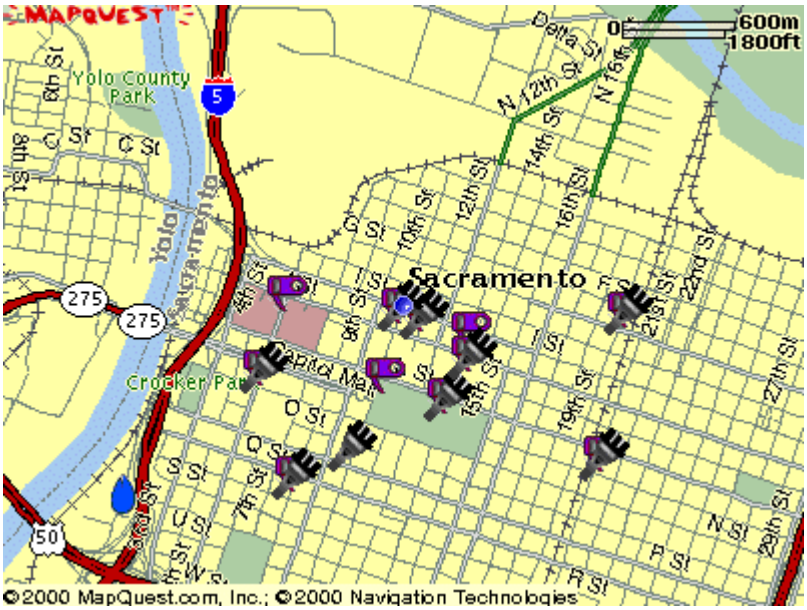
ZEV INFRASTRUCTURE



A Report on Infrastructure for
Zero Emission Vehicles
Prepared for the Air Resources Board
January 2001

EXECUTIVE SUMMARY

At the September 2000 hearing, the Board affirmed the ZEV requirement, but identified several issues for further action by ARB. These included identifying actions to maintain and expand public charging evaluating what can be done to reduce infrastructure costs and recommending whether standardization of charging systems is needed.

This report is an adjunct to the August 7, 2000 staff report. It provides staff's assessment of infrastructure issues as related to the ZEV regulations. The primary focus of this document is on infrastructure for battery electric vehicles (EVs). The report provides background on the status of public charging, EV charging technologies, safety standards related to EV infrastructure, infrastructure costs, and incentive programs related to infrastructure as well as recommendations for charger standardization.

EV infrastructure, including public infrastructure, is on-track given the current number of EVs on the road. Currently, there are just over 2000 EVs in California and over 3000 chargers (including nearly 1000 public chargers). However, home and public infrastructure will need to expand significantly to keep pace with demand in the future. Over the next two years (2001 and 2002) we expect the number of EVs to nearly double. In 2003, we expect the number to double again, to a total of over 10,000 EVs. EV sales are expected to grow steadily beyond 2003.

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 in the standardization of chargers. The six major auto manufacturers that have sold EVs in the last two years have used four different chargers. This issue is likely to create concerns among consumers and therefore limit EV marketability as we move forward. With the large expansion of EVs projected over the years, it is important that the industry move quickly toward a single charging system.

All charger systems being used have their advantages and disadvantages, as discussed in this report. Staff has done a preliminary review of available information and at this time believes the conductive “butt and pin” type charger has the most advantages as we move forward. Staff is prepared to begin a regulatory process to establish a standard connector for EVs. Such a proposal could be brought before the Board as early as June 2000, with a workshop in March, 2000. If adopted by the Board, implementation of the requirement should begin with the 2005 model-year.

The report also includes a number of recommendations related to public charging. ARB staff recommends working with stakeholders to identify additional public and private funding sources to support public charging infrastructure. This would not only take into account recent increases in electric vehicle usage, but also identify those areas where a lack of infrastructure has been a disincentive to

marketing vehicles. Activities should include the support of centralized information sources on the location of public charging sites and support to ensure that public chargers are maintained and repaired, so as not to erode confidence in the technology.

Staff recommends that an ongoing Stakeholder Working group be formed. This group would be structured to meet quarterly, beginning in February to provide input and develop suggestions for programs and activities to support, expand, and maintain the public charging network in California. The working group would also evaluate and provide recommendations on incentive programs to support infrastructure.

Significant progress has been made in establishing infrastructure for EVs. California is near to being ready for increased volumes expected in coming years as a result of the Zero Emission Vehicle regulations. Standardization, maintenance, and incentives for public infrastructure continue to need work. Staff looks forward to working with ZEV Stakeholders through the process described in this report to resolve and support these issues.

