels due to fundamental geophysical limits in supply. These limits were indicative, they said, of a transition to a permanent era characterized by "limits to growth" of all kinds.[1]

Two decades ago every environmental organization confidently forecast the end of the age of fossil fuels.

Instead of economic chaos inspired by energy shortages and soaring prices necessitating government intervention and rapid conversion to the ostensible nirvana of a renewable-energy-based economy, the world's economies kept expanding, fueled by abundant, low-cost conventional fuels. Oil reserves, far from declining, expanded to record levels even as consumption rose and prices collapsed. Global "proved" oil reserves in 1997 reached nearly 1,200 billion barrels; the finding cost for oil has dropped from an average of $4/bbl to about 50¢/bbl in the last four years alone.[2]

Mandated and heavily subsidized alternative and renewable energy programs, as well as conservation initiatives, fell out of favor in an environment of low prices and resource abundance.[3] Then came the popularization of the

[1] "Countries with expanding industry, rapid population growth . . . will be hit especially hard by economic energy scarcities from now on." *World Energy Strategies*, Amory Lovins, 1974.

[2] While beyond the scope of this paper, it is useful to note that widespread and profound advances in all aspects of technology have provided the fundamental drivers permitting rising reserves and production in the face of (actually because of) declining costs.
See "King Faisal and the tide of technology," P. Huber, M. Mills, *Forbes*, Nov. 16, 1998.

[3] See *Federal Incentives for the Energy Industry*, September 1998, Management information Services Inc., finds that in cumulative constant dollars, the second-largest recipient of federal energy subsidies have been renewable energy sources at $90 billion over the past five decades. (Oil received the largest cumulative funding.)

theory of human-induced global warming. This theory, anchored in the core assertion that carbon dioxide emissions from the use of carbon-based fuels (fossil fuels) threaten the planet's atmosphere, provides the basis for environmentalists' efforts to resuscitate the entire panoply of energy prescriptions and programs that have served as their raison d'être .

Carbon & Energy: Chemistry 101

This is not the place to delve into the fatal flaws in the theories of catastrophic human-induced global warming.[4] However, a little background is essential since the proposed restructuring of our entire energy infrastructure and economy is based on fear of carbon dioxide, CO_2, the primary gas implicated in the theories of catastrophic global warming.[5]

The proposed restructuring of our entire energy infrastructure and economy is based on fear of carbon dioxide.

As all middle-school students learn (or are supposed to learn), CO_2 is one of the minor natural constituents of the earth's atmosphere. CO_2 is partially responsible for keeping the surface of the earth warm by trapping the sun's heat in a phenomenon that was long-ago loosely termed the greenhouse effect — without which there would be no life on earth.[6] There are some additional important facts. The concentration of CO_2 in the atmosphere *has* been increasing for at least five decades (although, in terms of geophysical history, the time period of our direct measurements is a mere blink). It has been theorized that this increase in CO_2 concentration, measured in hundreds of parts per million, could lead to a catastrophic increase in the greenhouse effect and thus create the potential for world-threatening higher global average temperatures sometime in the next several decades or century.[7] Because the increase in CO_2 concentration is more-or-less coincident with global industrialization, and since carbon-based fuels are the primary source of civilization's energy, the theory is posited that human beings are: a) responsible for increasing global atmospheric CO_2 levels and thus, b) will be responsible for

[4] Lucid and scientifically grounded illumination of the scientific realities of global warming can be found in the newsletter *World Climate Report* (see www.nhes.com).

[5] It is useful to note that, by definition, the average temperature of the earth's atmosphere has not been and cannot be constant. Over time, the atmosphere is either warming or cooling in cycles. It *is* the case that the earth has been warming since the last Little Ice Age. An important consideration for humanity, again regardless of how warming might be induced (human or natural cycles), is whether it is better for the world to be getting warmer or colder; staying the same is not an option. Little has been said in the public debate about the debilitating human, agricultural and economic consequences of global cooling.

[6] There are other natural contributors to the greenhouse effect, of course, including water vapor (which incidentally, is an aspect of the geophysics of the atmosphere that has been generally ignored in human-induced global-warming computer models).

[7] The models that are purported to support this theory predicted, 20 years ago, that the average world's temperature would have been measurably higher before the year 2000. It isn't. Again, for on-going news about this scientific issue and, in particular, historic and current data showing global average atmospheric temperatures as measured by NASA satellites, see *World Climate Report* at www.nhes.com.

cataclysmic increases in future temperatures. This convenient coincidence[8] has resuscitated the fervor of environmentalists for renewable energy sources.

It is critical to note that CO_2 is not a pollutant, although environmentalists, and now the U.S. Environmental Protection Organization (EPA), are attempting to label it so through vigorous assertion.[9] Indeed, far from being a pollutant, i.e., an unintended by-product, carbon dioxide is the intentional product of activities needed to obtain energy, which is to say the oxidation (burning) of carbon to produce energy plus carbon dioxide.[10] A simplified "chem 101" formula looks like:

$$C + O_2 \text{ Þ energy} + CO_2.$$

Climate Insurance: You're In Good Hands?

Oil, natural gas and coal are all carbon-based natural resources. It is precisely because carbon fuels are so pervasive and so important to civilization that schemes to reduce or replace fossil fuels have such significance. Schemes to "meaningfully" reduce CO_2 emissions require reductions of 50 percent or more in the use of fossil fuels. The only way that environmentalists can justify the draconian measures required to meet such a target is to posit a consequence of enormous global scope, to wit, catastrophic global warming. But there is a problem with this approach. If, after all, global warming presents a problem so daunting that solutions seem fruitless, and if the problem is so far off in time that the risks from fuel combustion seem too theoretical, then environmentalists are left with little of sufficient immediacy to demand such massive federal (and international) intervention on behalf of non-fossil fuels.[11] The core strategy proposal is that the U.S. government is

Carbon dioxide is the intentional product of activities needed to obtain energy.

[8] It is far from clear in the scientific literature that one can attribute human production of carbon dioxide as the primary cause of geologically recent increases in atmospheric concentration; without going into the details here, this uncertainty arises from a great deal of ignorance (although improving yearly) about the historic and "normal" levels of CO2 in the atmosphere, and great uncertainties about natural sources and sinks of CO2 which together are at least an order of magnitude greater than those associated with human activities. For example, it has only recently been learned that the United States is probably a net absorber of CO2 (counting industrial emissions) because of agricultural uptake. (See *World Climate Report*, www.nhes.com, 10/26/98 edition.)

[9] See for example, "EPA's Authority to Regulate Pollutants Emitted by Electric Power Generation Sources," U.S. EPA Memorandum of 4/10/98 from the EPA Office of General Counsel to EPA Administrator Carol Browner.

[10] There are other byproducts which result from incomplete combustion and the presence of contaminants in the carbon fuels; these are properly called "pollutants" and their production mitigated by various engineering schemes. Other chemical reactions are available to produce energy, principally those involving hydrogen and oxygen, the basis for fuel cells. The problem with hydrogen is that, although it is the most abundant element in the universe, for all practical purposes there is essentially none left on Earth; it must be produced as a byproduct from the constituents of natural gas or water.

[11] To be fair to environmentalists, there are others in the global warming "game" who have much to gain by convenient association with schemes that are dominated by anti-coal proposals. Typifying this line of reasoning was the September 1998 announcement for The Aspen Institute whose headline says it all: "Top Energy, Environment Leaders Urge President and Congress to Depoliticize Climate Debate, Take Long View, Start Now."

obligated to begin immediately the transition to a low or zero carbon fuel future as an "insurance policy" precisely because the task is so daunting, and because by beginning now we might have time to avert calamity. The essence of this climate insurance policy strategy then is anchored in two premises:

- The stakes are too high to take a chance. What if human-induced global warming *is* real, the argument goes, the consequences are so serious that action by government and industry is needed now. Waiting makes the shift to new lower-carbon technologies more difficult and more expensive. Typical of this rhetoric is: "The longer we wait, the greater the accumulation of fossil-fuel-dependent capital stock, and the more disruptive and costly future greenhouse reductions will be."[12]

- We've got nothing to lose by starting the shift to renewable, non-fossil fuels and more efficient end-use energy technologies because looming shortages of conventional resources require us to shift away from fossil-fuel-based energy. This notion has provided the basis for environmental energy technology nostrums for decades. (It has served as the basis for Malthusian forecasts for two centuries.)[13]

According to global warming's true believers, the United States must abandon its "addiction" to carbon-based fuels.

According to global warming's true believers, we cannot delay. The United States must, they assert, abandon its "addiction" to carbon-based fuels soon anyway; and leading environmentalists, such as Bill McKibben, argue that we live in a "special moment in history" calling for bold government action.[14] This "special moment" is said to be created by our "understanding" of the emerging danger of catastrophic global climate change.

The technology insurance policy argument presents policymakers with a more comfortable motive, and moves the discussion from the arcane realm of global climate science to the gritty arena of government funding for energy technology programs. Alternative energy technology programs are viscerally appealing. Who can deny the appeal of solar power? Rationales for federal funding are anchored in the notion that we are going to need practical

---

[12] *Taking Action on Climate Change: Debunking the Myths*, World Resources Institute, www.wri.org.cpi.climyths/.

[13] Again, typical of this rhetorical argument are the following two conclusions published in eminent and credible journals: "Global production of oil from conventional sources [of oil] is likely to peak and decline permanently during the next decade." "Preventing the Next Oil Crunch," special section, *Scientific American*, March 1998.

"As the peak in [oil] production approaches, prices will begin to rise and the United States will have to quickly shift to new energy sources to mitigate the impacts on its heavily oil-dependent economy."

"Heading Off the Permanent Oil Crisis," James MacKenzie, World Resources Institute (WRI), *Issues in Science & Technology*, Summer 1996.

[14] "A Special Moment in History," by Bill McKibben, *Atlantic Monthly*, May 1998.

renewable energy technologies eventually, maybe even soon, regardless of the outcome of the climate science debate. The goal for advocates here is to attempt to obviate any debate over the scientific validity of the theory of global warming.[15]

The Role of Forecasting

Thus, central to the energy technology insurance policy argument, and to the core of all global-warming forecasts, is the credibility of energy technology forecasts in general. Forecasting skills are required in all aspects of energy in our society. One must forecast with accuracy the technologies that will determine how much energy can be found, extracted, transported and converted into useful forms. Additionally, one must forecast with reasonable accuracy how future technologies will impact the way in which energy will be used to make clothes, grow food, move people, manufacture cars and computers, ad infinitum. Because of the pervasive role of energy in society then, at the heart of all energy forecasts are presumptions regarding future technologies of all kinds.

Forecasts from the past provide a way to assess the credibility and accuracy of today's energy forecasts.

The technology forecasts of global warmers and alternative energy advocates encompass two time frames: 20 years and 50 to 100 years. The 20-year time periods for forecasting are essential for motivating policy-makers to allocate funds. This is the traditional time period used by virtually all forecasters in the energy business, including the authors of the annually released Energy Information Administration forecasts. The 50-to-100-year time period is required by the nature of global-warming theory — it is the time period during which the truly catastrophic consequences are forecast to occur, a time period in which we in this generation are said to face a "special" obligation to our descendants.

Global-warming adherents and alternative energy advocates appear by all counts confident in their technology forecasts, at least confident enough to encourage the profligate use of taxpayer funds for new energy programs. But do energy technology forecasts have any credibility? Who, 20 years ago, anticipated the energy requirements of PCs (their share of electrical use in commercial buildings is almost equal to the lighting load), or the energy and material needs for PC manufacturing? When it comes to 50-to-100-year forecasts, who in 1898 could have forecast the energy, infrastructure and economic (not to mention social) implications of cars and aircraft? Forecasts from the recent, and not so recent, past actually provide a way to assess the credibility and accuracy of today's energy forecasts. In addition, the energy forecasts of 20 years ago were made by many of the same organizations and

[15] Once again, from WRI: "The actions needed to address the threat of climate change, however, provide an opportunity to chart a more sustainable course into the future as individual firms and national economies become more efficient, embrace environmentally sound technologies, and *accelerate the transition to a global economy fueled by renewable energy resources*." http://www.wri.org/wri/cip/aboutcpi.html.

some by the very same people still active in advocating that economic life be adjusted to accommodate their vision of the future.

