A Critique of the National Research Council Study of the Potential for Improving Automotive Fuel Economy

John M. DeCicco

April 1992

Presented to the
1992 SAE Government/Industry Meeting
Washington, DC -- April 30, 1992
(Revised September 1, 1992)

American Council for an Energy-Efficient Economy
1001 Connecticut Avenue NW, Suite 801, Washington, DC 20036
2140 Shattuck Avenue, Suite 202, Berkeley, CA 94704

A Critique of the National Research Council Study of the Potential for Improving Automotive Fuel Economy

John M. DeCicco

Presentation to the
1992 SAE Government/Industry Meeting
Washington, DC, April 30, 1992
(Revised September 1, 1992)

These comments highlight some of our concerns with the National Research Council (NRC) report, *Automotive Fuel Economy: How Far Should We Go?* (released on April 7, 1992). The general conclusion of the NRC study is that, given sufficient time and resources, significant improvements in automotive fuel economy are possible. The report also found that safety concerns need not hold back efforts to improve fuel economy. Our differences with the report center on the assumptions used by the NRC committee in obtaining their quantitative estimates of how much improvement is possible and how much it will cost.

The committee's estimates of what is technically achievable over the next 10-15 years are seriously misleading for a number of specific reasons. First, the technology assesment is incomplete with respect to available automotive engineering developments over the period considered. We question the appropriateness of assumptions regarding product cycle, economics, and consumer acceptance. Finally, the report makes use of suspect data and neglects CAFE credits and other regulatory factors which affect the setting of standards.

This critique elaborates on these and other concerns identified in our review of the NRC study, references to which are given here by page number in the form (NRC:page). Before delving into the technical issues, however, some general comments are in order.

Our most serious objection to the NRC study is the extent to which the committee appears to have prejudged critical assumptions regarding what levels of fuel economy improvement should be considered for regulations. The committee denied that their study makes a recommendation on future fuel economy standards and provided many disclaimers regarding their estimates of what is technically achievable. Nevertheless, the committee clearly linked fuel economy levels which they term to be "practically achievable" with those that should be selected by policy makers for future regulations (NRC:1). The committee stated that it believes its findings of what is technically achievable set an upper bound for the fuel economy levels appropriate as regulatory targets, which should lie "between the levels that would be achieved without any governmental intervention and the technically achievable levels" (NRC:2). In fact, "the committee ... believes that it would be risky to set fuel economy targets at or above these [technically achievable] levels" (NRC:149). Through such statements, the prominent and poorly qualified presentation of the key quantitative results (Tables ES-1 and 8-1), and even the subtitle of the report ("How Far Should We Go?"), the NRC committee effectively abrogated its own guideline of not making a recommendation for future fuel economy standards.

Perhaps the sharpest picture of the NRC committee's quantitative conclusions is seen in its projection for the year 2001, given in Table 8-2 (NRC:153). The committee concludes that with "higher confidence" the new car fleet can reach 31 mpg by 2001, just 2.4 mpg (8%) more than the peak that occurred in 1988. They characterize an improvement to 33 mpg (15% higher than in 1988) as "technically achievable" with "lower confidence." For 2006, only slightly greater fuel economy levels are reported, as presented in the report's main summary table (NRC:4,152). These findings of limited improvement potential contrast starkly with a number of facts which have bearing on the issue:

* the actual 75% improvement in fuel economy achieved from 1975-88;
* the wealth of ongoing technological advances regularly reported in the press and engineering literature;
* the existence of many prototype vehicles with fuel economies *2 to 3 times* production averages;
* the existence of production vehicles demonstrating fuel economy improvements exceeding even the highest levels estimated by the NRC committee.

This last fact is borne out by the Honda Civic-VX, which has already demonstrated fuel economy improvement of 44% (34% for the California version) in just one, four-year product cycle. The NRC committee discusses the Civic VX but, as I shall note further below, the committee rationalizes away the vehicle's key improvements. In effect, the NRC study excludes *what is on the road today* from the set of technologies and designs which they term "technically achievable" *in 14 years*. The California version of the Civic VX, which meets the tougher emissions standards, is rated at 55 mpg, while the NRC report claims a "technically achievable" level of but 39-44 mpg for new subcompacts in 2006.

