Regulatory Impediments to Neighborhood Electric Vehicles: Safety Standards and Zero-Emission Vehicle Rules

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The California Air Resources Board mandated the production of zero-emission vehicles (ZEVs) starting in 1998. Other states may follow. Among the types of vehicles that may satisfy the requirements of this mandate are small, neighborhood electric vehicles (NEVs) that would be used in urban areas and on collector and arterial streets for a wide range of short trips. Although NEVs hold the potential for large energy and environmental benefits, their introduction is hindered by two institutional barriers. The first of these is the federal safety standards designed for full-sized, gasoline-powered automobiles. The second is the California ZEV regulations that may not award ZEV credits to manufacturers for all vehicles certified as ZEVs, particularly very small NEVs. Also there are important inconsistencies in the vehicle definitions used in these and other regulations and vehicle codes. This has created confusion with regard to their applicability to various small vehicle designs. The history of legislative rule making as it relates to small vehicles is explored, and possible strategies for overcoming these regulatory barriers to the production and sale of NEVs are discussed.

Persistent nonattainment of ambient air quality standards in many U.S. cities and the continued almost 100 percent reliance of the transportation sector on petroleum have prompted new federal, state, and local initiatives to introduce alternative transportation fuels. One of the most far reaching of these requirements for new vehicle technology has been enacted by the California Air Resources Board (CARB). Section 1960.1 of Title 13 of the California Code of Regulations requires that 2 percent of new cars delivered for sale by major automakers in California in 1998 be zero-emission vehicles (ZEVs). These proportions increase to 5 percent in 2001 and 10 percent in 2003. On February 1, 1994, 12 states in the Northeast requested permission from the Environmental Protection Agency (EPA) to adopt similar rules.

Battery-powered electric vehicles (EVs) represent the only available technology that currently meets the ZEV definition. Because of their zero tailpipe emissions and flexibility of energy supply, EVs are promising prospects. But because of the high cost and relatively poor energy storage characteristics of batteries, many market analyses conclude that few consumers would buy EVs (*1–3*). Although other studies differ in the conclusion (*4,5*), this uncertainty about the market for full-size battery-powered EVs highlights the need to explore other applications and designs for EVs.

One new type of vehicle that could help meet environmental and energy goals is the neighborhood electric vehicle (NEV) (see paper by Sperling, this Record). These efficient, clean vehicles could play a valuable role in reducing air pollution, energy consumption, dependence on foreign oil supplies, and greenhouse gas emissions. They would be used primarily in urban areas and would not, in general, be intended or designed for freeway travel. Their operating environment would be urban and suburban arterials, collector streets, and alleys.

Many of the policy issues confronting the introduction of NEVs can be grouped into the following broad categories:

- Modification of regulations and standards to eliminate institutional barriers to the sale and operation of NEVs,
- Development of incentives to stimulate manufacturers to produce NEVs and for consumers to purchase them, and
- Coordination between local, state, and federal agencies to develop the infrastructure and traffic control measures where necessary to provide an appropriate operating environment for NEVs.

This paper addresses two underlying institutional barriers in the first category: NHTSA federal motor vehicle safety standards (FMVSSs) and language in existing air quality and energy legislation (such as the definitions of ZEV promulgated by CARB), which may not formally recognize these vehicles as "passenger cars." This paper examines the recent history of rule making by NHTSA as it relates to small vehicles. The existing procedures under which vehicles that do not conform to the panoply of FMVSSs are sent to market and the potential for obtaining exemptions for or amending problematic standards are described. The paper then discusses the potential for the creation of a new vehicle category and proposes a vehicle definition scheme that would accommodate the specialized needs of NEVs. Finally the paper explores discrepancies in vehicle definitions in various codes and regulations, including the ZEV mandate, as they affect the regulatory treatment of NEVs.

COMPLIANCE WITH FMVSSs

The National Traffic and Motor Vehicle Safety Act of 1966 empowered the U.S. Department of Transportation to set national safety standards for motor vehicles under the authority of the National Highway Safety Bureau, which later became NHTSA (*6*). NHTSA's primary mandate is to set safety standards that define the minimum level of safety performance for motor vehicles (*7*). The standards promulgated by NHTSA generally fall into three categories: crash avoidance (series 100), crashworthiness (series 200), and postcrash (series 300). Automakers are responsible for "self-certifying" their vehicles. A second section of the FMVSSs in 49 CFR addresses the administrative considerations that are

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relevant to EVs, and this includes NHTSA enforcement (Part 554) and temporary exemption (Part 555) (*8*).

