# Electric Vehicle Community Market Launch Manual:

*A Guide to Prepare Your Community for Electric Vehicles.*

VOLUME II: THE "EV-READY" COMMUNITY:
INFRASTRUCTURE PLANNING AND DEPLOYMENT

Prepared by the Electric Transportation Coalition (ETC) and the Electric Vehicle Association of the Americas (EVAA) in cooperation with the U.S. Department of Energy (DOE) and the U.S. Department of Transportation (DOT).

December 1995

# Preface

Dear Reader:

Welcome to the *Electric Vehicle Community Market Launch Manual: A Guide to Prepare Your Community for Electric Vehicles*. This how-to guide is designed to assist communities in becoming "EV-Ready." This Manual was prepared by the Electric Transportation Coalition (ETC) and the Electric Vehicle Association of the Americas (EVAA) in cooperation with the U.S. Department of Energy (DOE) and the U.S. Department of Transportation (DOT). The ETC is a national nonprofit organization of industry, government, academic and other interests working to promote a public policy framework that supports the development of a widespread, sustainable market for electric vehicles (EVs). EVAA is an international nonprofit membership organization working to advance the commercialization of EVs in the United States, Canada and Latin America through comprehensive public information and market development programs.

This Manual results from a program initiated by the Electric Transportation Coalition known as the EV Market Launch Framework. The Framework is designed to result in the placement/commitment of up to 5,000 EVs in as many as 10 U.S. urban jurisdictions by the end of 1997. This initiative also calls for the deployment of infrastructure systems necessary to support EVs in operation, and the preparation of communities to assure the successful introduction of product into the market. The Framework builds upon EV America, a program which tests and evaluates EV technology to assure product quality and road-worthiness.

In order to help communities develop policies and deploy the infrastructure systems necessary to support the introduction of EVs, there is a need for a series of supporting documents to assist communities in this important activity. The three volumes that comprise the *Electric Vehicle Community Market Launch Manual: A Guide to Prepare Your Community for Electric Vehicles* were developed as a result of these needs. The Manual has been designed to identify issues and possible options/solutions to the development of the infrastructure necessary to support the introduction and eventual widespread use of EVs.

In order to assure that the information contained in this Manual is disseminated to those key urban jurisdictions that may wish to participate in a large-scale EV demonstration program, the U.S. Department of Energy and the U.S. Department of Transportation have joined with the ETC and EVAA to undertake a program of electric vehicle infrastructure workshops in a number of key communities around the United States. The joint government/industry EV infrastructure workshops are being organized and structured based on the information contained in this Manual.

We invite you to review this document and find out more about the important activities that need to be undertaken in order for a community to become "EV Ready." Only through the development of a large-scale demonstration of electric vehicles will we develop the knowledge necessary to build a sustainable market for electric vehicles in the United States.

Sincerely,

ETC/EVAA/DOE/DOT
December 1995

DISCLAIMER

# Organization of Manual

This *Electric Vehicle Community Market Launch Manual: A Guide to Prepare Your Community for Electric Vehicles* is designed to encourage community stakeholders to create the policies and infrastructure necessary to support a large-scale electric vehicle (EV) demonstration and prepare for successful EV market entry.

The Manual has been divided into three volumes. One volume is directed toward community leaders and others who focus on policy issues. Another volume is directed toward community participants who will be implementing EV programs and policies. The third volume is a reference guide. The three volumes are linked together by a recurring Executive Summary that outlines policy considerations, discusses infrastructure planning and deployment, and discusses the important link between adopted EV policy and successful infrastructure deployment.

## VOLUME I: GENERAL POLICY-LEVEL CONSIDERATIONS

Volume I addresses general policy issues communities may want to consider as they start to become EV-Ready. The five sections of this volume are designed to provide readers with information to answer the following questions:

- Why are EVs beneficial to an urban community?
- What is the status, type, and availability of EVs, batteries, and infrastructure support systems?
- What are the challenges confronting the development of EVs?
- When is a community considered EV Ready from a policy perspective?

In addition, Volume I describes a variety of materials that can be referenced to support state, regional, and local EV policies. These materials can be found in Volume III of the Manual.

## VOLUME II: THE "EV-READY" COMMUNITY: INFRASTRUCTURE PLANNING AND DEPLOYMENT

Volume II is designed to help communities turn policy into action. Specifically, it provides guidelines for developing an infrastructure deployment plan to prepare for the market entry of EVs. Each chapter in Volume II provides information on a particular aspect of the infrastructure deployment plan, addressing such issues as:

- Installation of EV charging stations
- Emergency fire and rescue training
- Battery recycling
- Public education materials

## VOLUME III: ADDITIONAL SOURCE INFORMATION

The third volume includes detailed source information and case studies referenced in the first two volumes of the Manual.

### *Supplements and Updates to the Manual*

A listing of all recipients of the Manual will be maintained by both ETC and EVAA. Any updates and/or supplements that may be produced will be provided to those on the distribution list.

### *Request of Readers*

This Manual is intended as a tool to assist in efforts to ensure the establishment of policies favorable to the introduction of EVs and the development of EV infrastructure systems. If there is a need for information not contained in this Manual, please contact the Electric Transportation Coalition (202/508-5995), the Electric Vehicle Association of the Americas (415/249-2690), the U.S. Department of Energy's National Alternative Fuels Hotline (800/423-1DOE) or the U.S. Department of Transportation (202/366-4000).

## ACRONYMS

| | |
|---|---|
| ACTS | American Coalition for Traffic Safety |
| ALABC | Advanced Lead-Acid Battery Consortium |
| ac | Alternating current |
| AFV | Alternative-fuel vehicle |
| BIA | Building Industry Association |
| BECO | Boston Edison Company |
| CAAA | Clean Air Act Amendments of 1990 |
| CARB | California Air Resources Board |
| dc | Direct current |
| DECO | Detroit Edison Company |
| DOE | U.S. Department of Energy |
| DOT | U.S. Department of Transportation |
| FMVSS | Federal Motor Vehicle Safety Standards |
| EDF | Electricité de France |
| ETC | Electric Transportation Coalition |
| EPAct | Energy Policy Act of 1992 |
| EPRI | Electric Power Research Institute |
| EV | Electric vehicle |
| EVAA | Electric Vehicle Association of the Americas |
| GM | General Motors Corporation |
| HOV | High occupancy vehicle |
| ICEV | Internal-combustion-engine vehicle |
| IWC | National Electric Vehicle Infrastructure Working Council |
| kW | Kilowatt |
| LADWP | Los Angeles Department of Water and Power |
| MOU | Memorandum of Understanding |
| NEC | National Electric Code |
| NEED | National Energy Education Development project |
| OEM | Original equipment manufacturer |
| QVM | Qualified vehicle modifier |
| RCRA | Resource Conservation and Recovery Act |
| RSO | Regional Support Office, U.S. Department of Energy |
| SAE | Society of Automotive Engineers |
| SCAQMD | South Coast Air Quality Management District |
| SCE | Southern California Edison Company |
| SMUD | Sacramento Municipal Utility District |
| SOC | State of charge |
| SRP | Salt River Project |
| TCM | Transportation control measure |
| USABC | United States Advanced Battery Consortium |
| UWR | Universal Waste Rule |
| VP | Virginia Power |
| W/kg | Watts per kilogram |
| Wh/kg | Watthours per kilogram |

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**Electric Vehicle Community Market Launch Manual:**
**A Guide to Prepare Your Community for Electric Vehicles**

**VOLUME II: THE "EV-READY" COMMUNITY:**
**INFRASTRUCTURE PLANNING AND DEPLOYMENT**

# Executive Summary

## THE "EV-READY" COMMUNITY

The authors of this Manual share a common vision of the future: a long-term, sustainable market for electric vehicles (EVs) in the United States—one where electricity is an attractive and affordable form of fuel for transportation.

Envision an enhanced quality of life resulting from the incorporation of EVs into the fabric of your community: EVs quietly pulling up to red lights, with no tailpipe emissions and using virtually no energy while at a standstill. Vehicles refueling conveniently at the home, office, or shopping center while the owners are occupied with other endeavors. And, citizens benefitting from the improved air quality that could result from EVs becoming an integral part of the community's transportation network.

With passage of the Clean Air Act Amendments of 1990 and the Energy Policy Act of 1992, the federal government recognized the important role alternative fuels can play to help improve air quality in congested, urban areas, reduce this nation's dependence on imported oil, reduce the trade deficit and improve national energy security. However, ensuring the successful introduction of alternative fuels, like electricity, into the transportation sector will require more than just the support of the federal government.

## CHARTING THE COURSE

Industry has charted a course—*the EV Market Launch Framework*—to assure that the next critical steps toward a sustainable EV market are taken. With active participation of the federal government, industry will begin to "roll-out" a limited, but significant number of EVs into controlled demonstrations in a few key areas of the country. The electric utility and automotive industries, in cooperation with government, have committed to place up to 5,000 road-worthy EVs into as many as ten (10) communities by the end of 1997.[1]

Similar to the redevelopment of a downtown corridor, the EV Market Launch Framework is designed to proceed one block at a time. This *building block* concept calls for establishing a core base of product and infrastructure in a small number of communities and then expanding that base, both within and between the communities, as technology improves, prices fall, the infrastructure matures, and markets broaden. Such an incremental approach can help to assure that infrastructure investments match product availability and, most importantly, that communities can adequately plan and prepare for increasing numbers of EVs.

## THE CLEAN CITIES CONNECTION[2]

One of the current challenges to EVs is finding a *select* group of communities to embrace these vehicles as they are provided by manufacturers in limited quantities and with limited-range batteries. Currently, 43 communities throughout the nation have been designated Clean Cities by the U.S. Department of Energy (DOE).[3] A Clean Cities community brings fleet owners, fuel suppliers, local utilities, auto manufacturers, and government together to make commitments to the creation of a viable alternative fuels market. Each of the designated Clean Cities is required to draft and sign a Memorandum of Understanding (MOU) between the city, its stakeholders, and DOE. The MOU describes the commitments made by the stake-

[1]The federal government's commitment is dependent on the availability of funding, and the cost and capabilities of the electric vehicles that are available for purchase.

[2]As a result of the practice dry-run workshop on December 19, 1995, the Executive Summary has been changed to clarify the partnership between the Clean Cities program and the EV Market Launch Framework.

[3]As of January 1996, 43 Clean Cities have been designated. At the time of the initial printing, 41 cities had become a part of the Clean Cities program.

holders to raise public awareness of alternative fuels and to cooperate in the administrative requirements of the national Clean Cities program. Since a network already exists in each Clean Cities community, selected Clean Cities will be among those targeted to commence the EV Market Launch program.

For more than two years, local Clean Cities Coalitions have been working to bring alternative-fuel vehicles (AFVs) to the American road. During this time, Clean Cities partners have undertaken the critical activities necessary to develop new markets for alternative fuels and alternative-fuel vehicles, including committing to new AFV purchases or conversions, investing in refueling and maintenance infrastructure, creating new jobs and commercial opportunities, and working with their community to increase public awareness and advance clean air objectives. In short, each Clean Cities community has created a favorable local market for AFV use and the critical mass of partners necessary for future investment and sustainable growth.

By working together with the local electric utilities, Clean Cities partners can use the *EV Market Launch Program* to advance new EV technologies and develop the necessary recharging infrastructure to make their communities *READY* for the EVs of the future. The local Clean Cities partnership in turn provides a willing and able network to raise public consciousness about EVs and help electric utilities identify and build new markets for EVs.

Some Clean Cities Coalitions will use the Market Launch Program to build upon the EV projects currently under way by EV working groups. Other Coalitions may use the Market Launch Program to generate interest in EVs. Either way, the Clean Cities Committee structure enables easy incorporation of the EV Market Launch Program into one of the existing committees.

In addition, the Clean Cities Coalition can readily communicate the EV message. Coalitions have already hosted many successful public relations events that captured the attention of print and electronic media. Some Coalitions also work to educate the drivers of tomorrow by working with teachers and students. In 1996, the national Clean Cities program will be working with the National Energy Education Development (NEED) project to develop and market to middle and high schools a *Let's Talk Energy Show on Alternative Fuels*. Finally, if a community needs assistance convincing legislators of the benefits of EVs, Clean Cities Coalitions across the country have been successful in getting favorable laws passed to encourage the use of alternative fuels, and it is likely they already know the key legislators who can make a difference.

Besides several Clean Cities, other communities may be targeted sites for an EV demonstration program because they are in the process of forming a Clean Cities program. In addition, if a community has evidenced a significant interest in EVs—through the conduct of EV research; development and demonstration projects funded through the Departments of Transportation, Energy, or Defense; participation in EV demonstration programs underway by original equipment manufacturers; participation in EV America; and/or the organization and conduct of other EV and infrastructure-related activities—that community also may be among those targeted to commence the EV Market Launch program.

As the Clean Cities program has learned, local business and government leaders are the key participants to assuring that a given community can contribute successfully to the development of a sustainable market for EVs in the United States. These local policy and opinion makers hold the key to assuring that the necessary actions are taken so that a community becomes *EV Ready*. The advent of the EV will not be a simple substitution of one vehicle technology for another. Because EVs have special charging needs and currently have limited travel ranges, their introduction will create the need for an expansion of the infrastructure which currently supports the automobile.

## ADDRESSING THE KEY ISSUES

To assure the successful integration of EVs into the community, there are four basic policy issues that community leaders are being asked to consider:

- A policy framework that will encourage the purchase and support the use of electric vehicles in the community
- Building, electrical, health and safety codes that support expedited and cost-effective deployment of EV charging equipment and the training of emergency, fire and rescue personnel
- A plan and schedule for the deployment of charging equipment
- A public information/awareness campaign

## ACCEPTING THE CHALLENGE

In accepting the challenge to become EV Ready, a community must recognize that, to be successful, appropriate policies supporting the commercialization of EVs must be set and adequate resources must be made available for infrastructure implementation. These two elements—appropriate policies and adequate resources—are interdependent. Therefore, it is critical that a coordinated effort involving all the key players be launched in order to assure the successful commercialization of EVs.

Based on the pace of implementation of infrastructure requirements already undertaken by some of the leading EV communities, it is generally believed that it will take between 18 months to two years of rigorous effort to adopt policies and begin implementing an EV infrastructure deployment plan. The graphic on the following page, entitled *"EV-Ready" Community Market Launch 2-Year Implementation Plan*, depicts the framework for activities that an urban jurisdiction needs to undertake and complete to be considered EV Ready, and suggests a timeframe in which these activities should be achieved. The list of activities is illustrative, but should assist a community in focusing its efforts on those issues of priority for the next two years. One should not assume, however, that the EV planning and implementation can end at the conclusion of a 24-month period—as the market continues to expand, planning and infrastructure deployment must continue.

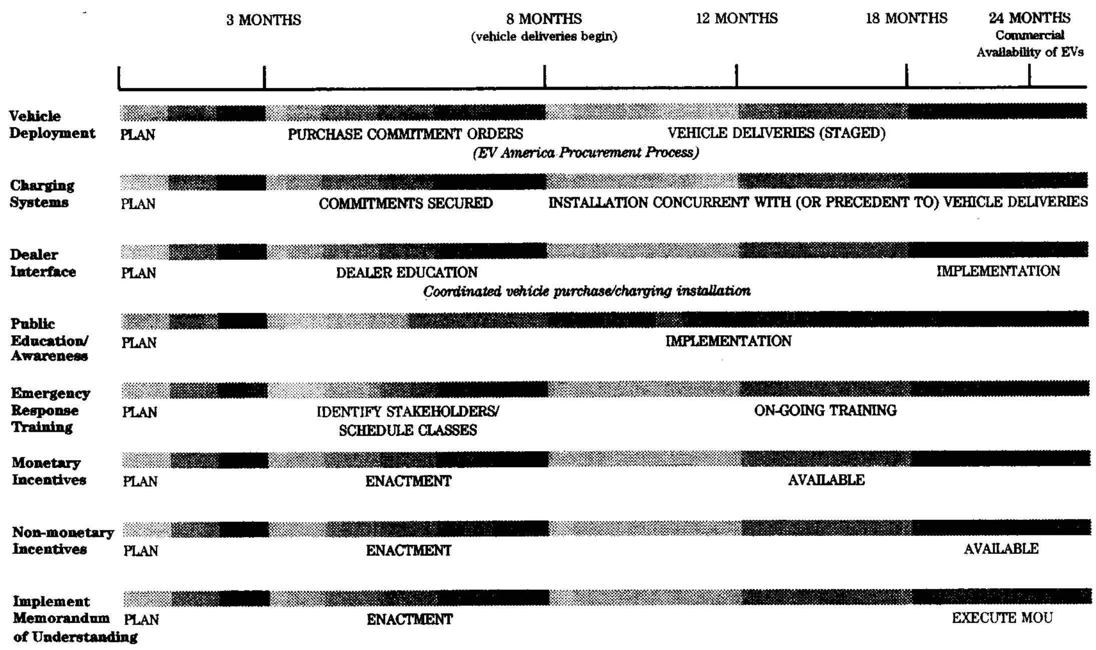
This Manual is designed specifically to assist those visionary community leaders who choose to accept the challenge to become EV Ready.

The U.S. Department of Energy, the U.S. Department of Transportation, the Electric Transportation Coalition and the Electric Vehicle Association of the Americas have worked closely with the automotive and utility industries to craft this Manual, which identifies the key stakeholders necessary to undertake the effort to become EV Ready; defines those key issues that must be addressed; suggests approaches for achieving EV Readiness; provides specific information on EV/infrastructure planning and deployment to those persons charged with implementation; and, includes case studies, reports, and other information that can be used to understand the elements and process involved in the introduction of EVs.

The electric utility industry is working with the federal government to assure that only road-worthy EVs are placed into demonstrations through a vehicle test and evaluation program known as EV America. The automotive and electric utility industries are working together to assure that adequate incentives (monetary and non-monetary) are in place to help jump-start the technology introduction and to assure the purchase and use of the vehicles. And the federal government is working in conjunction with industry to assure that communities are prepared to attract and support EVs as they become available.

This Manual represents a central element of the EV Market Launch Framework—preparation of communities for the commercial availability of electric vehicles.

### "EV-READY" COMMUNITY MARKET LAUNCH 2-YEAR IMPLEMENTATION PLAN




Assumptions: Electric utility(ies) commits to deployment of recharging
Local government commits to incentive package (to be defined)
Utility(ies), state government and local community all commit to purchase and/or lease a certain number of EVs (at least 500 per community)
Auto manufacturer(s) commits to provide agreed-upon number of road-worthy EVs (such as those tested and evaluated under EV America)
Stakeholders develop a plan for infrastructure deployment

# The "EV-Ready" Community: EV Infrastructure Planning

For a community to embrace electric vehicles, the stakeholders in that community—the electric utility, local government, businesses, and citizens—must develop and promote incentive programs that encourage early vehicle sales and investment in EV infrastructure systems. Simply stated, a community can be defined as "EV-Ready" once it has put in place the following policy elements:

- A policy framework that will encourage the purchase, operation, and support of EVs in the community
- Building, electrical, health, and safety codes that allow for expedited and cost-effective deployment of charging equipment and training of emergency, fire, and rescue personnel
- A plan and schedule for deploying charging equipment
- A public information/awareness program

The definition of an EV-Ready community focuses primarily on **development and adoption** of broad EV policies. However, EV infrastructure planning focuses primarily on **implementing** the policies that the local community has adopted.

With a collaborative effort at the community level (via the existing Clean Cities network and/or other community groups), EV infrastructure planning should incorporate the perspectives of policymakers, automakers, implementors, and the general public to develop a comprehensive plan that, when put in place, will provide EV users with the necessary equipment, support services, and conveniences that are currently available for users of today's automotive products.