The Stakes

Environmental organizations and alternative energy advocates in the Administration are vigorously pursuing an agenda to ensure that federal and state energy policies embrace radical changes in the energy supply system of the nation.[16] Even the prestigious national federal laboratories, at the invitation of the Administration, have weighed in with a multi-laboratory assessment of accelerating renewable energy, to mitigate carbon emissions from fossil fuels, of course.[17]

The economic costs of a wholesale federal funding of alternative energy technologies penetrates far deeper into the economy than the mere squandering of taxpayers' dollars.[18] It is not enough to fund programs to "advance" alternative energy; environmentalists want requirements and incentives to accelerate the market's use of the new technologies, not the least of which is the oxymoronic goal to establish mandated shares of electric supply from renewable energy as a keystone in the "competitive" restructuring of the electric industry.

At stake are literally trillions of dollars in net present-value capital assets in today's energy infrastructure.

Encouraging or requiring the use of different energy technologies (selected by government fiat) will impact capital markets, since funds will be needed to replace otherwise perfectly useful existing technologies that provide and use energy. This misdirection of funds not only represents a lost economic opportunity associated with capital (a truly limited resource) that could have been used productively elsewhere (say, to improve profits), but the technology/equipment that is being displaced also represents a loss to the economy in the form of the abandoned residual capital value. At stake are literally trillions of dollars in net present-value capital assets in today's energy infrastructure. The economic fallout resulting from ideologically driven and ham-handed tampering with future technology choices is potentially staggering. Alternative energy advocates have not quantified these costs, nor are they likely to. Opponents of policy proposals based on global warming point to studies showing job and gross domestic product (GDP) shrinkage from

---

[16] This goal is by no means isolated to global-warming-inspired theories; see for example the June 25,1998, "Proposed Changes to the Regional Haze Rule To Facilitate Grand Canyon Transport Commission Recommendations," from the Western Governors which contains the idea to establish a "renewable energy goal of 10 percent by 2005, and 20 percent by 2015" for Western states' total electric generation.
See also "Mideast Oil Forever?" April 1996, *Atlantic Monthly*, authored by two U.S. Department of Energy employees.

[17] *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy Technologies by 2010 and Beyond*, Interlaboratory Working Group on Energy-Efficient and Low-Carbon Technologies, prepared for the Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, September 1997.

[18] After all, the billions already spent on renewables over the past two decades in federal and state programs and incentives have brought the nation to the unremarkable point of having a mere 0.1 percent of total energy supply from the favored alternatives of solar, wind and geothermal.

higher energy prices. As serious as the economic penalties from higher prices may be, this could be the least of the damage.

DISMAL FAILURE: THE ENERGY TECHNOLOGY FORECASTING RECORD

"In the future, scientists will learn how to convert stupidity into clean fuel."
Scott Adams, Prediction #16, The Dilbert Future, *1997.*

The basis for the assessment of the energy technology forecasting record of environmentalists, complicit organizations, and individuals, is an archival collection of hundreds of studies, reports, books and articles issued during the energy crises epoch of about two decades ago.

In the 1970s and early 1980s, there were four core mantras for environmentalists, self-anointed energy prognosticators and apocalyptics:

1) All energy prices would soar;
2) Oil resources would soon disappear;
3) Renewable energy technologies were on the verge of becoming viable and cost-effective; and
4) Electricity consumption would not, and could not, be permitted to rise.

All four of the core tenets were shown by the passage of time to be wrong.

All four of the core tenets were wrong and were shown by the passage of time to be wrong for fundamental reasons relating to the progression of technology in a dynamic marketplace. Following are some representative citations from the studies and papers of that long-forgotten energy crisis era for each of the above four core areas. (A larger representative, but far from exhaustive, collection of forecasts is contained in the Appendix.)

Energy prices would soar

"Conservative estimates project a price of $80 a barrel [in 1985], even if peace is restored to the Persian Gulf and an uncertain stability maintained."
National Geographic, February 1981.

The price of energy is the single most important metric reflecting the collective impact of fundamental technology and resource trends.[19] Forecasting price thus is based almost entirely on the ability to anticipate the entire range of technology factors relating to how energy resources are found, transported, converted and used.

[19] It is obvious, but important nonetheless to state, that short-term price distortions can happen, have happened and will continue to occur due to political meddling, geopolitical strife and misguided policies; but over time such price variations disappear in the long-term price trends. Oil, for example, has oscillated around a price of $17/barrel (inflation-adjusted 1998 — see International Petroleum Encyclopedia) for 100 years, with brief excursions below (rarely lower than $10) and above the median.

During the peak frenzy years of the energy crises, there were many, in fact probably thousands, of price forecasts for energy in general and oil in particular. Even the esteemed National Geographic Society weighed in on this issue. The energy crisis was such a hot issue that *National Geographic* magazine took the step of producing a special issue devoted exclusively to the energy crisis. This rare seminal special issue led with the following conclusion. Far from stepping out on a forecasting limb, the *Geographic*'s introductory observation about future oil prices, a bellwether for all energy prices, was carefully researched and represented the widespread wisdom of the day. All official and expert projections of that era saw energy prices rising. When forecasters hedged by providing a range of possible future prices, even the low ends of their ranges were far higher than the prices we enjoy today. Typically, the projected range for energy prices made in 1975 for the year 1995 were (in terms of dollars per million BTUs of energy):[20]

The average price of fossil fuels is nearly 50 percent lower today than the peak prices experienced over the past two decades.

- Coal was projected to reach $3 to $5
  — actual price today ~$1;
- Oil projected $6 to $11
  — actual price today ~$3; and
- Natural gas projected $4 to $8
  — actual price today ~$2

For the record: the average price of fossil fuels is nearly 50 percent lower today than the peak prices experienced over the past two decades. Oil prices have difficulty sustaining the $20 per barrel level even during times of turmoil, such as the Gulf War; prices in 1998 hovered in the mid-teens. The $20 level is a mere fraction of the price forecast by experts and environmental alarmists in the 1970s. In inflation-adjusted terms, the $80 barrel would be over $160 in today's terms.

Well, so they were wrong about the energy crisis of two decades ago. The argument we are presented with today by environmentalists is that global warming is different and requires a new look at our energy future.

Oil resources would soon disappear

1974 "Countries with expanding industry, rapid population growth . . . will be hit especially hard by economic energy scarcities from now on."
World Energy Strategies, Amory Lovins, 1974

[20] See for example an excellent summary of historic price forecasts from the U.S. DOE's Energy Information Administration by Bruce Humphrey, "A Failure of Imagination," *Electric Perspectives*, May/June 1996.

1979 "The energy future is bleak and is likely to grow bleaker in the decade ahead. We must rapidly adjust our economics to a condition of chronic stringency in traditional energy supplies."

James R. Schlesinger, first Secretary of Energy, speech to the National Press Club, Washington D.C., Aug. 16, 1979, published in the Congressional Record, 9/24/79.

1980 "It is now *abundantly clear* that the world has entered a period of chronic energy shortages that will continue until mankind has learned to harness energy from renewable sources [emphasis added]."

Union of Concerned Scientists, 1980 Energy Strategy

1977 "The supply of oil will fail to meet increasing demand before the year 2000, most probably between 1985 and 1995, even if energy prices are 50 percent above current levels in real terms."

Massachusetts Institute of Technology International Workshop & Report 1977

1979 "The oil-based societies of the industrial world cannot be sustained and cannot be replicated. The huge increases in oil prices since 1973 virtually guarantee that the Third World will never derive most of its energy from petroleum."

Worldwatch Institute, 1979

Nothing resembling the gloomy forecasts cited above happened. In what is clearly in retrospect an alarmist viewpoint, James Schlesinger, President Carter's Secretary of Energy, the first to occupy that new post, was in fact merely reflecting the collective energy and technology wisdom of the times. As is now well-known, the nation's economic expansion since 1979 is almost unprecedented in the 20th century. So too has been the general economic expansion of the global economy. Secretary Schlesinger could be forgiven his pessimism in the context of the times. This was, after all, an era which spawned the Club of Rome's seminal study, "The Limits to Growth," and its progeny. These studies, all based on careful, thoughtful, intellectual analyses and computer models saw the near future in the same terms as articulated by this nation's first Secretary of Energy.

All technical and geological indicators point to a period of "chronic" low-cost conventional energy abundance.

Following OPEC's unwise short-lived price escalations of the 1970s, Americans experienced a period of energy abundance driven by normal market forces and profound improvements in technology which continue today. U.S. oil consumption continues today at about six billion barrels per year, and world oil consumption has risen by over 2.5 billion barrels per year. All technical and geological indicators point to a period of "chronic" low-cost conventional energy abundance for the foreseeable future. In fact, U.S. reserves of oil and natural gas are up and have increased by record amounts during the year when prices were at record *low* levels. Oil discoveries per exploratory well in 1997 were six times the rate of the early 1980s when oil prices peaked.[21] Following the oil embargo, the conventional wisdom was that U.S. reserves were doomed to plummet, and rapidly. Yet over the past 25 years, a cumulative total of 80 billion barrels has been pumped from U.S. oil wells, and another 24 billion found to add to reserves, yielding a total of 104 billion barrels of oil from domestic sources. The conventional wisdom

[21] "U.S. oil reserve gains," *Oil & Gas Journal,* Sept. 28, 1998, p. 27.

in 1973 was that the United States had 33 billion barrels of proved oil reserves left, and that was it.

As for the world, not only are the planet's oil wells producing at record levels, but proven oil reserves are double what they were two decades ago.

Renewable energy technologies were on the verge of becoming viable, and cost-effective

1979 The Carter Administration's goal is to provide 20 percent of all energy "from the sun" before the year 2000.
"A Progress Report on Alternative Energy Sources," *Fortune*, Sept. 24, 1979.

Windmills and solar power contribute to under 0.5 percent to the nation's energy.

1979 There is an " inevitable transition toward an economy based on renewable energy sources."
"The Good News About Energy," President's Council on Environmental Quality, 1979.

1980 "One clear solution emerges: an aggressive strategy emphasizing improvements in energy productivity and the implementation of a variety of attractive solar technologies that can lead us out of the morass and onto the road to a safe and sustainable energy future."
Energy Strategies by the Union of Concerned Scientists published in 1980

1979 "The range of energy possibilities grouped under the heading 'solar' could meet one-fifth of United States energy needs within two decades."
Energy Future , Energy Project of the Harvard Business School, D. Yergen, R. Stobaugh, 1979

1981 "The [energy] Plan will require massive investment in equipment and processes that use energy more efficiently and in solar energy processes over the next 20 years. ... The $675 billion [Federal] investment in energy efficiency required by the Plan over the next 20 years will end up saving our society at least $300 billion."
National Audubon Society's 1981 Energy Plan.[22]

For the record, windmills and solar power — the sources environmentalists and the general public perceive as energy "from the sun" — contribute to under 0.5 percent to the nation's energy.[23] The only thing that is "inevitable" about renewable energy sources is the inevitability that advocates will continue the same refrain.

---

[22] Note that the Audubon Society in 1981 suggested that efficiency investments would be partially paid back by future savings. They had not yet adopted the now bolder assertion from environmental organizations that virtually any, often expensive, energy efficiency investments achieve *full* pay back.

[23] DOE/EIA Annual Energy Review 1998.
Environmentalists and journalists are often loose in the implicit or explicit definition of both renewable and solar energy. To be sure, burning trash and wood, and large-scale hydro are frequently included in the broader "renewable" category — and some environmentalist even put wood and hydro in the "solar" category when attempting to disingenuously inflate the "solar" contribution (the sun makes the trees grow and the water evaporate yielding rain and thus rivers. . .). As a practical matter when advocates say renewables and solar in particular, they are generally referring to, and most people take it to mean, solar cells and windmills, which provide minuscule amounts of energy for the nation. Even when all the other "renewable" sources are included (except large scale hydro which is universally reviled by environmentalists), the national contribution still does not break the single digit percent range.

