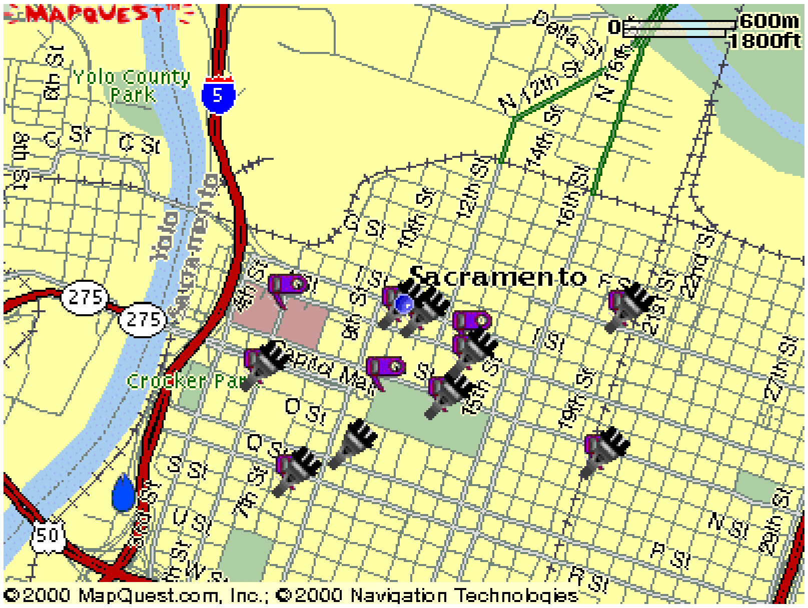
Staff Report: Initial Statements of Reasons

Proposed Amendments to the California Zero Emission Vehicle Regulations: Treatment of Majority Owned Small or Intermediate Volume Manufacturers and Standardization of Battery Electric Vehicle Charging Systems for the Zero Emission Vehicle Program.



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Date of Release: May 11, 2001
Scheduled of Consideration: June 28, 2001

EXECUTIVE SUMMARY

The California Zero Emission Vehicle (ZEV) regulations were originally adopted in 1990, as part of the first ARB Low-Emission Vehicle (LEV I) regulations. The ZEV program is an integral part of California's mobile source control efforts, and is intended to encourage the development of advanced technologies that will secure increasing air quality benefits for California now and into the future.

At a January 25, 2001, public hearing, the Board approved major changes to the ZEV regulations that will significantly reduce the number of ZEVs required during the near term. The amendments will result in an increase in the number of ZEVs and advanced technology vehicles over time. Since the amendments reflect numerous modifications to the originally proposed changes, they will be made available for a supplemental public comment period, after which the Executive Officer will take final action. The Board did not resolve all issues raised during the hearing. Among other things, it directed staff to investigate joint ownership issues associated with the treatment of small and intermediate volume manufacturers, and issues regarding battery electric vehicle (EV) charger standardization. The Board also directed staff to investigate providing ZEV credits for heavy duty vehicles. The staff has not completed this investigation, and plans to return to the Board with its finding later this year.

Proposed Modifications to the Regulations

In response to the Board's directions, ARB staff is proposing amendments that make two additional changes to the ZEV Program. The first is to change the way vehicle production volumes and associated ZEV requirements are calculated for a manufacturer that is majority-owned by another manufacturer. The second is to identify a single charging system – on-board conductive – for battery electric vehicles.

Majority Owned Small or Intermediate Volume Manufacturers. Small volume manufacturers are not subject to the percentage ZEV requirements, and an intermediate volume manufacturer may satisfy its entire percentage ZEV requirement with partial ZEVs (PZEVs), rather than no more than 80% of the requirement as is the case for large volume manufacturers. In recent years, there has been a lot of consolidation among vehicle manufacturers. Several previously independent manufacturers have become partially owned, majority owned or wholely owned by other manufacturers. These new relationships have made it difficult to delineate individual manufacturers to determine their vehicle volume status for purposes of the ZEV requirements. Typically these relationships involve one large volume manufacturer and one or more intermediate and/or small manufacturers. For example, Ford wholely owns Volvo, Jaguar and Aston Martin. General Motors wholely owns Saab. ARB staff is proposing to modify definitions of terms used in the ZEV regulation to clarify these relationships to ensure predictable and equitable treatment among the affected vehicle manufacturers.

ARB staff is proposing that the definitions of small and intermediate volume manufacturers be amended to clarify how companies in partial or wholely owned relationships are treated in determining the ZEV requirements. The California sales of two or more manufacturers would be aggregated if one has a greater than 50 percent equity ownership in the other. The aggregation requirements would become applicable starting with the 2003 model-year, and a manufacturer whose status would change in the 2003 model year due to aggregation would be subject to the ZEV requirements as an intermediate or large volume manufacturer starting with the 2006 model year.

Infrastructure Standardization/Single Charging System. The lack of a single charging system contributes to the public perception that the EV market is not yet mature and represents a significant barrier to marketing EVs to the general public. A standardized EV charging system would greatly improve the access and utility of the public charging system by creating a situation analogous to the refueling of gasoline vehicles in which all gasoline pumps and nozzles are standardized for all vehicles. A standardized charging system will ensure that every EV fits every EV charger, once the standard is fully implemented.

The current number of battery electric vehicles (EVs) in California is just over 2,000 with the number expected to rise to an estimated 100,000 by the year 2010. With this large expansion of EVs, the staff is proposing to require a single charging system. The proposal is to require all EVs that qualify for 1.0 or greater ZEV credit to be equipped with the standard charging system. The recommendation is that an on-board conductive charging be selected as the standard system. This requirement is designed to support a smooth progression towards the expanded commercialization of EVs.

Effect of Proposed Modifications

Majority Owned Small or Intermediate Volume Manufacturers. The proposed amendments to the small and intermediate volume manufacturer definitions will affect the vehicle manufacturers involved in situations where one company owns greater than 50% equity in another. The combined companies will potentially be required to produce more pure ZEVs and Advanced Technology PZEVs (AT PZEVs) as a result of combining their vehicle volumes. Under current ownership arrangements, there are only two combined vehicle manufacturers --- Ford Motor Company and Volkswagen --- that would have their ZEV requirements increased as a result of the proposed amendments. For Ford Motor Company the estimated cost of the proposed requirements is $2.6 million for the 2006 model year. This is due to an additional 165 pure ZEVs and 953 AT PZEVs, an 11 percent increase for each vehicle type from the current requirements. This estimate includes savings of $2.2 million to Ford Motor Company due to approximately 4,300 less PZEVs required. For Volkswagen, the added cost is less than $100,000 for the 2006 model year. This represents 125 additional PZEVs, less than a one percent increase for Volkswagen from the current requirements. Both of these cost estimates are based on 1999 vehicle volumes and are the initial cost of the proposed amendment for the first year. Future year costs are likely to be less as the costs of ZEVs and AT PZEVs are reduced.

Infrastructure Standardization/Single Charging System. The proposed Infrastructure regulation will have several positive affects for EV drivers and ultimately cleaner air for all Californians. A single charging system will increase consumer confidence and access to EV charging. It will focus technological improvements and foster competition among charger manufacturers resulting in a potential reduction in charger equipment costs. In addition, the selected charging system has a greater potential for future cost reductions than the other competing charging systems. Further, by having an on-board charging system, the charger will be just like any component on the car making charger repair easier and less costly for consumers.

The benefits of standardization will be more difficult to achieve if a decision is delayed. Delaying the decision on standardization by only three years would result in an estimated 43,000 additional new ZEVs. Therefore, it is likely that a substantial number of new EVs placed on the road could have incompatible charging systems in the future. The costs of retrofitting charging stations to the new standard will increase substantially as the number of EVs increases.

Standardization will greatly benefit the consumer by increasing access to public charging. In addition, it will also provide cost savings to public agencies and business partners that sponsor public charging. The installation, equipment and maintenance costs will be reduced as a result of having a single charging standard. Having a single charging system will require fewer public charging stations to be installed, thus reducing equipment costs for the affected parties. Costs for repairing and maintaining public chargers will also be dramatically reduced; it costs less to maintain one as compared to several competing technologies.

The proposed Infrastructure regulation primarily impacts six companies worldwide that manufacture California-certified light-duty vehicles and are subject to the ZEV regulations. Four companies will have short-term negative impacts because the electric vehicles they manufacture utilize an inductive charging system (General Motors, Nissan and Toyota) or an off-board conductive charging system (DaimlerChyrsler). The cost to the four companies is highly variable and will depend on the manufacturers individual product plans as well as their technical experience with conductive charging systems.

The ZEV regulation as modified by the Board in January 2001 allows significant flexibility in compliance strategies. Manufacturers can use city EVs, full function

EVs, neighborhood EVs and fuel cell vehicles (only the first two vehicle types will be impacted by this proposed regulation). Manufacturers can also use any combination of these vehicles in conjunction with hybrid EVs, natural gas vehicles and gasoline Super Ultra Low Emission vehicles (SULEVs). It is likely each of the four impacted companies will market at least one vehicle model required to utilize an on-board conductive charging system. However, because of the flexibility of the regulation, this not a certainty. Manufacturers have not been willing to share their product plans that would allow staff to determine which model(s) may be impacted and to better estimate the cost of the proposed regulation.

The impact of the proposed infrastructure regulation is also a function of the manufacturers' experience with on-board conductive charging. This experience varies significantly and ranges from almost no experience to manufacturers which currently have off-board conductive systems and those that previously had on-board conductive charging systems.

Two companies (Ford and Honda) will be potentially positively impacted because the electric vehicles they manufacture utilize an on-board conductive charging system. The remaining light-duty vehicle manufacturers are not impacted because either they are intermediate volume manufacturers (e.g. Volkswagen and BMW) or they qualify for the small volume manufacturer exemption (e.g. Ferrari) and are not subject to the pure ZEV regulations.

In addition, the proposed infrastructure regulation indirectly impacts businesses involved in manufacturing charging equipment to support light-duty passenger car and truck electric vehicles. Currently, there is one small company in California that produces charging equipment that will potentially benefit from this proposed amendment. The inductive and off-board conductive charging systems are currently produced by contractors of the four vehicle manufacturers mentioned above. Since charger manufacturing is a minimal part of the four vehicle manufacturers' business the cost impact is low.

The long term economic benefits of the proposed infrastructure regulation for 2006 and beyond outweigh the short-term costs. The cost to replace the public charging is an estimated $1.4 million to $2 million. This replacement would not be expected until after the year 2010 in order to allow those inductively charged vehicles marketed through 2005 to continue to utilize public charging. In addition, this cost will be offset by cost reductions for public charging resulting from reduced equipment and maintenance costs. As a result of having a single charging system there will be a dramatic increase in public/consumer confidence about EV technology and a corresponding increase in purchases of electric vehicles. If the decision is delayed three years, and the amount of inductive chargers is expanded to 2010, then the cost for retrofitting public charging would be expected to double or triple, to an estimated $4.2 million-6.3 million.

Staff Recommendation

The staff recommends that the Board adopt the modifications as proposed in this Initial Statement of Reasons. The proposed modifications simplify the determination of manufacturer vehicle volume status and remove a significant barrier to ensuring a smooth progression towards the commercialization of EVs by standardizing EV charging infrastructure.

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PART I TREATMENT OF MAJORITY OWNED SMALL OR INTERMEDIATE VOLUME MANUFACTURERS

A. INTRODUCTION

The Zero Emission Vehicle requirement for vehicle manufacturers is determined by the volume of passenger cars and light-duty trucks each manufacturer produces and delivers for sale in California. In recent years, there has been a lot of consolidation among vehicle manufacturers. Several previously independent manufacturers have become partially owned, majority owned or wholely owned by other manufacturers. These new relationships have made it difficult to delineate individual manufacturers to determine their vehicle volume status for purposes of ZEV requirements. ARB staff is proposing that definitions used in the ZEV regulation be amended to clarify these relationships. These changes will make the process of determining a manufacturer's volume classification and the associated ZEV requirements simple, predictable and equitable.

This section of the Staff Report describes the background, proposed amendments, alternatives and economic impacts, environmental impacts and cost effectiveness of the proposed amendments to the small and intermediate volume manufacturer definitions in the ZEV regulation.

B. BACKGROUND

The California ZEV requirement applies to manufacturers that are determined to be large and intermediate volume manufacturers. A large volume manufacturer must meet at least 20 percent of the ZEV requirement with pure ZEVs and may meet the remaining 80 percent of the ZEV requirement with 20 percent Advanced Technology partial ZEVs (AT PZEVs) and 60 percent partial ZEVs (PZEVs).

An intermediate volume manufacturer may meet the ZEV requirement entirely with partial ZEVs or credits generated by such vehicles. For the 2003 and subsequent model years, “intermediate volume manufacturer” has been defined as a manufacturer with California sales between 4,501 and 35,000 light- and medium-duty vehicles based on the average number of vehicles sold for the three previous consecutive years. The ZEV amendments approved in January will increase the cut-off for the maximum number of vehicles to 60,000 per year.

Under the ZEV regulation, a small volume manufacturer is exempt from all ZEV requirements. “Small volume manufacturer” is defined as a manufacturer with annual California sales of less than 4,500 new passenger cars, light-duty trucks, medium-duty vehicles, heavy-duty vehicles and heavy-duty engines based on the average number of vehicles sold for the three previous consecutive years. The rationale for providing less rigorous requirements for small and intermediate volume manufacturers is that smaller companies do not have the resources to develop new technology as quickly as larger companies. These manufacturers often wait for new technology to “trickle down” from the large manufacturers.

Typically a multi-manufacturer ownership arrangement involves one large volume manufacturer and one or more intermediate and/or small manufacturers. For example:

- Ford wholely owns Volvo, Jaguar and Aston Martin, and partially owns Mazda;
- General Motors wholely owns Saab and partially owns Suzuki and Subaru;
- DaimlerChrysler partially owns Mitsubishi and Hyundai.

For purposes of the ZEV requirements, the definitions of small and intermediate-volume manufacturers do not address the effect of partial or full ownership of one manufacturer by another. The ARB has not aggregated production volumes in such situations as long as the two manufacturers were “operationally independent.” Operationally independent is not defined in the ZEV regulations, resulting in a principle that is somewhat ambiguous, difficult to apply and subject to individual interpretation. The current vagueness of the term “operationally independent” had even caused some question as to whether DaimlerChrysler --- created by the 1998 acquisition of Chrysler Corporation by Daimler Benz AG (Mercedes Benz)--- could be considered “operationally independent.” To ARB staff this would have been an obvious circumvention of the term, since neither company, Daimler Benz AG or Chrysler Corporation, exists separately today. Nonetheless, this example demonstrates the need for clarity to ensure predictable and equitable treatment among the affected vehicle manufacturers.

On March 30, 2000, and February 27, 2001, the staff conducted public workshops to address multi-manufacturer arrangements in a regulatory arena. The workshops were held to develop a uniform method that would clarify ZEV related production requirements for companies in multi-manufacturer arrangements. At the first workshop ARB staff proposed that vehicle volumes of multi-manufacturer arrangements be combined when one company owns greater than 10% of another company. In general, the vehicle manufacturers have expressed that applying the 10% provision is too restrictive. At the conclusion of the workshop, each interested vehicle manufacturer agreed to submit to ARB how they interpret a company's "operational independence". ARB held a second workshop to present the currently proposed multi-manufacturer definition and receive comments on the proposal.

ARB staff received and reviewed comments submitted after each workshop. Based on the comments submitted no consensus on "operational independence" could be reached among vehicle manufacturers. ARB staff believes that instead of developing a definition of operational independence, the percentage of equity ownership should be used regardless of how operations are structured within a particular arrangement.

C. SUMMARY OF PROPOSED AMENDMENT

ARB staff is proposing that the definitions of small and intermediate volume manufacturers be amended to clarify how companies in partial or fully owned relationships are treated in determining the ZEV requirements. The California sales of two or more manufacturers would be aggregated if one has a greater than 50 percent equity ownership in the other. There would also be aggregation where both manufacturers are greater than 50 percent owned by a third party. The aggregation requirements would become applicable starting with the 2003 model-year, and a manufacturer whose status would change in the 2003 model year due to aggregation would be subject to the ZEV requirements as an intermediate or large volume manufacturer starting with the 2006 model year.

Below are two examples of how the proposed amendments would work. These examples assume that the ZEV credits will be fulfilled with 20 percent pure ZEVs, 20 percent AT PZEVs and 60 percent PZEVs.

