Technical Review of
State of California
Air Resources Board White Paper:
"Summary of Staff's Preliminary Assessment of the Need for Revisions to the Zero Emission Vehicle Regulation" and Attachments A to C

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Summary

The staff have correctly identified significant changes in policy objectives, technologies, and the marketplace that call for a reconsideration of the Zero Emission Vehicle (ZEV) program in order to, 1) make reductions of greenhouse gas emissions from light duty vehicles a central focus and, 2) simplify the regulatory framework. The staff correctly point out that PZEV and hybrid vehicle technologies are now commercial, although the commercial success of hybrids remains limited (2-3% of the market) and dependent to a degree on incentives and regulatory standards. The proposed "multi-pronged" approach is fundamentally sound, although it might be helpful to embed the various policies in an integrated, logical policy framework, some thoughts on which are offered below.

Attachment A, "Status of ZEV Technology Commercialization" is a sound and accurate appraisal of recent progress, current status and expectations for the development of hydrogen fuel cell and battery electric vehicle technologies. It would be useful to augment the documentation of recent progress, since it has been significant and suggests (but of course does not prove) that future goals may be met in the time frame envisioned by the ZEV program. A key conclusion of the MIT study that figures prominently in the staff's assessment of future potential concerning batteries does not appear to be fully integrated into the overall analysis. The projections of the MIT study do not indicate that batteries are ever likely to achieve the cost reductions and energy densities necessary to be competitive with internal combustion engine hybrid vehicles (HEVs or PHEVs) or with the projected future FCVs. This may imply that either further breakthroughs not anticipated in the DOE technology goals will be needed, or durable policies will need to be developed to support the commercial success of BEVs.

The business as usual and emissions reduction scenarios are useful for demonstrating the need for zero emission vehicles in order to meet the ambitious goal of an 80% reduction in GHG emissions by 2050. While these scenarios in no way demonstrate feasibility, they are useful for understanding the extent and timing of changes in vehicles, fuels and vehicle use that will be required if the 80% goal is to be met.

The discussion of Complementary Policies correctly recognizes that both vehicle and infrastructure must be addressed and that several policies will be needed. What it lacks is an overall policy framework that addresses how the full cost of a transition to ZEVs will be paid and how the evolution of the vehicle stock and energy infrastructure will be coordinated. This is not surprising, given that such a framework has yet to be developed, and that the analysis of such large scale energy transitions is still a new field.

Nonetheless, such a policy framework is probably needed in order for transition policies to be durable and sufficient to achieve a complete transition.

In summary, this reconsideration of ZEV regulations is appropriate and necessary. The staff have demonstrated a sound knowledge of the status of the key technologies and their prospects. They have presented a cogent analysis of what is likely to be required to meet a goal of an 80% reduction in GHG emissions my light-duty vehicles in California by 2050. They have proposed meaningful and realistic policy options for increasing the likelihood of success of a transition to ZEVs. However, there is still much to be done to create a durable and effective policy framework for dealing with the cost, timing, coordination, and risks of such a transition.

Two important energy issues are largely ignored in these reports: 1) energy security and oil dependence and, 2) sustainable energy for transportation. These should not be part of the central focus of this effort, of course, yet they represent important co-benefits of ZEVs that should always be mentioned.

Detailed Comments

White Paper:

While PZEVs and HEVs are now commercial technologies, HEVs still claim a small share of the market. This is because at current fuel prices and given the apparent undervaluing of lifetime fuel savings by consumers the incremental cost of a hybrid vehicle is greater than the perceived present value of fuel savings. Thus, hybrids (like PZEVs) rely on emissions or fuel economy regulations or incentives for commercial viability. The staff are still correct that these technologies no longer belong in the ZEV program.   The point is that even when ZEVs become "commercial" there will very likely still be a need for durable policies to insure continued market success.

