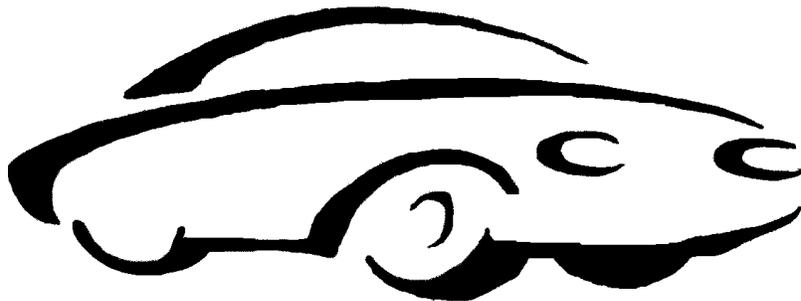


State of California  
California Environmental Protection Agency

AIR RESOURCES BOARD

**Executive Summary  
to the  
STAFF REPORT**

**2000 ZERO EMISSION VEHICLE PROGRAM  
BIENNIAL REVIEW**



**August 7, 2000**

## EXECUTIVE SUMMARY

In 1990, California embarked on an ambitious strategy to reduce vehicle emissions to zero. This objective was to be achieved through the gradual introduction of electric vehicles into the California fleet. Specifically, the Air Resources Board mandated that at least 2 percent, 5 percent and 10 percent of new car sales be zero-emitting by 1998, 2001 and 2003, respectively.

The Zero Emission Vehicle (ZEV) mandate for passenger cars has been adjusted twice since then, in 1996 and 1998. The underlying goal, however, has not changed. California remains committed to achieving zero emissions performance wherever feasible in the vehicle fleet. The challenge is determining *how* to achieve sustainable success in the field.

As evidence of the State's commitment, California has partially subsidized the introduction of battery electric vehicles through grants and fleet purchases. That support is expected to continue.

The rationale for California's commitment is simple. Zero-emission technology is necessary to achieve the State's public health protection goals. Health-based state and federal air quality standards continue to be exceeded in regions throughout California, and more areas of the State are likely to be designated as nonattainment with promulgation of the new federal eight-hour ozone standard. California's burgeoning population and robust economy mean continued upward pressure on statewide emissions. Manufacturing, power generation, petroleum refining, goods transport, home heating and cooling, personal mobility and a wide range of human activities all have direct air pollution consequences. Accomplishing zero emissions in any of these source categories (or portion thereof) mitigates their adverse impacts and protects human health.

Zero-emission technologies also transcend some of the persistent problems with conventional air pollution sources. Combustion-based engines are inherently higher emitting and prone to deterioration over time. Catastrophic failures are also a concern. Older gasoline-powered vehicles, for example, become gross emitters if their emission control systems fail. Combustible fuels also have significant "upstream" impacts. Refining, fuel storage and delivery all have associated emissions from both routine operations, accidents (breakdowns, fuel spills), and ongoing compliance problems (e.g., leaking underground tanks). Apart from upset conditions that may occur during electric power generation, zero emission vehicles have none of these vulnerabilities. A battery powered electric car will remain emission-free throughout its useful life.

## **Current ZEV Mandate**

ARB regulations require that 10 percent of the new light-duty vehicles offered for sale in California for model year 2003 be zero emitting. This requirement applies to intermediate and large volume vehicle manufacturers only.

Manufacturers have significant flexibility in meeting the ZEV requirements. Auto companies can earn extra ZEV credits by introducing vehicles before 2003, thereby reducing their total obligation. Extra credit is also available for battery electric vehicles with more than a 100 mile range per charge. Manufacturers may also delay compliance by one year provided they produce two years' worth of ZEVs by the end of 2004. Finally, large manufacturers can satisfy up to 6 percent of the 10 percent ZEV requirement with near-zero emitting technologies, and intermediate manufacturers may meet the entire 10 percent obligation via that route (producing no electric vehicles at all).

Eleven auto manufacturers are expected to qualify as "*intermediate*" in 2003: BMW, Hyundai, Isuzu, Jaguar, Kia, Mazda, Mitsubishi, Rover, Subaru (Fuji), Volkswagen and Volvo. Six auto companies are expected to qualify as "*large*" in 2003: DaimlerChrysler, Ford, GM, Honda, Nissan and Toyota.