To help ensure success, planners should view the EV and its infrastructure as *one cohesive system*, not two distinct systems that are eventually merged. Ultimately, the infrastructure that is put in place must be embraced by the EV user.

To implement the four broad policies mentioned above, community EV planners should consider organizing programs in each of these areas:

- EV charging facilities
- Support of electric vehicles and charging facilities
- Public information and awareness
- Education
- EV policy support

Organizing these EV programs can ensure that all policy elements are addressed and that decisions related to these policies are coordinated. These infrastructure programs will be dependent on one or more policy committees. For example, actions approved by the Infrastructure and Electrical/Building Codes Committees will affect the ability of the EV Charging Facilities Program to install charging stations. Likewise, the Public Information Committee will help determine what kinds of issues the Information and Awareness Program will focus on in educating the community.

The sections in this volume of the Manual discuss in detail elements that a community should include in its EV infrastructure and deployment plan. To provide readers a real-world perspective, sections also include case studies that focus on the accomplishments—and the work in progress—in a number of leading EV-Ready communities.

## HIGHLIGHTS OF SECTION

**PURPOSE**

Most experts agree that EV charging facilities are the most important infrastructure element. If consumers can't fuel EVs conveniently, they probably won't purchase EVs. This section of the Manual provides infrastructure planners with information on EV charging facilities that can help them develop a plan for deploying charging stations within their communities.

**ISSUES ADDRESSED**

- EV charging technology
- Location/quantity of charging facilities
- External factors affecting installation
- Charging facility installation issues
- Electric utility system impacts
- Investing in charging facilities

**GENERAL CONCLUSIONS**

The industry continues to develop two types of charging systems—inductive and conductive.

EV charging facilities must be available at the vehicle's primary garaging location.

Communities have taken different paths in studying and deploying public EV charging facilities.

Local communities must adopt changes to building and electrical codes to ensure EV charging facilities can be installed expeditiously and operated safely.

Local community stakeholders and EV purchasers should decide which parties will be involved in installing charging facilities.

Electric utilities should understand the impacts of EV charging on their generation, distribution, and transmission systems.

The costs of installing residential EV charging facilities are fairly well understood. Public EV charging facility costs are not well defined due to vast differences at each location.

Some electric utilities have shown that investments in EV charging facilities and other electric transportation programs can provide direct and indirect benefits to all customers.

# EV Charging Facilities

EV charging facilities are the most important infrastructure element. If consumers can't fuel EVs conveniently, they are not likely to purchase EVs. To ensure that the number and type of charging facilities established match customer needs and expectations, community EV planners should become familiar with the following aspects of EV charging:

- EV charging technology
- The desirable location and quantity of existing and future EV charging facilities in the community
- External factors affecting the installation of new charging facilities
- The charging facility installation process
- The impact of EV charging on the local utility's generation, transmission and distribution systems, and a building's electrical capacity
- The cost of charging facilities
- Justifications for securing investments needed to install additional charging facilities

The goal of this chapter is to provide implementors with the most current information—including case studies from the automotive and electric utility industries—on charging facilities. Using this information, implementors can work with other stakeholders to intelligently plan for and deploy EV charging facilities in residential and commercial structures and at public access locations. Throughout this process, each community will determine its own responsibilities, technology needs, and activities. Simply put, there are many avenues that a community can take to deliver EV charging facilities.

One pathway EV infrastructure planners might consider follows:

- Conduct a general planning meeting with all stakeholders to discuss relevant issues
- Survey early adopters of EVs to determine projected level of purchases, level of use, and charging requirements (timing, frequency, location, and billing system)
- Review available charging system technologies and determine approximate

locations, quantities, capacities, and levels of charging

- Work with local transportation planners, developers, and professional design firms to address land use planning and design issues
- Develop an action plan that includes milestones, stakeholder responsibilities, and funding sources
- Install charging facilities

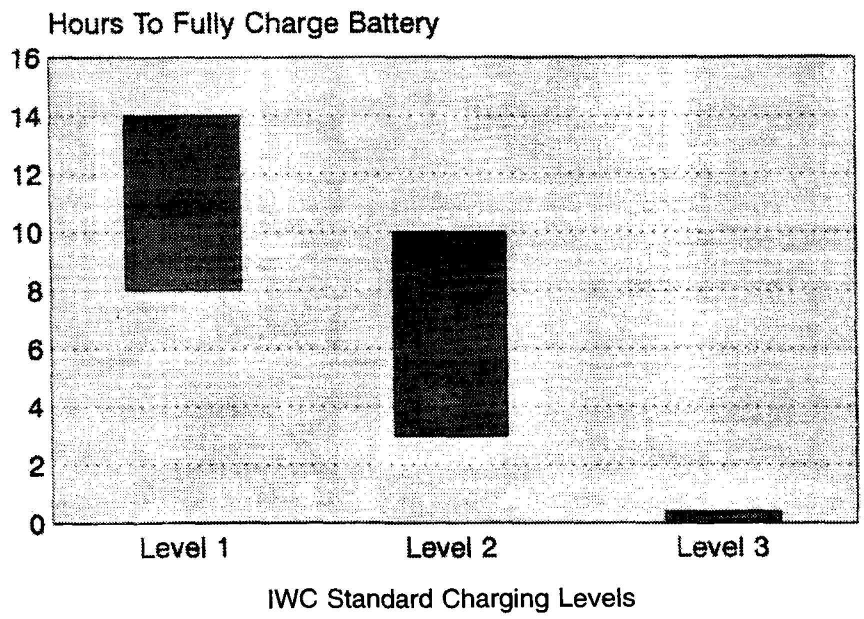
## EV CHARGING TECHNOLOGY

Equipment standardization is generally not the primary focus of technology developers, due to competition and the need to protect proprietary information. For example, both videotape player/recorders and personal computers are not standardized. EV charging equipment is no exception: a single plug and coupling interface for EV charging has yet to be established. In recent years, however, the industry has agreed on some issues that are pivotal in moving toward uniform charging systems.

This section on EV charging technology outlines the variables infrastructure planners should consider in determining which EV charging technologies are appropriate for the local community. Specifically, this section covers:

- Standard EV charging levels
- Conductive and inductive charging systems
- Communications requirements
- EV charger design standards
- Billing systems

**Expected Electric Vehicle Charge Times**




Note: Charge times vary due to battery type, temperature and other factors.

*Standard EV Charging Levels*

The National Electric Vehicle Infrastructure Working Council (IWC), a collaborative effort of the automotive, electric utility and other interested industries, announced in late 1994 the standardization of charging levels for EVs.[1] These include:

- Level 1: Charging that can be done from the standard, grounded 120 volt, 3-prong outlet available in all homes. Because it can involve lengthy charging times (see table) level 1 is not likely to become the preferred charging option.
- Level 2: Charging at a 240 volt, 40 ampere charging station with special consumer features to make it easy and convenient to plug in and charge EVs at home or a remote site on a daily basis. Offering greater convenience and shorter charge times than level 1 charging, level 2 is expected to be the primary home and fleet charging option.
- Level 3: A high-powered charging technology currently under development that will provide a charge in 5-10 minutes (from 80% to 20% depth of discharge), making it analogous to filling the tank of an internal-combustion-engine vehicle at a gasoline station.

[1]For information on IWC and on the impacts of these charging regimes on the utility system, see Volume III of this Manual.

Voltage and current power levels have not yet been defined for level 3 or "quick" charging. However, the industry has standardized the charging time and the amount of the energy transfer. Based on estimated EV battery pack capacities, level 3 chargers will need to be on the order of 50 kW or greater—typically over 100 kW—and should be served by three-phase power, at 208 or 480 volts.

IWC and the Electric Power Research Institute (EPRI) are working to develop common recommended standards and practices for level 3 charging facilities, identify any consumer and utility interface issues, and evaluate the feasibility and necessity for this type of charging.

*Conductive Systems*

Conductive charging systems shown to date use a plug and cord system that can vary by the type of connector used and the level of voltage and current. The charger can be located either on-board (built into the vehicle) or off-board (separate from the vehicle) depending on the design of the conductive system. For all on-board chargers, some type of off-board control and/or interconnection device will be required.

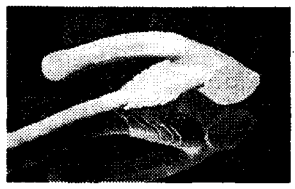
Led by EPRI, representatives of 20 companies,[1] many of which are represented on the IWC, are working to complete the physical and electrical specifications for a single standardized conductive coupling system. This system would include the vehicle inlet, the cord and plug, and the EV supply equipment. While focusing on level 2 charging, the project is planning for power requirements anticipated for level 3 charging. Once the specification for the conductive design is completed and tested, the design will be submitted to the Society of Automotive Engineers (SAE) for consideration as a recommended practice. Schedules call for delivery of prototype charging equipment in late 1995 for testing, and availability of production equipment in mid-1996.

*Inductive Systems*

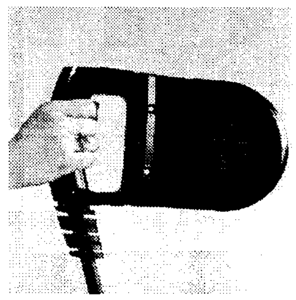
Inductive charging systems, such as the Delco Electronics *MAGNE CHARGE*™—Underwriter Laboratory (UL) and FCC approved—use a cord and paddle-shaped inductive coupler that transfers energy from the power source to the vehicle by means of magnetic induction. The charger for the Delco inductive charging system is located off-board the vehicle. The inductive paddle is the same size for all three charging levels, which could allow a single interface to charge the vehicle.

Recently, SAE adopted a recommended practice (see Volume III of this Manual) for the inductive charging interface design (SAE J1773).

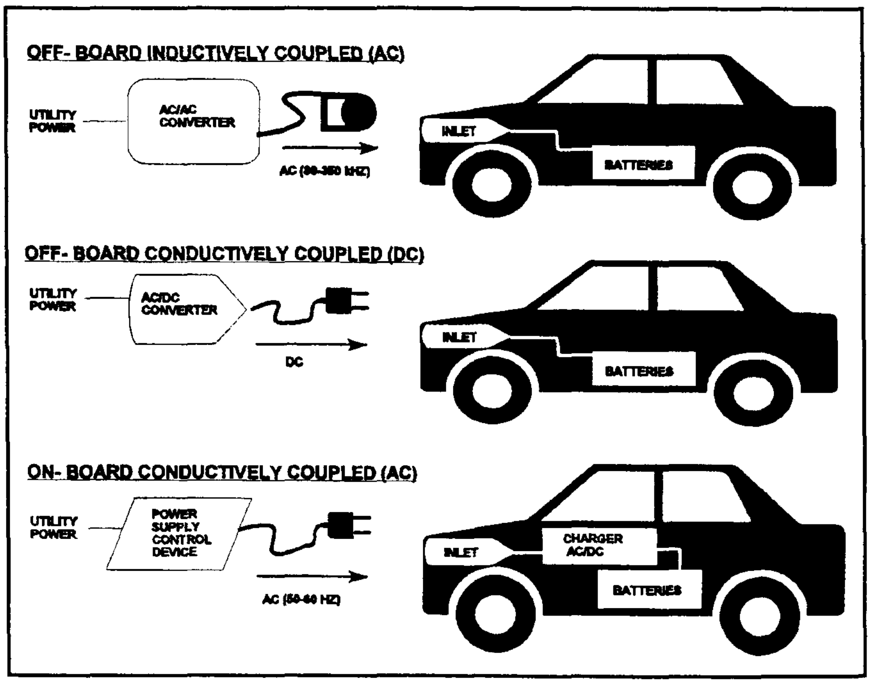
Both the conductive and inductive systems will need electronics off-board the vehicle to provide the communication and diagnostic capabilities required by the recommended



Proposed Conductive Coupler



Inductive Coupler




Off- and On-Board Charging Methods

[1]The group includes 11 overseas and domestic automotive manufacturers, 7 electric utilities, the Electric Power Research Institute, and the California Air Resources Board.

practices being developed. The only exception to this may be level 1 charging. Both the conductive and inductive charging systems have been successfully tested in fleet and/or consumer applications.

*Communications Requirements*

In the future, the serving electric utility will need to manage an increasingly large and widespread EV load. The IWC's Load Management, Distribution, and Power Quality Committee is establishing and defining a method the utility can use, with customer concurrence, to remotely control the charging process. This method will require development of a communications architecture and interface between the EV supply equipment and the vehicle. The ability to communicate will also help ensure safe and cost-effective EV charging, interoperability of supply equipment and vehicles from different manufacturers, and future expandability and compatibility of equipment. The IWC's Data Interface Committee has completed a preliminary definition of minimum operational and communication requirements, selected an established SAE digital communications protocol for use between the supply equipment and the vehicle, and has proposed changes to SAE to define data and communications requirements for EVs. This work should be completed before 1998.

*EV Charging System Design Standards*

Expecting the market for on- and off-board EV chargers to grow with the introduction of EVs, many businesses are planning to manufacture and market EV chargers to meet the increasing demand. Like similar equipment, chargers need to be built to some minimum recognized standards. The following is a list of industry-recognized standards that implementors should take into consideration when acquiring EV chargers:

SAE J551
Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30 Hz to 1,000 MHZ).

SAE J1211
Recommended Environmental Practices for Electronic Equipment Design, Nov. 1978.

SAE J1742
Connections for High Voltage On-Board Road Vehicle Electrical Wiring Harness.

SAE J1772
Electric Vehicle Conductive Coupling Recommended Practice.

SAE J1773
Electric Vehicle Inductive Charge Coupling Recommended Practice.

SAE J1850*
Class B Data Communication Network Interface, July, 1990.

SAE J2178*
Class B Data Communication Network Messages.

SAE J2293
Power Transfer Control for Electric Vehicles.

FCC
Code of Federal Regulations, Title 47 (parts 15A, B, and 18), Document # 869-019-00180-8.

UL 943
Ground-Fault Circuit Interrupters, Underwriters Laboratories Inc., Sept. 11, 1985.

UL 1012
Power Units Other Than Class 2, Underwriters Laboratories Inc., Aug. 21, 1992.

UL 1283
Electromagnetic Interference Filters, Underwriters Laboratories Inc., Mar. 26, 1984.

UL 2202
Outline of Investigation for Electric Vehicle (EV) Charging System Equipment, Nov. 1994.

NEMA 250
Enclosures for Electrical Equipment (1000 Volts Max.), National Electrical Manufacturers Assoc., 1991.

ANSI/IEEE
Guide for Surge Voltages in Low-Voltage AC Power Circuits, C62.41-1980, American National Standards Institute and Institute of Electrical and Electronics Engineers, 1980.

ANSI/IEEE
Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits, C62.45-1987, American National Standards Institute and Institute of Electrical and Electronic Engineers, 1987.

NFPA
National Electric Code, NFPA 70-1996, Article 625.

(*These standards are being updated to include information on communications for EVs.)

Charger power quality is another important issue. Use of low-performance equipment can create a number of effects of concern to the utility industry, including harmonics, voltage flicker, poor power factor, voltage drop, transients, electromagnetic interference and radio frequency interference. When hundreds of thousands of chargers are charging EVs, low charger power quality could cause real problems. Utilities, automakers, and charger manufacturers must anticipate and correct any power quality problems before electric vehicles and chargers are used by customers. The Institute of Electrical and Electronic Engineers (IEEE) is creating an equipment power-quality standard to address this important issue.

When planning for and installing EV charging facilities in public locations, implementors should consider the possibility of vandalism. The charging facilities should be designed to withstand rugged treatment and to protect the public from electrical shock associated with vandalism. The following case study describes how one utility is preparing for vandalism at a public charging facility:

> *New York Power Authority (NYPA)*
>
> ***NYPA, in cooperation with the MTA Metro-North Railroad and the White Plains Parking Authority, has initiated an EV station car program that allows EV users to carpool from a suburban train station north of New York City to their worksites in Westchester County. The EVs will be charged overnight and on weekends at the train station. NYPA's contractor, Diversified Technologies, Inc., has designed, fabricated, and installed 12 vandal-proof conductive charging stations that offer the user 110 or 208 volt charging. Each charging station enclosure will hold the plug and cord sets behind a locked panel when not in use. Furthermore, the charging stations are equipped with high efficiency lighting controlled by a motion detector. Volume III of this Manual contains a drawing of these charging stations.***

By working to establish connector and charging standards, automakers and electric utilities are helping to lay the foundation for successful EV introduction. These standards will allow utilities to provide the appropriate electrical service, manufacturers to develop compatible charging systems, and automakers to design and build compatible vehicles at the lowest possible cost.

*Billing Systems*

Simple and convenient billing systems are important to the successful commercialization of EVs. Several utilities across the nation have investigated existing and emerging billing systems that could be used for the following EV charging scenarios:

- Charging at home or in a centralized fleet garage, assuming the EV owner or operator is the utility's regular electricity customer for that site
- Charging at third-party remote charging sites, assuming the EV owner or operator is not the utility's regular customer for that site

A CALSTART study, *Billing Systems for Electric Vehicle Charging,*[1] has assessed the applicability of today's billing systems for each of these situations and reports the following findings:

- Residential and centralized fleet EV charging locations were most effectively billed using existing electric utility monthly billing practices.
- Third-party EV charging locations were most effectively served by point-of-sale payment options. However, the cost to implement such systems could be high.
- High transaction costs (i.e., merchant and card fees) relative to the cost of the elec-

[1]November 15, 1993. Prepared for CALSTART, the California Energy Commission, Federal Transit Administration, Hughes Power Control Systems, Pacific Gas and Electric Company, Southern California Edison Company, Los Angeles Department of Water and Power, and Sacramento Municipal Utility District.

tricity limit the attractiveness of credit and debit cards for EV charging. With much lower up-front costs, the less popular value card[1] and smart card[2] technologies may be better suited to EV charging.

- Smart cards, already popular in Europe, are expected to gain wider acceptance in the U.S.

It's anticipated that unmanned point-of-sale billing will be necessary at public charging facilities. Implementing such a system will entail hardware, transaction, and administrative costs. However, these costs will be amortized over the life of the equipment. Moreover, use of advanced systems greatly expands the flexibility of billing options, allowing, for example, utilities to implement billing mechanisms across service territories.

Any point-of-sale billing arrangement must be carefully structured to meet the approval of the state or local utility regulatory body.

The following case studies discuss experiences with billing systems.

***Detroit Edison Company (DECO)***

***After studying public charging issues in the 1980s, DECO determined that point-of-sale billing would not be cost effective due to transaction fees. DECO examined the use of credit cards to pay for the electricity at public charging facilities, but found that banks were not interested because the low value of each transaction would result in a low transaction fee.***

***Electricité de France (EDF)***

***EDF provided EV test drivers in La Rochelle, France, with public-access EV charging facilities that incorporated smart card technology. The card enabled the driver to pay for electricity, park free in municipal parking lots for 24 hours, and obtain information from the national training center in La Rochelle on charging station procedures and electricity rates. The card, now available in all EDF service centers, sells for $60, of which $24 is used to cover the 18-month subscription fee. The remaining $36 provides the user with 400 units of charging credit worth nine cents each. Users can add new units to smart cards at any time.***

If electric utilities have reciprocal-use agreements in place, a smart card programmed and purchased through one utility could be used at a charging facility owned by a different utility. Smart cards can also be programmed for other uses.

Some businesses operating EV charging facilities may decide to provide the EV user with electricity free of charge, as the cost of the electricity is expected to be minimal. Others may choose to recover their costs by charging for use of the charging facility or parking space, including the cost of electricity as an un-itemized element. Businesses that choose to recover the cost of electricity by direct pass-through of the cost to the customer will need to install metering to measure actual power usage and point-of-sale payment equipment.

