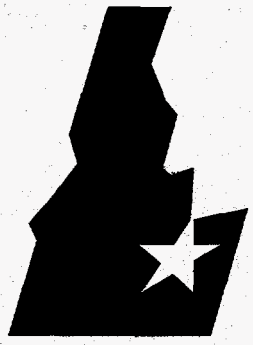

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July 1995

Electric and Hybrid Vehicle Program Site Operator Program Quarterly Progress Report for October through December 1994 (First Quarter of FY-95)

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Electric and Hybrid Vehicle Program Site Operator Program

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Idaho National Engineering Laboratory
Lockheed Idaho Technologies Company
Idaho Falls, Idaho 83415

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Executive Summary

The 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:

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

The 13 Program participants, their geographic locations, and the principal thrusts of their efforts are identified in Table ES-1. The EV inventories of each participant are summarized in Table ES-2.

Participants' experience with EV operation reflects three unrelated factors:

1. Operating climate and terrain
2. Current battery design and manufacturing technology, and charging/maintenance practices
3. Control and drive component technology and dependability

Factor 1 can noticeably influence the operating range of a vehicle. Factors 2 and 3, in that order, give rise to a great majority of the problems encountered. The effects of vehicle age, weight, and accumulated service mileage are also factors, and are noted by the operators in their service records. To summarize:

- Ambient temperature extremes and other climatic variations decrease vehicle range through both reduced battery capacity and increased accessory usage.
- Battery pack life for a given type is not uniform and frequently much shorter than expected; identical modules may show substantially different service lives.
- Electronic control system and drivetrain components are critical to vehicle operation and failures are not uncommon.

An appraisal of the overall current status of EVs for transportation emphasizes the following:

- Zero-emission vehicles have been mandated to specified percentages of new vehicles sold, by California law. Similar laws have been adopted by Massachusetts and New York and are under consideration in other states.

- For successful use of electric vehicles, conditions must be favorable, typically involving short-range service and infrastructure (i.e., charging and service) availability. Climate and terrain also impose limitations.

- Evaluation and test activities to date reflect the need for technology advances. Improved battery chemistry, design, and manufacturing practices are needed if adequate dependability is to be achieved. Powertrain and control system design will necessarily reflect battery technology changes, although control and powertrain design philosophy is potentially flexible. Examples are AC versus DC drive power, and the use (and operational problems) of regenerative braking. Some problems with weight overload when converting a chassis designed for ICE power have begun to surface.

- The additional cost of an EV over conventional ICE vehicles is largely in purchase price. Operating costs appear to be competitive.

- Vehicles representing relatively new designs (e.g., Solectria and US Electricar) are presenting a variety of equipment and operational problems to the users.

- Further effort is needed in hybrid vehicle development to achieve the necessary operating performance and overall dependability.

- Batteries and charging equipment continue to present generic problems, even in otherwise proven EV systems. Fast-charge technology is now under active investigation with several options available, and standardized testing protocols are being developed. A companion effort, the Rapid Battery Interchange Program, has been started at Pacific Gas and Electric Co.

Program Management covered a spectrum of activities:

- Reports of Program status.

- Public awareness activities.

- Purchase orders totaling 42 pickup conversions have been placed with two vendors subsequent to the Site Operator Users Task Force (SOUTF) bid evaluations. These units will be factory-equipped with the current version of the Mobile Data Acquisition System (MDAS). To date, a few deliveries have been made.

A Program Experience Overview, the result of analyzing Site Operator inputs, provides an insight into the variables that can affect electric vehicle performance and operating cost. These variables must be considered when making comparisons with conventional ICE-powered vehicles.

Graphic treatments of composite data for the reported G-Van, Escort, Chevrolet S-10, and VW Pickup, highlight the intrinsic differences among these vehicle types, as well as reflecting site-to-site differences attributable to operating requirements and environmentally seasonal influences. Separate presentations are made of (1) energy costs; (2) maintenance costs; (3) consolidated (all sites) energy costs; and, (4) service/repair costs for specified activity groups. The influences of vehicle type/weight, operating service requirements, operating environment, and vehicle age/cumulative usage are inherent in the results of the analysis.

It is noted that lighter-weight EVs (for example, the EVcort) have better performance and maintenance records. The apparent absence of such information from the graphic composite data reflects two factors:

1. Not all Site Operators report specific operating and maintenance data;

2. Some data are provided in a format that is not compatible with our analytical algorithm.

Conclusions

The conclusions reached from the overview results were:

- The larger, heavier G-Vans consume more energy than the smaller, lighter, Ford Escort, or the pickup trucks (i.e., Chevrolet S-10 or Volkswagen pickup).

- An electric vehicle that is used sporadically will use more energy/mile than one that is used more often, and for longer trips at uniform speeds. This is shown by the Ford Escort data.

- "Opportunity Charging" significantly affects the accuracy of the reported Site Operator data because energy added to the system during "opportunity charging" is often not recorded.

- Charging technology problems tend to impede effective utilization of EVs. These problems relate to:

  - Passenger comfort power demands

  - On-board charging equipment rate limitations

  - Charging equipment incompatibility with infrastructure features governed by local ordinance.

- Effective solar charging has regional limitations, but may be economically feasible when surplus power can be sold via a grid connection.

- Routine maintenance costs are comparable for the four (4) types of vehicles reported, although major maintenance needs can make this difficult to detect.

Recommendations

The following recommendations are made as result of the data analysis:

- Use of in-vehicle data acquisition systems will be used to eliminate the effect of unrecorded "opportunity charging," and reduce the labor required to edit data records containing errors.

- The area of charging technology should be surveyed to identify (and rank) its related problems and candidate approaches to controlling and minimizing their effects.

- More sites should report data utilizing the Site Operator Database. This would provide a larger data sample, give more reliable results, and reduce the amount of special handling required for data reported utilizing other media.

- A structured investigation of rapid charging should be conducted by implementing rapid chargers at selected sites and monitoring the effects on current vehicle battery system.

Table ES-1. Site Operator Program Participants.