A. INTRODUCTION

This report provides ARB staff's assessment of infrastructure issues, as related to the ZEV regulations. The primary focus of this document is on infrastructure for battery electric vehicles (EVs), although infrastructure for fuel cells, hybrid electric vehicles, and compressed gas vehicles is also briefly discussed. This document provides background on the current status of electric vehicle charging in California, followed by staff recommendations for future activities to both support and expands public infrastructure in anticipation of increased numbers of battery EVs expected over the next few years in California.

B. BACKGROUND: INFRASTRUCTURE FOR COMPRESSED NATURAL GAS (CNG) VEHICLES

There are currently about 230 CNG vehicle-refilling stations in California, of which 104 are available to the public. Most of these are the "fast fill" type stations that are capable to refilling CNG vehicles in as little as 2 to 4 minutes.

Although the "fast fill" dispensing infrastructure is relatively sparse, low pressure natural gas is already delivered to most residences in California. Thus, manufacturers are working to develop "time fill" devices that would be suitable for home refueling use. These "time fill" devices may take 6-8 hours (overnight) to fill a vehicle, but their availability could make dedicated CNG vehicles a much more viable option for non-fleet users.

C. BACKGROUND: INFRASTRUCTURE FOR FUEL CELL ELECTRIC VEHICLES

To address fuel cell vehicle and infrastructure issues, in April 1999 California Governor Gray Davis and industry leaders announced the formation of the California Fuel Cell Partnership (Partnership). The Partnership includes government partners, auto manufacturers, fuel providers, and a wide variety of associate members. The Partnership has a fuel cell vehicle headquarters facility in West Sacramento which houses fuel cell EVs and a hydrogen fueling station. The center serves as the operations base for the next four years.

In addition to testing vehicles, the Partnership will identify fuel infrastructure issues and prepare the California market for this new technology. Initial demonstration vehicles will run on hydrogen, directly from tanks on board the vehicles. Some of the subsequent demonstration vehicles may run on methanol fuels. Technology for other liquid fuels, such as a cleaner form of gasoline may also be evaluated. A key goal of the Partnership is to determine the best fuel infrastructure for the market entry of fuel cell EVs.

The Partnership will be devoting considerable attention to fuel cell EV infrastructure issues. ARB staff will monitor the Partnership's efforts in this regard, and report on the status to the Board, as appropriate.

D. BACKGROUND: GRID-CONNECTED HYBRID ELECTRIC VEHICLES

Grid-connected Hybrid Electric Vehicles (HEVs) are generally expected to make use of the same public and private EV charging infrastructure that is available for battery EVs. The staff recommendations for EV infrastructure will also greatly benefit grid-connected HEVs.

One possible difference is that Level 1 charging (110 volt) may be a more viable option for these vehicles, due to their smaller battery backs and the fact that they can run on the alternative power unit when their battery packs are depleted.

E. BACKGROUND: INFRASTRUCTURE FOR BATTERY ELECTRIC VEHICLES

1. Overview: EV Infrastructure in California

EV battery chargers have two main functions. They convert the alternating current distributed by electric utility providers to the direct current needed to recharge the battery, and regulate voltage in a manner consistent with the ability of the battery to accept current. Chargers can be located either on-board the vehicle or off-board.

Currently, there is no standard for a single charging system. 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 like a traditional plug, and are used with Ford, Chrysler, and Honda EVs. 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. Induction is a magnetic coupling between the windings of separate coils, one in the paddle and the other mounted in the vehicle. Inductive charging is used in GM, Toyota, and Nissan EVs.

Currently there are an estimated 3,300 chargers which have been installed in California. This includes nearly 1000 public chargers located at approximately 500 locations; 60% of these are inductive and 40% are conductive. In addition, there are an estimated 2300 residential, workplace, business and fleet chargers. Infrastructure providers install the vast majority of EV infrastructure; an estimated 10% may be self-installed.

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 and distinct 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.

EV infrastructure has been engineered for safety. This includes new statewide building and electrical standards and codes which specify where equipment can be placed, and details the standard safety features required of EV charging systems and supply circuit requirements. Charging equipment has undergone rigorous testing to establish the durability and safety for the consumer. In addition, considerable training and outreach materials have been established to ensure that EV infrastructure installed statewide meets the stringent safety standards established.