## THE DESIRABLE LOCATION AND NUMBER OF EV CHARGING FACILITIES

Part of the EV planner's job is to ascertain the number and location of existing fleet, residential, and public charging facilities, and project the number and location of future stations needed on the basis of expected EV sales.[3]

[1]A value card is a prepaid card that has varying amounts deducted from it until the balance reaches zero. The value of the card is encoded on a magnetic strip affixed to the card.
[2]A smart card is a prepaid card that has varying amounts deducted from it until the balance reaches zero. The value of the card, along with other information, is contained in a microchip embedded in the card.
[3]See Volume III of this Manual and the following sources to establish EV market potential: AAMA, *AAMA Motor Vehicle Facts and Figures*, published annually; National Association of Fleet Administration, (908) 494-8100; and Dwight's Energy Research, which provides fleet statistics, (800) 964-6001.

Surveys and focus groups to determine EV demand can provide useful information on the number and geographic distribution of EV sales, and consequently the number and location of EV charging facilities that might be required for residences and fleets. General information from the surveys might also help plan for public charging facilities.

This section addresses how some communities have planned for or installed charging facilities and how much EV users will pay for electricity at remote charging facilities.

The electric utility and automotive industries agree that an EV charging station must be available at the EV's primary garaging location. For an EV garaged at a single-family dwelling, one charging point would be required. The ideal location of this charging station would be in the garage or beside the driveway. In multi-family structures with reserved (single user) parking spaces, one charging station would be required adjacent to the parking space. In multi-family parking structures without reserved parking, a charging facility installed at one location could accommodate several users. For centrally fueled EVs in a fleet setting, one or more charging facilities could charge a number of vehicles at the same time.

The following case studies discuss results of charging studies performed by different groups:

***Salt River Project (SRP) EV Market Assessment Survey***

***A 1993 Residential Electric Vehicle Market Assessment Study[1] completed by SRP found that Arizona-based potential purchasers of EVs must be able to charge at home. To ensure the broad appeal of EVs, charging facilities must also be available at work locations. In contrast, the ability to charge an EV at shopping malls, parking garages, and restaurants was a low priority. The study results were obtained using a survey that was direct mailed to over 47,000 residential customers with household incomes of at least $40,000.***

***Southern California Edison Company (SCE) EV Evaluation Program***

***In 1992, SCE developed a three-year Demand-Side Management Electric Vehicle Evaluation Program. This multi-faceted and complex program analyzes and evaluates the electrical load that EVs will place on the utility system and develops strategies to mitigate the adverse impacts of additional EV-related load. The geographical information system being incorporated into computer models can provide projections of the optimal siting of charging facilities for large fleets and the public based on high commuter concentrations along primary transportation corridors.[2]***

***General Motors Corporation (GM) PrE-View Drive Program Results***

***Based on composite focus group information from the Los Angeles, Phoenix, San Francisco, Sacramento, Harrisburg, and New York area GM PrEView Drive locations (see*** **Status of EV Development** ***in this Volume for a description of the GM PrEView Drive Program), GM found the following:***

- ***Test drivers stated that the availability of public charging at locations other than the primary fueling location is critical to their vehicle purchase decision.***
- ***The widespread availability of public charging mitigates the "range issue," rendering the vehicle more useful.***

[1]*What is the Consumer Demand for Electric Vehicles*?, Linda Murphy-Lessor, Salt River Project, EVS-12 Symposium Proceedings, pages 49–54.

[2]*Modeling Electric Vehicle Utility System Impact Utilizing a Geographical Information System*, Richard E. Rice, P.E., Southern California Edison Company, EVS-12 Symposium Proceedings, pages 158–167

- ***The widespread availability of 6.6 kW (level 2) public charging is a critical factor in the vehicle purchase decision.***
- ***The availability of 25 kW (level 3) public charging is an important factor in a respondent's purchase consideration, especially among higher income respondents.***
- ***The use of the 6.6 kW versus the 25 kW public charging option appears to be highly correlated to household economics. Wealthier respondents indicated that they expected to use the 25 kW public charging option more than the 6.6 kW option, as they found saving time more important than the additional cost of level 3 charging.***

***The following table summarizes the expected uses of home versus public charging facilities, and the price premium that focus group participants would be willing to spend to charge their EVs at a public charging facility:***

| | *Home Charging Off-Peak (6.6 kW)* | *Home Charging On-Peak (6.6 kW)* | *Remote Charging (6.6 kW)* | *Remote Charging (25 kW)* |
|---|---|---|---|---|
| ***Composite Average*** | *85%* | *3%* | *6%* | *6%* |
| ***Data Spread**** | *65%-100%* | *0%-15%* | *0%-15%* | *0%-12%* |
| ***Average Premium***** | ***Base*** | *Not applicable* | *+100%* | *+250%* |
| ***Data Spread*** | ***Base*** | *Not applicable* | *0%-500%* | *0%-1,400%* |

***Actual responses spanned this range. Responses were averaged to create the Composite Average.***

*****Average Premium is defined as the most respondents would be willing to pay over the base cost of off-peak, level 2 power.***

*Installing Public Charging Facilities*

To date, several communities working to be EV-Ready have taken different paths in planning for and deploying public EV charging facilities. The electric utility industry is employing a host of strategies, from conducting in-depth charging system analyses (see the above description of SCE's study) to installing public charging facilities in selected high-traffic locations.

The following case studies describe experiences with installing public charging:

***Sacramento Municipal Utility District (SMUD)***

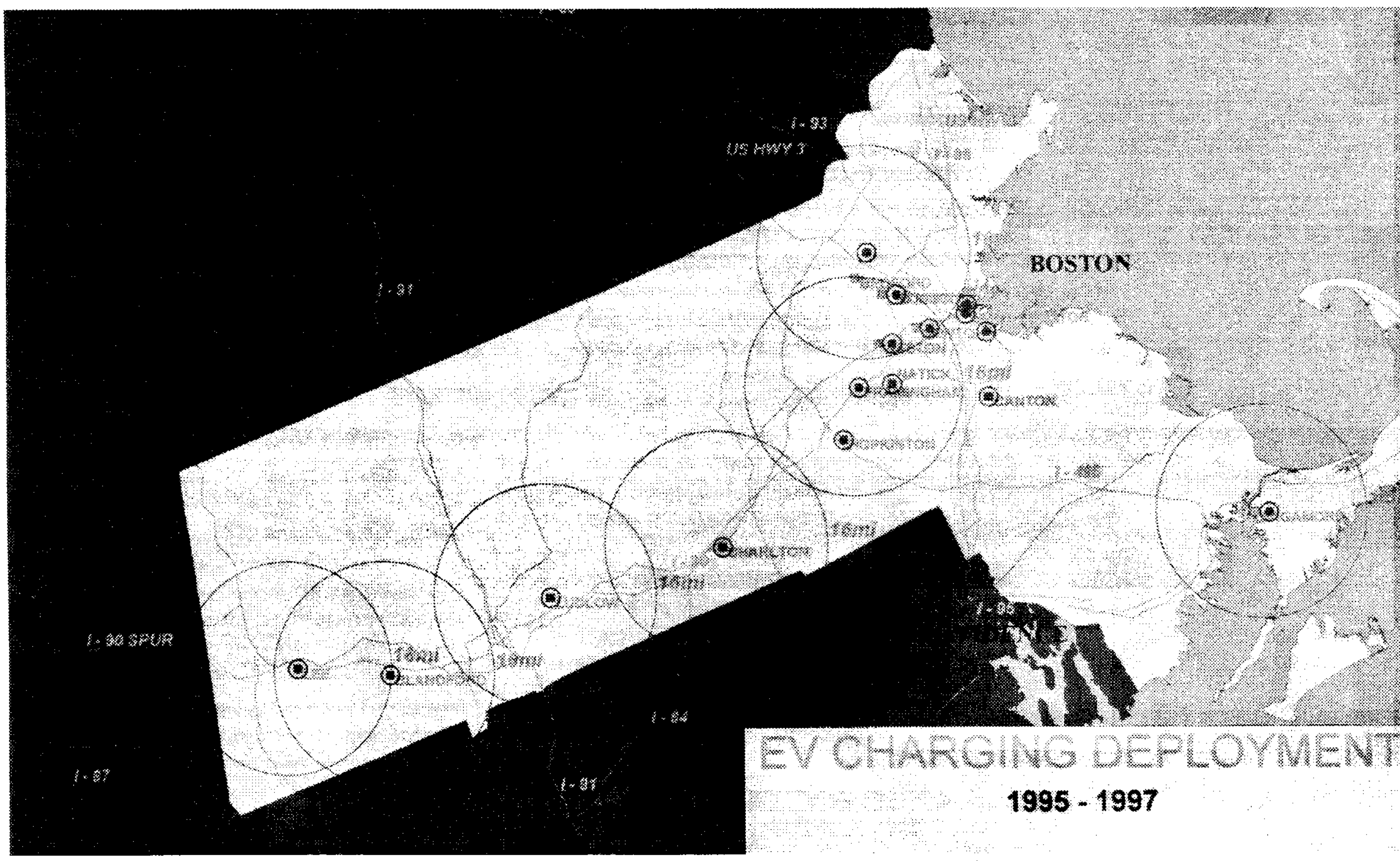
***SMUD has installed more than 137 EV charging stations at 29 public locations in Sacramento since August 1992. These charging stations are located at publicly owned and private parking structures primarily in major employment centers and light-rail parking lots. SMUD has installed the charging stations free of charge, and in return, the parking structure operator has agreed not to charge the EV user for electricity for a period of three years.***

***Los Angeles Department of Water and Power (LADWP)***

***LADWP has installed more than 120 public/semi-public charging stations at various LADWP-owned locations since late 1993. Currently, LADWP provides electricity free of charge to users of the charging equipment, but expects to charge for such electricity in the future.***

***Boston Edison Company (BECO)***

***Initially, BECO believed that public charging facilities should be installed at workplaces, shopping malls, and other locations. However, after analyzing results of the Massachusetts Electric Vehicle Demonstration Program, BECO has taken a different approach. The Program found that EV commuters generally charge their vehicles in locations***




Level 3 Charger Deployment in Massachusetts (1995–1997)

***with the most economical electricity and/ or parking fees. Since home charging is anticipated to be less costly than public charging, BECO believes public charging should be made available only on interstate highways, parkways, and other corridors of travel between major population centers. BECO's current plans call for deploying quick charge (level 3) locations at 35-mile increments along major routes circling Metropolitan Boston. Later, the Program would add such charging facilities along the Massachusetts Turnpike. The map above shows the distribution of level 3 chargers planned for Massachusetts.***

## EXTERNAL FACTORS AFFECTING CHARGER INSTALLATION

The infrastructure planner should be aware that out-of-date building and electrical codes could adversely affect the design and timely installation of EV charging facilities in residences, commercial buildings, and public charging locations. Therefore, the infrastructure plan must take into account the time that state and local governments require to incorporate changes adopted by national code organizations to ensure convenient installation and safe operation of EV charging facilities. Planners also need to know that some cities and counties have adopted ordinances that require installation of an EV wiring raceway—or, a conduit running from the electric service panel to a two-gang electric box in the garage—in new residential structures to help reduce the time and cost of installing an EV charging facility.

This section provides information on:

- How building and electrical codes are developed and adopted
- New EV electrical codes
- Proposed EV building code modifications
- One local ordinance that requires the installation of an EV wiring raceway in new residential construction

*Adoption of Building and Electrical Codes*

Building codes provide guidelines to engineers and construction workers for ensuring the health and safety of building occupants. Today's building codes address not only occupant health and safety issues, but also the products and materials that are moved into and out of buildings. The term *building codes* generally includes the following types of codes:

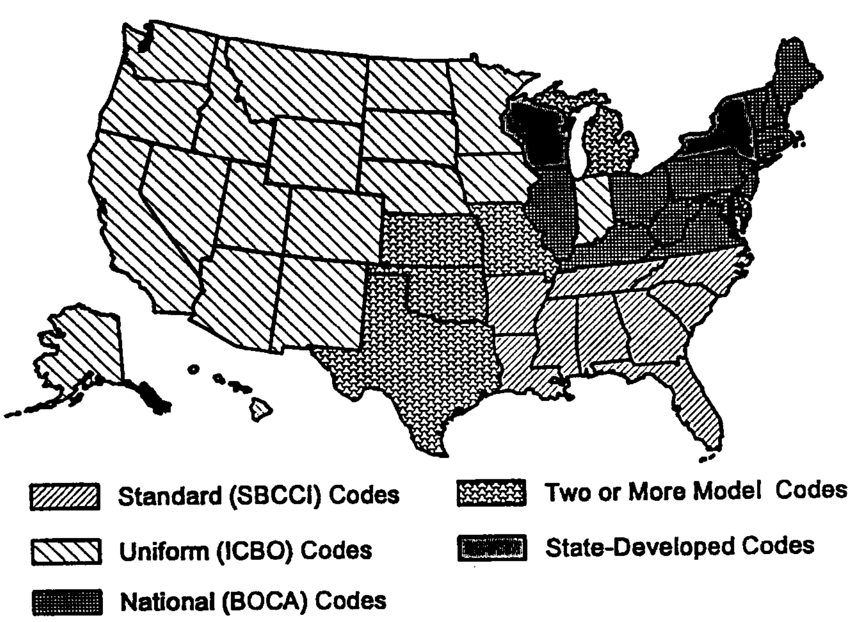
- Building Code: foundations, structural loads, occupancy classifications, fire protection systems, and egress
- Mechanical Code: air distribution and ducts, and heating, ventilation, and air conditioning systems
- Plumbing Code: water supply, drainage, and sewage
- Fire Prevention Code: operation and maintenance of buildings
- Energy Code: thermal envelope and lighting design
- Electrical Code: wiring and electrical equipment

Some states adopt a uniform, statewide code that cannot be amended by local communities. In other states, communities are allowed to amend state codes, usually to provide more stringent requirements. In still other states, code adoption is left to individual counties and municipalities. In all cases, however, enforcement occurs at the local level.

Many building codes adopted by states and local governments are based on major model codes developed by the private sector. Other states and local jurisdictions develop their own codes or adapt and modify model code provisions to fit their particular situations. Many of these state and local modifications address unique climate or geographical concerns. The major model code organizations and their respective publications are listed below:

- Building Officials and Code Administrators International, Inc. (BOCA): National Codes
- Southern Building Code Congress International (SBCCI): Standard Codes
- International Conference of Building Officials (ICBO) and International Association of Plumbing and Mechanical Officials (IAPMO): Uniform Codes
- Code Administrators and Building Officials, Inc. (CABO): One- and Two-Family Dwelling Code
- National Fire Protection Association (NFPA): National Electrical Code

**Map of Code Influence**




(Prepared by the National Conference of States on Building Codes and Standards)

In many cases, local regulators face challenges in applying current codes to EV charging facilities and EV fueling. These challenges could be overcome if model building codes, which have been developed and approved by the above-mentioned entities, are adopted at the local level.

Technical experts from IWC's Health and Safety Committee—which represents electric utilities, EV manufacturers, automotive engineers, regulatory agencies, and independent laboratories—have drafted model code language to cover safety and construction issues related to EV charging equipment and installations. The industry submitted to NFPA their recommended changes to Article 625 of the National Electrical Code (NEC), a model electrical code intended to be incorporated by states and communities. These changes were adopted by NFPA and incorporated into the 1996 version of NEC. Many other codes and standards cover other aspects of EV charging. NEC covers the wiring and electrical equipment between the EV and the utility system and contains only the minimum requirements for electrical safety. It does not specifically address mechanical, plumbing, or building.

Each of the model code organizations has its own revision schedule that typically runs on a three-year cycle. Communities that want to become EV-Ready should contact the appropriate model code organization and inquire about the status of incorporation of EV-related language into model codes. ICBO is expected to publish EV provisions in January 1997; CABO in January 1998; and BOCA in January of 1999. Planners should also seek direction on the proper procedure and timeline required for local consideration and adoption of these provisions. The following case study outlines the process that the State of California has taken to adopt changes to its codes to incorporate EVs:

***State of California***

***In 1995, the California Building Standard Commission opted to use an emergency (immediate) adoption procedure, a 45-day rulemaking process, rather than an annual revision cycle, to consider various EV-related codes. The Commission slightly modified the EV-related provisions adopted for the 1996 NEC, proposed revisions for the ICBO model building code, numbered them appropriately, and submitted the revisions for adoption under the 45-day rulemaking process. The California Building Officials Association, with financial assistance from the California Energy Commission, agreed to offer workshops throughout the State to bring local inspectors up to speed on measures designed to provide safe use and operation of EVs.***

*Provisions for EVs*

The IWC has prepared informational bulletins with answers to frequently asked questions on EV code issues. These documents can be found in Volume III of this Manual. The following excerpts summarize the recent provisions for EVs:

- The industry is moving toward "sealed" battery systems. However, vehicles may contain "open" (vented) batteries that emit hydrogen gas.
- When charging open batteries, ventilation may be required to ensure non-explosive levels of hydrogen. The minimum ventilation required is provided in a table in the 1996 NEC Article 625. Batteries listed as "suitable for indoor charging" do not require ventilation. Some local jurisdictions may chose to include ventilation provisions in their building and/or mechanical codes rather than in their electrical codes.
- Investigation and research have concluded that the weight of an EV poses no structural concerns for parking lots and that no specialized plumbing or drainage systems are needed. However, most building codes do need to be amended to add appropriate and consistent definitions of an EV and garage to include the storage and charging of EVs within the scope of the definition.