These renewable prescriptions are echoed in today's exhaustive "peer-reviewed" studies of the nation's energy options that are proposed to reduce the use of carbon fuels in a global-warming constrained world. The problem is that there have not been any fundamental changes in science or technology relevant to solar energy and the standard panoply of alternatives to portend any more likelihood of such forecasts materializing in the next 20 years.

Electricity consumption would not, and could not be permitted to rise

1984 "We see electricity demand ratcheting downward over the medium and long term. ... The long-run supply curve for electricity is as flat as the Kansas horizon."
Amory Lovins, interviewed in *Business Week*, July 23, *1984*.

1982 "In no industrial country can additional electricity be used cost-effectively because the 'electricity-specific' needs are already met by present capacity with a good deal left over."
Electrical Week, Aug. 2, *1982*, "Lovins charts soft path."

1980 "Because saturation levels for most major appliances are achieved, only minor increases in electricity consumption [will] occur."
Energy Strategy, Union of Concerned Scientists, *1980*.

1979 "Despite its much-touted abundance, coal will not become our major near-term solution to the energy problem."
Energy Future, Report of the Energy Project of the Harvard Business School, Ed. Robert Stobaugh, Daniel Yergen, 1979.

Total demand for electricity grew 70 percent over the past two decades.

Coal did become our major energy source, supplying about 45 percent of all net growth in the U.S. energy supply following the publication of *Energy Future*, which was the most widely read book on energy of that era.[24] More importantly from the market perspective, coal supplied two-thirds of all the increased supply of electricity over the past two decades. Over 90 percent of the GDP is associated with non-transportation activities, wherein 99 percent of all electricity is consumed, and where total demand for electricity grew 70 percent over the past two decades.[25]

Environmentalists both hoped and believed that electricity demand could not continue to rise. Massive federal and state investments were made in "demand-side management" programs, and utilities everywhere were discouraged or prohibited from engaging in promotional practices. There were substantial improvements in electricity efficiency. Yet demand for electricity has soared by 70 percent since 1977, despite two decades of anti-marketing. The central reason for the increased demand, and the failed forecasts, was the explosion of new electric technologies and applications which has taken place

[24] *Energy Futures* was the most popular energy document of those days and was, in fact, issued as a book and became a best-seller, possibly the only best-seller ever on the subject of energy. The book also has the dubious distinction of being wrong in virtually all of its important forecasts. See Appendix Table 1 for a sampling of other forecasts from the Harvard group.
[25] Data from DOE/EIA Annual Energy Review 1998, and 1998 Statistical Abstract of the United States.

(and continues to this day).[26] The obvious example, (cited earlier) relates to the emergence of an enormous electric demand from both the use of PCs and the associated industry to fabricate them. (Modern multi-billion-dollar integrated circuit "fab" plants rival steel mills in scale and cost.) What future technologies will be comparable in scope to the PC? Is it realistic to assume there will be no significant new future technologies?

Patterns from Past Prognostications

The studies of two decades ago reveal more than the failure to predict the end of fossil fuels. Like today's studies on global warming, energy experts two decades ago presumed to know much about the geophysics of the earth — although then they were concerned with what was below its surface, not above it. Clearly, those experts were wrong . (This is not to imply that the environmental community has abandoned the belief that fossil fuels are imminently running out, but it is a tough argument to sell in an era of collapsed oil prices.)

Experts exhibited a rampant pessimism about technology's ability to resolve contemporary problems.

The dominant picture that emerges when looking back at two decades of resource, price and technology forecasts with respect to energy is the same as for technology forecasts in general. Experts of the day exhibited a rampant pessimism about technology's ability to resolve contemporary problems or crises, and made linear extrapolations of doom for the near future. This should sound familiar even to those who follow popular articles about global warming on the most superficial level.

The other dominant picture that emerges from the energy forecasts of two decades ago is that many of the responsible organizations are still in the same forecasting business today. And many, if not all, of the forecasts use similar alarmist language, similar rationales, analogous scenarios of impending doom, and then offer the same energy technology solutions peddled two decades ago. Today's forecasts are driven by global-warming worries associated with using too many fossil fuels, while yesteryear's forecasts were driven by worries over the disappearance of fossil fuels. But the ostensible scientific certainty, the claimed "peer" consensus, and the technology nostrums are virtually identical.

They're At it Again

1996 "Based on a review of many studies of recoverable crude oil that have been published since the 1950s, it looks as though such a shortfall [in crude oil] is now within sight. As this time approaches, we can expect prices to rise — markedly and, most likely, permanently."

[26] For a representative compilation of new and emerging electric technologies, see "Breakthrough Technologies" published September 1998 by Mills•McCarthy & Associates Inc. See also "Electrotechnology reference guide," 1992, Electric Power Research Institute, as well as "Industrial Electrification in the Information Age," Schmidt et al., Edison Electric Institute, July 1994.

"As the peak in production approaches, prices will begin to rise and the United States will have to quickly shift to new energy sources to mitigate the impacts on its heavily oil-dependent economy."
"Heading Off the Permanent Oil Crisis," James MacKenzie, World Resources Institute, *Issues in Science & Technology*, Summer *1996*.

1990 "We are, however, running out of the cheap oil and natural gas that powered much of the growth of industrialized societies."
"Energy in Transition," J. Holdren, *Scientific American*, September 1990.

1998 "Global production of oil from conventional sources [of oil] is likely to peak and decline permanently during the next decade."
"Preventing the Next Oil Crunch," *Scientific American*, editorial introduction, March 1998.

The fact that history and technology have trashed the idea of energy scarcity and rising energy prices does not mean that environmentalists have abandoned faith in this central Malthusian tenet.[27] It continues to be useful to promulgate the idea that fossil fuels will inevitably run out in order to support policies that encourage a shift away from them. The idea is simple. Since they're going to disappear eventually anyway, maybe soon, it is a good thing to start the shift now. And if that shift away from fossil energy is made more urgent by global-warming fears, environmentalists can use this "fact" to power arguments for their alternative energy policies. The logic conveniently ignores the fact that if oil prices rise high enough, and stay there, private investment will rapidly shift to alternative energy sources, thereby obviating the need for government intervention (save perhaps to reduce the cost of capital).

It continues to be useful to promulgate the idea that fossil fuels will inevitably run out.

The conviction that oil must get expensive, and maybe soon, is tough to abandon for environmentalists and special interests associated with alternative energy sources. Laying the groundwork for funding a Federal government alternative energy program, two senior appointees of the U.S. Department of Energy wrote a feature article in the April 1996 *Atlantic Monthly* magazine, entitled "Mideast Oil Forever?" providing a litany of quotes from today's energy experts, all opining once more that oil is about to become scarce and permanently expensive.

While 20 years ago the proposed radical changes in the energy infrastructure were motivated by the forecast disappearance of fossil fuels, this time the urgent admonitions are motivated by claims that our continued dependence on now abundant (but soon-to-disappear-anyway) fossil fuels endangers the planet's climate. The similarities between the alternative energy proposals engendered by the oil crises of the 1970s and the proposals of today are very striking, despite two-plus decades of technology and industrial transformations.

[27] MacKenzie's claim echoes that of the 1980 Union of Concerned Scientists' energy study. Perhaps not surprising; MacKenzie worked for the UCS before joining the World Resources Institute. "It is now abundantly clear that the world has entered a period of chronic energy shortages that will continue until mankind has learned to harness energy from renewable sources." Union of Concerned Scientists, *Energy Strategy*, published 1980.

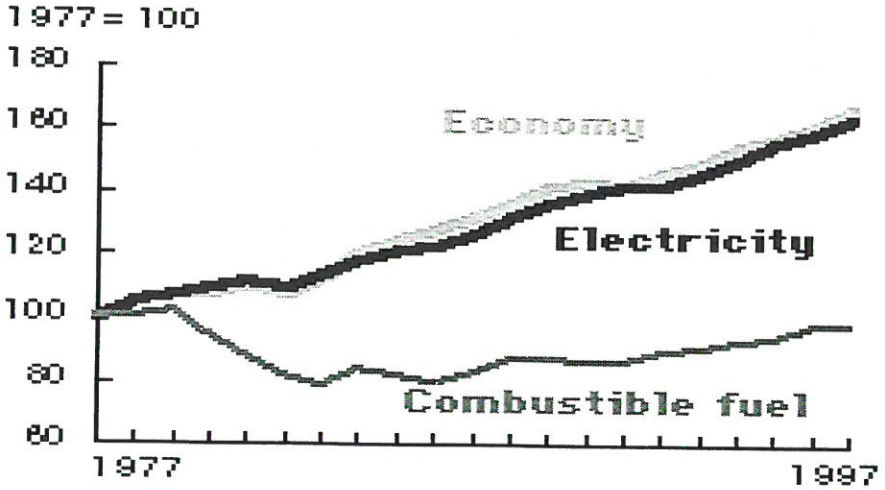
The actual (instead of forecast) energy record

The mere prospect of deregulation in electricity is causing a virtual collapse in the wholesale price of a kilowatt-hour.

For those who have forgotten, oil availability was accelerated by the removal of oil price controls, and natural gas resources ballooned with the abandonment of the misguided Fuel Use Act (prohibiting the use of natural gas for electric generation), along with relaxation of federal restrictions (and related federal revenues from auctions) on off-shore leases, especially in the Gulf of Mexico. And now the mere prospect of deregulation in electricity is causing a virtual collapse in the wholesale price of a kilowatt-hour — 56 percent of which comes from abundant low-cost coal resources. The combination of the movement of government out of the energy business, and the general improvement in the climate for capital formation, along with the acceleration of new technologies, have all brought the United States to a situation that no environmentalist in their worst nightmare could have imagined; to wit, compared to 20 years ago:

- Overall U.S. energy efficiency is 30 percent better, but . . .
- Total U.S. energy use *rose* the equivalent of 2.5 billion barrels of oil per year.
- Growth in energy continues to be biased to electricity with 85 percent of *all* new energy supply for the economy (excl. transportation) used to make kilowatt-hours. (See Figure 1.)
- Coal supplied nearly two-thirds of all new electric energy supply. (See Figure 2.)
- The deregulation of natural gas markets has recently accelerated a roaring return for gas-fired electricity, with over half of new kWh supply to 2020 forecast to come from gas (with still almost 40 percent forecast to come from coal).

Figure 1
Electricity & coal in the Information Age
(data excludes transportation)



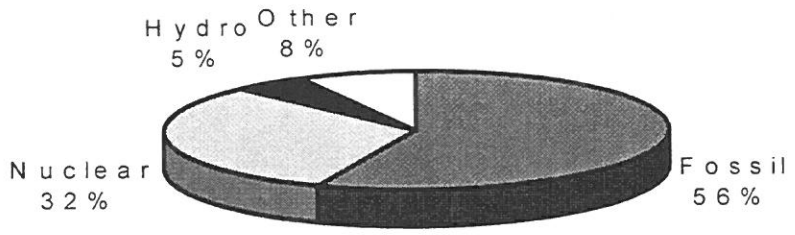
Data from DOE Energy Information Administration

- The U.S. GDP soared 70 percent in real terms, but total *spending* on all energy remained flat—despite rising energy use and, in particular, despite 70 percent growth in electricity use, ostensibly the most expensive form of energy available. (See Figure 3.)

Forecast: "The long-run supply curve for electricity is as flat as the Kansas horizon."
Amory Lovins, interviewed in *Business Week*, July 23, 1984.

Reality: The net effect of new technologies and of an expanding economy has been increased use of electric technologies, otherwise the relationship in Figure 1 would not have occurred.