The paper does not address but should address how highway user fees will be collected during and after a transition to ZEVs. There are two primary options: 1) convert the current motor fuel tax to a vehicle miles tax and, 2) convert the current motor fuels tax to an energy tax indexed to the average efficiency of vehicles on the road. The latter is to be preferred because it will have the same impact on vehicle travel and approximately twice the impact on reducing GHG emissions from light-duty vehicles before and during the transition, and because it will very likely be easier to collect and better received by the public.

The white paper notes that the penetration of ZEVs is likely to be slow and that this creates risk, and this is certainly true. Studies by the NAS and DOE have shown, however, that there are advantages to a faster transition. A faster transition reduces the number of years during which vehicle manufacturers and fuel providers must endure losses or, alternatively, must be subsidized. The problem, of course, is that technological success is not likely to be assured during the early stages of the transition. Thus, all investments will be risky. This calls for a strategy that is on the one hand sufficiently aggressive to make a transition happen but on the other hand sufficiently flexible to change course if circumstances require it. While this reviewer does not claim to know the solution, I will offer some more thoughts in the section on complementary policies, below.

The staff's cautious position on low-carbon biofuels is warranted. Biofuels policy needs a complete rethinking based on a comprehensive systems analysis: what to produce, where, how, how to convert, into what, and for what use? In the meantime it is clear that biofuels supply will be limited and that insuring near zero lifecycle emissions will be very difficult.

On page 14, the paper states that most manufacturers agree that DOE's targets are reasonable. While this is probably true of fuel cell stacks and balance of plant (BOP) it is not true of on-board hydrogen storage. In this regard, the most promising forms of storage are clearly compressed and liquefied hydrogen (or both). The question is whether commercial success is possible for FCVs even if the storage targets are not met. There are indications that this may be true based on the DOE and NAS' assessments of a transition to hydrogen, but more analysis is needed to be reasonably confident of this.

The assertion on p. 16 that the staff believes that all remaining technical issues will be resolved by 2015 seems overly optimistic. It is not clear that hydrogen storage issues will every be satisfactorily resolved (depending on one's definition of resolved), and the same can be said for battery cost and energy density. Indeed, it seems likely that the transition will have to start before it is clear that all technological and cost objectives can and will be met. This means risk will have to be considered, technological progress will need to be continuously monitored, and policies will need to be adaptable.

Attachment A, Status of ZEV Technology Commercialization:

This assessment is sound and well supported. The current status of technology is well described and the key barriers are correctly identified. The key message, that ZEV technology is not yet ready for commercialization and faces significant challenges but has made great progress and has the potential to be commercially viable (given reasonable policy support) is accurate and convincingly presented. More explicit documentation of recent (past 10-20 years) progress would be helpful, however, in making a more convincing case for the staff's expectations that most technological hurdles will be overcome by 2015.

The assessments by MIT and the IEA that are relied on heavily for expectations of future progress are sound and well done. It would also be appropriate to present more material from the NAS' study on the transition to hydrogen FCVs, PHEVs and BEVs. Even for conventional vehicles, the MIT studies point out clearly that supporting policies must be in place to insure that technologies are used to reduce GHG emissions rather than increase power, weight or accessories. The MIT study, however, is less optimistic about batteries and their future costs. Given the MIT projections, it is hard to see how BEVs will ever be commercially viable unless there is a breakthrough that the MIT researchers did not anticipate. This has implications for the ZEV program that should be examined because it has implications for the role of infrastructure provision and other supporting policies.

Conclusion 3.6 gives inadequate emphasis to hydrogen storage. DOE technology goals are not at all likely to be met. It seems to this reviewer most likely that even by 2025 the best options will still be compressed hydrogen or liquid hydrogen. The DOE program gives inadequate attention to the cost and performance of these options but that is another subject. The technology assessment should provide more information on the status and especially the prospects for these storage technologies.