*Local Ordinances Requiring EV Wiring in New Construction*

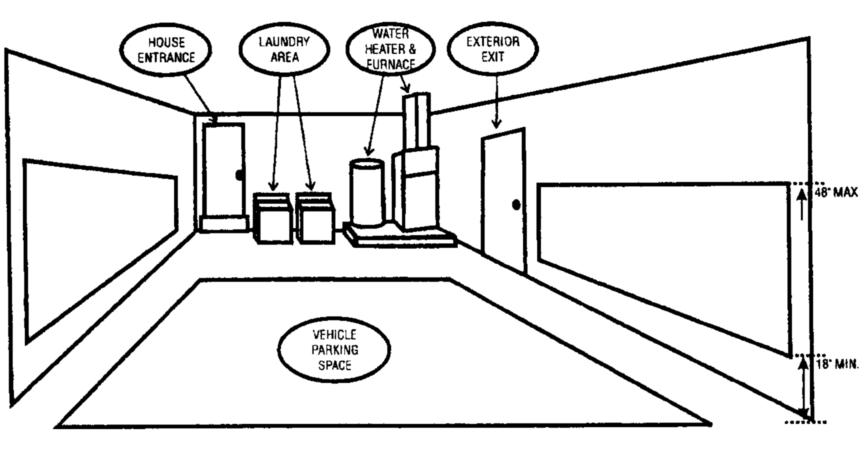
A local community may wish to adopt an ordinance that requires new residential construction to include an EV-wiring raceway. As noted above, this raceway consists of a conduit running from the electric service panel to a two-gang electrical box located in the garage. The raceway should reduce the cost and time of installing an EV charging station compared to retrofitting a residential structure: when a homeowner purchases an EV, an electrician can simply pull the required wiring through the raceway. The following case study describes an EV raceway ordinance:

> ***Sacramento, California***
>
> ***On June 14, 1994, the County of Sacramento, California, at the urging of SMUD, adopted the first ordinance of its kind that requires new residential construction after January 1, 1995, to include a wiring raceway for EV charging. In part, the ordinance states that "every new Group R-3 occupancy building (residential structures) shall provide for a future electric vehicle charging circuit by providing a 3/4 inch raceway from the service panel to a 2-gang box located in a location acceptable to the Chief Building Inspector." The City of Sacramento adopted identical language two months later. To help the building industry comply with the ordinance, the County and City of Sacramento have provided drawings that show the suggested location of the 2-gang box. Once the installation has been completed and approved by the local building inspector, the building inspector affixes a decal to the electrical box indicating that the wiring raceway is for EV use only.***

While the process of adopting a similar ordinance will vary among communities, the process is likely to involve the local fire marshall, electric utility, building industry association, contractors, land use planners, realtors, and the public. As in the case of Sacramento, each participant will view the proposed ordinance from a different perspective:

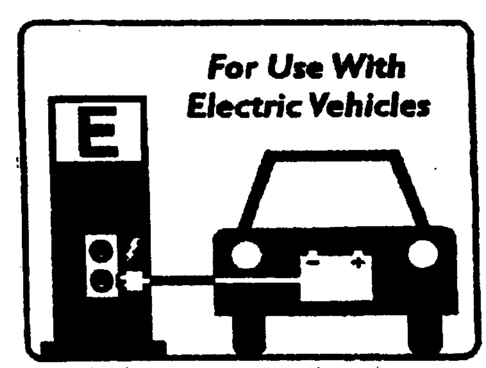
> ***Sacramento, California***
>
> ***As the process to adopt the Sacramento ordinance proceeded, the following questions had to be resolved to all parties' satisfaction:***

**City of Sacramento**
**Recommended Locations for Installation of Wiring Raceway**




(Two-Gang Electric Box to be Located in Shaded Areas)

**Decal Affixed by Building Inspector**



***Question:***
***What is the cost to install the wiring raceway in new residential dwellings?***
***Answer:***
***Labor and materials average $40.***
***Question:***
***Is there a need to increase the capacity of the electric service panel to accommodate the wiring raceway?***
***Answer:***
***No. As long as the local utility provides a load management device that encourages EV charging during the off-peak hours and/or ensures mutually exclusive loads. If not, an allowance for a 40 ampere additional service may be necessary.***
***Question:***
***Is there a need to install a ventilation fan?***
***Answer:***
***Systems labeled "safe for indoor charging" do not require mechanical ventilation. If a homeowner buys an EV with a charging system that requires ventilation, the building official can require the installation of a ventilation system.***
***Question:***
***Why is there a need for this ordinance?***
***Answer:***
***The installation of the wiring raceway during construction is significantly less costly than retrofitting.***

## EV CHARGING FACILITY INSTALLATION ISSUES

The electric utility industry has taken the lead in planning for and installing EV charging facilities. However, the automotive industry has been an active partner in working to design, test, and implement processes for the timely installation of EV charging facilities.

This section outlines some of the EV charging installation issues that implementors should consider. Specifically, this section addresses:

- EV charging facility installation process
- Helping consumers with EV charging installation

### *EV Charging Facility Installation Processes*

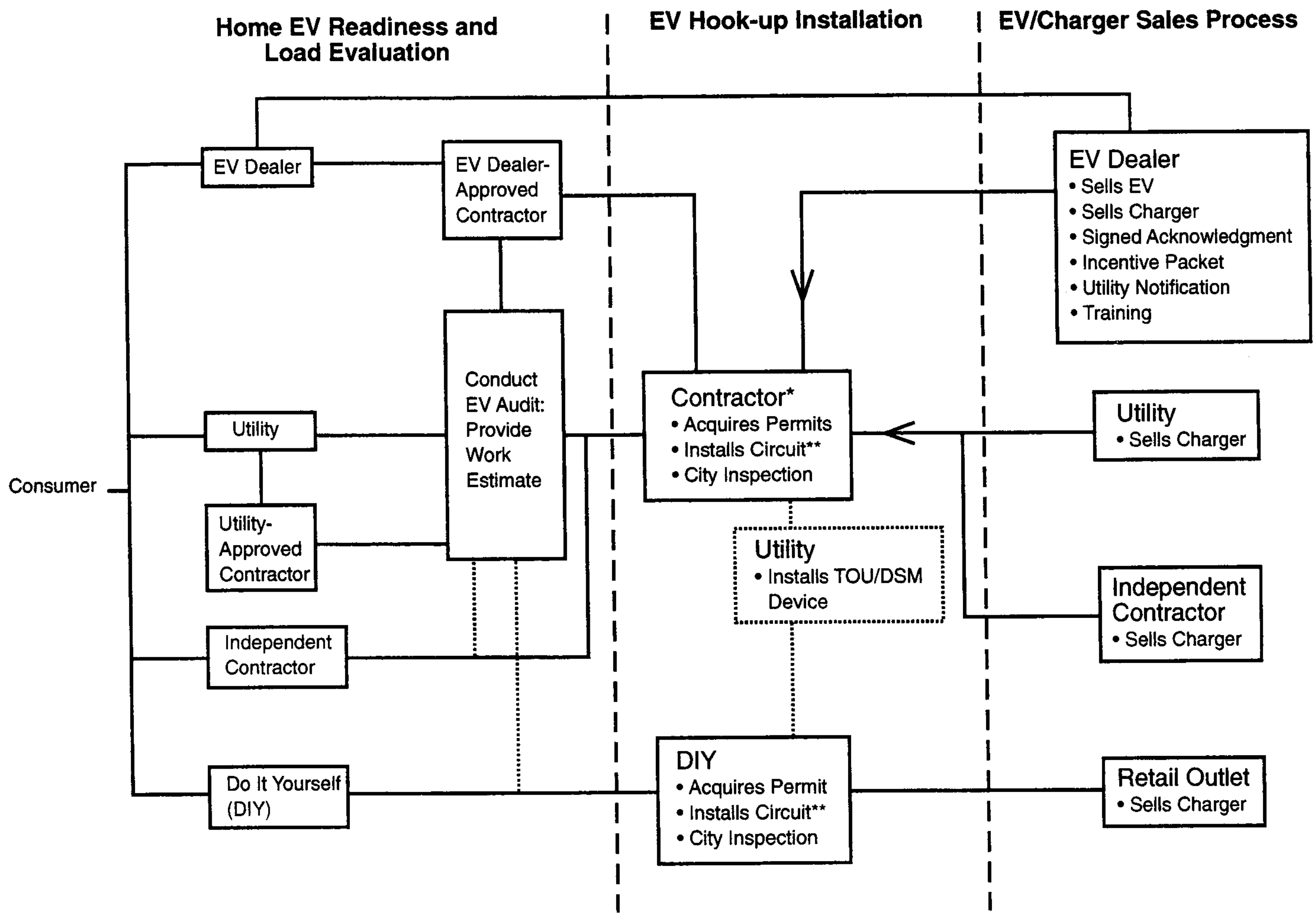
An EV installation process that satisfies the building permit regulations and EV customers will have to take into account the following:

- EV Readiness and Load Evaluation
  - → Calculate the existing electrical load connected to electrical panel
  - → Determine if electric service panel requires upgrade
  - → Determine materials required for the installation of the dedicated electric circuit, off-board charger or interface devices (for on-board charger), and load management device, if required
  - → Estimate the total cost of the circuit installation and panel upgrade, if required
  - → Determine best billing rate for customer
  - → Evaluate the added EV load impact to utility system
- EV Charger/Interconnection Device Sales Process
  - → Customer purchases necessary equipment from the dealer of his/her choice
- Electric Circuit Installation
  - → Obtain any necessary electrical, mechanical, or other installation permits
  - → Install the electric circuit and connect equipment using licensed, experienced electricians
  - → Control quality
  - → Have installation inspected by local enforcement agency
- Aftermarket Service and Warranty Support
  - → Ensure that the organizations that provided the above-listed products and services provide seamless service and warranty to the customer

Applying for a building permit for installing a charging facility sets in motion a sequence of events that can vary from one jurisdiction to the next. The public works or building department will most likely issue the permits. Officials in this department will likely not be

**Conceptual Installation Process for a Residential EV Charging Facility**[1]

## Base-Case Scenario




* Contractor may be dealer, utility or independent contractor.
** Contractor or DIY will install charger if needed.

[1]Diagram from the report, *Optimal Retail Process for Establishing Residential EV Charging*, prepared for the Federal Transit Administration, California Energy Commission, and CALSTART Infrastructure Program participants (Hughes Power Control Systems, Pacific Gas and Electric Company, Southern California Edison Company, Los Angeles Department of Water and Power, and the Sacramento Municipal Utility District), 1994.

familiar with EV charging equipment or installation requirements as the first installations are made. Consequently, these officials may be reluctant, resistant, or skeptical about issuing permits for such work.

EV implementors should therefore plan to spend time educating local officials and inspectors on EV technology, charging facilities, and applicable building codes. Local officials may also request information on lighting of the parking/charging area, buffers to protect the charging equipment from damage by the vehicle, and signage in public locations to designate the parking space as an EV charging station. To address these information needs, implementors could work with an engineer/consultant to develop a set of "boilerplate" drawings—including one line diagram, detailed views, and signage—for EV charging facilities. Developing boilerplate electrical specifications could also be useful. These could include the following items:

- Foundations for pedestal-type charging equipment
- Excavation and backfill for installing the electrical conduit and/or foundations
- Requirements for conduit materials and installation
- Trenching in paved areas for the installation of electrical conduit
- Types of wiring to be installed
- Wiring techniques permitted and not permitted
- Bonding and grounding requirements
- Panel board markings and ratings
- Field and functional tests to be conducted

This case study discusses the value of such drawings:

***Sacramento Municipal Utility District***

***Boilerplate drawings and specifications greatly aided SMUD in its successful pioneering efforts to become EV-Ready. SMUD and its consulting firm, Electric Vehicle Infrastructure, Inc., were able to gain the trust and cooperation of local public works officials by involving all interested parties in the formulation of the drawings and specifications. SMUD found that the EV charging installation permit application and approval process became familiar, routine, and time efficient. A copy of the drawings and specifications are included in Volume III of this Manual.***

*Helping Consumers with EV Charger Installation*

Many parties are expected to be involved in the siting, design, and installation of EV charging facilities, including the local electric utility, automobile manufacturers and local dealers, charger manufacturers, local electrical contractors, code enforcement officials, and individual consumers. To date, the industry has not agreed on a formal process for installing EV charging equipment that meets the time expectations and desires of a potential EV purchaser. The industry's ultimate goal is to establish a smooth, coordinated process that will ensure installation of the charging equipment at the consumer's residence within 72 hours.

In the early years, utility and government fleets are expected to be the primary customers for EVs. Most parties believe that fleet EV purchasers will install charging facilities for EVs as they are delivered, using the electric utility as a resource for any needed technical information.

The sale of EVs to consumers living in single- and multi-family dwellings may present substantially different challenges. A CALSTART study, *Optimum Retail Process for Establishing Residential EV Charging,*[1] concluded the following:

- Consumers want options as to who is responsible for installing the electrical circuit/charger in their homes.

[1]Prepared for CALSTART, the California Energy Commission, Federal Transit Administration, Hughes Power Control Systems, Pacific Gas and Electric Company, Southern California Edison Company, Los Angeles Department of Water and Power, and Sacramento Municipal Utility District, 1994.

- Consumers are extremely tolerant and patient regarding the turn-around time for EV charging installation. A reasonable turn-around time was one week after the purchase of an EV.
- Consumers require education on all aspects of EV ownership and operation.

Expanding upon the first conclusion, researchers found four basic installation scenarios that consumers would consider:

- The EV dealer is responsible for the installation.
- The consumer initiates the process by contacting the electric utility.
- The consumer initiates the process and coordinates activities with an independent electrical contractor.
- The consumer completes the work.

To date, electric utilities have taken different approaches to installing EV charging facilities in residences. LADWP, and SMUD intend to install, and in some cases retain ownership of, the charging circuit. Virginia Power and BECO intend to distribute off-board chargers to customers. And Arizona Public Service intends to simply provide information to the consumer on the installation process.

Automobile dealers have indicated that they want to control the process of the EV sale and installation of home charging. In this case, the process might flow as follows. The auto dealer and electric utility could set the stage by preapproving qualified electricians to install the charging equipment and by gaining a commitment from the building department to issue building permits and conduct inspections quickly. As a backup, local stakeholders may also agree to allow a temporary hookup, probably using level 1 charging, if the consumer requires a speedy installation and the 72-hour turn-around goal can't be met. Other preliminary steps would be to create lists of utility and building department contacts and of qualified electricians and to develop a standard form that auto dealers could use to initiate the installation process with the customer. The form would cover administrative details and provide information on topics the consumer might need to consider, such as the possibility of obtaining a special electricity rate for EV charging and the need for a local building official to inspect the consumer's home to determine whether an electrical panel upgrade or fan will be required. Dealers would review the form with EV purchasers and provide the lists of contacts. From this point, the consumer would handle installation details, using the dealer or electric utility as a resource.

The critical element in the successful sale of an EV, the installation of the EV charging station, and the operation of the EV is consumer education. It would be very unfortunate if a dealer sold an EV to a consumer who later found that the cost and complexity to install an EV charging station was not practical.

## UTILITY SYSTEM IMPACTS

The EV demand is much larger than that of most electrical appliances. In fact, EVs are likely to constitute a residence's largest single load. Further, because EVs are mobile, they can be charged at various locations. Because of these characteristics, future charging of a significant number of EVs could present a challenge to utility planners. (See Volume III for technical information on the impact of EV charging on the utility system.) To meet the community's needs, the local electric utility must be able to fuel all EVs upon request using the most reliable and economic means. Community planners should therefore work with utility planners as early as possible to ensure that sufficient electricity will be available.

This section briefly describes:

- How electric utilities might study the impact of EV charging on their systems
- How EV loads can be controlled
- Minimizing the need for electric panel capacity upgrades

### *Utility Issues*

An electric utility that wants to become EV-Ready might consider the following steps:

- Identify the size and likely locations of the EV electrical load

- Identify utility system limits and any system upgrades required as a result of the addition of EVs
- Study the load profile implications of EVs and evaluate load management opportunities
- Determine the best approaches to manage future EV loads

### *Load Management Options*

Strategies for safe, reliable, and economical management of EV loads hinge on employing load management techniques that equitably share the cost and split the savings between the EV customer and the electric utility. Load management provides a means for influencing customer use of electricity to lower the cost of service by decreasing the peak demand on generation and distribution systems. One way utilities manage loads is to offer customers more attractive energy rates during off-peak periods and to charge higher rates during the peak. Utilities can also, with customer agreement, manage loads by controlling when electricity can be provided to the customer.

For EVs charged at residences, a real-time pricing mechanism (see Volume III for a list of time-of-use rates) coupled with a "smart charger" programmed for least-cost charging is one possible load management option. At an EV fleet facility, real-time pricing to encourage off-peak charging, coupled with devices that stagger the charging of many EVs at one site, is another load management technique. And at public charging facilities, the operator might consider using some type of energy storage device. However, the price of electricity purchased at these facilities will likely be at a premium to reflect the higher cost of such facilities.

This case study looks at SCE's experience with EV load management:

***Southern California Edison Company***

***SCE has proposed a load management strategy that relies on a load management device and time-of-use rates to provide the user with a safe, reliable, and cost-effective method of charging an EV. Load management devices may include timers, voltage and current limiters, load-cycling devices, direct load-control devices and smart revenue meters. Some of these devices may ultimately be used in residential structures as part of the Electric Vehicle Interface (EVI) system that is being developed by SCE. The EVI will establish two-way communication between the EV owner and SCE for cost-effective management of EV loads.***

### Electric Panel Capacity Upgrades

Residential electric panel capacity can be an issue for consumers installing EV charging facilities. Ideally, EV buyers would be aware of this issue before making the purchase, as panel upgrades or other solutions can add to the cost and time of making a home EV-Ready.

In brief, each electrical panel can deliver only a certain amount of amperage at any given time. If the addition of 40 amps of EV demand exceeds that capacity, EV purchasers need to consult with local building officials and utility representatives to identify solutions and cost. One choice might be to replace the panel with a panel large enough to handle the additional load. Another might be to invest in a smart charger that allows EV charging only when other high-amperage appliances are not operating. Still another option might be a load management device that restricts EV charging to low demand off-peak hours, or turns off some other electric load before allowing the EV charging circuit to engage.

Communities can mitigate this problem for new houses by encouraging developers and builders to consider EV charging load requirements when choosing the size of electrical panel to install during new construction. Further, IWC is undertaking a survey and study to determine whether EV charging needs to be considered a "continuous load." Depending on findings, the group is planning to decrease the continuous load requirement of electric panels by modifying the 1999 National Electric Code.

The utilities that have been studying this issue have found the problem may not be widespread, as discussed in the case studies below:

*California Utilities*

***In 1993, SCE, Pacific Gas and Electric Company (PG&E), and LADWP studied the cost to retrofit about 300 single-family/multi-family residential structures with a 240 volt/40 ampere electric circuit from the existing electric service panel to the garage location. (The cost of off-board chargers and/or control panels were not included in the study.) Results showed that roughly two-thirds of those surveyed required no electrical panel upgrades.***

*Consolidated Edison of New York (Con Edison)*

***Seeking to minimize infrastructure costs during the PrEView program, Con Edison surveyed candidate participants from a list supplied by GM to identify those who had 3-wire, 220 volt, 100 amp service entering their off-street parking locations. This criterion did not eliminate any potential participants. In the few cases where the panel capacity would not support additional breakers, Con Edison installed a subpanel. One user agreed to forego using the home's air conditioner while the vehicle was charging, flipping a switch to control the selection. Infrastructure costs averaged $750 for each installation.***

## INVESTMENT IN RESIDENTIAL, COMMERCIAL, AND PUBLIC CHARGING FACILITIES

As with any new technology, investment in EV charging facilities will most likely be based on sound business cases that provide investors an adequate return on investment. The most likely candidate to help communities plan and build charging facilities is the local electric utility, as it is the fuel supplier. However, the infrastructure planner should be aware that other parties may be interested in investing in charging facilities at public locations, such as shopping centers, airports, and work sites.

This section provides information on the following:

- The cost of EV charging facilities
- Utility investment in charging facilities
- Point-of-sale billing at charging facilities

### *Cost of Charging Facilities*

Costs for EV charging station installations vary widely and are dependent upon the type of installation—residential, fleet, commercial, and public—and the specific location. However, studies and actual applications are supplying some cost information, as described in the case studies below.

***Residential EV Charging Circuit Installation Cost Analysis***

***The SCE-PG&E-LADWP infrastructure study described above found that the relationship between housing stock and the EV charger installation cost is complex. However, the estimated average cost to install the electric circuits was similar for all three areas, ranging from $709 for SCE to $874 for PG&E; the composite average was $805.***

***General Motors Corporation PrEView Drive Circuit/Charger Installation Costs***

***Participating utilities took different approaches to installing the electric circuits and inductive chargers to support the GM PrEView Drive Program. Those utilities that installed permanent 220 volt/40 ampere circuits have reported costs ranging from an average of $580 for Arizona Public Service to $887 for the Los Angeles Department of Water and Power.***

### *Electric Utility Investment/Justification*

As the fuel supplier for EVs, electric utilities have a responsibility to prepare the electric supply system for the arrival of EVs. Utilities can consider applying to regulatory agencies (public utility commissions) for funding of EV-related programs based on the utility's traditional obligation to provide safe, reliable, and cost-effective service. The following case study outlines some of the programs that one investor-owned electric utility has sought regulatory approval for:

> ***Southern California Edison Company***
>
> ***In 1993, SCE and other California-based, investor-owned utilities began seeking approval from the California Public Utilities Commission to invest in EVs and infrastructure support systems. Specifically, SCE requested approval to:***
>
> - ***Install the necessary electrical wiring in the residential structures of new EV owners to allow for vehicle charging***
> - ***Provide infrastructure upgrades before the meter when EVs increase the local load***
> - ***Provide load management programs and special rates to encourage off-peak charging***
> - ***Build and evaluate pilot charging facilities in public and employee parking lots, shopping malls and other convenient sites to determine customer need for charging outside the home***
> - ***Purchase EVs for meter reading use and other utility fleet vehicle applications***

These types of programs may be justified due to a utility's obligation to serve any electrical load, comply with regulatory and environmental requirements, and support local economic development. For example, utilities are required by the Energy Policy Act of 1992 (EPAct) to purchase alternative-fuel vehicles starting as early as 1996. Electric and combination electric and gas utilities have the option of selecting EVs, and can justify these purchases, even though EVs may cost more, on the need to comply with EPAct. Early purchases (those before 1998) can be justified on the need to learn how to service this new electrical load, train utility personnel, and generate EPAct credits.[1]

Also, utilities may be able to argue that they should take the lead in reducing their vehicle emissions by using EVs. In areas where mobile sources account for a significant majority of all pollution, it may make sense to publicly promote EVs as a solution to regional air quality problems.

