Searle Center on Law, Regulation, and Economic Growth

Northwestern LAW

The History of U.S. Alternative Energy Development Programs: A Study of Government Failure

Peter Z. Grossman
Butler University

RESEARCH SYMPOSIUM ON
BAD PUBLIC GOODS

Misprovision (Part I)
Tuesday, September 16, 2008
(10:45 a.m. - 12:30 p.m.)

The History of U.S. Alternative Energy Development Programs: A Study of Government Failure

Peter Z. Grossman
Butler University

1. Introduction

Over the past 60 years, the United States government had embarked on several major projects to achieve the commercial development of energy technologies intended to substitute for conventional energy resources, especially fossil fuels. These efforts have been particularly noticeable in the past 35 years since the first "energy crisis" of 1973. In the wake of that crisis, President Nixon became the first U.S. leader to announce a plan for energy autarky. The general thinking behind Nixon's "Project Independence" was followed by similar pledges by his immediate successors, Ford and Carter. 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, government embarked on highly publicized, heavily funded efforts at development of new technologies with specific timetables for commercial entry, or even in a few cases, a timetable for mass market substitution. Current mandates for ethanol and other biofuels fit this latter description.

Underlying government alternative energy programs, including the current ethanol program, is an implication of market failure. Presumably, a government program is needed because the market is undersupplying innovation in energy technology, causing the country to lose out on attainable gains to social welfare. Thus, the implication is that only through government intervention can the market failure be corrected and the social benefits of alternative energy technologies be realized.[1]

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 some domains appear to produce far more costs than benefits, and sometimes may worsen whatever market failure they were intended to correct (Winston 2006).[2]

Of course, it is often difficult to judge the effectiveness of government efforts to correct market failures. Methodologically, some form of cost-benefit analysis is typically used to determine empirically whether government intervention leads to increases in social welfare (Mansfield et al. 1977). But empirical evidence does not in itself answer the counterfactual that must inevitably arise when government programs are unsuccessful at improving social welfare. That is, if a market was failing to begin with, presumably there were net social costs—at least in terms of foregone benefits or misallocated resources. But if government is also failing in the same task we may have the problem of determining how much better or worse off we would be if the corrective had never been attempted. Government may fail but public action still might lead to a better outcome from a social welfare standpoint than if the market were asked on its own over time to find a socially superior equilibrium.

But from the evidence of alternative energy development, it seems far more plausible that the key problem has been government failure not market failure. Indeed, the market failure assumption has been typically based on the following premise: there is demand for alternative energy technologies but the market does not provide them. That is, market participants devote few or no resources to alternatives and create innovations with only limited application. Therefore government has to step in to induce the technological development the market fails to create. But the historical record shows that government has spent literally billions of dollars and has achieved almost no obvious benefits as a result. If indeed the market spends little or nothing to create nothing, while the government spends large social resources for the same result, then it would seem government failure, not market failure is a greater concern.

This paper will argue that in fact government policy with respect to alternative energy has been based on faulty premises not only about the existence of market failure but also about the nature and process of innovation. Economic premises behind policy have been incorrect in nearly all particulars. Moreover as this paper will show, there is a fairly recent case where private companies relying on the market succeeded in developing a similar commercial product to one that a government program was seeking but simultaneously failed to achieve.

The paper proceeds as follows: In section two, I discuss the basic idea of market failure and how it influenced at least implicitly the kind of programs the U.S. government has adopted with respect to alternative energy technology. But I will also suggest why government solutions have in fact been at odds with the process of technological innovation and have been unlikely to succeed even if a market failure was correctly identified. Section three will detail the history of government energy technology programs. It will focus in particular 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 these timetables were met, few of the benchmarks were achieved, and development funds were largely wasted. Or put another way, no evident social benefit resulted. A discussion and conclusion follow.

2. The Market for Innovation: Market Failure or Government Failure

Ronald Coase has argued (1964) that all forms of economic organization—markets, firms and government—are "more or less failures." That is, no real world arrangement of economic institutions leads to optimal allocative or productive efficiency of the sort represented in the neo-classical 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 this model is an ideal based on unrealistic assumptions, Coase argued, it had to be assumed that all markets fail to some extent. But then again, so do the alternatives. The goal, Coase suggested, was to choose the form of "social arrangement" that fail least in a given situation.

