Electric and Hybrid Vehicle Program
Site Operator Program
Quarterly Progress Report
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Contents

Executive Summary

The U.S. Department of Energy (DOE) Site Operator Program was initially established to meet the requirements of the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976. The Program has since evolved in response to new legislation and interests. Its mission now includes three major activity categories:

- Advancement of Electric Vehicle (EV) technologies
- Development of infrastructure elements needed to support significant EV use
- Increasing public awareness and acceptance of EVs.

The 11 Site Operator Program participants, their geographic locations, and the principal thrusts of their efforts are identified in Table ES-1. The EV inventories of each participant are summarized in Table ES-2.

A perspective of the Program since its inception in 1976 shows progress toward its major goals once the purpose of the Program was more clearly defined. The principal problems -- related to data collection, interpretation, and availability -- were identified and remedial efforts were undertaken when the contract for managing the Program was transferred to the INEL, in 1987.

The primary functions of the Program continue to be the collection, analysis, and dissemination of operating and maintenance data; and demonstrations of the technology to promote public awareness. Both efforts have been fruitful; in particular, practical methods and equipment for handling operating data are now in use, and the data is widely available via computer networks. The data represent more than 200 vehicles, of which about 50 are the latest generation vehicles. The vehicles are either Doe-owned, participant-owned, or participant-monitored units.

The participants – electric utilities, academic institutions, and Federal agencies – are geographically dispersed within the United States and their vehicles see a broad spectrum of service conditions. The contributions of the first two groups go well beyond the basic Program scope:

- The utilities have worked towards infrastructure development, battery recharging scenarios, and identification of operation/maintenance problems.
- Academic institutions have investigated alternative charging technologies (curbside and solar) and have developed a practical mobile data acquisition system. Other contributions are training materials for maintenance and operation, and the field testing of experimental or prototype systems and components.

The program participants have generally established working relationships with the industrial community where common interests exist. Experience to date emphasizes problems specific to electric vehicles:

- Climate effects
- Battery technology limitations
- Vehicle conversions versus ground-up design

In the context of existing or impending legislative mandates to increase electric vehicle usage for environmental reasons, two national organizations have joined DOE and the major vehicle manufacturers in EV promotion.

- The Partnership for a New Generation of Vehicles (PNGV) in America will identify and evaluate alternatives in vehicular technology.
- EV America, a utility-led program, will conduct performance and evaluation tests to support market development for electric vehicles.

In addition, DOE, the Department of Transportation, the Electric Transportation Coalition, and the Electric Vehicle Association of the Americas are conducting a series of workshops to encourage urban groups to initiate the policies and infrastructure development necessary to support large-scale demonstrations, and ultimately the mass market use, of electric vehicles.

Program redirection in the near and medium term is expected to involve hybrid systems, advanced EV's, add-on or upgraded components, advanced batteries and inputs from PNGV studies.

Table ES-1. Site Operator Program Participants.

Entity	Principal Thrusts of Program Effort
Arizona Public Service Co. Phoenix, AZ	a, b, d
Kansas State University Manhattan, KS	a, b, c, d
Los Angeles Dept. of Water & Power Los Angeles, CA	a
Orcas Power and Light Co. Eastsound, WA	a, b, d
Pacific Gas and Electric Co. San Ramon, CA	a, b, d
Platte River Power Authority Fort Collins, CO	a, b, d
Potomac Electric Power Co. Washington, DC	a, b, d
Sandia National Laboratory* Albuquerque, NM	a
Southern California Edison Co. Rosemead, CA	a, b, d
Texas A&M University College Station, TX	a, c, d
University of South Florida Tampa, FL	a, b, c, d
U.S. Navy* Port Hueneme, CA	a
York Technical College Rock Hill, SC	a, b, c, d
	a. Fleet evaluation, vehicle test b. Infrastructure development c. Technical education d. Public awareness

* Sandia and the Navy are not Site Operators, but they do share information with the Site Operator Program, and this information is provided to the reader of this report.

Table ES-2. Site Operator Program active vehicle inventory.

	Solectria	U.S. Electricar

	S-10	Force	Sedan	S-10	G-Van	Ecostar	TEVan	Honda	EVcort	Others*	Total
APS	6	2	-	3	4	-	1	1	3	9	29
KSU	-	-	-	-	-	-	-	-	2	-	2
LADWP	-	-	4	4	6	-	4	-	-	1	19
OPALCO	-	1	-	-	-	-	-	-	1	-	2
PG&E	-	-	-	5	3	5	-	5	-	-	18
PRPA	-	-	-	-	-	-	-	-	2	-	2
PEPCO	3	1	-	-	1	-	-	-	-	-	5
SANDIA	-	-	-	-	-	-	-	-	-	12	12
SCE	2	7	4	4	14	12	2	3	-	6	54
TAMU	-	1	-	3	15	-	9	-	-	2	30
NAVY	13	-	-	-	7	-	-	-	-	39	59
USF	-	-	-	-	2	-	-	-	-	10	12
YORK	-	1	-	1	1	-	-	-	-	8	11
TOTALS	24	13	8	20	53	17	16	9	8	87	248

*** The "Others" category includes various vehicle models, manufacturers, and converters, including: BAT Metro and Ranger, Specialty, Demi TVan, Ford Ranger, Venus Ranger, Griffin, Solar Car, Spartan, Unique, Soleq, Bear Skin, Jet, Volkswagen, Mitsubishi, utility company conversions, and others. It is assumed that these "Other" vehicles, while perhaps provide satisfactory day-to-day operating capabilities to their owners, generally have been and will be of limited production, and they do not represent the future electric vehicle market in the United States.**

Acknowledgement

The principle author thanks each of the Site Operator participants for their input, active participation, and timely comments in the form of their quarterly reports. The Site Operator Program report incorporates text and data from the quarterly reports that each of the Site Operator participants submit. Because of the significant amount of text that is draw from each of the individual Site Operator's reports, each of the individual Site Operators are listed as co-authors. However, any errors, emissions, or inaccuracies are the singular responsibility of the principle author.

Introduction

The Site Operator Program was initially established by the Department of Energy (DOE) to incorporate the electric vehicle activities dictated by the Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976. In the ensuing years, the Program has evolved in response to new legislation and interests. The Program currently includes eleven sites located in diverse geographic, metrologic, and metropolitan areas across the United States. Information is shared reciprocally with two additional sites (U.S. Navy and Sandia National Laboratory) that not under Program contract or control.

The Mission Statement of the Site Operator Program includes three major activities:

- Advancement of electric vehicle technologies
- Development of infrastructure elements necessary to support significant electric vehicle use; and
- Increasing the awareness and acceptance of electric vehicles (EVs) by the public.

The current participants in the Site Operator Program and their locations are shown in Figure 1, while Table 1 indicates the types EVs in each of the Site Operator fleets. Table 2 provides baseline information on several EVs currently in use by the Site Operators, or which have evolved to the point that they may be introduced into fleets in the near future.

The Program is currently managed by personnel of the Electric and Hybrid Vehicle Program at the Idaho National Engineering Laboratory (INEL). The current principal management functions include:

- Coordination of Site Operator efforts in the areas of public awareness and infrastructure development (program-related meetings, and educational presentations).
- Technical and financial monitoring of programmatic activities, including periodic progress reports to DOE.
- Data acquisition, analysis, and dissemination. The data from the Site Operators are made available to users through the INEL Site Operator Database.

The ultimate thrust of program activities varies among sites, reflecting not only the Operator's business interests but also geographic and climate-related operating conditions. These considerations were identified previously in Table ES-1.

In this issue of the Site Operator Program Quarterly Report, a brief perspective of the Program history and goals is presented. The current status is summarized, and detailed contributions of the participants to the promotion of a soundly-based electric vehicle capability are identified.

Table 1. Site Operator Program vehicle fleet.

Arizona Public Service Company

Unique sedan	2 ea.
Conceptor G-Van	4 ea.

Spartan/GE S-10	1 ea.
Soleq EVcort sedan	3 ea.
Solar Car Electric Colt	1 ea.
Chrysler TEVan	1 ea.
Solectria Force	1 ea.
Solectria S-10	3 ea.
DTS S-10	1 ea.
Specialty Vehicle	1 ea.
Brawner Motorsport S10	1 ea.
US Electricar S-10	3 ea.
TOTAL	22

Kansas State University

EVcort sedan 2 ea.

Los Angeles Department of Water and Power

Conceptor G-Van	6 ea.
Unique Mobility van	1 ea.
Chrysler TEVan	4 ea.
US Electricar S-10	4 ea.
US Electricar sedan	4 ea.
TOTAL	19

Orcas Power and Light Company

Jet Ford Escort	1 ea.
Solectria Force	1 ea.
TOTAL	2

Pacific Gas and Electric Company

Conceptor G-Van	3 ea.
Honda	5 ea.
Ford Ecostars	5 ea.
US Electric S-10	5 ea
TOTAL	18

Platte River Power Authority

Soleq EVCORT sedan 2 ea.