Entity	Principal Thrusts of Program Effort a. Fleet evaluation, vehicle test b. Infrastructure development c. Technical education d. Public awareness
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
* Information-sharing agreement	

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

Participant	G-Van	EVcort	Force	S-10	Jet*	Unique	Griffon	TEVan	Other	Total
APS	4	3	1	4	–	2	–	1	1 Solar Colt sedan; 1 Honda CRX; 1 Saturn	18
KSU	–	2	–	–	–	–	–	–		2
LADWP	6	–	–	4	–	1†	–	4	5 Prizms	20
OPALCO	–	–	1	–	1	–	–	–		2
PG&E	3	1	–	–	–	–	–	–	2 Ford Ecostars	6
PRPA	–	2	–	–	–	–		–		2
PEPCO	1	1	1	–	–	–	–	–		3
SANDIA	–	–	–	–	–	–	–	–	12 Electrica (Escort conversion)	12
SCE	15	–	5	4	–	–	–	2	6 Ford Ecostars, 3 Prizm Sedans, 1 Ranger pickup, 1 bus, 1 Dodge Caravan, 1 BAT sedan, 3 Honda sedans	42
TAMU	15	–	–	3	1	–	–	8	2 race cars	29
NAVY	5	–	–	6	42	–	11	–	2 Grumman	66
USF	2	–	–	10	–	–	–	–	1 Mirage, 1 Dakota	14
YORK	1	–	–	8	–	2	–	–	1 Solectria Force 1 Escort (Bearskin)	13
TOTALS	**52**	**9**	**8**	**39**	**44**	**5**	**11**	**15**	**46**	**229**

*** = various manufacturers** **† = hybrid**

Contents

APPENDICES

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 twelve sites located in diverse geographic, metrologic, and metropolitan areas across the United States (see Figure 1). Information is shared reciprocally with a thirteenth site, not under Program contract. The vehicles are operator-owned, except for two Griffon vans.

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

1. Advancement of electric vehicle technologies

2. Development of infrastructure elements necessary to support significant electric vehicle use; and

3. Increasing the awareness and acceptance of electric vehicles (EVs) by the public.

The current participants in the Site Operator Program are shown in Figure 2. Table 1 indicates the 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 in the near future.

The Program is currently managed by personnel of the Electric and Hybrid Vehicle Program at the Idaho National Engineering Laboratory. 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 authorized users through the Idaho National Engineering Laboratory (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 are identified below for each Program Status entry.

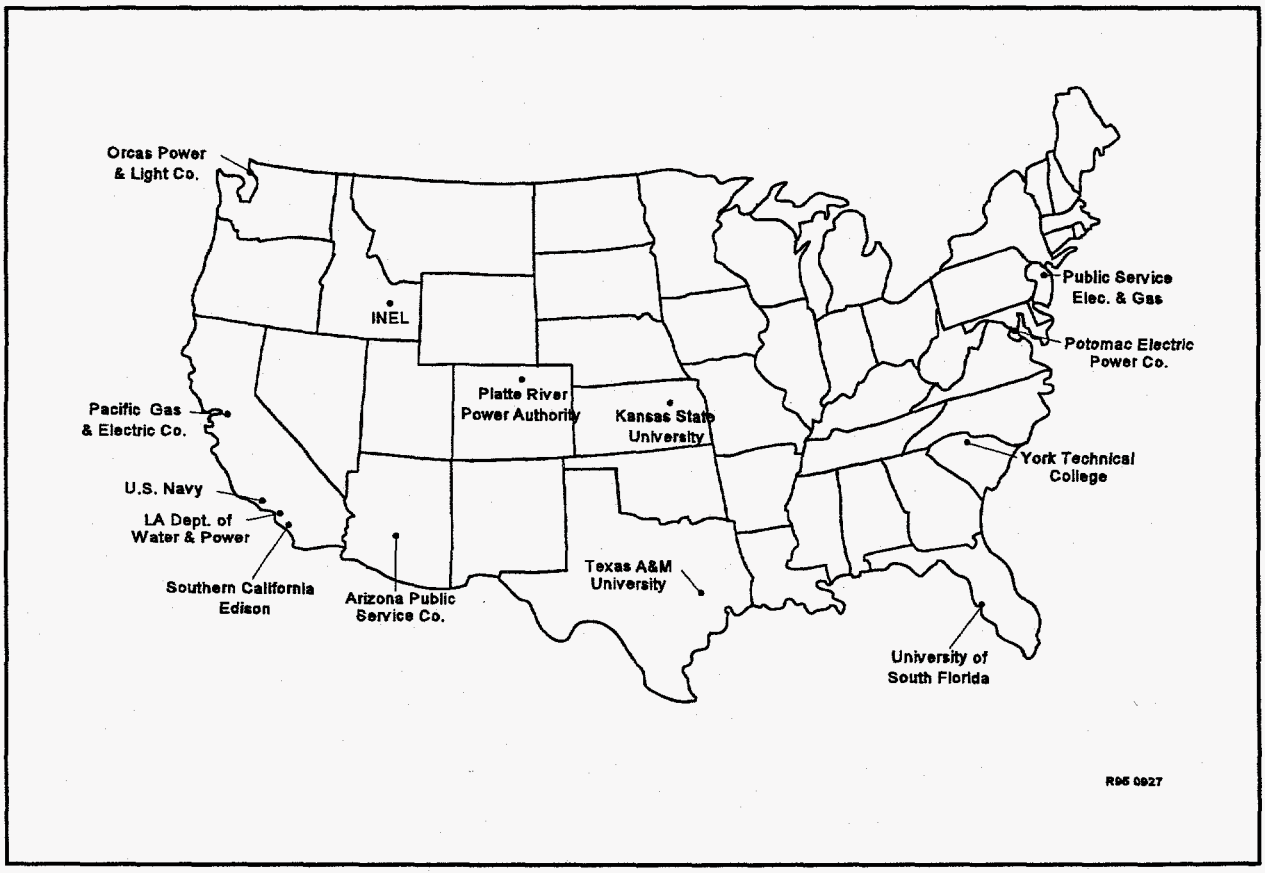

Figure 1. DOE electric vehicle Site Operator Program participant locations.

Table 1. Site Operator vehicle fleet.

Arizona Public Service Company (APS)

1.	Unique sedan	2 ea.
2.	G-Van (cargo)	2 ea.
3.	G-Van (passenger)	2 ea.
4.	EVcort sedan	3 ea.
5.	Solar Colt sedan	1 ea.
6.	TEVan	1 ea.
7.	Honda CRX	1 ea.
8.	Saturn	1 ea.
9.	Solectria	1 ea.
10.	S-10	4 ea.
	TOTAL	18

NOTE: Does not include 3 vehicles donated to local organizations

Kansas State University (KSU)

1.	EVcort sedan	2 ea.
	TOTAL	2

Los Angeles Department of Water and Power (LADWP)

1.	G-Van (passenger)	4 ea.
2.	G-Van (cargo)	2 ea.
3.	Unique hybrid passenger	1 ea.
4.	TEVan	4 ea.
5.	S-10 pickup	4 ea.
6.	Prizm sedan	5 ea.
	TOTAL	20

Orcas Power and Light Company (OPALCO)

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

Table 1. (continued)

Pacific Gas and Electric Company (PG&E)

1.	G-Van (passenger)	2 ea.
2.	G-Van (cargo)	1 ea.
3.	Ecostars	2 ea.
4.	EVcort	1 ea.
	TOTAL	6

Platte River Power Authority (PRPA)

1.	EVcort sedan	2 ea.
	TOTAL	2

Potomac Electric Power Company (PEPCO)

1.	G-Van (passenger)*	1 ea.
2.	Solectria Force	1 ea
3.	EVcort	1 ea
	TOTAL	3

Sandia National Laboratory

1.	Electrica (Escort conversion)	12 ea.
	TOTAL	12

Southern California Edison Company (SCE)

1.	G-Van (passenger)	9 ea.
2.	G-Van (cargo)	6 ea.
3.	Ford Ecostar	6 ea.
4.	Solectria Force	5 ea.
5.	Electricar pickup (S-10)	4 ea.
6.	BAT sedan	1 ea.
7.	Pickup (Venus Motors) (Ranger)	1 ea.