A market failure assumes that there is an impediment to market transactions that prevent the optimal utilization of societal resources in production or consumption. One type of market failure relevant to this discussion is the presence of an externality. While much of the literature focuses on negative externalities such as pollution, there are also important problems with "positive" externalities. That is, there are many cases where parties outside of a transaction nonetheless derive benefits that the main transactors cannot capture. A new energy technology, for example, might reduce the need for defense spending to protect oil supplies. But this benefit, while clearly welfare enhancing cannot be captured by the entrepreneur who created the technology; it remains a positive but external benefit. At the same time, she, the entrepreneur, bears all of the risk in development (which entails great uncertainty) including the risk of failure that the rest of society will not share. This problem—externalized benefits, internalized costs—means that entrepreneurs will be reluctant to develop innovative energy technologies, which will consequently be undersupplied; advances with high social benefit may not be developed at all if left to the market. In these cases, the government needs, it is assumed, either to provide incentives to entrepreneurs or to undertake development directly. Government programs for alternative energy have tried both strategies.[3]

But in any effort to solve a presumed market failure with respect to innovation, the government makes several at least implicit assumptions about the nature of technological innovation and government's abilities with respect to it. First, and perhaps most important, government must assume that innovation is (or at least can be) a demand-side phenomenon. That is, if consumers want something and it is not technically impossible, innovators should logically act to create those products. Since they do not in the case of alternative energy technologies, the assumption must be that the market is failing to provide the incentives for innovators to act.

The concept of demand-led innovation has had some academic supporters, and the issue has been argued for many years. There have been, for example, attempts to link the developments of the Industrial Revolution to a surge in demand. Jacob Schmookler (1966) theorized that inventors, entrepreneurs and others connected with the development and diffusion of new technology were responding to perceived changes in consumer demand in the late eighteenth century. Of course, consumers might like some things that are not technically feasible and so some supply side considerations could not be ignored. If there was not at least a prototype steam engine, there would not be innovations using it. But in this view demand side considerations outweighed those on the supply side. This theory seemed especially inviting at the time (the mid 1960s) since it echoed the Keynesian demand-side perspective that predominated in macroeconomic theory.

But most demand side arguments have failed to withstand further analysis—with respect to Industrial Revolution and subsequent innovations—and supply-side theories have had far more support. Some, for example Crafts (1977), have in fact taken the opposite extreme and have suggested that innovation is almost entirely stochastic. But other scholars, notably Nathan Rosenberg (1976) argue that scientific knowledge evolves if not randomly at least unevenly and its employment in marketable developments is certainly unpredictable and not necessarily consonant 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. Some of these may fail a market test; others succeed. In any event, Rosenberg's thesis is firmly rooted on the supply side. In other words, the thrust of the argument is that as technological developments occur entrepreneurs may see an opportunity for commercial development – and whether they are right or wrong will be tested in the marketplace. Supply-side theories of innovation have had much more success in explaining historical development than have ones that focus on the demand-side (Mokyr 1977). But government alternative energy programs, directed at correcting the market's failure to supply innovative products, by definition take for granted a demand side explanation to the innovation process.

It should be noted that there is a concept sometimes referred to in the literature as "technology forcing" that argues government can compel firms to innovate through the use of both incentives and disincentives. 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 forcing model has not proven robust when applied to alternative energy. There is no example of government forcing working to create 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. Rather government intervention engenders competition among entrepreneurs 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 incentives to prevent market competition from arising. Overall, this situation provides more of an incentive for innovative rent seeking of legislators than for commercialization of innovative technologies (Cohen and Noll 1991).

The problem is not only how government dispenses support but also to what. Another implicit assumption is that if there are competing technical ideas government is competent to choose the winner. But government has typically failed at picking winners of new technologies. The Japanese government, for example, was touted in the 1980s as the model of successful government-led technology policy. At that time, many were arguing that the U.S. needed more programmatic government projects to develop winners as Japan did through the Ministry of International Trade & Industry (MITI). The Japanese government did have a few successes in pushing development of established technologies in which Japan might excel. But when MITI backed a new analog standard for HDTV and tried to develop a so called “next generation” computer, no commercially viable innovation resulted (Beltz 1993, Pollack 1992).