Potomac Electric Power Company

Solectria S-10	3 ea.
Solectria Force	1 ea
G-Van (inactive)	1 ea
TOTAL	5

Sandia National Laboratory

Jet Electricas 12 ea.

Southern California Edison Company

Conceptor G-Van	14 ea.
Solectria Force	7 ea.
Ford Ecostar	12 ea.
Solectria S-10	2 ea.
US Electricar S-10	4 ea.
BAT Metro sedan	1 ea.
BAT Ranger	1 ea.
US Electricar Sedan	4 ea.
Chrysler TEVan	2 ea.
Specialty Shuttle	1 ea.
Honda CUV-4 sedan	3 ea.
DEMI TEVan	1 ea.
Ford Ranger	1 ea.
Venus Ranger	1 ea.
TOTAL	54

Texas A&M University

Conceptor G-Van	15 ea.
Jet Ford Lynx	1 ea.
Chrysler TEVan	9 ea.
Solectria Force	1 ea.
GM Opal	1 ea.
US Electricar S-10	3 ea.
TOTAL	30

U.S. Navy

Jet	16 ea.
Griffin	15

Solectria	13
Conceptor G-Vans	7
Taylor Dunns	1
Manufacturer not known	5
Shuttle Bus	2 ea.
TOTAL	59

University of South Florida

Conceptor G-Van	2 ea.
Solar Car Corp. S-10	7 ea.
Florida Power S-10	2 ea.
Mitsubishi Mirage	1 ea.
TOTAL	12

York Technical College

Conceptor G-Van	1 ea.
Jet Escort Sedan	3 ea.
Unique Sedan	1 ea.
US Electricar S-10	1 ea.
Bear Skin Escort Wagon	1 ea.
Volkswagen Pickup	3 ea.
Solectria Force	1 ea.
TOTAL	11

(Maintained for others 6 ea.)

Total All Sites 242

Table 2. Baseline vehicle information on selected electric vehicles.

VEH NAME	G-Van	EVCORT	Force	S-10	TEVan	ECOSTAR
MFG	Conceptor	Soleq	Solectria	Solar Car	CHRYSLER	FORD
BODY	VAN-PSG/CRGO	SEDAN	SEDAN	PICK-UP	MINI-VAN	STAT. WAG.
NO. PASS	7/2	4	2+2	2	7	2
BATT TYPE	LEAD-ACID	LEAD-ACID	LEAD-ACID	LEAD-ACID	NI-FE	NA-S

MODUL VLT	6	6	12	6	6	-
NO. MODUL	32	18	12	20	30	-
SYST VOLT	216	108	144	120	180	336
CHARGER	OFF BOARD	ON BOARD	ON BOARD	ON BOARD	ON BOARD	-
WEIGHT(GVW)	8600 lbs	3980 lbs	2450 lbs	3200 lbs	~6000 lbs	3950 lbs
WEIGHT(CURB)	7670 lbs(Pass) 7050 lbs(Cargo)	3560 lbs	-	3500 lbs	-	3200 lbs
MOTOR/HP	DC/60 HP	DC/42 HP	AC/25-DC/32	DC/28	DC/55	AC/75 HP
EST RANGE	60 MI.	60 MI.	46 MI.(FUDS)	40-70 MI	120 MI.	100 MI.
REGEN BRK	YES	YES	YES	OPTIONAL	YES	YES

VEH NAME	IMPACT	LA 301	ELECTRON-TWO	FEV	RAM 50 TRUCK	E1
MFG	GM	CLN AIR TRNS	SOLAR ELECTR	NISSAN	EVA	BMW
BODY	SEDAN	SEDAN	SEDAN	SEDAN	PICK-UP	SEDAN
NO. PASS	2	4	2	2	2	4
BATT TYPE	LEAD-ACID	PB-A w/HYBRID	LEAD-ACID	NI-CAD	LEAD-ACID	NA-S
MODUL VLT	10	6	6	-	6	-
NO. MODUL	32	32	18	-	20	-
SYST VOLT	320	216	108	-	120	120
CHARGER	ON BOARD	ON BOARD	-	ON BOARD	-	-

WEIGHT	2200 lbs	3894 lbs	3100 lbs	1984 lbs	3500 lbs	2600 lbs
MOTOR/HP	2 ea AC/57 HP	57	DC/23	2 ea	DC/38	DC/45
EST RANGE	80 MI	40-60 MI*	45-65 MI	100 MI	50-70 MI	155
REGEN BRK	YES	YES	-	YES	-	-
*BATT. ONLY; 150+ MI AS HYBRID						

Program Experience Overview

The Site Operator Program has evolved substantially since its inception in response to the Electric Vehicle Research and Demonstration Act of 1976. In its original form, a commercialization effort was intended but this was not feasible for lack of vehicle suppliers and infrastructure. Nonetheless, with DOE sponsorship and technical participation, a few results (primarily operating experience and data) were forthcoming.

In the early 1980s, DOE emphasis shifted to data collection and interpretation. A mechanism was set up to give money to participating sites and justify continuing the program. Several problems soon became apparent:

- Too much data was required
- Data collection methods were primitive
- Data quality was suspect
- Database operation was ineffective.

The contract for the Program was transferred to the INEL in 1987 and the basic premises of the Program were refined subsequent to the INEL takeover, to emphasize the following efforts:

- Operating and maintenance data collection, analysis, and dissemination
- Public demonstrations to promote general awareness of this developing technology.

Both of these efforts have been fruitful. In particular, practical methods and equipment now exist for acquiring and handling operating data, with increasingly broad distribution of relevant information.

The current Program comprises eleven sites and over 200 vehicles, of which about 50 are latest generation vehicles. DOE partially funds the Program participant expenditures and the INEL receives operating and maintenance data for the DOE-owned, and participant-owned or monitored vehicles, as well as Program reports.

As noted elsewhere in this report, participants represent several widely differing categories: electric utilities, academic institutions, and federal agencies. While both the utilities and the academic institutions tend to establish beneficial relationships with the industrial community.

Program participant efforts reflect varying combinations of day-to-day use, laboratory testing and evaluation, and successful promotion of public awareness by demonstrations, exhibits, and media dissemination of related activities and information.

The status entries in the last chapter provide more specific information concerning the Program participants and their overall interests, their programmatic activities, and their experiences with electric vehicles and accompanying problems.

The utilities have been concerned with infrastructure needs for electric vehicle operation, particularly those required for battery recharging. Several candidate technologies have been investigated and developed for commercial use. In addition, the problems associated with operating and maintaining an EV fleet have been scoped and workable solutions devised and implemented.

The academic institutions and electric utilities have been productive beyond the original Program scope in the areas of:

- Charging methods, both curbside and solar
- Vehicle operating data acquisition and transmittal, via mobile data acquisition systems (MDAS)
- Training courses and related materials for maintenance personnel and operators
- Field testing of experimental or prototype vehicles and components.

The INEL has worked closely with Program participants to improve acquisition methods and data quality. The INEL has also established a central database and arranged for the dissemination of a spectrum of EV-related information. Through Program reports, INEL also gains a broad picture of the state of EV technology and accompanying public awareness.

Some tentative conclusions can be drawn about the current state of EV technology and operation:

- The effects of climate are adequately documented by inputs from widely differing locations.
- Battery technology is a major limitation in achieving range and vehicle cost goals.
- Conversion of vehicles originally designed for internal combustion engine power can frequently severely reduce payload capability and the service life of key components.

· Production of useful data may be limited where up-to-date equipment is not available. Some of the operating units monitored by the program are approaching a 20-year service life.

Several states (notably, California and Massachusetts) have or are considering regulatory mandates to increase the use of electric vehicles for environmental benefit. Their eventual effectiveness is dependent upon establishing a viable EV manufacturing industry and an adequate infrastructure for vehicle operation and service.

In the context of these requirements, two national organizations have joined DOE and the major auto manufacturers in promoting EV use.

- The Partnership for a New Generation of Vehicles (PNGV) in America has been established as a joint Federal-Industrial-Academic effort to identify and evaluate vehicular transportation alternatives, including energy storage devices and alternative fuels.
- EV America is a utility-led program to accelerate development and introduction of electric vehicles into the marketplace. A key effort is performance and field test evaluation, with an initial procurement goal of 500 units by the end of 1995. Tests are planned to qualify up to 100 units to Federal Motor Vehicle Safety Standards, during 1995, and will include cold-weather exposures in the northern USA.

A third organization, Electric Vehicle Research Network, is an EPRI-sponsored group of 11 electric utilities who field test EVs, but are not Program participants.