Table 1. (continued)

Southern California Edison Company (cont'd)

8.	Sedan, Prizm	3 ea.
9.	TEVan	2 ea.
10.	Bus (Clean Air Transit)	1 ea.
11.	Honda sedans	3 ea.
12.	Van, Dodge Caravan	1 ea.
	TOTAL	42

*** Not currently in service**

Texas A&M University (TAMU)

1.	G-Van	15 ea. (Includes consortium vehicles)
2.	Jet	1 ea.
3.	TEVan	8 ea.
4.	Race Car	2 ea.
5.	S-10 Pickup	3 ea.
	TOTAL	29

U.S. Navy (NAVY)

1.	Jet (various)	42 ea.
2.	Grumman Van	2
3.	S-10	6
4.	G-Vans	5
5.	Bedford Vans	5
6.	Griffon Van	6 ea.
	TOTAL	66

University of South Florida (USF)

1.	G-Van (passenger)	2 ea.
2.	Chevy S-10 Pickup	10 ea.
3.	Dakota	1 ea.
4.	Mirage	1 ea.
	TOTAL	14

York Technical College (YORK)

1.	G-Van	1 ea.
2.	Escort (Bearskin)	1 ea.
3.	Unique Sedan	2 ea.
4.	S-10 Pickup	8 ea.
5.	Solectria Force	1 ea.
	TOTAL	13

TOTAL - SITE OPERATOR PROGRAM 229

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

Note: VW-Pickup curb weight = 3370 lbs; Griffon Van curb weight = 5513 lbs; Mitsubishi Mirage curb weight = 2590 lbs, Mitsubishi Mirage GVW weight = 3417 lbs.

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 Management

The Program report for the fourth quarter of FY-94 was issued.

Modification of the financial agreements with current participants is being discussed.

Orders for the remaining 22 electric vehicle conversions from GE/Spartan have been canceled by this supplier. The MDAS units originally slated for installation in many of these units from GE/Spartan will be used in other operator-sponsored vehicles.

Initial laboratory tests of two different versions of the Sigma Tec Systems MDAS unit have been completed at the INEL, and the results reported. Further laboratory tests of the more advanced version are planned, to provide a baseline for evaluating in-vehicle performance of this device.

Ten MDAS units are on order for use in the EV American Test Support effort involving testing at Virginia Electric Power Company.

Review of contract renewals for Program participants is completed. Task recommendations will be based on funding availability. The PEPCO contract has been renewed; others will be renewed as they expire.

The Interface Agreement between the Site Operator Program and EV America is in the review process.

The annual Site Operator Users Task Force Meeting was held during November 1994 in Washington, DC.

Table 3. Recommended MDAS distribution for S-10 pickup conversions.

Site	No. Spartan	W/MDAS	No. Electricar	W/MDAS	EV Operating Envionment
APS	6	4	–	–	Warm-hot/flat/urban
KSU	4	2	–	–	Warm-cold/flat-suburban
LADWP	–	–	5	3	Warm-cool/mixed/urban
PEPCO	2	2	2	2	Hot-cold/mixed urban
PRPA	5	3	–	–	Warm-cool/ mixed/suburban-rural
PG&E	–	–	5	3	Warm-cool/mixed/urban-suburban
SCE	3	2	3	2	Warm-cool/mixed/urban-suburban freeway
TAMU	–	–	3	3	Hot-cool/flat/rural-suburban
USF	2	2	–	–	Hot-cool/flat-urban-freeway
YORK	–	–	2	2	Hot-cool/flat/suburban-urban
Total	**22**	**15**	**20**	**15**	

Program Experience Overview

Because a principal interest, and corresponding activity, of the Site Operator Program is vehicle performance evaluation, various data acquisition and analysis methods and equipment are in use. Most recently, installation of the Mobile Data Acquisition System in several new Program vehicles will provide real-time operating data. However, these vehicles will not be operated all at a single site, nor under closely similar conditions. It then becomes necessary to arrive at a sound basis for data comparisons, groupings, and statistical interpretations. The objective here is to determine how many vehicles must be tested, and for how long a time interval, to assure a 95% confidence level in the data.

Two reports were transmitted to DOE on September 9, 1994:

1. "*Application of the Technique for Estimating the Number of Electric Vehicles and Length of Time Necessary for a Field Test to G-Van-C Data*"

2. "*Technique for Estimating the Number of Electric Vehicles and Length of Time Necessary for a Field Test.*"

Report 1 presents a classical statistical analysis of field test data for G-vans operated by Public Service Electric and Gas Company. Report 2 applies multivariate statistical methods to operating data from a Mobile Data Acquisition System installed in an electric vehicle from Virginia Power Corp. and tested at the Idaho National Engineering Laboratory.

The method, data, and the consequent calculations are presented in these two reports, and are available from the INEL Vehicle Database(s) within the Automotive Systems and Technology Department. The MDAS, combined with the multi-variate data analysis techniques will provide about 7 times better precision than the manual data acquisition method used to acquire the PSE&G, G-Van-C data. This improvement will allow the average vehicle efficiency to be measured with 95% confidence with the number of samples computed as 649.

Thus, with three vehicles per site as the lower limit recommended in Report No. 1, the classical analysis presented herein predicts that 216 samples are required; and with four vehicles per site, 162 samples are required. This result appears consistent with the trend of the results presented in Report No. 1, which demonstrated that for three similar vehicles, the results were just beginning to converge to the 95% confidence interval within 50 samples per vehicle.

MDAS units were tested at the INEL to compare with the Laboratory Data Acquisition System (LDAS). The MDAS was limited to 16 channels, a substantially increased flexibility as needed. The precisions are eight binary bytes for the MDAS and 16 for the LDAS. Sampling frequencies are adjustable for both systems; the data from either system can be normalized to give comparable results. The reports of this investigation are in publication.

At this time, there exists no comprehensive data to define the battery life for the seven vehicles analyzed, either in terms of the life of modules within the battery pack or in terms of the life of the battery pack as a whole. However, the INEL Energy Storage Test Laboratory has acquired limited data for a wide range of vehicle applications while advising the Site Operators concerning replacement of battery pack modules that failed prematurely. Based on this experience, it seems reasonable to estimate that some lead-acid battery modules, in a fleet operation environment, will begin to fail prematurely within 200 charge cycles. Thus, to assure that 95% confidence results can be achieved within the test time interval, and within the life of a battery module or pack, then four similar vehicles, tested for 162 charge cycles, must be recommended. As both MDAS and maintenance data are acquired, showing battery life cycle information, this estimate of battery life can be revised, as necessary.

