UNITED STATES POSTAL SERVICE
ELECTRIC CARRIER ROUTE VEHICLE PROGRAM
500 VEHICLE FLEET DEPLOYMENT REPORT

EXECUTIVE SUMMARY

ES.1 INTRODUCTION

In 1999, the United States Postal Service (Postal Service) contracted with the Ford Motor Company (Ford) for the purchase of 500 Electric Carrier Route Vehicles (ECRVs). The ECRVs were phased into service at 22 Post Office locations --- with 20 in California and two on the East Coast --- between February 2001 and October 2002.

This Fleet Deployment Report has been prepared by the Postal Service to document the performance of the ECRVs during the first two years of deployment. Through the implementation of the 500-vehicle ECRV program, the Postal Service has been able to assess the degree of maturity of Battery Electric Vehicle (BEV) technology and its suitability for mail delivery and collection services. The report includes information and analysis to document how well the ECRVs have performed to date. Some of the key topics addressed in the report are:

- Energy efficiency of the vehicles
- Carrier satisfaction
- Maintenance and repairs
- Availability and reliability
- Battery performance
- Infrastructure and charging system
- On-board data collection

ES.2 ECRV DEPLOYMENT AND CHARGING SYSTEMS

Prior to deployment of the ECRVs, the Postal Service conducted a detailed assessment of potential deployment locations. The evaluation process considered a wide range of siting factors, including potential impacts on mail delivery operations, local support and incentive funding for AFV programs, size of the vehicle fleet at each site, proximity to the Postal Service's Vehicle Maintenance Facility (VMF), route distance, topography and climate, degree of support available from the electric utility, and other factors. The final list of deployment sites is shown in Table ES-1.

As part of the ECRV fleet deployment, electric charging infrastructure was installed at the 22 Post Offices. Single PCS units were also installed at each of the twelve Postal Service VMFs that service vehicles for the Post Offices.

The ECRV uses an onboard conductive charger and the vehicle is connected to electric charging power via an off-board Power Control Station (PCS). The PCS is a DCS-55 Dual Charging Station manufactured by Electrical Vehicle Infrastructure, Inc. (EVI). In addition to the PCS units, the main electric infrastructure components installed at each Post Office include a new electrical service entrance with an electric meter and main circuit breakers, a new panel housing 50 amp circuit breakers for each PCS unit, a new step-down transformer when needed to supply the 208-volt current to the PCS units, a new or upgraded main transformer when needed to supply the required electrical current for the ECRVs, and a timer unit that controls the time-of-day when the vehicles are charged.

TABLE ES-1 ECRV DEPLOYMENT SITES

Post Office	Address	Number of Vehicles	Deployment Date
Alameda Main	2201 Shoreline Dr., Alameda, CA 94501-6200	20	Jan-02
Bicentennial Station	7610 Beverly Blvd., Los Angeles, CA 90048-9996	57	Feb-02
Blossom Hill Station	5706 Cahalan Ave., San Jose, CA 95123-3008	20	Oct-02
Bostonia Station	867 N. Second St., El Cajon, CA 92021-5805	20	Aug-01
Costa Mesa Main	1590 Adams Ave., Costa Mesa, CA 92628-9001	20	Jun-01
Covina Main	545 Rimsdale Ave., Covina, CA 91722-9200	20	Jan-02
Dockweiler Station	3585 S. Vermont Ave., Los Angeles, CA 90007-3977	39	Apr-01
El Monte Main	11151 Valley Blvd., El Monte, CA 91734-9000	30	Oct-01
Fountain Valley	17227 Newhope, Fountain Valley, CA 92728-9005	28	Jan-01
Glendora Main	255 S. Glendora Ave., Glendora, CA 91740-9000	20	Jan-02
Harbor City	25690 Frampton Ave., Harbor City, CA 90710-2979	5	Aug-01
Ida Jean Haxton Station	9151 Atlanta Ave., Huntington Beach, CA 92615-9000	25	May-01
Irvine Harvest Station	17192 Murphy Ave., Irvine, CA 92623-9000	24	Jun-01
La Mirada	14901 Adelfa Dr., La Mirada, CA 90638-4749	15	Aug-01
Lamond Riggs, DC	6200 N. Capital St, N.W., Washington, DC 20011-4108	14	Mar-02
Linda Vista Station	2150 Comstock St., San Diego, CA 92111-9998	22	Aug-01
Los Feliz Station	1825 N. Vermont Ave., Los Angeles, CA 90027-4212	32	Aug-01
Norwalk	14011 Clarkdale Ave., Norwalk, CA 90650-8112	26	Sep-01
Pico Rivera	6320 Passons Blvd., Pico Rivera, CA 90660-3300	16	Sep-01
Royal Oaks Station	2000 Royal Oaks Dr., Sacramento, CA 95813-9998	20	Nov-01
San Gabriel Main	120 S. Del Mar Ave., San Gabriel, CA 91778-9000	20	Dec-01
White Plains, NY	100 Fisher Avenue, White Plains, NY 10606-1919	7	Mar-02