In addition, DOE, the Department of Transportation, the Electric Transportation Coalition, and the Electric Vehicle Association of the Americas are conducting a series of workshops to encourage urban groups to initiate the policies and infrastructure development necessary to support large-scale demonstrations, and ultimately the mass market use, of electric

vehicles.

A change of Program direction in the future is expected. Probable candidates for operator testing and data acquisition are hybrids, advanced EVs (i.e., designed as such rather than conversions), add-on or replacement key components (i.e., energy storage devices, system control, and driveline), and devices resulting from PNGV findings.

Electric Vehicle Testing Results

The Site Operator Program, in conjunction with EV America, has conducted EV performance testing during the past two years (1995 and 1994). The testing has been performed with stringent testing procedures and minimum qualification standards that vehicles must meet to be accepted for testing. These standards and procedures allow a vehicle-to-vehicle, and year-to-year comparison of vehicle performances. Not only are performance trends established by using a standardized testing methodology, but more importantly, based on the results of this testing, potential fleet purchasers of EVs can now have greater confidence that his or her expectations of vehicle performance will be met if a vehicle passes the performance tests.

Based on the testing results of the twelve vehicles (Table 3) that were tested during 1995 and 1994, several trends are apparent. Average performance attributes for the three vehicles tested during 1995 and the nine vehicles tested during 1994 are plotted (Figure 2), and discussed below.

1994 tested electric vehicles. The average test results for each group of vehicles are plotted, and the listed variances are the deltas between the group averages for each test.

The average range (82.6 miles) for the 1995 vehicles, when driven at a constant speed of 45 mph, increased by 28% over the 1994 test group (64.8 miles). The single vehicle maximum range for the 1995 group was 106 miles and the maximum for the 1994 test group was 88 miles for a single vehicle (Figure 3).

Table 3. Performance testing results from the Site Operator Program and EV America 1995 and 1994 testing of electric vehicles. This is a partial list of testing results for the twelve vehicles tested during the two years. Some vehicles failed to achieve testing requirements and this is noted. (Complete testing performance profiles for all of the vehicles can be obtained on the Internet at http://spiderman.tis.INEL.gov).

	Constant speed range		Acceleration 0 to 50 mph	Maximum Speed	Battery		Time to Recharge
	@ 45 mph (miles)	@ 60 mph (miles)	@ 50% SOC (sec)	@ 50% SOC (mph)	Manufacturer	Type	Hrs.Min location
Vehicles tested during 1995							
1995 Solectria E-10 (1995 Chev. S-10 P/U)	80.8	49.9	17.4	68	Hawker	Sealed lead acid	11.11

1995 Solectria Force (1995 Geo Metro)	105.9	70.9	18.5	70	GM Ovonic	Nickel metal hydride	8.57
1994 Baker EV100 P/U (GMC full size P/U)	61.2	31.5	14.9	71	GM Ovonic	Nickel metal hydride	7.50
1995 average performance	82.6	50.8	16.9	70	-	-	9.19
Solectria E10 Pickup (Chevrolet S-10)	72.8	39.5	21.7	66	Hawker Energy	Sealed lead acid	6.52
Solectria Force (Geo Metro)	49.5	26.6	21.5	70	Hawker Energy	Sealed lead acid	3.54
U.S. Electricar Pickup (Chevrolet S-10 Pickup)	70.7	47.3	20.1	71	Hawker Energy	Sealed lead acid	15.40
U.S. Electricar Sedan (Geo Prizm)	59.3	41.5	16.2	81	Hawker Energy	Sealed lead acid	8.12
Bat International Pickup (Ford Ranger)	55.4	44.0	not achieved	not achieved	Trojan	Flooded lead acid	not available
Bat International Metro (Geo Metro)	88.4	51.6	26.0	67	Trojan	Flooded lead acid	10.40
Bat International Metro (Geo Metro)	47.1	39.6	16.5	81	Optima	Prototype deep cycle	not available
Dodge Caravan (Dodge Caravan)	86.4	57.0	33.9	62	Picher	Nickel iron	5.07

Unique Mobility Pickup (Ford Ranger)	53.5	38.3	30.3	70	Optima	Prototype deep cycle	10.50
1994 average performance	64.8	42.8	23.3	71	-	-	8.45

The average range (50.8 mi) for the 1995 group of EVs driven at a constant speed of 60 mph showed a 19% increase over the 1994 test group (42.8 mi). Within the 1995 test group, the maximum individual vehicle range at 60 mph was 71 mi, while the 1994 individual vehicle maximum range at 60 mph was 57 mi (Figure 4).

Acceleration tests from zero to 50 mph, performed at a state of charge of 50%, was performed on both the 1995 and 1994 EVs. The 1995 EVs, as a group, accelerated on average 28% faster (16.9 seconds) that the 1994 group (23.3 seconds). The single fastest acceleration time for the 1995 test vehicles was 14.9 seconds, while the 1994 group had a fastest acceleration time of 16.2 seconds. Two of the 1994 vehicles took over 30 seconds to accelerate to 50 mph (Figure 5).

The 1995 vehicles, as a group, displayed a 1 mph slower average maximum speed than the 1994 test group. However, this slight (1.4%) decrease in speed is acceptable given the previously discussed significant increases in range and acceleration. Also, the 1995 test group had all of their maximum speeds within 2 mph of the average, while two of the 1994 test vehicles were more than 5 mph below the average, and three of the 1994 test group EVs failed to reach the performance goal of 70 mph for maximum speed (Figure 6).

The charging results for the two groups indicated that 6.5% more time was required by the 1995 test vehicles to recharge their batteries than the 1994 test group. This increased recharge time, which translates to an average total time to recharge of 9 hours and 19 minutes for the 1995 group, is 34 minutes longer than the 1994 group (Figure 7). This increase in charging time should be considered in the content that the 1995 vehicle group included two

vehicles equipped with Nickel Metal Hydride batteries. The Nickel Metal Hydride batteries generally have higher energy storage capabilities, providing the enhanced range and acceleration results. Also, as a newer and more advanced battery than the lead acid batteries mostly used by the 1994 test group, the charging methodologies used to charge the Nickel Metal Hydride batteries are not as advanced as those for the lead acid batteries and this may be a reason for the longer recharging times exhibited by the 1995 test group.

Site Operator Activities

This section contains an overview of the activities at each of the eleven site operators, the U.S. Navy, and Sandia National Laboratory. The Site Operator Participants, the U.S. Navy, and the Sandia National Laboratory currently employ a total of 248 vehicles (Figure 8) that constitute a variety of models, manufacturers, and converters (Figure 9). The number of vehicles is constantly changing, as new vehicles are acquired, catastrophic breakdowns occur, and vehicles are totaled due to accidents resulting from real-world use. The EV data presented for the site operator vehicles is for the April–June period, unless otherwise noted.

Arizona Public Service (APS) maintains and operates 22 electric vehicles of various types (Figure 10) in its EV Program, primarily in the Phoenix area. Both passenger and cargo vehicles are represented. While some of the vehicle usage is demonstration, often under loan or lease arrangements, the main objective is to test and evaluate the viability of electric

vehicles, and to collect operation, maintenance, and battery data. The APS EV Program activity summaries also cover EVs leased to or owned by the cities of Phoenix and Scottsdale. Technical information is also coordinated with Southern California Edison, and the Electric Power Research Institute (EPRI).

Technical

Since 1979, APS has logged over 603,000 miles on their electric vehicles as part of the DOE EV Site Operator Program. During the April–June quarter, the APS fleet was driven 18,720 miles. The seven newest vehicles in the APS fleet, which are all 1995 models, were driven a total of 9,374 miles (Table 4) during this reporting period. Because the below seven vehicles represent some of the most current commercially available technology, the maintenance requirements are described. No cost information is provided for these maintenance activities as some of work is under warranty. However, the "old" fleet vehicles maintenance costs to APS are noted in the second table below (Table 5).

Table 4. Availability and miles driven for the months of April–June. The seven vehicles, which are Arizona Public Service's newest EVs, are all 1995 models.

		Availability			Miles driven		
	Battery manufacturer	April (%)	May (%)	June (%)	April (miles)	May (miles)	June (miles)
Solectria E-10 APS #254	Hawker	97	100	97	436	1,106	923
Solectria E-10 APS #134	Hawker	100	100	80	306	268	641
Solectria E-10 APS #135	Hawker	100	100	87	539	447	554
Spartan S10 APS #136	GNB	100	100	100	90	111	106
US Electricar APS #137	Hawker	100	55	87	568	427	663
US Electricar APS #138	Hawker	100	90	100	198	221	433
US Electricar APS #139	Hawker	100	87	100	286	411	640

Because the maintenance requirements for the above seven vehicles were generally minor, the availability of these EVs to meet fleet requirements were fairly high. The "new" fleet maintenance requirements for the quarter are listed below by their APS vehicle numbers.

