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# Electric Vehicle Field Operations Program

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## ABSTRACT

Electric vehicle use has reached a new era, as vehicles are now available as commercial products from original equipment manufacturers. While previous vehicles were considered test products or prototypes, today's electric vehicles are being purchased or leased by fleet managers for utility, government, and private fleets. Unfortunately, these vehicles do not have documented histories in fleet applications, and fleet managers often need support when determining if electric vehicles fit mission requirements. In support of the electric vehicle deployment effort, the U.S. Department of Energy's Field Operations Program evaluates electric vehicles in real-world applications and environments with the goal of increasing the awareness and acceptance of electric vehicles.

## INTRODUCTION

The Field Operations Program and its predecessor, the Site Operator Program, were established by the U.S. Department of Energy (DOE) to implement 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, interests, and technologies. The Field Operations Program goals include evaluating electric vehicles in real-world applications and environments, advancing electric vehicle technologies, and increasing the awareness and acceptance of electric vehicles. Personnel of the Idaho National Engineering and Environmental Laboratory (INEEL) manage the Field Operations Program. To support the field evaluation of electric vehicle technologies, during 1996 DOE selected two Qualified Vehicle Testers (QVT's) through competitive bids. One of the QVTs is the Southern California Edison Company. The other QVT is a consortium of Electric Transportation Applications (ETA), Arizona Public Service (APS), Salt River Project (SRP) and Potomac Electric Power Company (PEPCO); ETA is the consortium leader. The Program and its QVT partners use three testing methods to measure vehicle performance: Baseline Performance (EVAmerica), Accelerated Reliability, and normal fleet testing. In addition, Pomona Loop testing is performed by Southern California Edison. Not all vehicle models are subjected to all four test methods.

The Program has performed Baseline Performance testing on 20 vehicle models since testing began in 1994. In addition, as of midyear 1999, the Program has accumulated over 400,000 miles on 65 vehicles while performing Accelerated Reliability and Fleet testing. Total electric vehicle fleet experience for the Program and the QVTs exceeds 2.5 million miles. Vehicle testing is discussed in detail below. All of the testing has been cost shared 50-50 between DOE and the QVTs.

To increase the awareness and acceptance of electric vehicles by Federal fleets, the Field Operations Program has also developed an electric vehicle loaner project in conjunction with six electric utilities. Through the electric vehicle loaner activities, Federal fleets can use electric vehicles for free for up to 2 months at a time. This encourages greater understanding of electric vehicle performance and capabilities. In addition, the Field Operations Program provides incremental funding for any Federal Fleet that is leasing a light-duty commercially available electric vehicle.

This paper will communicate testing results and operations experience of commercially available electric vehicles and vehicle performance improvement trends. Other Program activities will also be discussed, including the Federal Fleet National Loaner Program and the Incremental Funding Program. For a more complete description of Program activities, Program reports, and testing results, visit the Program's Internet web site at http://ev.inel.gov/sop

## TESTING METHODS

Baseline Performance Testing. Baseline Performance testing, which has also been known as EVAmerica Testing, is performed on a closed track and a dynamometer. The Baseline Performance testing measures variables such as acceleration, braking, payload, charging, energy efficiencies, and vehicle range. Vehicle range is measured during constant speed tests at 45 and 60 miles per hour, and during a drive cycle (SAE J1634) test performed on a dynamometer. The testing and data qualification process takes approximately 2 months. Traditionally, this test is performed once for each vehicle. However several vehicles have been tested more than once, each time with a different battery technology (Table 1). The Baseline Performance testing provides a snapshot of a vehicle's performance characteristics that has evolved into the electric vehicle industry-testing standard. The final product is a vehicle fact sheet with the test results.

**Table 1.** Baseline Performance test vehicles, and battery technologies (Pb - lead acid, NiMH – nickel metal hydride, NiFe – nickel iron).

| Test Year | Vehicle Manufacturer, Model, and Battery Technology | | |
|---|---|---|---|
| 1999 | General Motors EV1 NiMH | Ford Ranger NiMH | Chevrolet S-10 NiMH |
| 1998 | Toyota RAV4 NiMH | | |
| 1997 | Ford Ranger Pb | Chevrolet S-10 Pb | |
| 1996 | General Motors EV1 Pb | Toyota RAV4 Pb | |
| 1995 | Solectria Force NiMH | Solectria E10 Pb | Baker EV100 NiMH |
| 1994 | Bat Intnl. Metro Pb | Bat Intnl. Metro Pb | Bat Intnl. Pickup Pb |
| | Dodge Caravan NiFe | Solectria Force Pb | Solectria E10 Pb |
| | Unique Mobility Pickup Pb | US Electricar Sedan Pb | US Electricar Pickup Pb |

Accelerated Reliability Testing. During Accelerated Reliability testing, several vehicles of the same model are driven in typical fleet applications, including employee commuting, with the explicate goal of maximizing mileage. The goal is to accumulate 25,000 miles within a single year to accelerate life-cycle vehicle performance information. The final product is a report describing energy use, miles driven, maintenance requirements, and overall vehicle performance.

Fleet Testing. During Fleet testing, several vehicles of the same model are used in everyday fleet tasks by utility employees. While Fleet testing has been able to document a vehicle's capabilities, or lack thereof, because of the limited range of many of the vehicles and the missions they are placed in, data accumulation is often very slow. In fact, manufacturers have changed their battery technologies and other vehicle features while testing was ongoing. This type of testing will not continue to be used in the future.

The Baseline Performance and Accelerated Reliability testing have proven to be very beneficial to both potential vehicle users and the vehicle manufacturers. Both types of tests provide timely information, documenting a vehicle's capabilities and identifying any operations problems. Additional testing information is provided below.

