CEEPR Center for Energy and Environmental Policy Research

Energy Policies and Their Consequences After 25 Years

by
Paul L. Joskow

03-013 WP July 2003

A Joint Center of the Department of Economics, Laboratory for Energy and the Environment, and Sloan School of Management

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Paul L. Joskow[1]
MIT
July 2003

ABSTRACT

Hans Landsberg and Sam Schurr each led research teams that produced two important energy futures policy studies that were published in 1979. The conclusions, policy recommendations, and energy demand, supply, and price forecasts contained in these studies are reviewed. Developments in U.S. energy policy over the last 25 years are discussed and compared with the recommendations contained in the two studies. The projections of energy demand, supply, and prices for 2000 contained in the studies is presented and compared to actual realizations. The nature, magnitudes, and reasons for the differences between the studies' forecasts and what actually emerged 25 years later are discussed. All things considered, the Landsberg and Schurr studies have stood the test of time very well.

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[1] Elizabeth and James Killian Professor of Economics and Management at MIT. This paper was prepared as part of a collection of papers written in honor Hans Landsberg and Sam Schurr. It will be published in *The Energy Journal* in October 2003. I am grateful for helpful comments on an earlier draft provided by Joel Darmstadter, Vito Stagliano, and G. Campbell Watkins and for research support from the MIT Center for Energy and Environmental Policy Research.

I. INTRODUCTION

About 25 years ago several comprehensive "energy futures" policy studies were released to the public.[2] They were released just as the disruption in oil supplies from Iran was causing oil prices to rise to unprecedented levels, the accident at the Three Mile Island nuclear power plant was shaking the nuclear power industry, and President Carter was preparing the public to respond to a long term energy crisis requiring efforts of a magnitude that would be the "moral equivalent of war" (Stagliano, pp. 31-33). These energy futures studies endeavored to identify the nation's energy problems and to propose public policies to help to ameliorate them. The leaders of the teams responsible for two of these studies were Sam Schurr and Hans Landsberg.

This is a good opportunity to look back at the energy policy recommendations, forecasts and supporting analysis contained in the two studies led, respectively by Sam Schurr (the "RFF study") and Hans Landsberg (the "Ford Study")[3] with the benefit of nearly 25 years of policy experience and realizations of energy demand, supply, and prices. As Jonathan Koomey *et. al.* argue in their paper in this volume, retrospective studies can be very useful from a number of different perspectives. This paper reflects this general view. The paper proceeds in the following way. I first review the major conclusions of the two studies and their explicit or (sometimes) implicit policy recommendations. Second, I offer a brief and necessarily incomplete review of the major features of U.S. energy policy over the last 25 years in the context of the policy

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[2] These studies included Schurr (1979), Landsberg (1979), Stobaugh and Yergin (1979) and National Academy of Sciences (1979).

[3] This "Ford Study" should be distinguished from the Ford Foundation Energy Policy Project led by S. David Freeman which released its conclusions about energy policy in "A Time to Choose, America's Energy Future," in 1974. Indeed, *Energy: The Next Twenty Years*, the Ford Study discussed here, and another Ford Foundation sponsored study *Nuclear Power: Issues and Choices*, published in 1977, were in part a reaction to the view that the conclusions of the 1974 study gave too little the role of market forces.

recommendations made in these studies. Finally, I examine the patterns of energy consumption and energy supply anticipated by the RFF and Ford studies, compare them with the actual supply and consumption patterns realized in 2000, and discuss how they have been affected by policy decisions and unanticipated changes in the structure of the U.S. economy. There is much wisdom contained in these two studies that both reflect "lessons learned" from experience with energy policies over the decades before the studies were conducted (Goodwin) and are still relevant today.

II. THE RFF AND FORD STUDIES: REALITIES AND POLICY PRESCRIPTIONS

To fully appreciate the studies prepared by the teams led by Schurr and Landsberg we must recall the context in which they were written (Stagliano, pp. 19-43). In the 1977-79 period when the studies were being prepared, there was widespread public concern about additional disruptions in world oil supplies, energy shortages, rising energy prices, slow economic growth and rapid inflation. Prices for virtually all sources of energy were regulated by the federal government. Shortages of natural gas in particular were growing and the gasoline lines of 1973-74 were hard to forget. Many opinion makers pitched the ideas (individually or in combination) that the world was running out of energy, that energy markets could not be trusted to work well, and that various evil doers in the energy industry were conspiring to keep prices high while thwarting cheap "soft energy path" opportunities from being made available to the public. At the same time, coal and nuclear power were facing increasing challenges on environmental and safety grounds. President Carter's first energy plan, and the legislation that flowed from it, reflected the view that there was a very serious energy crisis facing the country, that markets were the problem rather than the solution, and that what was needed were massive government initiatives to subsidize alternative energy supply sources and to mandate end-use efficiency standards while shielding the public from higher energy prices. The RFF and Ford studies were a reaction to the hysteria and the flawed policy initiatives that were rampant in the late 1970s.

In 1979, a Resources for the Future (RFF) research team, led by Sam Schurr as Project Director, published the book *Energy in America's Future* (the "RFF Study"). The book begins with the following insightful observations regarding the challenges confronting energy policy implementation:

> "There are many reasons why U.S. energy policy remains in dispute, but at least four problems come to mind in explaining the specific motivations that gave rise to this book and the basis on which its contribution to policy dialogue might be judged:
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> 1. There is disagreement --- and even some ignorance --- about some fundamental facts.
> 2. There is great uncertainty about what results the most commonly suggested energy policies might produce.
> 3. It is painful to choose between short-term and long term objectives. What is best for us this year may make things very unpleasant in 1990 --- and vice versa.
> 4. There is no clear national consensus on what the major long-term goals of U.S. energy policy should be." (RFF Study, page 1)

The RFF study endeavored to address all of these "…barriers to a workable, acceptable energy policy for our nation," (RFF Study, p. 1). The study contains a comprehensive empirical analysis of energy consumption drivers, the relationships between energy consumption and economic growth, and technological opportunities to use energy more efficiency (technically and economically). It contains a detailed discussion of mineral resource and production cost information; conventional electricity supply technologies, focusing on nuclear and coal; and non-conventional supply alternatives, focusing on synthetic fuels, solar and other renewable and decentralized "alternative" supply technologies. It clearly recognizes the interdependencies between energy consumption and production choices and their environmental impacts.

While the RFF study does not recommend a set of "best policies" it provides a thoughtful framework for considering energy policies choices in the context of uncertainty and the international setting in which U.S. energy choices and consequences are embedded. According to the RFF study, a primary motivation for energy policy actions is to reduce dependence on imported oil and natural gas from unstable areas of the world and to move the country gradually on to a path that can adapt to what were anticipated to be significant long run increases in the prices of oil and natural gas reflecting the higher costs of extracting oil and natural gas and the costs of meeting tighter environmental regulations.[4] However, the RFF study rejected the "we are running out of energy" perspective that was popular it the time. It took the clear view that the resource base was adequate to support growing world oil and gas consumption for at least a decade "… at cost levels not much higher than current prices." (RFF Study, p. 425).

Among the policies discussed favorably in the RFF study are strategic storage, diversifying the sources of oil and gas supplies, reducing petroleum demand to lower the probability of disruption, policies to remove market and non-market barriers to expand domestic fuel supplies (nuclear, synthetic fuels, solar energy) and to encourage more efficient use of energy by consumers ("conservation"). The book emphasizes the importance of relying primarily on price signals and removing the then prevailing price controls on oil and natural gas and the desirability of targeting government interventions

[4] Though the RFF study took the clear view that the resource base was adequate to support growing world oil and gas consumption for at least a decade "… at cost levels not much higher than current prices." (RFF Study, p. 425).

at market failures. Finally, the RFF study envisions a future energy system that involves a balanced combination of increased supplies from a variety of domestic conventional and some new sources plus significant improvements in energy efficiency.

The RFF study forecasts that aggregate energy consumption will continue growing, but at a slower rate than in the past, reflecting higher energy prices and increases in economical energy efficiency opportunities. The RFF study is particularly optimistic about efficiency improvements in residential heating, automobiles, process steam, and cogeneration. On the supply side it views the economics of nuclear vs. coal electricity generation as being reasonably favorable to nuclear, implicitly assuming that oil and natural gas will be too costly to use in the generation of electricity. While the book has a very positive assessment of the economic prospects for cogeneration, it is not particular bullish about widespread economical use of solar heating, photovoltaics, or wind except in a few locations with favorable technical and economic attributes. The book recognizes that these supply resources are unlikely to be economical unless real oil prices double from the level prevailing at the time. The study is sympathetic to government subsidies to advance the development of commercial synthetic fuel technologies based on the belief that these subsidies are justified by a variety of market failures, while recognizing that the costs of synthetic fuels are likely to be double the real price of oil prevailing in 1979. Indeed, synthetic fuels and shale oil appear to be the "backstop" technologies that cap oil prices at about twice the then prevailing prices.

At about the same time in 1979, a Ford Foundation Study *Energy: The Next Twenty Years* was published. The study group made up of distinguished economists, was chaired by Hans Landsberg. This study had the same goals and came to similar conclusions as did *Energy in America's Future*, though the former contains more detailed empirical analysis of resources, costs and technological options than the latter. However, the Ford study, clearly more concerned about the perceived gridlock in energy policy formation, and probably reflecting Landsberg's frustrations about energy policy formation (Landsberg 1983), focuses more on identifying a set of crisp "realities" and promoting a specific set of policy recommendations. Both the realities and the policy recommendations are worth noting (my paraphrasing):

Reality One: The world is not running out of energy. There are abundant energy resources at prices not much more than double those prevailing in 1979.