Public utility commissions and other approval agencies for municipal utilities must be convinced that EVs are coming and that they provide benefits to ratepayers. Potential quantifiable benefits to ratepayers can be significant and vary depending on the local electric utility. Typical ratepayer benefits can include a contribution to the utility's margin from EV owners and costs saved from the successful management of EV load (successful EV load management can help defer the need for additional power plants and distribution system upgrades). Indirect benefits may include enhanced air quality; improved national energy security; other environmental benefits, such as noise abatement and oil spill avoidance; natural gas ratepayer benefits, as additional natural gas may be used to generate electricity; and jobs or economic growth.

### *Point-of-Sale Billing at Charging Facilities*

Point-of-sale billing offers relative convenience for recovery of electricity costs. Nevertheless, its use can result in numerous legal and regulatory complications if not carefully crafted. If billing used such options as separate meters not owned by the utility, and the utility billed only the site owner, the site owner could be found to be selling power directly to the public. In most states, third-party electricity sales would trigger state utility com-

[1]EPAct regulations for Alternative Fuel Providers have recommended granting significant credits for the early purchase of EVs.

mission regulation for investor-owned utilities (or local regulation for municipal utilities) to address questions such as those related to the law governing the obligations and right of utilities to serve specific areas. In addition, state utility commissions (or local regulatory bodies) have the duty to regulate the rates for all such power sales, as well as the terms and conditions under which such sales take place. In addition, other legal or regulatory obligations could be imposed.

To minimize the administrative and legal complexities of implementing billing systems, contact the local utility. Utilities are well-versed in applicable law, and may already have investigated billing options acceptable to your state's utility commission (or local regulatory body), one of which could be ideally suited to local conditions. One or more options may even have been pre-approved by regulators, saving the community from the delays due to addressing and settling new legal questions.

HIGHLIGHTS OF SECTION

**PURPOSE**

As EVs take to the road, support systems must be put in place that will provide EV owners with the same level of service, maintenance, and convenience that is available for owners of today's internal-combustion-engine vehicles. This section of the Manual provides an overview on EV and charging facility support services.

**ISSUES ADDRESSED**

- Charging system maintenance
- Vehicle maintenance
- Battery recycling
- EV emergency response training

**General Conclusions**

Service for EV charging systems is crucial to ensuring that EVs are available for use.

Vehicle maintenance is expected to be provided to the consumer by the vehicle seller.

Today's automotive lead-acid batteries are being recycled at a rate greater than 95%.

*Local communities should support the establishment and expansion of collection points for all types of spent automotive batteries.*

Local communities should consider encouraging a secondary-market for EV batteries and recycling of batteries that are no longer usable.

Local communities must be prepared to offer the same level of emergency response for EVs that is currently available to internal-combustion-engine vehicles.

# Support of Electric Vehicles and Charging Facilities

As EVs take to the roads, communities must establish support systems that will provide the EV owner with the same level of service and maintenance that is available for owners of today's internal-combustion-engine vehicles. This virtually new support system is crucial to the successful introduction of EVs.

This section of the Manual provides the reader with an overview of:

- EV charging system maintenance
- Vehicle maintenance
- Battery recycling
- EV emergency response training

## EV CHARGING SYSTEM MAINTENANCE

EV owners must be confident that their vehicles will be available when needed. Therefore, any charger equipment problems need to be addressed quickly and reliably.

Like many appliances, the charger will require on-site repair. In the case of most privately owned EVs, that site will likely be at the home. For commercial fleets, the main charging site will likely be the fleet's centrally located garage.

The charger may be integrally linked with the vehicle (as in the case of an on-board charger system) or may have multiple charging components on the vehicle to support an off-board charger. For example, homeowners will have either an off-board charger installed at their residence or own an EV with an on-board charger, supplemented by a home connection device mounted on the wall.

In either case, the service organization must be qualified to examine the charger and the vehicle to determine which has malfunctioned. The customer will likely require the convenience of having the problem—be it vehicle or charger—diagnosed by the same service organization at the repair site. Repair authorization will be at the discretion of the customer.

The case study below discusses one utility's plans for an EV service network:

*Virginia Power (VP)*

***VP plans to develop a service network to support its customers' EV chargers. VP will sell or lease chargers to EV owners in an effort to create a common infrastructure in its service territory, and has chosen a technical service company to provide charger service and repair. As the network evolves, service personnel will be located in markets with the highest EV concentrations.***

***A consumer's request for service will begin with a call to VP's 1-800 service hotline, and advice will be given over the telephone. If the advice does not solve the problem, the next step will be a service call. If the charger is still under warranty and the problem is diagnosed as a charger component failure, low-powered (level 1 or 2) chargers will be replaced. If the charger is no longer covered by the warranty, the customer can rent a replacement unit while the charger is being repaired at the service center. High-powered chargers (level 3), which are more difficult to exchange than level 1 and 2 chargers, will likely be repaired on site.***

## VEHICLE MAINTENANCE

Just as with today's vehicles, OEM automakers will provide the same level of service for EVs as they currently offer for internal-combustion-engine vehicles through selected certified dealers. However, many fleets may decide to service EVs in-house. Repairs of some EV components—such as brakes and tires—will be routine. However, technicians at dealerships and in fleets will require training and qualification to effectively repair systems and components that are specific to EVs. The following case studies discuss EV training, service, and warranty issues:

*Virginia Power*

***Like many fleet operators, VP employs OEM factory-trained mechanics to service its fleet vehicles. To address the need for specialized EV expertise, VP has developed a training program for their mechanics and is offering the program to its customers.***

***OEM factory training is likely to supplant this training as OEM-produced EVs become available. Meanwhile, VP's training has been well received. The experience with EV troubleshooting has enhanced mechanics' proficiency not only to support EVs, but in dealing with the increasing number of electronic systems found in internal-combustion-engine vehicles.***

*Ford Ecostar Customer Service Program*

***Ford has been conducting a demonstration of 103 Ecostar electric minivans in the U.S., Canada, Mexico, England, and Germany. Of the 103 vehicles, 66 are being leased and operated by 17 independent fleet customers.***

***To provide customer support, Ford developed a complete Parts and Service program that included service manuals, owner's guides, quick reference cards, vehicle operation videos, technician training, police and emergency personnel response training, special service tools and equipment, a 24-hour technical hotline, field service engineering support, and dedicated parts warehousing.***

***Ford also established vehicle repair sites at nine selected Ford dealers and eight fleet customer repair sites. Selection criteria for the Ford dealers included location and the overall interest on the part of the dealer principal, service manager, and service technicians in becoming involved with leading edge EVs. A minimum of two technicians at each facility received special training, including 40 hours of dedicated EV service training, with emphasis on high-voltage safety. In early market launch years, when EVs will be available in low volumes, it is likely that OEM repair and service will be available only at selected dealerships.***

***Ford Qualified Vehicle Modifier (QVM) Program for the Converted Electric Rangers***

***Ford will offer Ranger "gliders"—factory-built pickup trucks without engines, transmissions, or fuel systems—to converters who meet Ford's stringent requirements for becoming an EV QVM. The goal of Ford's EV QVM program is to improve product quality and facilitate the efforts of others in producing EVs converted from Ford products.***

***To become QVMs, candidates must meet minimum standards for quality, safety, and customer support. In addition, they must demonstrate quality manufacturing processes, durability and other testing capabilities, and compliance with Federal Motor Vehicle Safety Standards (FMVSS) and regulatory requirements for all systems or components added, modified, or affected by the conversion.***

***The QVM specifies the engineering, design, testing, and purchase of unique EV components and converts the glider into a complete EV. The QVM is also responsible for providing service support and warranty coverage to the customer for the unique and modified components. Ford will provide a new product limited warranty on Ford components, except for failure of Ford components caused by or attributed to the modification. Except for the traction battery, the QVM is required to have the same warranty for the converted EV Ranger as is provided for the standard Ranger.***

## BATTERY RECYCLING

Ensuring environmentally responsible battery disposal is a critical EV infrastructure element. Recycling of lead-acid batteries is occurring today, and recycling capacity exists to accommodate the near-term increase of lead-acid batteries from EV commercialization. According to Battery Council International, more than 95% of all battery lead has been recycled for the last five years. Forty-two states currently have legislation requiring that spent lead-acid batteries be recycled and accepted by battery retailers and/or wholesalers in exchange for new lead-acid batteries (see summary of state lead-acid battery laws in Volume III).[1] In addition, battery recycling infrastructure for nickel-cadmium, nickel-iron, and to some degree nickel metal-hydride batteries is currently in place in the United States.

In most states, lead-acid batteries are banned from solid waste landfills. However, modified regulations have made the recycling system so accommodating that the majority of lead-acid batteries are being recycled. These regulations require retailers, wholesalers, or other authorized parties to exchange spent batteries for new batteries, but do not require these organizations to obtain a hazardous waste or storage permit. Likewise, transporters of lead-acid batteries are not required to register as hazardous waste transporters. For consumers, the process is seamless: they simply return spent batteries to the authorized retailer or wholesaler, who sends the returned batteries to a secondary lead smelter for reclamation.

Batteries presently for sale, as well as battery technologies being developed, meet the definition of hazardous waste when they are no longer useful, and are generally subject to extensive hazardous waste collection, transportation, treatment, and disposal regulations. Solid waste in the United States is regulated under the Resource Conservation and Recovery Act (RCRA) (see summary of RCRA in Volume III).[2] The primary objectives

[1]Summary of state lead-acid battery laws from the report, *Reclamation of Automotive Batteries: Assessment of Health Impacts and Recycling Technology*, California Environmental Protection Agency, Air Resources Board Research Division, Contract No. 93-323, March 1995.

[2]Summary of Resource Conservation and Recovery Act from the report, *Current Status of Environmental, Health, and Safety Issues of Nickel Metal-Hydride Batteries for Electric Vehicles*, National Renewable Energy Laboratory, Appendix C, TP-463-5475, August 1993.

of RCRA are to protect human health and the environment and to conserve valuable materials and resources. The U.S. Environmental Protection Agency (EPA) is responsible for developing the regulations and enforcing RCRA.[1]

Only the collection and transportation of lead-acid batteries are currently exempt from RCRA requirements, which still cover the treatment and disposal of these batteries. EPA has introduced the Universal Waste Rule (UWR), which would exempt all types of batteries from the collection and transportation requirements of RCRA. Once adopted federally, UWR would also have to be adopted by states, a process that could take several months or years. States with more stringent requirements do not have to adopt federal requirements.

According to the U.S. Department of Energy (DOE), reclamation and recycling processes for mid-term batteries, as defined by the United States Advanced Battery Consortium (USABC), are partially developed. A feasibility study has shown recycling of nickel metal-hydride batteries to be cost effective.

Long-term battery technologies, as defined by USABC (including lithium-polymer batteries), are still in the research and development stage. Therefore, the recycling processes for these types of batteries cannot yet be well defined. One of the stated goals of USABC is to develop batteries that are both recyclable and nontoxic.

The following table shows the existing U.S. and Canada battery recycling facilities and the types of batteries currently being recycled:

| Battery Recycler | Location | Battery Type Recycled |
|---|---|---|
| ToxCo | British Columbia, Canada | Lithium |
| Recovery & Reclamation | Pecos, Texas | Zinc |
| GNB | Los Angeles, California<br>Dallas, Texas<br>Columbus, Georgia | Lead-acid |
| RSR Quemetco, Inc. | City of Industry, California<br>Dallas, Texas | Lead-acid |
| Sanders Lead | Troy, Alabama | Lead-acid |
| Skuylkill Metals | Baton Rouge, Louisiana<br>Forest City, Missouri | Lead-acid |
| Refined Metals | Indianapolis, Indiana<br>Memphis, Tennessee | Lead-acid |
| The Doe Run Company | Boss, Missouri | Lead-acid |
| Kinsbursky Bros. | Anaheim, California | Lead-acid<br>Nickel-cadmium |
| INMETCO | Pennsylvania | Nickel-cadmium<br>Nickel-iron<br>Nickel metal-hydride |

[1]Hazardous waste regulations enforcing RCRA are found in Volume 40 of the Code of Federal Regulations (40 CFR), Parts 260-281.

Battery recycling programs can be either market-based or regulated. In the market-based recycling scenario, the value of the recycled materials exceeds or offsets the cost of recycling. In the regulatory scenario, recycling costs must be born, regardless of the value—or lack thereof—of the recycled materials. These costs are usually passed on to the user in the form of a disposal fee or by increasing the cost of the battery. In some cases, the government will bear the costs. While a market-based system is generally preferable as it helps reduce overall program costs, its success depends on obtaining a profitable recovery value for the recycled materials.

Encouraging the recycling of batteries at the community level involves the following:

- Supporting adoption of the Universal Waste Rule at the state and local levels
- Establishing a system of battery collection points in the community
- Determining whether battery recycling should be pursued as an alternative to other disposal methods

Communities should encourage a large number of collection points to collect the greatest number of different battery types. The techniques below have helped many communities successfully establish collections points for spent lead-acid batteries:

- Prohibiting the disposal of batteries in landfills
- Requiring a deposit when a battery is first purchased
- Relying on the materials recycled value

In some cases, a community might encourage the formation of a secondary battery market, followed by recycling when the battery is no longer deemed usable. Batteries that can no longer provide the performance needed to power a vehicle can still serve many other functions. Possible secondary uses include providing utility peak-shaving capabilities or back-up emergency power to hospitals. Encouraging a secondary market helps improve EV economics as well as ensure delivery of the maximum value from the battery before recycling.

## EV EMERGENCY RESPONSE TRAINING

EVs will require the same level of emergency response as is now available for internal-combustion-engine vehicles. To provide such service, communities must know how to minimize the risks to a variety of people—passengers; fire, rescue, and law enforcement personnel; maintenance workers; and the general public—from various vehicle collision hazards, such as electric shock and battery electrolyte spillage. To date, several EV emergency response programs have been developed by both the automotive and electric utility industries. The following case studies describe two such training programs:

***American Coalition for Traffic Safety's Electric & Hybrid Vehicle Emergency Rescue Training Program***

***The American Coalition for Traffic Safety (ACTS), in cooperation with General Motors Corporation, Ford Motor Company, Chrysler Corporation, Detroit Edison, DOE, CALSTART, and the Midwest Research Institute, developed the Traffic Safety Electric & Hybrid Vehicle Emergency Response Training Program, which provides information to emergency response personnel on EVs made by each of the participating automotive companies. The program includes:***

- ***A video and brochure detailing emergency rescue procedures and vehicle design characteristics, extrication procedures for occupants, and towing of damaged EVs***
- ***An instructor's manual***
- ***Field cards for use at the crash scene***
- ***A poster containing the same information as the field cards for use in law enforcement and fire facilities***

***Additional information regarding the ACTS training course can be found in Volume III of the Manual.***

***Electricore***

***Electricore, one of the seven regional consortia sponsored by the Advanced***

***Research Projects Agency (ARPA) Electric and Hybrid Vehicle Demonstration Project, is preparing a training course—including manuals and a video—for emergency responders. Partnering with state and local law enforcement agencies, Electricore plans to offer this as an accredited training course for emergency rescue personnel at the local, state, and national levels.***

Communities should be aware that the National Highway Traffic Safety Administration (NHTSA) has been conducting research to ensure that EVs perform as safely as their internal-combustion-engine counterparts. Since 1993, NHTSA has conducted six crash tests of EVs, for which films and reports are available, and investigated four crashes or incidents involving EVs. Information on these tests and investigations are available from NHTSA's EV safety research program. NHTSA has also published a notice in the September 30, 1994, *Federal Register* requesting comments on EV safety issues. Docket No. 91-94, Notice 05 contains responses to this notice, presenting the concerns of auto manufacturers, emergency responders, and others on safety issues.

# Public Information and Awareness

## HIGHLIGHTS OF SECTION

**PURPOSE**

Creation of public information and awareness programs that explain the importance of EV infrastructure will be crucial to the successful introduction of EVs. This section of the Manual provides guidelines for developing public information and awareness programs and for educating stakeholders on specific infrastructure systems.

**ISSUES ADDRESSED**

- Guidelines for developing public information and awareness programs
- Ideas for public information activities related to EV infrastructure
- Guidelines on educating stakeholders on specific infrastructure systems

**GENERAL CONCLUSIONS**

Comprehensive communications programs can change a person that generally supports EVs into one who is willing to take action in supporting EVs.

Communications programs and key messages should be tailored to specific EV audiences.

Key messages on EV charging facilities could report on the benefits of nighttime charging and the locations of charging facilities.

Key messages on EV service and maintenance could report on service training curriculum and local availability of service.

Key messages on batteries could report on advances in battery technology and battery recycling availability.

Key messages on community integration could report on strategies available for deploying the necessary infrastructure in buildings, and the availability of local EV emergency response programs.

Successful EV commercialization in any community will depend, in large part, on the development of a public information and awareness program. Comprehensive, credible communications programs can motivate people to support EVs.

This section includes the following:

- Guidelines for developing public information and awareness programs
- Suggestions for public information activities on EVs and their infrastructure
- Guidelines for educating stakeholders on specific EV infrastructure systems
- Case studies that detail successful public information programs and activities

### GUIDELINES FOR DEVELOPING PUBLIC INFORMATION AND AWARENESS PROGRAMS

Before developing a communications plan, communities must address several issues. First, communities should work with local organizations—such as utilities, Clean Cities Coalitions, and environmental groups—that are already highly involved with EVs to clearly define the plan's goals and objectives. The more specific these goals, the better. For example, one goal may be to obtain formal City Council support for local EV infrastructure programs. Another may be to increase the general population's level of awareness of EV benefits by a certain percentage, which can be measured through surveys. A third may include informing businesses about how to use available EV incentives.

Next, the community needs to identify its key stakeholders and target messages to each of these groups. Stakeholders are stratified audiences, such as the general public, the news media, elected officials, fleet operators, businesses, city employees, school children, college students, and potential early EV adopters.

The principal message to all stakeholders could be that the community is creating an EV infrastructure that will make EVs easy and convenient to own and operate. However, messages targeted to each group will be more effective. For example, a message targeted to fleet operators could state that EV technology today meets the needs of a number of fleet applications, and that it is relatively simple to provide a central recharging area for EVs at night. A key message for a business could be that a significant federal tax credit exists for companies that install EV charging stations. A key message for a potential purchaser is that a significant federal tax credit exists for individuals who purchase EVs (see Volume III of this Manual for a list of tax credits for businesses and individuals).

Before developing messages for each audience, it is important to determine, if possible, their probable biases and opinions about EVs. Drawing on the resources of national and local organizations[1] identified in this section can help accomplish this goal (see Volume III for an in-depth list of organizations). The local utility may have a mechanism for surveying its customers, and the community also may want to develop a brief questionnaire for opinion leaders to find out their top priorities and concerns relating to EVs before starting a communications program. Such actions can ensure that messages are on target.