The NRC committee's assumption regarding the timing of fuel economy improvement presumes no disturbance of the industry's "normal product evolution," which they take to be 10-15 years. This assumes the least competitive industry production performance, far worse than the state-of-the-art 4-5 year cycles that are now well demonstrated and are discussed elsewhere in the report. The long lead time assumption has two effects on the NRC's quantitative assessment: delaying the target year to 2006 and rationalizing exorbitantly high technology cost estimates under the guise of "premature replacement" of productive capacity.

A further shortcoming of the report is inadequate documentation of the analytic path by which the committee reached its key quantitative conclusions regarding what is technically achievable. The committee denies a specific link of their numerical results to previously reported estimates and the report does not specifically describe how the final numerical estimates were derived, except as a "structured judgmental process" (NRC:150) under numerous assumptions. Such poor documentation is irresponsible in a study of this importance on a contentious issue.

A careful examination of the assumptions and analyses behind the numbers reported by NRC reveals some of the reasons for their finding of so limited a potential for improving fuel economy, even over the 14-year time horizon they chose to examine. I have grouped my criticisms of their assumptions, methodology, and findings under the six headings in the discussion that follows.

1. Incomplete consideration of technologies

The NRC committee did state the limitations of its approach: "no allowance was explicitly made for the development of new technologies or for the refinement of existing ones" (NRC:136). However, since the committee used this very limited approach to set an upper bound on what they characterize as practically achievable over a 14-year time horizon, their technology assessment is incomplete. Two types of judgements were used by the NRC to restrict what they considered to be technically achievable:

(1) The panel ignored or dismissed the more efficient refinements of the "proven technologies" that they did identify, such as transmission control, variable valve timing, engine friction reduction, application of turbocharging to allow displacement reduction, and improvements in accessories, aerodynamics, and tires.

(2) The panel excluded any of the advanced or developing technologies that could start to penetrate the fleet given a regulatory push, such as lean-burn engines, two-stroke engines, direct injection diesels, idle-off (engine start/stop) and electric hybrid designs, tall gearing in manual transmissions, electronic throttle control, additional levels of material substitution and use of "space frames" for improved structural integrity at lower weight, and use of heat batteries to reduce cold-start fuel consumption and emissions.

A more thorough assessment would have presented such technologies and their benefits, adequately qualified, so that policy makers could judge for themselves the extent to which they should enter into a determination of what is practically achievable.

Regarding the technologies which were considered for their estimates of what is technically achievable, the report does not clearly document an analytic path leading from their tabulations of technologies and associated fuel economy benefits to their judgmentally derived summary estimates. Nevertheless, the lists of technologies, benefits, and costs given in Tables B-1 and B-2 (NRC:198-199) figured prominently in their assessment process, through what the committee calls its "shopping cart" approach (NRC:133-144). These tabulations are drawn from previous reports by EEA, SRI (1991), and other industry sources. The committee denies a specific link of their numerical results to these previously reported estimates. However, the "higher confidence" estimates for 2001 closely match those reported by the automotive industry, e.g., in SRI (1991). The "lower confidence" estimates essentially match those derived as "product plan" scenarios on various occasions by Energy and Environmental Analysis, Inc. (EEA, as reported, for example, in OTA 1991 and Johnston 1991). Our specific concerns with the SRI estimates were presented to the committee during the course of its deliberations (DeCicco and Tatsutani, August 1991) and are discussed further below.

The projections of "greater fuel economy gains," which are characterized as the "lower confidence" fuel economy values in the summary and Table 8-1 (NRC:152), largely match the estimates that have been derived by EEA in recent years.[1] For example, the NRC "lower confidence" estimates for 2006 from Table 8-1 work out to a new car fleet average of

[1] EEA-derived scenarios were reported by the Office of Technology Assessment (OTA), *Improving Automobile Fuel Economy: New Standards, New Approaches*, Oct. 1991; the Senate Energy and Natural Resources Committee, "Additional views of Senator Johnston," pp. 366ff., plus supplemental document, pp. 385ff., in *Report to Accompany S. 1220*, June 5, 1991 (Johnston 1991); and in various studies prepared for the Department of Energy (DOE) and the Environmental Protection Agency (EPA).

37.5 mpg, essentially matching the 37 mpg level described in Johnston (1991).[2] The technology benefit estimates in the EEA-related list are essentially the same values that have been reported for several years now; the potential for further efficiency enhancement through refinement of these technologies is not considered.