APS #133 Replacement of the power steering pump and trouble shooting for batteries.

APS #134 The chargers were replaced, 2 inch holes were drilled in the front battery box to increase ventilation, 12 battery pack modules were replaced due to a melt down, and a fast charge connector was installed.

APS #135 The chargers were replaced, 2 inch holes were drilled in the front battery box to increase ventilation, and a fast charge connector was installed.

APS #136 No maintenance required.

APS #137 Two battery modules were replaced, the battery box was ventilated, a fast charge connector was installed, induction charge ports were added, an Alt meter was installed, and the motor coupling bearings and housing were replaced.

APS #138 The battery box was ventilated, a fast charge connector was installed, the Alt meter was installed, and a Sander air conditioning unit was installed.

APS #139 The battery box was ventilated, inductor charger ports were added, and Alt meters were installed.

Table 5. Maintenance costs and miles driven for the months of April–June. The 15 vehicles are considered as members of Arizona Public Service's "old" EV fleet.

	Battery manufacturer	Labor man hrs	Labor cost	Part(s) cost	Total maintenance	Miles driven	Cost /mi
Unique sedan APS #100	GNB	14	$322	$1,184	$1,506	7	$8.61
Conceptor G-van APS #102	Trojan	19	$437	$960	$1,397	315	$4.43
Conceptor G-van APS #103	Sonnenschein	0	0	0	0	73	$0.00
Solectria Force APS #104	GNB	0	0	0	0	1,717	$0.00
DTS S10 APS #114	Trojan	16	$368	0	$368	1,371	$0.27
BMS S10 APS #115	Hawker	Vehicle incomplete	-	-	-	-	-
Chrysler TEVan APS #116	SAFT	0	0	0	0	684	$0.00
Unique sedan APS #298	GNB	0	0	0	0	0	-
Soleq EVcort APS #300	Sonnenschein	0	0	0	0	0	-

Soleq EVcort APS #301	Sonnenschein	0	0	0	0	0	-
Soleq EVcort APS #302	Sonnenschein	0	0	0	0	150	$0.00
Conceptor G-Van APS #3045	Trojan	0	0	0	0	466	$0.00
Solar Car sedan APS #105	GNB	0	0	0	0	293	$0.00
Conceptor G-Van APS #3051	Trojan	8	$184	$210	$394	1,150	$2.92
Specialty Vehicle (22 ft. bus)	Trojan	0	0	0	0	2,767	$0.00

Kansas State University

The Kansas State University (KSU) Site Operator Program is conducted at Manhattan, Kansas, in conjunction with the Kansas Electric Utilities Research Program (KEURP). The KEURP effort is a contractual joint venture of the seven major electric utilities that serve the residents of the State of Kansas; its mission is to undertake applied R & D to enhance reliability and minimize the cost of electric service in Kansas. Several industrial organizations within the state provide technical and financial support to the KSU Electric and Hybrid Vehicle demonstration program. The KSU Site Operator Program is currently based on two Soleq EVcort electric vehicles, maintained at the KSU campus and available for demonstration purposes on short-term loan to interested utilities and other companies. Further use is routine transportation by the Program and the Engineering Technology Department under ambient weather and driving conditions.

Technical

The EVcort, DOE number 151, was driven 816 miles during the April – June quarter (Table 6). Assuming a price of $0.056/kWh for electricity, and an equivalent 25 miles per gallon for an internal combustion engine 1993 Ford Escort, the cost of operating the EVcort on electricity equates to $0.87 per gallon of gasoline. The vehicle was transported to the Chicago Soleq facility ($1,500 cost to KSU) for warranty work on the regenerative braking, air conditioning, and preheat systems.

The second EVcort, DOE number 152, was driven 682 miles during the April – June quarter (Table 6). Assuming a price of $0.056/kWh for electricity, and an equivalent 25 miles per gallon for an internal combustion engine 1993 Ford Escort, the cost of operating the EVcort on electricity equates to $0.80 per gallon of gasoline.

Table 6. Operations summary for Kansas State University's two Soleq EVcorts.

	Miles	Daily Miles	Number of chargers	Miles per charge	kWh used	kWh/mi

EVcort # 151						
This quarter	816	19.4	42	19.4	447	0.55
Vehicle total	6,387	18.7	341	18.7	3,950	0.62
EVcort # 152						
This quarter	682	19.5	35	19.5	390	0.57
Vehicle total	3,750	17.3	216	17.3	2,507	0.67

Public Awareness

KSU provided a static display of an EVcort for the Kansas Seat Belt Association. The vehicle was used to help draw attention to a day long demonstration and display of the local rescue equipment currently in use. Included in the car's display was a presentation of special precautions to be taken during rescue and recovery of persons involved in accidents with alternative fuel vehicles. The purpose of this display was to inform the public that electric vehicles are a safe alternative to the vehicles currently in use.

An EVcort was displayed to the public in a local park during a state wide gathering of exotic and antique cars. A large percentage of the local population was able to view and ask questions about current and future alternative fuel transportation trends.

Los Angeles Department of Water and Power

The Los Angeles Department of Water and Power (LADWP) is a municipal utility serving the citizens of Los Angeles. LADWP marked its eighth year of involvement in aggressively promoting the electric transportation agenda of Los Angeles' overall air quality improvement program and as a means of improving the region's economic competitiveness through the creation of new industries. LADWP currently operates twenty electric vehicles (Figure 11).

Technical

U.S. Electricar S-10 Pickups

Tests performed on the five US Electricar S-10 pickups have determined that the vehicles have a range of 55 to 60 miles under average city/highway driving conditions. A complete charge from empty to full requires approximately 21 kWh of energy and takes about 7 hours. The vehicles have logged a total of 16,000 miles. Several issues were addressed with the trucks, and these include:

- Incompatibility between the trucks' ground fault circuit interrupter (GFCI) and the utility side GFCI continued to be a problem during the first, second, and third quarters of 1995. This incompatibility causes the GFCI on the 220 volt receptacle to trip while charging the vehicles. U.S. Electricar is working to resolve this problem.
- MDAS units were installed on three of the trucks.
- LADWP replaced most of the battery modules within one of the battery packs. Premature failure was attributed to the integrated charger under charging the battery.

- Due to sluggish performance at low speed, and poor gradeability, LADWP service technicians modified the drivetrains on two of the pickups by installing different transmissions. The 5-speed OEM transmission installed on one vehicle provides impressive results, while the new OEM automatic transmission installed on the other vehicle still requires some modifications.

Chrysler TEVans

The use of these vehicles has been very limited due to their very poor reliability. These vehicles continue to experience significant and repetitive problems that are design related. LADWP has received some fixes from the manufacturer, however, most of the problems are still present. Some of these problems include:

- The inability to charge the vehicle from a GFCI-equipped single phase outlet. These safety devices are required by the City of Los Angeles Building Code on all electric vehicle charging facilitates.
- The LADWP has repeatedly replaced motor controller units and auxiliary power units since the vehicles were delivered.

U.S. Electricar Sedans

Field testing showed these vehicles maintained a range of 50 to 55 miles under city/highway conditions. A full charge takes from 6 to 8 hours, and requires approximately 17 kWh of energy at the outlet. The vehicles have logged over 14,000 miles. Two of these units are equipped with MDAS units. Some of the problems and modifications that these vehicles incurred include:

- It was determined that the charging algorithm provided with the sedans is undercharging the batteries. As a result, one battery pack was damaged and subsequently replaced. LADWP, with input from the U.S. Electricar, modified the charging algorithm on one sedan.
- Low-rolling-resistance tires, manufactured by Michelin, were installed on all of the sedans.
- LADWP service technicians adjusted the state-of-charge gauge to increase accuracy.
- An air conditioning unit was installed on one unit. Prototype hoses for this unit created some problems and were subsequently changed.
- It was determined that the factory heating system was causing intermittent electrical faults. U.S. Electricar was notified of the problem and is working on a solution.

Other Electric Vehicles

Two of the G-vans continued in operation at the Los Angels International Airport and four in the LADWP's fleet. The Unique Mobility minivan was not operational.

Public Awareness

LADWP was involved in several public awareness activities, including:

- Co-coordinated introduction of a electric vehicle demonstration project with a downtown high-rise building and law firm.
- Co-coordinated the introduction of electric postal vehicles at the Harbor City Post Office.
- LADWP created an electric transportation exhibit and provided information on progress in the electric transportation arena to all of their customers via a newsletter that is included with monthly bills.

- Released results of the Los Angeles portion of the GM PrEView driver program, which received extensive coverage.
- Wrote and placed articles on the benefits of electric transportation in the publications of organizations like the Los

Angeles Chamber of Commerce and the Valley Industry and commerce Association.