Finally, there is the assumption 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 without coercive policies behind them. The assumption seems to be: Government backing leads to market domination. This is evident in the highly optimistic language of alternative technology mandates. For example, by “not later than the year 1990” controlled fusion power production will be achieved.[4] Alternatively the language is simply demanding as in the California rule that by 2003 10 percent of all cars sold in California “will have to be” zero emissions vehicles (ZEV). There is no consideration given to the process of technological adoption and nature of market behavior. This process actually 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 reliable. For instance, compact florescent light bulbs save money in the long run versus the more familiar incandescent lights, but people resist them nonetheless, in part it is thought because of high consumer discount rates as well as noticeable differences in the character of the light produced (Cole and Grossman 2004). But in any case, government mandates that 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 1998).

There is a way in which this outcome could be assured: Government can make a technology policy coercive. By a given date people must adopt a technology or face government retribution in the form of fines or imprisonment.[5] But most mandates for alternative energy assume no coercion but rather a process by which market success occurs. Exactly what that process is, is unknown because as the next section makes clear, alternative energy programs have always (often dramatically) failed.

3. The History of Alternative Energy Programs

The first effort of the U.S. government to promote an alternative energy technology was the nuclear power program, which was put into motion by The Atomic Energy Act in 1954. The legislation followed President Eisenhower's "Atoms for Peace" speech to the UN General Assembly in 1953. This development effort was not based on a presumed market failure. Indeed the intention was to take a technology over which government held a monopoly and release it to be utilized by the "genius and enterprise of American industry," (Strauss 1955). Though it was not cost competitive with conventional means of generating electricity, the presumption of the Atomic Energy Commission (AEC), which oversaw the program, was that while government would of necessity regulate and control nuclear materials, private enterprise would put them to cost effective use. Expectations for what industry would accomplish were extravagant to say the least. Lewis Strauss, the head of the AEC, famously told an audience at the Waldorf Astoria Hotel in New York that atomic power would be so plentiful and cheap it would be “too cheap to meter” (1954). Though that claim appears ludicrous in hindsight, it was if anything a moderate position at the time. Proponents of nuclear power claimed it would essentially substitute for all fossil fuels. Power, transportation, heating—everything would be nuclear. And it would all be astonishingly abundant and cheap. One scientist claimed that heat would be so plentiful we could use it to “melt snow as it falls…”(Hutchins quoted in Lapp 1953). Though proponents became more modest over time, one industry executive did predict in the mid 1960s that 50 percent of all US electricity would be nuclear by 2000 (Cantelon, et al. 1991).

With subsidies and promotional efforts totaling $1.25 billion (approximately $9 billion in 2008 dollars), plants soon came on line beginning in 1957 with Duquesne Electric’s Shippingport, PA facility. More followed but in 1962, an AEC report admitted that nuclear power was still not cost competitive without subsidies.[6]

And in fact it never was. Arguably, the problem was that government incentives propelled the development of nuclear power before it was ready either technologically or economically and that government promotion of commercialization set back that very process. Though market failure did not motivate the project’s inception, government efforts were wasteful and often counterproductive.

It is sometimes claimed that this failure was unique to the U.S., since France, Japan and others have continued to build and develop nuclear power. But it has been pointed out (Taylor and Van Doren 2007) that in all cases nuclear power survives only with government largesse. Indeed revival of nuclear power in the US, advocated by many analysts in 2008, will depend on Congressional loan guarantees and favorable regulatory rulings. Even now, with a technology more than 50 years old, it is not clear that nuclear power is economically comparable to other means of electric generation. The intent of government in creating commercial nuclear power was to create an energy technology that would over time be the lowest cost means of generating electricity; that intention has never been realized.

The Synfuels Program

Nuclear power was an unusual program in that it really was not about market failure but rather seemed motivated mainly by the desire on the part of government officials to prove to the world that, as Eisenhower put it (1953), the technology of atomic energy that the American government unleashed would not be "dedicated to [man's] death but consecrated to his life."

The government effort to develop synfuels also began with an intent other than that of correcting market failure. At first, synfuels seemed 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 widely in the event of wartime shortages of conventional oil- based fuels. It should be noted that "synfuels" refers to any unconventional source or form of oil or gas. For example, huge oil deposits are locked in shale in the western US, but extracting the oil is complex, costly and environmentally suspect. This, however, would be one form of imitation, or synthetic, oil. Much of the focus in US synfuels research has focused on the liquefaction or gasification of the fossil fuel resource we have in great abundance: coal. Shale oil and coal liquefaction were the areas the 1944 bill sought to study.