One of the report's major underestimates of technical capability is in the area of transmission improvement. For automatic transmissions, an estimated fuel economy benefit of only 0.5% is assumed from the use of electronic control. The opportunity for electronic control to implement a shift schedule that is better synchronized with the engine map for optimizing fuel economy was not considered by NRC. If this were done, the fuel economy benefit would be as much as 9%, accounting for interactions with engine technologies directed toward improving part-load efficiency.[3] This type of transmission control is similar in effect to the use of "tall gearing"[4] in a manual transmission (which was omitted from the NRC's technology list). Improved transmission control is a case where the technology exists, but yields only a small benefit under current market implementations. Such forms of transmission control may change the "feel" of driving, but they need not detract from measurable vehicle performance. Although it is valid to raise consumer acceptance concerns with this technology, it does not imply that the greater potential is not technically achievable, and, more to the point, that the potential benefit should be completely hidden from policy makers. A balanced assessment would have presented complete information and enabled policy makers to judge the degree of fuel economy improvement (e.g., between 0.5% and 9%) that might be appropriate for developing standards.

Another example is variable valve timing (VVT). The 4-year old EEA-based estimate is for a limited form of VVT, namely intake valve control for pumping loss reduction, which yields a 6% fuel economy benefit (as noted in Table B-1, NRC:198; Table E-1, NRC:233). The industry-derived estimates are even lower than this. But the report itself notes that including the proven ability for VVT to boost torque across the RPM range, enabling engine displacement reduction and gearing changes, would result in a significantly greater benefit, of the order 12%-16% (NRC:206). (VVT has also been implemented to enable lean-burn operation in the 1992 Honda Civic VX, as discussed below.) None of these higher fuel economy benefit levels appear to have significantly entered into the committee's summary assessment.

The second aspect of the NRC's incomplete treatment of technical potential is the exclusion of newly available and nearly commercial technologies, listed above under item (2). As noted above, the primary technology lists (NRC:198,233) behind the committee's estimates are not significantly different than those presented in the EEA over the past several years (e.g., EEA 1985 through OTA 1991). The list is therefore static with respect to advances in automotive engineering--it is essentially frozen at a level reflecting the state-of-the-art for the

[2] Although the NRC report's poor documentation impairs a detailed comparison, their "lower confidence" estimates differ only slightly from EEA's 2006 assessment for the Johnston (1991) Committee report. The latter is similar to the "maximum technology" scenarios for 2001 reported in OTA (1991), except that it allows 15 years of lead time to avoid any disruption of domestic industry product cycles and includes 30% penetration of two-stoke engines for the passenger car fleet in 2006. It does not appear that the NRC included the two-stoke in its estimates.

[3] Estimates of this more efficient form of transmission control (termed aggressive transmission management) were presented to the committee by M. Ross of the University of Michigan (NRC Workshop in Irvine, CA, July 1991, and the report by Ross *et al.* 1991).

[4] As used, for example, in Honda's CRX-HF and the Civic-VX.

mid-to-late 1980's even though the study purports to be looking out nearly 20 years beyond that time. The committee did discuss other technologies which have been widely identified, demonstrated in prototypes and even some limited production models, or are under active development. However, the failure to noticeably incorporate them into the quantitative assessment results in a significant downward bias to the results. Although these technologies have uncertainties, confidence would have to be very high indeed that none of them will work out in order to justify omitting them from "lower confidence" estimates of what is technically achievable over the next decade and a half.

The most prominent apparent omission is lean-burn, four-stroke engines, as demonstrated in the Honda Civic-VX.[5] The NRC study discusses lean-burn and notes that use of this technology alone could yield a potential fuel economy improvement of 7%-10% (NRC:217-219). They point out the serious concerns about its ability to meet the more stringent NO_x standards. However, a major automaker has introduced this technology and extensive development work is in progress on a NO_x reduction catalyst (NRC:76-78). It is therefore misleading to exclude it from appropriately qualified numerical estimates of technical capabilities.

The potential development of hybrid electric vehicles should also have been considered over a 15-year horizon. Electric and hybrid electric vehicles are being developed with definite plans for commercialization in California beginning no later than 1998 (some models are planned for introduction in 1994). Use of such vehicles is being driven by air quality requirements, but they also offer significant energy efficiency advantages. (Significant CAFE compliance credits will be earned by these and other alternatively fueled vehicles--the NRC committee's neglect of this regulatory consideration is discussed further below.) The potential for efficiency improvement through electric hybrid designs was presented to the committee,[6] but apparently ignored even for their "lower confidence" estimates of what will be achievable by 2006.