Reality Two: Middle East oil holds great risks, but is so valuable that the world will be dependent on it for a long time. The U.S. and its allies are vulnerable to serious economic disruptions due to supply disruptions in the Middle East. Dependence on the Middle East can only be reduced slowly.

Reality Three: Higher energy costs cannot be avoided, but can be contained by letting prices rise to reflect them. The higher costs need not have severe effects on economic welfare or lifestyles if they are properly managed. It is a dangerous misconception to think that government can somehow provide dependable, clean and plentiful energy cheaply. Most importantly, energy prices must be allowed to rise to reflect economic realities. In its internal discussions, the Ford team used the assumption that real world oil prices would double from their mid-1979 level by 2000, but oil prices could be anywhere in the $20 to $30/barrel range (in $1979 --- roughly $40 to $60 per barrel in 2002 prices).

Reality Four: Environmental effects of energy use are serious and hard to manage. The need to reduce environmental costs will be a major cause of rising energy costs.

Reality Five: Conservation is an essential "source" of energy in large quantities. Energy conservation cannot be mandated or managed centrally, but requires that information and incentives be provided to energy users who make their own adjustments.

Reality Six: Serious shocks and surprises are certain to occur in the form of short-term supply interruptions and price instability in world oil markets. But there will also be pleasant surprises, regarding new supply and conservation technologies.

Reality Seven: Sound R&D policy is essential, but there is no simple technical fix.

In light of these "realities," the Ford study made nine major policy recommendations:

Recommendation 1: Decontrol oil and gas producer prices.

Recommendation 2: Make regulated electricity prices to consumes better reflect real costs, by applying marginal cost pricing principles and pricing backup capacity economically.

Recommendation 3: Use science and technology to generate and define basic options, while relying primarily on the private sector to develop and deploy technology. Pursue large-scale government financed demonstration projects selectively and with great care.

Recommendation 4: Adopt a different approach to air pollution control. "Air pollution control should focus on providing incentives for making progress toward cleaner air in a way that is cost-effective over time. Emissions charges, marketable discharge permits, and similar market-like devices should be used."

Recommendation 5: Prepare for disruption in world oil markets by developing an effective stockpile program and by using market forces to manage stockpiles and crises.

Recommendation 6: Continue efforts to reduce the problems associated with nuclear power and improve long run nuclear options. Reprocessing nuclear fuel and breeder reactors will not be economical for many years into the future.

Recommendation 7: Work to improve the acceptability of coal, facilitate its use in industry and electricity generation, and learn as much as possible as soon as possible about the carbon dioxide problem.

Recommendation 8: Vigorously pursue conservation as an economical energy source. Temporarily subsidize energy conservation investments until energy supplies are properly priced. Increase "non-hardware" research to better understand the barriers faced by consumers in making wise appliance/equipment choice and energy consumption decisions. Aggressively market energy conservation to consumers.

Recommendation 9: Remove impediments to use of solar energy.

As I will discuss in more detail below, many of these recommendations were reflected in energy policy initiatives over the last 25 years.

III. WHY DO WE NEED NATIONAL ENERGY POLICIES?

The RFF and Ford studies were both motivated, in part, by the view that sensible energy policy was being thwarted by the absence of a clear articulation of energy policy goals and by conflicting views about the underlying attributes of energy supply and demand and their associated uncertainties upon which energy policy must be based. This state of affairs is not surprising for at least two sets of reasons. First, interest in energy policy does in fact reflect multiple goals whose relative importance has ebbed and flowed over time. Second, energy policies can have very significant distributional impacts --- on different industries, different regions of the country, on the well-being of Americans in different income groups, and on different countries around the world. The large and multidimensional distributional impacts inevitably stimulate complex and aggressive interest group politics to influence public perceptions about the nature of energy policy problems, to promote policies that favor one interest group over another, and to make the definition and efficient implementation of sound energy policies difficult.

Even after 25 years, there is still not widespread agreement about the absolute or relative importance of various energy policy goals. Energy policies are derivative policies reflecting a number of higher level policy objectives and considerations.[5]

a. *Important infrastructure sectors essential for economic growth and development:* While interest in energy policy issues increased significantly after the oil shocks in the 1970s and 1980s, energy resource and policy issues attracted scholarly research and policy interest long before then. Sam Schurr, Hans Landsberg, the staff at RFF and many other scholars and policymakers

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[5] The list is not meant to be exhaustive. Clearly, income distribution concerns have played a role in energy policy formation and implementation. So too have market imperfections which may make it difficult for consumers to make rational investments in energy-using structures, equipment and appliances. This section draws heavily on Joskow (2002). Goodwin (1981) contains a very interesting set of essays about U.S. energy policy from the 1930s until 1979, focusing primarily on the post World War II period. Stagliano (2001) briefly reviews this earlier history as well, but focuses on the development of energy policy in the early 1990s.

pursued work on energy and related natural resource issues long before the U.S. imported significant quantities of oil, before OPEC existed, and before Persian Gulf supply disruptions led to price spikes, recessions and public concerns about the "energy crisis."[6] Economical and reliable supplies of energy play an important role in fostering economic growth and development. Energy, like transportation and telecommunications services, is a key intermediate input into most sectors of a developed economy. Distortions in prices, consumption, supply, or reliability of energy infrastructure services can lead to large economic and social costs.

b. *Energy Security Concerns:* National security considerations have served as a rationale for energy policy initiatives going back to the period before World War II (Goodwin 1981). As imports of foreign oil increased, the potential adverse economic impact of oil supply disruptions in particular clearly has been a primary motivation for interest in energy policy since the mid-1970s. The Ford and RFF studies reflected and reinforced these economic concerns. However, empirical studies of the business cycle and economic welfare costs on the U.S. economy of energy supply disruptions are not consistent with the view that these costs are enormous.[7] Nevertheless, even if these costs are not as large as many policymakers seem to think, government policies that anticipate or respond to energy price shocks can still affect their magnitude either positively or negatively depending on the wisdom of the policies that are implemented.

c. *Environmental Impacts:* The combustion of fossil fuels is the primary source of air pollution targeted by environmental policies aimed at cleaning the air (NOx, SO2, CO, etc.) and accounts for most of the production of CO_2, a greenhouse gas generally thought to be a major contributor to global climate change.[8] The RFF and Ford studies both clearly recognized the importance of the interactions between energy and environmental policies and took the position that there was no fundamental conflict between increased energy consumption and improving environmental quality. The Ford study emphasized the desirability of relying more on market-based instruments to internalize environmental externalities and identified CO_2 emissions as an emerging environmental challenge.

d. *Competition Policy:* Important segments of the U.S. energy sector, in particular electric power and natural gas, have been subject to price and entry regulation for almost a century. These regulatory institutions have important implications for the performance of these important infrastructure sectors and,

[6] For example, President's Materials Policy Commission (1952)., "Resources for Freedom: A Report to the President, U.S. Government Printing Office, 1952.
[7] For example, Bohi and Toman (1993), and Bohi (1991). However, a recent study by de Miguel, Manzano and Martin-Moreno (2003) finds that oil price shocks imposed significant costs on the Spanish economy.
[8] Energy production and delivery also have significant potential impacts on water quality, water temperature, and land use. Environmental policies necessarily affect energy markets and energy policies necessarily have environmental effects.

therefore, for the performance of the economy. U.S. competition policies continually reexamine the rationale for and performance of price and entry regulation. Poor sector performance, as well as technological and economic changes that undermine the case for price and entry regulation, can make it desirable to design and implement competition policies that restructure regulated industries to expand opportunities for competition and shrink the expanse of price and entry regulation. However, aside from the recommendations to decontrol oil and natural gas prices, the Ford and RFF studies give essentially no consideration to more fundamental changes in the structure and role of competition in the gas and electricity sectors.

e. *Use of Publicly-owned Resources*: A significant fraction of domestic energy resources lie on or under land that is controlled by the federal government (and to a lesser extent state governments) and this fraction has been increasing. Hydroelectric resources lie on rivers and in locations subject to state or federal jurisdiction. The federal government has no choice but to develop and implement policies which define how these lands can be used for energy exploration and production. These policies also have impacts on the environment that further complicate the interactions between energy and environmental policies. The RFF and Ford studies recognized the need to optimize the use of energy resources on federal lands in an environmentally sensitive manner.

The energy policy-making and implementation process has several enduring features that have limited its success in achieving these and other sensible goals. First, there has never been *sustained* national leadership to develop and pursue a long-term energy policy program or to convince Americans that energy supply and demand are things that they should be concerned about. Instead, policy initiatives have been stimulated by short term supply shocks that have led to public concern about rising prices or shortages of fuel. These concerns stimulate demands (or opportunities) for something to be done by government, policy proposals are made and sometimes implemented, the impacts of the supply shocks and public reaction abate and the interest in energy policy quickly fades away soon after.

Second, the one proven way to reduce energy demand in the long run is to raise energy prices by allowing energy markets to function with unregulated prices and to reflect energy security and environmental externalities in energy prices by applying taxes or tradeable permits mechanisms to internalize the associated externalities. But the interest of Americans in energy policy issues is triggered by price increases and the public expects that policies will reduce prices. Politicians generally view supporting policies that would transparently increase energy prices as not being career enhancing decisions. Indeed, at the time the Ford and RFF studies were released, decontrol of oil and natural gas prices had only limited public support, despite the fact that there was growing evidence that the price controls on petroleum and the associated entitlements system were not constraining consumer prices significantly and that natural gas price controls were responsible for growing shortages (Arrow and Kalt, Smith and Phelps, Rogers). Accordingly, energy policy initiatives have tended to rely on the provision of targeted financial incentives of various kinds, R&D funds, and mandatory energy efficiency standards applicable to automobiles, appliances, new buildings, and industrial equipment.