(1) Company A large volume manufacturer owns Company B intermediate volume manufacturer

Before regulatory change

Company A large volume manufacturer

CA Vehicle Volume	ZEV credits required	Pure ZEV credits	AT PZEV credits	PZEV credits
100,000	10,000	2,000	2,000	6,000

Company B intermediate volume manufacturer

CA Vehicle Volume	ZEV credits required	Pure ZEV credits	AT PZEV credits	PZEV credits
30,000	3,000	Not required	Not required	3,000

After regulatory change

Combined Company

CA Vehicle Volume	ZEV credits required	Pure ZEV credits	AT PZEV credits	PZEV credits
130,000	13,000	2,600	2,600	7,800

(2) Company A large volume manufacturer owns 100% Company B intermediate volume manufacturer and 60% of Company C small volume manufacturer

Before regulatory change

Company A large volume manufacturer

CA Vehicle Volume	ZEV Credits Required	Pure ZEV credits	AT PZEV credits	PZEV credits
150,000	15,000	3,000	3,000	9,000

Company B intermediate volume manufacturer

CA Vehicle Volume	ZEV Credits Required	Pure ZEV credits	AT PZEV credits	PZEV credits
47,000	4,700	Not required	Not required	4,700

Company C small volume manufacturer

CA Vehicle Volume	ZEV Credits Required	Pure ZEV credits	AT PZEV credits	PZEV credits
3,000	Not required	Not required	Not required	Not required

After regulatory change

Combined Company

CA Vehicle Volume	ZEV Credits Required	Pure ZEV credits	AT PZEV credits	PZEV credits
200,000	20,000	4,000	4,000	12,000

D. REGULATORY ALTERNATIVES

1. Do Not Modify Program

As an alternative to the proposal, ARB staff considered keeping the definitions and current policy of applying operational independence to vehicle manufacturers to determine vehicle volume status and the associated ZEV requirements. However, much ambiguity has been created with applying the undefined term operationally independent to multi-manufacturer arrangements. Manufacturers not involved in multi-manufacturer arrangements have commented that the current method has resulted in equity and competitiveness issues between manufacturers.

2. Amend the Definitions to Specify Principle of Operational Independence

As mentioned previously, one of the results of the workshop held in March 2000 was that interested vehicle manufacturers advised ARB how they interpret a company's operational independence. ARB staff reviewed the comments and suggestions received. Staff was unable to combine the companies' characterizations of "operational independence" into a single clear and enforceable definition. No reasonable consensus could be reached.

3. CAP2000

In 1990, U.S. EPA adopted "small volume manufacturer" provisions that aggregated the vehicle sales of any other manufacturer that owns 10 percent or more of the manufacturer in question. This approach applied for purposes of the durability demonstration requirements for small volume manufacturers, and phase-in of the federal Tier 1 standards. It was also applied in the durability demonstration provisions in U.S. EPA's "CAP 2000" certification streamlining program adopted in 1999. As part of the California LEV II rulemaking, the ARB incorporated the federal CAP 2000 regulations, including the provisions aggregating sales volumes in 10 percent ownership for purposes of the durability demonstration requirements for small volume manufacturer. The alternative of applying the 10 percent ownership criterion for purposes of the ZEV requirement was explored at the March 30, 2001 public workshop. As mentioned above, the vehicle manufacturers have expressed that applying the CAP2000 provisions are too restrictive for this regulation.

E. ECONOMIC IMPACTS

The proposed amendments to the small and intermediate volume manufacturer definitions will affect the vehicle manufacturers involved in situations where one company owns greater than 50% equity in another and the majority owned company has been treated as operationally independent. The combined companies will potentially be required to produce more pure ZEVs and Advanced Technology PZEVs as a result of aggregating their vehicle volumes. Currently, there are only two combined vehicle manufacturers --- Ford Motor Company and Volkswagen --- that will have their ZEV requirements increased as a result of combining their vehicle volumes with companies which they own greater than 50%. The increase in cost to these combined companies is estimated to be low.

1. Legal Requirement

Sections 11346.3 and 11346.54 of the Government Code require state agencies to assess the potential for significant adverse economic impacts on California business and individuals when proposing to adopt or amend any administrative regulation. The assessment shall include consideration of the impact of the proposed regulation on California jobs, business expansion, elimination, or creation and the ability of California businesses to compete.

State agencies are also required to estimate the cost or savings to any state or local agency and school districts in accordance with instruction adopted by the Department of Finance. This estimate is to include any non-discretionary costs or savings to local agencies and the costs or savings in federal funding to the state.

2. Directly Affected Businesses

The businesses that will potentially be directly affected by the proposed amendments are those vehicle manufacturers involved in situations where one company owns greater than 50% equity in another. Under current ownership arrangements, there are only two combined vehicle manufacturers --- Ford Motor Company and Volkswagen --- that would have their ZEV requirements increased as a result of the proposed amendments. For Ford Motor Company the estimated cost of the proposed requirements is $2.6 million for the 2006 model year. This is due to the additional 165 pure ZEVs and 953 AT PZEVs, an 11 percent increase for each vehicle type from the current requirements. This estimate includes savings of $2.2 million to Ford Motor Company due to approximately 4,300 less PZEVs required. This reduced cost is due to the combining of vehicle volumes of two intermediate volume manufacturers, Volvo and Jaguar, with large volume manufacturer, Ford Motor Company. For Volkswagen, the added cost is less than $100,000 for the 2006 model year. This represents 125 additional PZEVs, less than a 1 percent increase for Volkswagen from the current requirements. These cost estimates are based on 1999 vehicle volumes and are the initial cost of the proposed amendment for the first year. Future year costs are likely to be less as the costs of ZEVs and AT PZEVs are reduced.

Although General Motors is also subject to this requirement in its relationship with Saab, General Motors is not claiming Saab to be “operationally independent.” Therefore, General Motors will not incur any incremental costs. Similarly, Daimler Chrysler is assumed to be one entity under the current regulations. Therefore, Daimler Chrysler will also not incur any incremental costs as a result of these proposed amendments.

3. Potential Impacts on Business Competitiveness, Employment, and Business Creation, Elimination or Expansion

The proposed amendments to the small and intermediate volume manufacturer definitions is not anticipated to have an adverse impact on California businesses’ ability to compete with businesses in other states. The proposed amendment will also not affect California employment or significantly affect business creation elimination or expansion. Only one motor vehicle manufacturing plant is located in California, the NUMMI facility, which is a joint venture between General Motors Company and Toyota. These manufacturers are not currently in multi-manufacturer arrangements and thus are not affected by the proposed amendment.

4. Potential Costs to Local and State Agencies

The proposed amendments will not result in any increased costs. ARB staff will experience some costs savings in decreased time spent determining vehicle volume status.

F. ENVIRONMENTAL IMPACTS

1. Introduction

This section outlines the emission impacts of the regulatory modifications proposed by staff. Staff believes the proposed regulatory change is necessary to remove uncertainty from the regulations and prevent competitive disadvantages. Nonetheless, there are also some emissions impacts. To assess the fleet-wide emissions impacts of both the ZEV program with the amendments approved by the Board January 25, 2001and the regulatory changes proposed in this report, ARB staff conducted an emissions impact analysis using the on-road emissions inventory model, EMFAC2000, approved by the Board on May 25, 2000. The model was adjusted slightly to address the unique attributes of PZEV evaporative requirements, to include recent changes to the air conditioning corrective factors, and to reflect new evaporative data and analysis not included in the published version. The results of the analysis represent the emissions impacts both with, and without the proposed definition changes.

Staff also assessed the indirect emissions impact that will occur from this change. These emissions include vehicle refueling, fuel transportation, fuel processing, and feedstock extraction attributed to vehicle operation. Staff's estimates of indirect emissions are based on contract work conducted by Acurex Environmental (now part of A.D. Little) in 1996 and updated in 1999.

2. Emissions Scenarios

Staff prepared estimates of the emission impacts in the South Coast Air Basin in 2010 and 2020. The vehicle totals used in these estimates reflect the total number of ZEVs, AT PZEVs and PZEVs that are expected under the ZEV amendments approved January 25, 2001 and the proposed definition changes. The proposed changes are expected to result in just over 165 more ZEVs and 953 more AT PZEV's and approximately 21,277 fewer PZEVs for the first year of implementation in 2006. More specifically staff analyzed the emissions impacts from:

1) a “Regulation with Pending Amendments” scenario that represents the ZEV credit calculation scheme used in the ZEV amendments approved by the Board on January 25, 2001. Manufacturers are expected to take full advantage of the 6 percent PZEV option. Within the 4 percent requirement, the scenario expects that manufacturers will meet half of their requirement with credits from pure ZEVs and half from AT PZEVs.

2) a “Staff Proposal with Definition Changes” scenario that assumes that a manufacturer currently classified as “operationally independent” intermediate but more than 50 percent owned by another manufacturer would would have its vehicle volumes aggregated with the large manufacturer as a result of the

proposed definition amendments. Again all manufacturers are expected to take full advantage of the 2 percent advanced technology PZEV option.

In the South Coast Air Basin in 2010, the staff proposal as compared to the current regulation will result in a 2010 net benefit of less than 0.1 tons per day of reactive organic gases and oxides of nitrogen. For 2020, this emissions benefit increases to about 0.2 tons per day.

3. Other Environmental Media

Given the relatively small number of pure ZEVs that will result from this change, staff expects that no significant impacts will occur in other environmental areas.

4. Energy Diversity and Energy Demand

The staff proposal will result in more pure ZEVs and AT PZEVs to be phased in beginning in 2006. This will directly encourage increased vehicle efficiency, and provide corresponding energy benefits. However, as noted above the total number of vehicles will be relatively small.

G. COST-EFFECTIVENESS

This section discusses the cost-effectiveness of the proposed amendments to the definitions of small volume manufacturer and intermediate manufacturer.

At the September 7-8, 2000 Board meeting, information from the August 7 Biennial Review staff report was used to show that the dollars spent per ton of pollutant reduced under the ZEV program will be much higher than for any other ARB regulatory measure. Despite this information, the Board voted unanimously to maintain the program with the belief that the ZEV program must be viewed and considered on a long-term basis. As is highlighted in Resolution 00-29, adopted at the September 7 meeting, the Board found the ZEV program to be an essential component of the State’s long-term air quality strategy, and further found that the ZEV program has brought about significant technological advances.

Given this background and context, the near term cost-effectiveness of the staff proposal is not a deciding factor in the Board’s consideration of the proposed changes to the ZEV program. Section 6 above concludes that the proposed definition change will result modest reductions due to the relatively small number of additional ZEV and AT PZEVs (an increase of approximately 10 percent) required.

PART II - INFRASTRUCTURE STANDARDIZATION

A. INTRODUCTION

1. Zero Emission Vehicle Program

In 1990, California embarked upon an ambitious strategy to reduce vehicle emissions to zero. This objective was to be achieved through the gradual introduction of electric and other zero emission vehicles into the California fleet. These requirements are known as the Zero Emission Vehicle (ZEV) requirements.

ZEV requirements for passenger cars have been adjusted several times since 1990, including most recently in January 2001. The underlying goal, however, has not changed. This underlying goal is to achieve zero emission performance whenever possible in the California vehicle fleet. This is because, over the long term, ZEV technology is necessary to achieve the State's public health protection goals.

The public health goals include the attainment of federal and state health based air quality standards for ozone and particulate matter, which are currently exceeded throughout the State. Conventionally fueled vehicles are significant sources of toxic air contaminants, and fueling for these vehicles has contributed to air, soil, and water contamination. In addition, there are some communities in California disportionately impacted by pollution from petroleum refining operations and a concentration of older, more polluting gasoline and diesel vehicles in their neighborhood.

Electric vehicles (EVs) and other zero emission vehicles transcend some of the persistent problems associated with conventionally fueled vehicles. Combustion based engines are inherently high emitting, and prone to deterioration over time. Catastrophic failures are also a concern. Older gasoline vehicles become gross emitters, if their emission control systems fail. Also, the refining, fuel storage, and delivery of gasoline and diesel fuels all have emissions, which result from routine operations, accidents, and periodic compliance problems.

2. Market Expansion

As a result of the modifications to the ZEV requirements adopted by the Board, the number of EVs in California will substantially increase over the next decade. As the ZEV program ramps up over the next decade, EV infrastructure needs to meet the needs of consumers, and keep pace with the expanding EV market. Successful market expansion will depend on enhancing current education, marketing, and outreach efforts. This includes increasing consumer confidence in EV technology, including charging infrastructure.

3. EV Infrastructure

EVs are "fueled" by a battery charger which transfers electricity provided by electric utilities back into the vehicle battery to "recharge" it. As opposed to gasoline vehicles where the primary fueling infrastructure is maintained by fuel providers at commercial stations, the primary EV charging station is located at the residence or fleet facility where the vehicle is garaged. In addition, there are EV charging stations at publicly accessible sites or workplaces which greatly enhance the convenience and utility of driving an EV.

Currently, there is no single charging system. Several public/private working groups have made considerable progress over the years in the area of chargers and infrastructure. Technical and safety standards have been developed and implemented. However, one area in which progress has not been made is reaching a single standard for EV charging.

The six major auto manufacturers that have sold EVs in the last two years have used four charger connectors, or plugs, and multiple power transfer techniques. This issue will create concerns among consumers and therefore limit EV marketability as we move forward. With the large expansion of EVs projected over the coming years, it is critical that we have a single charging system.

4. Public/Stakeholder Process

ARB staff released a report in January 2001, which provided an assessment of EV infrastructure in California. This report was considered by the Board at the January 25, 2001 hearing on modifications to ZEV program requirements. This report contained recommendations on a number of infrastructure issues as well as an analysis supporting the need for EV standardization. The Board subsequently directed staff to develop a proposal for standardization, to be considered at the June 2001 public hearing.

On February 27, 2001, staff held a public workshop to solicit comments on the need for standardization, proposed selection criteria, and provide a recommendation for which EV charging system should be selected. In addition, ARB staff established a Stakeholder Working Group (Working Group) made up of representatives from the auto manufacturers, charger manufacturers, public agencies, and a variety of other technical experts. Two Working Group meetings have been held (March 14 and April 10). Numerous meetings were also held with manufacturers and other stakeholders to solicit technical information, and identify any adverse impacts that standardization would have on them.

B. NEED FOR REGULATION

1. Need for Standardization

There are currently 2,000 EVs on the road and an estimated 3,000 EV charging stations installed to support these vehicles in California. As a result of the recent modifications to the ZEV regulations adopted by ARB in January 2001, the number of EVs is expected to double between 2001 and 2003, and to increase from 4,000 to 100,000 between the years 2003 and 2010. The majority of EVs are currently used by public and private fleets. However, successful creation of a sustainable consumer market for EVs will greatly contribute to the success of the ZEV program.

Consumer Confidence and Access

The lack of a standard charging technology contributes to the public perception that the EV market is not yet mature. This represents a significant barrier to marketing EVs to the public. The public is confused about a lack of a standard and the public has often expressed a clear desire for one standard charging technology. As an example, the Bay Area Air Quality Management District has found that the lack of a standardized charging system has been an important factor hindering their efforts to promote EVs to the public *(a).*

Public infrastructure and workplace charging significantly increase the convenience of driving an EV and enhance consumer confidence in the technology. Over 1000 public chargers have been installed in California; they are found at a variety of locations, including shopping centers, city parking lots, airports, hotels, public agencies, and other businesses. However, access and utility of public charging is compromised by the fact that not all public sites have both inductive and conductive charging systems.

Because of the difficulty of maintaining accurate and up-to-date information on public charging sites (on webpages or through booklets), EV drivers are often unsure of which type of chargers are at a particular location. In addition, the existence of multiple charging systems reduces the net capacity of the public charging system *(b).* If two vehicles needing the same charger want to use the same public site, only one vehicle will be able to charge at a time. If all the chargers were standardized so that all vehicles can use the same chargers, then the actual capacity of the public charging system will be greater.

To compare, assume a similar situation in which different gas nozzles and pumps were required for different vehicles. Imagine the confusion that would result if a Honda Civic required a different gasoline pump and nozzle than a Toyota RAV4, and not all gas stations had all of the different pumps and nozzles. A standardized EV charging system would greatly enhance the access and utility of the public charging system by creating a situation analogous to the refueling of gasoline vehicles in which all gasoline pumps and nozzles are standardized for all vehicles. Once the standard is fully implemented (with all vehicles equipped with the standard charging system) and all public charging sites are retrofitted to the standard, then every EV driver will be assured that their vehicle is compatible with each and every charging station in California.

Cost Savings

The lack of a single charging standard also affects the cost of installing and maintaining public infrastructure. Public agencies and business partners have already invested well over $5 million towards the installation of public chargers in California over the last six years. By reducing the need to install two different chargers at public sites, cost savings will be achieved.

Equipment costs currently represent 20-30% of the total installation costs*(c).* Standardization will most likely result in a reduction in the number of charging and other related equipment (mounting pedestals, etc) that would need to be installed at each charging site. An estimated cost savings of $430,000-$875,000 in the year 2007 could be achieved as a result of reduced equipment costs per public charging site, or alternatively, this cost savings could be reinvested by expanding the total number of public charging sites or total amount of equipment available.

However, these cost savings are likely to be off-set in the near term. This is because of the resources that will need to be allocated to fund the retrofit of inductive public chargers to the conductive standard. Retrofits or replacements of some public chargers could cost between $1.4 to $2 million dollars after 2010. However, after the retrofit is completed, savings from reduced equipment costs resulting from only having to install one technology will continue to accumulate.

