INEL-96/0080-Qtr 1

Electric and Hybrid Vehicle Program

Site Operator Program

Quarterly Progress Report for October through December 1995 (First Quarter of Fiscal Year 1996)

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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 the site operators totals about 250 vehicles. The individual fleets are summarized in Table ES-2.

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 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 EVs, 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		US Electricar								
	S-10	Force	Sedan	S-10	G-Van	Ecostar	TEVan	Honda	EVcort	Others*	Total
APS	3	1	-	3	4	-	1	-	3	6	21
KSU	-	-	-	-	-	-	-	-	2	-	2
LADWP	-	-	4	4	6	-	4	-	-	1	19
Orcas	-	1	-	-	-	-	-	-	1	-	2
PG&E	-	-	-	5	3	5	-	5	-	-	18
PRPA	-	-	-	-	-	-	-	-	2	-	2
PEPCO	3	1	-	-	1	-	-	-	-	-	5
Sandia	-	-	-	-	-	-	-	-	-	12	12
SCE	1	5	10	10	14	12	2	3	-	3	60
Texas	-	1	-	3	15	-	9	-	-	2	30
Navy	13	-	-	-	7	-	-	-	-	39	59
USF	-	-	-	-	2	-	-	-	-	10	12
York	-	1	-	1	1	-	-	-	-	8	11
TOTALS	20	10	14	26	53	17	16	8	8	81	253

* 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.

J.E. Francfort

Contents

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, meteorological, 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 details the types of 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 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. The reader may also note the addition of a new section to the Quarterly Report. For this Quarterly Report, a discussion is included about the Energy Economics of EVs in comparison to internal combustion vehicles. Hopefully, each of the future Quarterly Reports will contain a section that discusses relevant EV issues.

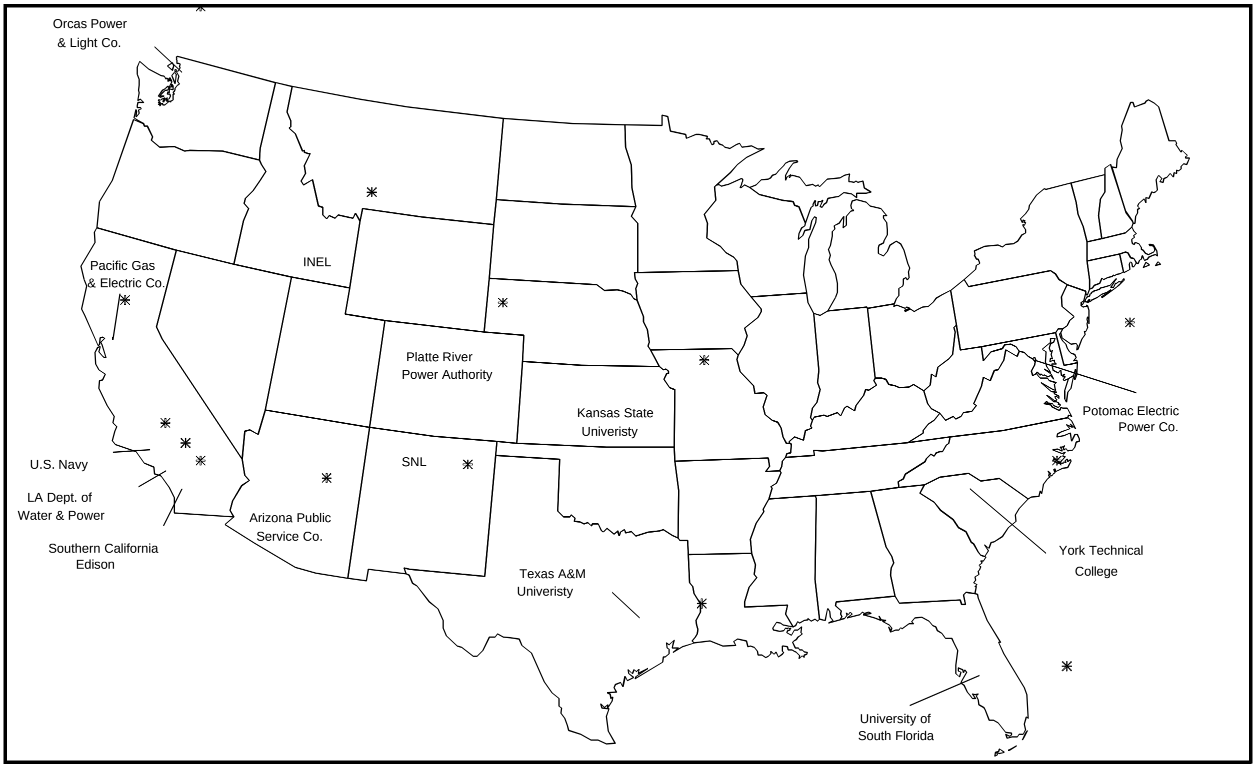

Figure 1. Site Operator Program participant locations.

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.
Brawner Motorsport S10	1 ea.
US Electricar S-10	3 ea.
TOTAL	21

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.
TOTAL	2

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.

Table 1. (continued)

Southern California Edison Company

Conceptor G-Van	14 ea.
Solectria Force	5 ea.
Ford Ecostar	12 ea.
Solectria S-10	1 ea.
US Electricar S-10	10 ea.
BAT Metro sedan	1 ea.
US Electricar sedan	10 ea.
Chrysler TEVan	2 ea.
Honda CUV-4 sedan	3 ea.
Ford Ranger	1 ea.
Venus Ranger	1 ea.
TOTAL	60

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 ea.
Solectria	13 ea.
Conceptor G-Vans	7 ea.
Taylor Dunn	1 ea.
Manufacturer not known	5 ea.
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 ***253***

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 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.

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.

The Site Operator Activities 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.

*E*lectric **V**ehicle *T*esting **R**esults

The DOE 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.

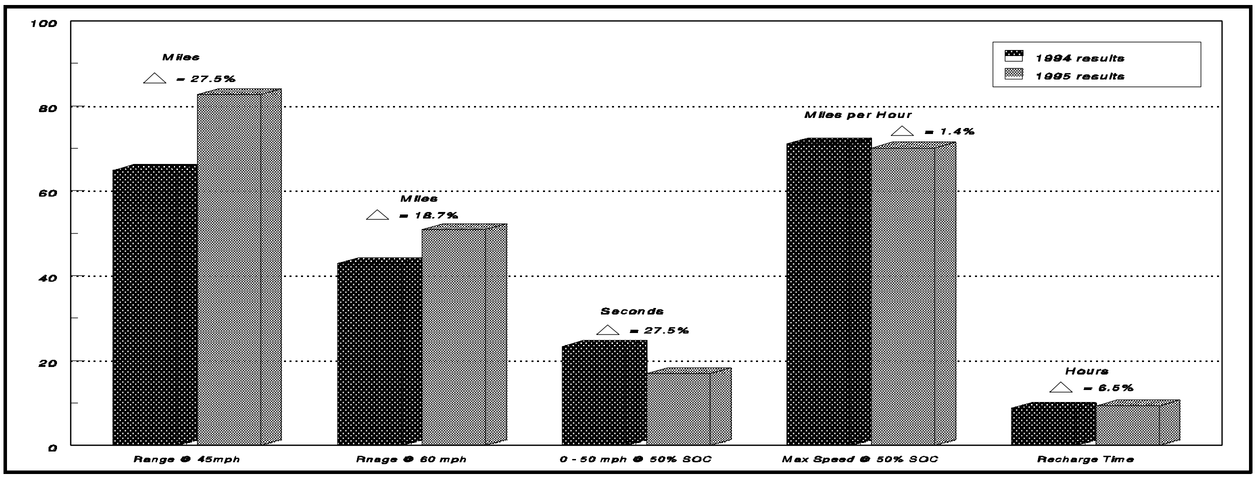

Figure 2. Site Operator Program and EV America performance testing trends for 1995 and 1994 tested electric vehicles. The average test results for each group of vehicles are plotted, and the listed variances are the deltas between the group averages for each test.

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).

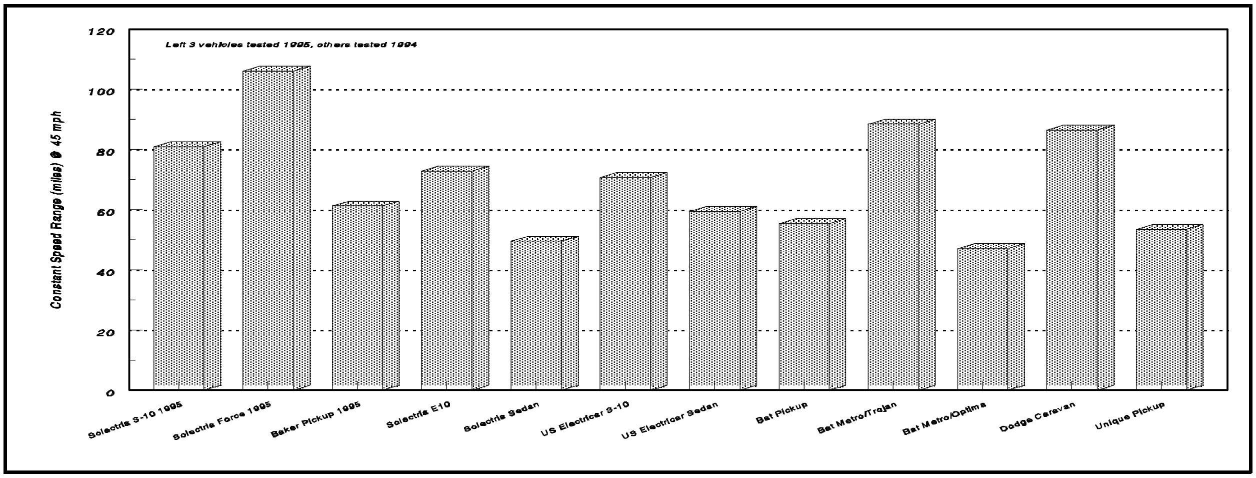

Figure 3. Range (miles) results for constant speed tests at 45 mph.

The average range (50.8 miles) 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 miles). Within the 1995 test group, the maximum individual vehicle range at 60 mph was 71 miles, while the 1994 individual vehicle maximum range at 60 mph was 57 miles (Figure 4).

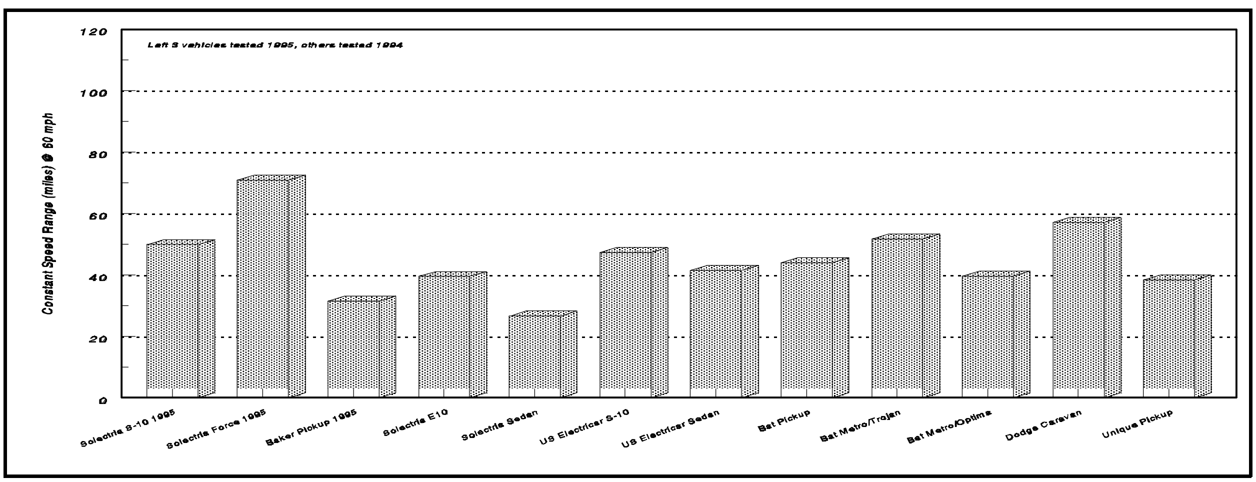

Figure 4. Range (miles) results for constant speed tests at 60 mph.