The FMVSSs were originally written for internal combustion engine vehicles, but the recent resurgence in interest in EVs, coupled with government regulations encouraging or mandating their use, has led NHTSA to reinvestigate the potential need for new or modified standards. The willingness of NHTSA to explore the development of specific standards for EVs suggests that there may also be potential for modifications in the rules that would allow NEVs to operate in specific environments. An examination of the recent history of NHTSA rule making with regard to both three-wheeled and lightweight vehicles sheds light on the potential to create new rules that would allow the production and use of NEVs.

Safety Standards and Vehicle Classifications

To demonstrate the interplay between rule making and vehicle design and to introduce the history of rule making regarding small vehicles, consider the case of three-wheel vehicles. Under the current federal vehicle classification system, a small, three-wheel EV would be a "motorcycle," but a small four-wheel EV would be considered a "passenger car." As a result three-wheel designs would be subject only to the minimal safety standards that apply to motorcycles, whereas four-wheel designs would face the much more stringent standards applied to full size passenger cars. The long history behind these rules, particularly with regard to the motorcycle definition, provides some insight into the future potential of small EV classification strategies.

On May 16, 1973, NHTSA published a notice of proposed rule making that examined the vehicle classification system with regard to the apparent inequity in the treatment of lightweight vehicles with similar purposes but with a different number of wheels. In that proposal, which sought to revise the motorcycle definition, NHTSA said "Whatever the requirements for lightweight vehicles may be in the future, there is no evidence . . . at this time that a dividing line based on whether they have three or four wheels is rational" (*9*). NHTSA went on to propose a motorcycle definition that would exclude enclosed, three-wheel vehicles (*9*). The proposal was subsequently deemed ambiguous and revised several times, but the long history of proposals, comments, and revisions ultimately resulted in no change to the motorcycle definition. The clear inequity in the treatment of vehicles with three and four wheels was never resolved, despite NHTSA's original concern that:

> . . . the present [May 16, 1973] definitional dividing line between three and four wheels would create a major incentive for manufacturers of small vehicles, *such as those that may be developed in the future for urban transportation,* to choose a three-wheeled design and thereby escape the necessity to conform to many safety standards. (emphasis added) (*9*)

One dilemma posed by this classification system with regard to the three-wheel EV is the trade-off faced by both potential manufacturers and consumers between the cost of compliance with safety regulations (and thus vehicle price) and consumers' own desire for convenient and safe, but inexpensive vehicles. A small three-wheel vehicle that qualifies as a motorcycle offers the lowest cost of compliance because of the relatively few standards that would need to be met. But the fact that these vehicles, like motorcycles, may be viewed as unsafe, coupled with the inconvenience to consumers of being required to abide by helmet laws, would likely result in a reduced potential market share, despite the relatively low cost of the vehicle. A four-wheel design, classified as a passenger car, would have to meet much more rigorous standards, resulting in much higher costs (*10*).

One solution to the problem of NHTSA compliance for NEVs is to define a new vehicle category that defines standards that small, lightweight vehicles must meet. In fact in 1967 the NHTSA safety regulations included a general exemption from motor vehicle safety standards for four-wheel vehicles that weighed under 455 kg (1,000 lbs). The exemption was justified on the premise that it would be impossible for such "lightweight vehicles" to meet the standards imposed on full-size cars. The wisdom of this decision was quickly challenged by the Center for Auto Safety, which argued that the exemption should be revoked.

> . . . the energy exchange in a collision between two vehicles will result in more disastrous consequences for the lighter of the vehicles. . . . Further delay in (lightweight) vehicle compliance may create an unreasonable and intolerable risk of harm to the motoring public. (*11*)

On August 16, 1972, NHTSA issued a notice of proposed rule making to remove the general exemption, citing the growing interest in lightweight vehicles and declaring that the potential safety hazard was an issue that needed to be addressed. At that time NHTSA conceded that lightweight vehicles might not meet all the safety standards, but emphasized that exemptions from specific standards that could not be met might be possible. Standards pertaining to structural strength and crush distance were determined to be potentially problematic for small vehicles, but those pertaining to lighting, braking, and glazing would easily be met. Because of the different standards that might and might not be met and because such standard specific exemptions already applied to heavy vehicles, NHTSA concluded