Third, energy policy debates are always extremely contentious and tend to reflect regional interests at least as much as partisan Democrat vs. Republican politics. They pit energy production states against energy consuming states. They pit big oil, gas, and utility companies against consumer groups --- including industrial consumer groups --- fighting for lower prices. The unfortunate history of natural gas price controls during the 1960s and 1970s is perhaps the clearest example of a contest between energy consuming and energy producing states (MacAvoy 2000). And increasingly over time, energy policy debates have become intertwined with environmental policy debates since energy production and use is the major contributor to air pollution, hazardous waste depositions, and land and water use issues. The confrontations between traditional "supply side" policies focused on increasing domestic energy supplies and "demand-side" policies built around energy conservation, renewable energy, and alternative vehicle initiatives, has continued to intensify over time.

IV. THE LAST 25 YEARS OF ENERGY POLICY THROUGH THE LENS OF THE RFF/FORD STUDIES

As discussed above, the Ford Study made a set of nine major policy recommendations. These recommendations are generally consistent with those made or implied, less crisply, in the RFF study. How do these recommendations compare to the actual course of energy policy since 1978? I will focus here on a subset of these recommendations:

a. <u>Decontrol oil and natural gas prices:</u> The deregulation of oil and natural gas prices was accomplished, quickly in the case of oil and more slowly in the case of natural gas. Price controls on oil were implemented as part of President Nixon's anti-inflation policies prior to the first oil shock in 1973-74. In 1975, President Ford signed the Energy Policy and Conservation Act, extending price controls on oil and implementing the crude oil entitlements program to allocate "old" price controlled oil (Kalt). Controls on the field price of natural gas sold in interstate commerce began in the 1950s, with regulatory obligations thrust on the Federal Power Commission by federal court decisions reinterpreting the provisions of the Natural Gas Act of 1938. By the mid-1970s, these price controls had created increasingly severe shortages of natural gas (MacAvoy and Pindyck).

In late 1978 Congress passed the Natural Gas Policy Act (NGPA). The NGPA, began the deregulation of "new gas" supplies while continuing price regulation of "old gas" supplies. Two months after President Carter signed the NGPA into law along with several other pieces of energy policy legislation, Iran ceased exporting oil following the Shah's overthrow, leading to an explosion in world oil prices. In April 1979, President Carter, responding to growing oil and gas shortages in the U.S., announced the gradual decontrol of oil prices. Then in early 1981, the President Reagan responded to the oil crisis of 1978-1980 by removing remaining price and allocation controls on the oil industry. The Natural Gas Wellhead Decontrol Act of 1989 completely removed the price controls on wellhead prices of natural gas with the last vestiges of field price regulation ended in January 1993.

The deregulation of natural gas prices went even further (beyond the "field") than the authors of the RFF and Ford studies had contemplated. Beginning in 1985, a series of Federal Energy Regulatory Commission (FERC) initiatives led to the unbundling of interstate pipeline transportation of natural gas from the sale of commodity natural gas itself, ultimately making it possible for local distribution companies, electricity generators and large industrial users to purchase commodity natural gas directly from producers or through intermediaries in unregulated competitive natural gas markets, purchasing transportation service separately at prices that were capped by FERC regulation. These restructuring, deregulation and regulatory reform initiatives led to the development of competitive markets for natural gas at a growing number of trading hubs, markets for gas storage, secondary markets for pipeline capacity, the development of a vibrant gas marketing industry, and the creation of financial derivatives markets giving wholesale gas consumers a wide range of contracting and risk management options.

b. Regulated electricity prices should more closely reflect the marginal cost of supplying electricity: Retail electricity prices are regulated by the states through their public utility commissions. At the time the RFF and Ford studies where written, it was widely believed that cost-of-service regulation was keeping electricity prices below the marginal supply cost of electricity and that electricity prices generally did not properly reflect variations in marginal cost between peak and off peak periods. Title I of the Public Utility Regulatory Policies Act of 1978 (PURPA) required states to determine whether they would introduce new pricing mechanisms to encourage more efficient utilization of electricity. Title II of PURPA obligated electric utilities to purchase power from cogeneration plants and small power production facilities using renewable and waste fuels. At the time PURPA was passed, Title I received much more attention than did Title II. In response to Title I, and after the RFF and Ford studies were published, each of the states went through a process to determine whether and how they would adjust electric and gas utility rate structures to provide better incentives to consumers, including the consideration of marginal cost pricing. Relatively little came of these proceedings, with a few states implementing voluntary time-of-use pricing tariffs and Title I is has now largely been forgotten.

Title II of PURPA has had a much more significant effect on the organization and regulation of the electric power industry which, in the long run, should ensure that retail prices reflect the competitive market value (marginal cost) of electricity. Title II of PURPA required electric utilities to purchase electricity supplied by "Qualifying

Facilities" (QF) producing electricity using cogeneration technology, renewable and waste fuels.[9] Consistent with the Ford and RFF studies, the objective of Title II of PURPA was to stimulate electricity production from more thermally efficient cogeneration plants and to encourage the use of renewable and waste fuels in the production of electricity. The states were required to develop regulations to ensure that electric utilities would stand ready to purchase power from QFs at prices reflecting their "full avoided costs." After various court challenges, in the early 1980s, several states, including California, New York, all of the New England states, New Jersey and Pennsylvania, embraced PURPA with great enthusiasm, requiring utilities to pay high prices for QF power under 20 to 30 year contracts.

As with natural gas, policies affecting the electricity sector have gone much further than the RFF and Ford studies had anticipated. Provisions of the Energy Policy Act of 1992, subsequent initiatives by FERC, and initiatives by several states has placed the electric power industry on a difficult and ongoing path of restructuring to support competitive wholesale and retail markets for electricity (Joskow 2003). Importantly, both the RFF and Ford studies completely missed the increasingly important role of natural gas and the central role of efficient combined-cycle gas turbine (CCGT) generating technology using natural gas in electricity generation and its role in evolving competitive wholesale power markets. These developments in turn were stimulated by the decontrol of natural gas prices and the subsequent restructuring of the natural gas industry.

c. Vigorously pursue energy conservation: There has certainly been no shortage of efforts to encourage energy efficiency improvements in the last 25 years. Whether they

[9] A more detailed discussion can be found in Joskow (1989).

are exactly what the Ford and RFF studies had in mind is hard to say. Energy efficiency or conservation policies have relied on a combination of building and appliance efficiency standards, tax subsidies, direct subsidies implemented through utility energy efficiency programs, and other means. The National Energy Policy and Conservation Act (NEPCA) was passed by Congress and signed by President Carter in late 1978, required the Department of Energy (DOE) to issue appliance efficiency standards for household appliances and charged the FTC with issuing appliance energy efficiency labeling rules. However, the Reagan administration opposed setting appliance efficiency standards required by this legislation and eventually promulgated "no-standard standards." The DOE was then sued for failing to enforce the National Energy and Conservation Act of 1978 and a Court of Appeals ruled against the Reagan administration.

Little progress was made in enacting federal appliance efficiency standards until the late 1980s, when new federal legislation was passed in response to a growing number of states enacting their own appliance efficiency standards and manufacturer concerns about the prospect of manufacturing appliances meeting numerous state-specific energy efficiency standards. The proliferation of different individual state standards then led appliance manufacturers to seek uniform national appliance efficiency standards. Manufacturers and energy efficiency advocates (environmental groups) negotiated what became the National Appliance Energy Conservation Act in 1987. This Act contains specific efficiency standards for 12 types of home appliances that are supposed to be updated from time to time by the DOE. The first standards became effective in 1988 and 1990 and the DOE has revised the statutory standards since then. President Clinton approved new standards for air conditioners and other appliances near the end of his second term.[10]

The Energy Policy Act of 1992 (EPAct92) was passed in October 1992. It was the only piece of major energy policy legislation passed during the 1990s. It grew out of legislation proposed by Congressman Phil Sharp entitled "The National Energy Efficiency Act of 1991" that was shaped and managed through the Congressional political thickets by Senators Johnston and Wallop. Unlike the supply-side program oriented proposals focused on increasing supplies of conventional fossil fuels submitted to Congress in early 1991 by the G.W. Bush administration, and rejected by Congress in June 1991, EPAct92 paid much more attention to promoting energy conservation and renewable energy. Among other things, EPAct92 provides tax and direct subsidies for energy efficiency and renewable energy technologies, requires new energy efficiency standards for buildings and industrial equipment, expands energy efficiency labeling requirements, and creates programs to improve energy efficiency in federal buildings. EPAct92 also made important changes in the Federal Power Act (FPA) and the Public Utility Holding Company Act (PUHCA) which helped to make subsequent electricity industry restructuring and competition initiatives feasible.

Improving automobile fuel efficiency plays a big role in the RFF study. Automobile fuel efficiency standards were first established by the federal government in the Energy Policy and Conservation Act of 1975 and a "gas guzzler" tax was included in the Tax Act of 1978, before the RFF and Ford studies were completed and the anticipated effects are incorporated in both studies. The 1975 Act established Corporate Average

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[10] Though the standard for central air conditioners were partially rolled back later by the G.W. Bush administration.