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).

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
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
Vehicles tested during 1994							
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
US Electricar Pickup (Chevrolet S-10 Pickup)	70.7	47.3	20.1	71	Hawker Energy	Sealed lead acid	15.40
US 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

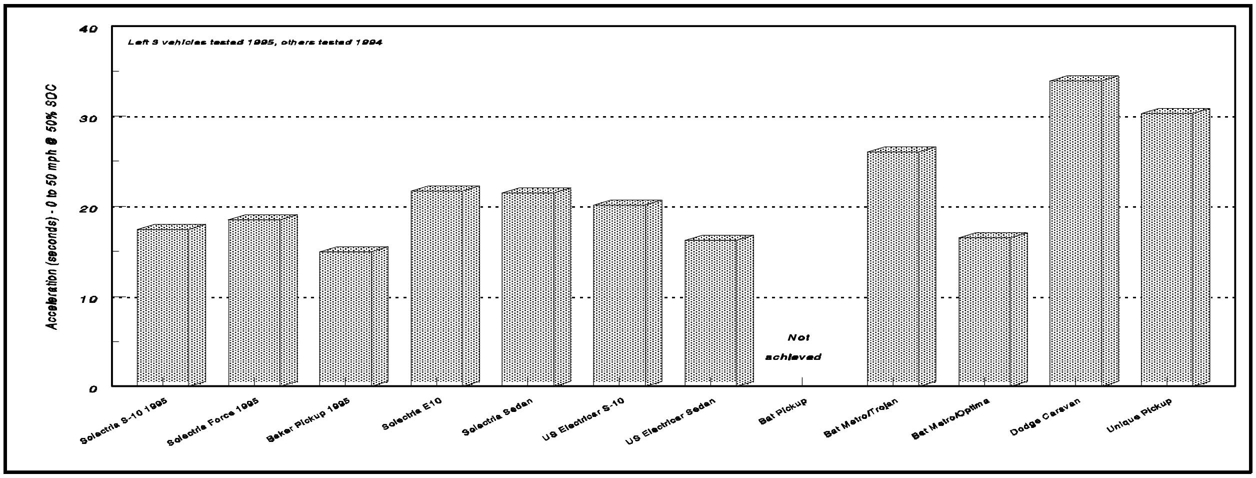

Figure 5. Acceleration (seconds) test results for zero to 50 mph acceleration at 50% state of charge.

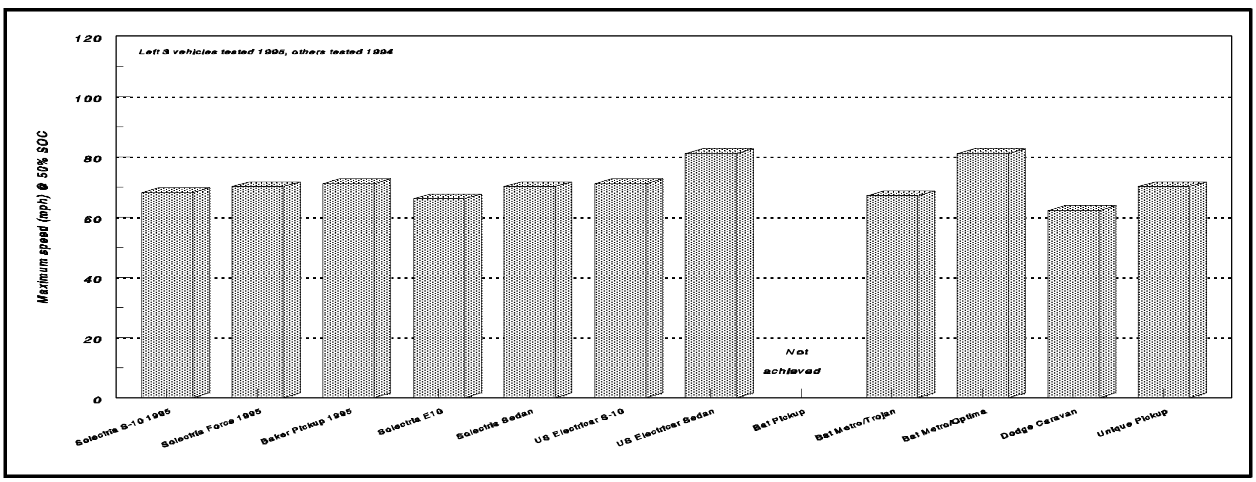

Figure 6. Maximum speed (mph) achieved by each vehicle when tested at 50% state-of-charge.

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 context 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 results. 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.

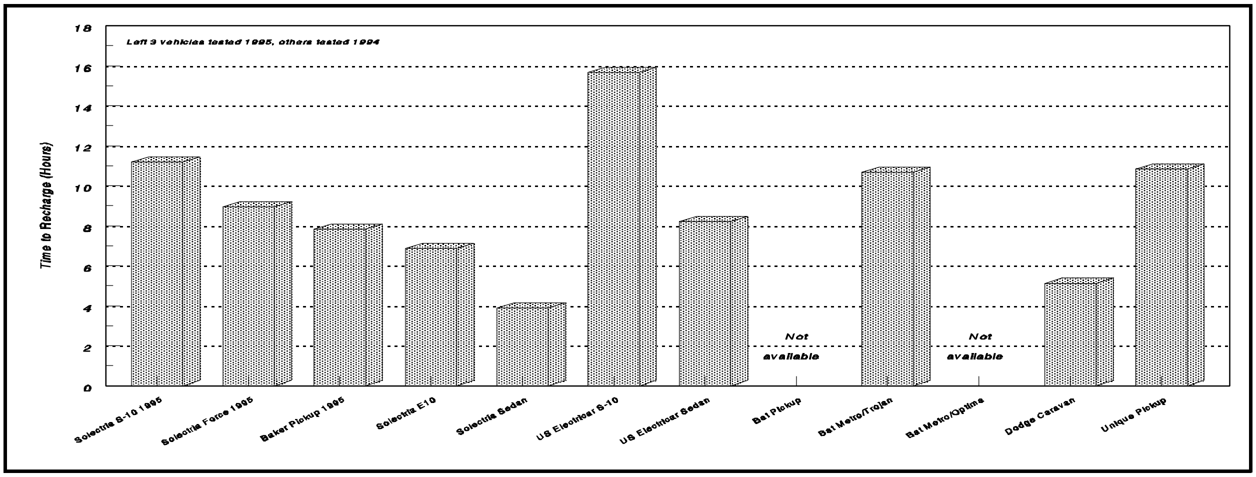

Figure 7. Time (in hours) to recharge a battery pack.

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 253 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 July, August and September period, unless otherwise noted.

The reader may notice that the sections describing the Site Operator activities at the Los Angeles Department of Water and Power, and at the Pacific Gas and Electric Company are repeated from the last Quarterly report, since these Site Operators provided a single report for both quarters. Also, testing results for the DOE/EV America test program are repeated a second and final time in this report for any readers that may have missed the report published in December 1995.

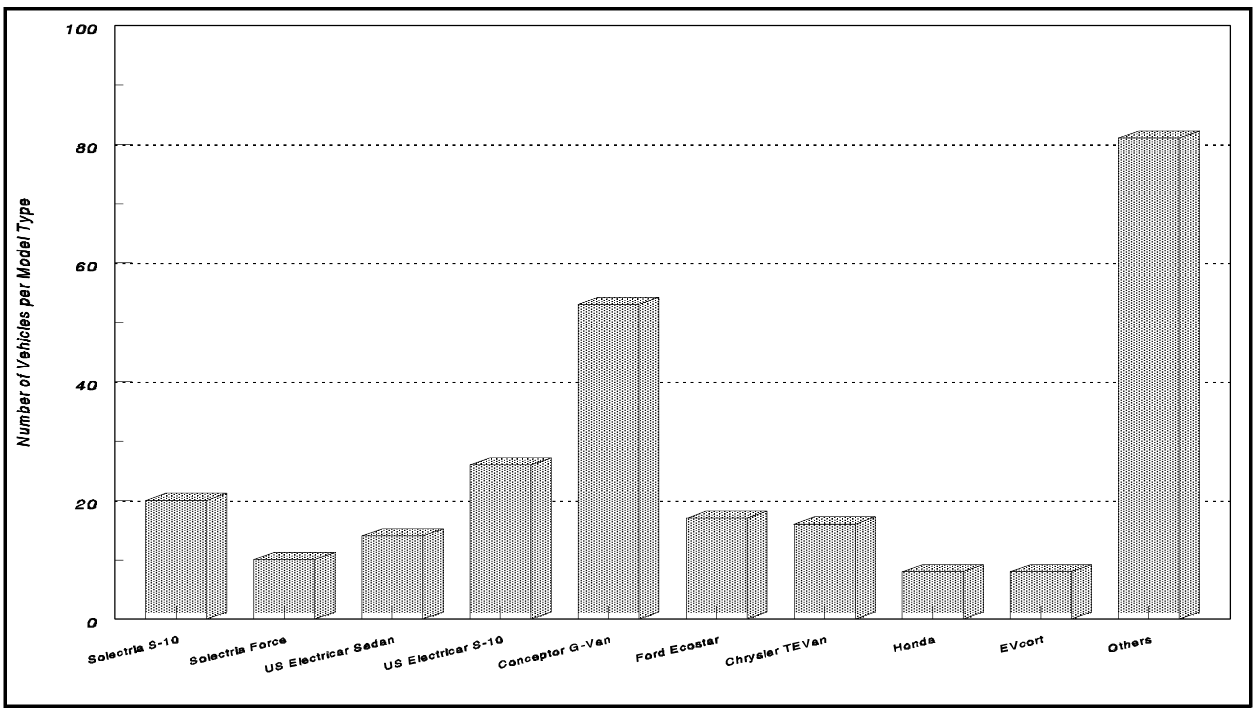

Figure 8. Number of vehicles in each of the SOP participants' EV fleets.

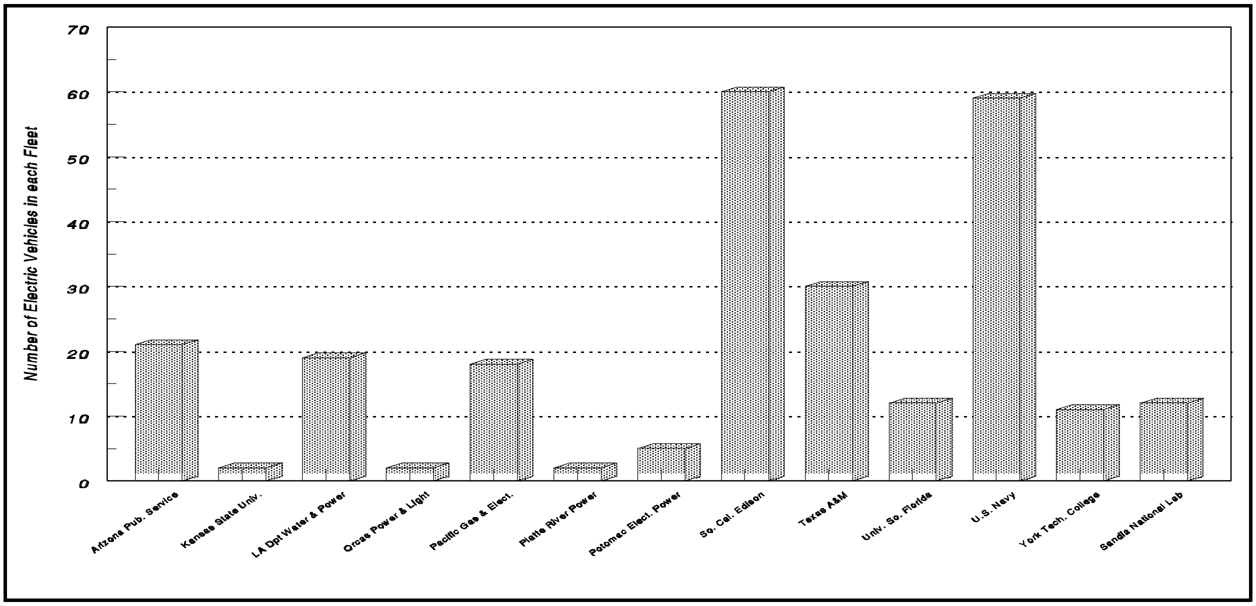

Figure 9. Number of vehicles by model/manufacturer/converter. The "others" category includes various vehicle models, manufacturers, and converters, including: BAT Metro and Ranger; Specialty; Demi TVan; Ford Ranger; Venus Ranger; Griffin; Solar Car' Spartan; Unique; Soleq; Bear Skin; Jet; Volkswagen; Mitsubishi; utility company conversions, and others.