> It thus appears in the public interest to consider the needs and problems of lightweight vehicles on a standard-by-standard basis *as is presently done in the case of heavy vehicles,* which receive differential treatment in several standards, rather than by an across the board exemption. (emphasis added) (*12*)

Thus, on May 16, 1973, NHTSA removed the general exemption for lightweight vehicles, but once again emphasized that potential manufacturers could petition for an amendment to any impractical standard or could petition for a temporary exemption on one of several potential bases (*13*). This policy toward lightweight vehicles remained unchallenged until 1979, when NHTSA received a petition for the creation of a lightweight vehicle category. NHTSA refused the petition in 1981, stating "As a general matter, cars of all sizes should comply with the same safety standards" (*14*). NHTSA argued that the lightweight vehicle exemption was unnecessary because it had found no evidence that the cost of meeting safety standards was preventing the manufacture of lightweight vehicles. Furthermore it argued that the technology was available to build "relatively" light passenger cars that could achieve a high degree of fuel economy while also complying with the standards. Finally NHTSA pointed out that although lightweight vehicles were in use in Europe and Japan, the vehicle mix in those countries was different from that in the United States and that the greater average vehicle weight in the United States would

result in a greater risk of severe injuries for occupants of lightweight vehicles if these vehicles were not able to meet the full range of safety standards. Thus the petition was denied and prospective manufacturers of lightweight vehicles were encouraged to develop designs that would comply with the standards to ensure the safety of the vehicle users (*14*).

This rule-making history suggests that in the short term it would be difficult to reinstate a general exemption for lightweight vehicles. A more feasible initial alternative would be to identify those safety standards that cannot be met for a given type of vehicle and to pursue exemptions or amendments for those standards to allow those vehicles to be licensed and operated on public roads.

Temporary Exemption from FMVSSs

The design, certification, and testing of vehicle models can be an expensive process. For example the cost in 1989 and 1990 for Conceptor/EPRI to test the compliance of the electric G-Van with seven FMVSSs approached $1,000,000 (*8*). Clearly the costs of compliance with all the FMVSSs, as would be required for a new vehicle design, could easily reach millions of dollars, because the procedure would need to include the cost of the test facility, multiple vehicles, damage to test equipment, and redesigning and retesting of prototypes. Sensitive to the needs of small companies, NHTSA allows manufacturers of lightweight vehicles to seek temporary exemptions from one or more of the FMVSSs (*8*). Under 49 CFR Part 555, an exemption from one or more standards may be granted for up to 2,500 vehicles per year on one of the following bases: facilitation of the development of new low-emission vehicles, substantial economic hardship, or the existence of an equivalent overall level of safety.

The exemption procedure is available to any manufacturer selling fewer than 10,000 units per year and might prove very useful to a company interested in marketing NEVs. For a small company with low (or no) annual sales, the exemption procedure may be the only way to put vehicles on the market, at least in the short term. In fact as of 1994 existing converters and manufacturers of "full-size" EVs were selling their vehicles under one or more of these exemptions. The exemption period could be used to facilitate demonstration projects and assessments of vehicle safety, potential markets, requirements for new infrastructure, and the operational feasibility of NEVs. If the trial period indicates that NEVs would significantly and positively advance air quality, energy, and mobility goals, manufacturers and regulators may wish to pursue the more challenging option of creating a new vehicle classification. Such a classification would remove manufacturers' uncertainty regarding design and operational characteristics, provide consumers with an appropriate standard of safety, and clarify for regulators the role of such vehicles in improving air quality and advancing energy policy.

NEVs would likely qualify for the exemption as "low-emission motor vehicles." The primary challenge in obtaining such an exemption would be in convincing NHTSA that the failure of a vehicle to meet one or more standards would not constitute an unreasonable degradation in its safety. To the extent that this would require detailed crash test reports demonstrating the safety of the vehicle, the cost of this process might become a hindrance to the small manufacturers included in the regulation.

