State of California
Environmental Protection Agency
AIR RESOURCES BOARD

Supplement to the Final Statement of Reasons for Rulemaking,
Including Summary of Comments and Agency Responses

THE 2003 AMENDMENTS TO THE CALIFORNIA ZERO EMISSION VEHICLE PROGRAM REGULATIONS

Public Hearing Dates: March 27-28 & April 24, 2003
Agenda Item No.: 03-02-4

Supplement dated February 20, 2004

One of the persons who submitted written and oral comments at the March 27-28, 2003 hearing of the Air Resources Board (ARB or Board) was Alec N. Brooks. Mr. Brooks has worked in the area of zero emission vehicles (ZEVs) for 16 years and has followed the ZEV mandate since it was originally adopted in a 1990-1991 rulemaking. At the hearing, Mr. Brooks submitted a document entitled “Comments relating to ZEV mandate for CARB Board meeting March 27, 2003.” Attached to this March 27, 2003 document was another document titled “Perspectives on Fuel Cell and Battery Electric Vehicles, [by] Alec N. Brooks, Presented at the CARB ZEV Workshop December 5, 2002.” After the Final Statement of Reasons (FSOR) was issued on January 9, 2004 and posted on the ARB’s website, Mr. Brooks expressed his concern to the ARB that the FSOR did not address the issues raised in his December 2002 workshop comments. The FSOR did summarize and respond to issues raised by Mr. Brooks’s 3-page March 27, 2003 “Comments” document.

The ARB concluded that although Mr. Brooks’s December 2002 workshop comments were originally presented before the “45-day” hearing notice was published January 10, 2003, those comments should have been addressed in the FSOR because Mr. Brooks resubmitted them as part of his March 27, 2003 presentation. Accordingly, this Supplement to the FSOR summarizes and responds to the December 2002 workshop comments of Mr. Brooks.

Preliminarily, it is important to note that the recommendations submitted by Mr. Brooks and other battery electric vehicle (EV) advocates prompted the Board to include significant modifications designed to promote the continued development of battery EVs. These modifications include allowing battery EVs to meet half of the alternative compliance path (see Section II.B.1.(c)(iii) of the FSOR, p. 21) and providing additional credits to existing battery EVs to promote their continued use (see Section II.B.10 of the FSOR, p.34.) In addition, the regulation provides equal credit for all pure ZEV technologies beginning in model year 2012.

As with all advanced technologies, there is a tremendous uncertainty in the pace of development and technological breakthroughs. The far-reaching nature of the ZEV program has both pushed technology and created the need for mid-course changes. The Board's focus on fuel cell vehicles represents the long-term commitment to commercially viable pure ZEVs. The Board will rely on an Independent Expert Review Panel to assess the progress made in pursuing this goal, and will have the opportunity to make further adjustments as necessary.

S-1. Comment: It appears that CARB has effectively given up on battery EVs, and is placing a high risk bet that fuel cell vehicles will in fact become practical in the future. While this may happen, it is not at all certain. First – what about driving range and efficiency of fuel cell vehicles – where is the data? There was recently a rally for fuel cell vehicles driving down Highway 1 between Monterey and Santa Barbara, a distance of 250 miles. There were four refueling stops set up along the way. The California Fuel Cell Partnership 2001 highlights showed 754 hydrogen refueling events for the 34,000 miles covered by the fuel cell vehicle fleet, or about 45 miles on average between refuelings. Actual range and hydrogen consumption data are very closely held, but there are some indications that might indicate that there are problems with range and efficiency. (Alec Brooks)

Agency Response: As noted in the comment, the range of current prototype fuel cell vehicles is closely guarded and would appear to be below that needed for commercialization. ARB acknowledges that storing adequate amounts for hydrogen as compressed gas is technically very difficult because of the large volume required. Research and development efforts are ongoing to resolve this issue with promising work in a variety of storage technologies including metal hydride, nanotube, and liquid storage. Additionally, relatively short range is mitigated by fast fueling, making hydrogen fuel cell vehicles more attractive. The Independent Expert Review Panel will evaluate this issue as part of its review and suggest changes if necessary.