This reviewer does not believe it is correct to use current lifecycle GHG emissions when considering the GHG implications of ZEVs. Current lifecycle emissions estimates are very nearly irrelevant for the following reason. If society is seriously addressing GHG emissions, upstream emissions from powerplants and large-scale energy conversion (such as from fossil fuel to hydrogen) will be regulated. All analyses I am aware of indicate that deep reductions in emissions from such processes can be achieved more cost-effectively than emissions reductions from any other major source. Given the magnitude of these sources, if their emissions are not drastically reduced, then society is not dealing seriously with greenhouse gas mitigation and there is no reason to expect society to want to reduce GHG emissions from vehicles either. Thus, lifecycle emissions from ZEVs should be evaluated in the context of future scenarios of emissions from electricity generation and other large-scale energy conversion processes in which GHGs are seriously curtailed. This should be the default assumption. Assuming that society will pursue ZEVs for GHG reduction but ignore powerplants and large-scale fossil fuel conversion is not logical.

Uncertainty about the recharging patterns of PHEVs is emphasized on p. 27. There may be uncertainty at this point but early research at UC Davis suggests that strong and predictable patterns are likely to emerge. With additional research and demonstration, these patterns should be identifiable, as should the ability to modify them with price or other incentives. For example, nearly all participants in the UC Davis PHEV demonstration analysis plug in their PHEVs as soon as they return home. This indicates a strong, and economically logical preference for convenience and to use as much relatively inexpensive electricity as possible. The impact on time-of-day electricity use is very likely easily controllable by use of timers. Those with access to (free) electricity at their place of work also tend to take maximum advantage of it. With additional demonstrations and careful research, it seems likely that highly predictable patterns will be identified.

Attachment B: 2050 Greenhouse Gas Emissions Analysis:

The “what if?” modeling approach taken in this analysis is appropriate, given that the question is not what will it cost or how will the market respond to ZEVs but rather what role could they play in reducing GHG emissions? By and large, the analysis is well done and demonstrates the need to have ZEVs if the 80% goal is to be met by light-duty vehicles. The report could make it clearer why this is a reasonable premise. For example, if transportation’s emissions (not just LDVs) were reduced by only 50%, then transportation would be emitting 14% out of the total 20% permitted, meaning that other sectors would have to reduce their emissions by over 90% to make up the difference. Then follow with a consideration of the potential to reduce emissions from the other, non-LDV transportation modes, implying that LDVs will likely have to do more than the other transport modes. This may seem like overkill, but I think economists will push back strongly on the "fair share" approach and a better response is called for.

Since economic issues are held in abeyance, it is critical that the modeling consider feasibility, especially with respect to the time constants of the transition. While the time constants are considered, it would be desirable to lay them out in detail for each scenario. That is, how soon are the technological targets met in principle ("in the lab"), how long does it take to incorporate them into mass production vehicles, how long does it take to redesign all mass production vehicles to offer this technology as an option, how long before all mass production vehicles use ZEV technology, how long to turn over the stock to achieve the desired goal.

This reviewer is a little disappointed that DOE's hydrogen transition analysis report (of which he is a co-author) is not cited in this report, especially since it generally supports the staff's conclusions (and may even have a few useful insights).

The report's assumptions about VMT reductions are quite optimistic given the historical record of the US in this area. I realize that California has ambitious plans in this area but, in my judgment, they are considerably more uncertain, less likely even, than successful achievement of the technology goals. Best of luck, however!

The analysts are right to be cautious about the availability of biofuels given continued difficulty in getting cellulosic biofuels going, important but unresolved concerns about indirect land use impacts of even cellulosic energy crops, and the competing demands for biomass for other uses. The analysis described on p. 25 indicates that the trade-off between low-C biofuels and the number of ZEVs required is very steep. Thus, ZEVs are a hedge against lack of biofuel availability and vice versa.

The sidebar on p.19 fails to mention cost as a "con" of PHEVs. It is a major problem that will not be easy to overcome.