The costs associated with retrofitting public chargers to the standard will increase substantially the longer a decision on a standard is delayed. Standardization is also expected to decrease costs to consumers and fleet operators. By selecting the charging system with the greatest potential for future cost reductions and technology improvements, overall consumer vehicle and charging equipment costs will be reduced. Fleet costs will be reduced by only having to install one charger, instead of multiple chargers, for fleets using diverse types of EVs.

In addition, marketing, overhead, and maintenance costs will be reduced through focusing resources on one charging technology. It costs much more to market, develop, and maintain two competing technologies as opposed to supporting one industry standard. Maintenance costs will be reduced through only having to train service personnel in one technology. Reduced manufacturing costs should be realized through higher volumes than could be achieved without standardization. Standardization encourages multiple manufacturers to enter the market (volume), thereby creating competition and price reductions.

Non-Regulatory Proposals

In addition to reducing costs from the proposed regulation, substantial savings could also be achieved through a variety of non-regulatory efforts that could be implemented at the state and local level. These non-regulatory measures are designed to reduce installation and labor costs associated with installation of EV charging equipment. The non-regulatory proposals are described later in this report, and would help reduce the costs attributed to providing the required electrical capacity to support EV chargers. These costs are not affected by the type of charger that is installed.

The non-regulatory proposals include development of guidelines for pre-wiring at new residential and business sites. Often it is dramatically cheaper to upgrade the required electrical capacity at the time of construction than after construction is completed. These measure, when combined with the proposed regulation, will contribute to additional cost savings to consumers, fleets, and sponsors of public charging.

Stranded Resources

There are two competing charging systems; each system has had significant resources allocated for technology advancement and development of an acceptable consumer product. Each charging system has made significant technological advancements over the last four years. The selection of one charging system will ultimately need to be made; this selection will "strand" investments made in the charging technology that is not selected. It is in the market's best interest that the decision on standardization is made as early as possible, to prevent any additional resources from being "stranded."

2. Need for Regulatory Action

As discussed above, the lack of progress towards a single charging standard is a major impediment to the successful development of a sustainable consumer market for EVs. The best approach to standardization would be through cooperative industry efforts. Progress has been achieved over the last six years to establish and implement industry safety and performance standards. These standards have assured that all EV charging systems meet rigourous safety, durability and other industry standards which protect the consumer. However, virtually no progress has been made towards the selection of one charging system as the standard.

Four years ago, ARB considered establishing standards that would govern the type of charger to be installed when public agencies provide incentives or funding for infrastructure. Staff also considered a regulatory approach similar to what is now being proposed. However, ARB was encouraged to wait and "let the market decide." Several years have passed and a significant number of cars have been marketed. Unfortunately, little progress in the selection of a charging system as the standard has been achieved.

In addition, progress is not likely to be achieved over the next few years without ARB regulatory action. This is due to the fact that the industry continues to be evenly divided with regard to advocates for both charging systems. There is no independent non-regulatory selection process that would allow for a consensus agreement to be reached among all advocates.

Because ARB is responsible for the successful implementation of ZEV regulations, ARB regulatory action is clearly warranted.

3. Timing

The best time to standardize is when EV volumes are low. Postponing a decision on standardization will only result in increased costs as well as greater inconvenience to consumers. For example, if a decision was left to the market, and standardization was not fully implemented until 2009, an estimated 43,000 EVs would be marketed between 2006-2008, assuming that half the ZEVs credits come from full function and half from City EVs. 25,000 of these vehicles would be produced by the four auto manufacturers that do not currently use an on-board conductive system. Retrofits of charging stations needed to support such a large number of vehicles would be costly.

C. SUMMARY OF PROPOSED REGULATION

To achieve standardization of EV charging systems, staff recommends that the Board adopt two basic requirements. These are requirements (1) for a conductive connector standard and (2) for a charger located on-board the vehicle. Connector requirements are needed because, without a single connector for EVs, standardization is not achieved. The connector is what consumers use on a daily basis to connect their EV to the charging station. Secondly, the charger location (on-board the vehicle versus off-board) must be specified, so that all equipment will be able to be used by all consumers. Standardization of both the connector and the charger location will result in every EV being compatible with every EV charging station. The proposed implementation date for this requirement is 2006.

Connection Standard

Staff proposes that the Board require all EVs which qualify for a ZEV credit of 1.0 or greater to be equipped with a conductive connector vehicle inlet which meets the specifications in the Society of Automotive Engineers Recommended Practices (J1772, revised version which is currently in draft form). In addition, staff proposes that all grid-connected hybrid electric vehicles (termed extended range HEV in ZEV regulations) also be required to have the specified conductive vehicle inlet. Staff proposes that J1772, which specifies the requirements for the conductive vehicle inlet and connector, be incorporated by reference into section 1962.1 of Title 13 of the California Code of Regulations when issued by SAE.

Charger Requirements

In addition, staff proposes that these vehicles be required to have an on-board charger with a minimum output of 3.3 kilovolt amps (kVA). The requirement for an on-board charger is needed for two reasons. One, it will keep costs at a minimum; off-board chargers are very expensive when compared to on-board chargers. In addition, if every EV is equipped with an on-board charger, it will ensure that every EV can charge at every EV charging site.

Exemptions from regulations

Staff proposes to exempt all EVs which qualify for less than 1.0 ZEV credit, including all vehicles defined as neighborhood electric vehicles. In addition, staff proposes to exempt all EVs which qualify for greater than 1.0 ZEV credit and which will only be capable of Level 1 charging. Finally, staff proposes to exempt all grid-connected hybrid electric vehicles that will only be equipped with Level 1 charging.

Level 1 charging is defined by SAE and in the proposed regulation as a charging method that allows an electric vehicle to be charged by having its charger connected to the most common grounded household receptacle, commonly referred to as a 110 volt outlet.

1. Effect of Proposed Changes

The proposed changes will result in all ZEVs which receive 1.0 or greater ZEV credit and which are capable of Level 2 (220 volt) charging being equipped with a conductive charge port and an on-board charger. Beginning in the year 2006, it is estimated that approximately 6,257 EVs could be covered by this regulation. This estimate assumes that these EVs are full function EVs, and not smaller vehicles. Up to 12,000 EVs could be affected, assuming that auto manufacturers primarily produce smaller City type of vehicles and that they are all equipped for Level 2 charging.

Manufacturers that currently produce inductively charged vehicles would have to redesign their vehicles to include an on-board charger and conductive inlet. Also, one manufacturer that currently produces a vehicle with an off-board conductive charger would also have to redesign its vehicle. This impacts four out of the seven large auto manufacturers, specifically General Motors, Toyota, DaimlerChrysler, and Nissan. Staff estimates that if all of these manufacturers provide full performance EVs for the market in 2006, then 3,742 EVs that would have had the non standard charging system, will now be required to meet ARB's new infrastructure requirements.

2. Proposal Considered but Not Recommended

Staff considered requirements that would have specified the location of the vehicle inlet port to the front or front side of the vehicle. The goal was to facilitate the charging of EVs at public sites. Staff also considered requiring all EVs to be equipped with a Level 1 charger, as a convience to consumers. Staff concluded that requirements on the placement of the vehicle inlet port could hamper the design and innovation of EVs and is overly prescriptive. Staff also concluded that Level 1 charging may not be well suited to all EVs, and that the decision to provide this feature is best left to the auto manufacturer and the demands of the market.

D. TECHNICAL BACKGROUND

1. Components of EV Charging Systems

There are three basic components to a charging system: (1) the battery charger, (2) the connector or "plug," and (3) the wiring at the premises.

EV Battery Chargers

A battery charger is a device that transfers energy from the electricity grid to the vehicle battery for the purpose of charging the EV traction battery. EV battery chargers have several specific functions. They convert the alternating current (AC) distributed by electric utility providers (that is delivered from a 220 or 110 outlet) to the direct current (DC) needed to recharge the battery (known as rectification). They also regulate voltage in a manner consistent with the ability of the battery to accept current.

There are two basic charging systems currently in use. These are the conductive, and inductive systems. The conductive systems use metal-to-metal contact to transfer electricity from the charger to the car, similar to the traditional plug. The inductive system uses a paddle that fits into a socket on the car. Rather than transferring power by a direct wire connection, power is transferred by induction, which is a magnetic coupling between the windings of separate coils. Please refer to Figures 1 and 2 for more detail.

Another important consideration is where the charger is located. A charger can be located on the vehicle itself; in this case the electronic components that comprise the charger are incorporated into and are part of the vehicle design. The charger, because it is part of the vehicle, always goes where the vehicle goes. Or, as is typical with most non-vehicle battery chargers, the charger is a separate piece of equipment, and is not part of the vehicle. In this case, the vehicle needs to go to where the charger is located in order to recharge the battery.

In a typical conductive system, the charger is located on the vehicle. This includes the EVs marketed by Ford and Honda. DaimlerChrysler markets a vehicle with an off-board conductive charger. For inductive charging, the electronics that comprise the charger are split, with the major portion located off-board the vehicle. For practical purposes, inductive chargers should be considered off-board chargers. Toyota, GM, and Nissan EVs use the inductive charging system.

Connectors

The mechanical means by which the EV is connected to the power source is very important. This is accomplished through the insertion of the "connector." The connector is attached by cable to the EV charging equipment permanently affixed to the electrical outlet (see below for more details). The connector is inserted into the charge port (or inlet) located on the vehicle. This establishes the electrical connection (the technical term for this is coupling) for the purposes of charging the vehicle and for information exchange. In conductive systems, the connector is a plug. In an inductive system, the connector is a paddle.

The connector is the device that the consumers will use on a daily basis to connect their vehicles to the electricity grid. Different connector designs have been used by both the conductive and inductive charging systems. Each connector type requires a different vehicle inlet design (or use of a cumbersome adapter) in order to achieve a safe and effective connection of the EV to the electricity grid. True standardization will not be achieved unless both the charging system and the connector are standardized.

Electric Vehicle Supply Equipment (EVSE)

There is a great deal of confusion with the term "charger." This is because a typical conductive "charging station" does not include the charger itself, but only the premises wiring, safety, communication, and other equipment needed to interface with the electrical outlet. However, the "charging station" is often incorrectly referred to by users as a charger, even though the actual charger is located on the vehicle. On the other hand, for the inductive system, the charger is what is actually installed along with other equipment where the vehicle is charged. This confusion is a result of the fact that the conductive charging station looks and performs in a similar manner as the inductive charger.

Electric Vehicle Supply Equipment (EVSE) is a better term to use. EVSE refers to equipment, power outlets, or apparatuses installed specifically for the purposes of delivering energy from the premises to the EV. With an on-board conductive charger, the EVSE generally refers to the wiring and other equipment that provides an interface between the electrical outlet and the coupler. With an off-board conductive or inductive charging system, the EVSE also includes the charger itself.

2. Charging Methods

There are three different types of charging, based on the power levels utilized.

Level 1 Charging

A charging method that allows an electric vehicle to be connected to most grounded receptacles (NEMA 5-15R), typically found in residential garages, and to a more limited extent in outdoor receptacles. The power levels specified by industry standards are 120 volt, single phase. (This is also referred to as a 110 volt receptacle). The maximum current specified is 12 amps (continuous) with a branch circuit breaker rated at 15 amps. Continuous input power is specified as 1.44 kW.

For a vehicle equipped with an on-board conductive charger, the equipment for

Level 1 charging consists of an extension cord with a built in Ground Fault Control Interrupter (GFCI), a plug which fits into the electrical outlet, and connector which is compatible with the vehicle inlet. For inductively charged vehicles, the Level 1 equipment consists of an extension chord with a GFCI, a plug that fits into the outlet, and a small (1.4 kW) charger, and connector (paddle).

The power limitations tend to limit the practical use of Level 1 charging for EVs with large battery packs. The usefulness of Level 1 charging is inversely proportional to the size of the battery pack. It can provide an important safety net for consumers if sufficient time is allowed (20-36 hours generally to get a 80% state of charge on a vehicle like the Honda EV Plus). It is likely to have much more practical applications with smaller EVs, such as Neighborhood Electric vehicles, or City vehicles, which have smaller battery packs.

Level 2 Charging

Level 2 charging is the most common method to charge EVs. It uses a dedicated charging station which connects the EV to the electrical AC supply. The EVSE can be located at private, public, or workplace locations. The EVSE includes equipment permanently interfaced and connected to the electrical outlet. The power levels specified by industry standards are 208-240 volt, single phase. The maximum current specified is 32 amps (continuous) with a branch circuit breaker rated at 40 amps. Maximum continuous input power is specified as 7.68 kW.

The Level 2 EVSE consists of a wall box permanently interfaced to the AC electrical outlet, and a cable which connects from the wall box to the connector. For the inductive system, the EVSE also includes all of the electronics which comprise the charger, including power conditioning, thermal management, and communication systems.

Level 3 Charging

Level 3 is a charging method that utilizes dedicated EVSE in either private or public locations. It uses an off-board charger; this charger is very expensive but has excellent applications for fleets. The maximum power supplied for Level 3 charging should be capable of replenishing more than half of the capacity of an EV battery in as few as 10 minutes. For conductive charging, Level 3 is currently defined by industry standards as a charging method that provides DC energy from an off-board charger; there is no minimum energy requirement but the maximum current specified is 400 amps and 240 kW continuous power supplied. The Level 3 charging specifications for inductive are 208-400 volt, three phase, maximum amp of 400, with continuous power supplied of greater than 7.68 kW. Other methods of providing a faster charge include utilizing a charger located on the vehicle which can use a modified Level 2 charge station. This is described in more detail in other sections of this report.

3. EV Charging Systems

As described earlier, there are three basic types of charging systems: on-board conductive charging, off-board conductive charging, and inductive charging.

On-Board Conductive Chargers

The system extends AC (alternating current) power to the charger, which is located on the vehicle. Conductive charging equipment (EVSE) can be described as a power outlet; connecting to the electricity grid that does not require proprietary or exclusive hardware. In essence, it is simply analogous to an upscale version of a GFCI. Since the charger is located on the vehicle, it allows each car manufacturer to optimize the charger to the vehicle battery requirements. Honda and Ford EVs, older models of the RAV4 EV, as well as buses and a number of off-road vehicles utilize on-board conductive chargers.

Off-Board Conductive Chargers

An alternate method of charging uses an off-board charger that can accommodate higher power levels (up to 440 volts). In this case, the vehicle is basically equipped with a charger port, and the charger is a separate piece of equipment that is installed at the facility where the vehicle is garaged. The vehicle is charged with direct current provided by an off-board charger. The off-board charger uses a control pilot conductor which extends to equipment permanently connected to the AC electrical supply. The DaimlerChrysler EPIC uses an off-board conductive charger.

Conductive Connectors

Again, the connector is analogous to a plug for household appliances; the part that connects the "charging station" to the vehicle. Over the last ten years, several conductive connectors have been developed and used. This includes the butt and pin connector (Avcon, in reference to the only manufacturer), the pin and sleeve connector (Yazaki), and the ODU. The butt and pin connector is used with Ford and Honda EVs, some models of the Solectria and a number of off-road vehicles and buses. The pin and sleeve connector is used with older models of the Toyota RAV4 EV. The ODU connector is currently used by DaimlerChrysler.

The industry has moved towards establishing the butt and pin connector as the standard conductive connector. Standards for the butt and pin connector were established through a collaborative process with stakeholders through the leadership of the Infrastructure Working Council (IWC). The butt and pin connector is IWC's recommended conductive connector for North America. The Society of Automotive Engineers (SAE) is now considering revisions to conductive charging recommended practices (J1772) that include, among other things, the butt and pin as the recommended connector. As a practical matter, the butt and pin connector is the standard conductive connector for virtually all public charging installations in California.

Inductive Chargers

Inductive charging is a method of transferring power from the charger to the battery magnetically, rather than by direct electrical contact. In an inductive charging system, electrical energy is transferred to the vehicle via an inductive coupling that has no metal contacts. High frequency alternating current is applied to a coil in the charger connector, which drives a coil in the vehicle receptacle to produce a similar current by magnetic induction.

Inductive charging is based on energy transfer in a two-part transformer. The primary transformer is the coupler (or paddle), and the secondary transformer is the vehicle charge port. When the coupler is inserted into the charge port, power is transferred magnetically, with complete electrical isolation. The charger converts power received from the electricity grid to high frequency alternating current. The alternating current is then converted to direct current in the secondary transformer (vehicle charge port). The number of windings of coil on the charge port needs to be matched to the vehicle's battery pack voltage, so that the same charger can charge any vehicle.

Inductive Couplers

The coupler in inductive charging is a paddle that fits into the vehicle's charge port. It contains magnetic coils for energy transfer, an antenna for communications, a magnet for checking the connection, and provisions for locking the coupler to the vehicle to prevent tampering. The paddle has a plastic exterior and contains no metal contacts, these design elements were used to provide durability. GM states that the durability of the paddle design has been demonstrated for up to 40,000 insertions (more than 13 years of use).

There are currently two paddle designs in use. The standard coupler since 1994 has been a larger paddle design that used radio frequency (RF) to communicate between the charger and the EV. A new paddle for inductive chargers has been developed and deployed beginning in the year 2000.