2. Product cycle assumptions

In determining the amount of lead time needed to make improvements in fleetwide fuel economy, the NRC committee assumed that there should be no disturbance of the industry's "normal product cycles," which they take to be 10-15 years (NRC:9). Many of the changes needed to achieve the limited improvements which the committee did identify would not require complete redesign and full retooling (all of the technologies specifically identified in the NRC "shopping cart" approach have been available for at least 4 years now). Moreover, over such a long time period, much greater efficiency improvements would be possible (e.g., incorporation of the more advanced technologies identified above as having been left out of the NRC "shopping cart"). The long lead time assumption has two effects on the NRC's quantitative assessment: delaying the target year to 2006 and rationalizing high cost estimates

[5] It may be that the committee considers that they did include lean-burn, subsuming it under their VVT benefit; however, as noted above, this results in a significant underestimate of the benefit.

[6] Presentations of A. Lovins and C. Mendler to the Committee's Irvine workshop, and as discussed in EEA (1991).

under the guise of "premature abandonment of productive capital investments" (NRC:139). Furthermore, by not revealing the competitiveness implications of their very long product cycle assumptions, the NRC committee presents an unrealistic picture of economic impacts.

The use of such a long lead time across the light duty vehicle fleet presumes the least competitive industry performance for product development and production. It is clear from the trade press that a much more rapid redesign period is easily state-of-the-art for some model lines, particularly high-volume, highly competitive segments of the market. This capability is no longer strictly limited to Japanese automakers. There have even been reports that the most competitive automakers are capable of moving yet more quickly, but are holding back so as to not appear too aggressive. Slow introduction of new products is widely acknowledged to be competitively disadvantageous. The NRC report itself notes that 4-5 year product development times are now practiced in the industry, even though the Japanese automakers are still ahead of U.S. domestics in terms of requiring less time and resources to bring a product to market (NRC:98-99). Nevertheless, it appears that the NRC assumed a 10-15 year turnover time for all market segments.[7]

Clearly, a 4-year product development assumption may be inappropriate for some market segments. Some lines have conventionally kept in production longer, particularly some light trucks. But this is partly a result of lower market and regulatory pressures for faster product evolution. Note again that the question is what can be done to meet regulatory needs, not what would be done under business-as-usual. Therefore, the existence of slow redesign times in the past should not completely inhibit judgements regarding what could be done to improve the fleet when the need arises. Many of the changes needed to achieve significant improvement do not require full redesign, anyway. The argument that there are reliability risks associated with more rapid technology introduction is contradicted by the fact that the most reliable makes also have the shortest product cycles. One might see some temporary stretching out of product cycles because of the economic downturn, but to not more than another year or so if an automaker wants to stay competitive. The NRC results would have been more credible if they had incorporated more up-to-date timing assumptions according to market segment; they discuss such more rapid product development times in Chapter 5. Although the committee noted that the restructuring and investment requirements may be challenging, they also pointed out that such changes are already underway and are necessary for competitiveness in a global automotive marketplace (NRC:98-102).

In essence, then, the timing question is directly related to competitiveness. The ability to bring out competitive products in response to new regulations is little different than the issue of bringing out competitive products in the face of market demands (or, external events, such as an oil supply disruption). CAFE regulation is just one of a number of factors automakers must all face as they compete with each other for market share. It may require higher investment rates than manufacturers would otherwise follow, but this could be a net economic benefit for the country even if it meant lower profits for the automakers. Allowing automakers to avoid investing in technology advancement may bolster short-term profitability. But the extent to which such profits are truly an economic benefit for the country is not clear. In fact, until the recent economic downturn, some domestic automakers collected enormous profits even while loosing market share, which is obviously a case of them choosing short-term

[7] R.A. Meserve, response to question at briefing on the NRC report, National Academy of Sciences, April 9, 1992.

gains over investments that would help the companies and their workers remain competitive. Consider the contrast in strategies: some automakers made profits by avoiding investment costs and producing relatively old model lines for many years, even while it meant loosing market share; other automakers rapidly invested, using short cycles to bring out continually more competitive products, gaining profits by capturing more market share. In short, by not elucidating such implications of their very long product cycle assumptions, the NRC report presented a misleading picture of economic impacts.