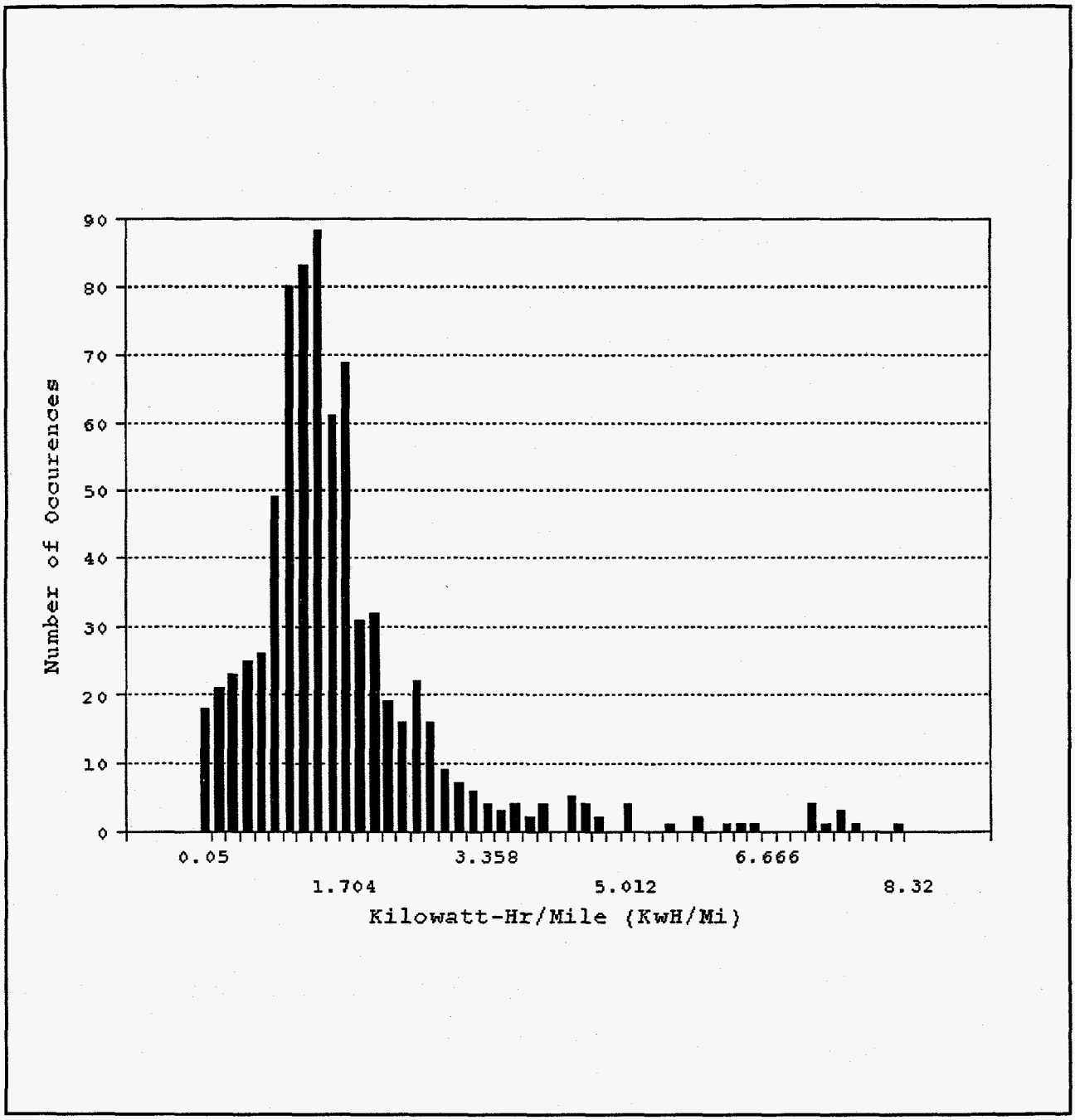

Figure 2. A frequency distribution histogram of the kilowatt-hours per mile for seven different cargo G-Vans (numbers 455 through 461), operated by PSE&G.

Summary

The DOE Site Operator Program currently receives input from 14 sites in the U.S. The participants are public utilities, educational institutions, a National Laboratory, and the U.S. Navy. (During this reporting period, no input was received from the Navy.) The number of electric vehicles now in use or undergoing test evaluations exceeds 175, ranging in age from new to twelve years. Body styles are mainly for utility (van or pickup) or passenger service.

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

The principal operating problem reported is a decrease in vehicle range, usually a direct result of battery pack problems, but also a function of the climate, especially the ambient temperature, in the operating environment.

The principal maintenance problems relate first to batteries and then to failures of electric components in the control systems and the powertrain.

Program management activities relate to issuance of reports, communication with sponsors (DOE) and cooperating institutions, determination of program goals/objectives, and evaluation of advanced EV-related components and systems.

An overview of Program experience, derived from the operator inputs, demonstrates unequivocally the differences in energy and maintenance costs for operating the principal types of electric vehicles used by the participants. A categorical breakdown of service/repair costs in $/km identifies the principal problem groups associated with each vehicle type. This information, presented in Appendix A, is not all-inclusive of the Site Operators; for the others, the data were either not provided or were submitted in a form that is incompatible with the Program's data-handling algorithms.

It is for these reasons that in-vehicle automated data acquisition systems will be implemented in the near future. The DOE data requirements are currently being developed for automated data systems, and a summary of these developments will be presented in a future Site Operator Quarterly report.

Despite apparent commonalities of interests among the Program participants, their individual contributions have been adequately diverse, for a variety of reasons related to equipment, operating environment, operating philosophy, and the overall objectives of each participant. The three major categories of the Program Mission appear to be well served.

APPENDIX A

SITE OPERATOR PROGRAM PARTICIPANTS' PROGRAM ACTIVITIES

Site Operators

Arizona Public Service (APS) - maintains and operates about a dozen electric vehicles of various types in its Electric Vehicle (EV) Program, primarily in the Phoenix area (see Tables 1 and 2). Both passenger and cargo vehicles are represented. Much of the vehicle usage is demonstration, often under loan or lease arrangements. As a public utility, APS benefits from EV usage throughout its territory because of energy sales to meet the battery charging requirements. The APS EV Program activity summaries also cover EVs leased to or owned by the cities of Phoenix and Scottsdale. This program is supported by several APS subsections. Technical information is coordinated with Southern California Edison, the U.S. Department of Energy (DOE), the Idaho National Engineering Laboratory (INEL), and the Electric Power Research Institute (EPRI).