The new design incorporates several improvements. These include reducing the coupler's size through the optimization of parts (cores, windings) and the cooling system. This smaller size is intended to make it easier to package in future EVs. In addition, the new paddle has replaced RF with infrared frequency (IR) communications, so that there would be greater world wide acceptance as a charging method. RF caused problems because many counties have regulations that limit the use of RF.

SAE Recommended Practices (J1773) has been revised for the new coupler design. The industry expects that by 2003, all inductive charging systems in the U.S. would be using the new coupler. J1773 provides requirements for an adapter, which allows vehicles equipped with a charge port for a large paddle inductive charger to safely use an inductive charger with the new small paddle.

The new smaller inductive charge port is now incorporated into the RAV4 Model Year 2000, the Nissan Altra and the Nissan Hypermini.

However, chargers with a large paddle are not able to charge vehicles equipped with the new small charge port. To address this situation, GM is planning to replace 480 public chargers with the new small paddle charger by the end of this year. This represents about 70% of the existing inductive public chargers. There is no specific plan to retrofit other types of chargers (residential and fleet) because these chargers are currently compatible with the vehicles leased by consumers and fleet customers.

4. Industry Standards

EV infrastructure has been designed and engineered for safety. There are a number of standards and recommended industry practices that provide the consumer with a very high level of safety and reliability. As part of the standard development process, charging equipment and components including the connector has undergone rigorous testing for safety and durability. In addition, considerable training and outreach materials have been established to ensure that EV infrastructure installed statewide meets the established standards.

Standards applicable to EV infrastructure include revisions to the 1996 California building code and the California and National Electric Codes. In addition, SAE Recommended Practices, as well as Underwriters Laboratory (UL) testing and listing requirements, have been developed and implemented.

These standards define EV charging equipment, specify where equipment can be placed, and detail all of the required safety requirements. The codes include requirements for acceptable connectors, cables, attachment plugs, outlets, and other devices for charging EVs. The standards also specify the minimum electrical supply that is required for EV charging systems, and safety features that are needed to prevent shock hazards. In addition, there are UL listing and labeling requirements which EV charging equipment must meet prior to being sold or installed.

Standards were developed through the collaborative work of stakeholders. Stakeholders include California Energy Commission (CEC), the National Infrastructure Working Council, auto manufacturers, ARB, ZEV advocacy groups, EPRI, charger manufacturers, infrastructure providers, electric utilities, and industry standard setting organizations. The industry standard setting organizations SAE, U/L, Fire officials, and building officials.

Society of Automotive Engineers (SAE) Recommended Practices

SAE developed recommended industry practices for conductive and inductive charging, but does not endorse either system as a standard. The recommended practices are developed through a "consensus" process in which SAE committee members identify and work through any areas of technical concern. Outstanding technical issues can be addressed through testing or further research until consensus is reached. SAE committee members include auto manufacturers, U/L, charger and component manufacturers, electric utilities, and other technical experts. SAE recommended practices are updated periodically to incorporate new information and keep pace with technology development.

The standard development process for SAE recommended practices includes, as a first step, endorsement by the SAE Electric Vehicle Charging Systems Committee (Committee). After approval by the Committee, the standard must be approved by the SAE Electric Vehicle Standards Forum, and finally the SAE Technical Standards Board. This thorough review process ensures that SAE standards undergo an extremely rigorous technical and scientific review. For this reason, ARB staff believes that SAE is the appropriate organization for establishing the appropriate technical specifications for incorporation into ARB regulations.

The goal of the recommended practices is to provide sufficient technical information so that potential manufacturers are able to design, construct, and develop EV charging equipment that is compatible with existing vehicles and charging equipment already in the market, as well as with new products. There is no specific compliance mechanism. For practical purposes, compliance is achieved through the U/L listing process. All charging equipment goes through a U/L testing and is listed by U/L prior to being used. The most important SAE standards cover coupling requirements (connector/vehicle inlet) for conductive and inductive charging systems.

SAE J1772 covers the technical requirements for the conductive coupler and vehicle inlet interface. It defines the general physical, electrical, and performance requirements for conductive charging and the vehicle inlet/coupler. The recommended practice identifies the primary means of conductive charging as a system which includes an on-board charger; however J1772 also accommodates charging with the use of an off-board conductive charger

J1772 was first issued in October 1996. A revised version of J1772 in draft form is scheduled to be issued later this year (July or August). The new version of J1772 will move the specifications for the butt and pin connector into the body of the report (from the Appendix of J1772), such that it will become the standard conductive connector for the United States.

The current version of J1772 does not specify the required dimensional test requirements for the vehicle inlet/connector interface because additional testing was being done when J1772 was issued. Appendix A of the Recommended Practice, which is not considered to be binding, identified the butt and pin connector (also known as the Avcon connector) as the connector that had out-performed all of the other connector/inlets tested. It states that the technology for this connector was in the process of being developed into a final proposed product design. Appendix A (of J1772) also proposed the pin and sleeve (also known as Yzaki) connector as an alternative, if needed.

SAE J 1773 covers the technical requirements for the inductive paddle/vehicle inlet coupling system. J1773 was issued in January 1995, and revised and reissued in November 1999. The latest version of J1773 was intended to provide additional detailed technical information on the vehicle inlet and connector so that it would allow manufacturers to build and test inductive charging components that would be compatible with other fielded systems.

The previous version of J1773 was thought to have focused too much on a specific application to the GM EV1. The revised J1773 is intended to provide a standardized set of requirements, and has removed a number of product durability and charge coupling efficiency requirements that were considered to be restraints hampering innovative design solutions for inductive charging. In addition, it included the specifications for the new small paddle as well as an adapter that could be used to allow vehicles equipped with a large paddle vehicle inlet to use the new small paddle chargers.

There are other SAE standards which cover EVs. One of the most important of these is J2293, which governs Energy Transfer Systems for Electric Vehicles. It is applicable to both inductive and conductive charging systems. J2293 is intended to ensure that energy flows from the EVSE to the battery once the driver couples the vehicle (i.e. the connector is put into vehicle inlet). The standard allows for electronic communication between the vehicle, the EVSE, and the utility grid on issues such as charging status, safety, ventilation, load management and maintenance. It is intended to ensure the interoperability of EVSE regardless of vehicle manufacturers or charger type. For a consumer this means that an EV equipped with an inductive charger can recharge at any charging station equipped with inductive chargers, and similarly for conductive chargers.

U/L Standards

EVSE is tested to SAE standards, and any other applicable UL requirements. If testing is successful, the product qualifies for a U/L listing. For practical purposes, U/L is the mechanism for implementation of SAE standards. Equipment without a UL listing is not considered safe for installations in California and is not used in public, commercial, residential, or fleet installations. U/L testing and listing is a comprehensive process, designed to ensure consumer safety.

U/L determines the appropriate testing program, based on an analysis of the product and a review and determination as to which standards apply to the particular product. U/L conducts the testing. If a product complies with all required testing, U/L issues a final report describing product test performance, construction details, and issues a Notice of U/L Listing. U/L staff conducts follow-up visits to the factory to determine compliance with U/L procedures. If the product and production facility complies, U/L sends a letter which permits the use of the U/L label.

5. Infrastructure Providers

Infrastructure providers are independent companies or municipal utilities who provide EV chargers and related equipment and services to public and private customers. All California infrastructure providers use licensed contractors to perform EV charger installations. Infrastructure providers may have distribution rights for specific charging equipment, and may share those rights with others.

Investor owned utilities are restricted by the Public Utilities Commission (PUC) to activities on the utility side of the electricity meter. However, investor owned utilities can form a company separate from the utility to install infrastructure. Because municipal utilities do not report to the PUC, but rather to local governing boards, they can have programs to distribute, install or finance infrastructure.

Currently, infrastructure providers install the vast majority of EVSE in California. They are responsible for ensuring that all installations are done safely and conform to applicable requirements, as specified in the California and National Electric and Building Codes. In addition, they are often called upon by consumers when problems are encountered with the charging of EVs because they are often the most accessible. These problems can be related to operator error, vehicle problems, electrical problems at the site, or with the EVSE.

E. TECHNICAL EVALUATION OF CHARGING SYSTEMS

The selection of a charging system will have a direct impact on consumers, auto manufacturers, charger manufactures, public agencies, electric utilities, and infrastructure providers. Most importantly, it has the potential to positively influence the marketability and acceptance of EVs by consumers, and thus can greatly contribute to the overall success of the ZEV program.

1. EV Charging Systems

There are three basic types of charging systems: on-board conductive charging, off-board conductive charging, and inductive charging. Below is a summary of each system. The previous section (Technical Background) contains a detailed description of EV charging systems.

<u>On-Board Conductive Chargers</u>
The on-board conductive system extends alternating current (AC) power to the charger, which is located on the vehicle. Conductive charging equipment can be described as a power outlet; connecting to the electricity grid does not require proprietary or exclusive hardware. Honda and Ford EVs, older models of the Toyota RAV4 EV, as well as buses and a number of off-road vehicles, utilize on-board conductive chargers.

<u>Off-Board Conductive Chargers</u>
An alternate method of conductive charging uses an off-board charger that can accommodate higher power levels (up to 440 volts). In this case, the vehicle is equipped with a charger port, and the charger is a separate piece of equipment that is installed where the vehicle is garaged. The DaimlerChrysler EPIC uses an off-board conductive charger.

<u>Inductive Chargers</u>
Inductive charging is a method of transferring power from the charger to the battery magnetically, rather than by direct electrical contact. In an inductive charging system, electrical energy is transferred to the vehicle via an inductive coupling that has no metal contacts. High frequency alternating current is applied to a coil in the charger connector, which drives a coil in the vehicle receptacle to produce a similar current by magnetic induction. The charger electronics are split, with the majority being located off-board the vehicle. For all practical purposes, inductive chargers are considered off-board chargers.

2. Evaluation Criteria

It is extremely important that the selection of an EV charging system as the standard be based on a thorough, comprehensive, and technical evaluation of information, utilizing objective data and input from all available sources. The comprehensive technical evaluation undertaken by ARB involved extensive public and stakeholder input.

ARB staff evaluated the three EV charging systems against a wide variety of objective criteria. These criteria can be broken down into three categories. All three of the broad categories were weighted equally.

- Cost and market considerations
- Consumer concerns
- Future technology growth and development

3. Cost and Market Considerations

Prices to consumers for charging equipment is an extremely important consideration. EVs currently cost significantly more to produce than conventionally fueled vehicles and are priced higher to consumers than a comparable gasoline vehicles. In addition, prices consumers pay for charging equipment and installation can be significant, and potentially act as a disincentive to consumers for purchasing or leasing an EV.

A distinction must be made between cost and price. Cost is the amount of resources spent in producing or manufacturing the charger and related equipment. Price is the amount which the buyer pays for the piece of equipment. Price usually includes a profit margin above the cost to produce, or conversely it can be subsidized by the manufacturer, in which case a profit is not made or a loss is sustained. Information on manufacturing costs is generally considered to be confidential.

The most important factors related to a determination of cost and market for EV charging equipment are:

<u>Total cost for producing the charging system</u>
This must include the entire cost, both for the charger components which are located on the vehicle, as well as any additional equipment the consumer must purchase. In addition, the potential for future cost reductions has been assessed, to the extent that information was available.

<u>Open Technology/Market Competition</u>
A competitive market is needed to encourage continuing product development and price reductions. An issue that is closely linked to a viable market is the availability of charging equipment, now, during the transition, and when standardization is fully implemented.

Another important consideration is the openness of the technology to additional manufacturers. Licensing fees or patents could limit the number of future manufacturers, and prevent a healthy competitive market that leads to continuing product development and technology advancements.

Other Cost Considerations

Consumers will be affected by the costs to service and maintain equipment, the costs to install charging equipment at public and workplace sites, as well as the cost for additional features, such as Level 1 charging and fast charging options.

4. Cost and Market: Summary of Technical Evaluation

Off-Board Conductive Charging Systems

Off-board conductive systems have very high costs when compared to either inductive or on-board conductive systems. The Manufacturers Suggested Retail Price (MSRP) for an off-board charger for a DaimlerChrysler EPIC is $8,000, which is dramatically higher than the comparable price of either the on-board conductive or inductive systems. These prices are prohibitive for public or workplace installation, and thus would essentially strand EV users from additional charging opportunities. Additionally, only one auto manufacturer with relatively small volume has produced vehicles with this charging system, and there is virtually no public charging available.

When compared to either on-board conductive charging or inductive charging, off-board conductive charging has substantially fewer advantages when evaluated in terms of cost and market. Therefore, ARB staff concludes that selection of off-board charging would require a major and extremely expensive transformation of EV infrastructure in California.

Comparing inductive and on-board conductive systems against cost and market considerations contributed to ARB staff's conclusion that on-board conductive charging has greater benefits that inductive charging. Staff's evaluation is summarized below.

Current Cost and Potential for Future Reductions

Information on manufacturing costs is considered highly confidential and difficult for staff to obtain. Based on the available information, staff has concluded that on-board conductive systems currently has lower manufacturing costs and will be able to achieve greater cost reductions in the future than inductive systems. This is due to several advantages of on-board conductive systems. These advantages would result in reductions in current manufacturing costs for full performance EVs, as well as the reductions that can be achieved by the production of smaller (and thus less expensive) chargers for vehicles with smaller battery packs. One of the most important advantages to an on-board conductive system stems from the fact that because the charger is on the vehicle, it can be sized for the vehicle traction battery. Thus, costs can be dramatically minimized for smaller City type vehicles.

Based on information provided to staff, at current production volumes, the system cost of the on-board charging could be as low as **$**1900 for a full performance vehicle. Staff estimates that current cost ranges between $1900-$2800. The cost of the charging system (on and off vehicle components) for City vehicles (with smaller battery packs) is expected to range from $1400-$2100. System costs are expected to decrease by 50% through system improvements and reductions due to large volume production (volumes of 20,000). This would result in a system cost of $950 for a full performance vehicle at $700 for a City vehicle.

The variability in cost estimates is a result of three factors. One, the size (or power rating) of the battery charger is variable and affects the total cost significantly. Two, the cost of the other on-board components is determined, in part, by how the charger is integrated into the vehicle system. And finally, the cost of the off-board conductive charging station varies significantly, based on the model and features selected. Currently, conductive charging stations can be purchased for as little as $350.

ARB staff estimates that current system costs for inductive charging system currently averages $3200. The Appendix contains a more detailed discussion of costs. Long term costs for inductive systems are highly confidential. As a rough estimate, staff applied the 50% reduction factor used in the analyses of the conductive system, which results in a system cost of $1600 for large volume production. This may be under estimated since, as opposed to conductive chargers which is an “off-the-shelf” and proven technology, the inductive system is still undergoing technology development and engineering design improvements. Improved engineering and less complex designs may have the potential to further reduce costs.

Fixed costs associated with the standard inductive charger located off the vehicle provide little flexibility for sizing the charger to the vehicle traction battery. In addition, changes or advances to the technology, such as the recent conversion to a smaller paddle, require replacement of the more expensive fixed infrastructure, as compared to the less complex and lower cost and conductive charging stations.

It should be noted that the costs cited above are for charger systems. The cost of the charging station, which the owner would put in their garage or which would be purchased for a public site, will be significantly less with the on-board conductive system.

Open Technology/Market Competition

One potential disadvantage to the inductive system is that patents covering technology development, and increased costs for servicing a more complex fixed off-board infrastructure will result in inductive technology having much greater difficulty in keeping pace with the expected cost reductions of conductive charging systems.

Locating the charger on the vehicle minimizes the need for patents and licensing fees and thus additional expenditures to new developers. This is because the majority of the "intellectual property" is located on the vehicle and is directly under each developer's control. The opposite situation exists with inductive charging, in which the majority of the "intellectual property" is located within the more complex fixed off-board infrastructure.

Development of inductive charging products has largely been done by GM, and more recently Toyota. There are a number of patents covering inductive technology and product development that could potentially inhibit other vehicle or charger manufacturers from developing competing but comparable systems. Several years ago substantial licensing fees were required. However, GM has recently submitted written comments to ARB stating that they encourage new manufacturers and do not currently require license fees as a prerequisite for producing inductive chargers based on their designs. Still, the uncertainty regarding patents and licensing fees represents a potential hurdle to expanding market competition**.** The potential future impact on new manufacturers could range from no impact (if licensing or patent fees continue to not be required) to significant impact (if substantial licensing fees are ever required in the future).

The conductive connector is licensed. The licensing fee for the conductive connector is $100,000 plus four percent of profits. This represents a small fraction of the entire cost of manufacturing a conductive system. If it is assumed that 21,000 vehicles are produced between 2006 to 2008, and the cost of the conductive charging (on and off vehicle components) is $1,000, total charging system costs are estimated to be approximately $21 million. Total projected costs attributed to the licensing agreement are estimated as $184,000 which represents less than 1% of the total manufacturing cost for a conductive charging system.

Both conductive and inductive equipment has experienced supply problems, due to the limited number of producers. Supply problems have been experienced in the past with both conductive charging equipment, and the availability of the connector. This has been due to the difficulty of small companies being able to keep pace with changing demand. The demand for EV charging equipment can often be unpredictable, due to unanticipated peaks and valleys in EV marketing efforts and vehicle availability.