S-2. Comment: The range problem might be overcome by a future hydrogen storage breakthrough that would allow enough hydrogen on board to match the range of what drivers are used to. But what about fuel economy? How much hydrogen do fuel cell vehicles consume per mile traveled? This is a more important metric than how efficient a fuel cell stack is at a particular operating point. Mr. Norihiko Nakamura, Toyota Executive Advisory Engineer for fuel cell development, said at the 2002 Future Car Congress that the best fuel economy that fuel cell vehicles can achieve is about 62 miles per kilogram of hydrogen (or about 62 miles per gallon equivalent). But today's hybrid vehicles, the Honda Civic and Toyota Prius, essentially match these numbers with 57 and 58 miles per gallon uncorrected combined EPA ratings. A benefit of the CNG hybrid version is that the driving range would be a whole lot better. Even though it uses on-board fuel energy at a 42 mile per gallon equivalent rate vs. 64 for the fuel cell vehicle, the same tanks would hold about 3.2 times more energy in natural gas as compared to hydrogen. This would yield a driving range that would be 2.1 times greater, or about 400 miles. (Alec Brooks)

Agency Response: Fuel cell vehicles offer zero-direct emissions as well as higher vehicle efficiency as noted in the comment. Unlike the hybrid vehicles mentioned, fuel cell vehicle emissions will not deteriorate over time. While the requirements for partial ZEV allowance vehicles (PZEVs) ensure that the vehicles have an emissions warranty for 15 years or 150,000 miles, the vehicle is ultimately susceptible to becoming a gross polluter if not maintained after this period.

S-3. Comment: The popular long-term vision for fuel cell vehicles is that the hydrogen would be made by electrolysis with renewable electricity. The flaw in this argument is that it is not fair to claim the cleanest form of electricity generation to a particular type of load, leaving the dirtier electricity generation to everyone else. Calculations of the upstream emissions associated with recharging battery electric vehicles are usually based on the average power mix; not by singling out the cleanest electricity just for battery EVs. All forms of generation involve some form of impact; there is always something about any form of generation that someone won't like. (Alec Brooks)

Agency Response: ARB has always based its estimates of upstream emissions from battery EVs on marginal emissions in the South Coast Air Basin. Under the assumptions used most recently by the California Energy Commission, electricity produced for battery EVs would come from extremely clean natural gas turbines. ARB would use the same process for determining the upstream emissions from fuel cell vehicles. And, like electricity, the ability to obtain hydrogen from clean renewable sources makes it especially attractive as a transportation fuel.

S-4. Comment: Making hydrogen with electricity is very inefficient. Compared with battery electric vehicles, electricity consumption will be from 3 to 6 times higher per mile. (Alec Brooks)

Agency Response: The Board agrees that the cost-effective and clean production of hydrogen and the efficient use of that hydrogen in the fuel cell vehicle are critical to improving any adverse impacts from fuel cell vehicles. Research is ongoing worldwide to develop efficient and clean techniques for hydrogen production.

S-5. Comment: Making hydrogen for a fuel cell vehicle from natural gas also makes no sense due to the losses in the conversion process. It is better to make a natural gas powered hybrid vehicle and use the natural gas directly. When hydrogen is produced from natural gas, fuel cell vehicles can, at best, only match the fuel economy of a comparable natural gas hybrid vehicle, and will have less than half the driving range for given tank volume and pressure. (Alec Brooks)

Agency Response: The primary focus of the ZEV program is the commercialization of a pure ZEV for use in urban centers not meeting air quality standards. The ZEV program acknowledges the environmental benefits of other technologies such as natural gas vehicles and has provided incentives to encourage their development as part of the ZEV program. As discussed in the response to Comment 2, the ZEV regulation is focused on air quality. Fuel cell vehicles provide zero tailpipe emissions where compressed natural gas hybrids do not.