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).[7] Note that this is a massive quantity of output and as I discuss below, a recurring number for synfuels advocates.

Government needed to be in charge, suggested the Bureau, because the agency saw a market failure of a kind that would prohibit 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.[8] The answer seemed to be that the market, especially the capital market, lacked sufficient foresight. No private firm was 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 or gasoline. The coal to liquid effort was dropped in the US in 1952.[9]

With the "energy crisis" of 1973, alternative energy development took on a new character and synfuels became a key element in a number of energy policy initiatives. In October 1973, after the embargo by Arab oil producers against the US for its support of Israel in the Yom Kippur War, President Nixon declared a programmatic goal called "Project Independence," an effort to make the US independent of foreign energy sources by 1980, and synfuels development and commercialization quickly became a focus of policy-makers' attention. Some interest was directed at oil shale, but most attention was given to coal, of which the US had proven reserves that would last more than a 150 years. Nixon's own 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).

Nixon's successor, Gerald Ford was more explicit. His revised Project Independence—a revision in part for the timing of "independence" from 1980 to 1985—called for the development of "20 major synthetic fuel plants," (Ford 1975) with the help of a proposal by Democratic Senator Henry Jackson for $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 Administrator but who became known popularly 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 would be expanded to 5 million by 1995 and 10 million by 2000. Zarb spoke also of a government "corporation" called the Energy Independence Authority (EIA) to manage synthetic fuel funding, an agency that as projected would control about $100 billion in development and commercialization funding (Cowan 1975).

The nature of the EIA was spelled out by Vice-President Nelson A. Rockefeller (1976) in a *New York Times* Op-Ed called "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—which was in his view a matter of urgent national interest. The market was failing not because of the lack of foresight but because of the high level of "uncertainties that exist in this area." Rockefeller himself appeared to be certain—certain that while some energy investments would fail to pay off, overall this government venture would be profitable economically as well as a boon to national security. Thus he was making the positive externality argument as the rationale for such a large undertaking.

Ford's synfuels efforts went nowhere, however. The EIA was not in the bill, and House of Representatives rejected any loan guarantees to private businesses even after they were trimmed from $6 billion down to $3.5 billion. The House led by Indiana Democrat, Rep. 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 was back and loomed larger than ever and the market failure aspects made more explicit. President Carter's first energy message in 1977 supported a "major" increase in research and development of 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 suggested that oil worldwide might be depleted by the end of the 1980s (Carter 1977).[10]

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 $83 today, inflation adjusted). Consequently, Carter proposed a new energy program with a massive synfuels effort—for both liquid and gaseous products—as one of the centerpieces. The Carter program envisioned a government investment of $88 billion (over $200 billion 2007 dollars) through the Synthetic Fuels Corporation (SFC), with a legislated, 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 the need for government action was not only because of the failure of capital markets, but it was also based on the argument that the energy market 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. Under this assumption large scale synfuel production would have been cost effective.[11]

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 et al. 1990). The price prediction was based on assumptions of declining supply coupled with rising demand, economic assumptions deservedly termed “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 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, Synfuels was a “quick-fix…high tech solution that embodied the panacea of massive investment and wondrous technologies,” (Willis 1987).

But it was quickly apparent that the technology was not at all economically viable nor was the technology sufficiently proven to be undertaken on such a vast scale (Stanfield 1984). As Willis (1987) noted, 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 (Grossman 1992).

Of course, the SFC was mismanaged as well as misconceived and the incoming Reagan Administration (after arguably worsening the corporation’s management[12]) eventually terminated the project, with a resulting waste of between $1 billion and $3 billion. 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 synfuel technology and market participants did not do so. Market failure presumes firms fail to respond to market signals. But instead, the signals market participants received were ignored by government. The market was essentially correct; government, on the other hand, appears to have 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 under provide. 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 shown to have a practical application, much less to have had that demonstrated, and so entrepreneurs will have little incentive to invest in such research. Thus 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 exemplar of this problem (Roncaglia 1989).[13] 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.[14] That is, if fusion energy could be controlled so that fusing hydrogen atoms produce 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 large, the outcome highly uncertain, and the potential return to investors far below the social benefit that would be achieved, private entrepreneurs it is assumed will not undertake the investment.