Arizona Public Service Company

Arizona Public Service (APS) maintains and operates 21 electric vehicles of various types (Figure 10) in its EV Program. One of APS's G-Vans is operated by the City of Phoenix and another is operated by the City of Scottsdale. The remaining 19 APS EVs are operated by APS 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. Technical information is also coordinated with Southern California Edison, and the Electric Power Research Institute (EPRI).

Technical

Since 1979, APS has logged over 617,000 miles on their EVs as part of the Site Operator Program. During the July–September quarter, the APS fleet was driven 14,185 miles. Because the below seven vehicles (Table 4) 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 the work is under warranty. However, the "old" fleet vehicles maintenance costs to APS are noted in the second table below (Table 5).

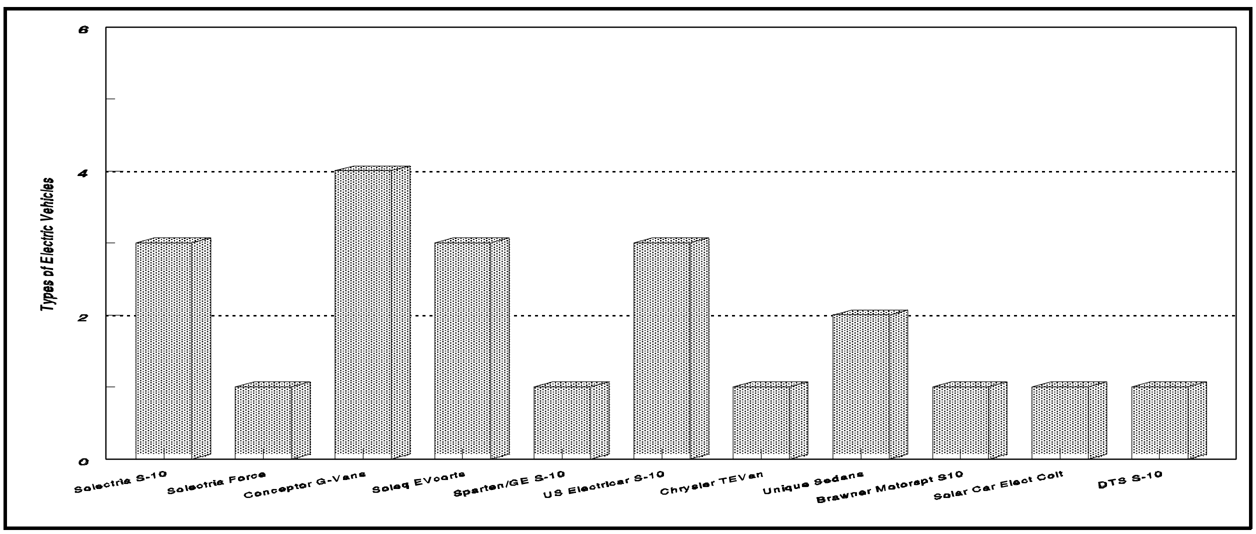

Figure 10. Number and types of vehicles in the Arizona Public Service electric vehicle fleet.

Table 4. Availability and miles driven for the months of July, August, and September. The seven vehicles, which are Arizona Public Service's newest EVs, are all 1995 models. (n.a. indicates the information was not available.)

	Battery	Pack miles	Availability July (%)	Availability Aug. (%)	Availability Sept. (%)	Miles driven July (miles)	Miles driven Aug. (miles)	Miles driven Sept. (miles)
Solectria E-10 APS #133	Hawker	7,492	100	35	100	568	201	397
Solectria E-10 APS #134	Hawker	3,481	84	87	97	na	628	na
Solectria E-10 APS #135	Hawker	2,951	100	100	100	na	391	185
Spartan S10 APS #136	GNB	0	100	100	47	72	189	27
US Electricar APS #137	Hawker	8,503	77	100	100	1452	1,782	1,735
US Electricar APS #138	Hawker	3,136	87	77	100	710	705	305
US Electricar APS #139	Hawker	2,801	100	100	100	517	504	61

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 time required, and the types of fleet maintenance and upgrade requirements performed on these "new" vehicles during the reporting period are listed below by their APS vehicle numbers.

APS #133 Out of service for EV America testing during half of September, and for 16 days during August for an unspecified vehicle upgrade. 133 also required a front end alignment, and the leaking rear axle seals were replaced.

APS #134 Vehicle upgrade for 4 days during August.

APS #135 No requirements.

APS #136 Seventeen days for vehicle upgrade during September and one day in August.

APS #137 Seven days for vehicle upgrade and two days for range tests during July.

APS #138 Twelve days for vehicle upgrades during the quarter.

APS #139 Twenty-seven days for vehicle upgrades during September.

Table 5. Maintenance costs and miles driven for the months of July, August and September. The 14 vehicles are considered as members of Arizona Public Service's "old" EV fleet. Vehicle 301's miles were accumulated while being tested at the INEL. Vehicle 105's cost was for front end repairs at a body shop.

	Battery manufacturer	Labor man hrs	Labor cost	Part(s) cost	Total cost	Miles driven	Cost /mile
Unique sedan APS #100	GNB	0	0	0	0	0	$0.00
Conceptor G-van APS #102	Trojan	2	$46	0	$46	398	$0.12
Conceptor G-van APS #103	Sonnenschein	0	0	0	0	191	$0.00
Solectria Force APS #104	GNB	0	0	0	0	0	$0.00
DTS S10 APS #114	Trojan	8	$184	$40	$224	320	$1.07
BMS S10 APS #115	Hawker	Vehicle incomplete			-	-	-
Chrysler TEVan APS #116	SAFT	0	0	0	0	633	$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	1,849	$0.00
Soleq EVcort APS #302	Sonnenschein	0	0	0	0	20	$0.00
Conceptor G-Van APS #3045	Trojan	0	0	0	0	104	$0.00
Solar Car sedan APS #105	GNB	0	0	$800	0	2	$400.00
Conceptor G-Van APS #3051	Trojan	10	$230	$832	$1,062	149	$7.13
Totals					$1,332	3,556	$0.37

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. the Engineering Technology Department, under ambient weather and driving conditions.

The Troy Design and Manufacturing company (TDM), with assistance from KSU, has started construction of a plant to convert Ford Ranger (pickups) gliders into electric vehicles and other alternate fuel vehicles in Manhattan, Kansas. Kansas State University has entered into an agreement to assist TDM in supporting the infrastructure and technical development for these vehicles.

Technical

The EVcort, DOE number 151, was driven 888 miles during the July – September 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 $0.85 per gallon of gasoline.

EVcort 151 experienced a total loss of power when the 400 ampere fuse in the front battery tray failed. Since this fuse completes the series connection for all eighteen batteries, operation of the car was impossible. It should be noted that the ampere meter located in the console regularly displays current readings of more than 450 amperes and sometimes even 500 amperes during full acceleration. These repeated conditions would cause the fuse to be subjected to currents beyond normal average ratings and could exceed peak ratings at certain points in time. Soleq, the manufacturer, was notified of the problem and two actions are possible: (a) adjust the vehicle's motor controller to ensure future average currents would be limited to less than 400 amperes or (b) increase the rating of the fuse. Since this vehicle has been driven over 7,000 miles with little or no limitations, it is now planned to replace the fuse with the same rated fuse and observe the conditions. This vehicle also had its two front tires replaced during this quarter. The existing "stock" tires had their steel belts showing when they were replaced. The Goodyear tires installed have an increased load rating and have already demonstrated better performance than the stock tires.

The second EVcort, DOE number 152, was driven 403 miles during the July – September 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 $0.91 per gallon of gasoline. This vehicle was operated without incident during this quarter.

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

	Miles	Daily Miles	Number of charges	Miles per charge	kWh used	kWh/mi
EVcort # 151						
This quarter	888	11.1	80	11.1	479	0.54
Vehicle total	7,275	18	421	18	4,429	0.61
EVcort # 152						
This quarter	403	6.1	66	6.1	189	0.47
Vehicle total	4,152	15.7	282	15.7	2,735	0.65

Public Awareness

Kansas City Power and Light, assisted by two KSU students, provided a KSU Soleq EVcort for display at the Missouri State Fair. This display occurred in conjunction with a Missouri Department of Natural Resources' educational exhibit explaining ways that individuals, cities, and governments can work to protect the environment.

Other Electric Vehicle Activities

KSU continues its work with other Kansas area companies and an automotive firm to develop new style charge stations for both public and home use. In addition, KSU is associated with the development of custom smart cards and integrated billing systems for public charge stations.

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).

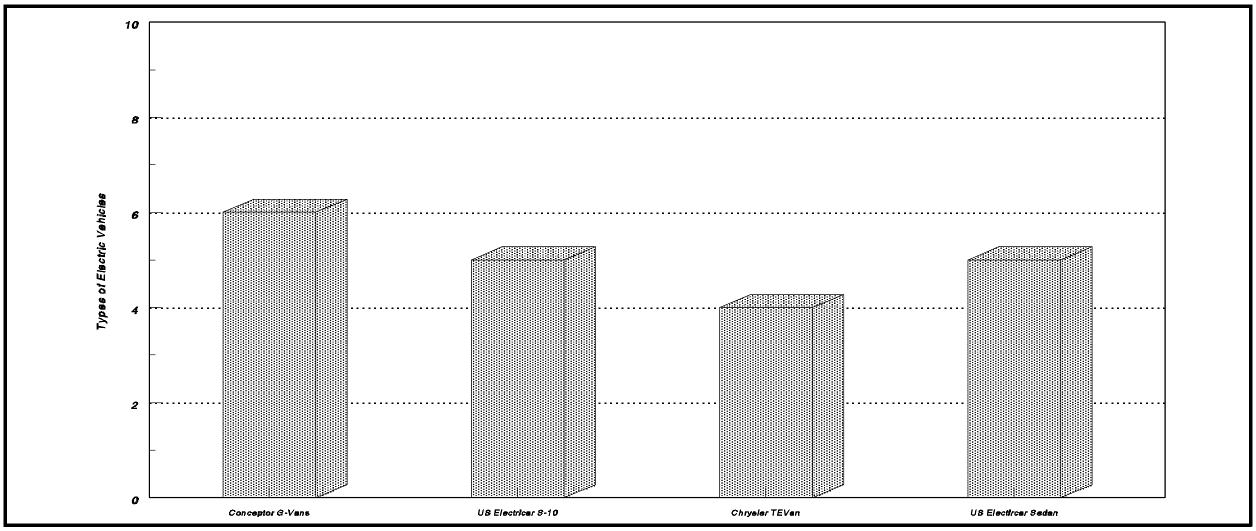

Figure 11. Number and types of vehicles in the Los Angeles Department of Water and Power electric vehicle fleet.

Technical

<u>US Electricar S-10 Pickups</u>

Tests performed on the five LADWP US Electricar S-10 pickups have determined that the vehicles have a range of 55 to 60 miles, per charge, 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 issues 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. US 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 manual 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.

- LADWP has repeatedly replaced motor controller units and auxiliary power units since the vehicles were delivered.

US 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 US 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. US 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 Angeles International Airport and the other four continue to operate in LADWP's fleet. The Unique Mobility minivan was not operational.

Public Awareness

LADWP was involved in several public awareness activities, including:

- Co-coordinated the 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.
- 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 is 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 (Orcas) of Eastsound, Washington, operates a Ford Escort that was converted to an EV by Jet Industries, and one Solectria Force EV as part of its participation in the Site Operator Program. This electric utility serves customers in the islands of San Juan County, Washington. The Orcas territory presents some unique driving conditions and operating problems not encountered by other Program participants.

Orcas 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 Orcas EVs) operating in the county.

Technical

Orcas reports driving their two EVs a total of 234 miles for the period. The milage efficiency for Orcas' Escort was 0.67 miles/kWh and for Orcas's Solectria Force the efficiency was 2.6 miles/kWh (Table 7).