S-6. Comment: And finally, there is the cost issue. If there are concerns that battery electric vehicles are too expensive to manufacture, there should be even greater concerns about fuel cell vehicles. (Alec Brooks)

Agency Response: ARB agrees that significant cost reductions are needed before fuel cell vehicles are able to compete in the marketplace. Automakers worldwide are now developing components and subsystems that have the potential for being mass-produced at low cost. The staged approach of the alternative compliance path is designed to address the relative cost of each stage of development. Time is needed to determine if the cost targets for commercialization can be met. Finally, the Independent Expert Review Panel will closely evaluate this issue as part of the Panel's review.

S-7. Comment: There has been some disappointment expressed by members of the Board that battery technology for electric vehicles hasn't progressed nearly as much as had been hoped. The reality is that battery technology has progressed significantly in the last decade. But vehicle manufacturers haven't been applying that technology in new products. (Alec Brooks)

Agency Response: The near-term focus of the ZEV program has been on battery EVs. While technically mature and well suited from a performance standpoint for many applications, battery EVs face severe cost challenges. As noted in the FSOR, ARB contracted with Dr. Anderman Menahem to determine if recent improvements in battery technology were significant enough to change this fundamentally issue. While ARB does not dispute that improvements have occurred during the last decade, the Board has found that the technology is still not ready for widespread commercialization. See the response to Comment 1 and Section II.B.1 of the FSOR.

S-8. Comment: It is interesting to look at what kinds of battery vehicles we could have had by now and to compare them with fuel cell vehicles. Three specific battery types that compare favorably to fuel cell vehicles include lead acid, sodium nickel chloride and lithium ion. (Alec Brooks)

Agency Response: ARB contracted with Dr. Anderman to review the status of those battery technologies currently used in battery EVs and which are at a stage of development where it would be possible to produce them in larger quantities if cost targets are met. While Dr. Anderman has more recently focused on issues related to battery chemistries used in hybrid EVs, he has extensive experience as a consultant in development assessment and application of battery technologies. This experience included participation on the Battery Technical Advisory Panel of 2000.

Throughout the ZEV program's history, ARB staff has met with battery developers to review advances in technology. During this latest regulatory process, no battery developers approached ARB with new information that would fundamentally alter the cost and performance situation.

Regarding the three technologies identified in the comment, Dr. Anderman did assess developments in advanced lead acid as part of his review. He concluded that although battery life has been slightly improved, there have been no significant changes in specific energy, cost, or life. Dr. Anderman also reviewed the latest development in lithium ion and concluded that current batteries do not have adequate durability, and their safety under severe abuse is not yet proven. Moreover, he concluded that, even in true mass production, the cost of the technology is unlikely to drop below cost of nickel metal hydride without advances in material and manufacturing technology. As for sodium nickel chloride, Dr. Anderman did not specifically address this technology. However, the use of sodium nickel chloride in battery EVs has not been seriously considered by automakers due to additional costs and concerns associated with the high temperature operation of the battery.

S-9. Comment: Battery electric vehicles based on the same platform as fuel cell vehicles can have greater range than the fuel cell version if latest battery technology is employed. We've looked at putting a pack of lithium ion cells into the Prius EV described above. The energy on board would be about 34 kilowatt-hours and the vehicle weight would be about the same as the stock Prius. Range would be between 160 and 200 miles. If the Prius EV were loaded down with more lithium batteries to equal the weight of the Focus fuel cell vehicle, it would have 400 miles range. How about a battery electric Toyota Highlander? Even with many special lightweight body components, the fuel cell vehicle weighs in at 4100 pounds, 616 pounds more than a 4 cylinder Highlander. An all-electric 4100 pound Highlander employing lithium ion batteries would have a range of more than 300 miles. (Alec Brooks)

Agency Response: We agree that current battery EVs can have greater range than the prototype fuel cell vehicles being demonstrated. We expect that fuel cell range will improve substantially as progress is made in system efficiency and hydrogen storage. These improvements, coupled with the relatively quick refueling capability of the technology, are expected to make fuel cell vehicles attractive to consumers.