In the short term NEVs that are not able to meet all of the FMVSSs could be allowed to operate under temporary, low-emission vehicle exemptions from specific safety standards. The high cost of meeting the provisions of the FMVSSs is a strong argument for the temporary exemption procedure, but the ease of obtaining an exemption would likely depend on the type and number of standards that the vehicle does not meet and the perceived safety risk of allowing the vehicles to be licensed without conforming to the standards. In the longer term the number of exempted vehicles that could operate in this manner is very limited. If NEVs are to be one part of an integrated solution to the problem of improving air quality and energy efficiency, a new vehicle category must be defined along with modified or new standards that apply to the safety concepts employed in small vehicles.

Permanent Amendment to FMVSSs

It is possible that a permanent amendment to one or more of the FMVSSs could be granted for NEVs on a standard-by-standard basis. Historically this has been attempted only for vehicles such as the motor-driven cycle and not for passenger vehicles. The process by which standards are added or amended is very time-consuming, particularly for those standards concerned with crash protection (T. Vinson, Office of Strategic Planning and Evaluation, NHTSA, unpublished information, March 15, 1993). A petition to alter a standard may be discussed and revised for 2 or 3 years before being accepted. Because of a lack of precedents, it is unclear exactly what argument would be necessary to convince NHTSA of the need for a standard to be amended, but this option is potentially less difficult than the creation of a completely new vehicle category and should be considered, particularly if only a few of the standards prove to be problematic.

Although the degree of difficulty in meeting these standards will differ by vehicle design, several standards were identified by NHTSA in 1978 as being potentially problematic for electric vehicles in general (*15*). Some other standards were not noted by NHTSA but have since been identified as presenting possible difficulties for small vehicles (*16*). A total of 15 standards have been identified to date, primarily in the level 200 (crashworthiness) category, which suggests that attempting to obtain separate amendments to each standard would be difficult and time consuming.

A careful examination of these standards suggests that gaining NHTSA approval for the operation of NEVs may be one of the greatest challenges facing those who wish to introduce these vehicles into the U.S. market. In its 1978 study NHTSA concluded that the CitiCar, a small EV that weighed less than 591 kg (1,300 lbs), would "no doubt have difficulty meeting existing safety standards (*15*). Given the number of standards with which compliance of NEVs is likely to be problematic or that are simply not applicable to the characteristics of the vehicles, potential manufacturers currently have few options: apply for temporary exemptions or attempt to operate under loopholes in the law, such as those that exist for three-wheel vehicles. Examples of vehicles that use each approach include two Danish designs: the Kewet El-Jet, a four-wheel vehicle that is operating under a temporary exemption, and the City-Com City-El, a three-wheel design that is classified as a motorcycle.

Creating a New Vehicle Category

A final alternative is to develop a new category of vehicle with an accompanying set of fully relevant standards. At the time of

the 1978 NHTSA study the CitiCar was determined to be so dissimilar from conventional vehicles that the agency considered developing rules for "a special class of vehicles with restrictions on weight, operational performance, passenger capacity, and use" (*8*). This option was subsequently deemed infeasible, but perhaps it will be reexplored if a sizable market for small vehicles develops.

There are two primary justifications for the creation of a new lightweight vehicle category with an accompanying set of crashworthiness standards. The first of these is that safety concepts designed to minimize the hazards of vehicle collisions (i.e., composite materials, air bags, and rigid passenger compartments) have improved much in the past 20 years, making it potentially easier for lightweight vehicles to provide a level of safety comparable to that provided by heavier passenger vehicles. The current FMVSSs in some cases are highly prescriptive, specifying the means by which standards are to be met (i.e., crush zone distance, etc.), and this approach excludes other safety concepts that may be more appropriate for small vehicles. The second justification for a new category is that NEVs are the only small vehicles that will require substantially different standards. Not only will they operate in low-speed environments that will not be as hazardous as those of freeway-capable vehicles but their safety can be enhanced through specialized traffic control measures and infrastructure design concepts. These measures can be employed to restrict the commingling of NEVs with heavier, faster vehicles when necessary (see paper by Stein et al., this Record). In a larger sense safety must be considered in context. In the case of NEVs the context is slow-moving traffic, a restricted operating environment, and tailored traffic controls.

The development of a new vehicle category will require that consensus be reached among manufacturers and regulators as to the description of this new class of vehicle. This may be somewhat difficult, but in the long term it seems unavoidable given that the characteristics of NEVs essentially preclude them from complying (at a reasonable cost) with all of the safety standards currently imposed on passenger vehicles. The following new definitions are suggested as a starting point for discussion:

Minivehicle (MV): a motor vehicle having three or more wheels in contact with the ground, a fully enclosed passenger compartment, a vehicle curb weight of less than 910 kg (2,000 lbs), and a top operating speed of over 65 km/hr (40 mph) and that is designed and used for the transportation of people.