The organizations in Volume III of this Manual can also help a community respond to any resistance or opposition it might encounter and better explain the beneficial role EVs and their infrastructure can play in a community.

Once the community has laid the groundwork for its communications plan, it can map out implementation strategies. There are no hard and fast rules for carrying out an effective campaign, but a successful plan usually includes several key elements:

- A component to reach the news media, via news events, news releases, ride-and-drive events, and more
- A component to reach legislators and regulators, via forums, briefings, written materials, or other mechanisms
- A component to reach the general public, via displays of EVs, mailings, utility bill inserts, etc.

As implementation of the plan progresses, it will become clearer which mechanisms prove most successful.

## IDEAS FOR PUBLIC INFORMATION ACTIVITIES TARGETING EVs AND INFRASTRUCTURE

The following is a sampling of some of the activities a community could consider as part of a public information and awareness action plan:

- Provide speakers to, and organize speaking engagements at, local business groups and chambers of commerce to educate members about EVs and EV infrastructure developments
- Create a display highlighting the community's progress in the EV arena to use at local fairs and events
- Demonstrate charging technologies at community events
- Hold news conferences to unveil new public charging stations
- Provide elected officials and the news media the opportunity to take an EV home overnight to realize the benefits of charging at home
- Conduct EV ride-and-drives for policymakers and the general public

[1]Local utilities; local Clean Cities Coalitions; Advanced Research Projects Agency local consortia; and national organizations such as the Edison Electric Institute, American Public Power Association, the Electric Transportation Coalition, Electric Vehicle Association of the Americas, and the National Electric Vehicle Infrastructure Working Council.

- Develop a slogan for the publicity program to enhance its recognition factor
- Develop materials to inform various stakeholders about EVs and their associated infrastructure (see Volume III of this Manual for examples of such materials)
- Determine organizations with which your community could form an alliance
- Identify a grassroots coalition
- Place visible signage at public EV charging facilities
- Develop a quarterly newsletter geared toward certain stakeholder groups to discuss EV issues

This case study describes an aspect of one utility's communications plan:

***Virginia Power "electroexpo '95"***

***The tremendous economic, technical, and efficiency advantages of EVs guarantee they will be a major component in the nation's transportation future. To heighten EV awareness in private and public sectors, VP, in conjunction with GM, sponsored an exposition to showcase commercially available EVs. "electroexpo '95," dedicated to market-ready technology, attracted nearly 3,000 visitors who toured displays, attended seminars, and experienced one of the largest gatherings of electric cars, trucks, buses and off-road vehicles ever assembled. The event attracted people from around the world—members of the public, federal, state, and local officials, private fleet operators, and representatives of other utilities.***

## GUIDELINES FOR EDUCATING STAKEHOLDERS ON SPECIFIC INFRASTRUCTURE SYSTEMS

### *Charging Facilities*

Most outreach programs to educate stakeholders on EV charging issues will be initiated by the local electric utility, Clean Cities Coalition, or EV retailer. This program should contain a component geared toward educating local code officials on charging technologies and installation practices. An education strategy for charging facility issues could include the following activities:

- Use existing research to understand and communicate charging preferences
- Develop mechanisms to convey the importance of off-peak (nighttime and weekend) charging
- Communicate the process for installing a home charging unit
- List existing charging locations
- Determine the most suitable locations for new facilities
- Provide information on costs of charging

This case study illustrates a strategy used in Los Angeles:

***Los Angeles Department of Water and Power Charging Station Publicity***

***LADWP unveiled the city's first public charging stations, located at its downtown headquarters building, via a well-attended media event in late 1992. Several months later, LADWP reached an agreement with the Music Center of Los Angeles County, located directly across the street, to allow Music Center patrons who own EVs to "park and charge" free at LADWP during performances. This offer garnered media coverage, and received free placement in a Music Center program distributed to all patrons during one month. The Music Center program provided people who meet the demographic profile of "early EV adopters" with information about the benefits of EVs and the progress underway to make Los Angeles EV-Ready.***

### *Service and Maintenance*

Potential EV purchasers—the general public and fleet users—must be assured that EV service and maintenance will be readily available. Likewise, local policymakers should understand the employment-related opportunities that come with expanded service and maintenance programs specific to EVs. An education strategy for EV service and maintenance issues should:

- Recognize that service and maintenance will be provided by OEM and others, such as certified independent mechanics
- Provide information, where available, on the costs of EV service and maintenance
- Provide information on local EV education programs and on establishing an EV service training curriculum
- Provide information on local electric utility EVs and EV service and maintenance programs

*Batteries*

Communicators must have a clear understanding of battery development and battery recycling, including:

- State-of-the-art and emerging battery technologies
- The local community's air quality concerns
- External sources of emissions in the community
- Government/industry goal to assure that all batteries developed are recyclable and nontoxic
- Current lead-acid battery recycling and rates of recycling

From a public communications standpoint, battery recycling is one of the more complex issues that must be discussed with the general public and key policymakers. This complexity can be misunderstood and create opposition for EVs. For example, in mid-1995, an article in *Science* cited a study that raised concerns about the potential environmental impact of the production and reprocessing of large amounts of lead-acid batteries. Because most EVs today carry lead-acid battery packs, the article implied that when such batteries are produced, used, and then recycled, air emissions of lead would be greater than for an internal combustion-engine vehicle operating on leaded gasoline.

The article and study were found by experts in the field to be misleading and not factual. Letters to the editor of *Science* cited numerous flaws.[1] For example, researchers from Argonne National Laboratory found that the study overestimated potential air emissions of lead by a factor of 5-50. The Union of Concerned Scientists faulted the study for using outdated data on batteries and electric vehicles and for overestimating the potential increase in lead demand resulting from use of EVs. A researcher from Princeton University's Center for Energy and Environmental Studies noted that the study failed to discuss the small market for EV batteries within the context of the immense market for automotive starter batteries, by far the primary consumer of lead. Many specialists pointed out the difficulty of performing such a complex environmental study, and requested a more detailed and careful review of all the issues involved. The Electric Vehicle Association of the Americas has summarized the problems with this study in a technical brief, drawing on information from utility, component, and automotive industry sources.[2]

Communicators need to be aware of the latest technical information to offset such problems. For example, the lead issue raised by the article could be addressed up front and include information on the advanced batteries now being developed for the next generation of EVs.

*Community Integration*

Local governments must provide a number of EV infrastructure systems to ensure successful EV introduction. Local policymakers must be educated on the need for adopting building, electrical, and health and safety codes; incentives to support EV usage; and training of local emergency response personnel. Some sample communications messages and strategies follow:

[1]*Science*, vol. 269, August 11, 1995. American Association for the Advancement of Science, Washington, D.C., pp. 741–745.
[2]*Technical Brief: Environmental Impacts of Lead-Acid Batteries in Electric Vehicles*, TB-1995-1, Electric Vehicle Association of the Americas, 1995.

- Communicate the importance of EV charging requirements and disseminate available information to ensure deployment of the necessary infrastructure in residential and commercial buildings
- Provide information on the mechanics of EV charging, the surrounding safety issues, and upgrades to existing wiring configurations that may be required
- Provide promotional literature on the advantages of EVs
- Provide vehicle demonstrations and technical overviews to police and fire personnel
- Perform rescue drills using actual EVs

Where appropriate, use the information contained in the American Coalition for Traffic Safety document entitled *Traffic Safety Electric & Hybrid Vehicle Emergency Rescue Training Program* (see EV Emergency Response information provided in the EV Charging Facilities/Vehicle System Support section of this Volume).

The case study below highlights one way to reach rescue personnel:

***GM PrEView Drive Program***

***General Motors field service engineers met with Ft. Lauderdale community fire and rescue leaders in October 1995. The GM engineers gave a thorough overview of the GM Impact, highlighting its various technical and safety features. A fire and rescue instructional video was shown, and a manual put together by Florida Power & Light Company, "Impact Emergency Responder Information Booklet," was provided for distribution to each department's personnel (a copy of this document can be found in Vol. III).***

# HIGHLIGHTS OF SECTION

**PURPOSE**

Educating students about EVs and infrastructure support systems may be beneficial in future years as these students become vehicle purchasers and explore new EV job opportunities. The purpose of this section of the Manual is to provide the reader background on how students from grade school to college can be educated regarding EVs and infrastructure, and the availability of education materials and curriculum that have been developed.

**ISSUES ADDRESSED**

- EV education at elementary, middle, high, and post-high schools
- Education materials
- Establishing relationships between the EV industry and local schools
- EV-based college curriculum

**GENERAL CONCLUSIONS**

Building general EV awareness can begin in elementary schools; career awareness can begin in middle schools; and skill building for careers can begin in high schools.

It is important that local businesses involved in EV industries work with local schools to help disseminate information regarding EVs.

Technical colleges are developing EV technology curricula.

# Education

Educating students about EVs and infrastructure support systems may be beneficial in future years as these students become vehicle purchasers and explore new EV job opportunities.

The purpose of this section of the Manual is to provide the reader background information on:

- How students from grade school to college can be educated regarding EVs and infrastructure
- The availability of education materials and curriculum that have been developed

## GENERAL EDUCATION

Developing awareness, understanding, interest, and a skills-base for EV technology in young people is a vital and long-term challenge. Young people—with open minds, a concern for the environment, and adroit ability with the tools of technology—will determine the long-term success of the EV market, technology, and infrastructure. Committees can reach young people, and students of all ages, appropriately and effectively by working with teachers, who are eager for ways to link academics to real-world experience.

Whether EVs are studied as an end in themselves or as a means of bringing basic academic disciplines to life, the study of EV technology is proving to be an increasingly popular topic in vocational, technology, science, mathematics, and engineering classrooms from the elementary grades through college. The table on the next page lists appropriate activities and topics for students at different levels.

Studying EVs allows students of all levels to learn about new technology; examine and debate related social, government, and environmental issues; engage in meaningful hands-on activities (whether building table-top models or designing full-size conversions); learn about the public's patterns of transportation and consumption; and become acquainted with the EV industry and its newly emerging job market.

**EV Education Topics and Activities by Grade Level**

| | Elementary School Grades K through 5 | Middle School Grades 6–8 | High School Grades 9–12 | Post High School |
|---|---|---|---|---|
| **Building Awareness** | ■ Transportation Days<br>■ Career Days<br>■ Science Fairs<br>■ Science Lessons | | | |
| **Building Understanding/ Career Awareness** | | ■ General Science<br>■ Physical Science<br>■ Technology<br>■ Education | | |
| **Building Skills** | | | ■ Electricity/Electronics<br>■ Automotive/Technology<br>■ Physics<br>■ Technology<br>■ Pre-Engineering<br>■ Drivers Education<br>■ Environmental Science | ■ Community College—Automotive, Electricity,& Electronics<br>■ College/University—Mechanical & Electrical Engineering, & Engineering Tech.<br>■ Adult Education<br>■ Proprietary Trade Sch.<br>■ Industry Training Programs |

Securing educators' interest in teaching EV technology is the easy part. The challenge lies in providing them with resources to bring the technology to students. While progress is underway, unfortunately, there is very little to be found about EVs in today's textbooks, instructional materials, or curriculum frameworks available to educators (see Volume III of this Manual for information on EV educational materials).

Until more educational materials about EVs are widely available, it is especially important that those involved and informed about the EV industry and its supporting infrastructure *establish relationships* with the appropriate programs in their local educational institutions. One strategy is to invite the local educational community to a ride-and-drive and information session about EVs. School and college administration offices can assist in identifying those most likely to teach EV-related disciplines. Another strategy is to participate in the National Energy Education Development (NEED) project, currently offered in 32 states. The NEED program develops and promotes energy education curriculum for middle school and high school age students. The National Clean Cities program is working with NEED to develop a *Let's Talk Energy Show on Alternative Fuels* that could be used by teachers in the 10 EV-Ready communities. A ride-and-drive using an electric school bus could be part of the activities (see Vol. III for more information on the NEED program and samples of NEED/Clean Cities educational materials).

Methods to build relationships with the educational community can include:

- Offer your organization to the educational community as a resource on EV technology
- Contact your local science museum about jointly highlighting EV technology through exhibits, demonstrations, ride-and-drives, teacher training, and more

- Establish relationships with automotive and electricity/electronics educators in your area high schools and community colleges
- Offer to serve on the advisory council for an automotive technology or electricity program
- Sponsor a vehicle conversion by a group of students, or an essay or art contest on EV issues
- Participate in or organize an EV competition for kids
- Become a resource for related higher education programs, especially engineering and pre-engineering classes
- Make your training program, manufacturing, or research facility available to educators for tours
- Offer EVs for "transportation days" at schools
- Let educators know your employees are available to give presentations about EVs
- Invite educators or promising students to "shadow" you for a day
- Donate EV books or trade publications to school, public, and university libraries
- Invite or sponsor educators' and students' attendance at trade shows or conferences
- Make education publications available to schools
- Add educators to your newsletter mailing list

The case study below addresses the need for developing and distributing education programs on EVs and their infrastructure:

***York Technical College, Rock Hill, South Carolina***

***York Technical College is a two-year public community college that was established to foster local economic development and meet the technical training needs of industry. The College has been involved with EVs for the last six years. It has been a member of the DOE Site Operator Users Task Force program and has developed material for this program.***

***In developing an EV curriculum, the College has identified five major challenges:***

- ***Lack of available information***
- ***Rapid change in vehicle technology***
- ***Changes in EV infrastructure***
- ***Changes in government policies and mandates***
- ***Lack of a clear vision of the future***

***To overcome these challenges, the College has worked with numerous partners. It has been involved in customized training programs on placing EVs into fleet applications for utilities, electric cooperatives, and municipal maintenance personnel. In addition, College personnel have worked with the organizers of EV races in Virginia and North Carolina, and College faculty have worked with high school students and faculty to give them a better understanding of EV construction.***

***The College has created a "Develop A Curriculum" (DACUM) for EVs and prepared a one-year program based on this DACUM. The College is currently teaching individual courses in Engineering Technology and technical areas related to EVs and looking to expand this effort by developing further courses using materials prepared under a variety of contracts. The College has also helped develop EV information packets for DOE and is creating a learning module for the DOE Hybrid Vehicle Program.***

***Furthermore, the College has developed workshops in the following areas:***

- ***Introduction to Electric Vehicle Maintenance and Repair***
- ***Introduction to Electric Vehicles***
- ***Fleet Managers Introduction to Electric Vehicles***
- ***Fundamentals of Electric Vehicle Safety***

***The College is committed to being a partner in the development of a comprehensive EV maintenance program to ensure an effective infrastructure and the success of EV technology.***

## FLEET MANAGER EV EDUCATION PROGRAM

York Technical College developed and published the *Electric Vehicle Workshop for Fleet Managers* for the CALSTART Infrastructure Program participants.[1] The workshop materials have been structured to address some of the concerns and questions that fleet managers may have regarding the integration of EVs into fleet applications. More specifically, the workshop materials provide information on the following topics:

- Environmental regulations and mandates
- Background on past and present EV technology
- Major EV systems, such as batteries, chargers, drive trains, and auxiliary systems
- Utility and environmental impacts of EVs
- EV-related infrastructure support systems
- Life-cycle cost information
- EV initiatives
- Preparation for EV ride-and-drives
- Information on developing a successful EV fleet operation

The workshop materials also include a lesson plan, instructor's manual, instructor's readings, students' readings, visual aids, and video tapes which can be used to train trainers.

[1]Hughes Power Control Systems, General Motors Corporation, Pacific Gas and Electric Company, Southern California Edison Company, Los Angeles Department of Water and Power, and the Sacramento Municipal Utility District.

## HIGHLIGHTS OF SECTION

### PURPOSE

Adopting favorable EV policies will make it easier for community stakeholders to work together toward EV-Readiness. Further, the development, deployment, and promotion of incentive programs are necessary to assure early vehicle sales and to encourage investment in EV infrastructure support systems.

This section of the Manual provides guidelines for the policymakers seeking support for EV policies at the state and local levels.

### ISSUES ADDRESSED

- Assessment of community needs
- Development of an EV policy support goal statement
- Development of incentive programs
- Building community support for EV policies
- Communications program
- Case studies on the process for passing three incentive packages

### GENERAL CONCLUSIONS

Communities can choose from a variety of ways to successfully introduce and obtain support for EV policies and eventually pass them into law.

Before selecting a course of action to seek support for favorable EV policies, it's crucial to assess community needs.

To develop an EV policy goal statement, determine both the proponents and opponents of EVs within your community and identify existing programs and policies in your community that could impact EV use.

Communities should undertake a number of activities to build support for favorable EV policies: conduct workshops for state agency officials; distribute accurate information about EVs to people who influence community policy decisions; conduct electric vehicle ride-and-drives for target audiences; and design an effective and targeted media campaign.

# EV Policy Support

Adopting favorable EV policies is a key to successfully introducing EVs into the community. These policies can be monetary incentives, such as a state tax credit for purchasing EVs and installing charging stations, or non-monetary incentives, such as exempting EVs from high occupancy vehicle (HOV) lane restrictions or providing preferential parking at municipal parking lots to EV owners. Communities can choose from a variety of ways to successfully generate support for EV policies and eventually pass these policies into law.

This section provides guidelines in the areas listed below to consider as you seek support for EV policies at the state and local levels, as well as three success stories:

- Assessing community needs
- Developing a goal statement
- Developing incentive programs
- Building support
- Communicating with stakeholders

## ASSESS COMMUNITY NEEDS

Before selecting a course of action to seek support for favorable EV policies in the community, it is important to assess the needs of the community. Questions to consider when assessing these needs could include:

- How will introducing EVs into the community affect transportation, land use, and environmental planning?
- Can EVs address local air quality issues?
- Do any existing mandates and regulations require the use of EVs?
- In addition to Clean Cities Coalition members, are there citizens in the community who advocate or support the use of alternative forms of transportation?

## DEVELOP EV POLICY GOAL STATEMENT

Once the needs assessment has determined that EVs could benefit the community, it is important to prepare an EV policy goal statement. This statement establishes the desired local programs and policies for supporting EV introduction. Before writing the goal statement, communities may want to conduct the following activities:

*Determine Existing Proponents and Opponents*

It is important to identify EV proponents within your community. Likely supporters of EV policies could include the electric utility industry, the automobile industry, the Clean Cities Coalition, environmental groups, local businesses, and local government. Ask supporters what policies they would like introduced into the community to support EVs and their infrastructure.

Also important is identifying EV opponents (both within your community and at the national level) and understanding why they oppose policies that support EVs.

*Determine Programs in Place*

Identify existing community programs and policies that could impact EV use. Does your community already fund an electric bus demonstration program? Does the local electric utility currently offer a reduced overnight recharge rate for EVs? To obtain information about statewide and local EV activities, contact national EV organizations. Additional resources to contact include the state energy office and the U.S. Department of Energy Regional Support Office (see Volume III of this Manual for resource contacts).

## DEVELOP AN INCENTIVE PROGRAM

The next step is to develop the EV incentive program. Reviewing the EV incentives enacted into law in other communities can facilitate this task. It may also be useful to obtain a copy of model state legislation developed by the Electric Transportation Coalition to help regulators and policymakers develop EV incentives for the state and local levels. This package of model legislation provides a framework for establishing a state program of regulatory and financial incentives that support initial customer purchases of EVs and development of the EV infrastructure. In addition, the National Clean Cities program has issued a *Guide to Alternative Fuel Vehicle Incentives and Laws.* Funding incentives for EVs are included in this state-by-state manual.

## BUILD SUPPORT

Once drafted, the incentive package will require community support. The EV supporters identified earlier can now be contacted to enlist their efforts and resources. The involvement of key supporters can help ensure that EV incentives are considered favorably by state and local governments.

