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U.S. Energy Policy and the Presumption of Market Failure

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Over the last 35 years, the U.S. government has embarked on several major projects to spur the commercial development of energy technologies intended to substitute for conventional energy resources, especially fossil fuels. Those efforts began with the 1973 energy crisis when President Nixon became the first U.S. leader to announce a plan for energy autarky. Presidents Ford and Carter followed Nixon's "Project Independence" with similar pledges. But beginning with Ford's 1975 energy act, plans for energy independence were tied directly to the development of new, alternative energy technologies. Under President Carter in particular, the federal government embarked on highly publicized, heavily funded efforts at developing new technologies with specific timetables for commercial entry and, in a few cases, a timetable for mass market substitution. Current mandates for ethanol and other biofuels fit this latter objective.

The presumption underlying government alternative energy programs, including the ethanol program, is that voluntary market action is insufficient to develop new energy sources. Therefore, government has to step in to induce the technological development the market fails to create. Only through government intervention, according to this logic, can the market failure be corrected and the

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social benefits of alternative energy technologies be realized (Weimar and Vining 1992).

Whether a market failure has or has not existed with respect to alternative energy technologies, it is nonetheless relevant to ask whether the government's action creates a solution or a failure of its own. The importance of government failure has been highlighted in recent years as government efforts in such diverse areas as inland waterway development, antitrust law, and public transportation appear to produce far more costs than benefits, and sometimes may worsen whatever market failures they were intended to correct (Winston 2006).[1] The evidence suggests that with respect to alternative energy development, government failure has in fact been a more persistent and costly problem than market failure.

This article will argue that government energy policy has been based on faulty premises not only about the existence of market failure but also about the nature and process of innovation. Moreover, as this article will show, there is evidence that the private sector can develop energy alternatives more efficiently than the government.

The article is organized as follows: first, I discuss the basic idea of market failure and how it has influenced U.S. energy policy. I also suggest that governmental solutions would have been unlikely to succeed even if a market failure had been correctly identified. Next, I focus on three efforts at government-directed innovation: synfuels, nuclear fusion electric generation, and the high-mileage automobile. All three were given significant funding and programmatic timetables with benchmarks of success. None of those timetables were met, few of the benchmarks were achieved, and development funds were largely wasted. Finally, I end with a discussion of how the federal government continues to pursue the same kinds of policies that offer the promise of more failure.

The Market for Innovation: Market Failure or Government Failure?

Ronald Coase (1964) argued that all forms of economic organization—markets, firms, and government—are "more or less failures."

[1]Coase (1964) raised the issue of government failure. Wolf (1979) provides a theoretical foundation for "nonmarket" failures; Zerbe and McCurdy (2000) take issue with market failure as a justification for government intervention generally.

That is, no real-world arrangement of economic institutions leads to ideal allocative or productive efficiency of the sort represented in the neoclassical model of perfect competition, which by definition allocates resources through markets so that there are no alternative arrangements that would lead to a higher level of social welfare. But since that model is based on unrealistic assumptions, Coase argued, it had to be assumed that all real-world markets fail to some extent, a point elaborated by Demsetz (1969). Of course, firms and government command systems clearly fail as well, and substituting command for markets does not guarantee success. The goal, Coase suggested, is to organize any particular type of economic activity using the form of organization that fails the least in a given situation.[2] Of course, one cannot know with certainty that one form of organization will fail less than another in a particular circumstance, although experience should provide some guidance. With respect to government energy development programs, there is 35 years of experience to draw on, but this history seems to be entirely ignored by decisionmakers in proposing new programs.

How is it that the alternative energy market is presumed to fail? A new energy technology could potentially be worth billions of dollars, but an entrepreneur must bear a considerable development expense while his reward is uncertain. Of course, the greatest uncertainty is simply: Will the technology be marketable? But even if it is, the entrepreneur may be unable to keep others from cashing in on his efforts with competing products, and certainly he cannot gain some benefits that are attained by society as a whole. For example, a new technology might reduce the need for defense spending to protect oil supplies, but that benefit—while clearly substantial—cannot be captured by the entrepreneur who created the technology. The problem of uncertain or unattainable benefits but fully internalized development costs means that entrepreneurs will be reluctant to invest in innovative energy technologies, which will consequently be undersupplied if left to the market alone (Arrow 1962).