3. Economic assumptions

The NRC report presents an unbalanced assessment of the costs and benefits of improving the fuel economy of new light vehicles. Arguments are made that CAFE standards are not cost-effective beyond certain low levels of fuel economy improvement. Yet none of the economic analysis fully includes the benefits of improvement, beyond those of the direct fuel savings which are buried in Chapter 8 (NRC:158). The summary presentation of fuel economy improvement levels and costs omitted even these discounted estimates of the savings to consumers, and no mention is made of the nationwide oil savings. In general, most aspects of the NRC analysis presume a socially optimal outcome of the unconstrained market, which is a questionable assumption for a number of reasons.

A thorough estimation of the costs and benefits of fuel economy improvement involves a variety of factors, some of which are difficult to quantify. The NRC committee identified potential benefits of: reduced consumer fuel expenditures, conservation of petroleum (a depletable resource), enhanced national security, improved balance of payments, improved environmental quality, enhanced diffusion of technology, and increased economic efficiency (NRC:23-24). They identified potential costs of: the requisite technology improvements, impacts on industry, impacts on employment, safety, and opportunity costs (NRC:24-25). Other economic issues not noted by the committee but which may affect a cost-benefit analysis are: subsidies to automobile use, income distributional effects, subsidies to the petroleum industry, and the fact that there is not an open market for efficient automotive technologies, since the ability to commercialize them is confined to a handful of firms around the world.

The committee quantified only the technology costs and the fuel savings. As noted above, they did not offset the technology costs by the fuel savings in their summary table, thereby masking even this one area of benefit. The inflated nature of some of the technology cost estimates was criticized earlier. These two points alone result in a negatively biased conclusion regarding cost-effectiveness. However, the bias is even more serious because of the neglect of other benefits, especially the reductions of externalities (e.g., national security costs, balance of payments costs, and environmental impacts). Granted that quantifying some of these external costs is difficult, there is nonetheless a significant literature on the subject, some of which was cited in the study. By not providing even a range of estimates for some of these costs that might be avoided by fuel economy improvement, the panel effectively assigned them a value of zero. The failure to explicitly incorporate these significant benefits in the economic assessment of fuel economy improvement is negligent in a study of this scope.

Another key issue missed by the committee is that the attribute mix of the entire vehicle stock (new and used) is determined by the decisions of a non-representative segment of the public, namely, new car buyers, automakers, and dealers. New car buyers are more affluent than the average car buyer (i.e., the average of buyers of both new and used cars); the median income of households buying new cars is significantly higher than that of all U.S. households. The car owning public at large is therefore likely to value fuel economy more than the decision makers in the new car market. More generally on this point, the way the value of costs and benefits differs with the income of individuals was not considered. That is to say, one dollar of fuel savings for a less wealthy consumer, who is more likely to operate a used car, has a greater societal value than a dollar of fuel savings to a more affluent new car owner. The NRC panel ignored this fundamental economic rationale for public sector intervention in the new car market.

Finally, some of the specifics of the cost-benefit analysis seem clearly chosen so as to disfavor efficiency. The committee's parameters most favorable to efficiency improvement are a 10% real discount rate and a 10-year term; they also consider a 30%/10-year and 10%/4-year combinations (NRC:157). It is not clear whether such a cost-benefit analysis had the effect of filtering out any technologies from their summary tables, but they were used to discount the value of fuel savings. Such high discount rates have no basis in principles of societal cost-benefit analysis.[8] Their application to this issue makes efficiency improvement appear less cost effective than it really is. More appropriate discount rates would be 3%-6% real. One can reasonably argue for zero discounting of fuel savings, since the rationale for regulation involves general public welfare, including consideration of all future users of the vehicle. For example, consider a used car buyer, who operates the vehicle, say, in its 10th year of life. Use of a 10% discount rate implies that this person's financial well-being is worth much less than that of the new car buyer--who is on average more affluent than the used car buyer anyway. In brief, our criticism here is not that high discount rates were used at all, but rather that the NRC panel chose only to look at one end of the reasonable range of parameters.