Table 7. Orcas Power and Light Company's vehicle performance profile.

Vehicle	Total Miles Driven	Miles per day driven	Miles per month	Average kWh/mile	Average Miles/kWh
Ford Escort	33	3.6	8.3	1.5	0.67
Solectria Force	201	9.3	67	.39	2.6

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, including:

- 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 California 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.

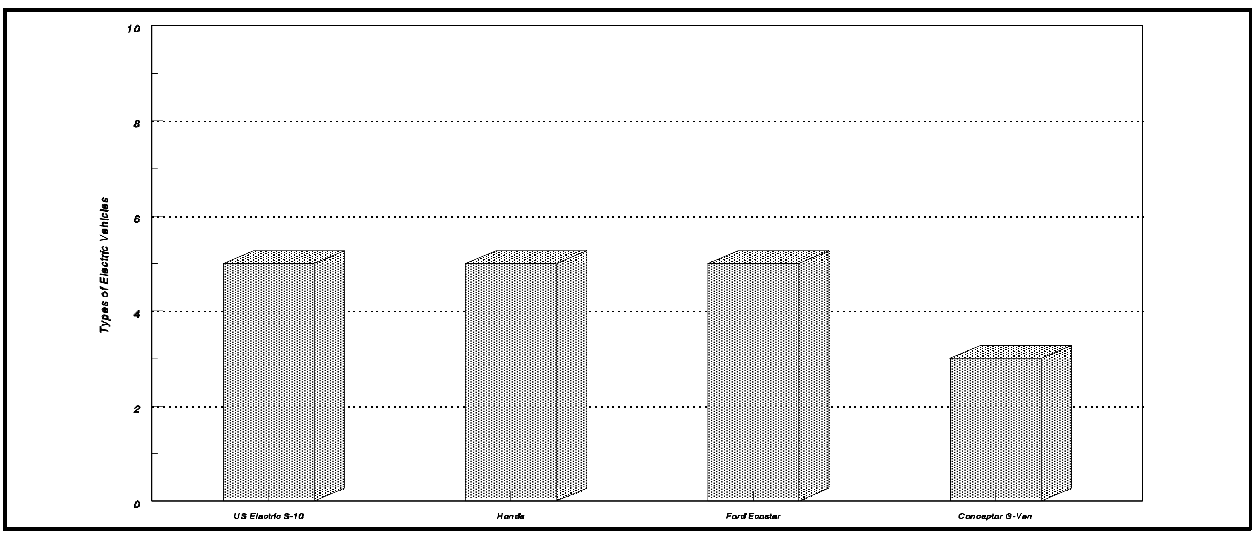

Figure 12. Number and types of vehicles in Pacific Gas and Electric's electric vehicle fleet.

Technical

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

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 the San Rafael, Concord, San Francisco, and San Luis Obispo areas. At Honda's request, PG&E is returning two of the cars this fall; they will be used next 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 to Cal Poly University for a rapid battery interchange project. The third 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, Emeryville, 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," which will be leased to employees of local business 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. 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 manufacturer, Personal Independent Vehicle Co., will supply forty vehicles in June of 1996.

PG&E is working with Yosemite National Park and its concessionaire, as well as 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 a 31-foot, 32 passenger Specialty Vehicle bus, and a 35-foot APS Systems bus. Both buses use Trojan quick-charge battery packs.

Other Electric Vehicle Activities

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 width 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 trials are scheduled for the first quarter of 1996.

Platte River Power Authority

The Platte River Power Authority (PRPA) operates two electric vehicles (Table 8) as part of its participation in the 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 transportation and public demonstrations.

Table 8. 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; 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 downloaded 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 compiled and used to produce a Quarterly Operational Summary report (Table 9), a EV Performance and Operations & Maintenance Summary report (Table 10), and a Fuel Cost Comparison Summary report (Table 11).

During the July, August and September 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 $0.042/mi 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 9. Monthly summary of the onboard meter and the odometer data for the Platte River EVs. (Note: the EVcort 356 was out of service from the beginning of the quarter to July 26 for controller upgrades. N/A signifies Data Not Available due to AC charge meter problems.

	Total Energy Usage (kWh)		**Miles Driven**		**Miles/kWh**	
	EVcort 355	EVcort 356	EVcort 355	EVcort 356	EVcort 355	EVcort 356
July	138.4	22.17	304.2	12.1	2.20	0.53
August	69.0	200.7	110.2	445.9	1.60	2.22
Sept.	209.4	n/a	443.1	212.0	2.12	n/a
Total	416.7	n/a	858	670	2.06	n/a

Table 10. Platte River's EVcorts variable operation and maintenance costs. The data presented is for a full one-year period, including the fourth quarter of 1994, and the first, second and third quarters (January through September) 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	3,272	1,650	1.98	$44.40	4	$112	$0	$0.048
EVcort #356	3,826	n/a	n/a	$n/a	6	$168	$0	$n/a
Average	3,549	n/a	n/a	$n/a	5	$140	$0	$n/a

Table 11. 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	$1.18	–	–	28	–	–	$0.042	$0.042
Soleq EVcort	–	$8.01	$0.027	–	3.079	1.98	$0.221	$0.014

Soleq EVcort, DOE# 355

During July - September reporting quarter, this vehicle was driven a total of 858 miles with an average total energy efficiency of 2.06 miles/kWh. The total cost of electricity for the quarter was $11.21. The maintenance performed on the vehicle includes:

- Replacement of a damaged motor cooling blower
- Cleaning of the air conditioner condenser and condenser fans
- Checking for air conditioner refrigerant leaks and charged system

In addition to the above maintenance, manufacturer upgrades were made on site to the controller during the quarter, including:

- Lowering of regeneration gain to increase stability of braking when the traction batteries are nearly at full charge
- Lowering of current limit gain to increase stability at high acceleration

Soleq EVcort, DOE# 356

During the quarter, this vehicle was driven a total of 670 miles. The AC charger meter would not down load its data, so the energy efficiency for the quarter is not available. The same two manufacturer upgrades that were made to vehicle #355 were also made to this vehicle, except they were performed by the manufacturer in Chicago.

Public Awareness

Platte River is participating as a member of the steering committee for developing the Weld/Larimer/Rocky Mountain National Park Clean Cities Program

A Platte River EV was loaned out twice to Colorado utilities during the quarter for regional utility events. These events were covered by the local media, including TV, radio and newspapers.

Potomac Electric Power Company

The Potomac Electric Power Company (PEPCO), serving over 1.6 million people in the Washington, D.C. 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 existing and emerging 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.

Three EVs were delivered to PEPCO during the reporting quarter for integration into PEPCO's corporate fleet as part of the EV America field test evaluation. Two of the vehicles are 1995 Solectria E-10's which were ordered last January under a cost share agreement with DOE. The third EV is a 1994 Solectria E-10 that was converted under the ARPA Program and assigned to PEPCO to manage. All three of these vehicles are equipped with MDAS units for data acquisition.

Technical

During the installation of the MDAS unit in the ARPA E-10 pickup, it was observed to have severely damaged batteries in the front battery pack. The battery cases were actually melted due to improper temperature monitoring during charging. The vehicle was returned to Solectria where the batteries were replaced and additional thermistors were added to the front battery pack. Once the vehicle was returned to PEPCO it was noted that the rear axle seal was leaking and as a result, the rear brakes required replacement. Each of these incidents were addressed quickly by Solectria and all parts replacements were performed under warranty.

During scheduled planned maintenance of the Force, battery testing revealed that seven of the flooded lead-acid batteries were in need of replacement. Due to a case modification, the new DIEHARD replacement batteries would no longer fit within the Force battery box. An equivalent battery from Interstate is being evaluated as a suitable replacement.

Because of the excessive length of time required to acquire commercial license tags from the District of Columbia, and the above noted maintenance problems, vehicle mileage was severely limited and mileage values are not available.

Public Awareness

The Solectria Force sedan and E-10 pickups were used for four public demonstrations. These events included presentations at the Montgomery County Fair, the Prince George's County Kiwanis Club, as part of PEPCO's "Take It To The Street" sidewalk energy fair, and for the Johns Hopkins Engineering Alumni Association.

Other Electric Vehicle Activities

Through a partnership between PEPCO and Metricom, Inc., PEPCO has received a license to install and operate a wide area wireless communications network that will include the greater Washington, D.C. metro area. This system, which is designed to allow remote access to the Internet, will allow for data transfer at rates as high as 57.6 Baud. PEPCO's EV Program has acquired several of these wireless modems and will evaluate the usefulness of this network for automatically downloading the MDAS data from remote locations within their service area.

Sandia National Laboratory

The Sandia National Laboratory operates 12 Electricas, 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 Electricas 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; none 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 12).

Table 12. 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**	**Total mi/kWh**
E-22410	10,839	8,583	248	298	1.3
E-22411	8,422	9,404	179	304	0.9
E-22412	11,095	11,156	139	229	1.0
E-22413	15,246	7,858	475	624	1.9
E-22414	10,637	10,660	672	667	1.0
E-22415	13,973	3,367	460	219	4.1
E-22416	6,337	5,272	175	221	1.2
E-27433	12,086	10,445	414	232	1.2
E-27434	8,259	7,442	195	147	1.1
E-27436	8,245	10,222	413	869	0.8
E-27440	9,495	9,601	423	739	1.0
E-27661	5,427	4,055	259	331	1.3
Total	116,657	93,533	4,050	4,880	-
Average	9,721	7,794	338	407	1.2

Southern California Edison Company

Southern California Edison Company (SCE), an electric utility, currently operates and maintains 60 electric vehicles as part of its participation in the Site Operator Program (Figure 13). During September, six new US Electricar sedans (converted Geo Prizms) and six new US Electricar S10s (converted S10 pickups) entered the SCE fleet. The SCE fleet applications for their EVs include:

- Meter Readers
- Field Service Representatives
- Service Planners
- Managers/Supervisors
- Mail Routes
- Pool Cars

The SCE EV 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.

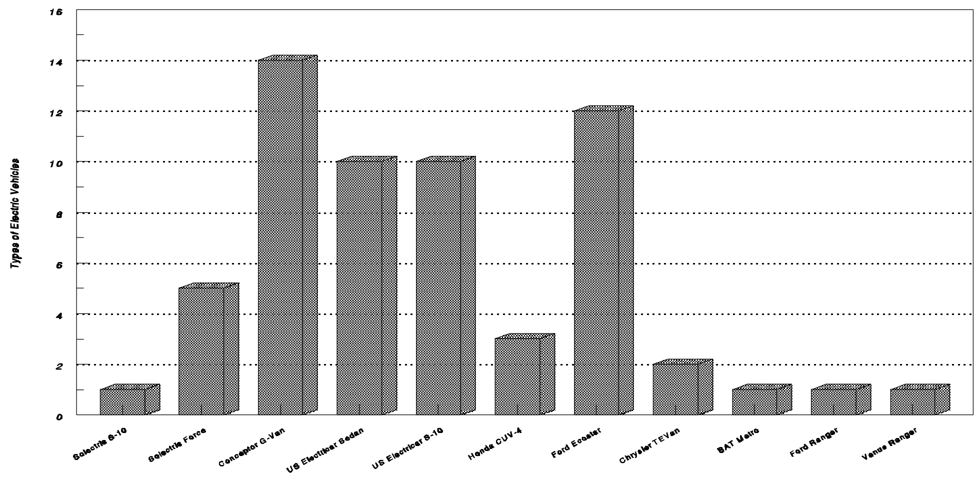

Figure 13. Number and types of vehicles in the Southern California Edison Company electric vehicle fleet.

Technical

SCE has implemented their own data acquisition system (DAS) in several SCE vehicles. The DAS consists of an "Alpha" kilowatt-hour meter and a "Silent Witness" trip logger. The SEC DAS measures fleet operations performance metrics such as miles per vehicle, miles per AC kilowatt-hour, miles per trip, and recharge time and time of use. To date, 28 SCE vehicles have been equipped with this DAS system and most of SCE's remaining vehicles will be so equipped. The SCE instrumented fleet includes Conceptor G-Vans, Solectria Force sedans, Solectria E10 pickups, a US Electricar sedan and a pickup, Honda CUV4 sedans, and a Chrysler TEVan. SCE also continues to use the factory supplied data system for the Ford Ecostars. With the exception of the Ford Ecostars, which use sodium sulfur batteries, all of the SCE EVs are equipped with lead acid batteries, except for a G-Van which uses a NiCad battery pack.