But even if this premise is accepted, it is not immediately clear what government can or should do to correct it. That is, with respect

[2]Demsetz (1969) termed the comparison of ideal and real-world "institutional arrangements" the "nirvana approach." This is in contrast to the "comparative institution approach" that looks at alternative real-world arrangements to see which is "best able to cope" with a particular economic circumstance.

to energy policy, what can government do that will lead to a successful new energy technology and not produce an even larger government failure? Policymakers have tried numerous schemes, some as low-cost and low-profile as simple information gathering. However, the most costly and the most visible by far have been efforts to induce innovation. Typically, policymakers have relied either on programs that provide incentives (usually tax preferences) to adopt a new technology or that undertake technology development directly.

Neither of those types of programs has been successful, but the second, direct development, is especially problematic in principle as well as practice. Government programs to create commercially viable alternative technologies of any kind rest on three implicit assumptions—all of them, at best, dubious.

First, and perhaps most important, is that government must assume that innovation is a demand-side phenomenon. U.S. energy policymakers appear to believe that since consumers want alternative energy technologies, someone should have built and marketed them. Since no one has, the assumption is that the market is failing to provide the incentives for innovators to act.

But the concept of demand-led innovation has very little empirical support. In the 1960s, a few scholars—notably Jacob Schmookler (1966)—attempted to link the technological developments of the Industrial Revolution to a surge in demand. This theory seemed especially inviting at the time because it echoed the Keynesian demand-side perspective that dominated macroeconomic theory.

But the demand-side explanation has not survived careful analysis. Today, nearly all scholars agree that innovation is a supply-side phenomenon (Mokyr 1977). As Nathan Rosenberg (1976), a leading economic historian of technology, has argued, scientific knowledge evolves if not randomly at least unevenly and its employment in marketable developments is certainly unpredictable and not necessarily consistent with consumers' desires at a given point in time. The complexity of science makes it hard to foresee, much less to program, what kinds of new ideas can generate what kinds of new products. Only after technological developments occur, will entrepreneurs evaluate opportunities for commercial development, and the verdict on whether they are right or wrong will be rendered in the marketplace. Though supply-side theories of innovation have had much more success in explaining technological development, government alternative energy programs directed at correcting the market's failure to supply innovative products take for granted a demand-side explanation to the innovation process.

Some experts argue that government can compel firms to innovate through the use of both incentives and disincentives. In the literature, this concept is sometimes referred to as "technology forcing." The catalytic converter in cars is the example most frequently noted (Gerard and Lave 2003). Government commanded a reduction in automobile pollution and the converter resulted (albeit a few years later than mandated). But the converter was not intended to compete with an existing conventional technology as alternative energy technologies are expected to do. In fact, there is simply no example of government "forcing" a commercially viable alternative energy product.

The second assumption is that if a technology has been demonstrated to be possible, government support will be needed to make it commercially viable. Exactly what this is based on is unclear. Government support is not by its nature designed to produce competitive market results. Instead, as Public Choice theory explains, government intervention creates competition among entrepreneurs primarily to gain government support. In the very nature of the funding process, money for development will often go to the entrepreneur that (a) is most likely to meet political goals of legislators, and (b) does the best job of convincing government officials of the superiority of his approach. Once support has been obtained, the entrepreneur has no need to work toward market competition and, in fact, has a great motivation to prevent market competition from arising. Overall, this situation provides more of an incentive for innovative rent seeking than for commercialization of innovative technologies (Cohen and Noll 1991).

The problem is not only how government dispenses support but also on what projects. Technology policy implicitly proceeds from the assumption that if there are competing technical ideas, government bureaucrats are competent to choose the winner. But governments worldwide have overwhelmingly failed at this sort of task. In the1980s, for example, Japan was touted as the model of successful government-led industrial policy. Of course, this assertion was wrong in almost every respect, but it was most obviously off the mark with regard to the development of new technologies. Japanese technology policy was a fiasco. Decisionmakers backed such ideas as an analog standard for HDTV and a so-called "next generation" computer, but they produced no significant commercial products and wasted enormous resources (Beltz 1993, Pollack 1992).

The third assumption in U.S. technology policy is that if a technology is shown to be technically feasible and appears cost competitive with a conventional resource, rapid and widespread adoption will soon follow. Put a bit differently, the assumption is government backing will lead quickly to market domination. In general, there is no consideration given to the process of technological adoption and the nature of market behavior. This process unfolds over time. It can take decades for full market saturation to ensue. Even when a technology seems to offer superior benefits on some margins, consumers may resist, preferring to wait until a technology is proven at least as reliable as—and more desirable than—the conventional product it is to replace. For instance, compact florescent light bulbs save money in the long run versus the more familiar incandescent lights, but people resist them, it is thought, not only because of high consumer discount rates but also because of noticeable differences in the character of the light produced (Cole and Grossman 2004). In any case, government energy programs that typically include specific timetables for both the beginning and extent of market penetration necessarily assume that when a product is ready for the market it will be consumed (Cassedy and Grossman 1990).