A variety of activities will help build support for EV policies at the state level and in the community:

- Conduct a workshop on EVs to get "buy-in" from state agencies
- Visit local officials, business leaders, legislators, environmental groups, and others to distribute accurate information about electric vehicles and gain additional support
- Conduct EV ride-and-drives for target audiences, including state and local policymakers, the media, fleet purchasers, community educators, and transportation planners
- Produce a media package that answers specific EV questions through such items as press releases, fact sheets, and lists of contacts

## COMMUNICATE INCENTIVE PROGRAM TO STAKEHOLDERS

Once the community has adopted EV policies, it must relay information on incentives to a variety of parties, including business leaders, policymakers, fleet owners and operators, the general public, newspapers, editorial boards, government agencies, national EV organizations, environmental groups, and others. Where appropriate, these groups should be recognized for the important role they played in ensuring the adoption of the incentive package.

## THREE SUCCESS STORIES

The following case studies detail the processes that garnered support for three different EV incentives currently available at the state, regional, and local levels.

***How Florida's EV Incentive Package Became Law***

***Florida's EV incentive package, passed into law June 15, 1995, by the Florida Legislature, provides an EV sales tax exemption for five years; prohibits surcharge on insurance premiums without supporting actuarial data; and exempts EVs from emission inspections.***

***This EV incentives package was successfully presented to the Florida Legislature as an economic development issue. Florida has a fledgling electric vehicle industry, which conforms with the state's goal of creating and retaining highly technical, better paying jobs in clean industries.***

***The primary sponsors of the proposed EV bill were carefully selected for their ability to work with people in the legislative system. The senators and representatives solicited as sponsors had at least one EV-related company within their districts that would benefit from the legislation.***

***The sales tax exemption was presented as a zero revenue loss, since the major EV market in Florida is local and state government, and government is exempted from paying sales tax to the state. It was also sold as a potential revenue producer at the end of the five-year exemption, since it is assumed that the industry will have ramped up by the sixth year. Another tactic involved holding EV ride-and-drives targeted to key legislators, which proved an extremely effective way to convince legislators about the advancements in EV technology.***

***California SCAQMD's "Quick Charge" Zero-Emission Vehicle Program***

***On July 14, 1995, the South Coast Air Quality Management District (SCAQMD) in the State of California unanimously passed a $7 million "Quick Charge" Zero-Emission Vehicle Program. The two-year Program (FY 1996-1997) is paid for by a $4 per vehicle registration fee assessed to motorists in the SCAQMD region to fund mobile source air quality improvement programs.***

***Quick Charge contains two components designed to help California communities become EV-Ready. The first, the Electric Vehicle Corridor Communities Program, will provide matching funds to help communities test the consumer market and demonstrate the infrastructure, permitting process, and coordination necessary for introducing large quantities of EVs. The second component, the Electric Vehicle Price Buydown Program, provides a $5,000 per vehicle price reduction to EV purchasers. (EVs must be priced lower than the price that triggers the application of the federal luxury tax). The discount will be available as reimbursement to qualified manufacturers on a first-come, first-served basis, for a total of 1,200 EVs between 1996 and 1998.***

***SCAQMD took the following steps to enact this program:***

***Assessing the need: In 1990, air quality mandates in the State of California were requiring increasingly expensive investments from local governments, air districts, and transportation communities. SCAQMD was faced with rising regulatory costs through substantial fees on stationary sources, which were politically difficult to assess and put California at a competitive disadvantage with other states.***

***Building support: Local governments, manufacturers, utilities, air districts, and transportation agencies joined to build political support at the state level for assessing a $4 annual registration fee on California motorists. Experience***

*from districts that have imposed the fee shows that this fee is one of the most supportable and least visible fees available to fund air quality and transportation programs.*

*The $7 million EV incentive program was part of a larger, $25 million, fuel-neutral legislative package put forward to the air board. The increasingly conservative board voted 10 to 0 in favor of the EV incentive program for one primary reason: a variety of stakeholders—state and local agencies, trucking companies, advanced transportation interests, transportation agencies, gas and electric utilities, and even some oil companies—shared the belief that the legislative package represented their diverse interests. For example, the heavy-duty and transit bus grant categories included in the incentive package was supported by United Parcel Service, trucking companies, and natural gas interests. A $2.5 million block of funds reserved for a future light- and heavy-duty vehicle scrapping program served oil interests, while transit districts benefited from at least $4 million to pay the differential costs of alternative-fuel transit buses.*

*The program held together because common interests were recognized, the South Coast Air District, the California Air Resources Board, and the California Energy Commission were vested in the project, and the program was exceptionally well planned and properly executed to assure political success.*

*Pre-Wiring Ordinance for the Local Building Code in the County of Sacramento, California*

*Community leaders convinced of the benefits of electric vehicles can modify their local building codes to require that all new residential construction include pre-wiring for EV charging. However, enacting such an ordinance can be a lengthy, political process that can take an average of 18 months from inception to adoption.*

*The first job is to approach one or more elected officials with the concept and convince them of the merits of electric vehicles in general and the EV pre-wiring ordinance in particular. Any local elected official willing to champion the cause should be asked to direct public works staff to work with the EV readiness team to draft the language and determine any code section numbers that should be assigned. The language itself can be very simple.*

*The County of Sacramento, California, adopted the first U.S. ordinance of this kind, which became effective January 1, 1995.*

*In Sacramento, the lead stakeholder was the Sacramento Municipal Utility District. An original proposal and modification, drafted in 1992, asked for the installation of wiring from the electric supply panel to the vehicle location. Both versions met with opposition on several counts:*

- *Some builders/developers feared they would have to install a larger, more expensive electric service panel to accommodate the increased electrical load, which would add to the cost of a new home. This would place these homes at an economical disadvantage relative to resale homes in the County and new homes in neighboring jurisdictions not subject to the ordinance.*
- *Some electricians balked at the cost and lack of some equipment necessary for the installation.*
- *Some fire officials questioned the safety of charging EV batteries in an enclosed garage.*
- *Some building officials questioned whether special circuit breakers would be required.*
- *Those not convinced that EVs would ever be commonplace considered requiring the installation in all homes to be excessive governmental regulation.*

*While the process and issues may vary among communities, review of the draft* *language is likely to involve the fire marshall, the local utility, the building industry association, contractors, land use planners, realtors, and general taxpaying citizens. Each will view the proposal from a different perspective. Proponents of the Sacramento ordinance were required to provide answers to the following types of questions:*

- *What is the associated cost?*
- *Is there a need to increase the capacity of the electric service panel?*
- *Is there the need for installing a ventilation system?*
- *Is this type of regulation needed at all?*
- *What is the impact on community growth and air quality?*
- *What are the benefits to the general taxpayer?*

*The key turning point in the Sacramento adoption effort was winning the support of a few progressive, environmentally committed builders who embraced the concept and were sufficiently influential among their peers to counter any opposition. The support of the Building Industry Association (BIA) was crucial, as well. The BIA came to realize that homes pre-wired for zero-emission vehicles would qualify for air quality mitigation credits. Therefore, even if a proposed new subdivision was expected to induce increased vehicle trips, the development would not be held accountable for inducing increased emissions, provided the homes were equipped for EVs.*

*Once past the public hearing hurdles of technical and advisory review bodies, the proposal will be heard by the locally elected officials. Proponents should arrange a meeting with each official voting on the item prior to the hearing date. The purpose of this series of meetings is to elicit and address any concerns that might remain on the part of any policymaker. Sacramento found that the testimony and written letter of support from the BIA were key factors in convincing the elected officials that this ordinance amendment had such broad-based support that they needn't fear any negative political repercussions. Final adoption should be celebrated and announced in a press release prepared in advance to include quotes by the officials who championed the cause.*

*Volume III of this Manual contains a sample resolution for requiring pre-wiring for electric vehicles.*

## HIGHLIGHTS OF SECTION

**PURPOSE**

Electric vehicle technology continues to improve. However, today's state-of-the-art EV still does not offer the range of a gasoline-powered vehicle and is expected to carry a significant price premium in early, low-volume production. This section of the Manual provides background information on the status of EV development by U.S. and overseas automotive companies.

**Issues**

- Status of EV development by U.S. original equipment manufacturers
- Status of EV development by overseas original equipment manufacturers
- Results of EV America testing

**GENERAL CONCLUSIONS**

Both domestic and overseas automakers have built limited numbers of electric vehicles.

All domestic and some overseas automobile manufacturers have been testing EVs in fleets or with the general public.

Peugeot/Citroen will begin selling two electric cars, the Peugeot 106 and the Citroen AX, to the general public in France in fall 1995.

Three "production" EVs tested by EV America have successfully complied with the minimum performance requirements set by EV America.

# Status of Electric Vehicle Development

(As of August 1995)

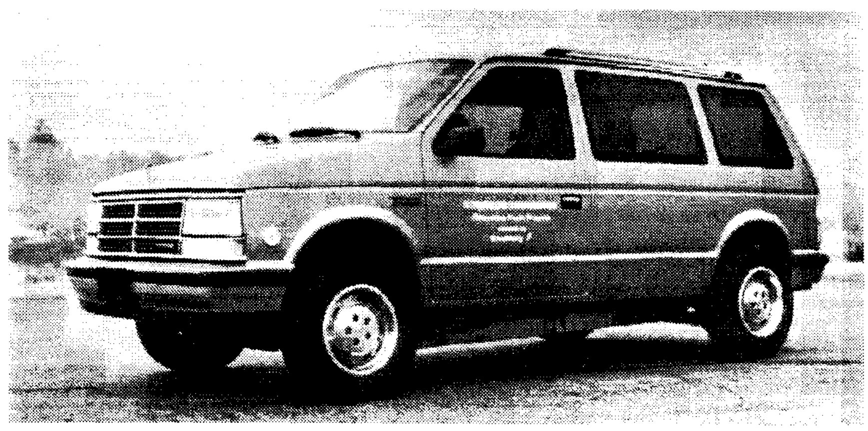
## U.S. ORIGINAL EQUIPMENT MANUFACTURERS

U.S. original equipment manufacturer (OEM) automakers are currently focusing on developing limited production runs of EVs. These vehicles are being tested and evaluated in the field to provide data on key performance features that are expected to be available to the consumer in the late 1990s.

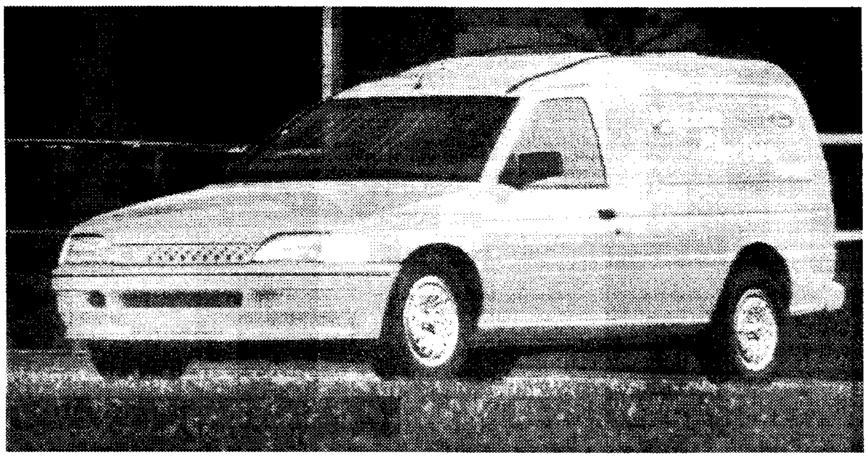
### *Chrysler Corporation*

Chrysler Corporation began placing 48 of its electric TEVans, based on the Dodge Caravan, into electric utility fleets during April 1993. The utilities are testing and evaluating each vehicle and providing results to Chrysler for further analysis. The TEVan has a payload capacity of five passengers plus 50 pounds of cargo, or 800 pounds of payload. Each vehicle is powered by a 70-horsepower peak dc traction motor with a range of 80 miles (SAE J227) between charges and a top speed of 65 mph. One-half of the TEVans are powered by nickel-iron batteries and the other half by nickel-cadmium batteries. The vehicles are recharged via a 240 volt/40 ampere or 208 volt/three-phase electric circuit using a traditional conductive plug and cord set.

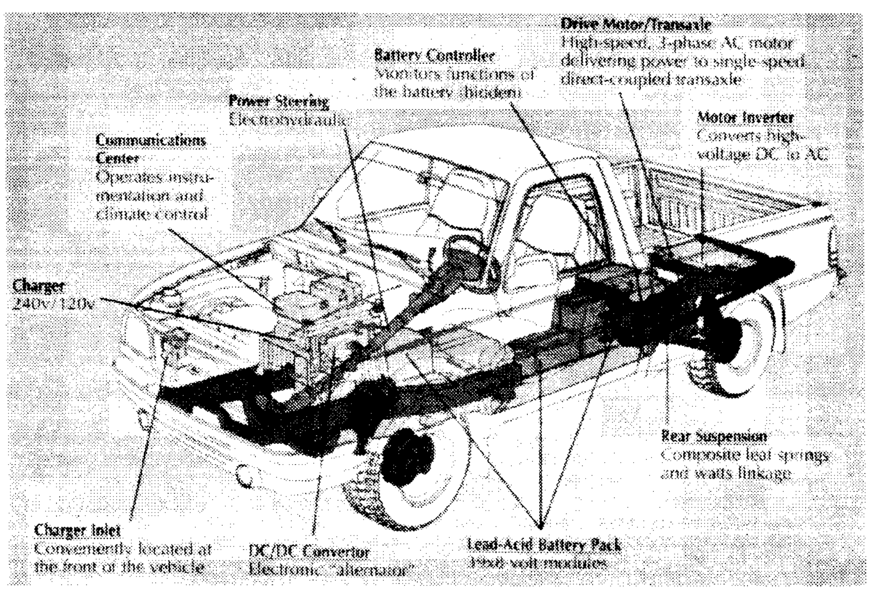
More recently, Chrysler announced that it is developing the next generation of an electric-powered van, the NS-series, that will incorpo-



Chrysler *TEVan*



Ford *Ecostar*




Cutaway of 1998 Ford *Ranger EV*

rate the Electrosource Horizon advanced lead-acid battery. The NS-series electric van is expected to be powered by a 100-horsepower ac motor that will accelerate from 0 to 60 mph in approximately 16 seconds. The vehicle is expected to be available by model year 1998.

*Ford Motor Company*

Ford Motor Company began placing 81 of its Ecostars, based on the European Escort van, into electric utility and other fleet operations in 1993. The fleet operators are testing and evaluating each of the vehicles and providing results to Ford for further analysis. As of May 1995, 103 Ecostars had been placed and driven a total of 500,000 miles. Equipped with a sodium-sulfur battery pack and a 75-horsepower ac induction motor, the Ecostar has a range of 100 miles (average based on actual customer experience) between charges, a governed top speed of 70 mph, and a payload of 1,020 pounds. The vehicle is recharged via a 240 volt/30 ampere or 120 volt/15 ampere electric circuit using a conductive plug and cord set.

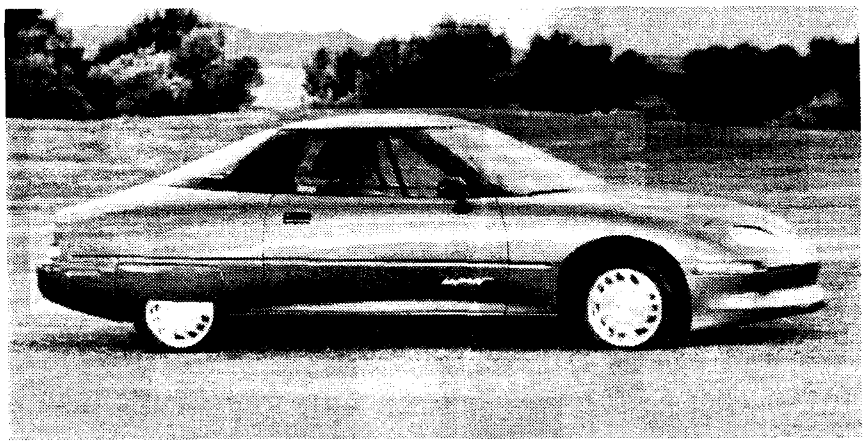
In April 1995, Ford announced its intention to sell Ford Ranger pickup truck "gliders"—vehicles without engines, transmissions, or fuel systems—to companies that will convert these vehicles to run on electricity. The first gliders will be available by the end of 1995 to Qualified Vehicle Modifiers (QVMs) that meet specific guidelines set by Ford. TDM Worldwide Conversions has indicated that beginning in 1996, it will produce for sale an electric version of the Ranger using the Ford-provided glider; the initial price is expected to be $20,000–$24,000.

In addition, Ford announced in June 1995 that it will offer for sale in 1998 an electric version of the Ford Ranger pickup truck. Equipped with a sealed lead-acid battery pack and a 75-horsepower ac induction motor, the Ranger will have a range of up to 58 miles between charges, a governed top speed of 75 mph, acceleration from 0 to 50 mph in less than 14 seconds, and a payload of 700 pounds. The vehicle is recharged via an on-board 240 volt/30 ampere or 120 volt/15 ampere charger. The initial price is expected to be about $30,000.

*General Motors Corporation*

In 1990, GM unveiled the Impact, a sporty two-seat purpose-built EV, and announced plans to produce and sell these vehicles by the mid-1990s. The Impact uses an advanced maintenance-free sealed lead-acid battery pack, and a 137-horsepower ac induction motor, which results in a range of 70–90 miles (Federal Urban Driving Cycle, 80% battery depth of discharge, 70°F), a governed top speed of 80 mph, and acceleration from 0 to 60 mph in 8.5 seconds. Designed as a purpose-built vehicle, the Impact incorporates several technical innovations, such as an aluminum body structure, low rolling resistance tires, a heat pump for interior cooling and heating, and an exterior shape that substantially reduces aerodynamic drag.

In 1992, GM reassessed the business climate for EVs and discontinued the Impact production program. In 1994, GM announced the $32 million GM PrEView Drive Program, in which 30 Impacts would be test driven for two or four weeks by 800 drivers in 12 U.S. cities over a two-year period. The goal of the PrEView Drive Program is to collect performance data on and assess the market potential of the Impact and to test a new inductively coupled charging system.