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.[15] 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 the “energy crisis” was 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 crisis, the Nixon Administration argued for increased funding of fusion as part of Project Independence,[16] 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 in 1980. In this instance 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.[17] 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 either 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. Rep. McCormack declared it "the most important energy bill ever passed by this or any other country," (quoted in Hershey 1980).

Funding of course rose, but the MFEE had changed the implicit argument about government support for fusion energy. No longer was this a pure research effort, but the bill was based on the belief that a) such a project was in fact technically feasible, despite the lack of demonstrated proof that this was the case; b) the market would be unwilling to develop something like a fusion reactor even though it had great commercial potential; and c) Congress knew which design would be the correct one. This was a remarkable position. Government leaders were effectively claiming that, they, public officials with no real technical knowledge, could induce marketplace winners—winners in technological developments for 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 ("Apollo-mode") before the end of the 1960s.

Of course this grossly misunderstood the differences between a fusion reactor project and the Apollo moon landing. When Kennedy took office the US had a manned space program and could lift payloads into earth orbit. The science of lifting them out of orbit was fairly clear. 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 and it was assumed that government subsidies would induce the necessary innovations. Congressional funding would be, it was further assumed, appropriate to the task. With a chosen design and a timetable in the bill, Congress was now substituting political judgment for scientific as well as market judgment. Thus the project, originally a pure research effort, had come to embody all of the dubious assumptions noted in Section 2 of this paper.

The results were predictable. Funding rose to a high of $469 million in 1984 but then fell as cheap energy resources ended the panicked search for alternatives. More important, advances in fusion were slow in coming. Indeed, despite the requirements of the program little innovation had been induced. By 1990, so far from having a demonstration of the principles of a working fusion reactor, the whole idea seemed more distant than ever. 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" (quoted in Carey 1990).[18]

Fusion maintained research support although at declining rates. By 2006 only $290 million was appropriated for fusion research of all kinds, in real terms less than a third 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 still has its proponents,[19] even with high energy prices in 2008, 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 to 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 project of the US 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 ultra low emissions and could achieve an average 80 miles per gallon (mpg) actually almost four times the national fleet average in 1993.

In this instance, 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 set for the project, which required a production prototype by 2004.

Given that by 2006 the price of gasoline had begun to rise one might argue that the market had lacked foresight. But to the extent that a market failure existed 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, this 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, 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 mandated 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," was working as advertised. Moreover, Kuttner explicitly made the 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).

In fact, the automakers in a sense met the benchmark of creating prototype high mileage cars, but the versions they created had no commercial prospects. In 2001, 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 80 mpg….Breakthrough ideas and talented people are more stringent constraints than money to achieving this goal." (quoted in Moore 2001) The public subsidy cost was about $1.5 billion in total; the PNGV did not work as hoped, but rather 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 battery-electric powerplant 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 engine.[20] But the cars either were too expensive or not efficient enough. With gasoline prices relatively low, consumer demand focused on inefficient SUVs and light trucks and US 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 2-passenger 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, close to 50 mpg. The irony was that both companies, despite rising production in the U.S., were pointedly excluded from any part in the PNGV.[21] 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 hardly as robust as their sales of low-mpg SUVs.

By 2008 with gasoline prices soaring to $4/gallon, however, the millionth Prius was sold worldwide. Honda had abandoned the Insight but not the technology and was selling vigorously 5-passenger hybrid Civic models that were getting 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 low mileage SUVs and light 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 significant 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.[22] 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 seems if anything more clearly a case of government failure than the efforts at synfuels and nuclear fusion.

4. Conclusion

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

This historical record is especially pertinent in 2008 when an ethanol program has been adopted that appears to embody all of the characteristics of those programs for synfuels, fusion and the high mileage automobile. The program mandates technological progress according to a timetable with a goal of commercialization. The program as passed in late 2007[23] stipulates that by 2022 the US will consume 36 billion gallons of ethanol annually, but this goal to be met requires the rapid commercialization of ethanol from cellulosic feedstocks. While the technology exists, it is not nearly cost competitive with conventional fossil fuel based resources and requires breakthroughs of the type that stymied previous alternative energy efforts.