Fuel Economy (CAFE) standards for each automaker, with domestically produced and imported vehicles counted as separate fleets. For passenger cars, the CAFE standards started at 18 miles per gallon with the 1978 model year and gradually increased to 27.5 miles per gallon for the 1985 model year. For light trucks, including SUVs, the CAFE standard began at 17.2 miles per gallon in 1979 and rose to 20.5 miles per gallon by 1987. These standards are based on laboratory tests that follow EPA guidelines and have not changed since 1985 and 1987 respectively. Efforts to tighten the CAFE standards have been opposed successfully by domestic automobile manufacturers for the last two decades, supported by scholarly studies that indicate that the implementation of the standards was very costly.

d. Nuclear Power: The RFF and Ford studies were just being completed when the accident at the Three Mile Island Nuclear Plant (TMI) occurred in March 1979. This reinforced already significant public opposition to nuclear power, leading to a temporary moratorium on the completion of new nuclear plants, and a temporary closure of some operating nuclear plants, pending a review of safety issues raised by the TMI accident. Delays and design changes following these reviews contributed to the already escalating costs of building nuclear power plants. While acknowledging the escalation in costs, lengthening licensing and construction times, and poor operating performance of nuclear plants, both the RFF and Ford studies are quite favorable toward nuclear power, viewing it as being very competitive with new coal plants, and arguing that constraints on expanding nuclear power would be costly. The RFF study seems to accept the DOE's range of estimates for installed nuclear generating capacity of 256-396 Gwe (p. 423) in 2000 and an overnight construction cost of about $530/kW in 1975 prices (about

$1500/Kw in 2002 prices) as being reasonable. The RFF study recommends that the U.S. continue efforts to reduce the problems confronting expansion of nuclear power electric generating capacity. It also argues that reprocessing nuclear fuel and breeder reactors will not be economical for many years into the future. Finally, it recommends a continuation of efforts to define and improve long run nuclear options and to resolve waste disposal issues and has a thoughtful discussion of waste disposal and nuclear proliferation issues.

Federal policy toward nuclear power during the 1980s and 1990s was primarily a policy of benign neglect, nether aggressively promoting nor actively discouraging construction of new nuclear power plants. Legislation was passed in 1982, 1987 and 1992 to identify and develop a site for storing waste fuel from civilian nuclear reactors consistent with the RFF studies' recommendations. Until the mid-1970s, U.S. energy policy assumed that separated plutonium from reprocessing would be recycled as a commercial nuclear fuel source. However, concerns about the potential for plutonium to be diverted and converted to weapons material, which could lead to the proliferation of nations with nuclear weapons, resulted in a 1977 presidential ban on reprocessing used nuclear fuel in this country. This ban and the supporting recommendations of the Ford study were very controversial at the time. Although the ban was subsequently lifted, the high cost of reprocessing and the availability of cheap uranium continue to drive decisions not to reprocess in the United States.[11] Federal funding for the development of the Clinch River Breeder Reactor was terminated in 1983 and the project cancelled due to technical problems, high construction costs, and the view --- shared with the RFF study --

[11] Nuclear Energy Institute Web Site. http://www.nei.org/doc.asp?docid=663.

- that reprocessing nuclear fuel to recycle plutonium would not be economical for many years.

While the Clinton Administration was not a big booster of nuclear power, it supported a number of "pro-nuclear" initiatives, including developing and applying re-licensing procedures for nuclear plants reaching the end of their initial license period and pre-certification of three new prototype nuclear plant designs. Nevertheless, although EPAct92 provides funds for R&D on advanced nuclear technologies, the Clinton administration gradually reallocated R&D funding and policy initiatives away from coal and nuclear R&D programs toward programs focused on promoting energy efficiency and renewable energy supplies, and the development of more efficient vehicles that use fuels other than petroleum --- electricity, natural gas, and ethanol. The George W. Bush administration has announced its intention to promote investments in new nuclear power plants more aggressively and to increase research funding for advanced nuclear technologies.

e. Synthetic Fuels from Coal, Solar Energy, and other alternative domestic energy resources: In addition to nuclear, both the RFF and Ford studies supported carefully crafted government policies to stimulate development of alternative domestic energy resources. They focus in particular on the production of synthetic fuels from coal[12] and expanded use of solar energy, including wind. They recognized that the production costs associated with these resources would be significantly higher than the then prevailing cost of oil, but they recommended a variety of basic research and modest demonstration initiatives to develop these technologies and to remove market and

[12] By this time, the U.S. already had significant experience with failed synthetic fuels programs and one wonders how much this experience affected the studies' policy recommendations.

regulatory barriers to their deployment. The studies also recognized that the prospects for these alternative resources depended on both technological developments and the anticipated increase in prices for oil and natural gas materializing. The Ford study was unsympathetic to large scale federal demonstration projects.

In the last 25 years there has been a plethora of federal policies to encourage alternative fuels and fuel-use technologies with little to show for the efforts. In June, 1980 President Carter signed the Energy Security Act, consisting of six pieces of legislation: U.S. Synthetic Fuels Corporation Act, Biomass Energy and Alcohol Fuels Act, Renewable Energy Resources Act, Solar Energy and Energy Conservation Act, Geothermal Energy Act, and Ocean Thermal Energy Conversion Act. These laws all provided an array of tax subsidies and direct subsidies for alternative energy supplies and to encourage energy efficiency. From an economist's perspective this was probably the low point in contemporary U.S. energy policy. However, the synthetic fuel and shale oil programs, to which President Carter had committed $88 billion, were later abandoned as costs rose and oil and natural gas prices fell during the 1980s.[13]

In addition to promoting energy efficiency as discussed above, EPAct92 includes a number of new programs to encourage renewable energy and alternative fuels. Among other things the Act provides various tax subsidies to encourage electric vehicles, solar and geothermal energy production, alcohol fuels, and R&D funding for the commercialization of renewable energy technologies, including electric and hybrid vehicles, and various technologies for the generation of electricity from renewables on-

[13] A modest amount of research and development activity on coal gasification continues in connection with the integrated gas combined cycle technology that would use synthetic gas produced from coal in a combined cycle gas turbine as part of the Clean Coal Program.

grid and off-grid -- fuel cells, heat engines, superconductors and other technologies. The Act also authorizes R&D expenditure for specified "clean coal" technologies.

Energy policy during the Clinton administration was guided by the framework established in the Energy Policy Act of 1992 and was heavily influenced by the Administration's environmental policy agenda, including concerns about global climate change. It gradually reallocated R&D funding and policy initiatives away from coal and nuclear R&D programs toward programs focused on promoting energy efficiency and renewable energy supplies, and the development of more efficient vehicles that use fuels other than petroleum. Federal expenditures supporting energy efficiency, renewables, and alternative fuel vehicles increased significantly while funding for coal and nuclear technology declined. However, the Clinton administration's efforts in these areas were first hampered by federal budgetary constraints that placed pressure on the DOE's budget. After 1994, these initiatives were impeded by a Republican Congress that was hostile to the DOE in general and the Clinton administration's favorite energy programs in particular. Congress prohibited federal agencies from even studying tightening the existing vehicle fuel efficiency standards, placed roadblocks in the way of evaluating and tightening appliance efficiency standards as required by EPAct92, and rejected or cut back Administration proposals for tax subsidies for renewable energy and alternative fuel vehicles. Congress also slowed down efforts by the Administration to shift funds toward renewable energy and energy efficiency programs.

f. Rely on economic instruments --- emissions taxes and tradeable emissions permits --- to internalize environmental externalities. Until the 1990s, there was little policy interest in using economists' preferred instruments to control pollution. However, the Acid Rain Title of the Clean Air Act Amendments of 1990 created a cap and trade system for emissions of sulfur dioxide from electric generating units. Moreover, in response to obligations to reduce regional emissions of NO_x provided for in the 1990 Clean Air Act, an emissions trading system has been introduced in the Northeast and other regions of the country to control NOx emissions as well. In the early 1990s, California also created a cap and trade system to control NO_x and SO_2 emissions (RECLAIM) in the South Coast Air Quality Management District. These programs are generally viewed as having been successful in reducing costs while meeting environmental goals (Ellerman *et. al*. and Ellerman, Joskow and Harrison). Economic instruments, especially cap and trade programs, to internalize environmental externalities are now widely accepted as attractive mechanisms to control pollution.

The Ford study was clearly way ahead of its time in recognizing the need to better understand the effects on CO_2 emissions on climate change. After 25 years of research, most developed country's energy policies are now closely linked with programs to control emissions of CO_2. Cap and trade programs are likely to play an important role in CO_2 emissions control programs in Europe and (eventually) in the United States and provide a framework for integrating developing countries into global CO_2 emissions control program.

g. ***Prepare for oil supply disruptions:*** The Ford study recommended that the U.S. lead a world effort to prepare for short-term disruptions in world oil markets by developing an effective stockpile program and by using market forces to manage stockpiles and crises. The establishment of a U.S. strategic petroleum reserve predates the RFF and Ford studies. The Energy Policy and Conservation Act signed by President

Ford in 1975 authorized the creation of a Strategic Petroleum Reserve (SPR) containing up to 1 billion barrels of petroleum.[14] The SPR is located in underground salt caverns along the Gulf of Mexico and now has an authorized capacity of about 700 million barrels of oil with about 600 million barrels actually in storage as of June 2003. The Act gives the President the authority to authorize releases from the SPR when the President determines that there is a severe supply interruption leading to a "national energy shortage" (full drawn down) or other circumstances that the President determines are likely to lead to significant domestic or international shortages of significant duration that would have adverse effects on the economy (limited drawdown). Through the International Energy Agency, the U.S. has agreements to coordinate withdrawals from reserves with other countries.

Oil has been withdrawn from the SPR in response to international oil supply disruptions only once --- during Operation Desert Storm in 1991 when 17.3 million barrels were sold from the Reserve. Oil has also been withdrawn in two test sales (1985 and 1990) and six times in the form of oil exchange arrangements authorized by the 1975 Act.[15] Most of the oil exchange actions have been in response to localized domestic supply disruptions, the latest in 2002 in response to disruptions in commercial oil shipments to Gulf Coast ports caused by Hurricane Lili. Non-emergency sales from the Reserve were also authorized by Congress in 1996 to raise revenues for the Federal government.