As would be expected, the energy efficiencies (for individual models) that are discussed in this paper will vary for each of the different types of tests. For instance, for every vehicle ever tested, the Baseline Performance constant speed 45 mph test always results in a higher energy efficiency than the constant speed 60 mph test for the same vehicle (the lower wind resistance at 45 mph will result in higher energy efficiencies). What the reader should be aware of is how and where energy efficiency is measured. For the Baseline Performance constant speed 45 mph, constant speed 60 mph, and driving cycle range (SAE J1634) tests, the energy use is measured in kWh-DC at the battery pack. The given energy efficiencies for all of the Pomona Loop, Accelerated Reliability, and Fleet tests are measured in kWh-AC, on the utility side of the charger. The Baseline Performance Charging Efficiency results are also measured in kWh-AC on the utility side of the charger. The hotel loads, which is the time a vehicle sits on charge without being used and the utility energy used to heat or cool a vehicle while on charge, also impact energy efficiencies.

## BASELINE PERFORMANCE (EV AMERICA) TESTING RESULTS AND TRENDS

The Field Operations Program and its electric utility partners have conducted Baseline Performance testing on 20 vehicle models since 1994 (see Table 1). Recent test vehicles (with nickel-metal-hydride batteries) include the electric Ford Ranger, General Motors EV1, Chevrolet S-10, and Toyota RAV4. The test results provide a good characterization of expected vehicle performance. The testing has documented range increases of up to 150% when comparing the 1999 test vehicles to the 1994 test vehicles. The 1999 results include a drive-cycle range of 140 miles and a constant speed (45 mph) range of 220 miles for the General Motors EV1. The DOE sponsored Baseline Performance testing was originally known as EV America testing, when it was performed under the Site Operator Program. The Site Operator Program was the predecessor to the Field Operations Program.

A commonly asked question has always been whether electric vehicle performance is improving. In an effort to answer this question, the Baseline Performance electric vehicle testing results are averaged on an annual basis and the results are presented here. The average annual testing results presented in the graphs in this section incorporate the testing results for the 20 vehicles that have undergone Baseline Performance testing from 1994 through 1999. The averages are the numeric means. The Baseline Performance test procedures and a testing result fact sheet for each vehicle are available from the Field Operations Program's website.

All three of the Range Tests (Driving Cycle [Figure 1], Constant Speed at 45 mph [Figure 2], and Constant Speed at 60 mph [Figure 3]) exhibit similar trends – the

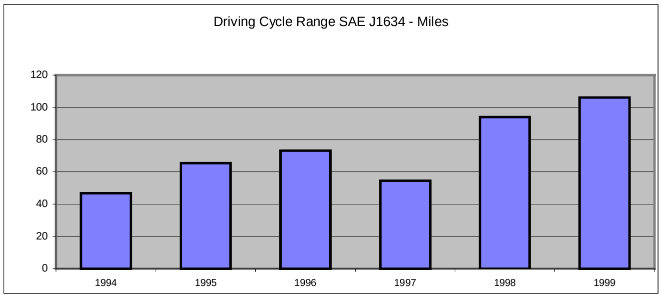


**Figure 1**. Drive cycle range test (SAE J1634) average annual testing results.

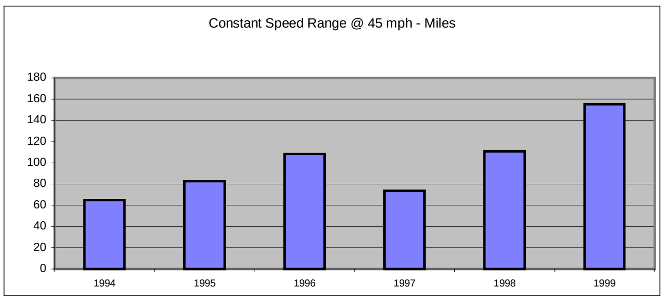


**Figure 2.** Constant speed (45 mph) range test average annual testing results.

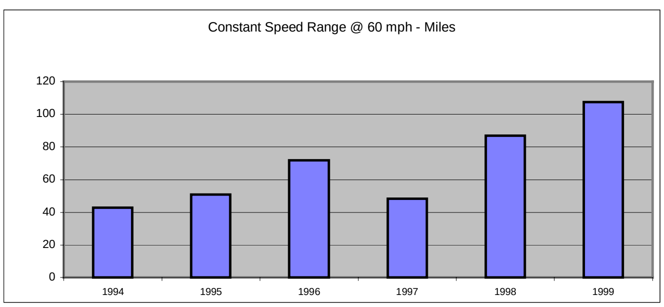


**Figure 3.** Constant speed (60 mph) range test average annual testing results.

test results improved every year except for the 1997 test vehicles. The 1999 results were driven by the EV1 equipped with the Nickel-Metal-Hydride (NiMH) battery. The EV1 had the highest test results to date; it went 221 miles in the 45-mph constant speed test, 161 miles in the 60-mph constant speed test, and 140 miles in the drive-cycle range test (Figure 4). The two pickups tested during 1999 were also equipped with NiMH batteries and they averaged 89 miles for the drive-cycle test, 123 miles in the 45-mph constant speed test, and 81 miles in the 60-mph constant speed test.

The 1997 decreases in range can be at least partially attributed to the type of vehicles tested that year. Both of the 1997 test vehicles were pickups, with lead acid batteries, intended for use in utility types of fleet applications. The 1997 vehicles (Chevrolet S-10 and Ford Ranger) have an average payload of 825 pounds (Figure 5). A single vehicle, the Baker pickup and its 1,719-pound payload (Figure 6), drove the payload average for the 1995 vehicles, while the other two 1995 test vehicles had an average payload of 546 pounds. The two 1996 test vehicles had an average payload of 533 pounds. One of these, the EV1, has a payload of 440 pounds. However, the EV1 is a sports coupe that clearly is not intended as a utility work vehicle with its light payload.

The average annual acceleration tests performed when each vehicle's battery pack is at a 50% state-of-charge shows an overall increase in vehicle performance (Figure 7). The average annual time to accelerate from 0 to 50 mph has decreased from the 24-second average recorded during 1994 to 10 seconds for the 1999 test vehicles. The 1996 vehicles also averaged 10 seconds in the acceleration testing. The lead-acid EV1, tested during 1996, had a 0 to 50-mph acceleration time of 6.7 seconds at a 50% state-of-charge (Figure 8). At 100% state-of-charge, the EV1 accelerated from 0 to 50 mph in 6.3 seconds (averages not shown for 100% state-of-charge testing).