The SCE EV fleet has a combined total mileage of over 365,000 miles, with two vehicles having over 20,000 miles of use. Several other EVs have also accumulated over 15,000 miles each (Figure 14). The variation in monthly usage is high, but several vehicles report over 1,000 miles of use during the latest three month reporting period (Figure 15). SCE reports an the energy efficiency of over 4 miles/kWh for two models (Figure 16). Also reported is the average time required to recharge seven different types of vehicles. Three of the EVs were reported as having average recharge times of under five hours each, and two are reported as having average recharge times of over 15 hours each (Figure 17).

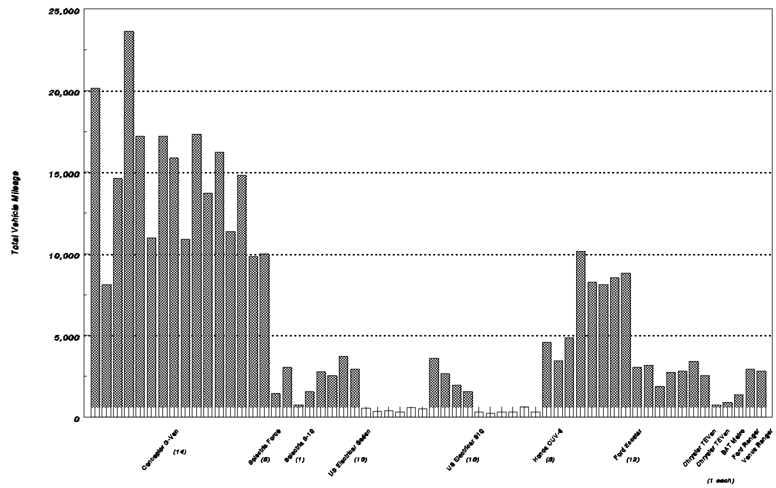

Figure 14. Reported total vehicle miles for each of Southern California Edison EVs as of September 30, 1995.

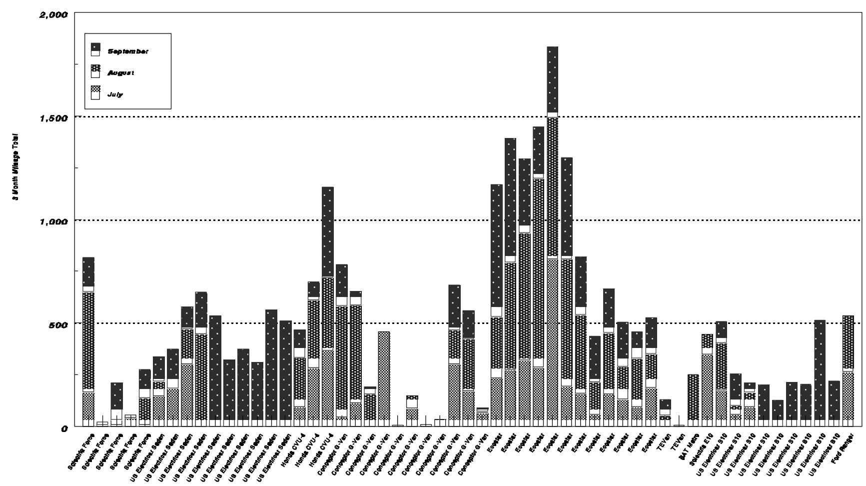

Figure 15. Reported mileage for SCE EVs during the 1995 months of July, August and September. The 13 vehicles not graphed reported zero miles traveled or did not report mileage data.

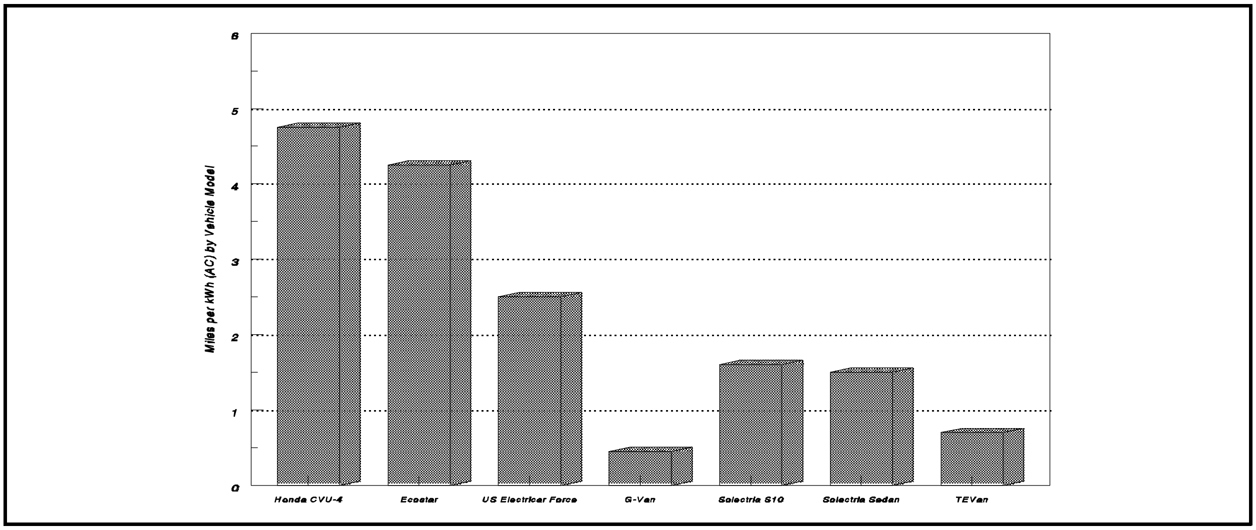

Figure 16. Energy efficiencies, by vehicle models, for several of the SCE EVs during July to September quarter. Energy data is not collected for all vehicles.

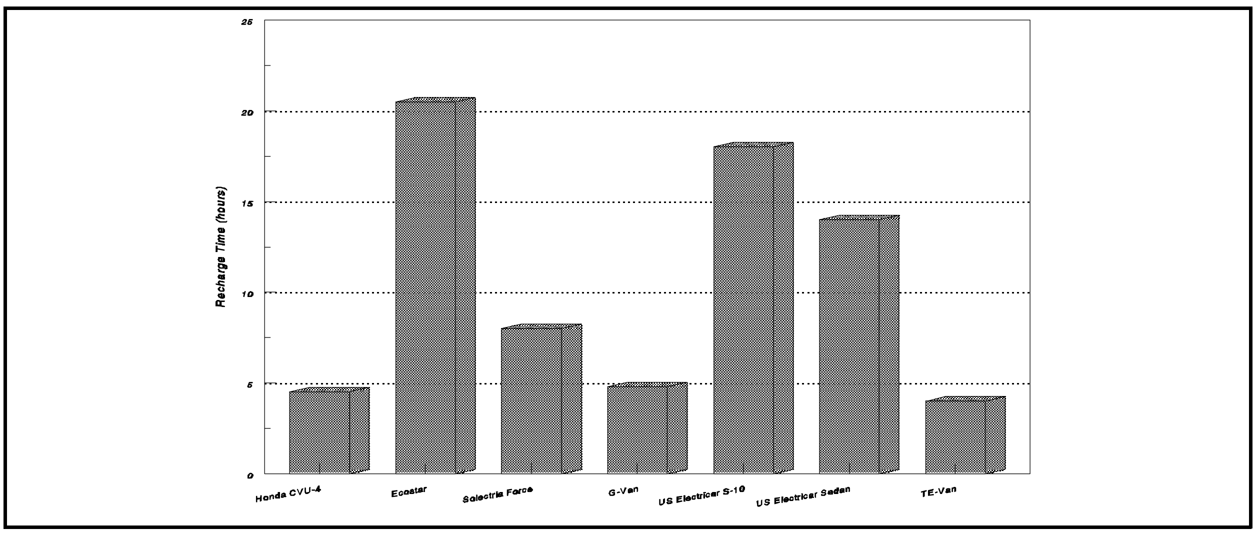

Figure 17. Average recharge time distributions by various vehicle models.

Public Awareness

No submittal was received for this period.

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 fuel cells. The ultimate thrust of the Program is education (i.e., graduate school support). The current complement of electric vehicles is comprised of 30 electric vehicles (Figure 18) 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.

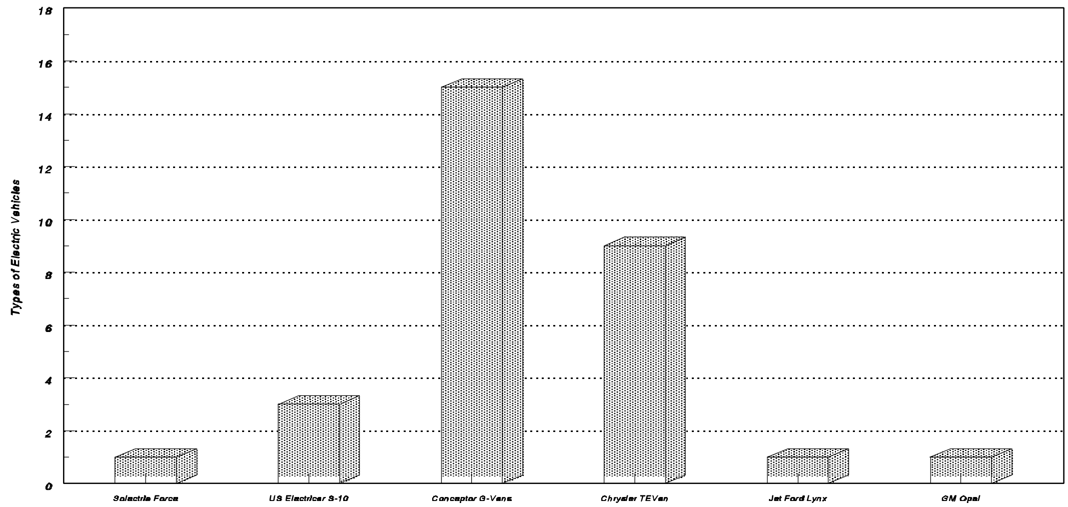

Figure 18. Number and types of vehicles in the Texas A&M electric vehicle fleet.

Technical

One of the US Electricar S-10s, DOE vehicle #628, uses a Hughes inductive charger and air conditioning was installed on this vehicle. After the installation of the air conditioning, this EV experienced a high voltage leak to the chassis ground due to a metal capacity case which had to be modified for proper installation. During the last week of September, this EV also experienced a battery failure during highway driving. The speed dropped from 55 mph to less than 30 mph. The vehicle was brought back to the service garage and an infra-red sensor was used to scan the battery box. A hot spot was discovered in the front passenger side of the battery box. The hot spot was caused by a bad battery in the lower battery layer; the battery was heating during discharge. This battery was removed, recharged and tested, but the required performance could not be restored. A new Hawker battery has been ordered, and it is desired that a battery from the same production batch will be found since it is Texas A&M's experience that batteries from different batches are different.

Another US Electricar S-10, DOE vehicle #629, has not accumulated many miles due to its long charging time. The conductive charger takes 14 to 18 hours to fully charge the vehicle.

All three of the US Electricar S-10's have been fitted with Mobile Data Acquisition Systems, and data collection has recently commenced. Two of the US Electricar S-10's have inductive chargers and air conditioning, and the third S-10 has conductive charging.

Texas A&M reports that their experience with the US Electricar S-10's has been mixed. They report that these EVs have performed better than all of the other EVs Texas A&M has operated in the past. However, problems such as controller failure, battery failure, and charger incompatibility are quite evident. It is Texas A&M's opinion that the conductive charger and the Hawker batteries are not a good match to these vehicles. The problem is not eliminated even when a programmable inductive charger is used because the battery manufacturer has not yet provided an algorithm which is suitable to completely charge the battery in a timely manner.

The inductive charger and the controller/inverter are both manufactured by Hughes, but they are not able to function together without encountering problems. As noted during the last quarter, a controller/inverter had a malfunction when the inductive charge paddle was reinserted with the battery pack close to full charge. Similarly, during the current reporting quarter, the vehicle was driven 62 miles on a single charge, and was then allowed to recharge. The inductive charger shut down after 70 minutes when indicating a full charge, but when the S-10 was driven, its range was only 20 miles. The vehicle was again recharged, and this time the charger took the regular length of time and the vehicle's range was normal.