There is a way in which this outcome could be assured: Government could make a technology policy entirely coercive. By a given date people would have to adopt a technology or face fines or even imprisonment.[3] But most programs for alternative energy assume no coercion but rather a process by which market success simply occurs. Yet that process is unknown because, as the next section makes clear, alternative energy programs have always (often dramatically) failed.

[3]That was in fact the case initially with California's zero emissions vehicle (ZEV) mandate, where automakers who failed to offer a sufficient percentage of ZEVs faced "stiff financial penalties" (*Economist* 1991), penalties that were not imposed when automakers failed to meet the mandate.

The History of Alternative Energy Programs

Beginning in 1973 with the energy crisis and President Nixon's announcement of "Project Independence," the U.S. government has provided funding and other resources to numerous alternative energy technology programs at various levels of support. The largest share of government funding, of course, has gone to development projects that specifically have aimed at the creation of viable market alternatives to conventional energy technologies and resources. A study of funding costs and benefits between 1980 and 2000 noted expenditures of more than $13 billion (Fri 2006). While some research produced measurable welfare gains, this research was almost always low cost and low tech. Of an estimated $40 billion in research-related benefits nearly all came from very modest research efforts. The study estimated that 0.1 percent of all money spent on energy R&D produced 75 percent of the benefits. The most productive research was related to window insulation technology, lighting ballasts, and refrigerator efficiency. More than $9 billion, however, was spent on high visibility alternative energy development projects intended to induce innovation and overcome perceived market failures; these "produced no quantifiable economic benefit" (Fri 2006). Three examples follow.

The Synfuels Program

In 1973, one alternative that drew immediate attention from government officials was synthetic fuel. "Synfuels" refers to any unconventional source or form of oil or gas. For example, huge oil deposits are locked in shale in the western United States, but extracting the synthetic oil is complex, costly, and environmentally suspect. The focus in U.S. synfuels development has been to some extent on shale, but it has mostly centered on the liquefaction or gasification of coal, the fossil fuel resource we have in greatest abundance.

Synfuels research began with a goal other than that of correcting market failure. At first, synfuels were seen as a matter of national security in time of war. In March 1944, Congress passed the Synthetic Liquid Fuels Act, with $30 million directed to research and development to determine how best to produce synfuels—from coal or shale deposits—in the event of wartime shortages of conventional petroleum.

Promoters of synfuels, notably officials of the U.S. Bureau of Mines, became highly optimistic about what could be achieved through synfuel development. By 1948, it was asserted by one scientist that synthetic gasoline would soon be cost competitive with the conventional oil-derived fuel (*New York Times* 1948), a belief reiterated by the Bureau of Mines a year later. The Bureau's Office of Synthetic Liquid Fuels proposed an $8.7 billion government-directed investment to reach an output level of 1 million barrels of oil per day (*New York Times* 1949).[4]

Government needed to be in charge, suggested the Bureau, because the agency saw a market failure of a kind that would inhibit subsequent development of synfuels. Why was private industry unwilling to invest in processes like synfuels? It was not the case that there was proprietary government ownership of the technology. Methods of coal liquefaction and gasification had been known for decades (Ridgeway 1982). The answer seemed to be that private entrepreneurs ("the market") lacked sufficient foresight. No private investor would be willing to take on an apparently profitable venture in synfuels because the quantity of oil was great and the price of conventional fuels low. But would it stay low? To many observers, the answer was "no." As Ridgeway (1982) notes, newspapers of the day were given to headlines such as "Oil Shortages Here to Stay!" How would we supply our needs unless we developed this technology? But the $8.7 billion was not appropriated, and demonstration projects showed that liquefied coal could not be produced at anywhere close to the price of conventional oil. The coal-to-liquid effort was dropped in the United States in 1952.

But after 1973, synfuels became a key element in Project Independence. Some interest was directed at shale oil, but most attention was given to coal, of which the United States had proven reserves that were expected to last more than 200 years. Nixon's proposals called initially for study: the Federal Energy Office was to evaluate what kinds of programs would "be needed to stimulate domestic production" of shale oil as well as oil and gas from coal (Nixon 1974), but production was assumed likely to follow.