Other Electric Vehicle Activities

LADWP is the manager of CALSTART's Infrastructure Program and also a participant in the Electric Bus/Mass Transit Program. CALSTART-oriented infrastructure efforts at LADWP include:

- Installation of public EV charging stations for opportunity charging.
- Revisions to building codes and standards to provide for charging facilities at home, the workplace and commercial establishments.
- Studies and recommendations to ensure that battery recycling is adequate.
- Creation and implementation of incentives, such as special electricity rates for the charging of EVs.

Orcas Power and Light Company

The Orcas Power and Light Company (OPALCO) of Eastsound, Washington, operates one Jet Ford Escort EV and one Solectria Force EV as part of its participation in the DOE Site Operator Program. This electric utility serves customers in the islands of San Juan County, WA. The OPALCO territory presents some unique driving conditions and operating problems not encountered by other Program participants.

OPALCO is actively encouraging EV ownership/operation by both public demonstrations and enlarging the necessary infrastructure with additional EV charging stations. San Juan County now has five public EV charge stations. There are a total of 13 EVs (11 private + 2 OPALCO EVs) operating in the county.

Technical

No submittal was received for this period.

Public Awareness

No submittal was received for this period.

Pacific Gas and Electric Company

Pacific Gas and Electric Company (PG&E), a public utility based in California's Bay Area, operates 18 electric vehicles as part of its participation in the Site Operator Program (Figure 12). The overall program effort relates to many broad areas of interest in addition to vehicle testing and performance evaluation:

- Infrastructure R&D is concerned with charging systems, and their load and distribution impacts.
- Joint efforts with the Bay Area Rapid Transit (BART) District reflect the benefits of increased usage of public transportation in the Bay Area.
- Collaboration with EPRI and the Electric Vehicle Association of the Americas is directed toward increased public awareness of EV technologies and benefits.
- Cooperative efforts with California universities and other utilities are studying demand-side load management.
- PG&E, other utilities, and EPRI are working to establish a test protocol for human exposure to electromagnetic fields.
- Jointly with two other utilities, PG&E has applied to the California Public Utilities Commission for approval of special EV billing rates.
- PG&E is actively involved in the California Electric Vehicle Task Force, concerned with issues affecting EV commercialization. Other Task Force members represent utilities, private industry, and state regulatory agencies.

- PG&E is also participating in the efforts of the Infrastructure Working Council, a subgroup of EPRI. The membership of this organization represents automakers, utilities, code specialists, and other EV stakeholders, with the goal of a standard, safe, and reliable EV charging infrastructure.
- PG&E is a member of CALSTART, a consortium of more than 40 public and private entities mobilized to create an electric transportation industry in California, and address related issues.

Technical

PG&E's five Ecostars report a consistent range of 90 to 100 miles and top speeds of 70 to 72 mph. All five have had modifications to the battery control logic modules, climate control logic modules, and the vehicle system controllers to prevent spontaneous fires. Ford also removed the charging cord reels due to retraction problems.

While the five Hondas have been only getting 35 to 40 miles per charge, they have demonstrated an excellent reliability record. The only reported problems have been a flat tire and a flashing sensor light that was due to a screw not being tighten after some tinkering. The Hondas have been used for marketing calls and short trips in San Rafael, Concord, San Francisco, and San Luis Obispo. At Honda's request, PG&E is returning two of the cars this fall; they will next be in use in a National Rental Car Demonstration with state employees.

The five US Electricar S-10s had been used for meter reading, parts pickup, and other missions, but fell into disfavor with PG&E drivers, who consider them unsafe to drive as the S-10s can not achieve speeds above 35 mph or a range above 22 miles. According to the acquisition contract, PG&E cannot modify the vehicles but must have US Electricar perform the upgrades, which is still pending.

The battery packs of the two G-Vans in San Luis Obispo have worn out and must be refurbished before the vans can be donated for Cal Poly University for the rapid battery interchange project. The other G-Van will remain at the San Ramon R&D Facility.

In a study performed with subcontractor Bevilacqua-Knight, PG&E estimated the cost of setting up and operating a public fast-charge station. To achieve a three-year payback, a six-charger station operating at 33% utilization (8 hours per day, open 24 hours) would have to charge consumers $0.31/kWh. Fast charging is estimated to cost about six times as much as at home charging, and twice as much per mile as filling up with gasoline.

Public Awareness

PG&E has established an informal user group comprising private and public organizations that own or want to own EVs. Group members include Bank of America; the cities of Alameda, Berkeley, Emergyville, San Francisco, South San Francisco, and Napa; the counties of Alameda, Contra Costa, and Santa Clara; UC Davis; the Federal GSA; and the Bay Area Air Quality Management District. This group meets every other month or so to discuss operating experience and lessons learned.

PG&E is participating with the Bay Area Air Quality Management District and other groups to demonstrate 40 "station cars," with will be leased to local business employees for driving to and from Bay Area Rapid Transit (BART) stations each day. Leasing costs are estimated to be in the $100 to $150 per month range, plus insurance. The maintenance and emergency road service are included in the fee. Battery charging can occur at the commuters home or at the three participating BART stations, where 120 V/240 V charging facilities are to be installed. A Norwegian manufacture, Personal Independent Vehicle Co., will supply forty vehicles in June of 1996.

PG&E is working with Yosemite National Park and its concessionaire, CALTRANS, the California Energy Commission, and Hughes Power Control Systems to demonstrate four or five electric shuttle buses in Yosemite Valley. The demonstration started this past September, with 31-foot, 32 passenger Specialty Vehicle bus, and a 35-foot APS Systems

bus. Both buses use Trojan quick-charge battery packs.

PG&E also continues its involvement with seven buses in the Berkeley, California, area, and with a hybrid electric bus project in California.

Other Electric Vehicle Activities

From October through March, 78 of PG&E's customers test-drove GM Impacts for two weeks each as participants in GM's PrEView program.

PG&E, in conjunction with other partners, is developing two new types of EVs, a Fleet Electric Vehicle (FEV) and a Narrow Lane Vehicle (NLV). The FEV looks like a small van, it will be able to haul moderate loads, and is targeted at in-town delivery fleets. The FEV will be displayed at auto shows during the coming year. The first FEV is being operationally checked out, and five more are being fabricated.

The NLV, based on its maximum with of 52 inches, is intended to ease congestion by operating side-by-side in conventional lanes. The design is a tandem configuration with the passenger located behind the driver in a cockpit-like shell. The first NLV is near completion and the second one is half-way completed. Road trails are scheduled for the first quarter of 1996.

Platte River Power Authority

The Platte River Power Authority (PRPA) operates two electric vehicles (Table 7) as part of its participation in the DOE Site Operator Program. PRPA, a political subdivision of the State of Colorado, maintains and operates facilities for generation and wholesale distribution of electrical energy to four Colorado municipalities: Estes Park, Fort Collins, Longmont, and Loveland. The thrust of PRPA activities under this program is threefold:

- Conduct electric vehicle tests, evaluations, and demonstrations.
- Investigate electric vehicle infrastructure issues.
- In conjunction with Colorado State University, develop EV infrastructure components.

The vehicles are operated in a real-world environment, for personnel transport and public demonstrations.

Table 7. Platte River Power Authority vehicle fleet description.

Vehicle	DOE No.	Battery Type	No. of Battery Modules	System Voltage	Charger Type	Charger Voltage
Soleq EVcort	355	Sonnenschein Lead Acid Gelled-electrolyte	18 (6 volt)	108	Soleq (onboard)	110
Soleq EVcort	356	Sonnenschein Lead Acid Gelled-electrolyte	18 (6 volt)	108	Soleq (onboard)	110

Technical

Both EVcorts are equipped with an onboard load profile meter that continually integrates the AC energy used for charging over every 15 minute time period, and the data is stored with its corresponding time interval. All vehicle charge data is automatically captured by the meter without any action by the vehicle user. The meter data is down loaded once a month by the City of Fort Collins when the other Platte River Facility meters are read. The meter data, along with monthly vehicle odometer data is complied and used to produce a Quarterly Operational Summary report (Table 8), a EV Performance and O&M Summary report (Table 9), and a Fuel Cost Comparison Summary report (Table 10).

During the April, May and June quarter, both vehicles were used as pool vehicles as well as commuter vehicles by Platte River employees. With the typical commuting distance for the majority of Platte River employees working at the Fort Collins facility being approximately 10 miles or less, the vehicles are able to be charged quickly enough to be utilized as both a pool and a commuter vehicle. Employees using the vehicles as a commuter vehicle quickly become comfortable with the vehicles and enjoy using then both as a commuter vehicle and as a second family vehicle.

The fuel cost for operating the EVcort is $0.014 per mile, as compared to the $0.043 per mile fuel cost for operating a 1991 Ford Escort wagon. The $0.014 value uses the city of Fort Collins small commercial electric energy rate of $0.027 per kilowatt-hour (Table 10).