Figure 2.
Growth in U.S. Electric Supply: 1977-97

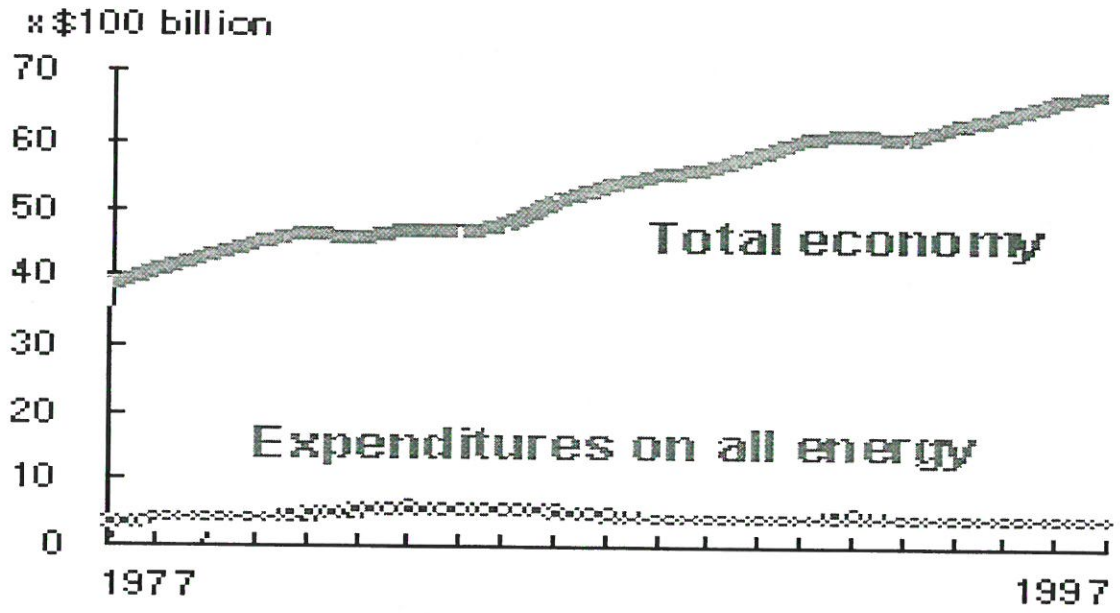


Date from DOE Energy Information Administration

Forecast: "Despite its much-touted abundance, coal will not become our major near-term solution to the energy problem."
Energy Future, Report of the Energy Project of the Harvard Business School, 1979.

Reality: Fossil fuels, with a primary share from coal, supplied the lion's share of new electricity. Without nuclear production for the next two decades, natural gas will need to grow 550 percent, while coal will still supply about 50 percent of supply in 2020.

Figure 3
GDP Growth vs. Total Energy Expenditures



Data from DOE Energy Information Administration

Forecast: "The energy future is bleak and is likely to grow bleaker in the decade ahead. We must rapidly adjust our economics to a condition of chronic stringency in traditional energy supplies." James R. Schlesinger, Secretary of Energy, National Press Club, Washington D.C., 8/16/79.

Reality: The U.S. economy grew by $3 trillion, but total spending on all forms of energy remained flat at about $500 billion. The alternative? Allow or encourage energy prices to rise and direct income away from investment to paying higher energy bills.

FORECASTS OF WISHFUL THINKING? THE LESSONS FROM THE RECORD

"Successful technologies are pulled along by the needs of the buyers, not pushed along by the ideology of the sellers."

Freeman Dyson, Professor Emeritus, Institute for Advanced Studies, Princeton.[28]

What overall lessons about technology and energy technology can one derive from looking back at these energy forecasts of 20 years ago?

First, Malthusian pessimism pervaded every forecast, and continues today.

[28] *Imagined Worlds*, Freeman Dyson, Harvard University Press, 1997, p. 45.

Every environmental or anti-fossil fuel organization eagerly embraced the notion of a permanent energy and oil shortage, permanent and rising oil prices, and a claimed vital need to shift to renewables. They were all wrong. Importantly, they were wrong because they gave short shrift to the power of advancing technology in general.

They were also wrong because experts in their own fields (renewable energy) imagined that technology would advance only for their favored devices, but not for anything else. Thus, while waxing enthusiastic about the potential for technology to lower the costs of windmills, solar cells, wave power, geothermal plants, biomass, even wood stoves and space power, they completely missed the possibility that technology would also advance in the fields of fossil fuel exploration, extraction and utilization, thus lowering costs there too — and as it happened much more rapidly than for renewables.

Energy experts then did not foresee the advances in super computers and geophysics that have allowed accurate long-range exploration; the advances in materials science and engineering that have permitted unprecedented construction of multi-billion-dollar oil platforms in waters over a mile deep; advances in robotics which have permitted operations in hostile and deep-water environments; advances in materials and combustion technology creating ever more efficient conventional power plants, both small (cars) and large (power plants); advances in mechanical engineering and controls which have permitted safer and low-cost extraction of coal, and on and on.

Energy experts did not foresee the advances in super computers and geophysics.

Second, technological myopia, even blindness, infects energy forecasters.

Reading the 20-year-old energy forecasts, and those of today, one sees that little has changed in the language, style and nature of scientific argument. Then it was relating to the validity of catastrophic oil shortages. Today, it is apocalyptic global warming . The common denominator between these two global issues is how little we still know about planetary-level issues of geophysics. The second common denominator is found in the almost universal hysteria in language: then, about the certainty of oil's demise; today, about planetary warming.

The energy forecasters of the 1970s and early 1980s employed powerful computer models and phalanxes of experts to develop mechanisms to peer into the future. Today's forecasters are using computer models and peer reviews too. The computers are more powerful today, but it cannot be argued that the crystal ball is any clearer. The single most important factor needed to make forecasts, regardless of the speed of the microprocessor, is an input that cannot be included in computer models because it cannot be quantified. This is the future technology factor. Forecasters have not only failed to anticipate specific technologies, but have also failed to anticipate the general direction and shape of technology trends in the energy industry. For some

inscrutable reason, energy forecasting seems to be infected with its own special myopia.[29]

Third, environmentalists did not, and still do not, understand the forces driving electrification.

Environmentalists then (and still today) failed to anticipate the continuing, productive electrification of the U.S. economy. They believed that electricity use would level off because of a saturation in the market's use of any devices or processes dependent on electricity; simplistically, once 95 percent of homes had refrigerators and lights, and factories had all the motors they needed, future demand would remain flat even with economic growth because of steady improvements in electricity efficiency. They also believed that any increased use should be discouraged because rising electric demand would cause decreasing societal energy efficiency. Both of these views, still widely held, have been discredited by history. Overall national energy efficiency improved even as, and, in fact, largely because, demand for electricity rose about 70 percent with comparable growth in the economy over the past two decades. To be sure, electricity efficiency in existing applications (lighting, refrigeration, motors) improved dramatically. Excluding transportation data, where electricity still has little relevance, total societal energy efficiency is 35 percent better today than two decades ago, counting the fuels used in power plants. What environmentalists failed to anticipate was a continual flood of new technologies that use electricity, a trend that continues to this day, in every sector of the economy, and the fact that these new technologies are so productive and efficient that their overall effect was to improve energy efficiency, even when the fuels used at power plants are taken into account.[30]

Environmentalists failed to anticipate a continual flood of new technologies that use electricity.

[29] When the president of the World Future Society published, in 1980, 29 predictions for the next two decades, of all the forecasts those that were most egregiously wrong related to how technology would impact the future of energy and resources. For example, reflecting the then popular Limits to Growth philosophy, the forecasts of 1980 included: mass extinctions, massive overpopulation, widespread destruction of ecosystems, terrorism against nuclear reactors, policies discouraging car ownership, battles over the control of seabed minerals. From "What if...?" *Forbes*, Nov. 2, 1998.

[30] It may appear difficult to accept the fact that an electric application is, on average, more energy efficient than a combustion process. True energy efficiency is visible only in a total fuel cycle approach in which the energy losses associated with generating electricity are balanced against the efficiencies in every step of the energy food-chain. Two examples provide some insight. The electric car is, overall, more energy efficient than a gasoline car. (This does *not* mean necessarily more practical, because in this case fuel storage is so poor in electric vehicles.)

— The total fuel cycle efficiency of an electric car is about 21 percent. This is determined by the combined efficiencies of: electric propulsion motors at 90 percent; batteries at 80 percent: the vehicle's drive system at 72 percent; and the efficiency of converting fuel to electricity and delivering of 30 percent.

— By comparison, a conventional automobile's total fuel-cycle efficiency is about 13 percent because of the combined efficiencies of: a gasoline-engine at about 15 percent; efficiency of converting oil to gasoline and delivering it to market at about 90 percent.

A more subtle example: the conventional means of drying paint (on a car for example) is with an oven heated by burning natural gas. This process is about 10 percent efficient; i.e., even though gas can be burned and converted to heat with 95 percent efficiency, only about 10 percent of the thermal energy does the actual work of drying paint. Alternatively, electric infrared lamps are increasingly used to direct radiant energy at paint, with a paint-drying efficiency of 80 percent — counting the power plant efficiency of 30 percent this yields a total paint-drying energy efficiency of 24 percent, or 2.4 times better than the combustion technique.

Fourth, environmentally motivated energy forecasts are based on ideology and driven by wishful thinking. (In the parlance of the technology transfer world, this is called technology push, rather than market pull.)

The *fourth* lesson that emerges is that environmentalists today, just like energy experts and environmentalists of two decades ago, are simply too vested in their own ideological agenda (alternative energy and global warming) to see the big picture, or to understand the complex interactions of demographics, industry, the economy at large and technology in general. They are driven, as Freeman Dyson succinctly notes in the citation at the top of this section, by their own "needs." Despite recent adoption of language meant to evoke a reliance on "market forces," environmental energy proposals are all still rooted in prescriptive designs for constraining energy choices in our enormous and dynamic economy.

Environmental energy proposals are all still rooted in prescriptive designs for constraining energy choices.

GLOBAL WARMING'S LONG REACH: 100-YEAR FORECASTS

1886 "I take this opportunity to express my opinion in the strongest terms, that the amazing exhibition of oil which has characterized the last twenty, and will probably characterize the next ten or twenty years, is nevertheless, not only geologically but historically, a temporary and vanishing phenomenon — one which young men will live to see come to its natural end."
Professor J. P. Lesley, State Geologist of Pennsylvania, 1886.[31]

1893 "All the forests will be gone [by 1993]. Lumber will be so scarce that stone, iron, brick, slag, etc., will be largely used in the construction of houses. As a result, fires will be almost unheard of, and insurance companies will go out of business."
John Habberton, popular writer of the 1890s.[32]

1893 "Three hours will constitute a long day's work."
John Carty, Electrical engineer, corporate organizer.

1897 "The occult sixth sense will be the predominant element in medicine and theology. Mesmerism will take the place of anesthetics in surgery."
"The pneumatic tube will be the means of transporting goods."
Ella Wheeler Wilcox, Popular poet.

1893 "I presume that a speed from 90 to 100 miles an hour could be secured with modern locomotives and with the improvements which are sure to come."
"Electricity as a motive power for passenger traffic will be used much. "
George Westinghouse.

1893 ". . .the principle of the paddle wheel will remain supreme."
Alfred Van Santvoord, successful freight businessman.

1893 "The farmer may plow his fields and heat his dwelling with a storage battery no bigger than a common brick, the coal monopoly will be as dead as Julius Caesar."
J. H. Beadle, Journalist, author, attorney.

---

[31] *Standard Oil Company (Indiana): Oil Pioneer of the Middle West*, P. Giddens, 1955.
[32] *Today Then: 1993 as predicted in 1893*, compiled by Dave Walter, American & World Geographic Publishing, 1992.

1893 Aerial navigation for special travel or exploration . . . not largely universal or commercial.
Walter Wellman, Adventurer, journalist.

1893 Railway formed between Buenos Aires and Chicago.
William Eleroy Curtis, Journalist, traveler, internationalist.

At the core, energy forecasting is fundamentally anchored in technology forecasting in general, which highlights the central problem because of the dismal record of technology forecasting. Not only is it important to understand the kinds of technologies which will be available to find oil, or make and deliver electricity, it is equally important to anticipate the technologies that will emerge which determine how much, and what kind of, energy society needs. If one really believed that a revolutionary battery were imminently practical, the nature of automobiles and their energy needs could indeed change.