Nixon's successor, Gerald Ford was more explicit. His revised Project Independence (a revision in part for the timing of "indepen-

[4]Inflation-adjusted, this amount would be almost $80 billion 2009 dollars.

dence" from 1980 to 1985) called for the development of "20 major synthetic fuel plants" (Ford 1975) that would be initiated with $6 billion in federally guaranteed loans to private industry (Cowan 1975). Ford's chief energy advisor, Frank Zarb (whose formal title was Director of the Federal Energy Administration but who became known as America's "energy czar") and Robert Fri, deputy head of the Energy Research and Development Administration (ERDA), told Congress that by the early 1980s synfuel capacity "could" be 350,000 barrels per day, which then "could" rise to 1 million barrels by 1985. Fri thought that output would be expanded to 5 million by 1995 and 10 million by 2000. Zarb spoke also of a government "corporation" to be called the Energy Independence Authority (EIA) to manage synthetic fuel funding, an agency that as projected would control massive resources for the development and commercialization of synfuels (Cowan 1975).

Vice President Nelson A. Rockefeller (1976) spelled out the nature of the EIA in a *New York Times* op-ed, "Toward Energy Independence." The EIA would have a board of five politically appointed directors and a budget of $100 billion, $75 billion of which would be raised through a special issue of government bonds. Rockefeller was explicit that such a corporation with its vast funding and power was necessary because private capital markets would not provide the money for a purpose that was, in his view, a matter of urgent national interest. He argued that the market was failing because of the high level of "uncertainties that exist in this area." Rockefeller himself appeared to be certain that while some energy investments would fail to pay off, overall this government venture would be profitable as well as a boon to national security.

Ford's synfuels efforts went nowhere, however. The EIA was not in the bill that came to Congress, and the House of Representatives rejected any loan guarantees to private businesses even after they were trimmed from $6 billion to $3.5 billion. The House of Representatives, led by Indiana Democrat Ray Madden, who disputed the implicit market failure rationale by calling the bill "a giveaway to the major energy companies" (Madden 1976), defeated all synfuel funding by a one-vote majority.

Before the end of the decade, however, the synfuels issue loomed larger than ever and the market failure aspects were made more explicit. President Carter's first energy message in 1977 supported a "major" increase in R&D for synfuels, both synthetic oil and natural gas, because the conventional resources of both, according to Carter and other officials, were rapidly running out. In fact, in his address, Carter (1977) suggested that global oil supplies might be depleted by the end of the 1980s.[5]

The intensity of the effort grew in 1979 when conflict in the Persian Gulf caused the price of oil to rise, eventually reaching a high of $35 per barrel in 1981 (about $84 in 2009 dollars). Consequently, Carter proposed a new energy program with a massive synfuels effort, for both liquid and gaseous products, as the centerpiece. The Carter program envisioned a government investment of $88 billion (over $233 billion in 2009 dollars) through the Synthetic Fuels Corporation (SFC), with a programmatic goal of 500,000 barrels a day of synthetic oil (or gaseous equivalent) by 1987 and 2 million barrels per day (or equivalent) by 1992 (Lyons 1980). The program was so large in scale and adopted by both houses of Congress so quickly that arguably the entire enterprise could be characterized as a panicked response to a perceived crisis, which under ordinary circumstances would never have been entertained (Ahari 1987).

Still, the vast undertaking was justified by market failure arguments. In this instance government action was needed not only because of the failure of capital markets and investor uncertainty, but also because (echoing the 1940s rationale) the energy market itself lacked foresight. In 1980, government analysts, as well as some in the private sector, were forecasting a steadily rising real price of oil to $120 per barrel by the mid 1990s, which, if true, would have made synfuels development profitable, and so should have induced significant investment in synfuels by energy companies. But investors just were not coming forward, leaving achievable gains unclaimed—a sure sign of market failure, according to those who supported the Carter program (Goulder and Robinson 1982).

But everything about the program was misconceived, and the decision to invest so much in synfuels seemed to critics an "emotional and romantic" response (Lee, Ball, and Tabors 1990). The price prediction was based on assumptions of declining supply coupled with rising demand, economic assumptions deservedly termed

[5]Carter's position was supported by a CIA study (*Newsweek* 1977), but the view was hardly unanimous. For example, a Rand study in 1978 argued that there was a 60–90 year supply of conventional oil worldwide (*Oil and Gas Journal* 1978).