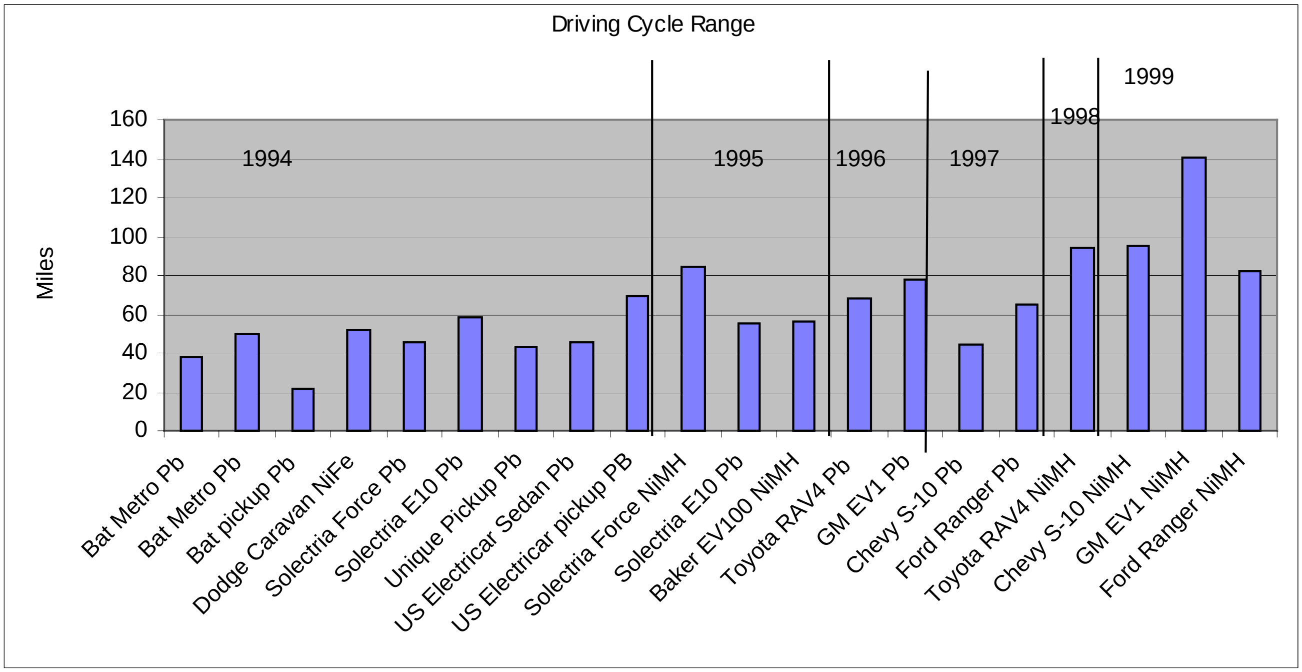


**Figure 4**. Individual Driving Cycle range (SAE J1634) testing results.

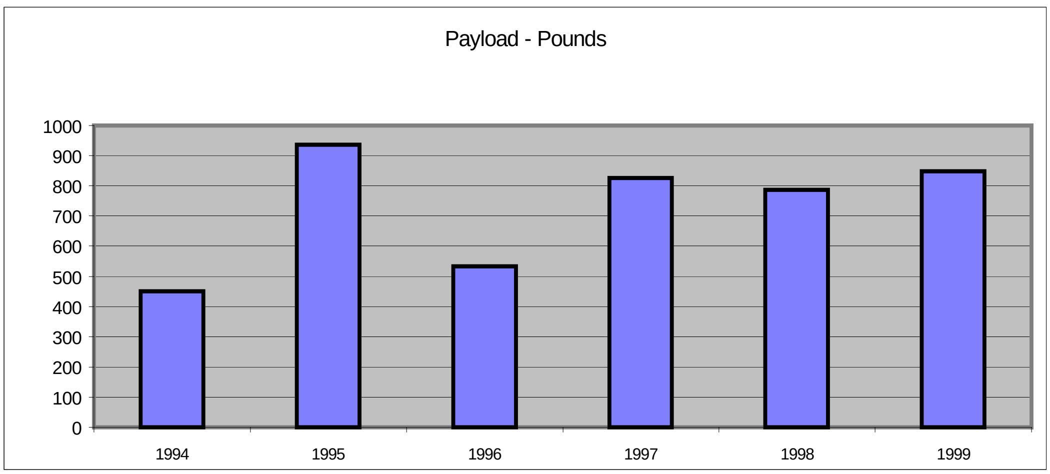


**Figure 5**. Average annual payloads.

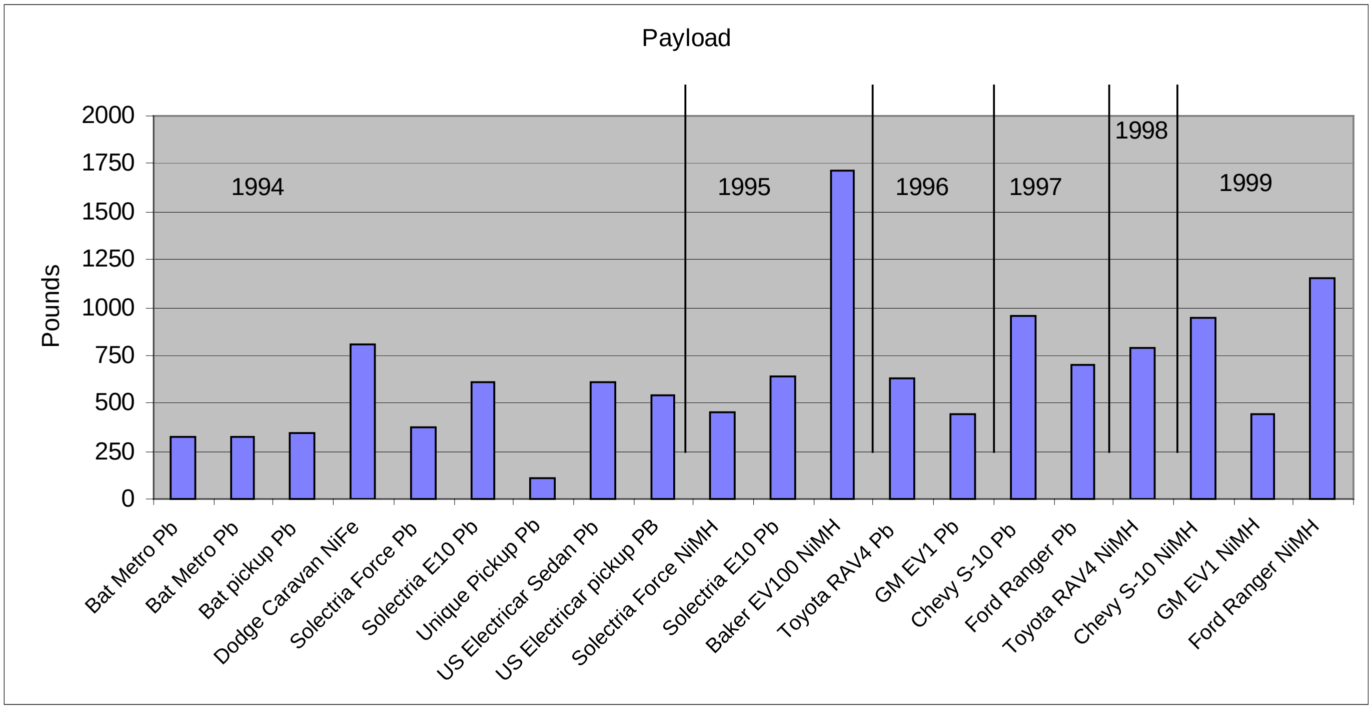


**Figure 6.** Individual vehicle payloads.

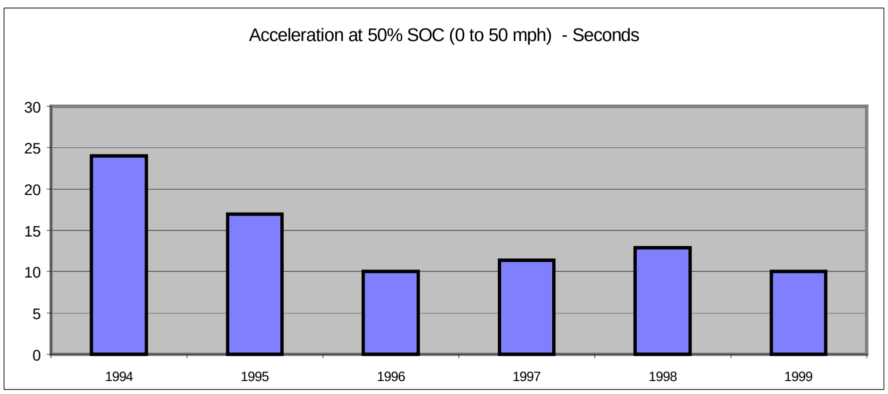


**Figure 7.** Average annual acceleration testing results.

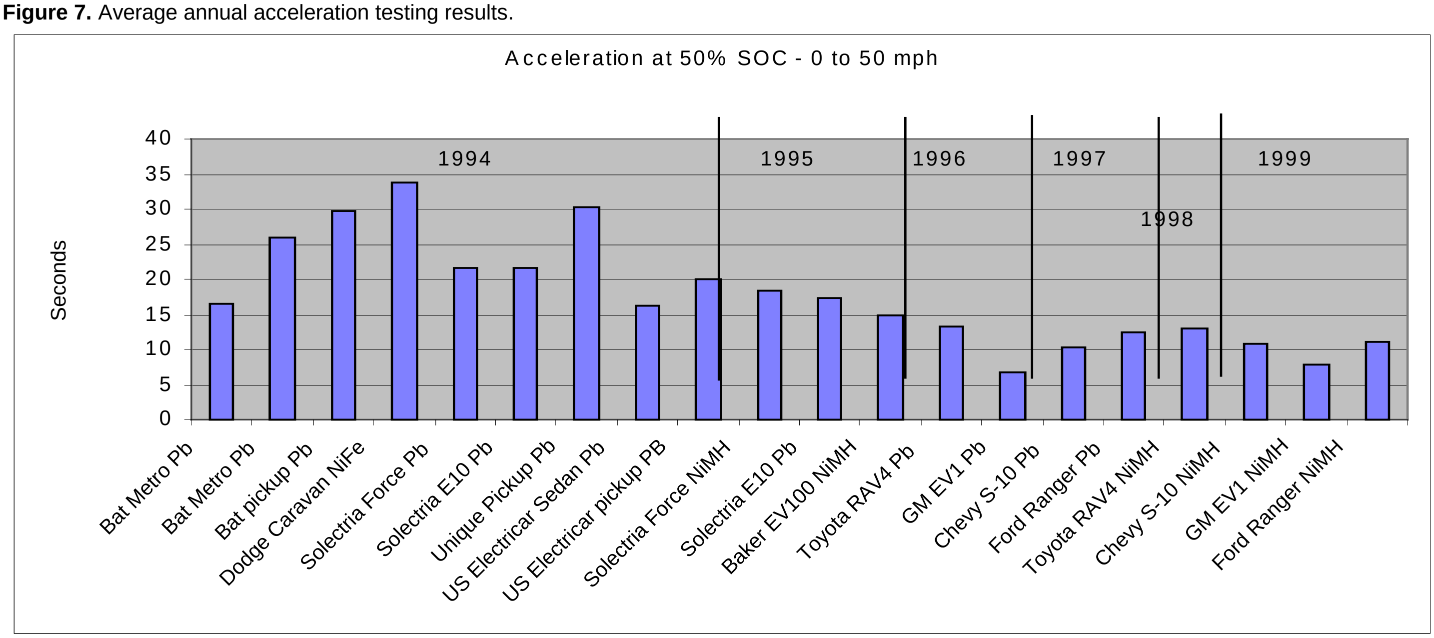


**Figure 8.** Individual testing results for acceleration 0 to 50 mph at 50% vehicle state-of-charge.

The average annual maximum-speed testing results at 1 mile and a battery pack state-of-charge of 50%, shows an upward trend, especially when comparing the 1994 and 1995 averages to the 1996 through 1999 averages (Figure 9). The 1996 vehicles had the highest average maximum speed, again led by the lead-acid EV1 with a speed of 80 mph.