If no change is made to today's ZEV regulation, staff estimates that approximately 22,000 electric vehicles would need to be offered for sale in 2003 to meet a four percent ZEV requirement. However, this total could change significantly, up or down, based on each manufacturer's actual production decisions and their chosen compliance path. As noted above, early ZEV introduction or the use of additional vehicles with extended range would decrease the 2003 obligation. Reduced reliance on PZEVs, on the other hand, would increase the number of ZEVs needed.

The ZEV mandate continues in 2004 and each year thereafter. Again, if the rule is unchanged, staff estimates ZEV availability will grow gradually over time, reaching 31,000 to 78,000 units (4 percent to 10 percent) by 2006.

## **The September 2000 Biennial Review**

When the ZEV mandate was adopted in 1990, electric vehicles were in a very early stage of development. To ensure successful implementation, the Board directed staff to report biennially on the status of technological progress. The September 2000 biennial review is the fifth in-depth examination of the technical and economic issues related to ZEVs. Since auto makers generally need three years' lead time for production, this biennial review is also the last significant opportunity to assess their readiness for meeting the 2003 requirements.

This report describes the current status of ZEV technology and the prospects for near- and long-term improvement. The analysis is based upon experience gained through the 1996 Memorandum of Agreement (see below), staff meetings with each of the affected

manufacturers, contract work performed by outside experts, and extensive comments received at two public workshops conducted earlier this year.

### **1996 Memorandum of Agreement**

The original ZEV mandate called for 2 percent penetration in 1998 (approximately 20,000 vehicles). However, in 1996, the ARB determined that a smaller introduction was warranted given the status of electric vehicle technology at the time. Accordingly, the ARB's Executive Officer entered into Memoranda of Agreement (MOAs) with large volume manufacturers to produce a limited number of ZEVs, specifically 3,750 vehicles between calendar years 1998, 1999 and 2000. Multiple credits for advanced batteries reduced the total legal commitment to just over 1,800 electric vehicles.

Today there are approximately 2,300 electric vehicles on the road in California. The products are highly attractive, high performing and range in style from vans, pick-up trucks, sport utility vehicles and station wagons to two-seater sports cars. All of these electric vehicles were introduced within the last four years. The only significant gap is the absence of a 4-door, 5-passenger ZEV sedan, which no manufacturer is currently producing.

Although the market is just forming, customer interest is encouraging and suggests that additional demand exists for ZEV products. Unfortunately, the full extent of this demand cannot be quantified because very few electric vehicles are available. Those manufacturers who have met their quotas have largely ceased production. Companies still making ZEVs have encountered production delays and are mostly marketing to fleets. This virtual "black out" condition was not anticipated when the MOAs were signed in 1996. It also complicates staff's analysis of market readiness for 22,000 ZEVs in 2003. When even the most motivated customers cannot obtain electric vehicles, the ability to gauge broader consumer interest and acceptance are severely diminished.

The primary reason for the "black out" is cost. Manufacturers are not yet able to produce a competitively priced electric vehicle without incurring significant losses on each unit leased or sold. The secondary reason is uncertainty. Car companies are unwilling to invest in volume production until they see the business case for each ZEV model, a certain market, and a definitive regulatory signal from the State.

### **Implementation of Year 2003 Requirements**

#### **1. Vehicle Technology Assessment**

There is no technological barrier to building battery powered ZEVs; the issue is cost and consumer acceptance. With regard to near-zero emission vehicles, technology exists which allows vehicles to achieve the required level of performance. Several manufacturers have stated, however, that due to lead time considerations they will not be able to build enough PZEVs to take full advantage of the partial ZEV option in 2003. If they cannot overcome those challenges, more battery electric vehicles will be needed

to meet the 10 percent ZEV mandate. Hybrid vehicles are an environmentally attractive product and could achieve near-zero (PZEV) emissions performance in the near future. Finally, hydrogen powered fuel cell vehicles have potential to become an additional pure ZEV technology, but will not be commercially available by 2003. These conclusions are explained in more detail below.

Battery electric vehicles are clearly technologically feasible. Seven models are on the road including GM's EV1 2-seat sports car; the Chevrolet S-10 and Ford Ranger pick-up trucks; Honda's EV PLUS (a 4-seat, 2-door platform comparable to Honda's CRV), the Toyota RAV4 sport utility vehicle; Nissan's Altra EV station wagon; and the DaimlerChrysler EPIC minivan. In addition, several classes of smaller battery electric vehicles are emerging. These include low-speed vehicles (LSVs, also referred to as "neighborhood electric vehicles" or NEVs) and low-range vehicles designed for in-city driving (City EVs). Examples of the latter include the Ford TH!NK, the Toyota E-COM, and Nissan's Hyper-Mini. All of these vehicles qualify as ZEVs under the current ARB regulation.