"farcical," (Cohen and Noll 1991). There was in fact no reason to believe that supply was declining worldwide, much less "running out." Higher prices in 1980 were spurring companies to search for more conventional oil and to find ways to enhance resource extraction. Arguably, the market, which was not investing in synfuels, was giving a useful and it turned out correct interpretation of future energy scarcity. Nonetheless, Congress passed the Synthetic Fuels/Defense Production Act by a four-to-one margin. As one critic later put it, the synfuels bill was a "quick-fix . . . high tech solution that embodied the panacea of massive investment and wondrous technologies" (Willis 1987).

It was quickly apparent, however, that the technology was neither economically viable nor sufficiently proven to be undertaken on such a vast scale (Stanfield 1984). As Willis (1987) noted, even as the project was being launched, five different agencies of government including the Office of Technology Assessment (OTA) criticized the program because the technology was untried and the goals overly optimistic.

The SFC was mismanaged as well as misconceived and the incoming Reagan administration (after arguably worsening the corporation's management) eventually terminated the project, with a resulting waste of between $1 billion and $3 billion.[6] The project had missed all of its benchmarks, failing to create the great technological feat Carter had envisioned. It has been argued (Cohen and Noll 1991) that the synfuels program was closed down in part because it lacked a particular constituency in Congress determined to fight for its preservation as a way to please local voters. It had been a program developed in a crisis atmosphere and in the aftermath no one had a vested interest in preserving it. But the synfuels act of 1980 certainly cannot be said to have righted a market failure—there was no market reason to invest heavily in synfuels technology, and market

[6]Shortly after taking office in 1981, President Ronald Reagan fired the entire board of the SFC and made new appointments led by oil services executive Edward Noble, who became SFC's chairman, and Victor A. Schroeder, an Atlanta real estate executive (with no other apparent connection to the energy business than that he was a friend of Noble's), who was named president. By 1983, three of the SFC's other directors were publicly calling for Schroeder's ouster, charging "mismanagement and improprieties." In August 1983, Schroeder resigned. Although the Justice Department dropped a criminal investigation into Schroeder's conduct because of "insufficient evidence," there seemed reason to believe that the SFC had been mismanaged under his watch (Kurtz 1983).

participants did not do so. Market failure presumes firms fail to respond to market signals. Yet, government ignored the signals market participants received. The market was essentially correct while government failed.

Nuclear Fusion

Pure scientific research is often cited as an unambiguous example of a case where market failure is inevitable (Salter and Martin 2001), the kind of good that markets will inevitably underprovide. Knowledge acquired from such research has social and commercial payoffs that are highly uncertain but potentially enormous. There may be no way to quantify the market potential of some concept that has not even been shown to have a practical application. Therefore, entrepreneurs will have little incentive to invest in such research. According to theory, the market will do too little pure research and government R&D funding may be the only means of realizing the social benefits that the universe of ideas could one day produce.

Nuclear fusion research would seem the ideal example of this problem (Roncaglia 1989). Nuclear fusion energy, the harnessing of hydrogen fusion reactions to produce heat and thus electricity, has never been proven practical but in theory could become what has been termed a "backstop" energy technology (Nordhaus 1979). That is, if fusion energy could be controlled so that fusing hydrogen atoms produces more energy than is required to induce fusion reactions in the first place, the world would have an energy source for the indefinite future. But at the present time, all work on controlling fusion energy (the hydrogen bomb is an example of demonstrated uncontrolled fusion energy) represents a pure research effort. The principle of fusion energy control is known, but harnessing it so as to produce more energy than the process consumes has never been achieved. Because the investment in such research is so large and the outcome highly uncertain, private entrepreneurs, it is assumed, will not undertake it.

The U.S. government has supported fusion research since the 1950s, when enthusiastic researchers suggested a fusion analog to the nuclear fission reactor was only a few years from realization.[7]

[7]Fusion energy scientist Lyman Spitzer said in 1951 that a fusion power system would be ready in five years (Carey 1990).

While research did not in fact lead to even a prototype fusion reactor, the research concept enjoyed modest public funding from the 1950s through the early 1970s. By 1973, before energy became a major public policy concern, fusion was receiving about $95 million annually for basic study of a variety of reactor concepts.