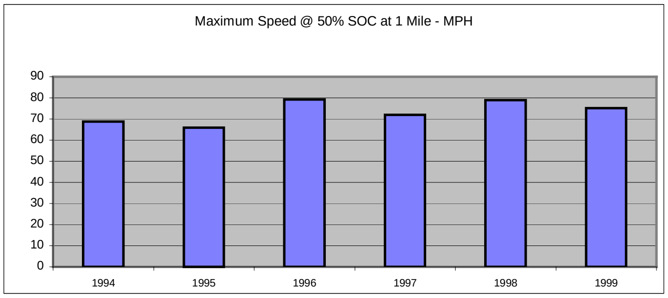


**Figure 9**. Average annual testing results for maximum vehicle speed testing in one mile at a 50% state-of-charge.

The graphs in this section provide a brief snapshot of several performance characteristics. These testing parameters suggest that the Baseline Performance-tested electric vehicles continue to exhibit annual improvements in their performance capabilities. In addition, other factors such as the warranties offered by the original equipment manufactures (OEM) support the belief that overall vehicle performance continues to improve. The OEMs are now warranting their vehicles for 3 years and 36,000 miles, with most of the vehicles only being available as 3-year leases. During the next few years, the Field Operations Program will continue to test electric vehicles with advanced battery technologies as well as hybrid vehicles. To obtain additional Baseline Performance vehicle testing results, including information on newly tested vehicles, visit the Field Operations Program website.

POMONA LOOP TESTING

In addition to the Baseline Performance range tests conducted by ETA, SCE also performs range tests know as the Urban and Freeway Pomona Loop tests. In contrast to the "closed track" nature of the Baseline Performance tests, the Pomona Loop tests are performed on Southern California urban streets and area freeways. The Urban Loop test is 19.3 miles long and its elevation varies from 900 to 1,500 feet above sea level. The Freeway Loop is 37.2 miles long and its elevation varies from 700 to 1,150 feet above sea level. The loops are considered fair representations of "typical" Southern California driving patterns. The tested vehicles are driven on each loop four times. Each trip is driven with either the minimum or maximum payloads and either with or without auxiliary power loads (such as air conditioning). Test results for all four testing variables are provided. As an example, Figure 10 shows the testing results for the Urban Pomona Loop test of a lead-acid equipped Chevrolet S-10.

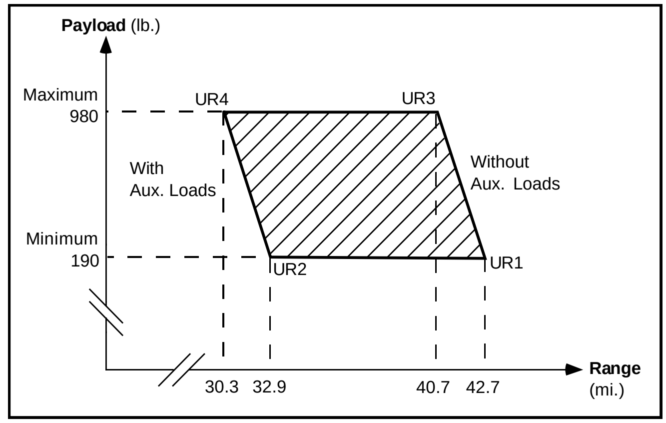


**Figure 10.** Chevrolet S-10 Urban Pomona Loop testing results. The S-10 is tested at minimum and maximum payloads (left axis), and with and without auxiliary power loads (bottom axis).

The results for the seven vehicles that have completed the Pomona Loop testing is graphed below (Figure 11). The graph includes the absolute minimum and maximum mileage results for both the Urban and Freeway testing for each vehicle. The graph ranges include the four testing scenarios for both the Urban and Freeway Loops for each vehicle. The battery technology is also provided.

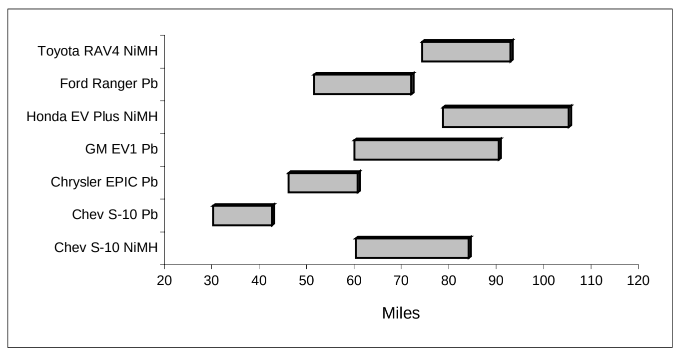


**Figure 11**. Urban and Freeway Pomona Loop test results. The battery technology (Pb – lead acid, NIMH – Nickel Metal Hydride) is provided for each vehicle.