Past failures notwithstanding, presidential candidates in 2008 and politicians of both parties continually propose their intentions to pursue the same kind of strategies—programmatic efforts at alternative energy development—that have failed so often in the past. Democratic presidential candidate John Edwards, for example, advocated almost doubling the ethanol mandate despite the likelihood that the existing mandate would not be met. Democratic nominee Barack Obama has called for [production of 60 billion gallons of ethanol by 2030 and has vowed to spend $150 billion on new technologies despite the fact that government spending has never produced any viable energy products.[24]

A reasonable question is: why do they persist in advocacy of programs almost certain to fail? This is a topic for another paper, but as Grossman (2008) points out, political candidates have the difficult task of reconciling the two energy dilemmas regarded as most urgent by the American electorate: high gasoline prices and dependence on foreign energy sources. To address the former, the US should cut taxes on oil producers, build more refinery capacity and import more. To reduce dependence, the government should raise prices through tax policy. In other words, with conventional resources, the policies are mutually exclusive. The only way to resolve this problem is to find a miraculous new technology that can reduce prices and dependence simultaneously. And even in the absence of finding one, promising one may be just as effective politically, even if it can never be delivered.

Notes

[1] See Weimar and Vining (1992) for explication of the basic theory. Note that government intervention to solve apparent market failures derives from Pigou (1920), which in turn was critiqued importantly by Coase (1960).

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

[3] Much of the analysis of market failures with respect to innovation stems from the paper by Arrow (1962).

[4] Language from Public Law 96-386-Oct. 7, 1980.

[5] That was in fact the case initially with the 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.

[6] Congress also limited the liability of operators in case of accident with the Price-Anderson Act of 1957. This act is still in force and will cover any civilian nuclear power plant constructed by 2026.

[7] Inflation adjusted this amount would be approximately $79 billion 2008 dollars.

[8] In 1909, the German chemist Friedrich Bergius demonstrated the principle of coal liquefaction, although attempts to scale up the process for mass production during World War I failed (Ridgeway 1982). However, after the war, the I.G. Farben Corporation did build a larger scale synthetic fuel plant that provided fuel to Germany's war effort in World War II. .

[9] South Africa during its apartheid period developed an extensive coal to liquids manufacturing capability that was producing 58,000 barrels per day (bbl/d) by 1983; the output was heavily subsidized as it was not cost competitive with conventional transportation fuels (Cassedy and Grossman 1990).

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

[11] For an economic analysis of the market failure arguments used at the time see Goulder and Robinson 1982.

[12] 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 company 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 SFC's 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).

[13] This idea was also advanced as a plausible justification for accelerated synfuels R&D Goulder and Robinson (1982).

[14] Refers to energy sources that are superabundant and essentially inexhaustible, see Nordhaus 1979

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

[16] Also, there was a fear that the Soviet Union was close to development of a fusion reactor (New York Times 1973).

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

[18] 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 an accelerated effort and promised success by 2005 (Dean et al 1991). But in fact billions more have been spent, albeit slowly, and none of the benchmarks has been met as of 2008.

[19] The non-profit Fusion Power Associates continues to advocate accelerated and expanded public efforts to develop fusion.

[20] 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 & Science 2004)

[21] 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.

[22] 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.

[23] The Energy Independence and Security Act 2007.

[23] Proposals were posted at: http://www.johnedwards.com/issues/energy/ and http://www.barackobama.com/issues/energy/.

Bibliography

Ahari, Mohammed E. (1987). "A Paradigm of 'Crisis' Decision Making: The Case of Synfuels Policy." *British Journal of Political Science* 17:1, 71-91.

Arrow, Kenneth J. (1962). "Economic Welfare and the Allocation of Resources for Innovation." In R.R. Nelson (ed). *The Rate and Direction of Inventive Activity: Social and Economic Factors*. Princeton: Princeton University Press.

Beltz, Cynthia A. (1993) "Lessons from the Cutting Edge: The HDTV Experience." *Regulation* 16:4. Available at: http://www.cato.org/pubs/regulation/reg16n4b.html.

Business Week, 1980, "A Push to Speed up Fusion's Timetable." Feb. 18, 74.

Cassedy Edward S. and Peter Z. Grossman (1990). *Introduction to Energy: Resources, Technology and Society*. Cambridge: Cambridge University Press.

Cantelon, Phillip L., Richard G. Hewlett, and Robert C. Williams (1991*) The American Atom: A Documentary History of Nuclear Policies from the Discovery of Fission to the Present, 2nd Edition*. Philadelphia: University of Pennsylvania Press.