In response to the energy crisis, the Nixon administration argued for increased funding of fusion as part of Project Independence, even though supporters of fusion admitted that a prototype was still years away. Still, promoters contended that a working fusion reactor and electric power generator could be achieved in a relatively short amount of time if more funding were provided. For example, in 1975, Robert Seamans Jr., the director of ERDA, suggested that a prototype demonstration reactor could be readied by the mid-1980s with commercialization likely a decade later (*New York Times* 1975).

Throughout the late 1970s, money for fusion research grew and by the end of the decade had tripled to over $300 million per year. But with the second energy crisis in 1979, a new urgency was added to this program as well. While economic theory might have justified increases in funding for fusion research, in fact the nature of the program was radically altered. Congress, led by Representative Mike McCormack (D-Wash.), initiated and passed the Magnetic Fusion Energy Engineering Act of 1980 (MFEE), which envisioned $20 billion for an "Apollo-like mode" project to first prove the principle of controlled fusion by 1990, and then develop a prototype commercial fusion reactor by 2001.[8] Moreover, Congress specified the basic design, called a tokomak. The measure passed overwhelmingly (there were only 7 votes against in the House of Representatives).

Though the tokomak design, using magnetic confinement of high-temperature fusion plasma, had seemed the most promising approach for some years, it did not have the unconditional support of the scientific community or even the Department of Energy. The DOE, while in support of additional research funding, objected to measures that foreclosed other options besides the tokomak (*Business Week* 1980). DOE scientists also argued that the timetable was too optimistic. Despite opposition within his own administration, President Carter sided with Congress and signed the bill.

[8]This amount ($20 billion) was a projection of the total cost. However, according to the bill, funds would have to be appropriated annually.

Rep. McCormack declared it "the most important energy bill ever passed by this or any other country" (Hershey 1980).

Funding rose, but the MFEE had changed the implicit argument about government support for fusion energy. No longer was this a pure research effort, but rather a program that declared: Controlled fusion was in fact technically feasible, despite the lack of demonstrated proof that this was the case; the market would be unwilling to develop something like a fusion reactor even though it had great commercial potential; and Congress knew which design would be the correct one. This was all quite remarkable; the course and timing of scientific knowledge itself was now to be guided by legislation. Government leaders were effectively claiming that they could induce a marketplace winner for a technology about which there was no clear evidence that any winners even existed. Money spent would validate this claim, it was assumed, as government had validated President Kennedy's promise to put a man on the moon before the end of the 1960s.

Of course this analogy demonstrated only that Congress did not understand the great differences between a fusion reactor project and the Apollo moon landing. When Kennedy took office the U.S. had a manned space program and could lift payloads into earth orbit. The science of lifting them out of orbit to the moon was fairly clear, and only better engineering was needed to achieve that goal. Apollo was also intended to be simply a demonstration project with no commercial intent. No firm would have undertaken such a venture when the assumption was that no commercial payoff was even possible.

However, the MFEE did have a commercial purpose, a purpose that was to be achieved through congressional guidance and appropriation of funds. With a chosen design and a timetable in the bill, Congress had substituted political judgment for both scientific and market judgments. Thus, the project, originally a pure research effort, had become an extremely fanciful example of a government energy development program.

The results were predictable. Funding rose to a high of $469 million in 1984, but then fell as cheap conventional energy resources ended the panicked search for alternatives. More important, advances in fusion did not follow the MFEE's timetable. By 1990, so far from having demonstrated the principles of a working fusion reactor, scientists conceded that the whole idea was nowhere near realization. Said one physicist, "People have been saying, 'Fusion is 30 years away—and always will be.' Except now, it seems to be 60 years away" (Carey 1990).

Still, promoters of fusion blamed the reduced funding for the failure to achieve the stipulated benchmarks and called for a renewed effort. One group of researchers argued for accelerated spending and promised success by 2005 (Dean et al. 1991). In fact, fusion did maintain research support, though at declining rates. By 2006, only $290 million was appropriated for fusion research of all kinds—in real terms less than a third of the amount spent in 1984. The largest tokomak magnetic confinement project was the International Thermonuclear Experimental Reactor (ITER), no longer even a U.S. project. Though accelerated fusion research and development continues to have its proponents, even with higher energy prices another crash program is very unlikely. Clearly, whatever market failure existed with respect to pure fusion research, the MFEE and the congressional effort to induce innovation failed far more dramatically. In fact, none of the benchmarks set in the original bill have ever been met. Increased "Apollo mode" funding today would be no more likely to get us there according to any timetable than it did in 1980.