2. EV Charging Technologies

Conductive Charging Systems

Conductive charging systems use a direct metal to metal contact between pins in the charge connector and the vehicle receptacle. Charger electronics are typically on-board the vehicle. Some of the advantages of conductive chargers are that they are less complex, and therefore have greater potential for reduced costs. Also cable length of current chargers can be modified (up to 25 feet), providing more options to accommodate vehicles at fleet and public charging sites. Finally, charger programming can be modified without making expensive changes to the charger. Current disadvantages with conductive chargers include some concerns with the durability of the connector, and programming incompatibility between different vehicles.

Progress has been achieved in the standardization of the conductive coupler (or plug) used. Most of the vehicles and chargers now use the "butt and pin" connector (often referred to as the "Avcon" connector in reference to the only manufacturer of the coupler). This standard was established through a collaborative process with stakeholders. The primary exceptions to this standard are older models of the Toyota RAV4 and all of the Chrysler EPICs currently on the road.

Multiple manufacturers have produced conductive chargers; currently 80% of the chargers in use are produced by EVI, Electric Vehicle Infrastructure, located in Auburn, California. EVI began designing prototype chargers in 1992 under the Sacramento Municipal Utility District's (SMUD's) direction, and in 1994 began ramp-up with wider scale manufacturing efforts. EVI estimates that they have manufactured over 3,800 units to date. Their chargers are distributed nationwide through designated distributors.

Inductive Charging Systems

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 actual charger electronics are typically off-board the vehicle.

Advantages of inductive charging include: the paddle is very easy for the consumer to use; an off-board charger reduces vehicle weight, which can contribute to extended vehicle range, and there are no exposed metal parts to corrode or degrade over time. One of the disadvantages of inductive charging is that the system is proprietary. Interested manufacturers must pay a licensing fee in order to obtain the right to manufacture. This could hinder additional manufacturers or small businesses from entering the market. Also, there is some efficiency loss associated with inductive charging.

A new coupler paddle design for inductive chargers has been developed. As a result, there are currently two different paddle designs that are incompatible. The new coupler paddle design is smaller and more lightweight. The chargers utilizing the new paddle design are currently manufactured by Toyota Auto Loom under a licensing agreement with GM, and GM Advanced Technology Vehicles (trademark Magne Charge). GM is also continuing to manufacture chargers with the large coupler paddle design for use with the EV1 and S10.

The new smaller coupler paddle is designed to be used with vehicles that have the small charge port. This includes the current models of Toyota and Nissan vehicles. It can also be used with vehicles that have a large charge port as long as an adapter is used. The adapter is placed on the small paddle, so those vehicles with a large charge port can be safely charged. If a vehicle with a large charge port is charged with a small coupler paddle without the use of the adapter, it could lead to misalignment of the paddle resulting in paddle touch temperatures sufficient to cause personal injury during paddle removal. Adapters are in the process of being distributed to existing EV drivers with large paddle ports by SMUD.

Because there are now two different paddle designs, this has caused concerns for access to public charging. Vehicles with small charge ports currently have limited access to public charging. A two-year retrofit program is currently underway to replace public inductive chargers with the large paddle coupler with chargers having the small paddle couplers. A number of public chargers have already been upgraded, including 30 in the Sacramento area.

3. Infrastructure Costs

Infrastructure costs are broken down into two areas: (1) costs for chargers and (2) costs for electrical installation work.

Costs for residential installations are generally less than commercial or fleet installations. However, installation costs can vary significantly, depending upon the electrical set-up at the site. Many residential or commercial sites do not have the minimum electrical capacity required by equipment manufacturers and electrical systems must be upgraded as part of the installation work. Electrical system upgrades can increase costs significantly.

Inductive chargers currently cost $2200 (not including mounting, brackets, or shipping). Conductive chargers have seen some important reductions in costs this year with new model designs. Conductive chargers cost between $800-$2100 (not including mounting, brackets, or shipping), depending on the model selected. Some manufacturers, including Ford, include a charger as part of the vehicle lease. Other manufacturers, including GM, participate in incentive grant programs that offset part of the installation and charger costs in certain areas of the State.

Installation costs for residential installations typically cost under $1500. Costs at fleet or commercial sites vary significantly, but on average, cost between $1500-$5000. Installation costs at sites can be dramatically reduced through pre-planning. This includes wiring new residential and commercial developments to be EV ready. Commercial installation costs can often be minimized through location of chargers near electrical panels. Also, costs of installing multiple chargers can often be very little more than installing several chargers, thus installation costs per charger can often be dramatically reduced through installation of two or more chargers at the same site.