Regarding PZEVs, the leading candidates are extremely clean gasoline-powered cars, with or without hybrid electric drive-train technology. To qualify for PZEV credit, a vehicle must be certified to the super ultra low emission level (SULEV) exhaust standards, have zero evaporative emissions, and come with a 150,000 mile warranty. To date, only the Nissan Sentra has achieved PZEV status. Three other vehicles (Honda Accord, Honda Civic GX, and Toyota Prius) have attained the SULEV criteria, but have not met the remaining requirements. Both large and intermediate volume manufacturers are concerned about their ability to overcome all the engineering challenges implicit in the PZEV criteria by 2003. If they cannot reach that objective, up to the full 10 percent of battery electric cars may be required. Staff concurs that the PZEV criteria are extremely challenging and that some manufacturers will be unable to take full advantage of the PZEV option in 2003.

Hybrid electric vehicles are the newest entrants to the advanced vehicle field. These vehicles combine batteries, a supplemental electric drive train, and a downsized conventional fuel tank to increase overall efficiency. Hybrid vehicles consume less fuel per mile of operation, thereby reducing upstream environmental impacts and releases of climate changing gases. Hybrid vehicles may also be low, ultra low or super ultra low emitting if they are designed to meet those respective exhaust standards. Two hybrid vehicles are currently available: the Honda Insight and the Toyota Prius. Although neither qualifies for PZEV credit at this time, there is no inherent technological reason why hybrids cannot achieve PZEV performance. The main obstacle is the time needed to design, test and perfect the necessary emission controls.

Fuel cell vehicle (FCV) technology has the potential to be zero emitting when powered by pure hydrogen from a relatively clean source. The California Fuel Cell Partnership is examining the potential for commercializing such technology, along with other FCV fuel types. A few prototype vehicles are available for testing and demonstration.

## 2. Battery Technology Assessment

Batteries are the single most expensive component of electric vehicles. For that reason, affordable battery packs--both today and when produced in volume--are crucial to achieving a sustainable electric vehicle market. ARB's existing regulations also place a premium on advanced (long-range) battery technology. This preference was based on early survey results and upon staff's judgment that electric vehicles with greater than 100 mile range will sell better, to more people and for more uses, than shorter range vehicles.

ARB contracted with a team of outside experts to obtain the best available information on battery advances, costs and future trends. The Battery Panel concluded that nickel metal hydride (NiMH) batteries were the most promising advanced technology, having both high performance and the longest useful life. Unfortunately, the Panel also concluded that battery costs are high and will not meet cost-competitive targets for some time. Although volume production will help, a breakthrough is needed to achieve truly affordable NiMH packs.

Several commenters have suggested that ARB revisit its preference for advanced battery technology. Lead acid (PbA) batteries, they suggest, could meet market needs at a far lower cost. Their justification is two-fold. First, several EV drivers testified at staff workshops that their actual driving needs were lower than they anticipated before they leased a ZEV and that they would not pay a premium for greater range. In addition, some auto manufacturers are closely examining the business case for lead-acid based City Cars that would be overtly marketed as limited range, niche vehicles. The opposing view is that advanced batteries meet a broader range of driving needs, produce less waste (since they last longer), and may ultimately serve a larger consumer market.

## 3. Infrastructure Assessment

Unlike conventional vehicles, battery powered ZEVs do not require an extensive "fueling" infrastructure since most customers will recharge at work or at home. The availability of public charging stations is nonetheless extremely important because of its influence on consumer confidence and acceptance. Public chargers also enable ZEV owners to drive longer distances, and to reach more destinations than they otherwise might.

The public infrastructure for electric vehicles continues to expand in California. Currently, there are about 400 public charging stations statewide with approximately 700 separate chargers. Most of these were constructed with a combination of government and electric utility funds. Recently, a few private companies have begun to offer electric charging services to their customers. The most notable example is Costco, which has a corporate-wide "all electric" philosophy. Staff expects these services to expand as additional local governments and private companies embrace electric vehicle technologies.