The folly associated with current long-term forecasts is most easily demonstrated by considering past predictions.

It would seem ludicrous on the face of it to expect governments to institute programs today that are directed at addressing technology needs for our descendants one century from now. However, in the context of what is implicitly and explicitly part of the global-warming community's goals and nostrums, we *are* being asked to spend taxpayer dollars today to fund government programs that inherently assume much about how technology will progress over the next 100 years. If global warming were to happen as its advocates believe, we are told that in 50 to 100 years the consequences will come into full effect. By definition, that future society will use the technologies then available to meet needs and manage whatever problems exist then. Is there any reason to believe that anyone can usefully forecast specific technologies for 100-year time-frames? The corollary then: Is it reasonable to undertake any kinds of programs today based on such preposterously long-range forecasts?

Only a modest knowledge of history would suggest the answers. The folly associated with current long-term forecasts is most easily demonstrated again by considering past predictions, but this time for the longer time frame of 100 years.

Textbooks in oil geology go back a century and are replete with regular forecasts of the imminent disappearance of cheap oil. A broader view of century-long technology forecasts, not just energy forecasts (there was no such discipline a century ago) is conveniently available in a book re-published a few years ago: *Today Then: 1993 As Predicted in 1893.* A few representative examples of the forecasts are listed at the top of this section.

The book contains a set of 74 essays originally published for the 1893 Chicago World's Fair. That event took place at a time when the economic and technological effects of the first industrial revolution were in full swing, epitomized by an entirely new class of mega-business, the railways. Also in place in the year 1893 was the realization of great impending changes as existing and emerging technologies advanced. Telephony and electricity, and

the technologies associated with them, were exciting the imagination of people across the country.

Today Then was produced by the Newspaper Guild of 1893 when they commissioned essays from leading thinkers, great industrialists (including Westinghouse and Vanderbilt) as well as government officials, popular writers and orators. Each was asked to describe the changes that they imagined would take place in America by the time 100 years had passed and the year 1993 arrived. The resulting collection of essays provides insight into the social, intellectual, and cultural biases of the day — all of which unavoidably affect thinking about the future. For perspective, many of the forecasters who wrote for *Today Then* were Civil War veterans.

Perhaps the most remarkable feature of this collection of 19th century visionaries is that they actually were more successful than energy forecasters of just two decades ago. Unlike these agenda-driven forecasters, the sages of 1893 actually had a surprising number of "hits." And while the hits were in a distinct minority, the prescience was remarkable.

19th century visionaries were more successful than energy forecasters of just two decades ago.

> "On account of fast and cheap travel, cities will become groups of suburbs."
> David Swing, minister, journalist.
>
> ". . . millions of dwelling houses will be artificially cooled in summer, as they are now heated in winter."
> Felix Oswald, *world traveler and writer with international readership.*
>
> "Electrical research and experiment will lead to an industrial revolution ."
> Charles Foster, *banking and petroleum industry.*

More typical of those who got it right (and these too were in a minority) were the few forecasters who painted the future with a very broad brush. Their visions were stated in grand terms based on their belief in the power of on-going technology progress:

> "It is useless to attempt to foretell the improvements in mechanics, in industrial arts and in modes of travel as it would have been 40 years ago for any one to have anticipated the telephone and its now universal use."
> Hempstead Washburne, *Mayor, attorney, banking businessman.*
>
> "The multiplicity of inventions, the variety of modes, and the expertness in application have wonderfully increased the efficiency of labor, diminished the cost of production and added much to the comforts of men."
> W.A. Peffer, *educator, attorney, senator, wrote influential farm journal.*
>
> "The commercial development of the United States in the 20th Century will be prodigious."
> Matthew Borden, *Director of Manhattan Bank.*
>
> "There is no apparent limit, except the limit of the world itself, to the growth of wealth, to the augmentation of opportunity, and to the achievements of this American people."
> Erastus Wiman, *printer, reporter, editor.*

However, despite glimmers of forecasting brilliance, there were few exceptions to the basic rule: century-long technology forecasts were fatally

flawed. Those that got something correct did so, as previously noted, when they were general; ". . . houses will be artificially cooled." The forecaster didn't say on what technology the cooling technique would be based, but rather simply expressed the view that science and engineering could accomplish this needed task. The confidence, and accuracy, in these kinds of forecasts arose from a combination of a sense of optimism for technology progress, and critically, a recognition that newly emerging scientific discoveries and technologies would surely make such things possible. At the time of the forecasts explored here, it was the dawn of the electric and automobile age — truly revolutionary changes in basic infrastructure technologies available to civilization. (The forecasts pre-dated the Wright brothers first powered flight by 10 years.) Many of the 1893 forecasters recognized the impending revolution, and envisioned substantial, but broad, changes because of it.

Environmental forecasters today are not optimistic about fundamental technology changes now underway.

"Steam and other sorts of power displaced by electricity."
Charles Foster, *Involved in banking and petroleum industries.*

"The use of electricity . . . serving the household exactly as gas, steam and coal now serve it."
John Carty, *electrical engineer, corporate organizer*

"Electricity will be the supreme power."
"Domestic life and avocations will be rendered easier, less costly, and less complete by the distribution of light, heat and energy through storage cells or from central electric stations."
John Ingalls, *attorney, orator, writer.*

Electricity providing power and light for cities as far as New York and Philadelphia on the east, and Cleveland, Cincinnati, and Toledo on the west.
(Albert Shaw, *New York Assembly, diplomat, President of the Canadian Niagara Power Company.*)

The salient difference with environmental forecasters today is that they are not (or perhaps cannot be) optimistic about comparable fundamental technology changes now underway, and thus cannot imagine or consider the scope of broad changes and new services, products, devices and benefits society is yet to gain from emerging technologies today. While even the more prescient visionaries of 1893 did not come close to anticipating the true and astounding scope of change that came to America over the subsequent century, they at least recognized that such change was not only possible but inevitable. Today's putative energy forecasters neither recognize, nor acknowledge, that comparable, or greater changes, are still likely over the time periods they use in their analyses. This is ironic considering that more technology change has occurred during our living memory than in that of the 1893 forecasters. Surely this would create a basis for understanding that more, and substantial, technology is not only possible but inevitable.

Time-lines & trajectories for technology

In 1893, the forecasters examined here were excited about the potentials of electric technologies. At that point in history, it had been nearly 60 years since the technology of the electric generator had been invented in 1832, but only 11 years after the famous Edison Pearl Street central electric generating station went into operation. The telephone was a somewhat more recent phenomenon for them; it been invented two-decades earlier (1876) with long-distance phone service inaugurated between New York and Boston in 1884.

What one sees from these time frames is that the forecasters in 1893 were only just beginning to experience the technological and economic acceleration of critical, new basic inventions and engineering capabilities, despite the fact that the core concept may have been known to them for 20 more years (the telephone) years and sometimes 60 years (the electric generator). One sees in this time lag the evolution of a new technology from concept to practicality. The emergence of the concept alerts people only to the general potential; historic analogies show a common 20-year-or-so time lag from idea to emergent, engineering potential.[33] Full penetration into society of a fundamental technology change took longer than two decades. Such changes created structural and economic impacts on the nation's infrastructure that took decades to be fully realized, and were generally unpredictable in their scope, nature and collateral effects. To be sure, very rapid and visible technological changes did take place in the 20-year periods. Consider that the 19th Century information revolution of telephony went from invention to practical long-distance service in less than 20 years. But the scope and depth of the impact of telephony on society and industry was not clear to anyone in those first 20 years, nor even during the subsequent two decades.

The 19th Century information revolution of telephony went from invention to practical long-distance service in less than 20 years.

At the time of the 1893 forecasts, the transportation revolution had yet to be realized, but was on the kind of trajectory just outlined. The Wright brothers first powered flight took place in 1903. The two decades following the invention did not see the development of a commercial aviation industry, but aircraft did begin to have their revolutionary impact in that two-decade period, seen vividly during the First World War. It was, however, 50 years after the first powered flight that widespread civil aviation became a major industry and force in human affairs, epitomized perhaps by America putting a man on the moon only 66 years after Kitty Hawk. The shape of this trajectory of change is common in history and has much to imply about both short-term, 20-year, and long-term, 50 plus year forecasting.

These time-frames are echoed in modern times. The integrated circuit was invented in 1958. By 1978, 20 years later, the power of the micropro-

[33] Such time lags are not relevant for improvements in, or variants on, a basic technology or invention. The time-cycles for improvement are sometimes extremely fast. The time-periods referred to here regard the emergence of a core idea, an electric light, a car, an airplane, a transistor, etc.

cessor seemed to be clear, creating new industrial giants such as IBM. But remember that it wasn't until 1973 that the first simple four-function calculators (the precursor of the PC) came on the market, priced at over $1,000 in $1998. A 15-to-20-year time-period did not reveal the real power of the microprocessor, nor did anyone in the 1970s correctly anticipate the magnitude and pervasiveness of the changes it would yet bring to industries and society.[34] The length of time it takes new technologies to overcome the institutional inertia in society's infrastructures suggests that the equivalent of the man-on-the-moon impact from integrated circuits is yet to be seen, and if the patterns hold is not likely to manifest itself until 2020 or so — some 50 to 60 years after the first invention. Without regard to what those impacts may be, they will surely have profound implications for the nature and magnitude of how energy is used. And it is certainly clear that global warming-inspired technology forecasts ignore such potentially profound change and progress.

Global warming-inspired technology forecasts ignore potentially profound change and progress.

History more than suggests, it virtually promises, overall technological changes of much greater magnitude than any envisioned by global-warming advocates. And we do have adequate information to at least map the landscape of change. There is as a minimum the historic record of technological trajectories and time-from-inception-to-market for major technological changes. When all of the technological assumptions associated with global-warming forecasts are viewed in the context of the historic record, they seem misguided, to put it mildly. The kinds of technology changes now underway will radically alter the nature of tools our children and grandchildren will have available. But the changes will not fully manifest themselves in the one or two decade time-periods that are reasonable for us to plan for and spend money on today.

Environmentalists may assert, or even believe, that such alternative energy technologies as solar power and windmills are the equivalent of the first powered flight, or the first integrated circuit. Indeed they have warned the conventional fuel industry of impending economic extinction should those companies fail to capitalize on the energy revolution environmentalists envision arising from their favored technologies. There is a central problem with the notion that alternative energy technology represents some kind of revolution-in-waiting. Windmills, solar power, indeed the entire panoply of favored alternatives, are not new or revolutionary inventions. They do not arise from newly discovered principles of science; neither are they based on, nor do they epitomize, fundamental changes in engineering capabilities. Indeed, most alternative energy technologies are more stone-age in character than high-tech: burning wood and trash, tapping hot springs, capturing

[34] As one who was employed as in the research and development aspect of integrated circuits in the mid 1970s, the possibilities seemed enormous to me; but I recall being struck at that time with the lack of practical interest in imagining such things, perhaps because they were relatively far away in time and were certainly substantially removed from the day-to-day demands of the job and company. In speculating that the integrated circuit technology we were developing then would make the possibility of true Dick Tracey-style communication feasible in a decade or two, I found the idea roundly labeled as improbable if not silly.

running water and the wind. The most exotic of the alternatives, solar photovoltaics, is based on the scientific phenomenon whose discovery yielded Albert Einstein a Nobel Prize, and led to the first solar-electric cell being demonstrated in 1925. We have had more than ample time — 75 years — for this technology to follow long-standing commercialization trajectories were it going to do so.[35]

PATTERNS IN TECHNOLOGY FORECASTING

"In human affairs —political, social, economic or business — it is pointless to try to predict the future, let alone attempt to look ahead 75 years. But it is possible — and fruitful — to identify major events that have already happened, irrevocably, and that will have predictable effects in the next decade or two. It is possible, in other words, to identify and prepare for the future that has already happened. [emphasis added]"

Peter Drucker[36]

The purview of most business forecasts remains, wisely, limited to rather short time frames.