S-10. Comment: To demonstrate the type of EV that could be made with the ZEBRA battery, we have developed a concept based on the Prius. The manufactured cost would be very close to that of the standard hybrid Prius, possibly lower. The vehicle weight would be about the same as the standard Prius too. Toyota could produce a battery EV Prius at the same cost as the hybrid Prius. (Alec Brooks)

Agency Response: According to Toyota, the latest generation of the Toyota Prius is being sold at a retail price premium of $1,500 – if one compares it to what a similar-sized, similarly equipped Toyota would sell for. If it were redesigned as a City EV and carried a 15-kilowatt hour of batteries at an eventual large volume price of $300/kilowatt hour, that would amount to $4,500 additional manufacturing cost (not retail). This difference is more than what would be saved by deleting the Prius engine and fuel system.

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Expansion of the response to Comment 278 in the Final Statement of Reasons

278. Comment: Volkswagen (VW) continues to believe it is being treated unfairly during the 2005-2008 period of the rule. VW is in the unique position of being the first manufacturer to transition from an intermediate manufacturer to a large manufacturer in the history of the ZEV mandate. VW's first model year to be legally required to provide ZEVs and AT PZEVs is in 2008, the last year of the first period of the rule. The rule requires that a manufacturer entering the alternative fuel cell pathway during any time of one the specified periods must provide the entire number of fuel cell vehicles required for that period. As written, this alternative pulls ahead VW's pure ZEV obligation by three model years. We believe the language is intended to prevent existing manufacturers from jumping in an out of the alternative pathway in an effort to reduce the number of vehicles they must build, not to penalize a manufacturer entering the rule for the first time. We ask that that our 2005-2008 volume for the alternative fuel cell pathway be pro-rated. (VW)

Agency Response: Under the final amendments, a manufacturer entering the alternative path at any point during an aggregated time period must provide the number of fuel cell vehicles required for the entire period. The commenter argues that this provision "pulls ahead VW's pure ZEV obligation by three model years". This is not the case. The provision in question only applies to the alternative path. A manufacturer on the base path is able to satisfy its ZEV obligation on a year-by-year basis.

With regard to the alternative path, requiring a manufacturer on that path to provide the entire number of fuel cell vehicles required during a time period is wholly consistent with the intent of the alternative path provision. The alternative path was established to allow a viable compliance option for manufacturers that are making an aggressive effort to commercialize fuel cells. Making an aggressive effort involves having a realistic ramp up in production levels, as opposed to minimal production in one phase followed by much larger production levels in the following phase. Under VW's proposed approach, the firm would have to meet its market share of only 83 Type III ZEVs during model years 2006-2008, but then ramp up to its market share of 2500 Type III ZEVs in model years 2009-2011.

It is also noteworthy that the ZEV regulation provides substantial lead time (at least six years) for a manufacturer that transitions from one size category to the next. Under section 1962(b)(7), VW would be subject to the large-volume manufacturer ZEV requirements starting in the 2008 model year if its average California production volume exceeds 60,000 units of new passenger cars, light-duty trucks, and medium-duty vehicles in model years 2000-2002. Thus manufacturers do have substantial notice of their compliance obligations and are able to plan their production accordingly.

Finally, on a global basis VW's sales are approximately the same as Nissan/Renault and DaimlerChrysler, and significantly larger than Honda. Thus although VW is currently classified as an intermediate manufacturer for ZEV program purposes based on California sales, it does have resources comparable to manufacturers that are currently classified as large. As a result, we do not consider VW to be unfairly burdened by its treatment under the amended ZEV regulation.