Technical

APS has logged over 550,000 miles on their electric vehicles since 1979 as part of the DOE EV Site Operator Program. The APS EVcorts consistently show the lowest operating costs, competitive with equivalent ICE vehicles.

A Chrysler TEVan is currently under evaluation by the APS Research Department. Mileage to date on this vehicle is 6,200; a nickel cadmium battery is used.

Delivery of parts for replacement of the controller in the Motorola S-10 pickup conversion with DC drive system has been delayed for six weeks. The chargers for this vehicle are not following the charging algorithm.

The accessory battery in one cargo G-Van required replacement.

The Spartan S-10 conversion with AC drive system required replacement of the accessory battery and power steering vacuum switch, and repair of a short circuit in the 12-volt wiring harness.

APS reports zero maintenance hours for a vehicle group comprising the TEVan, three Solectrias, and three U.S. Electricar S-10s. One of the Solectria is being tested for EV America.

Public Awareness

No submittal was received for this period.

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. The latter effort is a contractual joint venture of six major electric utilities in the state; 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 electric vehicles (see Table 1), maintained at the KSU campus and available for demonstration purposes on short-term loan to interested utilities and other companies. Further use is routine transportation by the Program and the Engineering Technology Department under ambient weather and driving conditions.

Technical

Both Soleq EVcorts were returned to the manufacturer for warranty service during the reporting period. One failed while in use; the charger on the other failed. Return to operational status is expected within the next quarter. Combined mileage to date exceeds 8,300 miles.

KSU experience with these two EVs emphasizes significant continuing problems in several areas:

- Passenger comfort and preheat systems
- Regenerative braking
- Unavailability of standard repair manuals and essential technical information because manufacturers want to protect their developing technology. In the absence of proper documentation, the operator is forced to perform even minor repairs through a "reverse engineering" process, which is both time-consuming and expensive.

In general, the spectrum of problems would cause potential customers to view these vehicles as other than proven technology.

Previously reported effects of battery weight overload on the EVcort suspension, brakes, and tires continue to mount. Increasing the wheel size to accommodate larger tires is complicated by associated brake replacement problems and is therefore cost prohibitive. KSU concludes that accelerated road use will result in premature wear and fatigue of other structural components of the vehicle, and that overall vehicle quality must be improved if EVs are to be marketable.

The four S-10 conversions on order from Spartan Motors still do not have a firm delivery date. KSU feels that issues surrounding the conversion process and product (discussed in the previous Site Operator Quarterly) cast increasing doubt on any fulfillment of this order.

Public Awareness

The EVcorts have been active during this quarter in numerous displays throughout the region.

Professor Hague was an invited guest speaker on electric vehicles at an Alternate Fuel Energy Programs event, sponsored by the Kansas Corporation Commission, and presented the KSU role and achievements at a seminar on alternative fuel vehicles. At the 1994 EVS-12 Exposition, Professor Hague chaired a session on EV Infrastructure, and manned a booth highlighting EV technology advances by participants in the Kansas Electric Utilities Research Program.

At the request of Kansas City Power and Light Co., KSU participated in the Alternative Fuels Vehicle Expo held at Kansas City, MO, and at the request of the Central Electric Vehicle Coalition, participated at the Central Electric Vehicle Symposium held in Oklahoma City, OK.

KSU is working an arrangement for the SunRayce '95 event to start in June 1995. The solar vehicle race (1000 students and 60 solar vehicles) will make an overnight stop at the KSU campus.

KSU was represented at the November meeting of the Site Operators Users Task Force meeting held in Washington, DC, in conjunction with the annual ETC year-end meeting and the EV America vehicle test data review.

Los Angeles Department of Water and Power (LADWP) - currently operates twenty (20) electric vehicles (see Table 1). Its participation in the DOE Site Operator Program involves only a hybrid minivan (Unique Mobility, Englewood, CO.), for test and evaluation, ultimately as a candidate fleet vehicle, and a Chrysler TEVan.

Technical

The UNIQ hybrid minivan remained nonoperational in the final quarter of FY-94.

The Chrysler TEVans continue to exhibit a variety of problems, primarily failures of motor control units and auxiliary power units. Fortunately, most of the failures have occurred during vehicle charging, rather than in operation.

A major, unresolved, issue is the inability to charge these vehicles from a GFCI-equipped 220-volt single-phase outlet. Use of GFCI devices is required on all electric vehicle charging facilities by the Los Angeles Building Code. A similar problem exists with the U.S. Electricar S-10 conversion.

During the last quarter of FY-94, and the first quarter of FY-95, LADWP took delivery of five U.S. Electricar Prizm sedans and five S-10 pickup conversions. Manufacturing and design issues were identified for supplier resolution; as a consequence, no comprehensive field test data could be obtained.

LADWP and Southern California Edison Company co-sponsored the PrEView Drive Program to evaluate EV use and infrastructure at the retail level. The program, involving the General Motors sport vehicle "Impact" and 2- to 4-week test drives by 80 customers, began during the final quarter of FY-94. Electrical service for charging stations was installed at 27 customers' residences. During the initial quarter of the program, no vehicle-oriented problems were reported for the Impacts.

Three electric shuttle buses were operated in the San Pedro Harbor area, eight hours daily and seven days weekly, with a few maintenance problems, including one motor controller failure. These buses logged 10,318 miles. A similar one-vehicle operation at the Los Angeles International Airport logged 1,260 total miles during the same period, and carried 8,251 passengers during the reporting period. Several equipment improvements were made.

Public Awareness

Preparations for the PrEView Drive Program included:

- Briefings and extended drives for LADWP board and management personnel, legislators, and regulators
- Displays and ride-and-drives for employees and business leaders
- Public displays in conjunction with local community and commercial events.

LADWP employees helped to staff most of these events.

Electric vehicle and infrastructure-related topics received continuing coverage in the area news media.

LADWP and the Southcoast Air Quality Management District have co-sponsored the Bank of America 22-passenger shuttle bus in downtown Los Angeles.

As a participant in the CALSTART Electric Bus/Mass Transit Program, LADWP is working with suppliers, operators, and political agencies to develop and implement pollution-free public passenger transport systems, and demonstrate existing capabilities. In conjunction with LA's Harbor Department and Department of Transportation, LADWP is operating three trolley-style electric shuttles in the LA Harbor area on a three-year demonstration program. Service is eight hours daily, seven days weekly. Since this service began in November 1992, the system has carried more than 30,000 passengers comprising a variety of interests.

Orcas Power and Light Company (OPALCO) - of Eastsound, WA, operates two (2) electric vehicles (see Table 1) as part of its participation in the DOE Site Operator Program. This electric utility serves customers in the islands of San Juan County, WA. The OPALCO territory presents some driving conditions and operating problems not encountered by other Program participants.

OPALCO is actively encouraging EV ownership/operation by both public demonstrations and enlarging the necessary infrastructure with additional EV charging stations.