Partnership for a New Generation of Vehicles

In October 1993, President Bill Clinton announced the "Clean Car Initiative" to "develop affordable, attractive, [family-sized] cars that are three times more fuel efficient than today's cars" (Clinton 1993). Soon after, the project was renamed the Partnership for a New Generation of Vehicles (PNGV), a joint effort of the U.S. government and the "Big Three" American automobile manufacturers: General Motors, Ford, and Chrysler. The goal became the development of a commercially viable car that would have ultralow emissions and could achieve an average 80 miles per gallon (mpg), almost four times the national fleet average at that time.

Clinton explicitly evoked market failure as the rationale for the PNGV, but he was not explicit as to just what that failure entailed. "There are a lot of things we need to be working on," he said, "that market forces alone can't do" (Clinton 1993). Clinton touted the public-private arrangement as a means of overcoming the purported market failure while at the same time avoiding "the inefficiencies, the bureaucracies, and the errors of government policy" by engaging private-sector participation. Still, he argued that government brought both technological and financial expertise, presumably to overcome the limitations of the market (Clinton 1993).

The nature of the market failure was spelled out more fully in a report for Congress (Sissine 1996). Market forces, the report argued, were actively discouraging development of high-mpg automobiles. Prices of fuel were low and consumers evinced little interest in such vehicles. The "failure" then was in the inability of the market to anticipate changes in the demand or supply of gasoline that might in turn alter the demand for higher-mileage cars. There was no explicit prediction of rising prices nor was it clear that the market would in fact be unable to respond to changes when and if they occurred. Nevertheless, that was the implication. A timetable was set for the project: production prototypes were required by 2004.

Given that by 2006 the price of gasoline had begun to rise, one might argue that the market had lacked foresight. But did a government-directed effort offer a real corrective? From the outset, there was reason to doubt it. As a White House press release noted, the PNGV presented "a technological challenge comparable to or greater than that involved in the Apollo project" (White House 1993). The continual evocation of the Apollo moon program revealed not only the expectation of a difficult technological challenge but also the continuing lack of comprehension of the major distinctions between pure demonstration projects and commercial development. Certainly a car could be made that would get 80 mpg, but could it be produced at a cost that would induce consumers to substitute it for conventional vehicles? Clearly in 1993 the answer was "no," but the expectation was that enough government funding would make it so.

As early as 1996, some scientists argued that such a car would not be cost competitive, indeed might be as much as $40,000 more than a conventional vehicle, many thousands more than a car that could have achieved 40 mpg (Coy 1996). Still, the public-private partnership persevered and its participants claimed the following year that there was progress, although more funding would be required to meet the timetable (Jewett 1997).

In early 1998, reports suggested that the project was successfully achieving the intended result. In a *Business Week* opinion piece, author Robert Kuttner described several prototypes on display at an auto show and declared that the PNGV program was "paying real dividends." Moreover, Kuttner explicitly made a market failure argument. "Clean-engine technology is a positive externality—a social good in which industry under-invests because the private rewards are too uncertain" (Kuttner 1998).

The automakers in one sense met the benchmark of creating prototypes of high-mileage cars, but the versions they created had no commercial prospects. Early in the new century, it became clear that the real goal of a commercially viable 80-mpg car would not be achieved. A report from the National Research Council stated, "The Committee believes that no reasonable amount of funding would ensure achievement of [the 80 mpg] goal. . . . Breakthrough ideas and talented people are more stringent constraints than money to achieving this goal" (National Research Council 2002). The public subsidy cost was about $1.5 billion in total and the PNGV did not work as hoped. Rather, it failed in the same way previous alternative energy technologies had failed. Whether or not there was a market failure, government efforts provided no corrective.

But in fact, there was evidence to suggest the market failure argument was itself wrong. The PNGV consortium decided early on that to develop the 80-mpg car the technology of choice would be a gas-electric hybrid engine. This type of engine, which had emerged from basic research conducted in the 1970s, matched a small gasoline engine with an electric battery power plant that would be recharged both by the engine and by "regenerative" braking, that is, taking energy dissipated in the braking process and capturing it for the battery.[9] But the cars either were too expensive or not efficient enough. With gasoline prices relatively low, consumer demand focused on relatively fuel-inefficient SUVs and light trucks, and U.S. automakers saw little upside in expanded development funding of low-emissions, very-high-mpg "supercars."