There were some supply problems with the availability of small paddle chargers produced by Toyota last year. This supply problem has largely been corrected, and was largely due to production start-up issues. Toyota began manufacturing chargers last year. Inductive chargers have some limits to availability imposed by manufacturers.

Toyota limits its charger sales to those agencies or individuals who lease Toyota or Nissan EVs. GM is currently not making its small paddle charger available for sale to those business and public sponsors of new public charging installations. However, GM is providing 480 small paddle chargers at no cost, as part of its retrofit program. This program, described in the next section, results in older, out-of-warranty chargers being replaced with new chargers.

Other Cost Considerations

There are many benefits to an on-board conductive charger. The charger goes where the vehicle goes, thus removing the need for installation of expensive fixed infrastructure at numerous locations. This consideration is extremely important when the costs for supporting public and workplace charging are considered. For inductive systems, a charger must be installed at each site, as opposed to the on-board conductive system, in which only a lower-cost charging station is needed to support additional charging capacity.

In addition, service and maintenance can be less expensive and more easily handled when the charger is located on the vehicle. Finally, because of the simplicity of the conductive charging station, it can easily be serviced by an electrician, as opposed to the more complex inductive charging station which would either require equipment replacement or specially trained service technicians.

5. Consumer Concerns

A number of issues or factors impact consumer acceptance of EV technology. These include the reliability of the equipment, access to public charging, charging efficiency, and the ability to use other features, such as Level 1 charging. The following factors were considered with regard to consumer issues.

Charger reliability, durability, and safety considerations

Charger reliability, durability, and safety are very important. As more EVs enter the marketplace and are driven by an increasing number of consumers, the reliability, durability and safety of chargers will contribute to consumer acceptance of the technology.

Consumer-friendly, Ease of Use and Product Support

The ease of use of the charger and connector and how "user friendly" it is perceived to be by the consumer contribute to the development of a wider market for EVs and acceptance of the technology. The support that manufacturers provide for their equipment greatly enhances a positive consumer experience.

Charger efficiency

The efficiency of charging systems will be of greater importance, as the number of EVs grows. Public charging is generally provided free of cost to EV drivers as an incentive to encourage the technology. However, electricity rates in many parts of the State have increased, or are expected to increase. As vehicle volume increases, staff anticipates that the time will come when property owners may wish to pass on costs for electrical use on to EV drivers. The EV charging system with the greatest efficiency would be able to keep such costs at a minimum.

Accessibility to public charging

Public infrastructure enhances the utility of EVs. Drivers can extend the length of their trips if they know that convenient recharging facilities will be available at their destination.

Level 1 Charging

The ability to charge using a standard household outlet when a Level 2 charger is not available can provide additional options to EV drivers and enhance acceptance of the technology.

6. Consumer Concerns: Summary of Technical Evaluation

When evaluated against a number of factors that directly impact the consumer, both on-board conductive and inductive charging technologies have demonstrated excellent safety, reliability, and durability. The analysis below indicates that inductive charging excels in several areas which impact the consumer. These include ease of use, product support, and greater accessibility of public charging. Conductive systems have definite benefits in other areas, these include Level 1 charging and higher charging efficiency.

Safety

All systems meet stringent industry safety standards. Charging equipment generally exceeds safety standards of conventional consumer products and assures the consumer of an extremely high level of safety. Inductive charging proponents have argued strongly that the inductive system has an inherent advantage with consumers due to the perception that the paddle design is safer. However, ARB staff has concluded that the safety of both systems is assured by compliance with industry standards. Perceptions of safety can be addressed through consumer education and outreach programs.

Reliability and Durability

There are no peer reviewed data with regard to charger reliability. However, both systems appear to perform well. Southern California Edison (SCE), which has one of the largest EV fleets in the country, tracks EV charger performance. ARB staff evaluated SCE data on the performance of charging equipment last year. This data covered 203 charging stations and indicated that both systems had very similar levels of reliability. ARB staff has had extensive experience with infrastructure through EV demonstration and lease programs. ARB has funded the installation of more than 150 permanent and 300 temporary charging stations. ARB's experience has also been that both charging systems have similar levels of reliability.

There have been some problems experienced in the last year, however. GM had to recall its 1997 model year EV1s and S10s, due to a defective component located in the vehicle inlet or charge port. The failure of this component could have resulted in a fire. GM has attributed the failure of this component, from a specific supplier, as the sole reason for the problem. GM staff has also provided information to ARB which supports the argument that the reason for the recall is not a result of any defect in the design or function of the inductive charging system.

The conductive connector has had some problems with excessive and unexpected breakage or wear. This problem does not cause any safety concerns. However it can result in the breakage of the vehicle charge port, or prevent the charge port mechanism from being engaged, thus not allowing the EV to accept a charge. The durability problem has been corrected through retooling, the use of improved molds and materials, including a higher grade plastic. The new connector has been tested in the laboratory for up to 10,000 insertions (the industry requirement) and is now considered to be very resilient.

Consumer Friendly, Ease of Use, Product Support & Access to Public Charging

Inductive charging equipment excels in many consumer attributes. The paddle is easy to use, and the charging equipment has been designed and packaged to be appealing to consumers. The paddle ergonomics are easier, with only one motion required, rather than two with the conductive connector. Conductive equipment is easier to use than a gasoline pump, but has not achieved the same level of ease of use as the inductive paddle.

Both conductive and inductive manufacturers warranty their equipment. Conductive equipment currently has product warranties which range from one to three years, depending on the model selected. Inductive chargers are warranted for three years. GM currently provides impressive customer support for their chargers. This includes dispatching its service providers to respond to both residential and public charger problems. They are currently funding the upgrade of 480 public chargers to the new smaller paddle design. They are also continuing to support out-of-warranty public chargers.

Public charging provides an important safety net and is an important factor in encouraging consumer usage of EVs. Both conductive and inductive public charging is available in California. Estimates of public charging provided to ARB by the California Electric Transportation Coalition indicate that currently there are 617 inductive and 378 conductive public chargers. This results in about 60% of the public chargers being inductive.

This disparity is a result of the fact that the EV1, an inductively charged vehicle, was marketed almost exclusively to consumers. Efforts were made to ensure that there was adequate public charging, particularly in Southern California, to support the consumer market. GM contributed over one million dollars for public infrastructure installation in the South Coast district. Many of the conductively charged EVs, in contrast, were marketed only to public and private fleets. An exception to this was the Honda EV Plus.

Charger Efficiency

Conductive charging appears to have a clear advantage with regards to charging efficiency. Most conductive chargers presently deployed have efficiencies greater than 92%. They are able to maintain high efficiencies at low power levels that exist as batteries finish charging for long periods of time. Although inductive chargers may have a peak efficiency of 92%, this drops off substantially at low power levels. This could be particularly important when considering consumer costs, or the use of smaller City type vehicles that charge at lower power levels.

Toyota provided efficiency data to ARB and submitted comments to ARB staff that conductive charging efficiencies would degrade over time, due to wear and corrosion of the conductive connector. Due to the lack of independent data on charging efficiency, ARB staff is now testing different vehicles and chargers and will provide the data on charging efficiency when tests are completed.

GM has provided written statements to ARB that efficiency should not be significant criteria in the selection of an EV charging standard. GM decided not to support ARB charging efficiency measurements on the EV1 and S10, because of the concerns that there was insufficient time in the regulatory development process to appropriately comment on test measurements and results.

Level 1 Charging

Level 1 charging is an option that allows a consumer to charger an EV by plugging a small device into a standard 110 household outlet. These outlets are usually available in outdoor locations and residential garages. Level 1 conductive units have demonstrated superior performance and lower cost compared to inductive units.

For the inductive system, a Level 1 charger consists of a GFCI plug and cord attached to a briefcase size 1.4 kilowatt charger and paddle. This device is relatively large, heavy and expensive when compared with the conductive system. Because the charger is on-board the vehicle, Level 1 equipment for on-board conductive systems is simply an extension cord, GFCI (safety device), and a connector which fits into the vehicle inlet.

7. Technology Advancement

The ability of charging systems to keep pace with technology advancements is an important consideration. EV and charging technology have made impressive advancements and continuing advancements are anticipated. The ability to incorporate new charging innovations and new vehicle applications, as well as consumer needs and demands will be important to ensuring the marketability of

EVs over the next decade. This is particularly important, given that infrastructure standardization will not be completely implemented until 2006. The following are the factors that ARB considered the most important with regard to promising technology advancements.

Vehicle to Electric Grid Power Services

There is growing interest in the use of EVs as a future resource for the California electric grid. EVs could be a source of power to the electricity grid when not in use; this is termed "vehicle to grid" power services. Deployment of EVs with vehicle-to-grid power delivery capability would provide another source of value to the owner of an EV, and thus provide an additional incentive to encourage the consumer to purchase or lease an EV. This incentive would be provided without public costs because the electricity market would be paying the vehicle owner for these energy services.

High Power Charging

The importance of high power charging is emphasized in the ZEV regulations. The ZEV regulation, as modified by the Board in January 2001, provides higher range multiplier values for ZEVs capable of fast refueling. High power charging has the potential to increase the real world driving range of the vehicle, and thus can provide attractive benefits to both consumers and fleet operators. Thus, high power charging can contribute to enhancing the marketability of EVs over the next decade.

There are two basic types of high power charging. One uses dedicated off-board chargers and is termed "Level 3" charging. The other alternative, Level 2+ (or 3AC) relies on an on-board charging system and can provide a faster charge than Level 2 charging, but has a longer charge time than required under the Level 3 charging definition.

Auto Docking

Auto docking refers to a method of connecting the EV to the charger. This is a method that would allow a driver to connect the EV to the charging equipment in a more automatic fashion, such as driving over an apparatus which would automatically engage the vehicle to the charging equipment. There has been some interest in this as a way to increase consumer appeal as well as provide a business opportunity to recoup costs for public charging.

8. Technology Advancement: Summary of Technical Evaluation

Vehicle to Grid Power Services

Vehicle to grid applications fall into several general categories. These include the use of an EV for (1) ancillary services, and (2) as a potential source of base power generation. In addition, there is an added potential to use EVs as a source of back-power when the residence, fleet facility, or contractor site is disconnected from the grid.

When the present EV charger connection systems were developed, they were only expected to deliver power to charge EVs. At that time, there was very little discussion of the possibility to deliver power from an EV to the electric grid. Much has changed in the last 10 years. During this time, the common definition of zero emission vehicle has been expanded from EV only to an entire family of electric-drive hybrid electric and fuel-cell vehicle configurations. ZEVs, including EVs, contain all of the basic components needed for a distributed power generation source.

ARB recently funded a study conducted by the University of Delaware, Green Mountain College, AC Propulsion, Inc., and the University of California. The goal of the research was to examine the viability of EVs as power resources. Their conclusion was that the estimated cost of electricity from EVs is too high to be competitive with base load power generation, but that EVs were found to be cost competitive in three other markets: “peak power,” spinning reserves, and regulation up/down. These last two markets are called “ancillary services” and are used by the California ISO to cover imbalances between scheduled and actual power flows.

A number of factors need to be thoroughly evaluated before vehicle-to-grid is a wide spread consumer option. Attention is now focused on assessing the long-term impact that vehicle to grid power would have on vehicle batteries, possible impacts with regard to power quality, coordination with electric utilities and the grid operator, identifying any safety issues, as well as assessing the potential economic benefit to consumers. However, the prospect for future vehicle to grid uses appears to be extremely promising.

Several auto manufacturers are investigating the viability of this. In August 2000, Nissan was awarded a patent called "Household Supply System Using Electric Vehicle". Daimler Chrysler and EPRI have expressed the view that vehicle to grid will be available in the future. Ford in currently researching the use of electric drive vehicles as a back-up energy source for residences and businesses.

Conductive charging connections are simply an extension of the 50/60 HZ AC electric grid to the EV with no intermediate conversions necessary as there are with inductive systems. All existing conductive charging infrastructure would be suitable for receiving power from electric vehicles with little or no modification to the charging station, cables, and connectors. However, on-board vehicle components must be designed to allow this application. The integrated chargers under development are anticipated to be capable of providing vehicle to grid power. Integrated chargers produced by AC Propulsion already have this capability.

Staff has concluded, based on the information provided in the above described report, that while vehicle to grid power flow from inductive chargers is possible, it would be cost-prohibitive. Today's inductive chargers are not capable of carrying vehicle to grid power. An inductive charger connection could be designed to do this. Such a design could use the same paddle and vehicle inlet, but would require adding components to the vehicle side so that it could send power, and adding components to the grid side so that it could receive power.

The duplication would add considerable cost complexity to inductive chargers. Another consideration is that increasing power capacity also would likely increase charger cost significantly. However, there may be some interest in vehicle to grid from inductive users, as Nissan has a patent for vehicle to grid inductive application.

High Power Charging

Level 3 charging has been demonstrated for both inductive and conductive systems. There are two major hurdles to the widespread deployment of Level 3 charging. These are, most importantly, the high cost of the off-board charge station, which has made it very difficult to demonstrate cost-effectiveness for this feature, given the current number of EVs. Second is the ability of the traction battery to accept a high current without adverse effects.

Off-board conductive charging stations can cost in excess of $45,000, and are not anticipated to come down in cost significantly due to the low production volumes in the mid-term. There are currently no high power inductive chargers commercially available. However, looking forward 10-15 years in the future when vehicle volumes exceed 100,000, it may become an economically feasible approach. Given that it is currently very difficult to show a business case that will recapture the high cost of the charge stations for a consumer market, it is unlikely that high power charging utilizing off-board chargers will move beyond specific fleet applications in the next decade.

Regarding commercialization of Level 3 charging, only one EV on the market is currently capable of Level 3 charging. The DaimlerChrysler EPIC, an off-board conductively charged EV, is capable of accepting Level 3 charging. Level 3 charging is now used successfully by some fleets with the EPIC. The other conductively charged passenger EVs, which include the Ford Ranger, Honda EV Plus, and older models of the RAV4, are not currently capable of Level 3 charging. A similar situation exists with all of the inductively charged vehicles on the road.

Level 3 charging for vehicles equipped with on-board conductive chargers will not be available until the auto manufacturers determine that there will not be any adverse impacts on the traction batteries, and high power connectors and vehicle inlets undergo further demonstration and testing. Currently, a high power version of the standard conductive connector (butt and pin) is not commercially available, but a prototype is available for testing and demonstration purposes. Avcon, the single manufacturer of the butt and pin connector, testified at the February 27, 2001 workshop on standardization that they are waiting for industry support before any additional resources are allocated to the commercialization of a high power connector.

Level 3 inductive chargers have been demonstrated in a six month demonstration study with the S10 pick-up truck. According to information provided by GM, that study successfully demonstrated the feasibility and usefulness of inductive high power charging. Other information has indicates that the small paddle has proven to be capable of charging at power levels from one to 120 kilowatts. These high power levels are accommodated through a liquid cooling system located in the coupler.

GM and Toyota have submitted comments that if there is a need for Level 3 charging, they would be able to produce high power chargers. To date, no manufacturer of inductively charged EVs has indicated an interest in producing a vehicle capable of accepting high power charging.

However, there is an unresolved issue as identified in SAE Recommended Practices for inductive charging (J 1773), which will need to be addressed prior to commercialization of Level 3 inductive charging. The Appendix of J1773 identifies an resolved issue regarding how to communicate the vehicle inlet power rating to the charger independently of the normal J1850 data communications interface. A second IR beacon has been proposed, but a detailed design has not yet been incorporated into J1773.

Level 2+ charging (also referred to as Level 3AC), is theoretically possible for an inductive system however no auto manufacturer of inductively charged EVs has announced any plans to develop such an application. In contrast, there are considerable resources committed to the development of conductive Level 2+ systems These systems appear very promising.

Many EV manufacturers and suppliers are considering the use of integrated charging systems, and several have patents or have publicly disclosed their designs or interest in this approach. These include Fuji, Ford, Toyota, Renault, and Volkswagen. Integrated charging systems utilize some or all of the power system components used to drive the vehicle for the charging function. It can result in a charger with a higher power capacity than that used by Level 2 charging, but less than required for Level 3 charging.

Integrated charging is considered by many in the industry as to be the only economical way, in the near to mid-term, to provide cost-effective higher power charging than currently available from Level 2+ charging. However, there are issues that would need to be further resolved prior to commercialization. The most important of these may be whether electrical upgrades would be necessary to accommodate higher current draws and whether such upgrades, if required, would be cost-effective for most consumers.

Because of the interest and technology resources currently invested in the development of these systems, it appears that Level 2+ has excellent prospects for commercialization by the proposed implementation year of 2006. Prior to deployment, it is likely that conductive charging standards would need to be updated by SAE.

Auto Docking

There are two basic types of auto docking systems. One is a "drive-over" system that automatically engages the charging system. The other involves the use of robotic arms that extend into the conventional charge inlets on the EV and commence the charging process for the user. Auto docking systems are considered by some as having potential for public charging applications, as well as for use in station car programs and residential installations.