Technical

The total vehicle mileage for the reporting period was 249, approximately half for each vehicle.

The Escort battery pack was replaced in December. Persistent battery problems with the Solectria severely reduced its usage, also.

OPALCO is concentrating on adding EV battery-charging stations at optimum locations in its service territory, with input from EV owners, public works officials, and property owners. The installations are exclusively EHV Corporation EDD-7, parking-meter-style, units. A report on installation and use patterns will be delivered to the supplier, Western Resources, a Kansas public utility. Station No. 3 is now in service. Four more of these units were purchased during the quarter, and sites have been secured for three.

Public Awareness

In the "Sustainable Technology Center of the San Juan Islands" project, a three-building complex will house demonstrations of new technologies in residential and commercial design and construction. Electric transportation will be emphasized. OPALCO will provide an EDD-7 charging station and two electronic watt-hour meters. Facility completion is expected in June 1995.

The San Juan County Electric Vehicle Association now holds regular meetings via an interactive video network, a distinct advantage in view of wide membership dispersion on a number of islands.

Fact sheets on electric transportation are made available at a local bank on San Juan Island, where Charge Station No. 3 is now in operation.

An OPALCO submission won third place in the "Best Customer Involvement" category of the "Excellence In Communications" competition, sponsored by the Northwest Public Power Association. The entry was an information card to be used when the public asks questions of an EV driver.

Details of the DOE/Site Operator Users Task Force Program, both general and specific to OPALCO, were presented at a forum on electric transportation, sponsored by the San Juan Sustainability Group.

OPALCO is participating in a research project sponsored by the National Rural Electric Cooperative Association. The purpose is to study the impact of electric vehicle commercialization on rural electric cooperatives. Thirteen cooperatives will contribute data from customer surveys.

Pacific Gas and Electric Company (PG&E) - a public utility based in California's Bay Area, operates three G-Vans as part of its participation in the Site Operator Program (see Table 1). The overall program effort relates to many broad areas of interest in addition to vehicle testing and performance evaluation:

- Infrastructure R&D is concerned with charging systems and their load and distribution impacts.
- Joint efforts with the Bay Area Rapid Transit (BART) District reflect the benefits of increased usage of public transportation in the Bay Area.
- Collaboration with EPRI and the Electric Vehicle Association of the Americas is directed toward increased public awareness of EV technology and benefits.
- Cooperative efforts with California universities and other utilities are studying demand-side load management.
- PG&E, other utilities, and EPRI are working to establish a test protocol for human exposure to electromagnetic fields.
- Jointly with two other utilities, PG&E has applied to the California Public Utilities Commission for approval of special EV billing rates.
- PG&E is actively involved in the California Electric Vehicle Task Force, concerned with issues affecting EV commercialization. Other task force members represent utilities, private industry, and state regulatory agencies.
- PG&E is also participating in the efforts of the Infrastructure Working Council, a subgroup of EPRI. The membership of this organization represents automakers, utilities, code specialists, and other EV stakeholders, with the goal of a standard, safe, and reliable EV charging infrastructure.
- PG&E is a member of CALSTART, a consortium of more than 40 public and private entities mobilized to create an electric transportation industry in California and address related issues.

Technical

No information was received for this period.

Public Awareness

No information was received for this period.

Platte River Power Authority (PRPA) - operates two (2) electric vehicles (see Table 1) as part of its participation in the DOE Site Operator Program. PRPA, a political subdivision of the State of Colorado, maintains and operates facilities for generation and wholesale distribution of electrical energy to four Colorado municipalities: Estes Park, Fort Collins, Longmont, and Loveland. The thrust of PRPA activities under this program is threefold:

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

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

Technical

Total mileage for the two vehicles during the reporting period was 1,139. The vehicles were used primarily as pool vehicles within the PRPA fleet, but their limited range precluded the more frequent, longer than 40-mile trips. Both vehicles required no maintenance during the reporting period.

The EVcorts are each equipped with an on-board load profile meter that automatically integrates AC energy used for charging, over 15-minute periods, and stores the load data for monthly download. Vehicle log sheets completed by the operator insure that no charge data are lost.

Five S-10 pickup conversions are on order from Spartan Motors, Inc.

Public Awareness

No public demonstrations of the two vehicles during the quarterly reporting period were made.

Potomac Electric Power Company (PEPCO) - At the present time, PEPCO in Washington, DC, operates three EVs in the Site Operator Program (see Table 1). The principal use is fleet service. PEPCO's primary interest in electric vehicles is sale of electric power for battery charging.

Technical

The PEPCO inventory includes a third EV, an EVcort, sent to York Technical College to be fitted with a nickel-cadmium battery pack from SAFT Battery Co. Still to be located is a charger that can produce the required algorithm specified by the battery manufacturer. Because the current charging method is a two-step, manual process, PEPCO has delegated the testing of this EV to York.

Two S-10 pickup conversions are on order from Solectria, for Spring 1995 delivery.

As a result of performance problems, the G-Van continues out of service.

The only EV in current use is the Solectria Force. Accrued mileage since last reported is 872. This vehicle serves primarily and frequently as a demonstrator. Unscheduled maintenance for this quarter totaled 10 hours.

PEPCO has developed a field test program to determine practical performance of EVs in fleet applications. Collected data will be divided into three levels:

1. Manually collected, including maintenance and reliability
2. Automated on-board systems output
3. Directed field test data.

In a planned two-month pilot program between PEPCO and Virginia Power, ten vehicles equipped with the University of South Florida Mobile Data Acquisition System will be monitored at Level 2, and 40 units will provide Level 1 input. The pilot program will evaluate data collection/reporting protocols before the Field Test Program is implemented on a national scale.

Public Awareness

Within the past three quarters, the Solectria Force has been publicly demonstrated 47 times, including two County Fairs. The PEPCO Electric Vehicle Program was presented to five different audiences.

PEPCO supported the demonstration drives of the General Motors Impact vehicle in the DC area during this quarter.

PEPCO is participating in an industry commercialization initiative, EV-America. The goals are at least 500 EVs to be procured for fleet and demonstration service by the end of 1995, and 5,000 by the end of 1997. DOE support of related test activities will be co-ordinated by the Site Operator Program.

As part of this participation, a formal protocol for EV testing was developed. The purpose was to set a benchmark for each vendor's product and establish a baseline for EV development. Related testing, conducted during the quarter in Phoenix, AZ, evaluated nine vehicles from five manufacturers. Results were released in December 1994.

Sandia National Laboratory (SNL) - at Albuquerque, NM is no longer involved with the DOE Site Operator Program, but contact with the SNL Electric Vehicle Program continues, with reciprocal information sharing. The reporting period for SNL is Calendar Year 1994.