Standardization

The lack of one standardized charging system has had several impacts. One, it has resulted in the need to install two charging stations at public and workplace sites in order to be able to accommodate most vehicles. Two, the expected reduction in charger costs has not occurred, primarily because no one system has been able to reach sufficient production volumes due to a divided market. And finally, it has made it more difficult and expensive to support and maintain public infrastructure. As we move forward, staff also believe the different charging systems will create a “Beta/VHS” issue that will make consumers apprehensive about EVs as a new technology.

4. EV Charger Performance

There are little or no peer-reviewed data on charger performance. However, there is considerable "hands-on" experience that has been gathered over the last six years. Generally, chargers in the field have performed extremely well.

Determining whether a charging problem is due to charger failure or vehicle problem can often be difficult. Problems can be due to charger failure, vehicle problems, improper installation or electrical problems at the site. Also, extremely hot temperatures can result in vehicles not charging properly, which many users may inaccurately diagnose as a charger problem. Some problems can also be

due to user error, including incorrect insertion of the paddle or connector. Infrastructure providers and charger manufacturers have done an excellent job in working with users to diagnose and correct any problems in the field.

5. Public Charging in California

Public infrastructure enhances the utility of ZEVs. Public charging infrastructure continues to expand in California. Public sites are located at shopping centers, airports, hotels, and other businesses. Drivers can extend the length of their trips if they know that convenient recharging facilities will be available at their destination. Significant public and private investment has been made for public infrastructure. Public infrastructure has been funded by local governments, California Energy Commission (CEC), infrastructure providers, electric utilities and business partners. An excellent example of the contribution provided by business partners is Costco. Costco has sponsored the installation of 42 chargers at their stores throughout the State.

Most of the public chargers are located in areas where vehicles have been marketed. This includes the greater Los Angles/South Coast area, the San Francisco Bay Area, Sacramento and San Diego areas. There is virtually no public charging available in the San Joaquin Valley, northern Sacramento valley, north coast, and mountain and Sierra foothill areas of the State. Local government fleets are beginning to lease vehicles in the San Joaquin Valley, and the lack of public infrastructure represents a potential concern that could hinder further procurement in the area.

Public Infrastructure Programs in the South Coast

The first and largest program to install public infrastructure has been sponsored by the Mobile Source Reduction Review Committee (MSRC) in the South Coast. The MSRC was the first to fund the installation of publicly accessible EV charging stations in California, as well as to develop and implement signage on freeways and roads, directing motorists to EV charging stations. In its first round of efforts, MSRC allocated $1.6 million in funding, which resulted in the installation of 205 inductive and 151 conductive chargers at 111 locations throughout the South Coast Air Basin (SCAB). MSRC worked directly with four county government agencies (one in each county of the SCAB). The County agencies then worked directly with each individual site. $500,000 was set aside for signage on freeways, streets, roads, as well as at the property site.

The MSRC awarded $1.7 million in funding towards the second round of infrastructure, known as EV Charge. In this first-come, first-service application, MSRC provides up to a 90% cost-share for a public charger site, and up to 40% cost share if the site is a fleet provider and not accessible to the public. MSRC also provided $322,230 for signage.

Public Infrastructure Programs in the Greater San Francisco Bay Area.

In 1999, the Bay Area Air Quality Management District (District), in partnership with the City of San Francisco, launched a new program: Charge! This program provides $350,000 for the installation of public charging within the District. The Department of Energy in a Clean Cities Grant provided $100,000 to the City of San Francisco, and the District from their motor vehicle funds provided $250,000. Program funding was made available through a solicitation process to interested applicants located within the jurisdiction of the District.

Charge! pays 40% of total equipment and installation costs for the installation of two chargers (one inductive and one conductive). During the first round, $160,000 was allocated for 24 sites. These sites are recently completed, or soon to be. A wide variety of public charger sites were funded, including several city halls, large shopping malls, grocery stores and other businesses, an airport, and several college campuses. There will be a second round of solicitations in the summer of 2001, for the remaining funding.

Programs for Public Charging in Other Areas of California

In the Sacramento area, the Sacramento Municipal Utility District (SMUD) has sponsored an impressive program which has resulted in the installation of 100 public chargers at over 40 locations throughout the Sacramento region. The installation and equipment costs have been provided by SMUD, or by SMUD in partnership with other private and public partners which include Cal/EPA, the cities of Sacramento and Citrus Heights, and business owners.