ES.3 ECRV ENERGY USE AND EFFICIENCY

The energy efficiency of the ECRVs was measured in terms of the miles driven for each kiloWatt hour (kWh) of electricity. Table ES-2 shows the vehicle miles driven for each site and for each four-week Accounting Period (AP) since deployment, and Figure ES-1 shows the average miles per day for the fleet by AP. The total distance driven by the fleet to date exceeds two million miles with an average of 10.0 miles per vehicle per day.

The electricity use for the ECRVs at the 22 Post Office locations was obtained from the electric utilities during the period from deployment through March 2003. The eight utilities that provide service to the ECRV Post Office sites are Southern California Edison, Los Angeles Department of Water and Power, San Diego Gas and Electric, Pacific Gas and Electric, Sacramento Municipal Utility District, Alameda Power, the Potomac Electric Power Company (PEPCO), and ConEdison. Figure ES-2 shows the average electricity use per vehicle per day by month, and energy efficiency is shown in Figure ES-3 (by site) and Figure ES-4 (by month). The energy efficiency at most sites is in the range 0.8 to 1.0 miles per kWh. The average cost for electricity has averaged $0.17c per kWh, inclusive all charges. It is likely that the average electricity cost could be decreased if charging practices were optimized to minimize use of on-peak electricity.

TABLE ES-2 MILES DRIVEN AND DAYS USED

Station Name	Number of Vehicles	Days Used	Days In Shop	Miles Driven	Average Miles/Day
Alameda Main PO	20	6,205	36	72,577	11.7
Bicentennial Station PO	57	14,216	581	10,8101	7.6
Blossom Hill Station PO	20	1,659	16	20,492	12.4
Bostonia Station PO	20	9,764	242	98,015	10.0
Costa Mesa Main PO	20	9,371	8	102,183	10.9
Covina Main PO	20	6,969	26	78,942	11.3
Dockweiler Station PO	39	21,818	41	178,362	8.2
El Monte Main PO	30	12,091	207	156,906	13.0
Fountain Valley PO	28	17,194	161	199,654	11.6
Glendora Main PO	20	6,512	26	90,203	13.9
Harbor City PO	5	2,410	0	22,878	9.5
Ida Jean Haxton PO	25	12,036	241	118,662	9.9
Irvine Harvest Station PO	24	12,457	204	151,265	12.1
La Mirada PO	15	6,310	111	63,711	10.1
Lamond Riggs PO	14	3,431	69	28,244	8.2
Linda Vista Station PO	22	10,659	197	99,454	9.3
Los Feliz Station PO	32	12,753	378	80,651	6.3
Norwalk PO	26	11,686	4	105,353	9.0
Rico Rivera PO	16	6,970	57	65,346	9.4
Royal Oaks Station PO	20	6,209	92	74,104	11.9
San Gabriel Main PO	20	7,938	1	65,492	8.3
White Plains PO	7	2,097	0	19,970	9.5
Totals	**500**	**200,755**	**2,698**	**2,000,565**	**10.0**

FIGURE ES-1 AVERAGE MILES PER DAY (ALL ECRVs)