Carey, John (1990). "Hot Fusion is Burning Dollars—and Little Else." *Business Week* 10/15/80, 62.

Carter, Jimmy (1977). Primary Sources: The President's Proposed Energy Policy. Televised address transcript available at: http://www.pbs.org/wgbh/amex/carter/filmmore/ps_energy.html.

Clinton, Bill (1993). Remarks announcing the Clean Car Initiative. Weekly compilation of Presidential Documents, 10/4/93. Available at:

http://findarticles.com/p/articles/mi_m2889/is_n39_v29/ai_14576044/print?tag=artBody;col1.

Coase, Ronald H. (1960). "The Problem of Social Cost." *Journal of Law and Economics*, 3, 1-44.

Coase, Ronald H. (1964). "Discussion." *The American Economic Review* 54:3, 194-197.

Cohen, Linda R. and Roger G. Noll (1991). *The Technology Pork Barrrel*. Washington, DC: Brookings Institution.

Cole, Daniel H. and Peter Z. Grossman (2004) *Principles of Law & Economics*. Upper Saddle River, NJ: Prentice-Hall.

Cowan, Edward (1975) "Congress is Asked for Fuel Funding." *New York Times*, Sept., 26, 1975, 51.

Coy, Peter (1996). "Eighty Miles Per gallon? Well…" *Business Week*, April 29, 1996, 8.

Crafts, N.F.R. (1977). "Industrial Revolution in England and France: Some Thoughts on the Question: Why England Was First?" *Economic History Review* 30:3, 421-441.

Dean, Stephen O., Charles C. Baker, Daniel R. Cohn, and Susan D. Kinkead (1991). "An Accelerated Fusion Power Development Plan." *Journal of Fusion Energy*, 10:2, 197-206.

Economist (1991). "Volting Along the Freeway." Nov. 16, 1991, 80.

Eisenhower, Dwight D. (1953) "'Atoms for Peace' Address to the United Nations General Assembly." 12/8/53. Text in" Congressional Record, 100, 61-63, 1/7/54.

Engineering and Science (2004). The Godfather of the Hybrid. Interview. 67:3. Available at: http://pr.caltech.edu/periodicals/EandS/articles/LXVII3/wouk.html.

Ford, Gerald R. (1975). "President Gerald R. Ford's Address Before a Joint Session of the Congress Reporting on the State of the Union." Available at: http://www.ford.utexas.edu/library/speeches/750028.htm.

Gerard, David and Lester B. Lave (2003). "Implementing Technology-Forcing Policies: The 1970 Clean air Act Amendments and the Introduction of Advanced Automotive Emissions Controls." Working Paper, Center for the Study and Improvement of Regulation, Carnegie Mellon University, Pittsbugh, PA.

Goulder, Lawrence H. and Marc S. Robinson (1982). "Synfuels: Justifications for and Consequences of Government Intervention." NBER Conference on Incentive Effects of Government Spending, Cambridge, MA, November 1982.

Grossman, Peter Z. (1992) "Alternative Energy Technologies: Market Solutions." Center For the Study of American Business, St. Louis, Working Paper 145.

Grossman, Peter Z. (2008) "If Ethanol is the Answer What is the Question?" *Drake Journal of Agricultural Law*, 13:1 (forthcoming).

Hershey, Robert D. Jr. (1980). "Nuclear Fusion Growth Aim of New U.S. Law." *New York Times*, Oct. 9, 1980, D1.

Jewett, Dale (1997). "Delivery of 80-mpg Car by 2004 Hinges on Funding." *Automotive News*, April 7, 1997, 4.

Kurtz, Howard (1983). "3 Directors Seek Ouster; Synfuels President Under Fire." *Washington Post*, Aug. 9, 1983, A1.

Kuttner, Robert (1998). "Don't Thank the Free Market for Eco-friendly Cars." *Business Week*, Feb. 16, 1998, 24.

Lapp, Ralph E. Lapp (1953). *The New Force*. New York: Harper Brothers.

Lee, Thomas H., Ben. C. Ball, Jr., and Richard D. Tabors (1990). *Energy Aftermath*. Cambridge, MA: Harvard Business School Press.

Lyons, Richard D. (1980). Conferees Accept Multibillion Plan on Synthetic Fuels." *New York Times*, May 22, 1980, A1.