The City of Vacaville allocated $85,000 for the installation of public charging. Vacaville partnered with GM and Honda to install a number of chargers in Vacaville. Vacaville is now entering into a second round of installations, utilizing a $210,000 grant from the federal Congestion Management and Air Quality Improvement (CMAQ) program. This funding will provide for additional public chargers at 10 sites. These installations are scheduled to be completed by this June. In addition, Vacaville is assisting the City of Dixon with the installation of public charging. A CMAQ grant of $50,000 will be used to install public charging in downtown locations and park and ride lots in Dixon. As a result of efforts in the Bay Area, Sacramento, Vacaville, and Dixon, access to public charging now exists through the Sacramento/Bay Area corridor.

In San Diego, the San Diego Gas and Electric company shareholders invested $50,000 in EV infrastructure.

California Energy Commission (CEC) Programs

The CEC has been involved with the installation of public charging. This includes $140,000 that they provided for the installation of public chargers to support the Honda/U.C. Riverside "shared car" program. This provided chargers at three different locations in Riverside County. In addition, CEC currently has $6 million to support the installation of public fueling (including electric chargers) to support

all alternatively fueled vehicles, including EVs. An advisory Group will be assisting CEC with the expenditure of these funds. A Request for Proposals is expected to be released shortly for CNG fueling stations. CEC intends to include EV charging stations as part of this program in the near future. The CEC also provides $875,000 in incentives for infrastructure, which is available to those individuals, public agencies, and businesses, which lease or purchase an EV. This program is described in more detail later in the report.

6. Infrastructure Safety

Standard Development

EV infrastructure has been designed and engineered for safety through collaborative work of stakeholders. Stakeholders include CEC, auto manufacturers, ARB, ZEV advocacy groups, EPRI, charger manufacturers, infrastructure providers, electric utilities, and industry standard setting organizations. The industry standard setting organizations include the Society of Automotive Engineers (SAE), Underwriters Laboratory (U/L), Fire officials, and building officials.

In 1994, the CEC became aware of challenges related to the installation of infrastructure for electric vehicle demonstration programs that were currently ongoing. These hurdles were more administrative in nature, and did not represent any significant technical or safety problems.

However, without explicit direction from the California Building Standards which govern the proper installation of electric vehicle charging and supply equipment, there were inconsistent requirements being imposed upon industry from building department to department which was hindering the installation of infrastructure to support the demonstration programs.

To address this problem, and make California EV ready, CEC began and coordinated a process to revise the standards. CEC worked closely with the California Building Officials (CALBO), an organization representing the majority of building officials throughout the State. CALBO staff had expertise in code development and training, and developed a proposal for revising the standards.

CEC formed a group composed of CALBO, electric utilities (LADWP, SMUD, PGE, SDG&E and SCE), ARB, GM, Hughes Power Control Systems, and the California Electric Transportation Coalition to revise the standards. The CEC also provided $90,000 to fund the project. CEC coordinated with the Infrastructure Working Council, which was undertaking a similar effort on a national level. However, IWC's work was not scheduled to be completed until 1998. The California Building Standards Commission adopted the new building standards in November 1995; these standards became effective in August 1996.

Accomplishments

As a result of these efforts, the 1996 revisions to California building standards and state and national electric codes were made that ensured that all EV charging installations would be done safely and uniformly throughout the State. This also included the establishment of the 1996 modifications to the California and National Electric codes.

These standards defined EV charging equipment, detailed how and where equipment can be placed, and specified 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 specified the minimum electrical supply that is required for EV charging systems, and safety features that are needed to prevent shock hazards. In addition, listing and labeling requirements for EV charging equipment were specified.

To ensure that all EV installations were done safely and uniformly throughout the State, extensive training and training materials have been developed. This includes training for building officials, as well as for contractors who install infrastructure. Training for building officials included:

- New building and electric code provisions
- Plan check and inspection techniques
- Overview of current and emerging EV technologies
- Permitting and inspection guidelines
- Hands-on experience with charging system equipment

Infrastructure Working Council

The Infrastructure Working Council (IWC) was established by EPRI to coordinate work and fund projects in partnership with automakers, battery manufacturers, SAE, U/L, and other stakeholders on issues that effect EV infrastructure, including safety and performance of standards related to EV charging. Under the MOAs, ARB committed to support IWC's efforts on standardization of power supply, emergency disconnect, and standard conductive and inductive charging systems.

The IWC completed work through several subcommittees. The subcommittees were: Connectors and Connecting Stations, Health and Safety, Load Management, Distribution, and Power Quality, Charging Controls and Communication, and a Bus/Non-Road Committee. Some of the accomplishments of IWC include:

- Working with SAE to complete Recommended Practices (J-1772 and J-1773) for design and manufacture of conductive and inductive connectors.