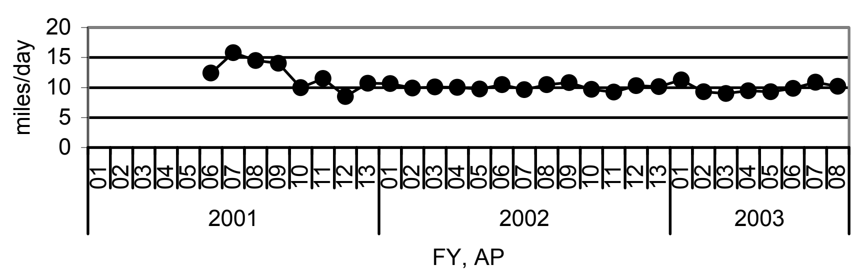


FIGURE ES-2
ECRV AVERAGE ELECTRICITY USE PER DAY

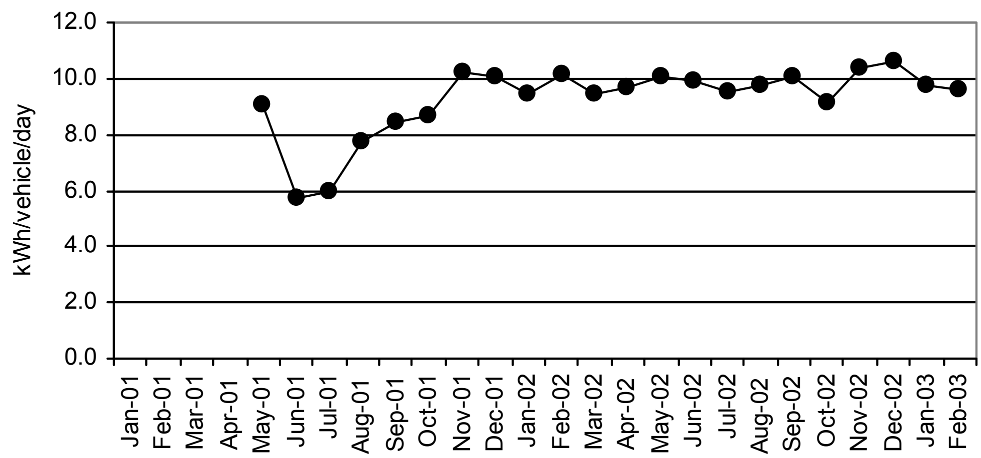


FIGURE ES 3 ECRV ENERGY EFFICIENCY

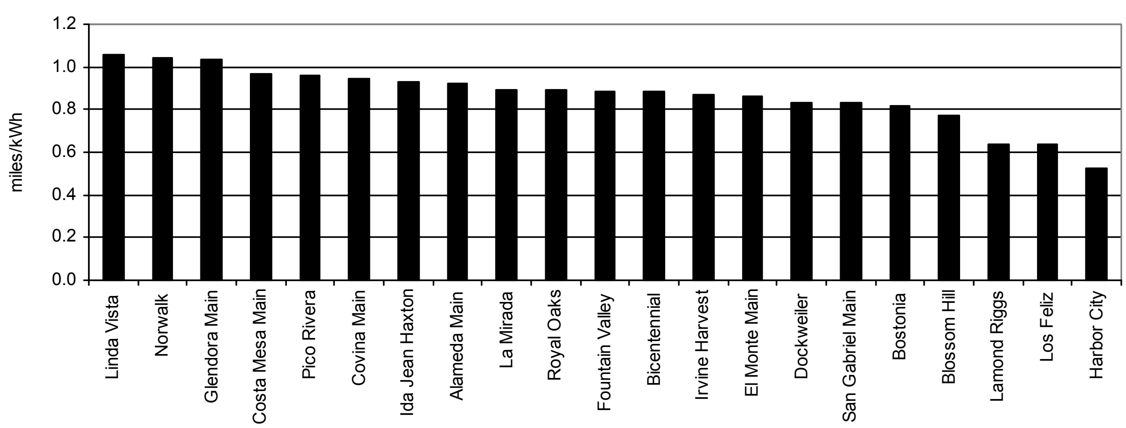
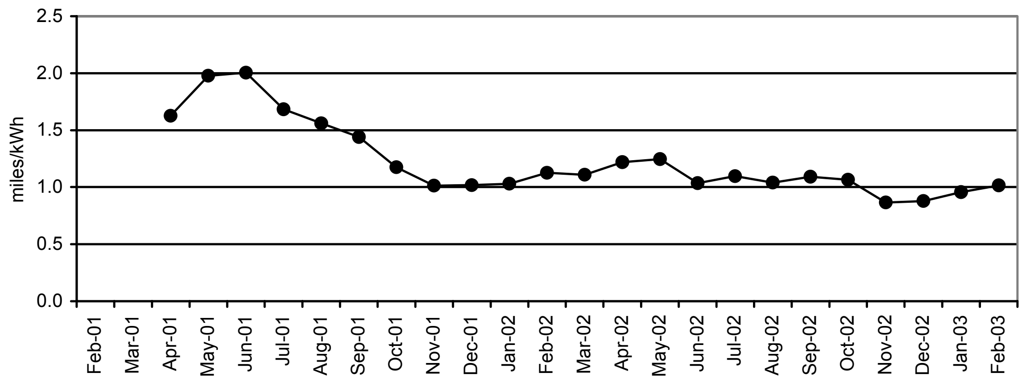