The SPR is not exactly what the RFF study had in mind. The RFF study favored more reliance on private stockpiles. It also recommended the development of protocols

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[14] http://www.eia.doe.gov/cabs/usa.html
[15] http://www.fe.doe.gov/spr/

for withdrawing oil from any strategic reserves that were based on other than hypothetical quantity measures of "shortfalls." Instead, the study recommended basing releases on large increases in prices from recent historical levels to cushion the effects of supply disruptions. It also recommended the development of clear release criteria before new international oil disruptions occur. Both of these recommendations were and are controversial and have largely been ignored as have more recent analyses supporting similar decision rules.

V. ENERGY DEMAND AND SUPPLY 25 YEARS LATER

a. Energy Consumption

Both the RFF and Ford studies were (wisely) cautious about making projections of the future paths of energy supply and demand under alternative policy scenarios. Yet both studies offer some forecasts for energy consumption and supply in 2000. In the spirit of the paper by Koomey *et. al*. in this volume, it is very instructive to compare what these studies thought would happen with what actually did happen and to try to understand the sources of the differences. The RFF study focused on the "Mid-range" projections of energy consumption by sector for the year 2000 displayed in Table 1 and I will focus on it here as well.[16] The forecasts are based on a detailed analysis of a few sectors, less detailed analyses of others, the assumption that real GDP would grow at an average rate of 3.2% per year, and the Census' mid-range population forecast of a 260.5 million person U.S. population in 2000. In RFF mid-range forecast is for 114 quads of energy consumption in 2000.

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[16] The RFF study (page 203) suggests a lower bound of 100 quads and an upper bound of 140 quads for total U.S. energy consumption in 2000.

The Ford study took a more aggregate "top-down" approach based on assumptions about future energy prices, demand elasticities, GDP growth, and reductions in the energy/GDP ratio to come up with an aggregate projection for U.S. energy consumption in 2000. For example, assuming real GDP would growth at 3% per year, that real energy prices would increase by nearly 50%, that the energy to GDP ratio would fall to about 22 BTU per dollar of GDP (at 1978 price levels) by the year 2000. The Ford study forecasts total U.S. energy consumption of about 120 quads in 2000, very close to the aggregate consumption forecast provided by the RFF study. Both recognize that such forecasts have large uncertainties associated with them.

Actual U.S. energy consumption in 2000 was just under 100 quads.[17] Thus, the RFF and Ford forecasts were 15% to 20% too high in the aggregate. At first blush, given the uncertainties and long forecast period, the forecasts do not seem to be too far off the mark. However, the studies forecast that energy consumption would grow by 40 to 45 quads between 1976 and 2000, while it actually grew by only 25 quads. So, in terms of <u>growth</u> in energy consumption, the forecasts were high by 60 to 80%. The difference cannot be explained by economic and population growth drivers. Real GDP increased by an average of about 3.2% per year during this period which is consistent with the assumptions underlying the RFF forecast (3% real GDP growth rate in the Ford forecast) and population grew faster (280 million rather than 260 million people in 2000) than assumed the RFF study assumed. Moreover, the differences between the forecasts and actual energy utilization for some of the individual consuming sectors are even larger. These differences are instructive both with regard to the effects of energy policies and

[17] Actual U.S. energy consumption in 2000 was at the low end of the forecasts made by energy studies released in the late 1970s (Schurr , pp. 204-217).

unanticipated changes in the structure of the U.S. economy on energy consumption patterns.

TABLE 1

RFF STUDY FORECAST OF ENERGY CONSUMPTION IN 2000

Sector		RFF Forecast (Quads)		2000 Actual (Quads)	
Residential					
	Space heating	8.0		6.2	
	Other	14.0		14.3	
	TOTAL		**22.0**		**20.5**
Commercial			**21.8**		**17.2**
Industrial					
	Process Steam	16.4		4.1 (1998)	
	Other	31.0		28.5	
	TOTAL		**47.4**		**32.6**
Transportation					
	Passenger vehicles	7.0		15.0	
	Freight	5.3		6.0	
	Air	3.3		3.6	
	Other	-		2.0	
	TOTAL		**15.6**		**26.7**
Other			7.0		2.0
TOTAL			**114**		**99**

Sources: Schurr, et. al. , Table 6-3; *Annual Review of Energy 2001* and *Annual Energy Outlook 200 3,* U.S. Energy Information Administration.

The RFF forecast for residential sector consumption in 2000 is off (high) by only about 10%. RFF anticipated significant improvements in the efficiency of home heating systems, forecasting a 10% reduction in energy used for space heating despite increasing population and per capita real income. In fact, residential space heating use declined by about 23%, twice the decline reflected in the RFF forecast, despite population growth greater and price increases smaller than assumed there.[18] Thus, energy efficiency improvements have been greater than expected, probably reflecting appliance efficiency standards, energy efficiency labeling and new building codes, since realized energy prices were lower than forecast (see below). The forecast for other residential energy uses, based on an assessment of other studies and incorporating significant improvements in energy efficiency are right on target.

The RFF forecasts for industrial energy consumption in 2000 are about 30% higher than the realized level of energy consumption in the industrial sector. The RFF study examines process steam use (about 35% of industrial energy use in 1976) in detail to yield a mid-range forecast of about 16 quads of energy associated with process steam in 2000. For the rest of the industrial sector, the forecasts simply assumed that the manufacturing sector would grow at a rate 20% faster than GDP and that energy efficiency would continue to improve at the pre 1973-74 embargo rate.

The difference between actual industrial energy consumption and what was forecast by RFF is probably due primarily to changes in the structure of the economy. The manufacturing sector did not grow faster than GDP as was assumed, but more slowly. In 1978, manufacturing accounted for 22.5% of GDP while in 2000 it accounted for 15.8% of GDP. Moreover, the share of some of the most energy intensive sectors (primary metals, paper and allied products, lumber and wood products, stone, clay and glass) shrunk from 26% of manufacturing GDP in 1980 to 18% of manufacturing GDP in

[18] To 1997, the last year for which EIA data are available. I cannot reproduce the residential space heating numbers from the RFF study. They report 8.8 quads in 1976. The EIA reports about 7.4 quads in 1978 and 6.0 quads in 2000, assuming that electricity is produced with 10,000btu/Kwh.

2000. It is likely that improvements in energy efficiency were also greater than had been anticipated.

The RFF forecasts for energy consumption in the Commercial sector in 2000 is about 25% higher than realized consumption. The RFF forecasts were based on Oak Ridge National Laboratory (ORNL) studies which incorporated assumptions consistent with a 3.2% real GDP growth rate and real energy price increases of 1.6% per year. Without going back into the details of the ORNL model, it is hard to know what the sources of the difference lie. Higher prices than forecast or slower economic growth do not explain the difference since actual prices were lower and actual growth of the Commercial sector higher than forecast. Commercial energy consumption reflects energy consumption decisions by a wide range of industries, including wholesale and retail trade, finance, insurance and real estate, and "services." The share of these components of GDP as a whole increased significantly between 1978 and 2000 (from 43% to 57% of GDP). As with the residential sector, the commercial sector should have benefited from improvements in space heating, cooling and lighting efficiency in buildings. The changing mix of commercial activity and greater improvements in energy efficiency also probably account for a significant fraction of the difference.

Finally, turning to transportation, the RFF study projected a decline of about 30% in energy used by passenger vehicles and an increase of about 33% in energy used in freight transport with overall energy consumption in transportation being flat between 1978 and 2000. In fact, energy consumption in the transportation sector increased by about 30% between 1978 and 2000.[19] This is the only sector where the RFF forecast was

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[19] The energy consumption for transportation reported in the RFF study do not match the EIA numbers. For 1976 (the year used in the RFF study), RFF report transportation sector consumption of about 15.6

too low. Most of the difference is associated with energy consumed in personal transportation vehicles. The RFF forecasts are based on a series of assumption about growth in the number of vehicles per capita, miles traveled per vehicle, and vehicle fuel efficiency that lead to the projection that vehicle miles traveled would increase by 38% between 1976 and 2000. In fact, vehicle miles traveled increased by 150% between 1977 and 2001 based on U.S. Highway Administration data.[20] The number of passenger vehicles per capita and the average miles driven per passenger vehicle are all much higher than assumed by RFF. In addition, the RFF study assumed that the 27.5 mile per gallon CAFE standard would be achieved by all passenger vehicles by 2000. While new passenger vehicles have met the 27.5 mile/gallon CAFE standard (based on laboratory tests) when they are sold, in practice passenger vehicles got only 22.0 miles per gallon in actual use. Moreover, while the RFF study clearly noted the existence of the "light truck loophole" (page 151) and even the potential increased popularity of "trucklike" vehicles for personal transportation use, the shift to SUVs, with lower fuel economy standards, was not reflected in the forecasts.

In summary, the RFF and Ford studies used mid-range forecasts that implied that aggregate U.S. energy utilization per dollar of real GDP would fall by about 1/3 between the late 1970s and 2000. In fact energy utilization per dollar of GDP fell by about 10% more than predicted (36% vs. 33%). As we can see from Figure 1, however, the ratio fell more quickly from 1978 to 1985 (when energy prices were very high and the effects of

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quads while EIA reports 19 quads. So, to the extend that RFF was forecasting from a different base this explains part of the difference between the forecast and actual numbers. Accordingly, I will focus on the differences between the forecast and actual percentage changes in consumption.