The robotic systems would not necessarily require modifications to the vehicle charge port, and are quite similar to automatic gasoline dispensing systems that have been taken to the level of public demonstrations in Europe. The robotic type of auto dock system could be fitted with either inductive or conductive couplers at the end of the robot arm. Staff is not aware of any work or resources committed to the development of robotic type auto docking systems.

There have been several efforts to develop and demonstrate drive over auto docking systems for EVs. Inductive drive over systems have been demonstrated, product concepts proven, and several patents for applications exist. However, staff has been unable to identify any significant resources that are currently being allocated for the development of commercial drive over inductive system. Inductive drive over auto docking systems are more feasible and cost-effective than one based on a conductive application. Staff's assessment is that inductive charging has a clear advantage regarding the development of auto docking "drive over” systems," but that commercialization of this application does not appear to be very promising at this time.

For consumer applications, it is not clear whether the additional complexity and cost of auto docking is justifiable. In a recent study on grid connected hybrid electric vehicles, participants were asked about their preferences for vehicle options on the basis of plugging in versus going to the gas station. The results were that approximately 36% of participants were neutral, but 63% preferred the option of nightly plugging, and less than 1% preferred periodic gasoline refueling.

These results and other EV driver market surveys suggest that manually plugging in a EV at home does not pose a significant inconvenience, and is preferable to stopping at a gasoline refueling station periodically. At this time, it is difficult to ascertain whether consumers will ever be willing to pay for the added cost of auto docking.

9. Summary of Technical Evaluation of Charging Systems

The table below summarizes ARB staff's evaluation of EV charging systems.

Criteria	Inductive	On-Board Conductive	Off-Board Conductive	Priority
Cost and Market				
Total Cost for producing the charging system (current)	++	++	+	Medium
Total cost for producing the charging system (future)	++	+++		High
Open Technology/Market Competition	+	++	++	High
Other Cost Considerations		++		Low-Med
Summary Cost & Market		✓		
Consumer Concerns				
Accessibility to public charging	+++	+		Medium
Consumer-friendly, Ease of Use	+++	+		High
Reliability and durability	+++	+++	+++	High
Product Support	+++	+	+	Medium
Safety	+++	+++	+++	High
Charger efficiency	++	+++	++	High
Level 1 Charging	+	++		Low
Summary Consumer Concerns				
Technology Advancement				
High Power(Level 3)	+	++	+++	Med-Low
High Power (Level 2+)		++		High
Vehicle to Grid		++		High
Auto Docking	++	+		Low
Summary: Technology				

The previous table shows the results of an analysis which weights each category equally: Cost and Market, Consumer Issues, and Technology Advancement Within each category, specific criteria were given a low, medium, or high priority. On-board conductive systems, ranked equal or better than inductive and off-board conductive systems in seven out of the eight criteria identified as high priority. In addition, on-board conductive systems showed clear and significant advantages in two broad categories: cost and market and future technology advancement, when compared to the other two systems.

Greater focus will need to be paid to public charging issues. Inductive charging proponents have made significant financial commitment and support for the installation of public infrastructure. There is a need to expand commitments and resources for public charging. To this end, focused efforts must be made to ensure that access for inductively charged vehicles are not disrupted and public chargers are maintained. Additionally, auto manufacturers and public agencies will need to work closely together to retrofit and support existing public charging during the transition.

On-board conductive charging has clear advantages in terms of cost and market and future technology development. However, there is need for improvement with regards to some consumer issues. Specifically, improvement in product support and ease of use is expected to occur during the transition period, as conductive charging products are further developed into attractive consumer products.

F. OUTSTANDING ISSUES

Since the January 2001 Board meeting, staff has held one public workshop, two stakeholder meetings, plus a number of meetings with individual Stakeholders. Topics at these meetings included discussion of ARB staff's technical evaluation of charging EV systems, need for standardization and impacts, both positive and negative, of standardization. In addition, staff discussed and explored a number of different implementation strategies, including the proposed regulatory strategy recommended in this report.

As a result of these meetings and discussions, staff has identified several issues needing resolution as we move forward with EV charger standardization.

1. Potential Impacts on Vehicle Marketing

The transition to the standard will occur between 2001 and 2006. Nissan, Toyota, and General Motors have expressed concerns regarding the ability to market inductively charged vehicles during the transition to the standard. The expressed concern is that both consumers and fleet customers would be reluctant to purchase or lease inductively charged EVs with the standard that is not selected.

ARB staff has been unable to collect any data that indicates there would be any significant marketing problems. ARB staff has asked to meet with manufacturers to discuss product plans and identify any potential marketing issues. To date, neither GM, Nissan nor Toyota has agreed to meet with ARB staff to discuss marketing plans. In addition, staff has had discussions with utility fleets who leased the majority of EVs produced by Toyota, and they have indicated that they would still purchase or lease inductively charged vehicles through the transition. Depending on product plans (which have not been shared), impact on fleets would range from no impact to mild impact.

However, most important, there is the impact for the consumer. Without a standard, they may be confused as to which charging equipment to purchase for their garage. They may be very concerned about being "stuck" with a technology that will not be used in the future. Delaying standardization by only three years, results an additional 43,000 EVs in being marketed; 25,000 of these vehicles would be produced by the four auto manufacturers who currently do not use an on-board conductive system. This would result in considerable confusion for the consumer.

2. Public Charging Retrofit

Some public charging would, over the next five to eight years, need to be retrofitted to the standard. This will involve removing inductive chargers and replacing them with conductive chargers. Currently, an estimated 60% of public charging statewide is inductive.

Staff anticipates that all public charging would not need to be retrofitted by the year 2015. This assumes that inductively charged EVs continue to be marketed through the year 2005, and that they remain in service for 10 years. The retrofit of public charging will need to be based on the deployment of EVs, with a particular focus on those EVs that are marketed to consumers. The goal is ensure that all consumers continue to have access to public charging and are not "stranded".

ARB does not have responsibility for installation or maintenance of public infrastructure. Public charging has been supported by the California Energy Commission, local air districts, other public agencies, business partners, and auto manufacturers. Funding will need to be secured for this retrofit, responsibilities allocated, and a plan developed which is closely coordinated with EV deployment. ARB staff estimates that the retrofit would cost approximately two million dollars, spread out of many years.

Some of the past sponsors of public charging may not be willing to provide new funds for this retrofit. In particular, General Motors has been one of the largest sponsors of public charging, but has made comments both opposing standardization and the selection of conductive charging system as the standard.

3. Supply During the Transition

It is anticipated that public and workplace installations will immediately focus on conductive equipment only, if the standardization proposal is adopted in June. Currently, there are two small companies that manufacture conductive charging equipment; one of these companies is currently the only supplier of the conductive connector. While not anticipated, there is a possibility that there could be short-term supply problems during the transition period. However, should this occur, it is anticipated to be only a temporary problem. Once the standard is fully implemented, additional manufacturers are expected to enter the market.

4. Transition Plan

It is very difficult to develop a transition plan as part of the regulatory proposal. These difficulties stem from the fact that ARB does not have lead responsibilities for public infrastructure, and that many of the stakeholders are currently focused on responding to the ZEV regulatory requirements. Also, it is extremely difficult to develop a transition plan without information on auto manufacturer's product plans.

Staff recommends that the ongoing Infrastructure Stakeholder Group be asked to assist in the development of a Transition Plan. Members of the Stakeholder Group include CEC, auto manufacturers, air districts, charger manufacturers, and other technical experts. ARB staff proposes to return in late 2002 with a non-regulatory Transition Plan for the Board's review.

5. Vehicle and Charger Compatibility

Toyota staff has expressed concern regarding compatibility of charging equipment produced for the proposed regulations. They state that there is not enough specificity in J1772 to ensure that equipment manufactured by different companies will be "front and back" compatible. "Front and back" compatible refers to the need to ensure that a Toyota EV would be able to charge using equipment and connector produced by another company. Given that five years is proposed for implementation, ARB staff concludes that any compatibility problems could be addressed by the auto manufactures working together, as they currently do in SAE committees, and other technical forums.

G. REGULATORY ALTERNATIVES

1. Take No Action

The Board could take no action, and make no further changes to the ZEV regulations regarding charger standardization. This approach would defer state regulatory action to market forces. The Board would continue to "let the market decide," as it has for the last four years on the selection of EV charging technology. This would leave the process up to auto manufacturers, charger manufacturers, and individuals and businesses with an economic interest in the outcome to cooperatively agree on a single charging system and connector standard.

This would likely result in EVs continuing to have different charging systems and different connectors. Consumers would continue to be confused, and be more apprehensive about embracing EV technology. The market expansion for battery EVs could be severely compromised. Costs of charging equipment would not come down in price as quickly as with regulatory action, because of the additional resources which are needed to manufacture, distribute, and maintain several different technologies. The costs of installing and maintaining public infrastructure would continue to remain high.

2. Public Policy Initiative

An alternative to a regulatory requirement is to establish a non-regulatory State policy to encourage auto manufacturers to produce cars with the conductive charging system. This would involve the issuance of a Governor's Executive Order to establish a policy applicable to all new and existing State funding allocations, and similar initiatives at the local level which would apply to cities, counties, and air districts. On a parallel path, funding for infrastructure installation and ZEV incentive funds would be limited to the compliant conductive charging equipment and those vehicles equipped with the standard.

This approach relies heavily on government policies and public funds to encourage the EV market to voluntarily move towards the standard EV charging system. However, there is much less guarantee of success than with a regulatory approach. There is considerable uncertainty as to how actively it would be embraced by state and local agencies

3. Alternative Standards

The Board could select either inductive or off-board conductive as the standard. This approach would result in all vehicles, beginning in the year 2006, being required to be equipped with a new standard that has higher costs and less advantages for the consumer that the on-board conductive system.

Off-board conductive charging systems have high equipment costs than either on-board conductive or inductive systems. In addition, there is virtually no public charging has been installed because only one EV produced in relatively small volumes has been equipped with this charging system. Selecting off-board conductive as the standard would result in the highest equipment costs and require a major and relatively expensive transformation of public EV infrastructure in California.

Inductive charging systems are not expected to achieve the reductions in cost that on-board conductive systems will in the next few years. Selection of inductive as the standard would result in ARB requiring all auto manufacturers to use the charging technology that has higher manufacturing costs, lowest charging efficiency, and less potential for future technology growth.

H. ECONOMIC IMPACTS

The proposed addition to the Zero Emission Vehicle program will increase costs borne by some automobile manufacturers, and affect two large auto manufacturers that produce charging equipment. However, the proposed amendments have the possibility of increasing opportunities for additional companies to enter the market and produce charging equipment. This would result from the increased equipment volumes which could be realized by moving the California EV market to one charging technology. Currently, it is difficult for new manufacturers to enter the market because of low volumes due to a divided EV market. Thus, the proposed regulation could positively impact small business by encouraging California employment, business status, and competitiveness.

1. Legal Requirement

Sections 11346.3 and 11346.54 of the Government Code require state agencies to assess the potential for adverse economic impacts on California business enterprises and individuals when proposing to adopt or amend any administrative regulation. The assessment shall include consideration of the impact of the proposed regulation on California jobs, expansion, elimination, or creation, and the ability of California businesses to compete.

State agencies are also required to estimate the cost or savings to any state or local agency and school districts in accordance with instruction adopted by the Department of Finance. This estimate is to include any non-discretionary costs or savings to local agencies and the costs or savings in federal funding to the state.

2. Directly Affected Business

Manufacturers of light duty passenger cars and trucks are primarily affected by this regulation. In addition, any business involved in manufacturing charging equipment to support light-duty passenger car and truck electric vehicles would be affected by the proposed regulation. This charging equipment can include products manufactured separate from the vehicles, or components sold to auto manufacturers, and which are incorporated into the vehicle design.

Only one motor vehicle manufacturing plant is located in California, the NUMMI facility, which is a joint venture between GM and Toyota. Two charging equipment manufacturers are located in California. These include EVI-Electric Vehicle Charging Infrastructure, which is located in Auburn, California, and AeroVironment, located in Southern California. GM sells chargers through its Advanced Technology Vehicle facility in Torrance, California.

3. Potential Impact on Manufacturers

The proposed infrastructure regulation primarily impacts 6 companies worldwide that manufacture California-certified light-duty vehicles and are subject to the ZEV regulations. Four companies will have short-term negative impacts because the electric vehicles they manufacture utilize an inductive charging system (General Motors, Nissan and Toyota) or an off-board conductive charging system (DaimlerChyrsler). The cost to the four companies is highly variable and will depend on the manufacturers individual product plans as well as their technical experience with conductive charging systems.

The ZEV regulation as modified by the Board in January 2001 allows significant flexibility in compliance strategies. Manufacturers can use city EVs, full function EVs, neighborhood EVs and fuel cell vehicles (only the first two vehicle types will be impacted by this proposed regulation). Manufacturers can also use any combination of these vehicles in conjunction with hybrid EVs, natural gas vehicles and gasoline Super Ultra Low Emission vehicles (SULEVs). It is likely each of the four impacted companies will market at least one vehicle model required to utilize an on-board conductive charging system. However, because of the flexibility of the regulation, this not a certainty. Manufacturers have not been willing to share their product plans that would allow staff to determine which model(s) may be impacted and to better estimate the cost of the proposed regulation.

The impact of the proposed infrastructure regulation is also a function of the manufacturers' experience with on-board conductive charging. This experience varies significantly and ranges from almost no experience to manufacturers which currently have off-board conductive systems and those that previously had on-board conductive charging systems.

Two companies (Ford and Honda) will be potentially positively impacted because the electric vehicles they manufacture utilize an on-board conductive charging system. The remaining light-duty vehicle manufacturers are not impacted because either they are intermediate volume manufacturers (e.g. Volkswagen and BMW) or they qualify for the small volume manufacturer exemption (Ferrari) and are not subject to the pure ZEV regulations.

In addition, the proposed infrastructure regulation indirectly impacts businesses involved in manufacturing charging equipment to support light-duty passenger car and truck electric vehicles. Currently, there is one small company in California that produces charging equipment that will potentially benefit from this proposed amendment. The inductive and off-board conductive charging systems are currently produced by contractors of the four vehicle manufacturers mentioned above. Since charger manufacturing is a minimal part of the four vehicle manufacturers' business the cost impact is low.

The four auto manufacturers could also experience difficulty in marketing vehicles during the transition to the standard. It is anticipated that it would take a minimum of three years for these three auto manufacturers that currently produce inductively charged vehicles to produce vehicles with an on-board conductive system. During the interim, these manufacturers will need to market vehicles with inductive charging systems. Consumers may be more apprehensive about purchasing or leasing vehicles that have the non-standard charging system. This is a short-term problem, and will be completely resolved by the implementation year (2006). In addition, many of these vehicles will be marketed to fleets, that have less apprehension about the changing standard.

Two auto manufacturers will lose capital that has been invested in the development of inductive charging technology and future profits that could have been realized. An estimated $50 million has been invested in the development of inductive charging technology. This capital has been allocated to the development of inductive charging for current EV vehicles and for refining chargers into an attractive consumer product. However, these two auto manufacturers could elect to manufacture their own conductive charging equipment, and therefore, still make a profit on selling chargers.

If the two manufacturers elect not to produce conductive charging equipment, then it is estimated that they will have lost a potential market share of 20,000 chargers in the year 2010. If a profit of 20% is realized on each charger sale, and chargers cost $1,000, then total profit losses for the two auto manufacturers could total $4 million. However, this $4 million in lost profits, will be gained by manufacturers of conductive charging equipment, including those located in California.

4. Potential Impacts on Dealerships

The proposed regulations are expected to have a positive impact on dealerships because EV charging standardization will enhance the marketability of EVs and consumer acceptance. Thus, standardization is expected to assist in increasing EV sales.

5. Potential Impacts on Vehicle Operators

The proposed regulations are expected to have a positive impact on vehicle operators. Vehicle operators will have greater access to charging and reduced costs for charging equipment.

6. Potential Impact on Business Competitiveness

The proposed regulation is not expected to cause a noticeable change in California employment relating to motor vehicles. This is because California has only a small amount of motor vehicle and parts manufacturing employment. The proposed regulation will have a small, but positive, impact on employment for California companies that produce charging equipment.

7. Potential Impact on Business Creation, Elimination, or Expansion

The proposed regulation is not expected to affect business creation, elimination, or expansion.

8. Potential Costs to Local and State Agencies

There are no requirements for State and local agencies to install public infrastructure. However, the proposed regulations will increase costs to some local and State agencies, particularly those that have sponsored the installation of public charging for EVs. Costs for retrofitting public chargers to the standard could cost up to two million dollars. However, these costs will be offset by future costs savings for new public charging installations. Future cost savings will accrue from reduced equipment costs and the ability to install and maintain one, rather than two, different charging technologies.

I. ENVIRONMENTAL IMPACTS

1. Introduction

This section outlines the emission impacts of the regulatory modifications proposed by staff. The proposed regulatory modifications for infrastructure standardization are intended to support the ZEV program implementation, and do not result in any additional emission reductions.