So what can one derive from the record of technology forecasting? Today there is a thriving private and academic business discipline associated with technology forecasting techniques. For analysts in 2020, there will be a rich body of material to make hindsight judgments about today's forecasters. The explosion in the professionalization of technology trend forecasting arises from a broad realization (at least outside of the environmental community) that technology is changing rapidly, and changing much about all businesses. However, the purview of most business forecasts remains, wisely, limited to rather short (often less than 10-year) time frames. But today, because of the activities of global-warming advocates, the government has chosen to concern itself with technology policies that are being driven by forecasts encompassing 20-year time frames and beyond.

Some fairly clear lessons and threads of continuity emerge from the ideas contained in the previous tables and discussions regarding 20-year and 100-year technology forecasts.

In the very long run (~100 years) no one really has a clue about what specific technological and associated social, economic and institutional changes will occur.

> A few prescient and lucky people will make correct guesses about a few general aspects of the future. The record suggests they are most likely *not* to be engaged in any aspect of the technology or industry about which they are prognosticating. Poets seem to be more likely to get it right than industry experts.

[35] The real problem with solar energy is, of course, simple: regardless of the technological tricks to convert light to energy (something plants do wonderfully), the sun's energy once it arrives at the earth's surface is too weak to be practical for the energy needs of our industrial society. Indeed, were the sun's energy powerful on arrival at the earth's surface, there would be no life on earth. Energy technology progress has always been characterized by movement towards increasingly concentrated forms of energy.

[36] *Harvard Business Review*, September/October 1997.

- *The most consistent problem with long-term (50 - 100 year) forecasts is that they underestimate the magnitude, nature and pace of change.*

  Over the long term, generational changes in businesses, institutions and physical equipment occur. In addition, there are fundamental changes in basic science (such as the discovery of electricity, the genetic code, etc.) that create whole new classes of technologies, often inherently unpredictable and frequently occurring for serendipitous reasons, thus defying government or any other directed research.

- *The most consistent problem with short-term (~20 year) forecasts is that they frequently over-estimate the pace of change.*

  In the short run, pundits tend to ignore the inertia inherent in organizations, human institutions, and something one might term "capital inertia," since existing investments in equipment have enormous market value in this "short" term. Also in the short term one must deal with the physical realities of how long it takes to design, build and bring-to-market major infrastructure changes — even where the marketplace wants to use the new technologies.

- *Another consistent short-term forecasting error arises from a failure to differentiate between what is simply possible, and what is practical or useful.*

  It is possible to build personal, Buck Rogers-style jet backpacks. They were first built in the late 1950s. They're commercially available today. They're just not useful. Windmills are the Buck Rogers equivalent in the alternative energy community. They're commercially available, they're just not generally useful.[37]

- *Those directly engaged in or profiting from a technology activity of the day are often the worst at anticipating the direction and nature of technology change in their area of expertise.*

  The phrase "peer reviewed" in technology forecasts is a danger signal (unlike in the fields of basic research, where it is a critical positive signal). "Peer reviewed" when it comes to technology forecasts usually means that other people of similar limited vision and parochial interests have reviewed and added little of imaginative value to the topic in question. The experts of the day may be very good at the business of extracting value from a technology they are familiar with, but frequently myopic about emerging technologies that could capture their market niche.

On May 24, 1844, Samuel Morse successfully transmitted the first electric message from the U.S. Capitol building to Baltimore. Within a decade the

[37] In a special issue devoted to near-future advances in technology, *Scientific American* magazine's editor noted succinctly: "Why do some innovations fall so far short of what is expected of them, whereas others succeed brilliantly? One recurring reason is that even the most knowledgeable forecasters are sometimes much too optimistic about the short-run prospects for success." "To survive, a commercial technology must not only work well, it must compete in the marketplace." *Scientific American*, September 1995.

United States had 23,000 miles of telegraph wire, and within three decades the telegraph circled the world and revolutionized communications, government, and business. It was the kick-off for the communications revolution that continues today. But Morse himself thought the telegraph would only be useful to governments for sending important messages. In fact, he was so certain of its limited value that he tried to sell the rights to the federal government for $100,000. Even Alexander Graham Bell suffered from the same technological myopia. He too attempted to sell the rights to his invention, the telephone, about 30 years after Morse's similar attempt. Bell offered to sell his rights for $100,000 to the Western Union company. Amazingly, Western Union, which by that time was a major communications company, had no concept of the value of telephony and turned Bell down.[38]

Environmentalists today try to use this lesson for their own purposes by suggesting that energy companies run the same risk of not buying into windmills or photovoltaics. This is wrong-headed. Windmills and photovoltaics are neither new nor revolutionary, and offer no economic, operational or practical advantages over competing technologies.

Windmills are neither new nor revolutionary.

- *Generalities tend to yield more accuracy and insight than narrow technology-specific projections; forecasts of the direction and nature of change, as opposed to product-specific predictions are more often winners.*

  Westinghouse, in 1893, thought about travel in 1993 in terms of how fast trains might travel — which he egregiously underestimated in any case. Others, not involved in the rail industry of 1893, foresaw a future enhanced by far faster and different forms of travel, including aviation, despite the fact that the Wright brothers' first historic flight was at that time a decade away.

- *Technologies change, but human behavior does not.*

  Technology forecasting that assumes implicitly or explicitly that human behavior will change in some fundamental way can be safely ignored. Little has changed in recorded history regarding the basics of human behavior and social interactions; even less has changed since the days of Shakespeare, whose observations about human behavior are so pointedly accurate that they have become clichés. The toys change but the people don't.

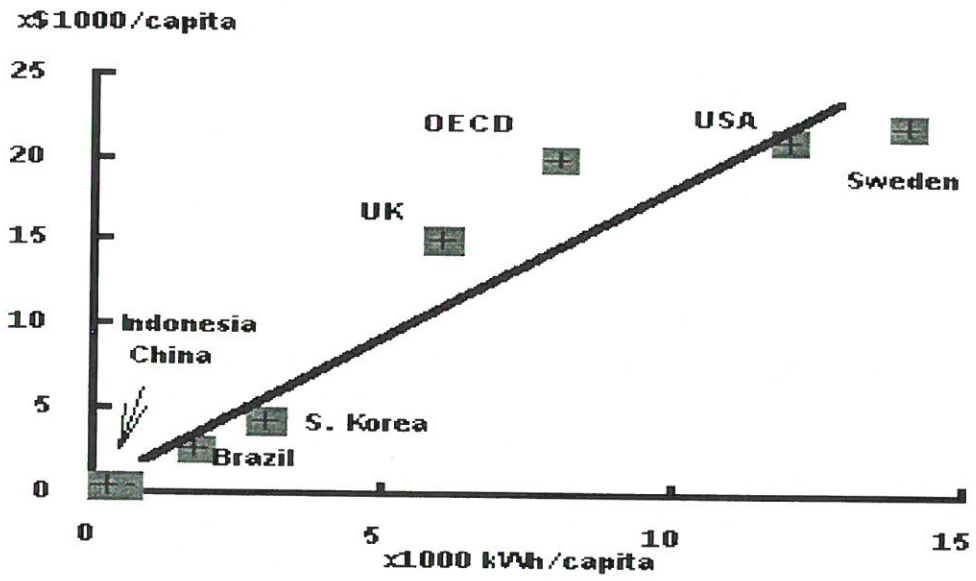
Peter Drucker is arguably one of the more insightful thinkers and generalists of our time. When it comes to forecasting, there are some useful observations that can be offered based on Drucker's advice to "identify major events that have already happened, irrevocably, and that will have predictable effects in the next decade or two. It is possible, in other words, to identify and prepare for the future that *has already happened*."

[38] "Technology of the Future," John Gordon, *American Heritage*, October 1993.

As national economies expand, demand for electricity will rise.

When Drucker refers to what has "already happened," he frequently cites basic demographic and physical trends. The population is growing, becoming older, more affluent, etc. These trends have important predictive value. The fact that world trade is increasing, and telecommunications becoming cheaper are portents with predictive value. Increased affluence and accelerating technology will lead to rising use of the energy sources most tightly linked to economic growth, to wit, electricity. Increased global affluence will bring about not only rising electricity demand, but also rising oil use as more people can afford automobiles. There is no technical invention in place today that can meet the magnitude of energy demands for transportation and electricity *for the next two decades* other than those already existing.

The following graph illustrating the relationship between average national electricity consumption and average national GDP is powerfully predictive. As national economies expand, demand for electricity will rise, as will demand for oil. No other reasonable conclusion can be reached in the 20-year time periods for technology forecasting. Programs to discourage this trend can only be socially and economically damaging.



Data from OECD, EIA

THE END OF TECHNOLOGY?

"Life in the future will not be like Star Trek."
Scott Adams, Prediction #7, The Dilbert Future, 1997.

Science fiction writers, legislators, and the general public, all believe that technology will advance. While it is unreasonable to believe that we can today accurately forecast the long tomorrow, it is reasonable to believe that it will

be dramatically different and that technology will be a major driving force. But to believe what Malthusians believed and continue to believe, and more specifically, what energy Malthusians said, and continue to say, one has to believe that technology progress has basically stopped.

Malthusian believers continue to make forecasts about the purported condition of the economy and the fate of humanity for the next century, despite 200 years of failure for their predictive methods.[39] Today's neo-Malthusians continue to prophesy impending gloom from depleted resources, rising prices, population explosion, famine, etc. No doubt many of us are fascinated by long-term forecasts of any kind. But much of what passes as forecasting on the part of environmentalists and Malthusians (generally one and the same) reflects a profound lack of imagination and an inherent pessimism about the kinds of basic scientific and technological changes that are inevitable over the next century. Malthus' failure was, fundamentally, that the extrapolations he used in his famous essay of 1798 assumed that no new technologies or scientific knowledge would appear in the future. This is also the inherent failure in Malthusian thinking today.[40]

While environmental Malthusians exhibit endemic failure to foresee or believe in continued technology progress, to be fair even the best in the field of science fiction have only managed to anticipate accurately very narrow areas of technology change. The difference is that the science fiction writers believed that change would continue.

Today's neo-Malthusians continue to prophesy impending gloom.

But how could forecasters, even in the guise of fiction writers, anticipate the technologies that would emerge from inventions that didn't exist in their day? Even fanciful extrapolations require some kind of basis. How could one forecast today's technologies before the vacuum tube was invented, not to mention the transistor and integrated circuit? A number of the most prescient forecasts made in 1893, while vague, at least recognized the impending changes from the emergent technologies of electricity generation and use. The early engineering forays into generating electricity provided the kernel of ideas for forecasters of 1893. But a few decades earlier, it would have been impossible to envision anything relating to the entire array of technologies using electricity because neither the basic scientific ideas nor the engineering tools even existed. Virtually all future technology possibilities changed in a fundamental way when James Clerk Maxwell, a Scottish mathematician and physicist, produced his crowning achievement which set the stage for the entire age of electricity between 1864 and 1873. Maxwell put into mathemati-

[39] "A special moment in spin control," Mills, *World Climate Report*, May 11,1998.

[40] One of the currently popular neo-Malthusians, Bill McKibben, recently attempted to resurrect the credibility of his and his colleague's craft, i. e., doomsaying. In a lengthy April 1998 *Atlantic Monthly* essay, McKibben tackles the 200-year failure record of Malthusianism. With superficial daring McKibben admits that "Each new generation of Malthusians has made new predictions that the end was near, and has been proved wrong." And later: "So Malthus was wrong. Over and over again he was wrong. No other prophet has ever been proved wrong so many times. At the moment, his stock is especially low."

cal form a few simple, elegant, and profound equations that expressed all the varied phenomena of electricity and magnetism. Maxwell's equations provided the keys to a new technological era based on electricity.

Many brilliant scientists who preceded Maxwell provided much in the way of basic information and understanding that led up to Maxwell's equations, and many others followed to elaborate and expand on his work. Nonetheless, his equations were the catalyst that in one century changed the world so profoundly as to defy anyone's imagination in the years prior to Maxwell's conception. Once scientists and engineers discover the rules that underlie certain basic forces, they soon develop the ability to use those rules to fabricate new and previously impossible products and devices.