[20] http://nhts.ornl.gov/2001/html_files/trends_ver6.shtml. Accessed June 8, 2003.

the CAFE standards were kicking in)) than it has fallen since 1985 (as energy prices have fallen). The accuracy of the forecasts for the individual sectors is much more variable.

b. Fuel Use

The RFF study also contains a breakdown of the projected use of primary fuels and electricity by end-use consumers consistent with the demand forecast (page 195). Table 2 compares the projected breakdown with the actual breakdown in 2000.

TABLE 2
PRIMARY ENERGY CONSUMPTION BY SOURCE IN 2000

	1976	RFF 2000	ACTUAL 2000
Coal	5.5%	10%	2%
Gas	23.1%	17%	19%
Oil (liquids)	42.6%	33%	38%
Electricity	28.7%	40%	39 %

Note 1: Electricity's share is based on primary inputs into the production of electricity
Note 2: 1976 and RFF columns from RFF study Table 6-4.
Note 3: Actual 2000 column calculated from *Annual Review of Energy 2001*, U.S. Energy Information Administration.

The overall trend toward electrification of the economy envisioned by the RFF study has been realized. However, the utilization of coal in end-use applications (i.e., aside from the production of electricity) has fallen rather than increased, reflecting the changing composition of the economy discussed earlier, environmental regulations, and the availability of relatively inexpensive natural gas as a boiler fuel in industry. Accordingly, natural gas use is higher than predicted. As discussed previously, petroleum consumption is significantly higher than the RFF study projected, due primarily to much higher than predicted petroleum use in personal transportation.

Neither the RFF nor the Ford studies provides a prediction for the primary fuels that would be used to generate electricity in 2000. However, the focus of both studies is on nuclear and coal as being the primary economical alternatives for generating electricity, combined with industrial cogeneration, and with some longer run possibilities for renewable (wind and solar) applications. Neither study saw any future for natural gas in the generation of electricity, and while combined-cycle gas turbine (CCGT) generating technology is mentioned in the RFF study, it does not play a significant role in the visions of the future offered by the RFF and Ford studies. I do not think that the RFF study's perspective on the use of natural gas to generate electricity reflected the widespread view prevailing at the time that natural gas was a "premium fuel" that should not be "wasted" to generate electricity. Rather, it reflects the view that coal and nuclear power would be less costly sources of electricity.

Table 3 provides the breakdowns of fuels used to generate electricity in 1978 and 2001. The fuel use in the generation of electricity is broadly consistent with the policy recommendations in the RFF and Ford studies. Despite tougher environmental requirements coal use in electricity generation has risen steadily since 1978. Coal and nuclear have increased their shares of electricity generation from 47% to 72%, while petroleum has almost disappeared as a fuel for generating electricity. However, natural gas' share of electricity generation is higher than it was in 1978 and is projected to continue to rise in the next twenty five years to about 30% in 2025 (U.S. Energy Information Administration (EIA) 2003). About 150,000 Mw of new generating capacity has been completed in the U.S. in the last five years, almost all of it CCGT or single-cycle gas turbine generating facilities (Joskow 2003). The important role of natural gas, combined-cycle gas turbine generating capacity, and the restructuring of the electricity industry to rely on competitive wholesale markets are developments that were missed completely by both the Ford and RFF studies but are, in a sense, a direct but unforeseen consequence of the recommendations to decontrol oil and natural gas prices, to bring electricity prices to market levels, to stimulate cogeneration,[21] and to rely more on competitive market forces.

TABLE 3

FUELS USED TO GENERATE ELECTRICITY

	1978	2001
Coal	44%	51%
Natural Gas	14%	16%
Oil	17%	3%
Nuclear	13%	21%
Hydro	13%	6%
Renewable	1.8% (1989)	2.1%
Cogeneration	7.3% (1989)	9.7%

NOTE 1: Consistent data for renewable energy sources other than conventional hydro and for electricity produced as part of a cogeneration process are not available prior to 1989
NOTE 2: The renewable row excludes conventional hydro
NOTE 3: The fuels used for cogeneration are included in the fuel categories above. 62% of the cogenerated electricity is produced with natural gas.

Source: *Annual Review of Energy 2001*, Energy Information Administration.

The quantity of electricity generated from nuclear power has increased significantly over the last twenty years as 45 plants under construction or announced in 1979 were completed and as nuclear plant operators were able to increase the operating

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[21] PURPA stimulated investment cogeneration facilities which in turn stimulated interest in the development of combined cycle generating technology. These developments stimulated interest in expanding competitive opportunities for independent power producers (Joskow 2000). However, the penetration of cogeneration in 2000 is significantly lower than RFF's assessment of its economic potential.

performance of the nuclear plants from average capacity factors of 65% in 1978 to average capacity factors of 89% in 2001. However, all of these post-1979 plants had been announced by the time that the Ford and RFF studies were released. No new plants were announced after 1979, about half of the nuclear plants that were under construction or had been announced by 1979 were subsequently cancelled, and about a dozen operating nuclear plants were closed during the 1980s and 1990s. Current nuclear generating capacity is less than half of the lower bound government forecasts cited in the RFF study. The nuclear plants that were completed during this period were wildly over budget and, contrary to the forecasts in the RFF and Ford studies, investments in new nuclear plants are now been widely perceived to be uneconomical compared to coal and gas-fueled alternatives. No nuclear power plants are under construction in the U.S. and few are under construction elsewhere in the world. As a result, nuclear's share of electricity production is projected by EIA (2003) to fall from 20% to about 15% by 2025.

The RFF study contains detailed analyses of synthetic fuels and solar energy applications (including wind) and the Ford study devoted a lot of attention to solar energy's potential. Both studies recognized that costs would have to fall and/or the prices of substitute energy supply sources rise for renewable energy to be competitive absent special subsidies. Public policies were subsequently implemented to promote both synthetic fuels and solar energy, as well as other renewable energy supply technologies. As already noted, the synthetic fuels program was largely abandoned in 1986. Its remnants can be found in the clean coal program's initiatives on coal gasification for use in combined-cycle power stations and some controversial tax subsidies for synthetic fuel technology. A variety of tax and direct subsidies have been given to solar and other renewable energy sources and these sources were favored for use in generating electricity through the implementation of PURPA.

Despite all of these policy initiatives, renewable energy, excluding conventional hydroelectric energy, accounts for only about 3% of total energy supplied to consumers today. About 2/3 of this is accounted for by wood used primarily in space heating. Solar and wind energy account for only 0.1% of energy supplied in the U.S. However, renewable energy supplies, especially from wind, are growing rapidly as a consequence of various subsidies provided in EPAct92 and state-mandated purchase obligations, and supplies are projected to rise to about 6% of total energy consumed by 2025 (EIA 2003).

c. Energy Prices

The Ford and RFF studies were motivated primarily by three interrelated problems: increasing dependence on imports of petroleum, a long run trend of rising energy prices, and the impacts of energy production and use on the environment. Both studies envisioned energy prices rising over the following 20 years, but to a long run level no more than double the prices prevailing in 1979. Soon after the studies were published, energy prices began to rise rapidly in response to disruptions in oil supplies from Iran. However, energy prices peaked in the mid-1980s and then fell rapidly. Overall, energy prices were at about the same real level in 2000 as they were in 1979. EIA projects real annual end-use energy prices to be about constant over the next 25 years and oil prices to stay below the $40-$60 range (2002 price levels) projected by the Ford study (EIA 2003, p. 123). Figure 2 displays the real price of crude oil, natural gas, and a fossil fuel price index over time. Following the price break around 1984-85, prices have moved around their 1979 levels, with considerable volatility. Figure 3 displays a similar pattern for retail gasoline prices. Real retail electricity prices display similar patterns, with less volatility. In summary, contrary to expectations in 1979, real delivered energy prices were about the same in 2000 as they were in 1979.

d. Environmental Indicators

The impacts of energy production and use and the interactions between energy and environmental policies were a central concern of both studies. They both argued that it would be feasible to accommodate increased energy consumption without increasing damage to the environment and to do so without dramatically increasing the cost of energy to consumers. Table 4 provides data on emissions and air quality for the primary criterion pollutants covered by the Clear Air Act. It is clear that air quality has improved significantly over the last 20 years in almost all dimensions.[22] The Ford study recognized that CO_2 emissions associated with the combustion of fossil fuels was a potential, though highly uncertain, source of climate change. The study recommended more study of the relationship between CO_2 emissions and global climate change. It also recommended putting off any policies to restrict coal use on account of CO_2 emissions. The U.S. has followed both components of this recommendation. U.S. CO_2 emissions have increased by over 20% since 1980 with most of the increase occurring after 1990.

e. Oil Imports

The RFF and Ford studies were very concerned about rising dependence on foreign oil. In 1979 the U.S. was importing about 8 million barrels per day of petroleum. In 2001, the U.S. imported 10.6 million barrels of petroleum per day, a trend that the studies did not have in mind. As world oil prices rose after 1979, domestic petroleum production increased slightly, petroleum demand fell significantly and imports fell to

[22] Air quality and emissions patterns may differ because air quality is monitored primarily in dense urban areas. Acidic deposition has also declined significantly since 1995 when the new SO_2 cap and trade program went into effect.

about 4 million barrels per day. As world oil prices then fell during the second half of the 1980s these supply and demand patterns reversed. See Figure 4. At the same time, imports of natural gas, primarily from Canada have increased significantly as well.

TABLE 4

AIR QUALITY AND EMISSIONS 1982-2001

Air Quality
Percentage Change

Pollutant	1982-2001	1992-2001
NO_2	-24%	-11%
O_3 1-hour	-18	- 3
O_3 8-hour	-11	0
SO_2	-52	-35
PM_{10}	N/A	-14
CO	-62	-38
P_b	-94	-25

Emissions
Percentage Change

Pollutant	1982-2001	1992-2001
NO_x	+9%	- 3%
VOC	-16	- 8
SO_2	-25	-24
PM_{10}	-51	-13
CO	0	+ 6
P_b	-93	- 5

Source: *Latest Findings on National Air Quality: 2001 Status and Trends,* U.S. EPA. September 2002.