4. Consumer acceptance arguments

The industry's arguments of how consumer preferences may limit the acceptance of fuel economy improvement were too uncritically taken up by the panel (Chapter 6). The extreme version of this line of reasoning is that changes in the fleet forced through regulation will so slow fleet turnover, with people holding onto their old cars longer, that overall fuel economy improvement would be significantly slowed. The committee provides no quantitative backup for this assertion. In fact, there is no evidence linking fleet turnover to regulation-induced changes in vehicles.[9] Vehicle lifetimes have lengthened, and it is widely accepted that this is because of improved reliability. Given the committee's line of reasoning, it would seem ironic that this reliability improvement--undoubtedly a public benefit--has been coincident with increasing regulation of vehicles.

[8] The NRC committee failed to distinguish discount rates that are observed when modeling the decision-making behavior of consumers or firms (which are often high, particularly for consumers) from the discount rates that are appropriate for societal cost-benefit analysis.

[9] Some economists, such as Crandall *et al.* (1986), have made this argument, but their conclusions are theoretically rather than empirically based.

New car sales volume changes are almost wholly driven by the health of the economy. Past regulations, which have been significant and have entailed vehicle cost increases, have not driven buyers from the showrooms. As a former industry executive noted in his address to the NRC committee, "It has long been established that government has the right and the obligation, for the common good, to establish rules for the kind of motor vehicles that are sold ... Hypothetically, Congress could require that all U.S. cars be painted red, white, and blue! ... given adequate lead time ... total sales would not be affected. Market share would shift, however, to those manufacturers who were most creative and innovative in producing a range of products complying with such mandates."[10] Congress is not considering something as hyperbolic as mandatory car coloring, but improved fuel economy is clearly in the public interest. With oil imports accounting for $45 billion of the U.S. trade deficit, improved automotive efficiency can only help the economy. Customers will undoubtedly buy a fleet much more efficient than the present fleet. In fact, the recent years with the highest new vehicle sales, 1987-88, also had the highest new fleet CAFE levels.

Also neglected in the NRC's discussion of customer acceptance issues is the difference between what is valued by the individual acting alone as a *consumer* and what is valued by society acting collectively as *citizens*.[11] This crucial distinction is important in understanding the difference between polling results that consistently show support for stronger fuel economy standards (even if it means paying more for a car) and the car buying preferences of consumers that are revealed in showrooms, where fuel economy is not consistently sought out. Moreover, as noted above under economic issues, the decision makers in the new car market are more affluent than the average car owner. Therefore, it is likely that the public at large values fuel economy much more than the average new car buyer. This may also explain why polling data show that a majority of the public favors stronger CAFE standards even though fuel economy is not high on the shopping list of new car buyers. It also relates to the way economy cars, with higher than average fuel economy, often hold their value better than average in the used car market.

A technical point on the consumer acceptance issue related to the NRC's assumption about the power performance level of the fleet (as represented, for example, by 0-60 mph acceleration times and top speed ability). The committee assume performance levels of 1990, a recent year in what has been a trend of increasing power performance. In Table 7-6 (NRC:145), the committee estimated the fuel economy benefits of a drop back to 1987 performance levels; the potential improvements average 1.7 MPG for cars and 1.0 MPG for light trucks. Such a trade of performance for fuel economy is certainly well within the realm of what is technically achievable, but the NRC did not call attention to this critical issue in their summary assessment. They also failed to note that there is likely to be a cost savings associated with such a tradeoff, since it is technically easier to achieve a given fuel economy rating at a lower power performance level.

---

[10] T. Feaheney, presentation to NRC Committee's Irvine workshop.

[11] As pointed out by W. Kempton in his presentation to the NRC Committee's Irvine workshop.

5. Uncritical use of industry-supplied information

In any area involving technical issues, a range of estimates exists over which there can be reasonable disagreement because of the uncertainties involved. However, in forming its range of estimates for feasible fuel economy improvement, the NRC relied heavily on a deceptive study funded by the automotive industry (SRI 1991). This was not counterbalanced by input from other experts, many of whom addressed the committee and provided much higher estimates of what is technically achievable. This independent information was downplayed and apparently neglected in forming the committee's estimates of what is technically achievable. The resulting unbalanced treatment of available information pulled down the apparent range of so-called reasonable estimates. It appears that the SRI study served exactly that purpose: to produce a misleadingly low range of estimates by asserting very low numbers of fuel economy improvement for the technologies presented, very high cost numbers, and subjectively excluding other available technologies. Scrutiny of the SRI results reveals cost/benefit estimates widely out of range of the data that have been publicly available for several years (DeCicco and Tatsutani 1991). SRI manipulated cost/benefit inputs that were derived and justified under industry-dictated assumptions of "what the market will bear," thus begging the question of what would be possible with regulatory intervention. That the nature of the assumptions behind the SRI and other industry-derived results was not more critically treated by the NRC committee appears to reflect an imbalance in the judgement of committee. The resulting unqualified incorporation of such results seriously undermines the credible scientific and engineering bases for the study.