The Pomona Loop and Baseline Performance testing minimums and maximums are graphed below (Figure 12) for those vehicles that have had both tests. The graphed Pomona Loop testing results include the minimum and maximum ranges for all four vehicle scenarios (with and without auxiliary loads, and minimum and maximum payloads) both for the Urban and Freeway loops. The graphed Baseline Performance testing results are the minimum and maximum ranges exhibited for the constant 45 and 60 mph speed tests and the drive cycle test. While there is some overlap within the testing results, the nature of each type of test

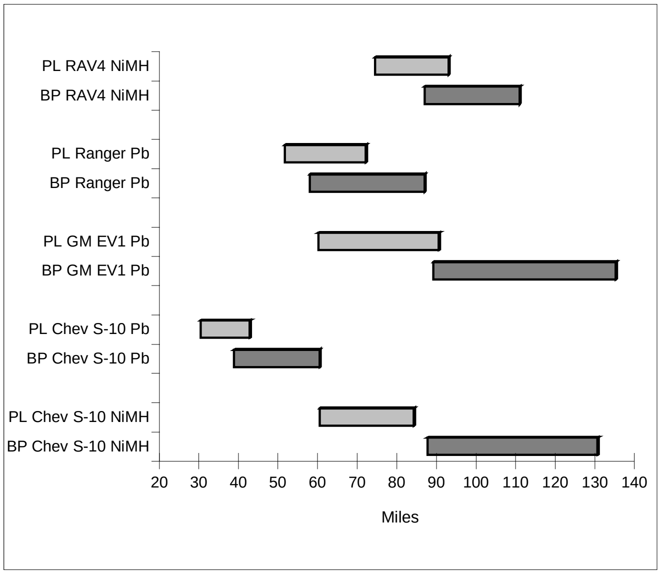


**Figure 12**. Pomona Loop (PL) and Baseline Performance (BP) range testing results. Battery technologies are NiMH and lead-acid (Pb). The Baseline Performance testing includes 332 pounds for the driver and test equipment.

influences the testing results. Generally, the Pomona Loop testing results will be lower than the Baseline Performance testing results. The Urban Pomona Loop test includes over 50 stop signs and traffic lights, while the Constant Speed tests do not include stops and reacceleration. The Freeway Pomona Loop can include many stops, depending on traffic conditions.

The lowest range results for all of the graphed Baseline Performance test vehicles occurred during the 60-mph Constant Speed testing. The highest range results for all of the graphed Baseline Performance test vehicles occurred during the 45-mph Constant Speed testing. The results for all of the graphed Baseline Performance Drive Cycle test vehicles fell in between the Constant Speed 45 and 60 mph test results.

## ACCELERATED RELIABILITY

Another of the field evaluation tasks of the Program is the accelerated reliability testing of commercially available electric vehicles. Vehicles that are subjected to Accelerated Reliability testing are operated by electric utilities with the goal of placing 25,000 miles on individual vehicles within 1 year. Since the normal utility fleet vehicle is only driven approximately 6,000 miles per year, this type of an operations mode allows an accelerated life-cycle analysis of vehicles. Driving is done on public roads in a random manner that simulates actual fleet operations. Data is collected and reported through the INEEL. The Program has completed Accelerated Reliability testing on the S-10 (see discussion below) and the results are reported here. The other vehicles currently undergoing Accelerated Reliability testing include the Chrysler EPIC, Ford Ranger, and Toyota RAV4 (Table 2).

**Table 2.** Accelerated Reliability Test vehicles, test miles, and testing locations and organizations as of July 1, 1999. Unless noted otherwise, all of the vehicles are Level II charged. The Ford Ranger Level III testing will not commence until the fall of 1999. (SCE – Southern California Edison, ETA – Electric Transportation Applications, Pepco – Potomac Electric Power Company).

| Vehicle Model | Number Vehicles | Testing Miles | Vehicle Tester | Location |
|---|---|---|---|---|
| Chevrolet S-10 | 3 | 21,447 | SCE | CA |
| Chevrolet S-10 | 2 | 50,137 | ETA/Pepco | AZ |
| Chrysler EPIC | 1 | 16,934 | SCE | CA |
| Ford Ranger | 3 | 39,283 | SCE | CA |
| Ford Ranger (Level III) | 3 | Start fall 1999 | SCE | CA |
| Ford Ranger | 2 | 10,299 | ETA/Pepco | AZ |
| Toyota RAV4 | 3 | 64,226 | SCE | CA |
| Total number of vehicles | 17 | 202,326 | | |

### Chevrolet S-10 Accelerated Reliability Testing

The Accelerated Reliability testing for the Chevrolet S-10 (Figures 13 and 14) has resulted in divergent operating experiences. While ETA was able to obtain their test vehicles almost immediately after the dealer received them, SCE's test vehicles went unused for a significant period of time while in transit from the manufacturer and while at the dealer. The difference in the amount of time that the vehicles went unused, as well as the difference in ambient temperatures between Phoenix and Southern California, resulted in contrasting test results.

**Figure 13.** Chevrolet S-10.

Without battery issues and the associated range limitations, the S-10s proved to be very desirable vehicles to drive. They exhibited operating characteristics (such as acceleration) equaling or exceeding that of the gasoline-powered S-10. However, the early version of lead-acid batteries (Delphi) used to power the electric S-10s had imperfections when operating conditions were not optimal. In spite of any environmental constraints due to the battery technology originally used, the S-10s displayed many positive operating characteristics that are discussed below.

The two S-10s operated by ETA in Phoenix were driven a combined total of more than 50,000 miles with only a single battery module failure. The two vehicles were placed on charge 1,429 and 3,087 times respectively, and they had AC energy efficiencies of 2.25 miles/$kWh_{AC}$ and 2.16 miles/$kWh_{AC}$. Assuming an energy cost of 7¢/kWh, the energy cost for operating the two vehicles for 50,000 miles, was about $1,600; this correlates to about 3.18¢/mile. The maintenance cost over the test period for these two S-10s was zero. Therefore, the total operating and maintenance costs for the S-10s operated by ETA was 3.18¢ per mile. If battery pack replacement is included in the operating cost at $5,000 per pack, the total operating and maintenance cost becomes 23.2¢/mile. The cost to lease a lead acid equipped S-10 is about $350 per month. Assuming the vehicles are driven about 6,000 miles per year in normal fleet use (24 miles per day times 50 weeks) results in a per-mile-cost of 70¢ per mile. Adding the energy cost of 3.18¢ per mile results in a life-cycle cost of just over 73¢ per mile. It should be recognized that based upon the loss of range and the spread of individual module voltages under load, that both of the ETA operated S-10s reached the end of their battery life at 25,000 miles each.