The discussion of risks on pp. 26-27 is very important and needs elaboration (more on this below). On the one hand, the ZEV transition must proceed aggressively to meet GHG goals. On the other, California's GHG strategy must be able to adapt depending on the progress of technology and market acceptance. It would be highly desirable to have an overall strategy for managing this dilemma.

Attachment C: Complementary Policies

This is a well-reasoned assessment of the roles different policies (mostly already existing) can play in successfully fostering the early market development of ZEVs. What is lacking is an overall framework for these policies, a framework that justifies the nature, timing and intensity of policy interventions. That is not a surprise, since no such framework has been proposed and this reviewer does not claim to have the answer, only a few ideas. Certainly, externalities play a role but are only part of the story. Co-benefits are relevant, such as energy security and sustainable energy. Other market failures come into play as well, but there is more to the transition than all of these, as studies by the NAS and DOE of potential hydrogen transitions has demonstrated.

What is different about large scale energy transitions in general and the ZEV transition in particular is the existence of significant economic and social hurdles to a truly novel, large scale energy technology, combined with the uncertainty of technological achievement. The DOE study contains the beginning of an approach for dealing with the economic hurdles: it measures them. It measures the cost of overcoming the cost of lack of fuel availability, the cost of lack of diversity of choice (how many hybrids could be sold if the Prius were the only model available?), risk aversion (few want to buy the first realization of a technology and most would rather wait until it is proven), the cost of marching down the learning curve, and the cost of achieving economies of scale. If there is a clearly "better mousetrap" and the benefits are all or substantially all private benefits, governments need not worry about such issues (e.g., beta v. VCR, PC v. Mac, etc.). But when the benefits are public goods and the mousetrap someday will be arguably just as good in terms of private benefits as the technology it is intended to replace, then government policy is needed.

My suggestion is this: all the natural transition costs mentioned above can be viewed as *positive* externalities, i.e. as external benefits. Some, such as fuel availability, are clearly network external benefits, a category well-recognized in the economics literature. Others may be less clearly network external benefits but are clearly some form of external benefits. For example, consider learning by doing. The first purchasers induce learning which lowers the cost for all subsequent purchasers, thereby generating an external benefit for them. The same would apply to risk aversion. Early adopters reduce the risk of the early and late majorities. And so on. Since these external benefits can be at least approximately measured, they can provide guidelines for justifying the timing and magnitude of subsidies.

Of course, one must prove that the transition is worth the total cost. Again, that can be done, at least approximately. Once it is established that the transition is worth the cost of the subsidies (subsidies can be by the private sector as well as by government, and can be indirect via regulation, or cross-subsidies as feebates) the above logic follows.

The problem is uncertainty. What if the technology or technologies are not sure to succeed? Does that change the amount one should be willing to spend? How does one decide when to "give up" on a technology (and, for example, stop subsidizing hydrogen infrastructure)? I don't have an answer to these questions yet, but I am confident that efficient strategies exist.

On more detailed points, the concept of a trigger approach for the CFO mandate fails to recognize the need, stated on p. 26 of Attachment A, for the vehicle stock and fueling infrastructure to expand in parallel. This is an important point since lack of fuel availability is a major concern for vehicle owners and could be a source of considerable dissatisfaction during the early stages of a transition. Severe dissatisfaction could destroy public support and derail the transition. The idea of lowering the vehicle stock thresholds is obviously intended as a way to get at this problem. But what is needed is a plan for expansion in parallel. Indeed, infrastructure will clearly have to be deployed well in advance of levels that would make it cost-effective. The principle should be to determine how much infrastructure is needed, and when, for an efficient transition. Moving the compliance burden upstream to firms with greater resources is a very good idea. Not only do these firms have the resources but they stand to benefit more than the small business station operator from the transition to a sustainable energy source for transportation. Use of the LCFS as a way to induce stations to be built is also likely to be successful for much the same reasons.