6. Neglect of credits and other regulatory factors

The availability of credits must be considered when determining fuel economy targets to be used in standard setting--what that NRC committee would call the "practically achievable" levels. This issue comes up as a criticism of the NRC report because of their judgement that what they find to be technically achievable puts an upper bound on what is practically achievable. The NRC did not consider the availability of CAFE compliance credits over the time horizon of their results. Current law provides for two types of CAFE credits: carry-forward credits and alternatively fueled vehicle credits. There are also a test procedure adjustments (which operate like credits) for conformity with the statutory requirement that the fuel economy rating procedure be equivalent to that established in 1975.

Carry-forward credits are earned by automakers who have exceeded the standard in a given year and may be applied to offset their required CAFE in a future year. Because they generally represent fuel economy improvements actually achieved by automakers and because they may be exhausted, particularly over decade or more time horizon, carry-forward credits need not be of great concern regarding the practically achievable levels.

There are two types of alternatively fueled vehicle (AFV) credits. For dedicated alternatively fueled vehicles, a very large credit is given based on the fact that petroleum is displaced. For flexibly fueled vehicles, a generous credit is given, based on an assumption that petroleum fuel is used no more than half the time, but the maximum fleetwide flexible fuel vehicle credits a manufacturer can apply is capped at 1.2 MPG. The extent of AFV credits will mainly depend on pressures for clean air compliance, particularly in California and other non-attainment areas. However, a strengthening of CAFE standards may induce automakers to produce more AFVs than they otherwise would, and so earn more credits. Automakers decisions will depend on how the cost of producing AFVs compares to the cost of improving the fuel economy of gasoline powered vehicles by an amount equivalent to the AFV credit. Given a rising marginal cost of fuel economy improvement, stronger CAFE standards will provide a greater incentive to produce AFVs instead. Production of flexible fuel vehicles sufficient to earn the full credit is particularly likely, since the cost of adding flexible fuel capability is low.

As shown by the Congressional Budget Office (Farmer 1991), the amount of petroleum displaced by the AFVs will be less than the added consumption induced by the loss of fuel economy due to the credits--in other words, the AFV credit system will result in increased oil consumption in spite of its purpose of displacing oil with alternative fuels. Moreover, the fact that manufacturers may produce some AFVs does not change their technical capability for fuel economy improvement. Therefore, the likely AFV credit availability in a given year should be added to the technically feasible fuel economy level in order to establish the standard. Farmer (1991) derived AFV credit estimates for a CAFE standard increase to 30 MPG by 1996 and 34 MPG by 2001, similar to the larger of the levels given by Table 8-2 (NRC:153). Only a few AFVs are expected by 1996, yielding credits of only 0.3 MPG. Depending on the cost assumptions, the credits for 2001 range from 0.7 MPG to 1.6 MPG; the breakdown by dedicated and flexible fuel vehicle types was not reported by Farmer (1991). OTA (1991) points out that it is likely that manufacturers will fully avail themselves of the flexible fuel vehicle credits of up to 1.2 MPG. Therefore, Farmer's value of 1.4 MPG is a reasonable estimate of the AFV credits available in 2006.

Some have argued that it is not fair to add AFV credits to an estimated technically feasible CAFE level, since this would require that manufacturers produce vehicles more efficient than the technically feasible level if they do not produce enough AFVs to earn the full amount of credits. We disagree with this position, because the intent of the two laws (Alternative Motor Fuels Act and proposed CAFE law) is to induce both availability of AFVs and improvement of fuel economy; automakers should not be enabled to trade one goal against the other, which insures that only one of the goals will be met rather than both. This is particularly true if, rather than being technology forcing, the CAFE standard is based only on existing technology, as are the levels estimated by the NRC. Allowing a weakening of such modest effective CAFE levels because of AFV production is a particularly poor trade-off, since it will result in greater gasoline consumption. Manufacturers will have a greater incentive to produce AFV vehicles under a more stringent CAFE standard, and so it is appropriate to add the available AFV credits to a technically based fuel economy target.