The S-10s operated by SCE in Southern California had mechanical or electrical problems. It became evident that most of the problems encountered early in the program were due to the time required for transporting the vehicles from the factory and for delivery to the customer. There was no record of what the state-of-charge (SOC) of the battery was when the vehicles left the factory. Unfortunately, after the vehicles were received at the dealer, they were stored off-charge for several months while the paperwork was being completed. It should be recognized that the Accelerated Reliability testing process is a test of *commercially available* vehicles; and, part of the *commercially available* process includes shipment through the vehicle dealer system and all of the benefits or negatives that entails. SCE's experience highlights the different shipping and handling requirements of electric vehicles compared to internal combustion-powered vehicles.

**Figure 14.** Chevrolet S-10 parked at inductive charging stations.

After the battery packs were replaced in all three of SCE's vehicles, average ranges were between 38 and 40 miles. However, testers noticed that the ranges would fluctuate from 30 to 45 miles during morning and afternoon driving cycles. The probable cause of these fluctuations was the ambient temperature (the vehicles performed poorly in cooler temperatures).

ETA also reported variations in vehicle range, with their S-10s having the highest average ranges during the summer months. Changes in ambient temperature from night to day and from season to season impacted range by as much as 10 miles. However, this can be mitigated by garaging the vehicles overnight and during the day when not in use.

The S-10 drivers also noted that excessive use of power during acceleration had a dramatic effect on vehicle range. The traction drive of the S-10 provides very spirited performance and creates a great temptation to the inexperienced electric vehicle driver to "have a good time" and to fully utilize the performance the vehicle offers. Unfortunately, the price of injudicious use of power is greatly reduced range and a long-term reduction in battery life. The range using full-power accelerations followed by rapid deceleration in city driving has been 20 miles or less.

Charge times also varied significantly due to environmental factors. The S-10 battery pack is actively cooled by the vehicle's air conditioning system. Refrigerant is diverted to a battery pack evaporator/fan when battery pack temperatures exceed 45° C. The high ambient temperatures in Phoenix presented a significant challenge to the pack cooling system. During summer daylight hours, air conditioning resources were always diverted to pack cooling, leaving the cabin without air conditioning. It was only well after dark that the pack would ever cool enough for pack cooling to stop and the refrigerant was diverted back to the cabin. This was the source of many negative driver comments with regard to cabin comfort. The high battery pack temperatures also frequently extended charge times as the chargers have significantly reduced charging power at high battery temperatures

The range of the S-10, as originally equipped with the Delphi lead-acid batteries, presented a challenge in finding applications where the mission requirements are enveloped by the vehicle range. Typically, fleet missions requiring a range of 25 miles or less are appropriate. The mission should also require daily use to ensure repeatable performance. Driver training should be provided to inform the vehicle driver of the effect of high power use on both range and battery life, as well as to instruct the driver in energy saving driving techniques.

The S-10 Electric has acceleration, handling, and payload capabilities that match or exceed most electric vehicles currently on the market. With the exception of cabin cooling issues, the vehicle's driving qualities and the comfort of the driver are considered very good by most of those who have driven it. The problems experienced have been largely related to the Delphi 12V battery modules originally used. In that regard, GM has been diligently making an effort to replace the battery packs of the S-10s with more reliable and better performing lead-acid or Nickel Metal Hydride (NiMH) batteries. The Panasonic lead-acid batteries are believed to provide at least 20% more range and be more reliable. The Program was preparing to Baseline Performance test the Panasonic equipped S-10 (and EV1) when this paper was due. Baseline Performance testing of the NiMH S-10 resulted in a drive cycle range test of 95 miles, more than double that of the original Baseline Performance testing results (43.8 miles) of the Dephi equipped S-10.

## FLEET TESTING

The Program has 57 vehicles undergoing Fleet testing. Vehicles involved in the Fleet testing (Table 3) provide data that are used to develop a report at the conclusion of vehicle testing. Operations information is also posted on the Program's web site. This data includes parameters such as miles per kilowatt hour charged (Figure 15) and miles driven per charge (Figure 16).

**Table 3.** Field Operations Program Fleet Test vehicles. Unless noted otherwise, all of the vehicles are level II charged. (SCE – Southern California Edison, ETA – Electric Transportation Applications, Pepco – Potomac Electric Power Company, APS – Arizona Public Service, and SRP – Salt River Project).

| Vehicle Model | Number Vehicles | Testing Miles | Vehicle Tester | Location |
|---|---|---|---|---|
| Chevrolet S-10 | 5 | 13,817 | SCE | CA |
| Chevrolet S-10 | 5 | 21,650 | ETA/APS/ Pepco | AZ(4), DC(1) |
| Ford Ranger | 13 | 11,669 | SCE | CA |
| Ford Ranger | 14 | 37,485 | ETA/APS/ Pepco/SRP | AZ(4), DC(10) |
| Toyota RAV4 | 10 | 100,364 | SCE | CA |
| Toyota RAV4 | 10 | 19,495 | Pepco | DC |
| Total number of vehicles | 57 | 204,480 | | |