The most difficult issue affecting public charging infrastructure is the absence of uniform charging standards or equipment. A little more than half of the chargers are inductive; the rest are conductive. Current vehicles use a 220 volt system. When City Cars come to market, they will introduce the need for a new minimum voltage of 110. There is no easy way around this dilemma. Because the chargers are integrally linked to vehicle design and have competitive characteristics, manufacturers are unwilling and may actually be unable to move toward full standardization.

Fast charging has been successfully demonstrated in the DaimlerChrysler EPIC minivan and holds great promise for the future. However, there is a significant economic barrier: fast charging is more expensive per station and would require extensive financial support to implement. Fast chargers also require special battery packs that can receive rapid charging without producing excessive heat.

#### 4. Market Assessment

There is significant disagreement over the extent of market demand for electric vehicles. Manufacturers assert that the lack of leases during the first years when vehicles were available means that the market can only absorb a few hundred ZEVs per year. Electric vehicle advocates and fleet operators point to current waiting lists as evidence of strong customer interest and pent-up demand. Staff views this as the most difficult area in which to develop reliable estimates. The entire market is new and product availability has been constrained such that true consumer interest is exceedingly difficult to gauge.

The recent emergence of fundamentally new ZEVs—namely city cars and neighborhood EVs—further complicates staff's assessment. Although the business case for inexpensive, in-town EVs appears to be promising, there is as yet no market experience for selling these products in the U.S. Manufacturers will have to start from scratch in building consumer awareness and interest.

Left unchanged, the current ZEV requirement will result in approximately 22,000 electric vehicles by 2003. That represents almost a ten-fold increase over the number of ZEVs on the road in California today. The quantity of ZEVs will grow in 2004, 2005 and 2006 as ZEV production ramps up per the current ARB regulation. Whether all of these vehicles can be successfully marketed and placed is a key issue facing the Board.

Studies and surveys indicate that the primary factors affecting EV market demand are range, recharge time and competitive pricing. Based on experience to date and public testimony, staff has identified several other factors that are critical to ongoing success. The single greatest need is for near term ZEV availability, followed by a smooth, orderly buildup from the current base. Other important factors include public infrastructure, additional vehicle platforms, public education (including real time information on available products, subsidies, station locations, and how to go about obtaining a ZEV), and making all ZEV products available to retail customers.

## **Cost Estimates**

Today's ZEVs are more costly for manufacturers to make than any other vehicle technology being produced for sale between now and 2003. As noted above, most of that cost differential stems from the battery pack. The cost gap will narrow as technology improves and manufacturers move to volume production. However, there is no getting around the fact that near-term ZEVs will be relatively more expensive to produce. Staff estimates that the incremental costs for ZEVs in 2003 will range from \$7,500 for City EVs, up to more than \$20,000 for freeway capable ZEVs with advanced NiMH batteries. These calculations exclude the costs incurred for research and development of each ZEV model.

Under an optimistic but nonetheless plausible scenario, battery EVs could become cost-competitive with conventional vehicles on a lifecycle cost basis. This scenario assumes volume production of more than 100,000 ZEVs.

It is important to distinguish cost from price. Staff has estimated the cost of ZEV production to manufacturers, and the cost of operating ZEVs over their useful life. That is not the same as estimating the price at which various electric vehicles would be offered for sale. Price is set in a competitive environment and can differ from cost for several reasons. In initial years, manufacturers will not be able to recover the full cost of ZEV production through prices alone. This shortfall will be wholly borne by the automakers unless California offers full or partial subsidies to mitigate the revenue gap.

During the MOA period, California provided \$5,000 per vehicle "buy down" grants to offset the higher incremental cost of producing ZEVs. These grants were given to the auto manufacturers, who applied them as a discount to their ZEV lease or purchase prices. With some exceptions, the \$5,000 grants were funded fifty/fifty by the California Energy Commission and local air pollution control districts. CEC's funding for this program came from the State's Petroleum Violation Escrow Account (PVEA), while districts have relied upon their motor vehicle registration fee surcharge revenues. Subsidies of up to \$500 were also available for the installation of individual, at-home charging stations. Both of these financial incentive programs are funded only through FY 2000-2001.

To support a significantly higher penetration of ZEV vehicles, California will need to continue its subsidy programs—at least through the initial years. It will also be necessary to identify an alternate fund source. The State's entire PVEA account will be exhausted by the end of next year. Moreover, local air districts have multiple, competing claims on their vehicle registration fee revenue (including heavy-duty diesel clean-up programs) and are unlikely to be able to continue to allocate large amounts to ZEV subsidies.