Madden, Richard L. (1976). "House Rejects Guaranteed Loans for Synthetic Fuel Development." *New York Times*, Sept. 24, 1976, 17.

Mansfield, Edwin, John Rapoport, Anthony Romeo, Samuel Wagner and George Beardsley (1977). "Social and Private Rates of Return from Industrial Innovations." *Quarterly Journal of Economics* 91:2, 221-240.

Mokyr, Joel (1977). "Demand vs. Supply in the Industrial Revolution." *Journal of Economic History*, 37:4, 981-1008.

Moore, Miles (2001). "80-mpg Vehicle Won't be Ready by 2004." *Rubber & Plastics News*, Aug. 27, 2001, 3.

New York Times (1948). "Synthetic Gasoline: Derivative of Coal May Compete with Refinery Product." Feb. 22, 1948, E9.

New York Times (1949). "Oil from Coal." Feb. 27, 1949, E9.

New York Times (1973). "Leapfrog into Fusion." (editorial), Oct. 30, 1973, 42.

New York Times (1975). "'New' Energy." Aug. 8, 1975, 20.

Newsweek (1977). "A Chilling CIA Forecast." April 25, 1997, 22.

Nixon, Richard M. (1974) "Message to Congress on Energy." Excerpt*: New York Times*, Jan. 24, 1974, 24.

Nordhaus, William D. (1979). *The Efficient Use of Energy Resources*. New Haven: Yale University Press.

Oil & Gas Journal (1978). "Rand Sees 60-90 Years of Oil Supply." Oct. 9, 1978, 37.

Pigou, Arthur (1920). *The Economics of Welfare*. London: Macmillan.

Pollack, Andrew (1992). "'Fifth Generation' Became Japan's Lost Generation." *New York Times*, 6/5/92.

Ridgeway, James (1982). *Powering Civilization*. New York: Pantheon.

Roncaglia, Alessandro (1989). "Research in Fusion as Investment." *Giornale degli Economisti e Annali* 48:7-8, 293-307.

Rockefeller, Nelson A. (1976). "Toward Energy Independence." *New York Times*, Feb. 24, 1976, 35.

Rosenberg, Nathan (1976) *Perspectives on Technology*. Cambridge: Cambridge University Press.

Salter, Ammon J. and Ben R. Martin (2001). "The Economic Benefits of Publicly Funded Basic Research: A Critical Review." *Research Policy* 30:3, 509-532.

Schmookler, Jacob (1966). *Invention and Economic Growth*. Cambridge, MA: Harvard University Press.

Sissine, Fred (1996). "CRS Report for Congress: The Partnership for a New Generation of Vehicles," 96-191 SPR, Feb. 28, 1996.

Stanfield, Rochelle L. (1984). "Why Won't the Synfuels Corporation Work? The Real Problem May be the Technology." *National Journal*, June 9, 1984.

Strauss, Lewis, L. (1954). Speech to the National Association of Science Writers. New York, 9/16/54.

Strauss, Lewis L. (1955). "My Faith in the Atomic Future." *Readers Digest*, August 17-21.

Taylor, Jerry and Peter Van Doren (2007). "Hooked on Subsidies." *Forbes* 11/26/07. Available at: http://www.forbes.com/columnists/forbes/2007/1126/034.html.

Weimar, David L. and Aidan R. Vining (1992). *Policy Analysis: Concepts and Practices*, 2nd Ed. Englewood Cliffs, NJ: Prentice-Hall.

White House, Office of the Press Secretary (1993). Historic Partnership Forged with Auto Makers Aims for 3-Forl Increase in Fuel Efficiency in as soon as Ten Years." Press Release "Clean Car Announcement," Sept. 29, 1993.

Willis, Sabrina (1987). "The Synthetic Fuels Corporation as an Organizational Failure in Policy Mobilization." In: E.J. Yanarella and W. C. Green eds. *The Unfulfilled Promise of Synthetic Fuels*. New York: Greenwood Press.

Winston, Clifford (2006). *Government Failure Versus Market Failure*. Washington, DC: AEI-Brookings Joint Center for Regulatory Studies.

Wolf, Charles, Jr. (1979). "A Theory of Nonmarket Failure: Framework for Implementation Analysis." *Journal of Law & Economics* 22:1, 107-139.

Zerbe, Richard O. and Howard McCurdy (2000). "The End of Market Failure." *Regulation* 23:2, 10-14.