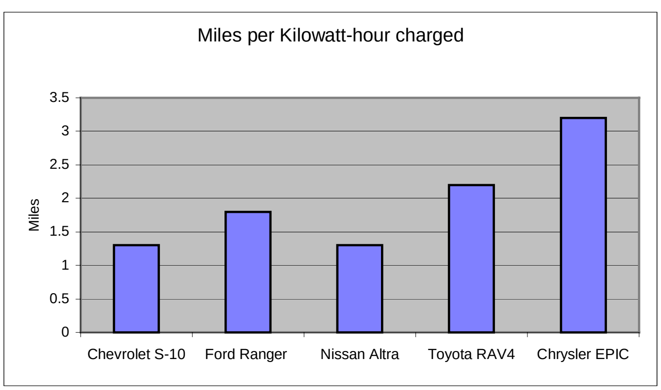


**Figure 15.** Average miles driven per kilowatt-hour charged by vehicle model for vehicles in Fleet testing.

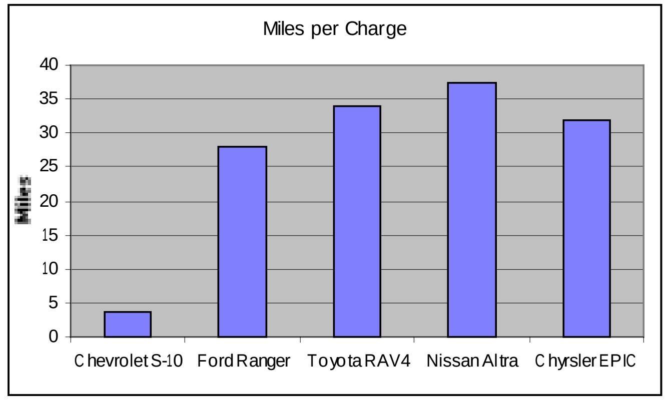


**Figure 16**. Average miles driven per charge for vehicles Fleet tested.

## NATIONAL LOANER PROGRAM

In an effort to increase electric vehicle awareness and acceptance, DOE is conducting a National Loaner Program that makes electric vehicles available to Federal fleets on a trial basis. This allows Federal fleets to test-drive the electric vehicles, usually for 1- or 2-month periods. This activity is being conducted in partnership with six electric utilities around the country as part of the Field Operations Program. The six utilities are: Virginia Power, Southern California Edison, San Diego Gas and Electric, Potomac Electric Power Company, Georgia Power, and Boston Edison.

Each utility has three to ten vehicles that are loaned to Federal Fleets within the utilities' respective service territories. The utilities are responsible for procuring and maintaining the vehicles; identifying, contacting, and coordinating with the Federal fleets for the temporary placement of the loaner vehicles; and, providing temporary charging infrastructure. The utilities have also committed to supporting the Federal fleets if they decide to lease an electric vehicle by helping to install permanent charging infrastructure, helping the Federal fleets decide which electric vehicle is the "right" vehicle for the Federal fleet's mission needs, supporting the leasing process, and providing assistance with any maintenance problems. If a Federal Fleet decides to lease an electric vehicle, it can then take advantage of the incremental funding being offered by DOE.

## INCREMENTAL FUNDING PROGRAM

To support and encourage Federal Fleets to lease electric vehicles, DOE will pay 50% of the incremental costs when a Federal agency leases an electric vehicle. The incremental funding is available through the Field Operations Program.

The incremental cost is the difference between the General Services Administration's cost to lease a gasoline-powered vehicle and the cost to lease an electric version. For example, the GSA's lease rate for a gasoline-powered small pickup is about $220 per month, while an electric Ford Ranger with lead-acid batteries can be leased for $349 per month. The difference, or incremental cost, is $129 per month. The Field Operations Program pays half of this amount, or $64.50.

Ford is leasing Rangers equipped with lead-acid batteries in all states except California. There, Ford is leasing Rangers equipped with NiMH batteries, and this vehicle is leasing for $450 per month. Another vehicle available in California with NiMH batteries is the Chrysler EPIC minivan, which is also leasing for $450 per month. General Motors is offering a NiMH-equipped version of its Chevrolet S-10 in California for $440 per month. The lead-acid equipped S-10 is available nationally. All of the electric vehicles have 3-year, 36,000-mile warranties and the lease periods are for 3 years.

The Incremental Funding Program, while only starting during the spring of 1999, has proven to be popular with various Federal Agencies; over 30 agencies or divisions have requested information from the Field Operations Program. Some of the information requested has included help in identifying available electric vehicles that fit the agency's mission requirements, whether to lease or purchase an electric vehicle, how to lease an electric vehicle, and identifying vehicle manufacturer contacts. To date, these 30 agencies and divisions expect to order about 200 electric vehicles during 1999, with incremental funding support from DOE.

## CONCLUSIONS

Electric vehicle performance continues to improve as battery and propulsion technologies improve. This improvement is at least partially driven by the commitments show by original equipment manufactures as they have replaced vehicle converters as the primary suppliers of electric vehicles; vehicles tested over the years by the Field Operations Program mimics this supplier evolution.

The Program continues to document vehicle performance to support the fleet managers' efforts to obtain quality electric vehicles. Baseline Performance testing continues to be the testing benchmark that all electric vehicles are measured by. It is anticipated that vehicle performance will continue to improve as more advanced battery technologies are commercially deployed, and battery quality and production processes improve.

The Program will continue to keep the fleet manager and other potential vehicle users as the central focus for the information generated by the Program, while continuing to work closely with the electric vehicle industry. The Program will continue to work closely with its private section partners to ensure that relevant vehicles are selected for testing to established standards that reflect industry needs. In addition, the Program will continue to support the placement of electric vehicles by activities such as the Federal Fleet Loaner Program and by providing incremental funding for electric vehicles.

With an eye towards the future, the Program is developing hybrid electric vehicle testing procedures to enable it to test the next generation of vehicles with electric propulsion drive-trains and more advanced energy storage and production systems. These new vehicles will likely have combinations of energy production engines such as fuel cells, direct injection diesels, gasoline, or natural gas engines, connected to energy storage systems using next generation storage platforms such as advanced batteries possibly in conjunction with ultracapacitors.

## REFERENCES

The Accelerated Reliability information for the Chevrolet S-10 is derived from testing conducted and reported by the Field Operations Program's Qualified Vehicle Testers partners Southern California Edison (J. Arguleta and M. Wehrey) and Electric Transportation Applications (D. Karner and L. Tyree)

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