Mini-electric vehicle (MEV): a minivehicle that is powered by electrical energy.

Neighborhood electric vehicle (NEV): a motor vehicle having three or more wheels in contact with the ground, a fully enclosed passenger compartment, a vehicle curb weight of less than 910 kg (2,000 lbs), and a top operating speed of 65 km/hr (40 mph) or less and that is powered by electrical energy.

This scheme can be represented as shown in Figure 1.

This classification system is useful because it accomplishes three important tasks. First, it makes the basic distinction between small vehicles, with a vehicle curb weight of under 910 kg (2,000 lbs), and larger vehicles. This distinction is necessary because the current set of FMVSSs has been designed for full-size vehicles, and all small vehicles, regardless of their propulsion system, may benefit from standards specifically designed for them. Second, a useful distinction is made between the vehicles that employ electric propulsion (i.e., NEV, MEV, and EV) and those that do not. This is the most basic division needed for the purpose of applying different propulsion-related standards to various vehicle types and for accommodating current and future incentive policies that lower the price and increase the convenience of EVs to encourage their socially desirable emission and energy use characteristics. Other refinements can be added to this basic framework for full size and small hybrid vehicles and for other alternate-fuel vehicles. Third, this classification scheme distinguishes between MEVs, which will likely be freeway capable and should meet the intent of the FMVSSs (although possibly employing new safety concepts), and the slower and generally smaller NEVs, which are not freeway capable and thus have clearly distinct requirements for safety standards.

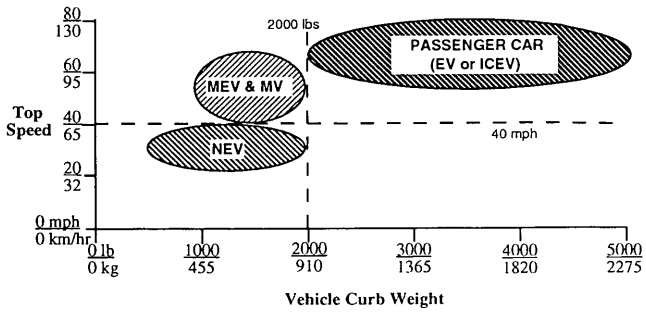

FIGURE 1 Proposed vehicle classification scheme.

Thus a new classification scheme would provide a simple framework that could be used for the dual purposes of developing incentive policies for the use of clean, efficient vehicles and of developing safety standards that address the specific needs of different vehicle types and sizes. It is important to note that the majority of the standards will be met without difficulty by small vehicles, but in the long term standards that are based on vehicle speed and size will need to be modified, particularly for NEVs, for these vehicles to be brought to market at a reasonable cost.

INCONSISTENT REGULATIONS AND ZEV MANDATE

The primary motivation for manufacturers to introduce EVs in California is the ZEV mandate promulgated by CARB in Section 1960.1 of Title 13 of the California Code of Regulations. But the applicability of that mandate to NEVs is unclear because of the inconsistent and vague vehicle definitions in regulations and codes. The ZEV mandate applies only to passenger cars and light-duty trucks. Although the definition of a "passenger car" used by CARB is "any motor vehicle designed primarily for transportation of persons and having a design capacity of 12 persons or less," at this time some vehicles, particularly NEVs with three wheels, that would be certified as ZEVs (for purposes of tax credits and other incentives) would not be awarded ZEV credits (California Code of Regulations, Title 13, Section 1900). Manufacturers of four-wheel NEVs apparently would receive ZEV credits, but CARB has yet to make an official determination on the inclusion of various types of NEVs in the credit scheme. The fate of NEVs with regard to this critical mandate is therefore unclear.