If one were to judge the success of U.S. energy policy over the last 20 years solely by looking at whether oil imports had increased or decreased, one would have to conclude that it has been a failure. However, this is too narrow a perspective even if we focus only on the "energy security" goal among the broader set of goals for energy policy. While oil imports have increased, the importance of oil in the economy has declined dramatically. About 50% less oil per dollar of real GDP is consumed in the U.S. today than was the case in 1979. Almost no oil is used to generate electricity or to heat homes and businesses. Moreover, the relative importance of oil produced in the Persian Gulf has declined since 1979 as oil producing areas were developed in other parts of the world. We have a Strategic Petroleum Reserve, though it has been used rarely and erratically. Finally, we have had two disruptions in oil supplies in the last dozen years due to war in the Persian Gulf region. Oil prices rose in connection with both of them, but (apparently) the damage to the economy was not significant or long lasting. Indeed, many economists have questioned whether the economic costs of oil supply disruptions, in terms of macroeconomic and associated aggregate welfare impacts, are nearly as large as policymakers and the public have generally assumed.

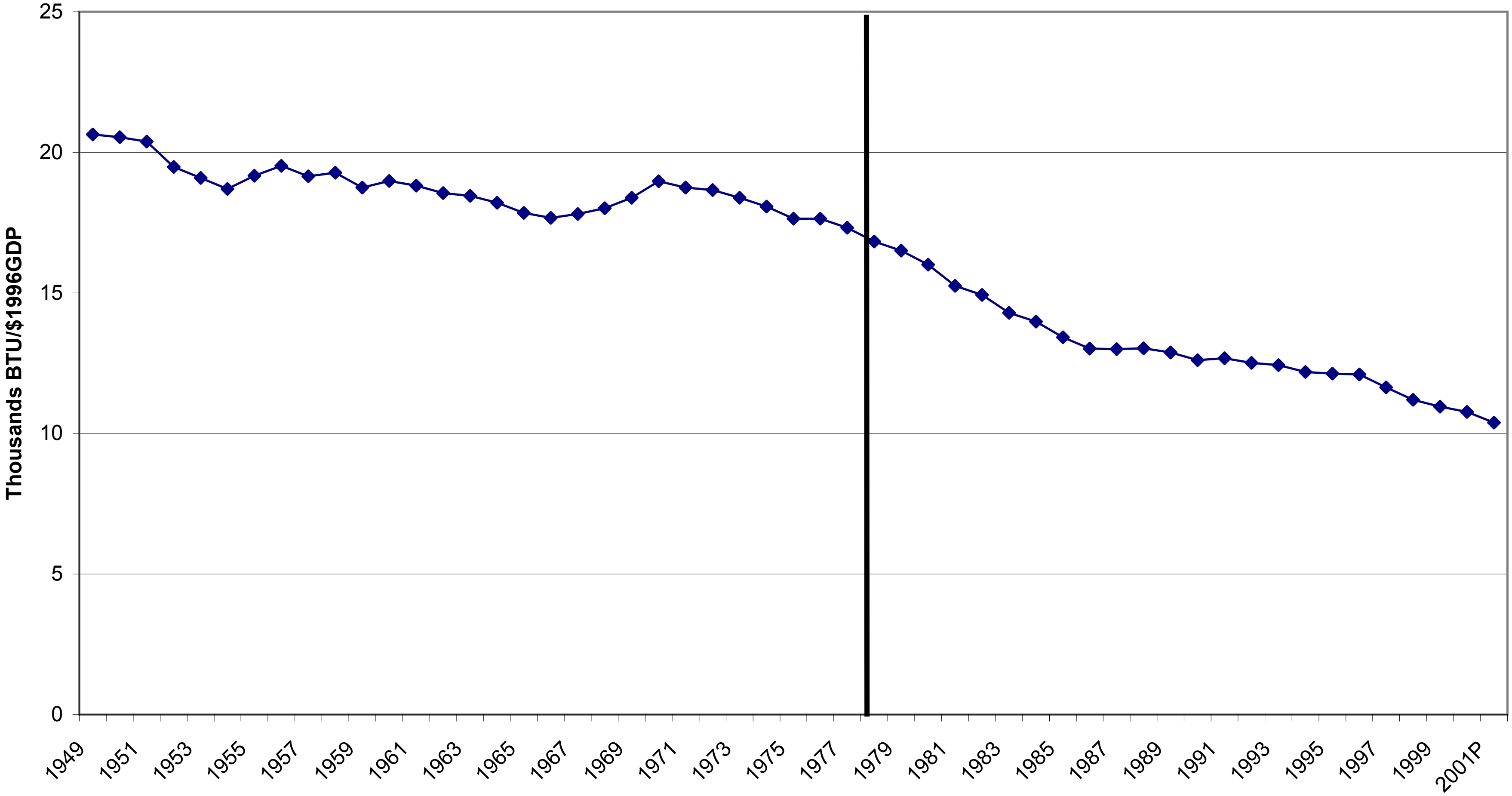
VI. CONCLUSIONS

The RFF and Ford studies have stood the test of time quite well; and "quite well" is hardly a poor grade when projecting trends and articulating policy recommendations and their effects predicated on the complex interplay of demographic, economic, technological, and environmental factors over long time periods. The framework and policy perspective remain relevant today. There are few things in this book that one looks back on and says "big mistake." Many of the studies' recommendations have been reflected in national energy policies. The country is now reaping the benefits of the end of many inefficient energy policies first implemented during the 1970s and early 1980s and subsequently abandoned: oil and gas price controls, fuel-use restrictions, protectionist policies for oil refiners, and publicly funded mega-projects to promote specific supply sources all came to an end. Because much of the regulatory apparatus of the 1970s and early

1980s had been dismantled by 1990, some of the tools for doing mischief in response to energy supply and price shocks were not readily available to respond (inefficiently) to oil price shocks in 1990-91 and oil and gas price shocks in 2000, 2001, and 2002. This made it easier for the economy to adapt smoothly to changes in supply and demand conditions. Environmental policies are being implemented more efficiently than could have been imagined in 1979.

There are important energy consumption and use trends that the studies got right. Significant opportunities to reduce the energy intensity of the economy have been demonstrated. This was accomplished with much smaller price increases than the studies anticipated. Coal use has steadily increased in the generation of electricity while air quality has improved. Nuclear energy plays a significant role in supplying electricity, though the studies underestimated the costs of building nuclear power plants and overestimated investment in new nuclear capacity. The studies were probably too optimistic about the costs of synthetic fuels and solar energy, though they included little of either in their 2000 supply forecasts. They were not optimistic enough about the positive effects on supply and prices of natural gas price decontrol and the subsequent restructuring of the natural gas industry. They did not see the dramatic changes in the electric power industry, driven in part by the availability of cheap natural gas and the technological innovations making it economical to use natural gas efficiently to generate electricity The study leaders' primary disappointments would probably be with the large increase in consumption of petroleum in personal transportation and the increasing dependence on foreign oil produced in unstable areas of the world. These studies continue to contain much wisdom that is relevant today as we embark on another round of energy policymaking and implementation.

FIGURE 1
ENERGY CONSUMPTION PER DOLLAR OF REAL GDP



Source: ***Annual Review of Energy 2001,*** **Energy Information Administration**