Yet ironically at this time there was commercial development of high-mileage gas-electric hybrids. Toyota and Honda both introduced models—Toyota, the Prius, and Honda, the two-passenger

[9]Hybrid technology had been developed primarily in the 1970s initially by Victor Wouk through the Federal Clean Car Initiative Program and later through the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976, which was enacted despite President Ford's veto. These remained research programs mostly although patents obtained during this time provided the basis for later hybrid technology developments (*Engineering and Science* 2004).

Insight—that used this technology and obtained relatively high-mpg fuel economy. The Honda achieved close to 60 mpg, while the more family friendly Prius achieved close to 50 mpg. The irony was that both companies, despite rising production in the United States, were pointedly excluded from any part in the PNGV.[10] Both introduced the cars even though they apparently lost a significant amount of money in the first years of market participation. By 2000, Honda's sales were only in the hundreds per year, Toyota's were better, but much lower than its sales of low-mpg SUVs.

Eight years later, however, with gasoline prices reaching more than $4 per gallon, the millionth Prius was sold worldwide. Honda had abandoned the Insight but not the technology and was selling vigorously five-passenger hybrid Civic models that were getting about 50 mpg. In other words, the Japanese manufacturers took their own initiatives in bringing hybrid cars to market. There was no timetable or benchmark set by a government program, but there was a recognition that low energy prices were not immutable and that innovative high-mileage alternatives might be a useful line to pursue along with their conventional cars and trucks. Put another way, market participants following their own strategies risking their own finances brought alternative automobile technologies to market, lost money in the short run but made profits as market conditions changed. The lack of foresight of market participants, the unwillingness to take risks when the prospects were uncertain, clearly did not apply to Toyota and Honda. They applied more aptly to the American Big Three, who were unwilling to employ new technologies without significant government subsidies and remained unwilling even after Toyota and Honda demonstrated that the technology had plausible commercial potential.[11] Incentives matter, and in this case it seems that government incentives were far less productive than market ones. Since there is a basis for comparison between the market's performance and the government's, the PNGV program

[10]The Japanese car makers did receive some development funding from their government to help them meet stringent California requirements, but it was split among eight car makers and was not geared toward a particularly strict programmatic outcome like the PNGV (see Sissine 1996). Moreover, the decision by Honda and Toyota to launch commercial hybrids was made by the companies and they were not compensated for initial losses commercial entry entailed.

[11]Ford did introduce a hybrid version of its small SUV, the Escape, in 2004, achieving only around 30 mpg; other automakers followed later as gasoline prices rose, that is, once the market provided the incentives to do so.

seems the clearest example of government failure in energy development programs.

Conclusion

Market failure is in theory a plausible argument for government sponsorship of alternative energy technologies. But in practice, even where the argument would be strongest—for example, nuclear fusion—there is little reason to believe that government programs actually have corrected the purported failures. One can certainly imagine the benefits that would result from successful development of new technologies, but history has demonstrated that government energy programs reach for more than they are ever likely achieve, and end up misallocating resources.

This historical record is pertinent today. Less than two years ago, an ethanol program was adopted that appears to embody all of the unfortunate characteristics of the programs for synfuels, fusion, and the high-mileage automobile. The program mandates technological progress according to a timetable with a goal of commercialization. The ethanol legislation, the Energy Independence and Security Act, as passed in late 2007 stipulates that by 2022 the United States will consume 36 billion gallons of ethanol annually, but to meet this goal there must be rapid commercialization of ethanol from cellulosic feedstocks. While the technology exists, it is not nearly cost competitive with conventional fossil fuel resources and requires breakthroughs of the type that stymied previous alternative energy efforts (Grossman 2008).

And more of these sorts of policies seem likely in the years ahead. During his campaign for the presidency, Barack Obama called for production of 60 billion gallons of ethanol by 2030, 1 million plug-in hybrid cars on the road by 2015, and 25 percent of electricity from renewable sources by 2025. He vowed to spend $150 billion on new technologies despite the fact that government spending has never produced any viable alternative energy products.

Faced with an economic recession, President Obama has focused mostly on the vacuous idea of "green jobs" (Morriss et al. 2009) while still pledging to spend $150 billion over 10 years to "transition to a clean energy economy" (White House 2009). But the grounds for these expenditures are no different from the ones that gave us the synfuels, fusion, ethanol, and PNGV programs. Government still believes that energy markets are deficient because they are not transitioning to "a clean energy economy" on their own. But there is not the slightest reason to believe that that analysis is any more correct today than it has been for the last 35 years. Even if there is some sort of market imperfection, government is not likely to provide an improvement. Indeed, government failure, with its attendant waste of resources, seems certain to be the outcome.

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