In addition to the uncertainties surrounding the CARB ZEV regulations, NEVs face the problem of a lack of consistency among the vehicle definitions used by various regulations and vehicle codes. The EPA Clean Air Act Amendments (CAAA), the Corporate Average Fuel Economy (CAFE) standards, the federal Uniform Vehicle Code (UVC), and the California Vehicle Code (CVC) all use different motor vehicle definitions, adding greatly to the confusion surrounding policy and regulatory issues related to NEVs. To choose a particularly bewildering example, a three-wheel EV capable of 50-mph travel (an early prototype made by the Horlacher company would meet these criteria) would be considered a "passenger vehicle" by CVC, a "motorcycle" by UVC, a "passenger car" by CARB, a "light-duty vehicle" under CAAA, and possibly a "passenger automobile" and possibly not (depending on a determination by the Secretary of Transportation) for purposes of inclusion under the CAFE standards.

The definitions used in promulgating the CAFE standards and the regulations of CAAA are confusing in that the terms *passenger car*, *passenger automobile*, and *light-duty vehicle* are all used to mean essentially the same thing, but subtle differences do exist. A *passenger automobile* is defined, for the purposes of CAFE standards, as a vehicle designed to carry "no more than 10 individuals," and a *light-duty vehicle* is defined, for the purposes of CAAA, as being "capable of seating 12 passengers or less." Thus a vehicle seating 11 passengers is a "light-duty vehicle" but not a "passenger automobile" (40 CFR §600.002-85 and 40 CFR §86.082-2). Of greater relevance to the NEV is the language of the CAFE regulation defining an *automobile* as a "four-wheel vehicle." The exclusion of vehicles with fewer than four wheels would hold barring a determination by the Secretary of Transportation that such vehicles would be "substantially used for the same purposes" (40 CFR §600.002-85).

A first and obvious recommendation would be to combine the terms *passenger car*, *passenger automobile*, and *passenger vehicle* and give the resulting term a clear and consistent definition throughout the various codes and regulations. The authors suggest using the term *passenger car*, as used in UVC, because it is the most widely used and thus the easiest to standardize and also because it has a simple definition that clearly excludes motorcycles and could easily be modified to exclude other vehicle categories. Another recommendation would be to define the terms *light-duty vehicle*, *medium-duty vehicle*, and *heavy-duty vehicle* primarily in terms of the weight of the vehicle and to restrict the usage of these terms to situations in which the weight of the vehicle is important. In cases in which weight is not an issue, more general terminology should be used (i.e., *passenger car*, *neighborhood electric vehicle*, etc.).

In summary simplifying and reconciling the terms used to define vehicles would remove a considerable amount of confusion that currently exists. A consistent and precise definition scheme would allow manufacturers to know with certainty how various vehicle designs would be affected by laws and regulations and would aid them in their strategic planning in bringing their vehicles to market and in meeting the ZEV mandate. Given the potential importance of the mandate in California and elsewhere in promoting the sale of EVs, the success of the NEV concept may depend on it being included in the provisions of the rule. Such inclusion would likely have to be supported by analyses of how much pollution and gasoline vehicle use is reduced as a result of each NEV purchase. If analysis shows that NEVs are used much less than gasoline-powered vehicles (and full-sized EVs), fractional ZEV credits could be awarded.

CONCLUSIONS

The introduction of small, limited-performance NEVs to consumers and cities confronts a rule-making system tied to full-size, gasoline-powered cars. Standards and rules need to be made more flexible to accommodate differences. A first step is to define appropriate classifications, definitions, and standards for NEVs and other small vehicles. Specifically the development of NHTSA safety regulations that are appropriate for small vehicles operating in restricted environments and the inclusion of all NEV designs in the credit scheme of the ZEV mandate are critically important for the success of the NEV concept. The second issue, qualification for ZEV credits, is of especially great importance because it creates a potential market for NEVs.

A research agenda designed to address the issues raised in this paper must include safety, emissions, and vehicle use studies. Development and testing of new safety concepts, new materials, and the interaction between vehicles in low-speed operating environments will clarify how safety standards can be modified to allow for the safe operation of NEVs. The potential for these vehicles to substitute for short, low-speed, urban trips suggests that their emissions reductions may be far greater than indicated by the number of trips or number of miles they travel. Thus the ability of NEVs to complement, rather than replace, gasoline-powered vehicles within a household stock of vehicles must be assessed.

With the cooperation of vehicle manufacturers and federal and state agencies, procedures and policies that will allow NEVs to meet the requirements of ZEV regulations in California and other states and to provide safe transportation can be implemented. If this is done the viability of the ZEV mandate will be strengthened and a new mode of safe, efficient, and environmentally benign transportation will become available.

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