## **Environmental, Energy and Economic Benefits**

ZEVs provide comprehensive environmental, energy and societal benefits.

With respect to the environment, ZEVs are the “gold standard” for vehicular air pollution control. They reduce both criteria and toxic pollutant emissions to the maximum feasible levels. High-efficiency ZEVs and hybrid electric near-ZEVs also cut emissions of carbon dioxide and other greenhouse gases. Finally, ZEVs minimize the multi-media impacts of vehicle operation, eliminating the need for a whole host of upstream petroleum refinery, storage and delivery activities. Admittedly, ZEVs have their own upstream impacts related to power generation and create new waste disposal issues. However, on an overall lifecycle basis, they are environmentally superior to conventional automobiles. As California’s power generation system becomes increasingly cleaner, so too will the upstream emissions associated with ZEVs.

Regarding energy use, vehicles powered by grid electricity increase the diversity of California’s transportation energy system. This reduces the State’s dependence on foreign oil and contributes to greater stability in the overall transportation fuels market. Advanced battery ZEVs and hybrid electric near-ZEV technologies are also highly efficient; reducing absolute energy demand per mile of vehicle operation. Finally, ZEVs have the potential to be powered by renewable sources of energy such as wind, hydropower or solar energy.

The societal benefits of ZEVs include their clean, quiet operation in neighborhoods and on city streets. ZEVs can also benefit the State’s economy. Because of their high technology leadership, California companies have the technical and scientific capability to play significant roles in the design, development and production of advanced technology zero emission components and vehicles.

In public comments, automakers stated that the direct air quality benefits of the ZEV program are minor and, therefore, not worth the investment in electric cars. Staff recognizes that in the near-term, due to the small penetration of ZEVs and corresponding improvements in conventional cars, fleet-wide benefits will be modest. However, this is a long-term strategy. On a per vehicle basis, ZEVs are significantly cleaner than even the cleanest gasoline-powered alternative. They will steadily reduce emissions as their fleet penetration grows. Even more importantly, ZEVs have no risk of in-use emission control system failures. They are the only technology that is guaranteed to *permanently* reduce emissions over time.

## **Conclusion**

California has made significant technological progress toward its zero emission objectives. More than two thousand battery EVs are on the road, illustrating that ZEVs can be built and deployed. There are a variety of attractive ZEV platforms. Also, their respective characteristics meet a wide range of market applications including fleets, small businesses and private commuting. While electric vehicle range is limited and recharging times are long, ZEVs are in everyday use in many different circumstances across the state. All evidence and testimony points to the fact that those who are using today’s EVs are very pleased with their performance.

Progress has been less pronounced on the economic side. Staff's cost analysis concludes that both the initial and lifecycle costs of battery EVs will significantly exceed those of comparable conventional vehicles in the 2003 timeframe. However, in volume production and with improved technology, battery EVs could become competitive on a lifecycle cost basis.

The near term cost premium for ZEVs is not surprising since every incremental step in pollution control provides benefits at a higher marginal cost. The ZEV program, moreover, is not a typical step-wise adjustment but a transformative leap forward. Given the sweeping nature of ZEVs' environmental, energy and societal effects, it is reasonable to expect that the program will be more expensive in its early years than more limited measures. At the same time, the fact that costs impose burdens must also be acknowledged. While higher costs persist, state subsidies could be very important to mitigate impacts on auto manufacturers and to nurture a growing ZEV market.

The market for battery EVs is just starting to be understood and is very difficult to quantify. As noted above, the 2003 ZEV mandate represents a ten-fold increase in the number of actual battery EVs on the road. Placing all of those vehicles within a year or two and sustaining those sales in 2004, 2005 and beyond is a significant marketing challenge by anyone's measure.

Staff has identified a number of applications that are well suited to using ZEVs and which could absorb several thousand units. Actual vehicle sales/leases will depend on consumer awareness and interest, available products and their net market price (minus any subsidies or tax incentives that may be provided). These factors suggest that much more extensive public education is needed. In addition, continuity of ZEV production is critical. Market acceptance cannot build, and volume production cannot be achieved, if ZEVs continue to be available only in boom and bust cycles.

The 1996 MOA was a highly collaborative effort between the State of California, automakers, public utilities, local governments, fleet operators and many private ZEV enthusiasts who put their own dollars on the line. As ZEV penetration grows, this partnership needs to continue and expand. Teamwork among all the interested parties will increase the probability of success and hasten the advent of a truly self-sustaining ZEV market.