Are comparable transformations in scientific understanding and engineering capabilities possible in the future, especially over the long time-frames often considered by global-warming theorists? To assume not is to assume that there is nothing fundamental left to discover, a ludicrous notion.[41] And without considering fundamental technology changes, it is inconceivable that energy forecasts for the next two decades, much less half-century-plus, have any credibility. There are, of course, a variety of areas of basic science and technology where profound changes are clearly possible, wherein there are profound implications for resource and economic, not to mention social, institutional and political systems.

It is inconceivable that energy forecasts for the next two decades have any credibility.

The end of technology, or just the beginning?

One of the remaining great mysteries in physics is gravitation. Einstein spent much of his life attempting to develop the basic rules of gravitation, the search for a unified theory. Scientists appear closer today, but the equivalent of Maxwell's keys have not been uncovered. One can only begin to imagine the implications of controlling gravity, which is a virtual inevitability once science produces the rules that engineers can use. Could this happen before a century passes? No one can possibly know for certain. But nothing in history suggests that this puzzle will not eventually yield to human inquiry. Indeed, current scientific progress and history suggest that this particular puzzle could be solved within a century. The world of 2098 could look quite different indeed. Control of gravity would change everything — literally. Certainly space travel becomes easy.

Similar impending changes, perhaps of lesser or greater magnitude, attend the emerging fields of biotechnology and nanotechnology. Freeman Dyson believes the 21st century will be the "century of biology."[42] Considering the prodigious medical implications of biotechnology, there are many

[41] The idea that somehow this generation, dominated by baby-boomers, has discovered it all, and knows it all, surfaces frequently.

[42] *Imagined Worlds*, Freeman Dyson, Harvard University Press, 1997.

others. Already bioengineered organisms make it possible to extract, or clean up, oil more efficiently. It is likely that the natural resources of fossil fuels — of which the planet holds an astounding abundance in difficult-to-extract form (oil shales, tar sands, etc.) could be tapped inexpensively with bioengineering assistance. There is already some suggestion that bioengineering organisms can be produced that will have the capacity to convert carbon dioxide emissions from combustion into useful (perhaps even economical) ethanol.

The field of nanotechnology holds the potential for changes that are already giving rise to new excursions of fancy in science fiction. The possibilities are tantalizing because the next 100 years promises changes that could be even more dramatic than any that have appeared over the past 100 years. Engineers have shown that they are capable even with today's nascent technology, of fabricating microscopic motors and devices.

The next 100 years promises changes as dramatic as any of the past 100 years.

The field of mathematics will yield surprises yet. Today's computers, for example, owe their ability to function to the logic (software) ideas established by Von Neuman in the 1950s. Can scientists take us beyond today's software as developers seek to bring new functionality to computers? What future mathematician, perhaps only born last year, may provide in his or her lifetime a new mathematical framework as profoundly important as Von Neuman's, revolutionizing software and computational power? Any such development would be amplified by the continuing growth in basic microprocessor capabilities, one reinforcing the other to increase computational capabilities by orders of magnitude. Real thinking machines could emerge. Peter Drucker has written recently about the profound failure of computers, in effect their software, to improve the most important part of daily business and political life — decision making.[43] A different approach to computing could bring electronic devices that can actually help decision making. What then?

The point of these cursory observations about fundamentally important, emerging changes in technology is that imagining our great grandchildren's world is as difficult for us as imagining today's electric world would have been for people in the pre-Maxwell days of the early to mid-1800s. Many environmentalists today are doing the equivalent of worrying about finding better lamps to burn whale oil at the dawn of the age of electric lighting. Better to let science and technology flourish. Not only did electric lights replace whale oil lamps, electric lighting gave birth to entirely new uses for light which no one could have dreamed of a century ago. Lighting technology today is not only used for convenience, decoration or advertising purposes, but also to process materials, cure paint, destroy pathogens in water, and even clean air. The most powerful of all lights — lasers — are used to weld, cut metals and fabrics, selectively catalyze chemical reactions, perform surgery, play music and may even launch micro-rockets. Could the whalers of New England have foreseen these possibilities? Did even Thomas Edison forecast

[43] *Forbes*, ASAP, September 1998.

such specific technological derivatives from his work? Did forecasters 25 years ago?

Unless one presumes that the progress of science and technology has ended, that no significant new basic discoveries and technologies are possible, it is ridiculous to engage in plans to manage, anticipate or direct technology over time periods beyond 20 years. Yet this is precisely what many in the expert community engaged in promoting the theory of global warming are attempting to do. We are being asked to put at risk trillions of dollars in investment in existing energy technologies on the basis of 20 and 20+ year technology forecasts that have no validity.

Table 1
Energy & Energy Technology Forecasts Made circa 1979 for the Years 1990 to 2000

The industrial world was awash in studies, books and reports on the energy problem from the mid-1970s to the mid-1980s. The market for such books and studies dried up as an energy crisis failed to materialize, and as the price of oil relaxed back to the level it has been at for more or less a century (in inflation-adjusted terms). The following is a very small sampling of predictions and claims from the energy studies, reports and committees of that era. Despite the certainty, and often grandiose scope of many of the forecasts, they were all proven by the passage of a mere two decades to be wrong.

Prediction	Source
"Cheap oil and gas are running out."	*Our Energy: Regaining Control*, M. Ross, R. Williams, 1981
"The oil-based societies of the industrial world cannot be sustained and cannot be replicated. The huge increases in oil prices since 1973 virtually guarantee that the Third World will never derive most of its energy from petroleum."	"Solar Possibilities" Denis Hayes, Worldwatch Institute, *Energy Journal: Special Issue: Renewable Energy Prospects* ,October 1979.
"Although we hear much about various future sources of energy the work of our civilization is wedded to the fossil fuels — coal, oil, and natural gas — sources of energy that are dwindling rapidly."	*Energy for Survival: The Alternative to Extinction*, W. Clarke, Anchor/Doubleday Books, 1974.
"It is now abundantly clear that the world has entered a period of chronic energy shortages that will continue until mankind has learned to harness energy from renewable sources."	Union of Concerned Scientists, *Energy Strategy*, published 1980.
"Despite its much-touted abundance, coal will not become our major near-term solution to the energy problem."	*Energy Future, Report of the Energy Project of the Harvard Business School*, Ed., Stobaugh, Yergen, 1979.
"The range of energy possibilities grouped under the heading 'solar' could meet one-fifth of U.S. energy needs within two decades."	
". . . domestic oil and gas, coal, and nuclear power, as a group, can increase their contribution to cover, at most, one-third to one-half of the nation's additional energy needs over the next decade."	
"In that case, new electric generating plants might even be permitted to use natural gas. This seems, on the available evidence, to be the least likely outcome, but it is possible."	
"The essential point is that the nation should not plan on greater quantities of natural gas to stop the rise in oil imports. Indeed, it will be a challenge to find enough new gas reserves to maintain production at current levels."	
"The only realistic two options for the short-term are wood and wood waste, and on-site solar technologies, such as solar heating, small hydropower, and small wind."	
"There are four conventional sources of domestic energy: oil, natural gas, coal and nuclear power. But all four are likely to deliver less energy than projections by their advocates would lead one to believe."	Speech by James R. Schlesinger, first Secretary of the U.S. Department of Energy, Sept. 24, 1979
"We must rapidly adjust our economics to a condition of chronic stringency in traditional energy supplies."	
"In short, if we are effectively to grapple with our energy problems, we must accept an adjustment, indeed a decline, in our historic expectations. How will the American society respond to this revolution of declining expectations?"	
"Countries with expanding industry, rapid population growth ...will be hit especially hard by economic energy scarcities from now on."	*World Energy Strategies*, Amory Lovins, 1974

Business Week, July 23, 1984, interview with Amory Lovins, "Soft path for hard-pressed utilities.	The long-term prospects for selling more electricity are dismal. ... However, we see electricity demand ratcheting downward over the medium and long term.
	We would expect in the short term that a recovery would stimulate electricity demand to recover toward its previous levels. However, we see electricity demand ratcheting downward over the medium and long term.
	The long-run supply curve for electricity is as flat as the Kansas horizon. We will never get, we suspect, to a high enough price to justify building centralized thermal power plants again. That era is over.
	Far from there not being enough renewable sources to run an advanced industrial society, we will find there are too many. There won't be enough demand to support them all.
"The fragility of domestic energy," Amory Lovins, *The Atlantic*, November 1983.	In sum, all of the energy sources currently being promoted as the backbone of American energy supplies into the 21th century are precisely those least-suited to surviving the uncertainty and violence that seem likely to characterize the future.
Electrical Week, Aug. 2, 1982, "Lovins charts soft path."	"In no industrial country can additional electricity be used cost-effectively because the 'electricity-specific' needs are already met by present capacity with a good deal left over."
Union of Concerned Scientists, *Energy Strategy*, published 1980.	"One clear solution emerges: an aggressive strategy emphasizing improvements in energy productivity and the implementation of a variety of solar technologies that can lead us out of the morass and onto the road to a safe and sustainable energy future."
	"Because saturation levels for most major appliances are achieved, only minor increases in electricity consumption would occur."
"Energy soothsayers not saying the whole sooth," P. Basile, *The Bulletin of the Atomic Scientists*, November 1980.	"We now know future energy supply with much more accuracy than we know demand, or macro-economic growth."
"The Good News About Energy," Report of President Carter's Council on Environmental Quality, 1979.	"Achieving low-energy growth will not be easy or cheap, but it will be far easier and less costly than achieving high-energy growth. In an age increasingly beset by all kinds of limits (resource, environmental and social), conserving energy through improving fuel productivity is the single-most-effective means of easing our long-term environmental and energy problems. And it provides an essential link in the inevitable transition toward an economy based on renewable energy sources."
National Audubon Society's 1981 Energy Plan.	"The [energy] Plan will require massive investment in equipment and processes that use energy more efficiently and in solar energy processes over the next 20 years. ... The $675 billion [Federal] investment in energy efficiency required by the Plan over the next 20 years will end up saving our society at least $300 billion."
"A Progress Report on Alternative Energy Sources," *Fortune*, special report, Sept. 24, 1979.	"Indeed, we might feel obliged to restrict use of the new [synthetic] fossil fuels long before their supply ran out." "If Americans can pay $2 for a gallon of milk, it is hard to see why such prices for energy would seem outlandish."
	". . . the Carter Administration's pledge that the nation will be getting 20 percent of its energy from the sun by the year 2000."
"World Energy Outlook," Exxon Background Series, April 1978.	"At the projected rates of consumption and discovery, the limited availability of discovered reserves could cause oil production growth to taper off and possibly reach a plateau before the end of the century."
"The Deceptive Glut," OECD *Observer*, November 1982.	"The main conclusion of a new study of the OECD's International Energy Agency [is that] from the late 1980s onward, oil supplies will not be able to keep up with the demand for oil."
Energy: Global Prospects 1985 - 2000, Workshop on Alternative Energy Strategies, MIT, 1977.	"The supply of oil will fail to meet increasing demand before the year 2000, most probably between 1985 and 1995, even if energy prices are 50% above current levels in real terms."