Table 8. Monthly summary of the onboard meter and the odometer data for the Platte River EVs. (Note: the EVcort 356 was out of service from June 9 through the end of the month for battery cable repair and controller upgrades).

	Total Energy Usage (kWh)		**Miles Driven**		**Miles/kWh**	
	EVcort 355	EVcort 356	EVcort 355	EVcort 356	EVcort 355	EVcort 356
April	198.5	409.7	417	873	2.10	2.13
May	201.6	294.1	502	611	2.49	2.08
June	215.3	89.6	497	209	2.31	2.33
Total	615.4	793.3	1416	1693	2.30	2.13

Table 9. Platte River's EVcorts variable operation and maintenance costs. The data presented is for a full one-year period, including the third and fourth quarters of 1994, and the first and second quarters (January through June) of 1995.

(12 month reporting period)					Maintenance			
	Miles	AC Charge Energy (kWh)	Energy Efficiency (miles/kWh)	Total Energy Cost at $0.0269/kWh	Labor (hours)	Labor (@$28/hr)	Parts & Service	Variable Cost ($/mile)
EVcort #355	3,597	1,771	2.03	$47.64	2	$56	$0	$0.029
EVcort #356	3,494	1,868	1.87	$50.25	10	$280	$0	$0.095

Average	3,546	1,819	1.95	$48.94	6	$168	$0	$0.061

Table 10. Platte River electric vehicle versus gasoline fueled vehicle fuel cost comparison. (Notes: a. The numbers are 12 month rolling averages; b. Fuel cost for energy only assumes vehicle charging during off-peak period; c. Fuel cost with demand charge assumes vehicle charging over peak demand period).

	Gasoline ($/gal)	AC demand cost ($/kW)	AC energy cost ($/kWh)	Vehicle efficiency (miles/gal)	Veh. max demand (kW)	Vehicle efficiency (miles/kWh)	Fuel cost w/ demand charge ($/mile)	Fuel Cost energy only ($/mile)
Ford Escort	$1.20	–	–	28	–	–	$0.043	$0.043
Soleq EVcort	–	$8.01	$0.027	–	3.079	1.95	$0.221	$0.014

Potomac Electric Power Company

The Potomac Electric Power Company (PEPCO), serving over 1.6 million people in the Washington, DC area, operates five EVs in the Site Operator Program. The principal vehicle use is fleet service. With the exception of one county, the entire service region is classified as a serious, ozone non-attainment area, and PEPCO is considering whether to utilize electric vehicles to meet the requirements for fleet conversion to alternative fuels.

The objectives of the PEPCO EV program include the demonstration of EV technology to the Washington, D.C. community, the evaluation of EV components and systems to meet fleet driving requirements, to demonstrate PEPCO's commitment to supporting EV development and the Clean Air Act objectives, assist the utility industry to make informed EV purchase decisions, and to help establish a self-sustaining market for EVs which in turn results in higher EV reliability and lower per unit costs.

Technical

The Solectria Force was driven a total of 271 miles during the April to June quarter. Based on the vehicle's input energy use of 59.7 kWh, the energy consumption efficiency was 4.54 mi/kWh. The vehicle only required six hours of preventive maintenance during the quarter. All other vehicle work was in the form of cleaning and transportation for demonstrations.

Public Awareness

The Solectria Force was used for the following public awareness functions.

- Demonstrations at MetNet for Earth Day over several days
- Demonstration of the Force and presentation on PEPCO's EV program for the American Society of Mechanical Engineers

- Demonstration at the National Naval Medical Center for Earth Day
- Demonstrated at Landon School
- Demonstrated for the Regency House Seniors
- Demonstrated at Centro Espanol
- Demonstrated at the PEPCO Service Center, Martin Luther King Avenue.

Sandia National Laboratory

The Sandia National Laboratory operates 12 Electrias, manufactured by Jet Industries during the early 1980s. (This summary covers Sandia's operating experience for the 1995 fiscal year – October 1, 1994 to September 30, 1995). The 12 Electrias incurred total preventative maintenance and repair costs of $5,541, or an average of $462 per vehicle for the fiscal year. These costs are less than half of the 1994 costs; gained experience and Sandia's preventative maintenance program are helping reduce the cost of operating their fleet.

Unfortunately, the vehicles are experiencing component failures due to the age of the vehicles. An example of a component failure is the battery compartment exhaust fan disintegration, which in turn causes an unbalanced shaft which ruins the bearings on the 12 volt fan motor. Another age related problem is the inability to obtain air conditioning replacement parts; non of the five air conditioning vehicle units operate. In spite of any age related problems, the vehicles continue to provide fleet service. As of October 1, 1995, the 12 vehicles have accumulated 116,657 miles, with a total energy use of 93,533 kilowatt-hours. During the 1995 fiscal year, each of the vehicles was driven an average distance of 338 miles per year (Table 11).

Table 11. Sandia vehicle fleet performance for fiscal year 1995 (October 1, 1994 to September 30, 1995).

	October 1, 1995		Totals of FY 1995		
Vehicle No.	Odometer	kWh	Miles	kWh	kWh/mi
E-22410	10,839	8,583	248	298	1.20
E-22411	8,422	9,404	179	304	1.69
E-22412	11,095	11,156	139	229	1.64
E-22413	15,246	7,858	475	624	1.31
E-22414	10,637	10,660	672	667	0.99
E-22415	13,973	3,367	460	219	0.48
E-22416	6,337	5,272	175	221	1.26
E-27433	12,086	10,445	414	232	0.56

E-27434	8,259	7,442	195	147	0.76
E-27436	8,245	10,222	413	869	2.10
E-27440	9,495	9,601	423	739	1.75
E-27661	5,427	4,055	259	331	1.28
Total	116,657	93,533	4,050	4,880	-
Average	9,721	7,794	338	407	1.20

Southern California Edison Company

Southern California Edison Company (SCE), an electric utility, currently operates and maintains 50 electric vehicles as part of its participation in the DOE Site Operator Program (Figure 13). The SCE effort involves major roles in electric vehicle and component testing/evaluation, battery technology development, recharge infrastructure development, demand-side management, and overall technological leadership in meeting the air quality and transportation requirements of the area.

In filling the final role, SCE shares its technical expertise and test results with two California regulatory agencies: The South Coast Air Quality Management District and the California Air Resources Board. The results of this continuing cooperation can be seen in the electric shuttle operated by several Southern California cities and technical assistance in feasibility studies of truck and bus conversions.

SCE also provides support at many levels to the CALSTART program, which is intended to position California "high tech" industries in a leadership role as developers and suppliers of EV-related products. In the Site Operator Program, CALSTART's participation ranges from battery recycling processes and vehicle/infrastructure testing, to promoting public interest in zero-emission vehicles.

The Research, Development, and Demonstration Department of SCE has the primary responsibility for carrying out the tasks covered by the Site Operator Program. In turn, it has access to the necessary corporate resources and facilities/manpower.

Technical

While SCE continues to use several of the MDAS units for data collection, they have also implemented their own data acquisition system (DAS) in several SCE vehicles. The DAS consists of an "Alpha" kWh meter and a "Silent Witness" trip logger. The SEC DAS measures fleet operations performance metrics such as miles per vehicle, miles per AC kWh, miles per trip, and recharge time and time of use. To date, twelve SCE vehicles have been equipped with this DAS system and most of SCE's remaining vehicles will be so equipped. SCE also continues to use the factory supplied data system for the Ford Ecostars.

The SCE EV fleet has a combined total mileage of over 300,000 miles, and several of the EVs have accumulated over 15,000 miles each (Figure 14). The variety in monthly usage is high, but several vehicles report over 1,000 miles of use during the latest three month reporting period (Figure 15).

The SCE data collection system is scheduled to be implemented on 25 vehicles by year end, but as of report time it is still being implemented and the reporting results are limited. However, SCE does report that the energy efficiency for a U.S. Electricar during May and June was about 1.6 miles per AC kWh and the average trip was about 1.6 miles. Also during May and June the average recharge times for the U.S. Electricar S-10 and Sedan was over 18 hours each. SCE also reported various battery performance data (Table 12).

Table 12. Southern California Edison battery performance for select batteries as of 6/30/95.