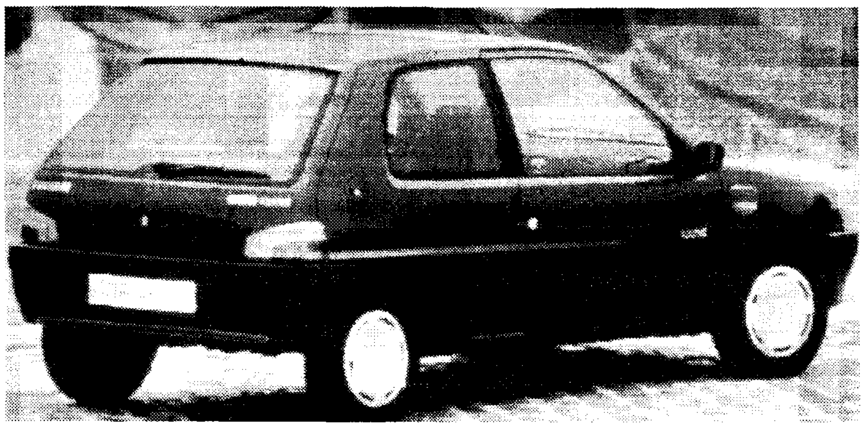


General Motors' *Impact* electric vehicle

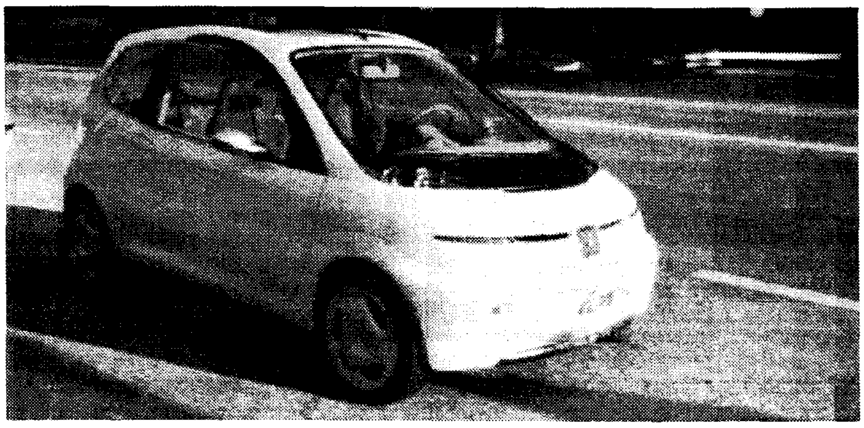
**Summary of U.S. OEM EV Technology as of 1995**

| Attribute | General Motors Corporation *Impact* | Ford Motor Company *Ecostar* | Chrysler Corporation *TEVan* |
|---|---|---|---|
| **Acceleration** | 0–60 mph in 8.5 seconds | 0–50 mph in 12 seconds | 0–50 mph in 27 seconds |
| **Top Speed** | 80 mph (electronically limited) | 70 mph (electronically limited) | 70 mph |
| **Range** | 70–90 miles | Up to 127 miles[1] | Up to 80 miles |
| **Motor** | 137 HP ac induction | 75 HP ac induction | 70 HP dc traction |
| **Battery Pack** | 16.8 kWh lead-acid | 30 kWh sodium/sulfur | Nickel-iron or nickel-cadmium |
| **Charge Time @ 220 volts** | 2–3 hours | 6 hours | 6–8 hours |
| **Charger Location/ Type** | Off-Board/Inductively Coupled | On-Board/Conductively Coupled | On-Board/Conductively Coupled |

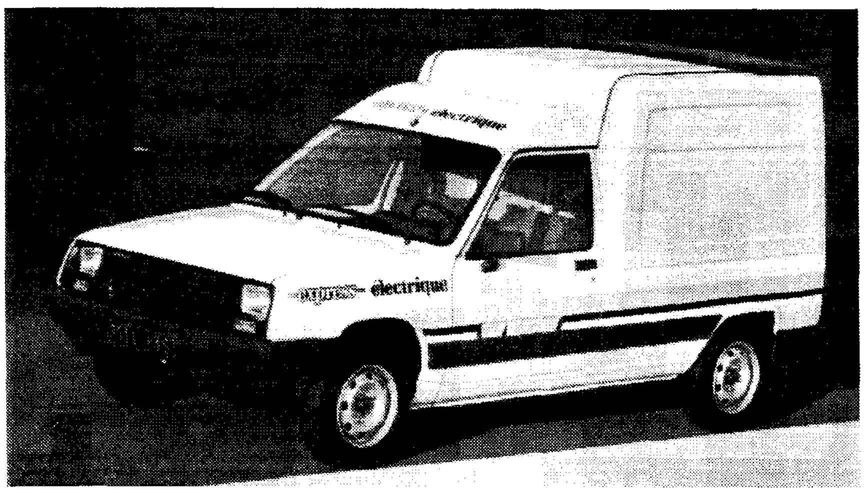
[1]Based on the Federal Urban Driving Cycle.



Electric *Peugeot 106*



Peugeot *Ion*



Renault *Express Electrique*

## OVERSEAS OEMs

Overseas OEM automakers are actively pursuing EV development programs. Many of the manufacturers in recent years have shown concept vehicles and have deployed limited quantities of EVs for test and evaluation.

*French Automobile Manufacturers*

**Peugeot/Citroen**

After successful public trials of its prototype EVs, the Peugeot 106 and Citroen AX, in La Rochelle, France, Peugeot/Citroen (PSA) announced in late 1994 that it would begin commercial production of EVs in 1995. These vehicles will be available for sale during fall 1995 in France. Equipped with a nickel-cadmium battery pack, the Citroen AX has a range of 55–100 miles between charges, a top speed of 55 mph, and acceleration from 0–30 mph in 9 seconds. These vehicles will retail for about $3,000–$4,000 more than the corresponding gasoline-powered model (excluding the battery) but will benefit from a $3,000 rebate provided by the federal government and the state-owned electric utility. The nickel-cadmium batteries will be leased for approximately $100 per month. In addition, PSA recently announced the Peugeot Ion, a purpose-built precursor of an EV that PSA intends to produce before the turn of the century.

**Renault**

Renault has produced 52 large Express electric vans equipped with lead-acid batteries, and 30 smaller Master electric vans equipped with nickel-cadmium batteries. These vehicles are part of a one-year test and evaluation program by major fleet users located in France and other European countries. In addition, Renault is developing the Clio, which should be available to the general public in 1996. The Clio is a four-passenger vehicle equipped with a nickel-cadmium battery pack and a dc motor that offers the driver a range of 60 miles per charge and a maximum speed of 60 mph.

*German Automobile Manufacturers*

**BMW**

Over the last few years, BMW has shown two prototype purpose-built EVs: the E1, a two-door, four-passenger commuter vehicle, and the E2, a four-door, four-passenger vehicle. Both vehicles are powered by sodium-sulfur batteries and have a top speed of 75 mph. The E1 has a range of 75 miles and the E2, a range of 161 miles.

**Mercedes-Benz**

The electric vehicle program of Mercedes-Benz A.G. includes passenger cars, commercial vehicles such as transporters, small electric buses, and buses with overhead lines. Mercedes-Benz has demonstrated an electric version of its new C-class sedan, a five-passenger vehicle powered by sodium nickel-chloride batteries. The electric passenger car being developed for the U.S. market is based on the smaller A-class car, a completely new compact vehicle. This EV is powered with a 30-kWh sodium nickel-chloride battery, and has a minimum range of 100 miles, a top speed of 75 mph, and acceleration of 0–60 mph in approximately 15 seconds.

In March 1994, Mercedes-Benz announced that it would also manufacture an ultra-compact EV, the Smart (Swatchmobile), the product of a joint venture with Swiss watch manufacturer Swatch. The production facility for the Swatchmobile will be built in Hambach, France, and the first vehicles will be delivered to selected markets in the late 1990s.

In October 1992, Mercedes-Benz, Opel, and Volkswagen began a $30 million, 60-vehicle test and evaluation program on Rugen Island in the Baltic Sea. This program, scheduled to be completed mid-1996, was partially funded by $15 million from the German government.

*Japanese Automobile Manufacturers*

**Honda**

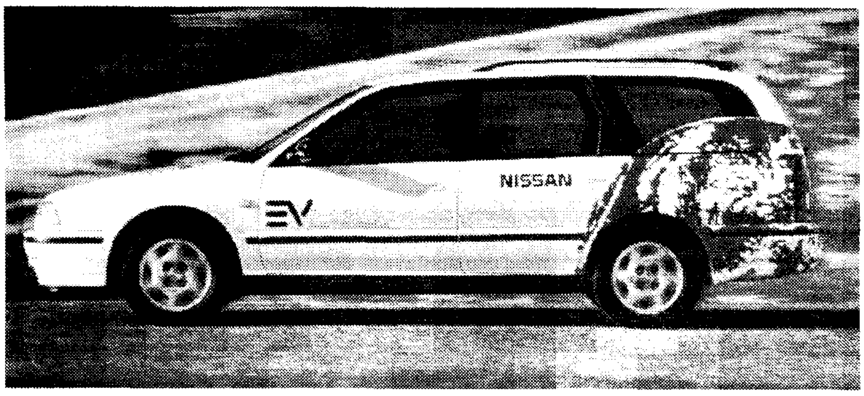
In late 1994, Honda delivered three Civic-based EVs to SCE and five Civic-based EVs to PG&E for a two-year test and evaluation program. This two-door, four-passenger vehicle is powered by a sealed lead-acid battery pack and has a 40–70 mile range and a top speed of 80 mph. The vehicle is equipped with an on-board 120/220 volt charger with a recharge time of 6–8 hours on 220 volts.

Renault *Master Electrique*

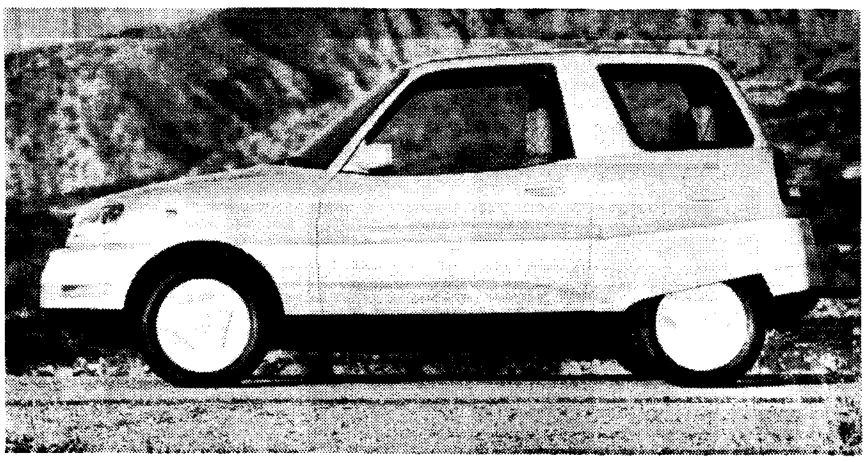
**Mazda**

Mazda has shown an electric MX-5, two-seat car based on the Mazda Miata. This vehicle incorporates an ac motor and a nickel-cadmium battery pack that delivers 0 to 60 mph acceleration in 14.7 seconds, a top speed of 81 mph, and a range of 112 miles at 25 mph constant speed.

1994 Honda Civic-based electric vehicle




Nissan *Avenir*



Toyota *EV-50* concept vehicle

**Nissan**

In 1994, Nissan produced the Cedric EV, converted from an internal-combustion-engine vehicle, for use mainly by government agencies. This vehicle is equipped with valve-regulated lead-acid batteries and has a top speed of 63 mph, a range of 25 miles under urban driving conditions, and a recharge time of 5 hours.

In late 1994, Nissan produced and sold the Avenir EV commercial van for use by utility companies in Japan. The Avenir, equipped with valve-regulated lead-acid batteries, has a top speed of 72 mph and a range of 50 miles under urban driving conditions.

**Toyota**

At the 1993 Tokyo Motor Show, Toyota unveiled the EV-50. This vehicle has been equipped with either a 40-kW (max power) ac induction motor, or a 40-kW (max power) dc permanent magnet motor. The permanent magnet motor increases vehicle range. Equipped with lead-acid batteries, the EV-50 has a range of approximately 111 miles at 25 mph.

## OTHER U.S. EV MANUFACTURERS

The chart on the following page provides performance specifications on three "production" EVs that are available now for purchase from some other U.S. manufacturers. These figures are based on the results of a 60-day proving ground evaluation that began in August 1995 and was conducted by EV America with support from the Department of Energy. The full performance specifications as published by EV America can be found in Volume III of this Manual. All of these vehicles meet the minimum performance requirements set by EV America. However, none met all the stringent long-term performance goals.

With assistance from the DOE Site Operator Users Task Force program, EV America is also conducting field evaluations of these vehicles. The objective of these evaluations is to replicate proving ground results over an extended period and to demonstrate vehicle reliability. EV America is also conducting proving ground evaluations of "prototype" EVs through December 1996. EV America cannot distribute information on evaluation results for "prototype" vehicles without prior approval from the manufacturers.

**Summary of EV America Results[1]**

| Attribute | Solectria Force Converted Geo Metro | Solectria E10 Pickup Converted Chevrolet S10 | Baker EV 100 Pickup Converted GMC Full-Size Pickup |
|---|---|---|---|
| Acceleration 0–50 mph @ 50% State of Charge (SOC)[2] | 18.5 seconds | 17.4 seconds | 14.9 seconds |
| Top Speed @ 50% SOC[3] | 69.9 mph | 67.9 mph | 71.1 mph |
| Driving Cycle Range[4] | 84.5 miles | 55.1 miles | 56.6 miles |
| Battery | Nickel metal-hydride | Sealed lead-acid | Nickel metal-hydride |
| Charge Time[5] | 8 hours 57 minutes | 11 hours 11 minutes | 7 hours 50 minutes |
| Charger Location/Type | Trunk/Conductive | Under hood/Conductive | Off-Board/Inductive |

[1]Statistics for vehicles tested in 1995 can be accessed on the Site Operator Home Page on the Internet at the following address: http:\\spiderman\tis\inel.gov
[2]Performance Goal: 13.5 seconds or below.
[3]Performance Goal: 70 MPH in one mile or higher.
[4]Performance Goal: 60 miles when subjected to the combined UDS-HWFET Drive Cycle established in SAE J1634.
[5]Performance Goal: 8 hours or below.

## HIGHLIGHTS OF SECTION

**PURPOSE**

Continuing progress in EV battery research and development is improving EV acceleration and range, thereby enhancing commercialization prospects. This section of the Manual provides background information on EV battery technology.

**ISSUES ADDRESSED**

- Battery technology
- Advanced Lead-Acid Battery Consortium
- United States Advanced Battery Consortium
- Progress report on battery development

**GENERAL CONCLUSIONS**

Lead-acid batteries continue to be the major battery type commercially available for EVs.

In 1996, GM/Ovonic will begin producing a nickel metal-hydride battery developed by Ovonic that is currently being tested in vehicles.

Advanced batteries with a lower purchase price and higher performance are key to producing and marketing an EV that will be widely accepted by today's consumer. Many individuals and companies are working to solve these continuing challenges.

According to the Battery Technical Advisory Panel, a group created by the California Air Resources Board, EVs with commercially produced advanced batteries could become available in 2000–2001.

# Summary of Battery Technology

## BATTERY TECHNOLOGY

To provide rapid acceleration and enable long-distance trips, EV batteries must have both high specific power[1] and high specific energy,[2] respectively. They must also be low-cost, easy to maintain, safe under normal operating conditions, and tolerant of the abuse vehicles typically receive in daily operation.

The lead-acid battery continues to be the major battery type commercially available for EVs. Research to enhance lead-acid batteries focuses on increasing specific energy, specific power, and cycle life, and decreasing maintenance requirements, volume, weight, and cost. The Horizon advanced lead-acid battery, developed by Electrosource, is now available. Some alkaline systems—including nickel-cadmium—have been successfully adapted for use in EVs. In 1996, GM/Ovonic will begin limited production of a nickel metal-hydride battery developed by Ovonic that is currently being tested in vehicles.

The need to develop a battery with higher specific power, higher specific energy, and a longer cycle life resulted in the formation of the Advanced Lead-Acid Battery Consortium (ALABC) and the United States Advanced Battery Consortium (USABC).

### *Advanced Lead-Acid Battery Consortium*

Formed in March 1992 within the charter of the International Lead Zinc Research Organization, Inc., ALABC's membership is composed of 51 companies, including battery manufacturers, suppliers, and automobile manufacturers from 11 countries. ALABC has imple-

[1]Specific power is a measurement of the battery's power-to-weight ratio (or watts of power held in the battery per kilogram of mass) which, in terms of vehicle performance, translates into acceleration.

[2]Specific energy is a measurement of the battery's energy-to-weight ratio (or watthours of energy held in the battery per kilogram of mass) which, in terms of the vehicle's performance, translates into range and energy to power accessories, such as the heater, air conditioner, and windows.

mented a four-year research plan at a funding level of $19.3 million, half of which comes from industry contributions and half from government grants and contractor matching funds. To date, DOT's Federal Transit Administration has provided $1.2 million in funding to ALABC. ALABC has identified five critical goals to improving lead-acid batteries for use in EVs:

- Improve specific power: 150 watts per kilogram (W/kg) at 80% depth of discharge.
- Improve specific energy: 50 watthours per kilogram (Wh/kg) at a three-hour discharge rate.
- Improve battery life: 3 years or over 500 cycles based on the simplified Federal Urban Driving Cycle with less than 20% capacity loss.
- Improve cost per battery pack: $150 per kWh.
- Improve rapid charging: 100% charge in 4 hours, 80% in 15 minutes, and 50% in 5 minutes.

*United States Advanced Battery Consortium*

USABC is a collaborative partnership that includes the following organizations:

- GM, Ford, and Chrysler
- DOE
- EPRI
- Four U.S. electric utilities: PG&E, SCE, Public Service Electric and Gas Company, and Southern Company
- The Empire State Electric Energy Research Corporation, which represents electric utilities in the State of New York.

DOE provides half of the funds and the USABC partners, along with EPRI, individual electric utilities and battery developers, provide the remainder. With $262 million committed through 1995, USABC has been developing a mid-term battery—nickel metal-hydride—for the late 1990s, and a long-term battery—lithium polymer—for the year 2003. Enhancing specific energy, specific power, and

**Summary of United States Advanced Battery Consortium Goals**

| USABC Goals | Specific Power | Specific Energy | Lifetime | Cost |
|---|---|---|---|---|
| Mid-Term Goal | 150–200 W/kg | 80–100 Wh/kg | 5 years | $150 or less per kWh |
| In a typical EV, this would mean | 0–50 mph acceleration in 12 seconds | A driving range of 100–125 miles in normal use | Battery cost could be amortized over 5 years | $4,500–$6,000 battery |
| Long-Term Goal | 400 W/kg | 200 Wh/kg | 10 years | $100 or less per kWh |
| In a typical EV, this would mean | 0–60 mph acceleration in 9 seconds | A driving range of 200 miles in normal use | Battery cost could be amortized over 10 years | $4,000 battery |

cycle life, while maintaining a reasonable cost, are the major battery research goals for USABC.

## PROGRESS REPORT ON BATTERY DEVELOPMENT

CARB created a special panel, the Battery Technical Advisory Panel,[1] to identify and investigate conventional and advanced batteries that might be available for EVs in 1998–2003. The panel offered its preliminary findings during a CARB workshop on the status of zero-emission vehicle technology held on October 11, 1995, in its presentation, *Performance and Availability of Batteries for Electric Vehicles:*[2]

- Lead-acid batteries will be available for EVs in 1998.
- Several types of high energy/high power batteries are emerging—specifically, nickel metal-hydride, sodium/sulfur, and sodium-nickel chloride—that promise to satisfy USABC mid-term goals.
- Advanced batteries are expected to cost more than lead-acid batteries. However, their longer life cycle should balance out the higher purchase cost.
- The key step required in the next few years is pilot-scale production of advanced batteries in numbers sufficient to prove the technology and refine the production process.
- Fleet testing in EVs of most of the advanced batteries being reviewed is expected to occur between 1996–1999. These batteries will be produced in pilot-scale plants and are expected to cost between $1,000–$2,000/kWh.
- Close collaboration between battery developers and automakers is critical to build automaker confidence that EVs powered by advanced batteries will be acceptable to consumers.
- Building of commercial-scale battery production facilities will not occur until developers receive commitments from automakers for 10,000–40,000 battery packs per year.
- Once commitments are secured, it will take two years and an investment of $50–$100 million for each battery type to achieve commercial quantities.
- EVs with commercially produced advanced batteries could become available in 2000–2001.

[1]The Battery Technical Advisory Panel is co-chaired by Dr. Fritz Kalhammer (Electric Power Research Institute) and Dr. Carl Moyer (Acurex Environmental Corporation), and includes Dr. Akiya Kozawa (Union Carbide Company, retired) and Dr. Boon Owens (Research International).

[2]The final report, Performance and Reliability of Batteries for Electric Vehicles: A Report of the Battery Technical Advisory Panel, was submitted to CARB on December 11, 1995, by the Battery Technical Advisory Panel.