"Liquid and gaseous fossil fuels are relatively benign and until recently were both abundant and cheap. How will we cope with their increasingly limited availability and unreliable sources of supply? How well can we adjust to their higher prices?"	*Energy in America's Future: The Choices Before Us*, Resources for the Future, 1979.
"Not too surprisingly, the first policy step is getting prices right, so that both consumers and producers of energy will treat it as the more precious stuff it has become."	
"As to future energy supplies and costs, we find that there are serious short-run producibility problems for oil and gas."	
"On average, nuclear energy was found to be cheaper than coal ... for new power plants that could be constructed for operation in the mid-1980s."	
"It appears that energy resources have been depleting faster than technology has been improving, so that the cost of energy has gone up recently relative to that of other goods and services."	
"A chief problem facing the new administration in Washington is devising an energy strategy that encourages American economic growth while coming to grips with the international economic balances that are being so radically altered by the pressures of energy cost and social unrest."	"Energy: A special report in the public interest," *National Geographic,* February 1981.
"Conservative estimates project a price of $80 a barrel [in 1985], even if peace is restored to the Persian Gulf and an uncertain stability maintained."	
"[Policies will require] adjusting to high and rising energy prices." H. Landsberg, Resources for the Future.	
"Instability in that region will almost certainly continue to increase in the years ahead, with interruptions to supplies more frequent, and oil prices increasing at rates that will pose an even greater threat to the stability to the world economy than today." John F. O'Leary (former Secretary of Energy).	*Beyond Oil: The Threat to Food and Fuel in the Coming Decades*, Gever et al., Ballinger Press, 1986.
"In short, because of high interest rates and uncertain returns on fuel-related capital investments, the market is not likely to make a timely response to dwindling supplies of oil and gas. The necessary incentives are just not there. To avert the problems that a delay would cause, then, some government pump priming is in order."	
"If present trends continue, and there is every reason to believe they will, the quality of fuels available to the U.S. economy will deteriorate. Total energy consumption will stagnate."	
"The generally rising real price of energy lends advantage to higher investments in both supply and conservation . . . . As prices rise in the coming decades, more such opportunities will appear."	*Energy in Transition 1985-2010*: National Academy of Sciences, 1979.
"Given the probability that world oil production will peak in the 1990s and decline gradually thereafter, it is thus extremely unlikely that the United States will be able to offset its declining domestic production of fluid fuels by increasing its share of world imports."	
"A major energy transition of some kind is inevitable"	"Solar Possibilities" Denis Hayes, Worldwatch Institute, *Energy Journal*:, October 1979.
"A careful inquiry suggests that sunlight could eventually be the primary, and even exclusive, source of heat, electricity and synthetic fuels for the entire world, continuously and eternally."	"Global Aspects of Sunlight As A Major Energy Source," J. Weingart, Solar Energy Group, Lawrence Berkeley Laboratory, *Energy Journal*: October 1979.
"The Department of Energy and NASA are jointly conducting a (three-year $15.5 million) feasibility study to be completed in mid-1980 to arrive at an optimum engineering design ... for the Satellite Power System [where] energy from the sun is collected by an array of solar collectors in geostationary orbit and converted to microwave energy directed toward the earth in a focused beam."	"Impacts of Satellite Power System Technology," H. Moses, U.S. Dept. of Energy, *Energy Journal*,October 1979.
"OTEC can provide the U.S., and many of the nations with a renewable resource at a price competitive with other technologies."	"Ocean Thermal Energy Conversion," Lavi and Lavi, Carnegie-Mellon University, *Energy Journal*: October 1979.

Energy for Survival: The Alternative to Extinction, W. Clarke, Anchor/Doubleday Books, 1974.	"We are faced with a grave problem. Since the industrial revolution, the industrialized nations have been engaged in a race to increase energy consumption in order to increase population and build great bases of political power."
	"Energy conservation policies will be necessary on a massive scale to forestall shortages of both energy and material goods in the economy in future years."
	"Avoidance of environmental and economic collapse is possible if the industrial societies shift the current emphasis on high growth into a transitional phase of planetary maintenance, not exploitation."
1994: The World of Tomorrow, U.S. News & World Report, 1973.	"To save our civilization, we must do more than curb air and water pollution . . . we must slow down the present rate of population growth."
	"Many experts contend, however, that only a wide-ranging program can chart a way out of the present crisis. Such a program would implement all of the following: increased imports of oil and natural gas, technological efforts to improve efficiency of energy production, massive research efforts to develop fuel alternatives, and drastic changes in consumer demands."
	"Although there is plenty of energy, it may not be available to Americans because of price, environmental effects, geographic and political considerations, or technological capability."
	"The most urgent immediate problem facing America is the shortage of natural gas."
	"S. David Freeman, head of a Ford Foundation study of the energy situation, points out: 'There are two things wrong with coal today. We can't mine it and we can't burn it.'...In addition, coal is expensive and difficult to transport."
	"We can thus say with some confidence that, under the assumption of no major change in the present system, population and industrial growth will certainly stop within the next century, at the latest."
	"The internal combustion spark-ignition engine in use today-which may become a thing of the past long before 1994 comes around."
"An Interim Look at Energy," Hammond, Editor, *Science*; 10 Feb. 1978.	"Energy research now occupies tens of thousands of scientists and engineers in this country, and the R&D budget for the federal government alone exceeds $3 billion a year. Still lacking are the willingness to face up to an era of more expensive energy and a political consensus on how to deal with our changed energy circumstances."
Barry Commoner, "Energy Panel Looks to Sun As Solution," The New York Times, Oct. 9, 1980.	"There's one basic answer to the energy crisis. We've got to shift as rapidly as possible from a 95 percent dependence on non-renewable fuels to full dependence on renewable ones. Otherwise, we're in grave economic danger.''
Goals for Mankind: A Report to the Club of Rome, 1977.	Socio-economic development could fail for lack of adequate and economically priced energy and materials supplies, while competition for scarce and expensive resources could escalate into violence.
"Energy in Transition," J. Holdren, *Scientific American*, September 1990.	"We are, however, running out of the cheap oil and natural gas that powered much of the growth of industrialized societies."
	"It appears, then, that expensive energy is a permanent condition, even without allowing for its environmental costs."
Union of Concerned Scientists, *Energy Strategy*, published 1980.	"What seems certain, at least for the foreseeable future, is that energy, once cheap and plentiful but now expensive and limited, will continue to rise in cost."
Energy We Can Live With, Ed., D. Wallace, Rodale Press, 1976	"America is a country of energy drunkards. Alternate approaches to energy production and use are [the] most real because none of them require advanced technology or years to make practical. Greenhouses that grow food in winter with the help of the sun are available now, as are wood stoves, compost piles, thermal underwear and bicycles."

Table 2
Some Who Got It Right

The record of energy and technology forecasters of two decades ago is not entirely barren of visionaries who did guess correctly. But their views were either completely buried at the time in the mountain of expert studies and media frenzy, or pilloried. Two writers at the time saw the future differently from those expounding the current mass wisdom; however, they were largely ignored. Many constituencies had a lot to gain in political and economic terms, at least in the short term, by going along with, if not encouraging, the idea of energy shortages. (The parallels with the global-warming debate here are obvious.) Consistently accurate in the arena of economic and resource forecasting, the recently deceased and brilliant thinker Julian Simon was, quite literally, a sane voice in a wilderness of intellectual inaccuracy:

> "Extrapolation of long-run cost trends ... promises continually **decreasing** scarcity and cost [for energy], though this runs counter to popular opinion."
>
> *The Ultimate Resource*, Julian Simon, Princeton Press, 1981.

More visible, but no less ignored at the time, was Peter Drucker, who coyly claims he does not make predictions. He recently made the following observation about forecasts on the subject of energy:

> "In 1979, I made myself absolutely impossible by publishing an article in the Wall Street Journal in which I said the petroleum cartel — OPEC — is dead. I predicted that the price of oil would not go up any further, and **I got more brickbats for that than I ever got in my life**. ... I said that between 1980 and 2000 petroleum prices would not go above $20 a barrel"[emphasis added].
>
> "Peter Drucker's Takes the Long View," *Fortune*, Sept. 28, 1998.

Some who got it right...	
"Coal has the potential to contribute substantially to future energy supplies. Although the resource base of other fossil fuels, such as oil sands, heavy oil, and oil shale is very large, they are likely to supply only small amounts of energy before the year 2000." "Other than hydroelectric power, renewable resources of energy — e.g., solar, wind-power, wave-power — are unlikely to contribute significant quantities of additional energy during this century at the global level."	*Energy: Global Prospects 1985-2000, Workshop on Alternative Energy Strategies*, MIT, 1977.
"It is still too early to make a reliable assessment of what can be accomplished in the next decade and beyond, and it would be premature to conclude that energy problems will necessarily constrain world economic development during this century or beyond."	"World Energy Outlook," Exxon Background Series, April 1978.
"A major feature of the world energy outlook is the continuing trend toward greater use of energy in the form of electricity, but the rate of future electricity growth is projected to be slower than in the past."	
"In the most general of terms, this book concludes that profitable and expanded petroleum and electric utility industries will be required if the nation is to stand any chance at all of developing a meaningful energy base now and in the future."	*Fuels for Tomorrow*, Dr. L. Rocks, PennWell, 1980.
"Many special-interest groups would like ... a crash program of commercial development of [unconventional energy systems] through heavy government subsidies."	
"Coal must be used in increasing quantities, and mainly with the current technologies, until at least the turn of the century, regardless of what happens with respect to such alternatives as nuclear fission or solar energy."	*Energy in Transition 1985-2010*: National Academy of Sciences, 1979.
"The actual choice of which solar technologies to deploy should be made in as decentralized a manner as possible. In other words, the decisions should be left to private industry and individual consumers."	

Energy in America's Future: The Choices Before Us, Resources for the Future, 1979.

"Challenges in the Implementation of Energy Conservation," S. Penner, Energy Center, U. California, San Diego" *Energy Journal: Special Issue: Renewable Energy Prospects*, October 1979.

"Of course, technological change is unpredictable, and a new wave of innovation could lower energy costs." (footnote on p. 463.)

"Inventions and innovations in technologies that are not motivated by energy-conservation goals (e.g., introduction of new generations of motor vehicles, aircraft, entertainment facilities, such as color TVs, stereo systems and video-tapes) have played dominant roles in improving what many people view as their standard of living. These inventions and innovations have been responsible for rapidly escalating energy-use rates. In developing future scenarios for energy conservation, it is important to allow room for important inventions not yet conceived or not yet available (e.g., personal electric vehicles) and for the corresponding radical changes in energy-use patterns that may accompany their introduction. Without this provision, the most benign energy-conservation scenarios may not justifiably be viewed as maintaining the quality of life."

ORIGINALLY PUBLISHED, MAY 1999
REPRINTED WITH TYPOGRAPHICAL CORRECTIONS, JULY 1999

ABOUT THE AUTHOR

Mark P. Mills is president of Mills-McCarthy and Associates Inc. (MM&A). MM&A is a Washington, DC-based research and consulting firm specializing in technology strategy focused on the energy industry. Mills is a Senior Fellow with the Competitive Enterprise Institute and serves as a Science Advisor to the Greening Earth Society. Mills is the founder and publisher of the national newsletter *Breakthrough Technologies*, which covers new and emerging energy-related end-use technologies. He has worked with over 80 utilities in providing strategic plans, marketing support, speeches, seminars, executive briefings, expert testimony and analytic research.

A physicist by training, Mills holds several patents in the fields of integrated circuits, fiber optics, and solid state devices. He also pioneered a quantitative approach to accounting for total fuel cycle energy and environmental benefits of the use of electricity, and has produced groundbreaking research on the role of electrotechnologies and electricity in the economy, including a commodity-based model of kilowatt-hours.

A frequent expert witness in hearings before Congress and state legislatures, Mills has served as a staff consultant to the White House Office of Science and Technology Policy (under President Reagan), a number of National Research Laboratories, the former Congressional Office of Technology Assessment, and the U.S. Department of Energy.

The Competitive Enterprise Institute

The Competitive Enterprise Institute is a public policy organization committed to advancing the principles of free enterprise and limited government. Founded in 1984 by Fred Smith, Jr., CEI promotes classical liberal ideals through analysis, education, coalition-building, advocacy, and litigation. A non-profit, tax exempt organization under Section 501 (c) (3) of the Internal Revenue Code, CEI relies entirely on donations from foundations, corporations, and private individuals. Contributions are tax deductible to the extent allowed by law.

For more information, contact:

COMPETITIVE ENTERPRISE INSTITUTE

1001 Connecticut Avenue, N.W.
Suite 1250
Washington, D.C. 20036
Phone: (202) 331-1010
Fax: (202) 331-0640
E-mail: info@cei.org
Web site: http://www.cei.org