Public Awareness

During August, one of the US Electricar S-10's was displayed at the Earth Day celebration in Oklahoma City, Oklahoma. This fair was attended by approximately one thousand people. DOE's support was duly highlighted.

U.S. Navy

As seen in the below figure (Figure 19), the U.S. Navy has 59 EVs. The Navy's EVs represent several manufacturers and body styles, and a broad span of vehicle ages. The 59 EVs are located at eight different Navy facilities (Figure 20). 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 Navy, as part of a larger Department of Defense procurement effort, will be ordering more than 30 newest generation EVs during the 1996 fiscal year.

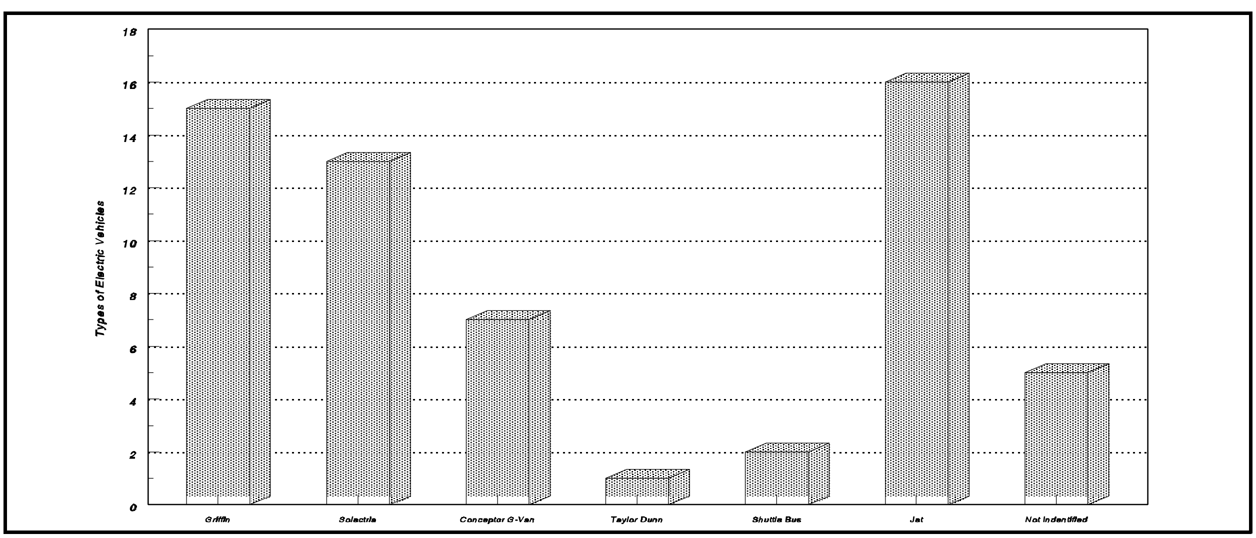

Figure 19. Number and types of vehicles in the US Navy's electric vehicle fleet.

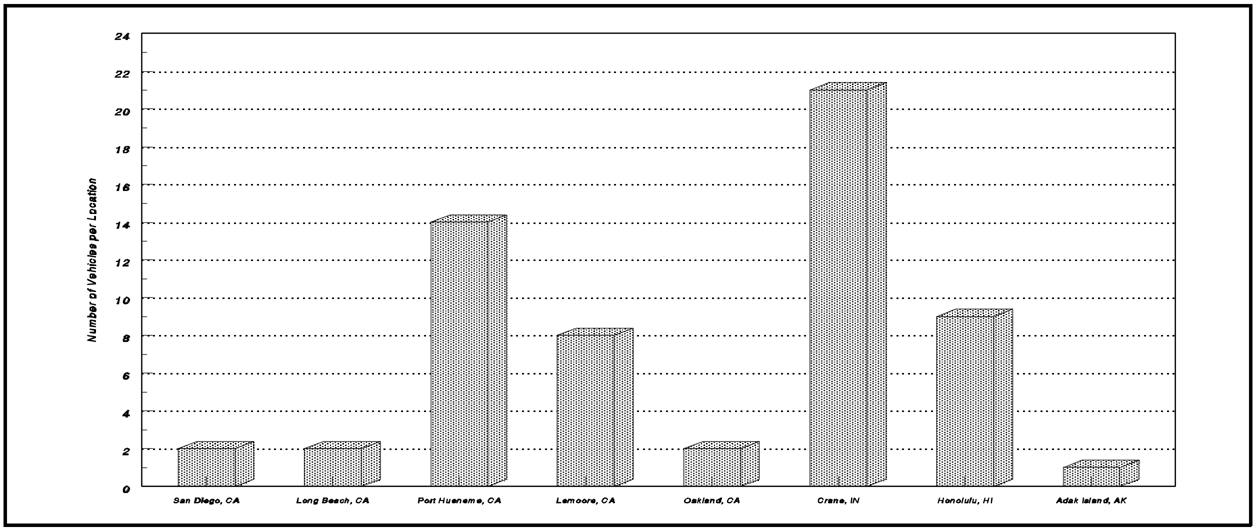

Figure 20. Locations of U.S. Navy's electric vehicle fleet.

University of South Florida

The University of South Florida (USF) at Tampa, monitors and tests 12 electric vehicles as a participant in the Site Operator Program (Figure 21). USF's principal collaborating organizations are Florida Power Corp. (FPC), Tampa Electric Co., 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 this 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.

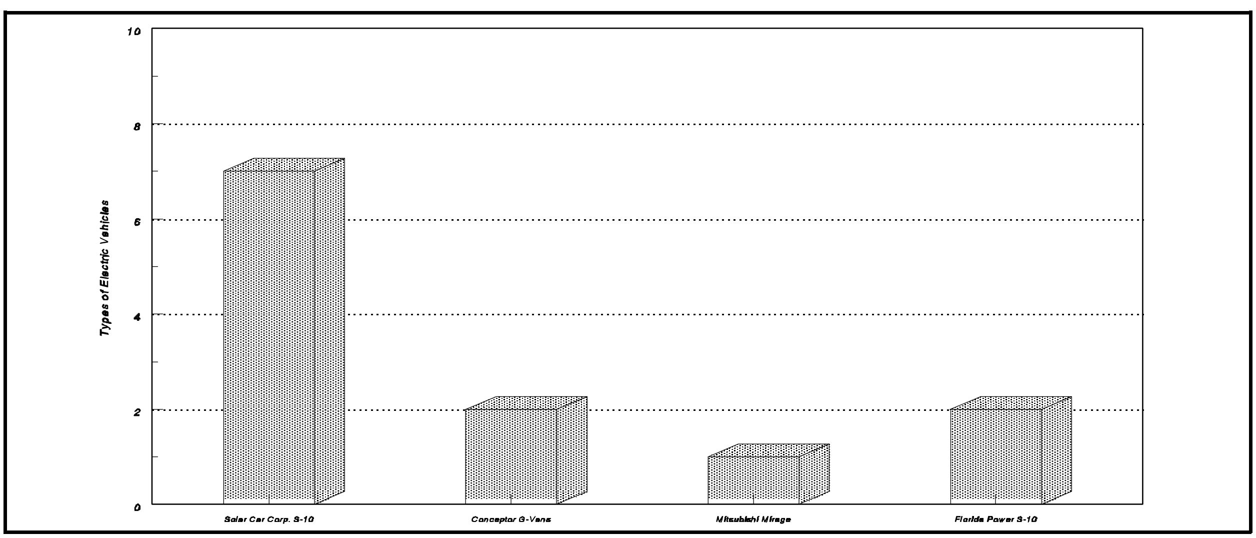

Figure 21. Number and types of vehicles in the University of South Florida electric vehicle

fleet.

Technical

Vehicle Performance

Table 13 provides a summary of the performance characteristics for three of USF's EVs during the reported quarter. The performance results were obtained from data collected by their MDAS units. The charging summaries are derived from driver logs. As can be seen in this table, the G-Van battery pack efficiency was 28.5%. Unfortunately, the range of this vehicle continues to decrease. However, the fact that the battery pack has accumulated 11,000 miles may explain this downward efficiency trend.

One of the Solar Car Corporation (SCC) S-10's (Figure 22) experienced an average efficiency rate for the quarter of 1.67 mi/kWh(DC).

The Mitisubishi Mirage showed an efficiency of 0.7 mi/kWh(DC) for the month of August (Figure 23). It should be noted that during the month of August, the Mirage only received one charge and it was a short charge, meaning the battery pack was nearly full throughout the charge. Routinely, when a battery pack is nearly full, the charger is least efficient and this would account for the low efficiency in August.

Table 13. Vehicle performance results for two of the University of South Florida's EVs. The SCC-10 vehicle is a Chevrolet S10 pickup that the Solar Car Corporation converted to an EV, and the G-Van is a GMC van that was converted by Conceptor.

Quarterly Trip Summary

	G-Van DOE# 650, USF# G1	SCC S-10 DOE# 658, USF# S6
# of days in use (days)	33	51
Total # of trips	128	292
Total trip time (hours)	18.5	39.4
Total time at rest (hours)	4.9	9.8
Total distance (miles)	400.0	850.0
Average speed (mph)	23.2	26.4
Max. battery temp. (°C)	47.0	-
Avg. battery temp. (°C)	35.8	-
Total A/C energy (kWh)	4.9	n/a
Total discharge energy (kWh)	214.0	287.2
Net DC energy eff. (mi/kWh)	1.9	3.0

Quarterly Charger Summary

	G-Van DOE# 650, USF# G1	SCC S-10 DOE# 658, USF# S6
Total # of charges	18	44
Total charge time (hours)	209.0	284.3
Max charge current (A)	37.4	27.0
Ave. charge current (A)	17.4	17.0
Max. battery temp. (°C)	38.2	41.7
Avg. battery temp. (°C)	30.7	32.0
Total charge energy (kWh)	750.0	546.4
Gross DC energy eff. (mile/kWh)	0.5	1.6
Battery pack eff. (%)	28.5	52.6

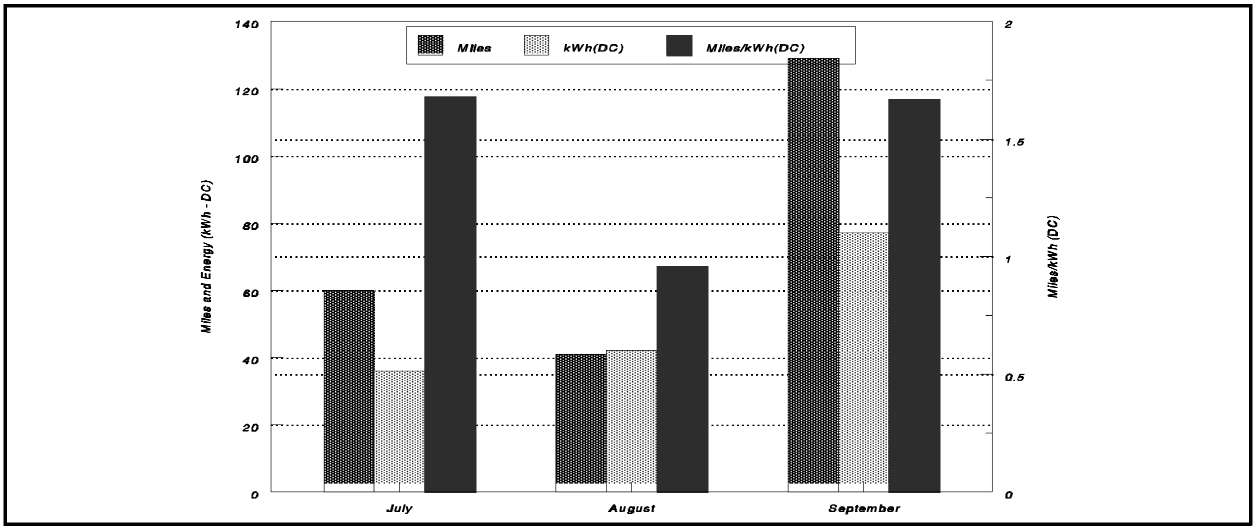

Figure 22. Total miles driven, charger energy (kWh - DC), and driving efficiency for a Solar Car Corp S-10 (DOE# 652, USF# S1) at the University of South Florida. Miles and kilowatt-hour values use the left scale, and the miles/kilowatt-hour value uses the right scale.