Seven "Electricas" (Ford Escort conversions) have been in service since 1981; four additional vehicles were obtained from the U.S. Navy, refurbished, and put into service in November 1987. A twelfth Electrica (1983 model) obtained from Public Service Company of New Mexico, was placed in service during September 1993. SNL has operated these vehicles on a daily basis in missions that vary from benign to very hard.

Technical

Fleet mileage for FY-94 was 4,434. Cumulative mileage now exceeds 112,000, with a single minor accident. Fleet average energy use for 1994 was 1.172 kW·h/mi. A preventative maintenance program for the fleet, implemented in CY-90, checks each vehicle at 6 to 8 week intervals. Repairs and replacements are made as needed. A survey shows the following problems, in decreasing order:

- Failure of the 12-volt auxiliary battery from heavy accessory drain causes the speed controller to lose logic. A modified charging algorithm to maintain the traction and auxiliary batteries independently, coupled with an efficient DC-to-DC converter, appears to be needed.

- Failure of the state-of-charge system causes vehicle stranding. Original units by Anderson are no longer available. Seven vehicles now have defective state-of-charge units. A modified Curtis Instrument #934 device was installed and tested; it gives the correct state-of-charge only for a specific load on the battery pack. A Model STSOC-LAI device is on order from Sigma Tec Systems, Inc. of Tampa, FL. Delivery, installation, and evaluation is planned for early 1995.

- Exhaust fan failures are caused by corrosive vapors from the battery compartment.

- Logic board component aging causes shut-off failures in the charging cycle. Replacement boards are no longer commercially available. A Sandia-made replacement was not successful, but development work continues.

- Faulty micro-switch in the power brake pressure sensing unit fails in the "ON" position. Additional battery drain occurs, but no safety problem is involved. Switch adjustment or replacement has so far been an adequate remedy.

- The consequences of vehicle aging and wear are becoming obvious. OEM clutch assembly failure this year is new; all five air-conditioning units are inoperative and repair parts are no longer available.

- Gasoline heater system components continue to develop problems.

Public Awareness

SNL has addressed environmental safety and health issues associated with EV operation in a document "ES&H Standard Operating Procedure for the Electric Vehicle - Electrica," and a supplement, "Electrica Operating and Safety Manual."

The 14-year-old technology represented by the current vehicle complement is not well suited to public awareness program. If SNL is to continue to show and demonstrate EVs, a substantially newer – state-of-the-art – vehicle should be obtained for this purpose.

Southern California Edison Company (SCE) -

an electric utility, currently operates and maintains 42 electric vehicles as part of its participation in the DOE Site Operator Program (see Table 1). The SCE effort involves major roles in electric vehicle and component testing/evaluation, battery technology development, recharge infrastructure development, demand-side management, and overall technological leadership in meeting the air quality and transportation requirements of the area.

In filling the final role, SCE shares its technical expertise and test results with two California regulatory agencies: The South Coast Air Quality Management District and the California Air Resources Board. The results of

this continuing cooperation can be seen in the electric shuttle operated by several Southern California cities and technical assistance in feasibility studies of truck and bus conversions.

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

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

Technical

Cumulative EV mileage to date for 27 vehicles, other than G-Vans, now in operation exceeds 81,000. SCE continues to expand its EV fleet. Thus far, G-Vans (15) constitute the majority of the current fleet and are the basis for most of the previously reported operating and experience data. A 30-month lease for twelve Ford Ecostars has been executed, with delivery of the last five during this quarter. Six Ecostars are assigned to the Huntington Beach Post Office for mail service.

The US Electricar vehicles delivered in 1994 all require retrofit on some key systems.

Four additional vehicles were received this quarter: One BAT sedan, and three Honda sedans on a two-year lease. A BAT pickup truck and a Solectria S-10 conversion are currently on order. Three S-10 conversions ordered from Spartan Motors as part of the 1994 DOE "Group Buy" project will not be received; Spartan canceled the entire 22-vehicle order.

The Mobile Data Acquisition Systems originally specified for these three vehicles will (subject to DOE approval) be used in other SCE-controlled electric vehicles. Additional Level 2 automated data acquisition systems have been ordered for other SCE electric vehicles. These two-part systems have a capability similar to the MDAS.

Performance characterization testing of the Electricar Prizm and the Chrysler TEVan was completed and test reports submitted to the Site Operator Program.

Major maintenance was required on the Ecostars:

- Replace vehicle system controller (all units)
- Replace sodium-sulfur batteries (two units)
- Replace transaxle (two units).

The Honda units also received much attention during their break-in and test sequences. A variety of maintenance and repair activities were needed for most of the other operating units.

Existing vehicles are variously assigned, comprising company field operations, vehicle and component research, public events, and infrastructure development. SCE plans to loan vehicles to outside users on a continuing basis, when appropriate to SCE and program purposes. Loan agreements with several companies have been finalized.

Vehicle and component testing by SCE or on contract serves not only to identify technical advances and problems, but also provides essential input to planning and operating the electric utility system.

Maintenance logs indicate a spread of mechanical and electrical operating problems with both vehicles and associated service equipment. However, the most common problems continue to be electrical, related to either the battery pack or the charger.

SCE is participating in workshops to revise procedures for the planned EV America performance testing efforts, co-funded by DOE.

Public Awareness

SCE has loaned electric vehicles from its fleet to other companies and individuals operating within the SCE service territory, in order to determine what types of customers might buy EVs, how such EVs might be used and recharged, and how vehicle performance affects usage. This information will permit SCE to develop and implement the electric utility infrastructure needed for widespread commercial deployment of EVs.

As part of the Infrastructure Program, SCE provides guest speakers for local organizations upon request. Electric vehicles and their benefits are a popular topic.

SCE is also involved with the EV fleet activities of other entities operating within the utility's service territory, and is currently participating with CALSTART in the conversion of two school buses to electric. These units are now in service in the Santa Barbara and Santa Monica areas. In addition, SCE is participating in the demonstration and field tests of the General Motors Impact EV.

Texas A&M University (TAMU)

- conducts a Site Operator Program at its Center for Electrochemical Systems and Hydrogen Research, Texas Engineering Experiment Station, College Station, TX. The current complement of electric vehicles comprises 24 passenger and cargo vehicles (see Tables 1 and 2) and two zinc-bromine race cars. The ultimate thrust of the Program is education (i.e., graduate school support). 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), respectively.

The South Central Electric Vehicle Consortium (SCEVC), based at TAMU, supports the TAMU Electric Vehicle Program and also brings together EV fleet owners and operators throughout Texas and Oklahoma.

Technical

Three S-10 conversions were received from U.S. Electricar. None of them was equipped to the Site Operator Program Specifications. As received, the vehicles had a variety of problems and deficiencies; some were remedied by TAMU personnel, and others were brought to the supplier's attention. To date, MDAS units have been retrofitted to two of the three, but are not yet trouble-free. On-board charging (requiring 11 to 18 hours charge time) has been replaced by inductive charging (less than 4 hours) on two of the vehicles. These trucks are now in service with SCEVC member fleets in Austin, Dallas, and Oklahoma City.