Manufacturer	Model	Chemistry	Battery Type	In Service date	Total Cum Cycles as of 6/30/95	Total miles as of 6/30/95	Total module replacements to date
Hawker/Gates	G12v38ah	Lead acid	VRLA (AE)	8/93	163	3,023	6
Sonnenschein	6V160	Lead acid	VRLA-Gel	1/92	257	7,858	7
Saft	STM5-200	Nicad	Flooded	7/93	193	3,489	0
Sonnenschein	6V160	Lead acid	VRLA-Gel	5/93	87	1,313	0
Trojan	36CEB325	Lead acid	Flooded	12/94	67	3,007	0
Deka	8G27	Lead acid	VRLA-GEL	2/93	227	4,545	0
Deka	8G27	Lead acid	VRLA-GEL	3/93	209	4,172	0
Deka	8G27	Lead acid	VRLA-GEL	11/93	62	1,214	0
Deka	8G27	Lead acid	VRLA-GEL	11/93	149	3,218	0
GNB	Evolyte	Lead acid	VRLA-GEL	12/94	28	469	1
Hawker/Gates	G12V26AH	Lead acid	VRLA-GEL	2/95	45	1,127	0
Hawker/Gates	G12V26AH	Lead acid	VRLA (AE)	12/94	92	1,788	5
Hawker/Gates	G12V26AH	Lead acid	VRLA (AE)	12/94	108	2,154	0
Hawker/Gates	G12V26AH	Lead acid	VRLA (AE)	11/94	159	3,124	0
Hawker/Gates	G12V26AH	Lead acid	VRLA (AE)	1/95	115	2,284	0
Hawker/Gates	G12V26AH	Lead acid	VRLA (AE)	12/93	154	3,080	0
Hawker/Gates	G12V26AH	Lead acid	VRLA	12/94	120	2,406	0

Hawker/Gates	G12V26AH	Lead acid	(AE)	12/94	86	1,737	0
Hawker/Gates	G12V26AH	Lead acid	VRLA (AE)	12/94	77	1,534	0
ABB	30 kWh	Sodium Sul	VRLA (AE)	11/93	na	8,967	bat pk #3
ABB	30 kWh	Sodium Sul		2/94	na	6,879	bat pk #2
ABB	30 kWh	Sodium Sul	VRLA (AE)	3/94	na	6,801	bat pk #2
ABB	30 kWh	Sodium Sul	VRLA (AE)	3/94	na	7,010	bat pk #3
ABB	30 kWh	Sodium Sul		2/94	na	6,970	bat pk #2
ABB	30 kWh	Sodium Sul	VRLA (AE)	10/94	na	1,763	bat pk #2
ABB	30 kWh	Sodium Sul	VRLA (AE)	11/94	na	2,354	bat pk #2
ABB	30 kWh	Sodium Sul	High temp	11/94	na	1,450	bat pk #2
ABB	30 kWh	Sodium Sul	High temp	11/94	na	2,055	org bat pk
ABB	30 kWh	Sodium Sul	High temp	11/94	na	2,320	bat pk #3
ABB	30 kWh	Sodium Sul	High temp	5/94	na	2,930	bat pk #3
ABB	30 kWh	Sodium Sul	High temp	5/94	na	1,989	bat pk #3
Optima	800S	Lead acid	High temp	2/95	19	604	0
Eagle Picher	NIF-200-5	Nickel iron	High temp	7/94	32	901	0
Marathon	MAP120/36	Nicad	High temp	7/91	na	340	0
Optima	800S	Lead acid	High temp	12/94	58	1,127	0
Hawker/Gates	G12V38ah	Lead acid	High temp	12/93	120	2,400	3
Trojan	T105	Lead acid	High temp	7/92	140	2,801	0
			High temp				
			VRLA (AE)				
			Flooded				

			Flooded VRLA (AE) VRLA (AE) Flooded				

Public Awareness

SCE continues to promote EV awareness on a semi-monthly basis through public forums such city council meetings, Rotary clubs, senior groups, and other civic groups. Support is usually in the form of providing an EV for inspection and answering questions. SCE has two full time staffers dedicated to their public awareness program.

Texas A&M University

Texas A&M University (TAMU) conducts their Site Operator Program at its Center for Electrochemical Systems and Hydrogen Research, Texas Engineering Experiment Station, College Station, Texas. The Center also conducts research in the areas of advanced batteries and hydrogen as alternate fuel. The ultimate thrust of the Program is education (i.e., graduate school support). The current complement of electric vehicles comprises 30 electric vehicles (Figure 16) and two zinc-bromine race cars. The vehicles are in regular local fleet use except for two G-Vans that are used as demos in Houston (by EPRI) and Austin (by Lower Colorado River Authority). The South Central Electric Vehicle Consortium (SCEVC), based at TAMU, supports the TAMU Electric Vehicle Program and also brings together EV fleet owners and operators throughout Texas and Oklahoma.

Technical

One of the US Electricar S-10s, DOE vehicle #627, required 15 to 24 hours for a recharge and it experienced a slight floating charge on the truck body when charged with the on-board charger. The Ground Fault Interrupter (GFI), on the Dolphin controller in the vehicle, did not interface well with the main GFI, and the main GFI in the system was disconnected. The dolphin controller/inverter in the vehicle had a charging malfunction when the inductive charger paddle was reinserted in the charger port at the time when the battery was close to full charge. EV Power, Inc. of Dallas, the distributor for the Hughes controller, promptly replaced the Dolphin controller and reprogrammed the charging algorithms. Since then, this vehicle has performed satisfactory. It can easily maintain a speed of 55 to 65 mph on the highway and cover a range of approximately 60 miles per charge at an average speed of 55 mph. Since the installation of the inductive charger the range has improved and the best range noted on this vehicle is 62 miles on a single charge at 55 mph. An air-conditioner will be installed on this vehicle in the near future.

Another of the US Electric S-10s, DOE vehicle #628, covered a distance of 748 miles for the reporting period. The average energy use was less than 0.5 kWh per mile, but after installing the air-conditioner on this vehicle in early June, the fuel consumption has increased to 0.6 kWh per mile. This vehicle also experienced a charging failure while using the inductive charger due to the failure of the 300 amp solid state fuse in the battery box, which was probably caused by some solder residue on the high voltage connectors which did not have the shrink tubing. The vehicle also failed during a highway test run at 60 mph. The failure was due to a faulty motor encoder, which was replaced. The encoder fault reoccurred once again the following month, and the encoder had to be replaced a second time. Since the second replacement, the vehicle has performed satisfactorily. During the process of installing the air-conditioner, the heater-box had to be removed, and the system experienced a burnt heater element. The reason for this problem was that the heater pump was wired with reverse

polarity; it was thus unable to purge all the air from the system and caused an air pocket burn in the heater element. The polarity of this pump was corrected.

Some of the problems reveled by the field tests of the three US Electricar S-10s are due to poor quality control of the vehicle converted, and others are simply due to equipment failure. The problems are diagnosed, corrective actions are taken, and US Electricar is informed accordingly. The suppliers are prompt in delivery of parts covered by the warranties. The field test results on the one vehicle equipped with an air-conditioning system show that when using the air-conditioning, energy consumption is increased by about 20%.

Public Awareness

On April 22, the Center took part in the Earth Day celebrations in the Woodlands near Houston. One G-Van, one S-10, and the solar car built by the Texas A&M electrical engineering students were displayed. The fair was attended by more than 500 people, and DOE support was highlighted.

The South Central Electric Vehicle Consortium (SCEVC) participated in the Texas Alternate Fuel Symposium in Austin, Texas, May 1 through the third. The S-10 and the DAX Industries electric Porsche were displayed. Approximately 2,500 people attended this show.

During the period May 5 through May 13, the SCEVC took part in the Houston Annual Auto Show. The DAX Industries electric Porsche was displayed. It was the only electric powered car in the show. The attendance for this auto show exceeds one million people.

U.S. Navy

As seen in the below figure (Figure 17), the U.S. Navy has 59 electric vehicles, representing several manufacturers and body styles, and a broad span of vehicle ages. The 59 EVs are located at eight different Navy facilities (Figure 18). The principal thrust of this Navy operation is fleet evaluation. The current age span of their EV inventory contributes substantially to a vehicle experience (rather than test) data summary.

The University of South Florida (USF) at Tampa, monitors and tests 12 electric vehicles as a participant in the DOE Site Operator Program (Figure 19). The principal collaborating organizations are Florida Power Corp. (FPC), Tampa Electric Col, Hillsborough County, and the City of Tampa. The purpose of the USF effort is to determine EV efficiency under commuter and fleet conditions in Florida. A part of the effort is the testing of a utility-interconnected photovoltaic 12 bay EV parking/charging system. Additional associations include Florida Power and Light Co., Florida Energy Office, Naval Weapons Center, GTE Mobilnet, and the National Renewable Energy Laboratory.

Technical

Mobile Data Acquisition System

The Mobile Data Acquisition System (MDAS) pulls a small amount of current when it is not collecting data. The current can be from 25 mA to 50 mA from the 12 V system (which equals approximately 1 mA from the 120 V main battery pack). This can put a drain on the 12 V auxiliary battery if the vehicle is not used regularly. Every time the vehicle is turned on the 12 V auxiliary battery is charged either from the main battery pack or by an alternator. The amount of current pulled by the MDAS when the unit is not collecting data can run down the 12 V auxiliary battery if the vehicle is not used for 2 weeks. The leakage current on the main battery pack can be as large as 100 mA. The MDAS uses 1 mA of current from the main battery pack, when not collecting data. The leakage is small, about 1%, compared to the main battery pack's leakage current. It is recommended that if the vehicle is not used or charged for over 2 weeks, the MDAS should be unplugged so as not to

run down the 12 V auxiliary battery.