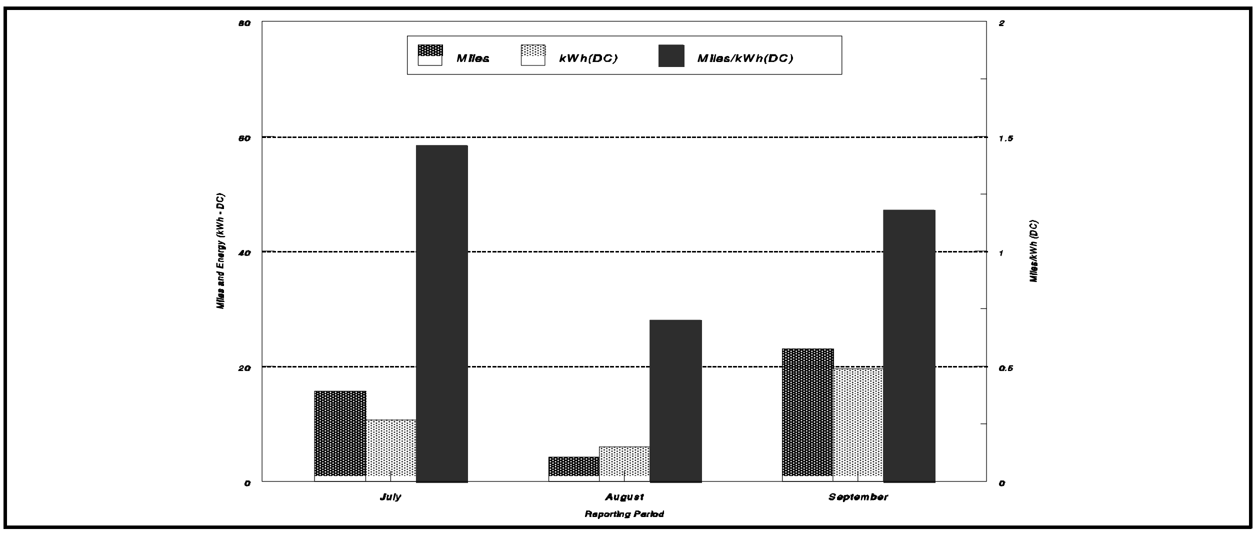

Figure 23. Total miles driven, charger energy (kWh - DC), and driving efficiency for the Mitsubishi Mirage (DOE# 654, USF# M1) at the University of South Florida. Miles and kilowatt-hour values use the left scale, and the miles/kilowatt-hour value uses the right scale.

Battery Watering

Table 14. Battery watering requirements for a G-Van (DOE #650, USF #G1), and a Solar Car Corporation converted S-10 Chevrolet pickup (DOE #652, USF #S1).

Vehicle	Dates	Liters of water added	Miles between watering	Miles per liter of water	Man hours to water vehicle
G1	9/28	54	372	6.9	2.0
S1	8/1	5.0	300	60.0	1.25
	9/15	6.5	148	22.8	1.25

Regenerative Braking Test

A G-Van (DOE #650, USF #G1) was used to evaluate regenerative braking. The G-Van was chosen due to the fact that its regenerative braking system is automatic. That is, the regenerative braking starts as soon as the brake pedal is depressed; there are no switches or buttons to touch to start regenerative braking.

The test was conducted over 20 days of normal driving conditions. Forty-one cycles were chosen for the analysis. The charge cycles were eliminated for obvious reasons. When the regenerative braking system in the G-Van was used, an average of 28.4% of the current generated by the motor (during the regenerative braking) actually reached the battery pack. The amount of current generated by the motor that reached the battery pack ranged from 9.2% to 59.0% (Table 15). The standard deviation was 7.4%. Obviously, all of the current produced by the regenerative braking does not reach the main battery pack. It is possible that if all the current were to go directly to the battery pack the batteries would be damaged. The additional current generated by the motor may be going to the other components that require energy (e.g. power steering and brake motor, air conditioning motor, and the DC to DC converter), to storage devices in the controller, and/or to ground.

Table 15. Regenerative braking test results on a USF G-Van.

Day	Driving cycle	Motor Regen. Charge (Amp-hours)	Battery Regen Charge (amp-hours)	Percentage to reach battery from motor
248	1	4.57	1.51	32.99%
248	2	6.01	2.14	35.69%
248	3	1.89	1.12	58.96%
248	4	2.06	0.57	27.51%
248	5	4.61	1.46	31.76%
248	6	2.11	0.59	27.74%
249	0	4.05	1.26	30.99%
249	1	1.91	0.49	25.73%
249	2	2.58	1.11	43.22%
249	3	3.61	1.24	34.20%
250	0	3.16	0.82	25.93%
250	1	1.24	0.34	27.48%
250	2	1.59	0.38	23.95%
250	4	3.95	1.45	36.72%
250	6	2.29	0.83	36.14%
250	7	2.15	0.56	25.91%
251	0	2.80	0.78	27.96%
251	1	4.32	1.16	26.91%
251	2	5.12	1.26	24.60%
251	3	4.28	0.82	19.15%
251	4	4.33	1.16	26.84%
261	1	3.03	0.77	25.38%
262	0	3.72	1.14	30.68%
262	2	2.75	0.85	31.12%
262	3	0.95	0.20	21.51%
263	0	3.38	1.06	31.47%
263	1	3.51	1.08	30.68%
263	2	1.19	0.24	20.26%
263	3	0.82	0.21	25.73%
264	0	3.85	1.00	26.06%
264	2	3.97	0.94	23.77%
264	3	4.25	1.16	27.26%
264	4	3.16	0.70	22.23%
265	0	1.28	0.33	25.74%
265	1	4.40	1.30	29.54%
266	0	5.22	1.16	22.13%
266	1	2.63	0.68	25.73%
267	0	5.62	1.54	27.40%
267	1	2.62	0.71	27.06%
267	2	0.17	0.02	9.19%
267	3	3.99	1.21	30.36%

Other Maintenance/Repair Activities

The 12 V auxiliary battery in one of the SCC S-10s (DOE #652, USF #S2), was replaced. The original battery was defective. The S-10 also had a new onboard charger installed for the new batteries installed. An AC power sensor was added to help evaluate the efficiency of the new chargers. A total of 12 labor hours was required for these maintenance activities.

The brake system in another SCC S-10 (DOE #652, USF #S1) failed. The vacuum sensor did not have the wires connected properly. This repair required 0.75 hours of maintenance.

In a G-Van (DOE #650, USF #G1), the fuses in the control box for the power steering motor continued to blow due to unknown reasons. The manufacturer (Conceptor) recommended that the fuse rating be increased by 5A. This solved the problem for a while, until the wires in the power steering motor control box burned up. This resulted in having to replace the control box and a 40kA fuse in the main controller. These maintenance activities required 12 hours of labor.

The main battery pack fuse block in the Mitsubishi Mirage (DOE #654, USF #M1) is being replaced due to heat stress. The DC to DC converter is also being replaced due to the heat stress from the summer months. Nine hours of maintenance was required.

Air Conditioning Energy Use

As was reported in the last Site Operators Quarterly Report, USF has been studying the impact of air conditioning use on their G-Van. The results of air conditioning use in city driving was previously reported in the last Quarterly report. A test to investigate the impact of air conditioning use during highway driving conditions was conducted during the July, August, and September quarter, and the results are reported in this Quarterly report. The test was conducted by leaving the air conditioning off until the EV was on the on-ramp to the freeway. This was done to conserve energy in order that a longer highway test might be conducted.

Table 16 lists the results, in five minute intervals, for the highway test. Only the DC current values are reported since the air conditioning is at the same voltage as the battery pack, therefore, the current difference represents the power or energy differences. Note that column four is the percentage of energy consumed by the A/C during each five minute interval of the trip. The table shows a nearly constant percentage of energy use by the A/C, this is a consequence of both the driving conditions for the test and the heat load on the vehicle during the test. The speed was also fairly constant, in the 55 to 60 mph range. The next table (Table 17) provides the running total of the same variables as reported in the previous table. From the last column in Table 17, it can be summarized that the A/c used 8% of the total energy to cool the vehicle during the first ten minutes of the test trip, and that the A/C consumed 7% of the total energy used by the vehicle during the entire trip.

Table 16. Air conditioning highway test data for a University of South Florida G-Van. Column one is the time interval, column two is the average net current, column three is the average air conditioning (A/C) current, and column four is the percentage of the average net current that the air conditioning uses.

Time Interval (minutes)	**Average Net Current (Amps) (During Interval)**	**Average A/C Current (Amps) (During Interval)**	**A/C Percentage of Net Current (During Interval)**

0-5	132.04	10.38	8%
5-10	133.53	9.56	7%
10-15	150.03	9.90	7%
15-20	148.74	10.05	7%
20-25	161.77	10.01	6%
25-27	115.85	9.39	8%

Table 17. Air conditioning highway test data for a University of South Florida G-Van. This table is the running time totals of the above table. Column one is the total elapsed time in minutes, columns two and three are the running totals, and column four is the percentage of the average net current that the air conditioning (A/C) uses up to the time shown in the first column.

Time Interval (minutes)	**Average Net Current (Amps) (During Interval)**	**Average A/C Current (Amps) (During Interval)**	**A/C Percentage of Net Current (During Interval)**
5	132.04	10.38	8%
10	265.57	19.93	8%
15	415.61	29.84	7%
20	564.35	39.89	7%
25	726.11	49.91	7%
27	841.97	59.30	7%

Photovoltaic Solar Power Charging Station

During the July, August, and September quarter, the twelve-vehicle photovoltaic (PV) solar power charging station generated 5,770 AC kWh of energy, and 5 DC kWh of energy. All of the DC was used to charge EVs, and 1,167 AC kWh of the 5,770 AC kWh generated by PV station, was used to charge the EVs. The remaining 77% of AC kWh (5,770 - 1,167) was supplied to the utility grid. The amount of energy used for charging the EVs was low during this quarter because of vehicles being unavailable for use due to maintenance requirements. During the past year, the amount of PV generated kilowatt-hour used for charging has averaged 3,212 kWh/three-month quarter.

Public Awareness

USF was involved in several public awareness efforts this quarter, including:

- Tenth graders toured the USF EV and photovoltaic parking/charging station.

- The USF Clean Energy and Vehicle Research Center was represented at the dedication of the Pinellas Suncoast Transit Authority's new Electric bus for the "Pinellas Park Shuttle". This route provides morning, noon and afternoon service to 14 neighborhoods and area shopping centers.

- Two representatives of the Florida House Partners were given a tour of the USF EV and photovoltaic parking/charging station.

- USF met with MacDill Air Force Base (AFB) to discuss alternative fuel vehicles for the base. Special attention was directed to EVs. USF will be working with MacDill and Robins AFBs to identify and demonstrate operating performance of alternate fuel vehicles.

- USF displayed an EV at Tampa's Environmental Trade Conference.

- USF displayed an EV at the ENERGY '95 conference in downtown Tampa.

York Technical College

Located at Rock Hill, South Carolina, York Technical College operates 11 EVs (Figure 24). 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.

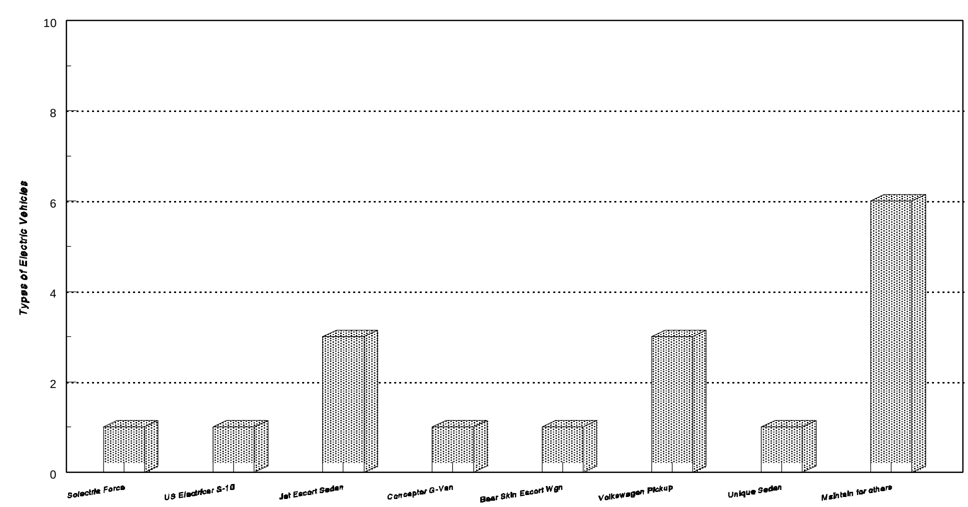

Figure 24. Number and types of vehicles in the York Tech electric vehicle fleet.