- National distribution of emergency response training materials developed by California's Office of State Fire Marshall.

- Development of a protocol for a battery charger test that also identified the impact of charging on the electricity grid.

- Record of Consensus on 16 power quality issues and factors such as how a battery charger affects utility systems, as well as how utility voltage variations impact the battery charger.

- Work to ensure that appropriate standards are in place to ensure the interoperability between vehicles and EV supply equipment, and to standardize charging and energy transfer systems regardless of the vehicle manufacturer or type. For a consumer, this means that using a vehicle with a conductive (or inductive) charger can recharge at any stations equipped with a conductive charger (or inductive). This included the establishment of SAE Recommended Practice J-2293, Energy Transfer Systems for Electric Vehicles

- Provided extensive input to SAE, which adopted a single standard for the butt-type connector (avcon) used by Honda and Ford.

The IWC completed most of its objectives for on-road EVs, and has now restructured to focus on off-road and bus charging issues.

7. Power Quality and Impact on the Electrical Distribution System

Power Quality

The increase of residential electrical usage from large numbers of EVs could represent a potential concern for power quality, delivery, and energy consumption. These are often referred to as the "secondary impacts of EV charging". This issue has been explored extensively by both the CEC and IWC. In particular, CEC and other stakeholders sponsored research to evaluate this issue. Sponsors included CEC, SMUD, PG&E, Georgia Power and Virgina Power Company.

The conclusions of this research were that chargers engineered consistent with standards do not give rise to excessive voltage. The rise in voltage due to EV charging should not be a cause for concern. However, it was recommended that load management strategies such as off-peak charging be encouraged.

A recent analysis by ARB staff supports the conclusions of the above-discussed research. This analysis indicated that if you assume 23,000 EVs are distributed statewide, energy demand would be approximately 166 GWh annually, or 0.05% of California's total energy demand for 2003.

Off-Peak Charging

Most utilities have separate rates available for electric vehicles to encourage overnight charging when electricity demand is generally at its lowest. Customers

make use of dual meter adapters that track electric vehicle electricity separately and timers that can set overnight charging for the least cost hours. Analysts have estimated, and early electric vehicle studies have confirmed, that over 80% of electric vehicle charging occurs during nighttime hours. Total nighttime electricity demand is as low as one-half of peak demand. In fact, with ZEVs utilizing the over-capacity of off-peak electricity, the overall efficiency of the electricity system can be improved.

F. STAFF RECOMMENDATIONS FOR BATTERY EV INFRASTRUCUTRE

1. Standardization

There are still two competing charging technologies, with a single charging standard no closer. As discussed earlier, both charger types have proven reliable and convenient to use. Because of the vehicles that are available, conductive chargers dominate fleet applications, while inductive chargers are more evenly divided between fleet and consumer applications.

The lack of progress towards a single electric vehicle charging standard affects both the cost and utility of public infrastructure. Significant EV charger cost reductions have not been realized until very recently (and only with conductive chargers). This is due to the much higher costs associated with small volume production. Also, lack of a standard significantly increases the costs of maintaining and expanding the current public charging network. In addition, costs for retrofitting or expanding public charging are expected to be significantly increased if a decision on a single standard is not reached before an increased number of vehicles are marketed.

ARB had previously considered the possibility of establishing standards that would govern the type of charger to be installed when public agencies provide incentives or funding for infrastructure. However, ARB was encouraged to wait and "let the market decide." Several years have passed, and unfortunately, very little progress has been achieved. The market appears no closer towards moving to a single charging standard.

Staff believes that ARB has the regulatory authority to establish standards for electric vehicle charging systems. Such regulations could be incorporated as modifications to the ZEV regulations. Staff recommends that ARB develop such standards this year, following a regulatory schedule aimed at a June Board Hearing with full implementation targeted for the 2005 model year. Development of the standard would need to include a stakeholder process that provides the opportunity for input from all involved stakeholders.

In particular, staff encourages input and participation from infrastructure providers, electric utilities, auto manufacturers, component and charger manufacturers, vehicle users, and government partners. Any standard that is set by ARB should include provisions that provide for the continued support of the de-selected charging technology prior to full implementation of a new standard.

Vehicles using the non-standard charging technology should not be "stranded" from access to public charging.