FIGURE 2
REAL PRODUCTION PRICE FOR FOSSIL FUEL

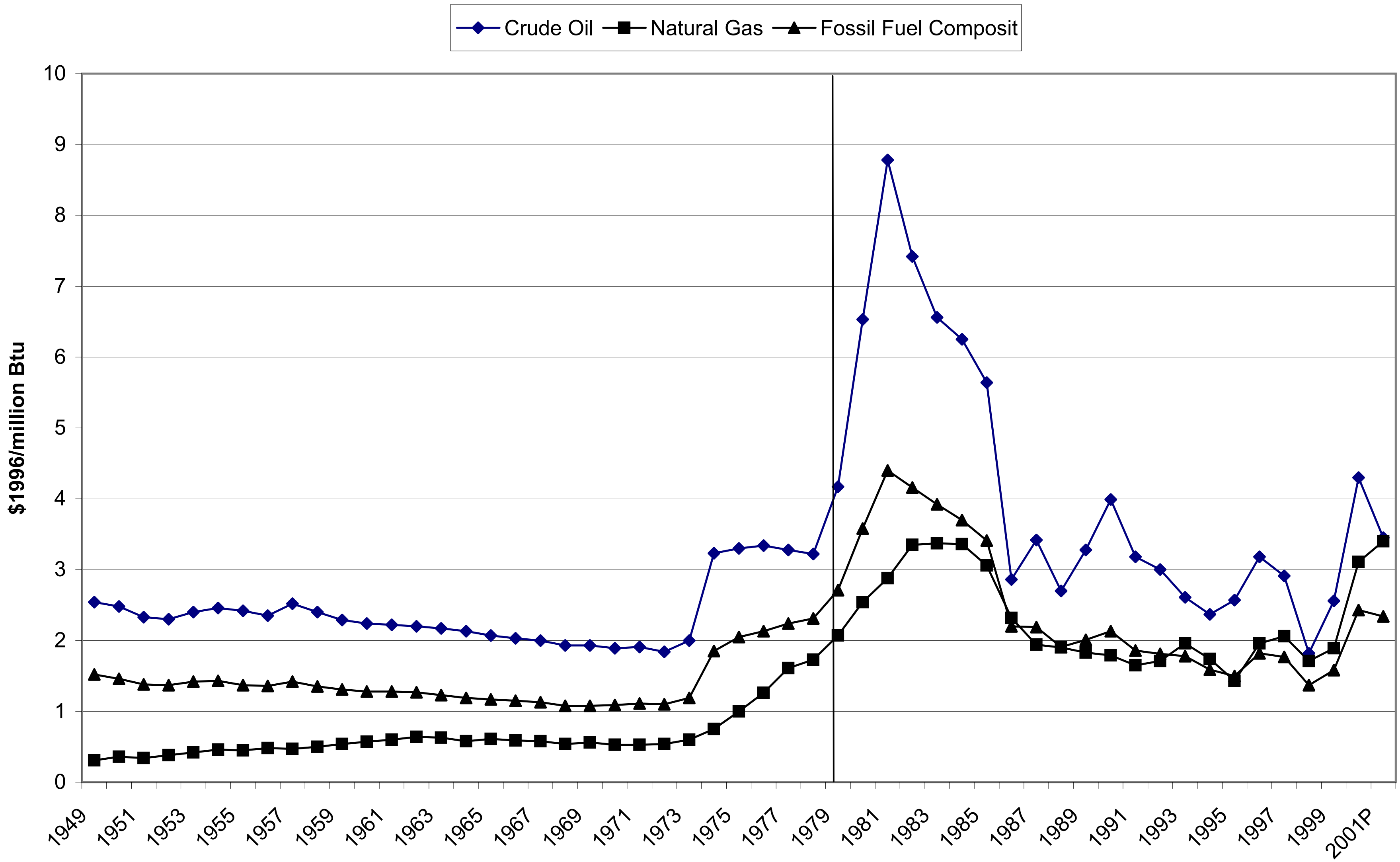
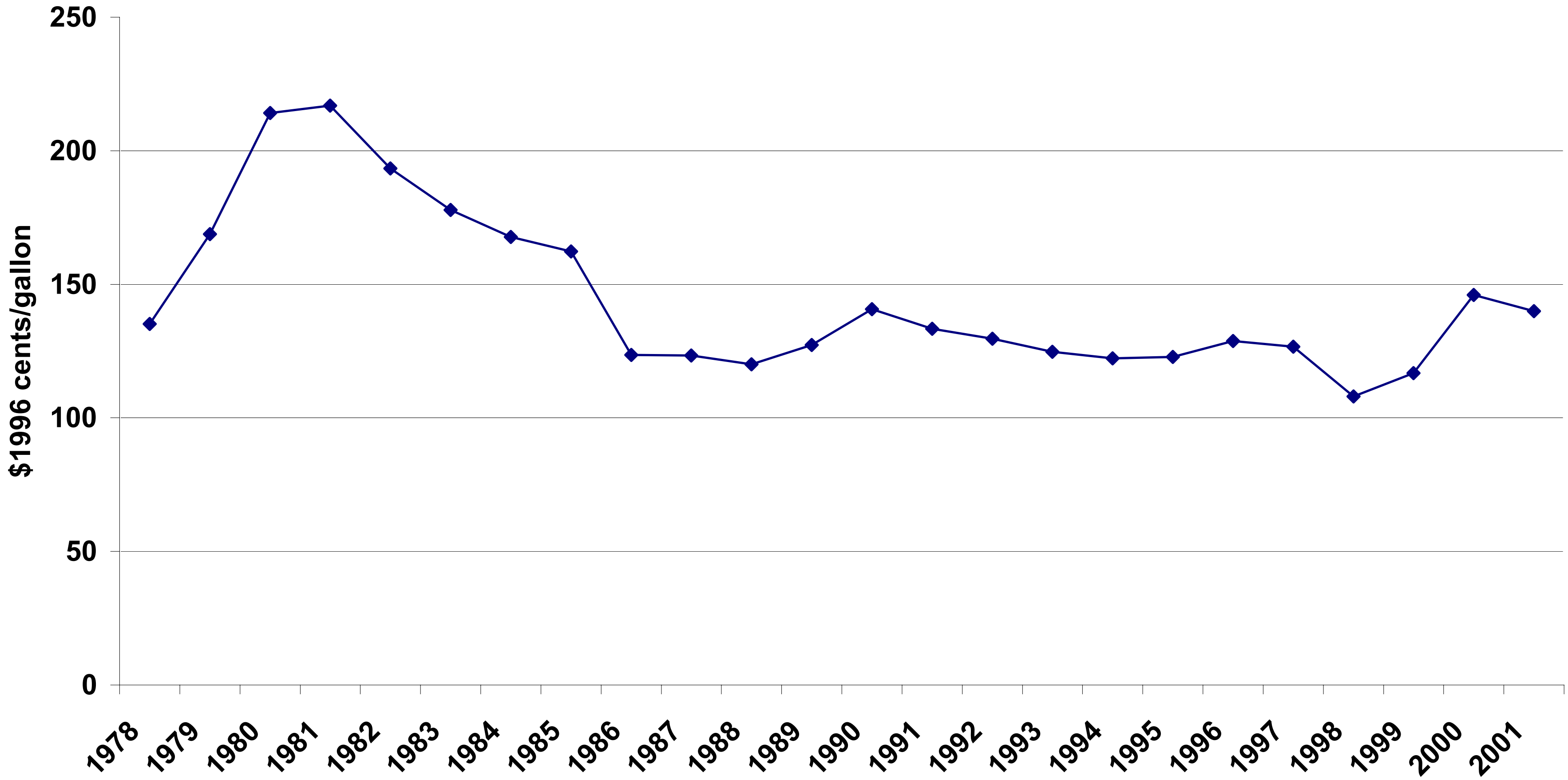
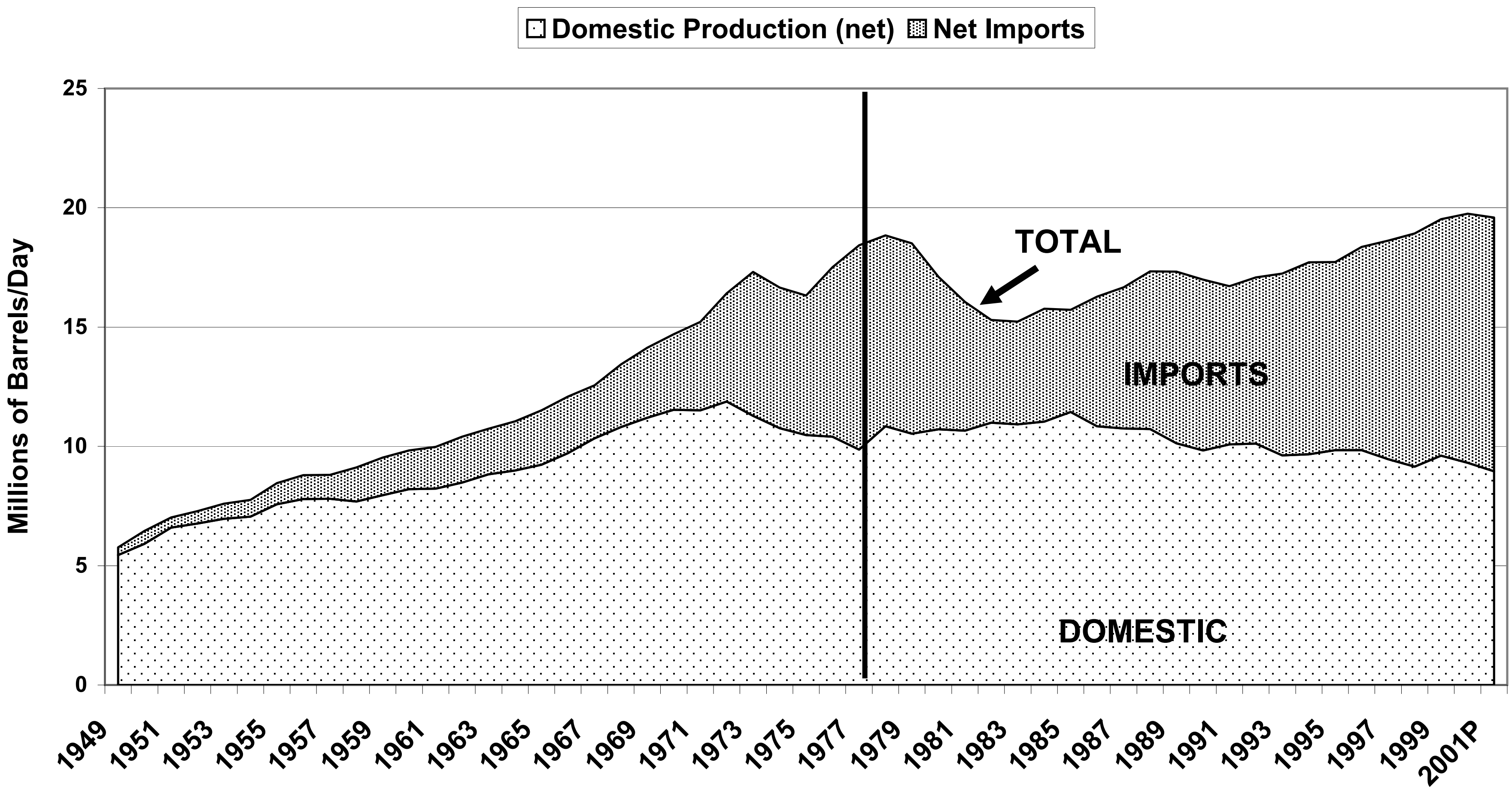


FIGURE 3
Real Retail Gasoline Prices (All Grades)



Source: ***Annual Review of Energy 2001*** **, Energy Information Administration**

FIGURE 4
Petroleum Supplies



Source: *Annual Review of Energy 2001,* Energy Information Administration

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