Motor Vehicle Emissions

Infrastructure standardization will greatly assist in attaining the emission reductions anticipated from the ZEV regulations. This includes dramatically reduced tailpipe emissions, and reduced emissions from vehicle refueling, fuel transportation, and fuel processing.

Other Environmental Media

As was noted in the August 7, 2000 Biennial Review Staff Report, ZEVs can make significant positive contributions in other environmental areas. Just as the gasoline refining, marketing, and distribution system results in air pollution emissions, it likewise results in water pollution due to fuel leakage and wastewater discharges, and is a source of hazardous waste. ZEV requirements will make an important contribution in reducing the environmental impacts that gasoline marketing, refining, and distribution have on water and soil pollution. The proposed requirements for standard EV infrastructure will support the attainment of these environmental goals.

Energy Diversity and Energy Demand

EV standardization will help reduce the demand for gasoline by making EVs more appealing to consumers. Reducing demand for gasoline can have important benefits for California. First, a reduction in demand could help eliminate shortages of cleaner-burning California gasoline that have led to rapid price increases. Second, a successful effort to reduce gasoline demand would also reduce the need for additional refining, transportation, and distribution facilities, thus reducing air and water pollution as noted above.

EVs provide significant alternative fuel benefits because electricity can be produced from a variety of non-petroleum energy resources. Moreover, because both electricity and hydrogen can be produced from renewable resources such as solar, wind, or hydropower, or biomass feedstocks, these technologies can help pave the way towards a sustainable energy future.

J. COST-EFFECTIVENESS

Additional emission reductions are not projected from this regulatory proposal. However, standardization will support the expanding consumer market and help achieve all of the environmental and air quality benefits expected from implementation of the ZEV program.

The cost of the proposed regulation is estimated to be minimal on the affected auto manufacturers: Toyota, GM, Nissan, and DaimlerChrysler. This estimate is based on the assumption that they would have five years to absorb any costs.

In addition, there will be a cost of approximately $2 million to retrofit public chargers to the new conductive standard. This cost will be borne by public agencies and other sponsors who have installed and assumed responsibility for the EV public charging network in California. This cost will be off-set by future equipment and maintenance cost reductions that will accrue from the standardization regulation.

K. NON-REGULATORY PROPOSALS

In addition to cost savings expected to be achieved with standardization, additional non-regulatory actions are recommended. These recommendations are intended to provide further cost savings for EV installation, as well as support expanded EV infrastructure. Recommendations include pre-wiring for new residential and business sites, encouraging the expansion of public charging, EV parking policies, and the use of standardized pedestal and mounting equipment. Below is a brief summary of non-regulatory recommendations.

The following recommendations could be considered by the Infrastructure Stakeholder Working Group, or undertaken by ARB staff. ARB staff could work with cities and counties, and incorporate recommendations into our draft model ordinance.

1. Pre-Wiring Requirements

A large part of EV installation costs can be attributed to upgrading electrical capacity needed to support EV charging equipment. If residences, fleet facilities, and commercial properties were pre-wired during construction, considerable reduction in EV installation costs could be achieved. It often costs only a fraction to upgrade electrical service during construction.

Local agencies should be encouraged to adopt resolutions and ordinances requiring new residential and commercial construction be equipped with 220 volt, 40-60 amp conduit and breakers in vehicle parking areas to facilitate low-cost installation of EV charging, as demand warrants.

2. Standard Pedestal Design

Additional costs are incurred for pedestal and brackets needed for charger installation. Standardization of brackets and pedestals could reduce costs, as well as make installations more uniform throughout the State.

3. Encourage Public Charging Expansion

Public charging needs to expand significantly to keep pace with a growing consumer market for EVs. Local agencies can undertake a number of efforts to encourage public charging. These include identifying potential business partners to sponsor public charging installation, funding public charging installation at city and county public parking lots, and developing ordinances which require the installation of EV charging stations at major new development projects in areas where EVs are being marketed.

The variety of EVs is expected to increase in California. This includes Neighborhood Electric Vehicles, City Vehicles, and electric scooters and bikes.

There is growing interest in having access to Level 1 (110 volt) public charging. However, there are some concerns of property owners that may need to be addressed prior to expanding Level 1 charging These include issues concerns to liability, safety, resulting from the ability to use the outlets to be used for other purposes.

It is recommended that Stakeholders work together to assess the need for Level 1 public charging, identify outstanding issues, and develop a set of recommendations for cities and counties, and State agencies to consider.

4. EV Parking Policies

A problem with many public charging sites, is that they are often occupied by non-EVs. Thus, when an EV driver needs to charge, they are unable to gain access to the charger. Development of EV parking policies would help address this program, and provide increased consumer access to EV charging.

Specifically, it is recommended that local agencies amend parking enforcement codes to: (1) levy fines for non-electric vehicles that park in EV charging spaces or other parking spaces specifically reserved for EVs, and (2) to allow for towing of non-electric vehicles that park in EV charging spaces or otherwise block access to parking spaces equipped with EV chargers. Enforcement of EV parking of policies has been found to be extremely successful.

5. Maintenance of Public Charging

In the January 2001 report on ZEV Infrastructure, ARB staff recommended a number of actions to support existing EV infrastructure. These include establishing centralized information sources, both printed and electronic, for tracking public charging sites. Two, establishing centralized information so that public chargers can be repaired, when needed. This could include some type of insurance program to support out of warranty chargers, including an out of warranty demonstration program.

6. Workplace Charging

Workplace charging can provide additional access to consumers. In many instances, it could be more convenient than public charging because of the time that an EV driver spends at their work location. However, there are some hurdles to expanding workplace charging. These include the reluctance of employers to provide a benefit to only one or two employees, and the expense of installing EV infrastructure.

It is suggested that additional analyses be done to develop a set of recommendations to identifying the benefits of workplace charging, assessing utilization of current workplace installations, ways to encourage employer participation and reduce costs, and outreach efforts that may be needed to encourage expansion of workplace charging.

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APPENDIX A

DETAILED TECHNICAL EVALUATION OF EV CHARGING SYSTEMS

DETAILED TECHNICAL EVALUATION OF EV CHARGING SYSTEMS

COST AND MARKET

1. Production Costs (on and off-vehicle components)

Total manufacturing costs are a very important consideration. While some charging equipment is currently subsidized, it is not likely that such subsidies will continue into the future. Reducing overall costs, and thus the price to the consumer, is a very important step in the process of developing a healthily and vibrant consumer market for EVs.

Toyota is the only large automaker that has had production vehicles with both charging systems. Toyota testified at the ARB February 27th workshop and provided subsequent written comments on March 14th that the total system cost difference between the two systems is small, and costs of producing inductive systems would be nearly equivalent to on-board conductive systems in the near future. General Motors also provided written comments that inductive charging (on and off-vehicle components) is on a similar cost plateau as on-board conductive charging. Both Toyota and General Motors produce inductive charging equipment as well as inductively charged vehicles. However, ARB also received comments from AC Propulsion, an independent manufacturer, and others that argued that the total costs for inductive are substantially higher than on-board conductive.

On-Board Conductive Charging

The total system costs of an on-board conductive charging system is estimated to range between $1900-$2800. Smaller "City" vehicles have estimated system costs of $1400-$2100. This assessment is based upon proprietary manufacturing information as well as on the cost to auto manufacturers for the purchase of on-board chargers.

Conductive chargers are not generally produced by auto manufacturers but purchased from suppliers, based on technical specifications. At current production levels, on-board conductive chargers have a cost of approximately 24 cents per watt. At this rate, the cost of the on-board charger for a full-performance vehicle would range from $1300-$1600 depending upon the power rating of the charger (from 5.76-6.7 Kw). Costs for the other on-board components are expected to cost less than $500. The manufacturing cost for the off-board charging station (EVSE) is proprietary, and would vary based on the model and features selected. As can be seen from this discussion, the cost of conductive system is variable; this variability is a reflection of the ability to size the charger to the vehicle traction battery, as well as variation in costs for the on board vehicle components and the off-board conductive charging station.

The EVSE to support the on-board charger currently has an MSRP of $350-$1800, depending on the model and features selected. ARB does not have detailed information on actual production costs for the EVSE, and this information is considered to be highly confidential. Based on information available to ARB, staff has concluded that the price of the mid and high end EVSE models are not subsidized.

Staff has obtained manufacturer estimates of future conductive system costs. These costs are highly confidential, but in general staff can disclose that cost reductions of 50% due to technology improvement and volume production would be able to be achieved. This would put future conductive system costs at $950-$1400 for a full performance EV, and $700-$1100 for a City vehicle.

Inductive Charging

Inductive chargers currently have an MSRP between $1899 to $3524. Based on this analysis and confidential information provided to ARB, staff has concluded that the current price of inductive chargers is partially subsidized by the auto manufacturers, except possibility the high end chargers. Staff is using a favorable cost estimate of $2700 (the average of the low and high MSRP) to estimate current costs of the off-board charger. If it is assumed that the on-board components of the inductive system cost approximately $500 or less, then the average “system” costs of the inductive system (based on MSRP) are assumed to be about $3200. The inductive system does not allow for significantly lower costs for smaller vehicles.

Long term costs for inductive systems are highly confidential. As a rough estimate, staff applied the 50% reduction factor used in the analyses of the conductive system, which results in a system cost of $1600. This may be under estimated since, as opposed to conductive chargers which is an "off-the shelf" and proven technology, the inductive system is still undergoing technology development and engineering design improvements. However, further development of inductive technology has the potential to result in simpler, less complex designs, which could further reduce costs.

Off-Board Conductive Chargers

Off-Board conductive chargers currently have an MSRP of $8,000. They are provided with the purchase of an EPIC. In the absence of actual production costs, this price will be assumed to represent cost. This is a significantly higher price than for an on-board conductive charger.

Public Charging

The costs discussed above are for total system costs. It is important to keep in mind that actual charging station costs. These are discussed in more detail later in the Section 3 of the Appendix.

2. Open Technology/Market Competition

Licensing Fees and Patents

One striking advantage that on-board conductive systems have is the location of the charger. The charger, which comprises the largest part of the entire system, is on the vehicle. This reduces the need for patents and licensing fees because virtually all of the proprietary components are on the vehicle and thus under the manufacturer's control. This encourages technology advancements and product development, without having to enter into expensive licensing agreements with other competing manufacturers.

Inductive systems, by placing the charger off the vehicle, have the opposite situation. There is great potential to have to rely on patents and licensing fees in order to protect intellectual property rights. This becomes very complicated and difficult to address in a vehicle/infrastructure market in which the charger technology needs to continue to grow and remain compatible with a wide variety of new as well as existing vehicles and equipment.

3. Other Cost Considerations

Infrastructure (EVSE) Costs

The costs for charging equipment, which is primarily the charging station that the consumers will have purchase for their EVs, is very important. In addition, public and workplace charging installations are affected by the cost of the charging station (or EVSE). The cost of the charging station, including that needed for public and workplace installations, impacts the total societal charging equipment costs.

For inductively charged vehicles, a charger is needed for each and every charging site. This could result in considerable difference in cost to support public and workplace charging. If it is assumed that 1.5 chargers are needed per vehicle (or 0.5 public chargers per vehicle), the conductive system has lower costs. Because the charger is located on the vehicle, only one charger per vehicle is needed for the conductive system. Additional charging capacity is achieved through the installation of the lower cost conductive charging station (or EVSE).

TABLE A
COMPARISON OF CHARGING STAION COSTS (EVSE)

Type of Vehicle supported	EVSE Manufacturer	List Price Comparable Features***	List Price Additional Equipment Models***	Type of EVSE
DaimlerChrysler EPIC		$8,000	N/A	Off-Board conductive charger
Honda EV Plus, Ford Ranger, Toyota RAV4 (98)	EVI-Electric Vehicle Infrastructure	$1800	$2100 (dual model)- $800****	Equipment to support on-board conductive charger
Ford Ranger	Avcon	N/A	$350	Equipment to support on-board conductive charger
EV1, S10, Toyota RAV4 Nissan Altra	Mange Charge (General Motors)	$1899-$3524	N/A	Off board inductive chargers (large & small paddle)
Toyota RAV4 (99-01) Nissan Altra & Hyper Mini	TAL (Toyota Auto Loom)		$2084	Off-board inductive charger (small paddle)

Equipment Maintenance Costs
Warranty and service costs are another important consideration. Keeping maintenance and repair costs at a minimum lowers overall costs, and assists with developing a EV consumer base. The EVSE for on-board conductive systems are simple, consisting only of a wall box, chord set, GFCI, and simple circuit boards. They are designed to be serviced by ordinary electrical personnel. In contrast, the off-board inductive or conductive charger is very complex, and will continue to require specially trained service personnel.

Costs of other benefits
The other section compares future technology advancements. Several auto manufacturers are developing integrated charging systems. These on-board charging systems integrate the vehicle propulsion systems into the charger electronics. They have the capacity to reduce charger costs dramatically, as well as to provide higher power charging. Ford estimates that the integrated charging system it is currently working on will reduce charger costs by 45%. AC Propulsion, an independent manufacturer, estimated that it could produce an integrated charging system for $1,000 at small and $450 at large volumes. These integrated charging systems will bring conductive charging systems significantly down in price, as compared to inductive. Integrated charging is not an option for inductive charging.

Other developments discussed later include the possibility of using the vehicle to provide energy to the electricity grid, thus allowing the consumer to recoup some of their equipment costs by reselling electricity. Inductive systems are not capable of providing " vehicle to grid" without major and expensive modifications to the charger.

Finally, Level 1 charging systems can be a benefit that many consumers want. Level 1 charging systems are significantly cheaper with conductive systems, as opposed to inductive systems. Staff estimates that the cost difference between the two could be as high as $1,000.

CONSUMER CONCERNS

A number of issues or factors impact consumer acceptance of EV technology. Below is additional information on charging efficiency and Level Charging.

Level 1 charging

For the inductive system, a Level 1 charger consists for a GFCI plug and cord with an attached 1.4 KV charger and paddle. This device is relatively large, heavy and expensive when compared with the conductive system. Because the charger is on-board the vehicle, Level 1 equipment of conductively charged vehicles is an extension cord, GFCI, and a connector which fits into the vehicle inlet.

Early inductively connected EVs were available with “convenience” chargers made by Delco. These were included as standard equipment on early GM EV1s with lead acid batteries, and on the first 30 Nissan Altra EVs. When compared to Level I conductive in-cord systems, inductive Level 1 systems are larger, heavier, more difficult to deploy, not weatherproof, less efficient, and much more costly. However, current generation conductive Level 1 chargers provided with the Honda EV Plus proved to be very sensitive to variations in amperage, and appeared to have a much higher failure rate than Level 2 chargers.

Charging Efficiency

Conductive charging systems offer higher charging efficiency than inductive ones. Most conductive chargers presently deployed have efficiencies well above 92%, but what is also important is that these are able to maintain relatively high efficiency even at low power levels that are required by EVs with smaller battery packs or during finish charge phases. Although inductive charging systems may have a peak efficiency only a few percent less than conductive, this difference increases substantially at lower power levels. Because EVs frequently finish charging at low power levels, staff believes that the overall charging efficiency of inductive systems may be significantly lower than conductive.

An accurate assessment of the true impact of this difference in efficiency between inductive and conductive systems is difficult to obtain because the answer also depends on:

- How EVs are driven (fully discharged each trip versus partially discharged), and
- What type of battery chemistry and charging algorithm is employed.

If an EV is fully discharged and then recharged with commonly available battery technologies, the charging system delivers most of it's energy at a high power level where inductive performance is optimized and the efficiency penalty relative to conductive charging may only be a few percent. If, however, the EV is driven predominantly on short trips, as most are, the charging system delivers significant amounts of energy at consistently low power levels because the battery pack charging controls usually taper to low power during finish charging.

Because staff has been unable to locate non-proprietary test data for production EV charging system efficiency during partial discharge operation, ARB has begun a series of tests at our El Monte labs. Results will be made available when testing is completed.

TECHNOLOGY ADVANCEMENT

1. Vehicle to Grid Power Services

When the present battery electric vehicle connection systems were developed, they were only expected to deliver power to charge EVs. At that time, there was very little discussion of the possibility to deliver power from an EV to the electric grid. Much has changed in the last 10 years. During this time, other vehicle types with electric drives (fuel cells, hybrids as well as EVs), contain all of the basic components needed for a distributed power generation source.

The ARB recently funded a study conducted by the University of Delaware, Green Mountain College, AC Propulsion, Inc., and the University of California. The goal of the research was to examine the viability of EVs as power resources. Their conclusion was that the estimated cost of electricity from EVs is too high to be competitive with base load power generation, but that EVs were found to be cost competitive in three other markets: "peak power," spinning reserves, and regulation up/down. These last two markets are called "ancillary services" and are used by the California ISO to cover imbalances between scheduled and actual power flows.

Future Prospects

A number of factors need to be thoroughly evaluated before vehicle-to-grid is a wide spread consumer option. Attention is now focused on assessing the long-term impact that vehicle to grid power would have on vehicle batteries, possible impacts with regard to power quality, coordination with electric utilities and the grid operator, identifying any safety issues, as well as assessing the potential economic benefit to consumers.