The test procedure adjustment varies from year to year and manufacturer to manufacturer (it also depends on fuel composition). However, it has always been positive; an average value of 0.3 MPG is given by EEA (1989).

In summary, approximately 1.7 MPG should be added to estimates of what is technically achievable before using them to constrain what is considered to be practically achievable for standard setting. Adding the 1.7 MPG estimate of the fuel economy gain from a modest power performance rollback (NRC:145) yields a 3.4 MPG adjustment to the NRC's estimate of what is technically achievable for automobiles. This would push their larger estimate up to 40.9 MPG. For the reasons noted earlier, this is a still very restrictively derived estimate that cannot be fairly characterized as representing a "lower confidence" upper bound on the industry's capabilities for improving fuel economy over the next decade and a half.

Conclusion

In summary, we are disappointed by the extent to which the NRC committee dodged the basic question set before it. The question is how much better could the fuel economy of the U.S. fleet be if, through the mechanisms of public policy, the government intervenes in the marketplace in order to accelerate the development, refinement, and timely introduction of technologies for improving fuel economy. The report is most misleading because of the NRC's pretense that they did answer this question, when in fact, they circumvented it, by using assumptions of limited technologies, pessimistic industrial performance, neglect of externalities and other unbalanced economic assumptions, and the other problems identified here. No more than lip service was paid to the notion that regulation can induce, for the public good, investments in new technologies that will otherwise sit on the shelf--perhaps forever. The report acknowledged the many benefits of improved fuel economy, some of the more promising new technologies, and the more rapid design and production capabilities of the modern automotive industry. However, in the final analysis, they made no attempt to fold any of these significant positive factors into their quantitative assessment. By imposing many prior assumptions of "market acceptance," they ultimately begged the question, now before the Congress and American citizenry, of what can be done through scientifically enlightened public policies to improve the fuel economy of the nation's cars and light trucks.

Acknowledgement

The author is grateful to a number of individuals for sharing their reactions and perspectives on the NRC fuel economy report and for reviewing drafts of this critique. I list no names so as to take full responsibility for the comments made here, but you know who you are, and thank you.

References

Crandall, R.W., H.K. Gruenspecht, T.E. Keeler, and L.B. Lave. Regulating the automobile. Brookings Institution, Washington, DC, 1986.

DeCicco, J.M., and M. Tatsutani. Comments on the SRI report prepared for MVMA. Statement provided to the NRC Fuel Economy Committee, American Council for an Energy-Efficient Economy and Natural Resources Defense Council, Washington, DC, August 22, 1991.

EEA. Documentation of the characteristics of technological improvements utilized in the TCSM, Report prepared for the U.S. Department of Energy, by Energy and Environmental Analysis, Inc., Arlington, VA, June 1985.

EEA. Domestic manufacturers' fuel economy capability to 2001: an update. Report prepared for the U.S. Department of Energy, by Energy and Environmental Analysis, Inc., Arlington, VA, October 1989.

EEA. An assessment of potential passenger car fuel economy objectives for 2010. Report prepared for the U.S. Environmental Protection Agency, by Energy and Environmental Analysis, Inc., Arlington, VA, July 1991.

Farmer, R.D. CAFE incentives for the sale of alternative-fuel vehicles. CBO Staff Memorandum, Congressional Budget Office, Washington, DC, November 1991.

Johnston, J.B. (Sen.) Additional views of Senator Johnston, Report to accompany S. 1220, National Energy Security Act of 1991, 102nd Congress. Pages 366-408, Report 102-72, Committee on Energy and Natural Resources, U.S. Senate, Washington, DC, June 5, 1991.

OTA (Office of Technology Assessment). Improving automobile fuel economy: new standards, new approaches. Report OTA-E-504, U.S. Congress, Washington, DC, October 1991.

NRC (National Research Council). Automotive Fuel Economy: How Far Should We Go? Report of the Committee on Fuel Economy of Automobiles and Light Trucks. National Academy Press, Washington, DC, April 1992.

Ross, M., M. Ledbetter, and F. An. Options for reducing oil use by light vehicles: an analysis of technologies and policy. American Council for an Energy-Efficient Economy, Washington, DC, December 1991.

SRI. Potential for improved fuel economy in passenger cars and light trucks. Report prepared for the Motor Vehicle Manufacturers Association (MVMA) by SRI International, Melno Park, CA, July 1991.