In addition, the choice of standard should take the following issues into consideration:

- Current charger cost, and potential for cost reductions
- Charger performance, durability, and safety considerations
- Warranty and manufacturer support
- Suitability for high power (level 3) and low power (level 1) charging applications
- The prospects for multiple manufacturers to enter the market
- The prospects for vehicle volumes using the standards

Conductive chargers have realized significant cost reductions in the last year; costs for chargers have decreased from $2100 to models that are now available for $800. Conductive charging systems are non-proprietary, which makes it much easier for new manufacturers to enter the field. Conductive chargers have also moved towards one uniform connector, the "butt and pin,:

Inductive charging technology is proprietary and potential manufacturers must pay significant licensing fees to GM. This has resulted in little, if any, cost reductions in charger technology. In addition, there are currently two different connectors in use, which has resulted in limited access to public charging for vehicles equipped with small port inductive charger ports.

2. Expansion of Public Charging Network

ARB staff believes that the expansion of public charging is needed to support increased numbers of EVs. In particular, ARB staff recommends working with stakeholders to support public charging expansion. This effort should include a thorough review and revision, if necessary, of the criteria for selecting public charging locations that would target public infrastructure in the most critical areas. This would not only take into account recent increases in electric vehicle usage, but also identify those areas where a lack of infrastructure is a potential disincentive to marketing vehicles. The latter should include a focus on the San Joaquin Valley, which faces significant air quality challenges as its population continues to grow, but has virtually no public infrastructure to support EVs.

Such an effort should also identify business partners that could make public infrastructure a part of their customer service, as Costco as done. To be successful these efforts should also include the development of outreach and marketing materials targeted at encouraging public and private investment in public charging infrastructure.

3. Other Issues Associated With Public Charging

Public charging needs to be accessible to EV drivers when needed. EV drivers often depend on public charging to complete their trip. Many public charging sites suffer from non-EVs using the parking space, thus preventing an EV driver from charging. In addition, often there is more than one EV driver who has need of the charger.

ARB staff recommends that stakeholders work together to develop model local ordinances that would discourage non-EV parking and enforce EV parking policies. As part of this effort, recommendations for uniform signage and designs should be considered. Also, stakeholders should consider recommendations for courtesy charging protocols that could be publicized to allow more than one EV driver to use a charging spot.

4. Centralized Information on Public Charging

Many drivers routinely depend upon public charging to extend the range of their vehicles. In order to effectively locate and use chargers centralized information on new charger locations, and operational status is important. In addition, information needs to be routinely updated so that drivers have access to the most recently installed public chargers and are warned of chargers that are not working.

User-friendly information for the vast majority of drivers would be in the form of a booklet that can be kept with the vehicle. ARB staff recommends that booklets with information on charger locations, similar to the ones published for the Sacramento area by SMUD, should be available for all of the major urban areas of California. Dealers should provide this information to consumers when vehicles are leased or sold, or provided by infrastructure providers when chargers are installed. Each region of the State should work together to produce and update the published information annually. EV users could subscribe to specific geographic areas and mailed updates.

In addition, centralized and up to date information in other formats is essential. Clean Car Maps (www.cleancarmaps.com) along with several other sources, is an excellent source of information on the Internet. Clean Car Maps is funded by the South Coast Air Quality Management District and CALSTART. Clean Car Maps provides lists of charging stations, interactive maps, information on operational status, operator information, and point to point driving directions. Clean Car Maps also allows users to report new or non-operational sites using a submission form and electronic bulletin board.

5. Maintenance of Public Chargers

Although charger failure and vandalism rates have been much lower than expected, it is extremely important that any needed charger repairs be done as expeditiously as possible, so as not to erode public confidence in the technology. Most charger repairs are currently covered by the manufacturer under charger

warranty, although damage caused by vandalism may not be covered by all manufacturers. However, many public chargers are beginning to exceed their three year warranty period, so the best way to continue to support these chargers is not clear.

Because there are currently two different charging systems utilized, there may be gaps or significant differences in how repairs of public chargers are handled. Also, information on where to report charger problems is often not easily accessible at the charger site. There is confusion as to who the responsible party is for repairs. Repairs to public chargers can be delayed if information on how to contact the property owner is not readily accessible.

In addition to services provided by charger manufacturers, their distributors, or EV charger installers, Clean Car Maps also provides a bulletin board through which EV drivers can report charger problems. ARB staff recommends that all stakeholders work together to determine the gaps that currently exist with regards to maintenance of public chargers, and identify those areas where Clean Car Maps could assist. ARB staff recommends that Clean Car Map activities for EVs be fully supported, and if necessary, expanded by stakeholders.