Several auto manufacturers are investigating the viability of this. In August 2000, Nissan was awarded a patent called "Household Supply System Using Electric Vehicle". Daimler Chrysler and EPRI have expressed the view that vehicle to grid will be available in the future.

On-Board Conductive Charging Systems

Conductive charging connections are simply an extension of the 50/60 HZ AC electric grid to the EV with no intermediate conversions necessary as there are with inductive systems. All existing conductive charging infrastructure would be suitable for receiving power from electric vehicles with little or no modification to the charging station, cables, and connectors. However, on-board vehicle components must be designed to allow this application

Inductive Charging

While vehicle to grid power flow from inductive chargers is possible, it would be cost-prohibitive. Today's inductive chargers are incapable of carrying vehicle to grid power. An inductive charger connection could be designed to do this. Such a design could use the same paddle and vehicle inlet, but would require adding components to the vehicle side so that it could send power, and adding components to the grid side so that it could receive power. The duplication would add considerable cost complexity to inductive chargers. Another consideration is that increasing power capacity increases charger cost. However, there may be some interest in vehicle to grid from inductive users, as Nissan has a patent for vehicle to grid inductive application

2. High Power Level 3 Charging

Level 3 charging has been demonstrated for both inductive and off-board conductive systems. There are two major hurdles to the wide spread deployment of Level 3 charging. These are, (1) the ability of the battery to accept a high current charge without adverse effects. And. (2) perhaps more important, the high cost of charge stations and the difficulty of demonstrating the economic viability of these costly charge stations. It is very difficult to demonstrate a business case that will recapture the high cost of the charge stations for a large consumer market, beyond specific fleet applications that can recoup charger investments. High power charging stations can cost in excess of $45,000.

Conductive Level 3 Charging

SAE Recommended Practices for Conductive Charging (J1772 adopted October 1996) defines Level 3 conductive charging as a direct current connected charging method with an off-board charger at any power level. It does not require or specify the minimum power capacity of a Level 3 charger, and Level 3 chargers may have lower power capacity than Level 2 chargers.

The maximum power delivery capability of the Level 3 protocol is 240 kW (400 A at up to 600 VDC), while the maximum pair capability of the Level 2 varies from 6.6 to 7.8 kW depending on the supply voltage (208 VS 240 VAC). While Level 1 & 2 conductive systems may make use of a low-cost J1772 control pilot circuit for communications, Level 3 systems must incorporate both a control pilot signal and an SAE J1850 communication system.

At present, the only passenger EV that is compatible with Level 3 charging is the Daimler-Chrysler EPIC. The EPIC has no on-board charger and must connect to a Level 3 station in order to charge. It is available with a medium-power Lockheed-Martin “blue box” 10-14 kW Level 3 charging station. The EPIC is also compatible with the ODU-connector version of the only commercially available, SAE-compliant Level 3 high-power charging station, the AeroVironment PosiCharge system.

The AeroVironment PosiCharge Level 3 product is available in both 60 kW and 120 kW maximum power versions and has been used in California in a number of applications, including fast charging of shuttle buses in Southern California. AeroVironment has sold 70 of its 60 kW Level 3-only charging stations for on-road use, 14 of which have been installed in California. The 60 kW standard version is currently offered at a Manufacturer Suggested Retail Price (MSRP) of $45,000. PosiCharge installations in California include 10 Avcon-connector units for electric shuttle bus charging for the Los Angels Department of Water and Power, and 4 ODU-connector units for use with EPIC minivans, including several in the Los Angeles International Xpress Shuttle taxi fleet.

DaimlerChrysler EPIC electric vans are compatible with PosiCharge stations without modifications and are capable of drawing on the full 60 kW that is available from these chargers. Xpress Shuttle has 11 EPICs, and each can routinely cover 200 miles/day with some logging over 300 miles/day. An EPIC traveled more than 350 miles in a 10-hour shift while carrying passengers in a fast-charge demonstration at the NAEVI conference in 1999.

Level 3 charging for vehicles equipped with on-board conductive chargers will not be available until the auto manufacturers determine that there will not be any adverse impacts on the traction batteries, and high power connectors and vehicle inlets undergo further demonstration and testing. Currently, a high power version of the standard conductive connector (butt and pin) is not commercially available, but a prototype is available for testing and demonstration purposes. Avcon, the single manufacturer of the butt and pin connector, testified at the February 27, 2001 workshop on standardization that they are waiting for industry support before any additional resources are allocated to the commercialization of a high power connector.

Inductive Level 3 Charging

Inductive Level 3 charging has been demonstrated. In 1998 and 1999, GM, Edison EV, and Southern California Edison developed, deployed, and tested a 50 kW inductive charging system. The goal was to demonstrate the effectiveness and flexibility that fast-charging might provide to fleet EVs. This six-month demonstration program used S-10 pick up trucks with charge ports that were similar to the liquid-cooled Gen. II 6.6 kW units, with the exception that the alternating current output cable was upgraded for higher current capacity.

This program successfully demonstrated the technical feasibility and usefulness of a high-power inductive charging system. The small paddle has proven to be capable of charging at power levels from one to 120 kilowatts; high power levels are accommodated through a liquid cooling system located in the coupler. However, similar to on-board conductively charged vehicles, no inductively charged vehicles are currently capable of accepting Level 3 charging. In addition, inductive Level 3 chargers are not commercially available.

There is an unresolved issue which will need to be addressed prior to commercialization of Level 3 inductive charging. This unresolved issue is described in the Appendix of J1773 and concerns how to communicate the vehicle inlet power rating to the charger independently of the normal SAE J1850 data communications interface. A second IR beacon has been proposed, but a detailed design has not yet been incorporated in J1773. Both GM and Toyota staff have both indicated that if there is a need to provide Level 3 charging, this issue could easily be addressed.

3. Level 2+ (also termed Level 3AC)

Level 2+ (3AC) is a type of charging that uses an on-board charger to provide a faster charge than Level 2, but usually slower than Level 3. The most promising systems are under development use an integrated charger. Integrated charging is a type of charger implementation that utilizes some or all of the power system components used to drive the vehicle for the charging function also.

Many EV manufacturers and suppliers are considering the use of integrated charging systems, and several have patents or have publicly disclosed their designs or interest in this approach. These include Fuji, GM, Ford/ Ecostar, Toyota, Renault, and Volkswagen, and Honda. These systems are most often considered as a means of reducing costs for EVs, which are much higher than comparable conventionally fueled vehicles.

Integrated charging is considered by many in the industry as to be the only economical way, in the near to mid-term, to provide cost-effective higher power charging than currently available from Level 2 charging. With integrated charging, the Level 2 conductive charging system can become a Level 2+ high power charging station through upgrades to the some of the components. These upgrades are estimated to cost considerably less than either an inductive or conductive off-board Level 3 charging station. It is estimated that a Level 2+ charging station could retail between $500 to $2,000 (in high volumes), depending upon the modifications that would be required. This compares favorably to an off-board high power charging station, which retails from $45,000-60,000.

Current Status

In 1999 AC Propulsion, Inc., proposed modifications to SAE J1772 to allow Level 2 off-board conductive stations to deliver alternating current power to EVs above the former Level 2 limits of 7.8 kW. These higher-power integrated chargers could provide fast-charge benefits with infrastructure costs that are much lower than Level 3 and nearly comparable to Level 2. AC Propulsion claims that existing EV drive system components could be reconfigured to deliver charging power of 20 kW or more. While on-board integrated chargers could potentially charge EVs at very high power levels, J1772 did not allow for delivery of high power AC, only DC.

The existing butt and pin connector is, however, equipped with 2 large contacts rated at 400 A DC, and these would have a similar rating for AC if J1772 could be altered to allow for AC connection on these same high-power contacts. EVI Inc., of Auburn, CA, has already developed this Level 2+ (3 AC) conductive charging station product, and plans to submit this design for U/L approval if sufficient quantities are ordered. This product is substantially the same as EVI's existing models with the substitution of a contractor that provides higher current-switching capability

Although integrated charging has the potential to provide much higher charging power capability than Level 2, staff believes that the cost-reduction advantages will continue to be the main reason that auto manufacturers and parts suppliers consider this type of charging system.

APPENDIX B

PROPOSED REGULATION ORDER

PROPOSED REGULATION ORDER

The text of the proposed amendments is shown in underline to indicate additions and ~~strikeout~~ to indicate deletions. In sections 1900(b)(18) and 1962(b)(4), title 13, California Code of Regulations, changes approved by the Air Resources Board at a January 25, 2001 hearing, but not yet finally adopted or in effect, are shown in dotted underline to indicate additions and ~~***bold italic strikeout***~~ to indicate deletions.

1. Amend section 1900(b)(17) and 1900(b)(18), title 13, California Code of Regulations, to read as follows:

(b)(17) "Small volume manufacturer" means, with respect to the 2001 and subsequent model-years, a manufacturer with California sales less than 4,500 new passenger cars, light-duty trucks, medium-duty vehicles, heavy-duty vehicles and heavy-duty engines based on the average number of vehicles sold for the three previous consecutive model years for which a manufacturer seeks certification; however, for manufacturers certifying for the first time in California model-year sales shall be based on projected California sales. A manufacturer's California sales shall consist of all vehicles or engines produced by the manufacturer and delivered for sale in California, except that vehicles or engines produced by the manufacturer and marketed in California by another manufacturer under the other manufacturer's nameplate shall be treated as California sales of the marketing manufacturer. For purposes of compliance with the zero-emission vehicle requirements, heavy-duty vehicles and engines shall not be counted as part of a manufacturer§s sales. For purposes of applying the 2003 and subsequent model year zero-emission vehicle requirements for small-volume manufacturers under section 1962(b), the annual sales from different firms shall be aggregated in the case of (1) vehicles produced by two or more firms, each one of which either has a greater than 50% equity ownership in another or is more than 50% owned by another; or (2) vehicles produced by any two or more firms if a third party has equity ownership of greater than 50% in each firm.

(b)(18) “Intermediate volume manufacturer” means any pre-2001 model year manufacturer with California sales between 3,001 and ~~***35,000***~~ 60,000 new light- and medium-duty vehicles per model year based on the average number of vehicles sold by the manufacturer each model year from 1989 to 1993; any 2001 through 2002 model year manufacturer with California sales between 4,501 and ~~***35,000***~~ 60,000 new light- and medium-duty vehicles per model year based on the average number of vehicles sold by the manufacturer each model year from 1989 to 1993; and any 2003 and subsequent model year manufacturer with California sales between 4,501 and ~~***35,000***~~ 60,000 new light- and medium-duty vehicles based on the average number of vehicles sold for the three previous consecutive model years for which a manufacturer seeks certification. For a manufacturer certifying for the first time in California, model year sales shall be based on projected California sales. For purposes of applying the 2003 and subsequent model year zero-emission vehicle requirements for intermediate-volume manufacturers under section 1962(b), the annual sales from different firms shall be aggregated in the case of (1) vehicles produced by two or more firms, each one of which either has a greater than 50% equity ownership in another or is more than 50% owned by another; or (2) vehicles produced by any two or more firms if a third party has equity ownership of greater than 50% in each firm.

* * * *

Note: Authority cited: Sections 39600, 39601, 43013, 43018, 43101, and 43104 Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39500, 40000, 43000, 43013, 43100, 43101, 43101.5, 43102, 43104, 43106, and 43204, Health and Safety Code.

2. Amend section 1962(b)(4), title 13, California Code of Regulations, to read as follows:

(b)~~***(4)***~~(5) *Changes in Small Volume, Independent Low Volume, and Intermediate Volume Manufacturer Status.*

(A) In 2003 and subsequent model years, if a small volume manufacturer's average California production volume exceeds 4,500 units of new PCs, LDTs, and MDVs based on the average number of vehicles produced and delivered for sale for the three previous consecutive model years, or if an independent low volume manufacturer's average California production volume exceeds 10,000 units of new PCs, LDTs, and MDVs based on the average number of vehicles produced and delivered for sale for the three previous consecutive model years, or if an intermediate volume manufacturer's average California production volume exceeds 60,000 units of new PCs, LDTs, and MDVs based on the average number of vehicles produced and delivered for sale for the three previous consecutive model years, the manufacturer shall no longer be treated as a small volume, independent low volume, or intermediate volume manufacturer, as applicable, and shall comply with the ZEV requirements for independent low volume, intermediate volume or large volume manufacturers, as applicable, beginning with the ~~***fourth***~~ sixth model year after the last of the three consecutive model years.

(B) The lead time provided in section (b)(5)(A) shall be four rather than six years where a manufacturer ceases to be a small or intermediate volume manufacturer in the 2003 or subsequent years due to the aggregation requirements in majority ownership situations.

* * * *

Note: Authority cited: Sections 39600, 39601, 43013, 43018, 43101, 43104 and 43105, Health and Safety Code. Reference: Sections 39002, 39003, 39667, 43000, 43009.5, 43013, 43018, 43100, 43101, 43101.5, 43102, 43104, 43105, 43106, 43107, 43204, and 43205.5, Health and Safety Code.

3. Adopt section 1962.1, title 13, California Code of Regulations, to read as follows:

§ 1962.1. Electric Vehicle Charging Requirements.

(a) This section applies to:
(1) all Battery Electric Vehicles which qualify for 1.0 or greater ZEV credit; and
(2) all extended range hybrid electric vehicles.

(b) Beginning with the 2006 model year, all vehicles identified in subsection (a) must be equipped with a conductive charger inlet port, which meets all the specifications contained in Society of Automotive Engineers (SAE) Surface Vehicle Recommended Practice: SAE Vehicle Conductive Coupler J1772 (SAE J1772, 2001 revision, currently in draft form). All vehicles must be equipped with an on-board charger with a minimum output of 3.3 kilovolt amps.

(c) This section does not apply to:
(1) Battery Electric Vehicles which qualify for less than 1.0 ZEV credit;
(2) Neighborhood Electric Vehicles;
(3) Battery Electric Vehicles which qualify for 1.0 or greater ZEV credit and which are only capable of Level 1 charging. "Level 1 charging" means "a charging method that allows an electric vehicle or extended range hybrid electric vehicle to be connected to the most common grounded receptacle (NEMA 5-15R)." A vehicle that is only capable of Level 1 charging is one that is equipped with an on-board charger capable of accepting energy from the existing AC supply network. The maximum power is 12 amps, with a branch circuit rating of 15 amps, and continuous power of 1.44 kilowatts.

(d) The following industry standard is incorporated by reference: SAE Surface Vehicle Recommended Practice: Conductive Coupler J1772 (2001 revision, currently in draft form). SAE Surface Vehicle Recommended Practice: Conductive Coupler J1772, as adopted in 1996, is not incorporated by reference.

Note: Authority cited: Sections 39600, 39601, 43013, 43018, 43101, 43104 and 43105, Health and Safety Code. Reference: Sections 39002, 39003, 39667, 43000, 43009.5, 43013, 43018, 43100, 43101, 43101.5, 43102, 43104, 43105, 43106, 43107, 43204, and 43205.5, Health and Safety Code.

APPENDIX C

GLOSSARY OF TECHNICAL TERMS

GLOSSARY OF TECHNICAL TERMS

AC	Alternating Current. Electric current that reverses its direction periodically. Energy from the electrical grid is in the form of AC.
Amps	The standard unit for measuring the strength of the electric current.
Charger	An electrical device that converts alternating current to direct current for a battery, and may also provide energy for operating other vehicle electrical systems. It may be located either on-board the vehicle or off-board the vehicle.
Charge port	The vehicle inlet into which the connector is inserted for charging a vehicle.
Connector	A plug or paddle that fits into a charge port located on the vehicle that establishes a connection for the purposes of charging an electric vehicle.
Control pilot	The primary control conductor on conductive systems that is connected to equipment ground through control circuitry on the vehicle.
Coupler	A mating vehicle charge port and compatible connector set.
Current	Rate of flow of electrical charge in a medium (or conductor) between two points.
DC	Direct Current. Electric current flowing in one direction.
EVSE	Electric Vehicle Supply Equipment includes the conductors, connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatuses, installed specifically for the purposes of delivering energy from the premises wiring to the electric vehicle.
Level I	A charging method that allows an electric vehicle to be connected to the most common grounded receptacle (120 VAC, 1-phase).

Level 2	A charging method that utilizes dedicated electric vehicle supply equipment in either private or public locations. The maximum power levels are 208 to 240 VAC, 1 phase.
Level 3	A charging method that utilizes dedicated electric vehicle supply equipment to provide direct current energy from an appropriate off-board charger to the electric vehicle. The maximum power supplied for Level 3 charging equipment should be capable to replenish more than half of the capacity of an EV battery in less than half an hour.
Rectification	Transformation of alternating current to direct current. Battery chargers require that electricity be delivered as DC.
Transformer	A device containing no moving parts and consisting of two or more coils of insulated wire that transfers alternating current by electromagnetic induction from one winding to another at the same frequency but usually with changed voltage and current values.
Voltage	Difference in electrical potential, expressed in volts.
Volts	A practical unit of electromotive force, that specifies the difference in electrical potential between two points.