During initial testing, a combination of very short trips and absence of energy input measurements made it difficult to obtain accurate performance data. Kilowatt-hour meters have now been installed for input. A single measurement shows energy consumption of 0.69 kW·h/mi.

During this quarter, two of the TEVans required 83 hours and 7 hours of unscheduled maintenance, and 1 hour and 17.5 hours of scheduled maintenance, respectively.

Public Awareness

A U.S. Electricar S-10 pickup was displayed and demonstrated (ride-and-drive) at the Central EV Symposium in Oklahoma City, and at the Texas Fleet Operators Alternative Fuel Vehicle/Gas Expo held in Houston. The TAMU EV team also made a presentation and gave rides to sixth-grade students at the College Station Elementary School.

U.S. Navy (NAVY) - As noted in Table 1, the U.S. Navy installation at Port Hueneme, CA, has a large complement of electric vehicles, representing several manufacturers and body styles, and a broad span of vehicle ages. 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.

Technical

Initial contributions of fleet operating and maintenance data are reported in the Program Experience Overview section of this report. No other input was received for this quarter.

The University of South Florida (USF) - at Tampa, monitors and tests 14 electric vehicles as a participant in the DOE Site Operator Program (see Table 1). The 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 the effort is the development of a utility-interconnected photovoltaic EV charging system. Additional associations include Florida Power and Light Co., Florida Energy Office, Naval Weapons Center, GTE Mobilnet, and National Renewable Energy Laboratory.

Technical

The reported vehicle inventory comprises:

- Two G-Vans
- Ten Chevrolet S-10 conversions, one a hybrid vehicle
  - One operated by Pinellas County Air Quality Office
  - One operated by Bruderly Engineering Associates of Gainesville.
  - One operated by Jacksonville Air Quality Division
  - Two in use at USF by the Electrical Engineering Department
  - One, a hybrid, operated by Dade County
  - One operated by Hillsborough County Environmental Protection Commission
  - One operated by Orlando Air Quality

- One Mitsubishi Mirage conversion, in use at USF for light delivery and commuter service.
- One Dakota pickup
- The Solectrica Force was destroyed in a single-vehicle accident.

The overall USF plan is to locate site operators and participating vehicles throughout the State of Florida. Collection of performance data from such a widespread territory and a varied spectrum of driving cycles is greatly simplified by the Mobile Data Acquisition System (MDAS). Its hardware and software, while standardized, offer wide flexibility in measurement capability. As currently used in a G-Van, a Mirage, a Solectria, and two S-10s, it monitors main battery pack voltage, current, and temperature; and in addition, EV velocity, cab temperature, and ambient temperature, all relevant to optimum EV use in the Florida climate. Other options for specific EV types or models are being evaluated by the USF EV research group. An Automatic Data Retrieval System (ADRS) acquires the MDAS output via cellular or land-line telephones for processing and analysis by computers at USF, and subsequent distribution. To date, MDAS units have been installed in electric vehicles owned or operated by:

- University of South Florida
- Bruderly Engineering
- City of Jacksonville
- City of Tampa
- Orange County
- Pinellas County
- Volusia County
- Hillsborough County
- Florida Power Corp.

Data from additional EVs acquired and operated in the Tampa/St. Petersburg metro area by Florida Power Corp. will be included in the USF database. Other operators contributing to this database will be located in the counties of Alachua, Volusia, Pinellas, Dade, Polk, Duval, Brevard, and Orange.

Tests of Hall Effect sensors used for measurement in MDAS units show significant current drift with increasing temperature. It was concluded that separate Hall Effect sensors are needed for accurate measurement of the low-range charging currents and the higher discharge currents.

The photovoltaic charging system is in operation. Four source circuits accommodate the DC-DC controller for direct charging the S-10 pickup batteries. All source circuits are interconnected to the electric utility grid, via a microprocessor-controlled inverter. An automatic photovoltaic data acquisition system acquires data (voltage, current, temperature, and irradiance) from the arrays to analyze and compare the performance and effectiveness of each array, as well as overall performance.

Reconfiguration of source circuit components now allows current control by 3.2 ampere multiples, up to 41.6 A. This arrangement provides for a relatively smooth charging curve, particularly in the current-controlled charging regimen for the last 20 to 30% of charge. The charging rate is maximized and the effects of irradiance fluctuations are minimized. Charging rate control is based on a calculated battery gassing voltage.

A variety of investigations have been conducted in conjunction with system hardware and software modifications. The continuing objective is to improve and more accurately measure system performance and efficiency. It is noted that charger losses vary through the entire range of charge, but not in the same manner from one method to another.

DC-DC sun-charging shows an overall efficiency exceeding 93%. However, the less efficient AC-DC operation may be required under conditions of low or no sunlight. The data acquisition system for the photovoltaic charging site has been integrated with the DC-DC charging software, and the resulting system will be referred to as DC-DAS. Analysis of the data permits an evaluation of the strengths and the deficiencies of DC-DC and DC-AC-DC charging methods. Preliminary evaluations of the fixed tilt angels (insolation) of the three photovoltaic arrays indicate that the 15° angle is more efficient for year-around use in the Tampa area.

During this quarter, the system generated energy equivalent to 440 vehicle miles per week, more than was needed for the USF EV fleet.

Two vehicle damage investigations were conducted:

- The Solectria Force was destroyed in a single-vehicle accident
- The Pinellas County S-10 pickup suffered fire damage.

Another complete battery pack replacement at 5,530 miles was found necessary as a result of degradation of a majority of the units. A stringent watering and equalization schedule is now in place, along with driver education on effects of over-discharging.

Public Awareness

Details of two electric bus projects were established during this quarter:

- A project with Hillsborough Area Regional Transit, including a photovoltaic system in downtown Tampa.
- A project with Pinellas Suncoast Transit Agency for a circulator bus in Pinellas Park.
- Electric vehicles were driven to and displayed at public events in Lakeland and Tampa.
- USF was represented at the Fall 1994 ARPA Technical Program for electric vehicles.
- A technical paper entitled, "*Data Acquisition and Performance Analysis From a Network of EVs, Including PV Charging*," was presented at EVS-12.
- USF personnel continue participation in efforts sponsored by Advanced Research Projects Agency, with the Southern Coalition for Advanced Transportation.

York Technical College (YORK) - at Rock Hill, SC operates 13 electric vehicles under the Site Operator Program (see Table 1). Interest in EV technology at YORK goes beyond the nominal Program scope and is well demonstrated by the school's growing Electric Vehicle Program and emphasis on public awareness. Programmatic associations and interchanges continue with local electric utilities, other Program participants, municipalities, South Carolina State Energy Office, regional secondary schools and colleges, and the Clean Air Transport Association.

Technical

No information was provided for this period.

Public Awareness

No information was provided for this period.