Technical

No submittal was received for this period.

Public Awareness

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

- Displayed EVs at the Galeria Mall in Rock Hill, South Carolina. The display consisted of three EVs inside the mall area, as well as static displays. The display was in place for seven weeks and it was manned eight hours per day, seven days per week.

- In conjunction with Duke Power Company, 25 area school teachers received an EV presentation that included a ride and drive event.

- Hosted a meeting with representatives of the Santee Cooper Power Company of South Carolina to answer their questions regarding an EV fleet application.

- Participated with Duke Power Company to provide an EV display at the Greenville County Fair.

- Provided EV public awareness exhibits to the Jubilee Fest in Rock Hill, South Carolina and the People's Fest in Wadesboro, North Carolina.

- A 1981 Ford Escort Sedan was upgraded and placed in service with the Coastal Center in Charleston, South Carolina, for the purpose of evaluating EVs for fleet use.

Other Electric Vehicle Activities

York Tech performs maintenance and other activities for EVs that are not directly part of their fleet. Some of these activities included: York Tech and Duke Power Company supplied Michelin Tire Company with two EVs for special tire research which resulted in an improved low-rolling-resistance tire for the Geo Prizm; staff attended a one week S-10 pickup air conditioner installation program presented by US Electricar; power steering kits were installed on two of Charlotte's EVs; kilowatt-hour meters were installed in several EVs; and, tests performed on Duke Power Company's Saturn traction battery pack revealed four bad modules.

Energy **Economics of** *Electric* **Vehicles**

This section takes a look at the energy economics of EVs and how the energy costs of EVs compare to the energy costs of vehicles fueled by internal combustion engines (ICE). While there are other variables that affect the total life-cycle costs of EVs, only the energy costs are examined here. It is acknowledged that other costs, such as the initial capital costs of the vehicle and a charger (if offboard), minus any applicable tax credits, and the capital costs of the ICE used for comparison, can have significant impacts on total life-cycle costs. However, many of these cost comparison questions are difficult to quantify for EVs. For instance, should the cost of GM's EVI/Impact be compared to a ICE that has similar range, or similar luxury (like a Lexus?), or similar handling and acceleration (like a Porsche?). Capital and/or leasing costs may be examined in a future Quarterly report, when the capital/leasing costs to obtain an EV from the "big three" are better quantified.

Assumptions

In order to perform an energy economics comparision, several assumptions must be employed and these assumptions can generate controversy, as not all are willing to accept the same set of assumptions. To mitigate this potential controversy, the assumptions used are clearly stated and are hopefully reasonable.

- An average miles per gallon (mpg) value of 28 mpg is assumed for ICEs. An Energy Information Agency publication[1] lists the 1992 value of 21.6 mpg, with an average annual increase of 2.6% for the previous 19 years. This equates to a calculated 1996 rate of 23.9 mpg. However, it is assumed that the newer ICE vehicles will have a combined value of 28 miles per gallon, to avoid the implication that the analysis is disfavorable to ICEs.

- An EV efficiency value of 4.0 miles/kWh is assumed for the analysis. There is no strong historical basis for EV fleet efficiency, given the continuous increases in EV technology over short periods of time. However, some miles per kilowatt-hour information is available, including: the GM EVI/Impact which is expected to perform in the 4+ miles/kWh range. Southern California Edison (SCE) is reporting that their Honda and Ecostar fleet vehicles are achieving over 4 miles/kWh (see the SCE section of this report, Figure 16). The DOE/EV America test results from 1995 and 1994 also support the use of 4 miles/kWh. Using the 45 mph constant speed test, the 12 tested vehicles averaged 4.47 miles/kWh (Figure 25). In fact, 7 of the 12 EVs exceeded the 4 miles/kWh assumed value, and 3 of the EVs exceeded the assumed 4 miles/kWh values by greater than 50% (+6 miles/kWh).

- The next assumption is the cost of gasoline. Based on the February 23rd Lundberg Survey of 10,000 gas stations nationwide, the average pump price for gasoline was 119.13 cents. The prices for unleaded gas at self-serve pumps were 112.42 cents for regular, 122.64 for mid-grade, and 131.20 cents for premium. At full-service pumps, the nationwide prices for regular, mid-grade, and premium unleaded gas were 149.01

[1] Energy Information Administration. *Alternative to Traditional Transportation Fuels*. June 1994. Table 13. U.S. Department of Energy. Washington, D.C.

cents, 157.87 cents, and 164.80 cents, respectively.[2] The price of 1.19 cents/gallon is used in this analysis.

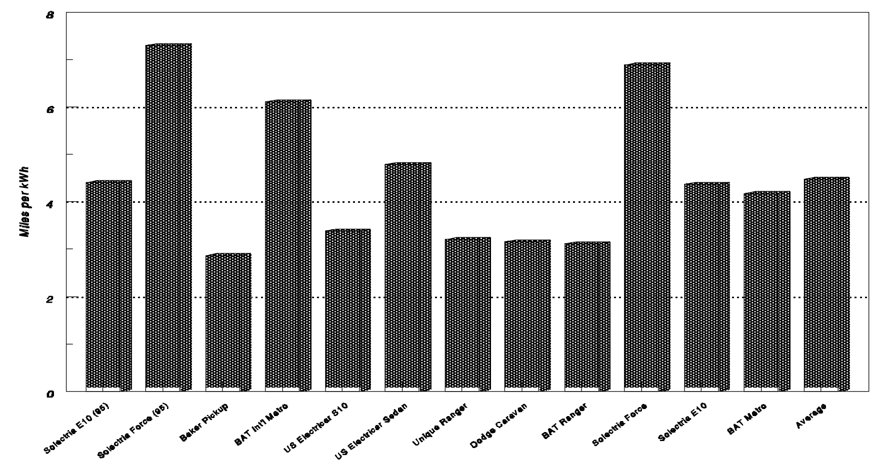

Figure 25. Energy efficiency, measured as miles per kWh. The values for all 12 vehicles are computed based on EV America/DOE testing during 1995 and 1994. The three vehicles on the left are 1995 test vehicles, and the remainder are 1994 test vehicles. The miles per kWh are based on the vehicles' ranges and energy use, as demonstrated in the Constant Speed Range Test, at 45 mph.

- The cost of electricity may be the most difficult assumption to reach agreement on, because of the many different on-peak, off-peak, off-off-peak, partial peak, and other adjustable rates per kilowatt-hour. However, the national average for residential customers is known, and through October of 1995, the kilowatt-hour rate for the year was averaging 8.47 cents/kWh.[3] During the month of October 1995 (most recent complete data), the per kilowatt-hour rate in the United States ranged from 14.1 cents in New Hampshire to 4.6 cents in Washington State. The California average was 11.5 cents/kWh. All of these rates are residential, which assumes at home charging. The other types of rates include commercial (7.75 cents/kWh), industrial (4.73 cents/kWh), and others (6.70 cents/kWh). The "others" category includes street lighting, railroads, and sales to other public authorities. An additional complication is the range of variable kilowatt-hour rates by time-of-day, and these rates can range from 3 cents to over 30 cents/kWh. Because of possible rates associated with different charging scenarios, the national average of 8.47 cents/kWh will be considered the base case. However, other kilowatt-hour costs are discussed.

- The analysis also uses the hypothetical fillup of 12 gallons of gasoline per refill. No documentation exists, the author just likes this value because he usually fills up his car with about 12 gallons when his 15 gallon tank is low.

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[2] Idaho State Journal, February 26, 1996, P B4, *Biz Briefs: Gas Prices Jump Again, Up 1.5 cents*, Pocatello, Idaho.

[3] Energy Information Administration. *Electric Power Monthly*. January 1996. Table 60. U.S. Department of Energy. Washington, D.C.

Results

Based on a 12 gallon refill, 28 mpg, and $1.19/gallon, the average ICE range is 336 miles (12*28). At a total fillup cost of $14.28 (12*$1.19), this equates to a cost per mile of 4.25 cents ($14.28/336).

Based on an electricity cost of 8.47 cents/kWh, and an energy efficiency of 4 miles/kWh, the same 336 miles requires 84 kWh of energy (336/4), for a total 336 mile cost of $7.11 (84*8.47), and a cost per mile of 2.1 cents ($7.11/336).

Using the national average energy costs of $1.19/gallon for gas, and 8.47 cents/kWh for electricity, the EV per mile cost is 51% lower than the ICE cost [(4.25-2.1)/4.25]. The inverse, of course, is that the ICE cost is 102% more expensive [(4.25-2.1)/2.1] than the EV cost.

If an EV owner is able to take advantage of an off-peak rate of 3.5 cents, the per mile cost is 0.9 cents ([(336/4)*3.5]/336). The 0.9 cents per mile rate is less than one-quarter of the ICE cost of 4.25 cents/mile.

As the reader can see from the below figure (Figure 26), the per mile energy costs for EVs do not exceed the ICE vehicle's energy costs until the kilowatt-hour rate exceeds 17 cents/kWh (Figure 26, breakeven point).

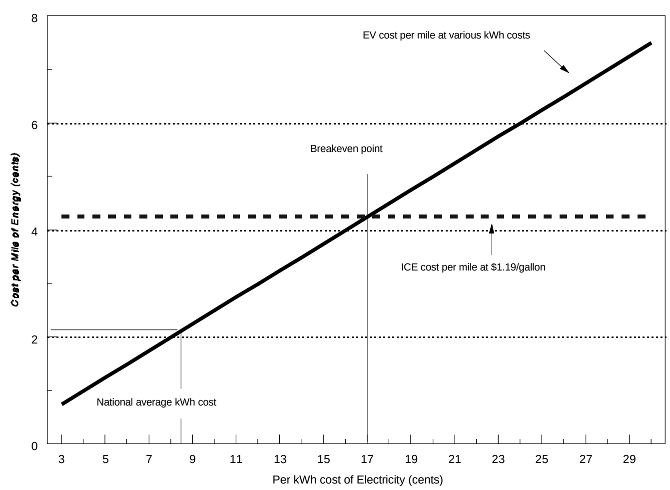

Figure 26. Comparison of the gasoline cost per mile for an internal combustion engine (ICE) fueled vehicle, and the electricity cost per mile for an electric vehicle (EV) at varying kilowatt-hour energy rates. For the ICE, the analysis assumes 28 mpg and a national average gasoline cost of $1.19/gallon. The EV analysis assumes 4 miles/kWh and varying energy costs. The assumptions are further described, and sources noted, in the accompaning text.

Discussion

As seen in the graph (Figure 26), the per mile cost to fuel an EV can be significantly lower than the cost to fuel an ICE. The consumer has the ability to control his/her behavior as to when to fuel the EV, provided of course that they do not exceed the vehicles's range on any given day. Exceeding the range would likely require on-peak refueling at a public recharging station. Such recharging would include the use of more expensive peak-energy costs, as well as a payment to the charging station for this convenience.

Other EV cost factors to be considered include the cost to replace the battery pack, the initial capital cost of the vehicle, tax incentives, and the avoidance of ICE costs that EVs do not incur. These avoided costs include the 3,000 mile oil changes, the replacement of the muffler system, timing belt replacements, tune ups, changing the antifreeze and fuel filter, and other miscellaneous costs. Of course EVs will have maintenance costs that are unique to EVs. Future Quarterly Reports will attempt to examine these issues and compare the cost tradeoffs. It may be difficult to quantify some EV benefits, including the noise and pollution reductions, and the shifting away from dependence on foreign fossil fuels that will someday prove to be of a finite quantity.