Support may include funding for timely updates to charger location information, as well as the reporting, dispatching, and funding, if needed, for the repair of public chargers. Stakeholders should work with ARB and Clean Car Maps to determine whether some type of "insurance" fund is needed to support the repair or upgrade of chargers no longer warranted or damaged by vandalism.

6. Workplace Charging

Workplace charging provides significant advantages. It allows employees to double the range of their vehicle, and can be a powerful incentive to encourage other employees to consider leasing or purchasing an EV. Workplace charging is also another important way to expand the charging network in California.

A few employers have installed infrastructure to support their employees' EVs, or as a way to demonstrate their support of advanced technology, even though they don't currently have employees who currently lease EVs. One example includes Apple Computers in Cupertino, which offers free parking and charging to employees who drive EVs until 25% of the vehicles that their employees drive to Apple are electric. Other examples of companies who have demonstrated their support of ZEV technology are Hewlett Packard in Roseville and Intel in Folsom.

The much higher cost of installing commercial infrastructure, as compared to residential infrastructure, often makes it difficult for many employers to fund installation projects at their work sites. In addition, many employers are reluctant to fund improvements at the facility that may only benefit one or two employees. Other disincentives can include the often difficult process of dealing with property managers of leased property who may not be knowledgeable about EV infrastructure and hesitant about allowing installation at their property.

Incentives will be critical to expanding workplace charging in California. ARB staff recommends that grants to cover part or all of the installation costs should be made available. Grant programs will likely be the most attractive to potentially interested employers. Programs should be targeted to those work sites where employees have leased or bought an EV, as well as large employers in regions where EVs are being marketed or large employers located in heavily congested regions where employees would benefit from the use of the HOV lane. The most effective programs will include the support of automakers, infrastructure providers, air districts, and local government agencies. Grants of $1000-2500 would significantly reduce costs and encourage participation.

7. Other Incentives

The CEC provides $875,000 for infrastructure incentives. These incentives are available to those who purchase or lease an EV. The CEC partners with automakers, who also contribute funding or provide equipment. The typical grant provides approximately $1,000 towards the cost of an EV installation. Staff recommends that CEC, ARB, and other stakeholders work together to review and evaluate the effectiveness of these programs, and identify areas where additional incentives to offset the costs of residential and commercial installations may be needed or modifications to existing grant programs should be made.

8. Power Quality and Impact of EV Charging on the Electrical Grid

California is currently facing a significant electrical energy crisis. All evidence gathered to date indicates that EV charging has minimal, if any, impact on the current crisis. However, ARB staff recommends that ARB, CEC, and the electric utilities take a proactive role in further analyzing, sponsoring further research if needed, and communicating to the public on this issue. ARB recommends that a working group, separate from the proposed stakeholder process described below be established to further evaluate this issue and prepare information for the public and stakeholders. CEC would be the best suited agency to lead this effort.

G. SUMMARY OF STAFF RECOMMENDATIONS FOR BATTERY EV INFRASTRUCTURE

1. Standardization

Staff recommends that ARB consider the adoption of regulations for a single charging standard. Since this decision is needed prior to the availability of increased numbers of EVs, staff recommends that the Board consider these regulations in June of this year. To meet this schedule, ARB staff recommends that an initial meeting of stakeholders be convened in early March, with a workshop to follow.

2. Stakeholder Working Group

Staff recommends that an ongoing Stakeholder Working group meet quarterly, beginning in February to provide input and develop suggestions for programs

and activities to support, expand, and maintain the public charging network in California. This working group would also evaluate and provide recommendations on incentive programs to support infrastructure, and attempt to resolve other issues discussed in this document. Below is a proposed schedule for activities:

Month/Tentative Date	**Activity**
February 2001	Solicit Working Group Members
Mid/Late February	Draft Action Plan for EV infrastructure issues prepared by ARB
Late February	First Working Group Meeting: Focus on Standardization, and information related to charger performance, cost and other issues
Late March	Public Workshop on Standardization
June	Public Hearing on Standardization
Late June/Early July	2nd Stakeholder Meeting. Focus on public infrastructure
September/October	3rd Stakeholder Meeting: Focus on incentives
October/November	Public Workshop on Public Charging/Infrastructure incentives
December/January	4th Stakeholder Meeting: Focus on implementation/status regarding standardization

3. Conclusion

Significant progress has been made in establishing infrastructure for EVs. California is nearly ready for increased volumes expected in coming years as a result of the Zero Emission Vehicle regulations. Standardization, maintenance, and incentives for public infrastructure continue to need work. Staff will work with ZEV Stakeholders through the process described above to resolve and support these issues.