Air Conditioning Energy Use

Figure 20 shows the total percentage of energy consumed by the air conditioning for 19 separate G-Van trips, each of a different length. It should be noted that all results reported for this test were obtained under city driving conditions. The fluctuations in the height of the bars in the graph are due to a combination of variations in city driving conditions, ambient temperature and individual driving habits. Despite these variations, Figure 20 shows a definite trend towards an average of near 15% for the amount of energy consumed by the air conditioning. For short trips (five minutes or shorter), a high percentage of energy is consumed by the air conditioning; the air conditioning does not cycle for the first five minutes of driving and therefore the air conditioning uses a larger portion of the total energy. For moderate to long

trips (ten minutes or longer), the temperature within the cab decreases, the air conditioning begins cycling, and the percentage of energy consumed by the air conditioning decreases. The other contributing factor to the reduction in the percentage of energy use by the air conditioning during moderate to long trips is the vehicle's main motor is pulling more power because it is now off campus and driving in traffic. The effect of the main motor drawing more power is to reduce the percentage drawn by the air conditioning.

The air conditioning G-Van test results suggest that a major factor in determining the impact of the air conditioning on the range of the vehicle is the amount of time the vehicle is idle during a trip. For two trips of equal length in time (27.5 minutes) but different numbers of miles covered (12.5 and 9.4 miles), it was found that the percentage of energy used by the air conditioning was 9.7% and 12.8% respectively. Cumulative results which were derived from air conditioning data collected during the second quarter of 1995 shows that the percentage of the G-Van's total energy consumed by the air conditioning during all trips was 4.15%. This value was calculated using the vehicle's discharger energy as measured by the on board MDAS and is therefore independent of the battery pack efficiency. When using only the energy discharged while the air conditioning was in use, it was found that the percentage of energy consumed by the air conditioning for the entire quarter was 14.54% (Table 13).

Table 13. Quarterly G-Van air conditioning test data. Row one is the total amount of energy discharged while the air conditioning was turned on. Row two is the total energy consumed by the air conditioning. Row three is the percentage of the total discharge energy that the air conditioning consumed, or row two divided by row one. The average temperatures were obtained from the National Weather Service.

	April	May	June	Totals
Vehicle discharge energy (kWh) (while A/C in use)	18.576	72.465	5.566	96.607
Total energy consumed by A/C (kWh)	2.704	10.488	0.862	14.054
Percentage of vehicle discharge energy consumed by A/C *(while A/C in use)*	15.44%	14.47%	15.49%	14.54%
Average ambient temperature (·F)	73.5	81.7	80.2	78.4

Photovoltaic Solar Power Charging Station

During the April, May, and June quarter, the twelve-vehicle photovoltaic (PV) solar power charging station generated 6,560 kWh of energy, of this 1,745 kWh (27%) was used for charging EVs. The remaining 73% of the excess PV energy was

supplied to the energy grid. During the previous quarter, 41% of the PV energy was used to charge EVs, and during the last quarter of 1994, 91% of the PV energy was used to charge EVs. Because of limited EV driving during the most recent quarter, several EVs were not charged and this is reflected by the high percentage of PV energy supplied to the grid.

Other Activities

General trip summaries and charging summaries are available in Table 14. Some of the more specific vehicle activities include:

- For DOE vehicle #653 (Solar Car Corporation (SCC) S-10) the DC/DC converter was replaced and the battery pack was replaced with gel batteries. A charger salvaged from a Solectria pickup was returned to the manufacturer for reprogramming and was then reinstalled in this vehicle.
- For DOE vehicle #658 (SCC S-10), the MDAS unit was replaced. The unit shorted out after rain water was allowed into the unit. The batteries removed from vehicle #653 were transferred to this vehicle.
- The drive motor failed and was rebuilt in DOE vehicle #654 (Mitsubishi Mirage).
- The auxiliary batteries were replaced in vehicle numbers 653, 658 and 654.
- A total of 31 labor hours were devoted these activities.

Table 14. Vehicle performance results for five of the University of South Florida's EVs. The SCC-10 vehicles are Chevrolet S10 pickups that the Solar Car Corporation converted to EVs.

Quarterly Trip Summary					
	SCC S-10 DOE# 652	**G-Van DOE# 650**	**Mitsubishi Mirage DOE# 654**	**SCC S-10 DOE# 658**	**SCC S-10 DOE# 657**
# of days in use (days)	31	46	23	5	23
Total # of trips	95	211	75	25	104
Total trip time (hours)	13.5	32.0	12.7	5.1	10.7
Total time at rest (hours)	4.1	10.8	2.9	1.3	4.4
Total distance (miles)	273.1	566.0	267.3	118.4	141.4
Average speed (mph)	23.4	21.9	25.2	27.9	13.8
Max. battery temp. (·C)	40.0	44.0	45.6	42.2	37.5
Avg. battery temp. (·C)	33.2	34.2	37.3	38.4	22.6
Total A/C energy (kWh)	n/a	14.1	n/a	n/a	n/a

total discharge energy (kWh)	87.6	338.0	73.6	34.7	51.2
Net DC energy eff.	3.1	1.7	3.6	3.4	2.8
Quarterly Charger Summary					
	SCC S-10 DOE# 652	**G-Van DOE# 650**	**Mitsubishi Mirage DOE# 654**	**SCC S-10 DOE# 658**	**SCC S-10 DOE# 657**
Total # of charges	33	30	15	4	24
Total charge time (hours)	164.3	140.5	64.7	19.7	77.5
Max charge current (A)	33.8	37.5	26.5	27.0	13.9
Ave. charge current (A)	7.6	23.7	11.0	20.3	3.9
Max. battery temp. (·C)	41.2	39.1	36.4	38.4	36.1
Avg. battery temp. (·C)	30.3	29.3	28.0	33.9	25.6
Total charge energy (kWh)	170.4	873.6	103.8	51.9	78.2
Gross DC energy eff. (mile/kWh)	1.6	0.7	2.6	2.3	1.8
Battery pack eff. (%)	51.4	38.7	70.9	66.9	65.5

Public Awareness

A SCC S-10 pickup was used for the Polk County Earth Day festivities and local junior high school students were given a tour of the USF EV and photovoltaics facilities and equipment.

York Technical College

Located at Rock Hill, South Carolina, York Technical College operates 11 EVs under the Site Operator Program (Figure 21). Interest in EV technology at York Tech goes beyond the nominal Program scope and is well demonstrated by the school's growing Electric Vehicle Program and emphasis on public awareness. Programmatic associations and interchanges continue with local electric utilities, other Program participants, municipalities, South Carolina State Energy Office, regional secondary schools and colleges, and the Clean Air Transport Association.

Technical

A range test was performed on the U.S. Electricar S-10, and the range results equal 67 miles, with 22 kWh of energy used. The driving scenario was 70% interstate travel and 30% urban travel.

Public Awareness

York Tech's public awareness activities included the below events.

- Performed safety inspections on electric vehicles which were converted by area high schools for the Electra Challenge at the Charlotte Motor Speedway.
- Displayed EVs and provided EVs for the ride and drive event at the York Technical Annual TechFest.
- EV staff participated as judges and inspectors in Electra Challenge events at Charlotte Motor Speedway.

- Participated in Earth Day events at Science Nature Museum.
- Conducted EV exhibits for "Clean and Green" celebrations.
- Participated in the City of Rock Hill's "Open House" with EV displays and exhibits.
- Conducted EV exhibition and display for girl scout troops.
- Hosted a meeting for South Eastern Electric Vehicle Association with 27 attendants.
- Conducted electric vehicle exhibits for home realtors meeting in Spartanburg, South Carolina.
- Demonstrated an S-10 and presented the EV story to 450 students at Belmont, North Carolina, Junior High School.
- Meet with Industrial Electrical Equipment class to discuss EV safety.

Other Electric Vehicle Activities

York Tech performs maintenance and other activities for EVs that are not directly part of their fleet. Some of this activities include preparation of a Volkswagen pickup in the Palmetto Electric Co-op fleet for the conversion process; installation of MDAS units on a Duke Power Company S-10 pickup and a Geo Metro; performed scheduled maintenance on a Charlotte City EV Prizm; performed a battery capacity test on a City of Charlotte EV; performed a range test on a City of Charlotte EV; and, installed a new battery, motor, and controller in a Ford Escort Sedan intended for fleet use.