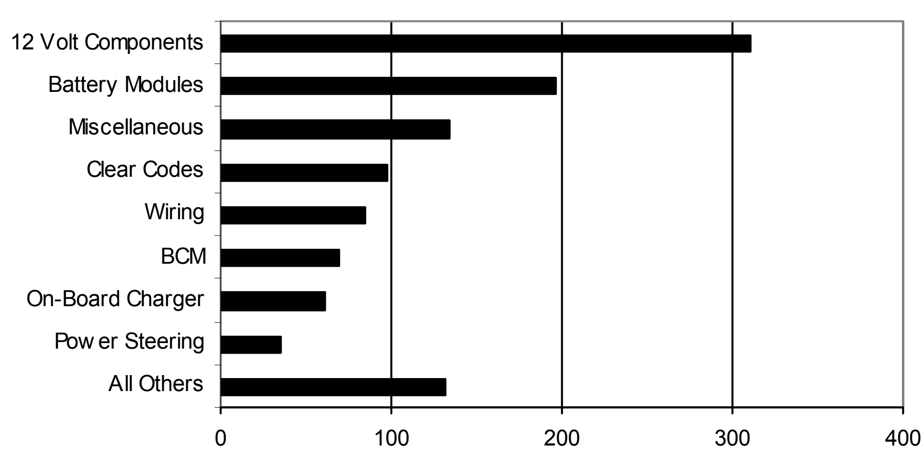
FIGURE ES-4
AVERAGE ENERGY EFFICIENCY BY MONTH
POST OFFICES IN CALIFORNIA



ES.4 MAINTENANCE, RELIABILITY AND AVAILABILITY

During the warranty period, Ford has completed many repairs on the 500-vehicle ECRV fleet. Figure ES-5 shows the number of repairs that have been made for each of the repair categories established by Ford.

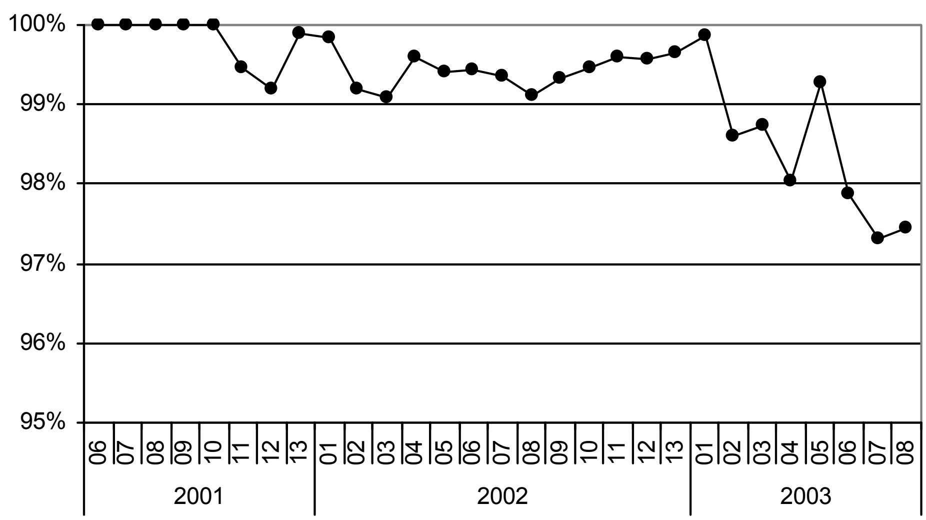
FIGURE ES-5
NUMBERS OF ECRV CONCERN REPORTS BY CATEGORY
(Excluding Pre-Delivery CRs)



In terms of reliability, component failures of most concern are those that can occur frequently, and those that result in costly repairs or extended periods of vehicle downtime. The analysis of ECRV repair data shows that the types of repairs that meet these criteria include the 12 volt components, the battery module and pack repairs and the wiring and harness repairs.

The availability of the ECRV fleet over time is shown in Figure ES-6. Availability has been consistently high (above 99%) until the last seven APs. For comparison, the availability for gasoline Carrier Route Vehicles is typically in the range from 97% to 99%.

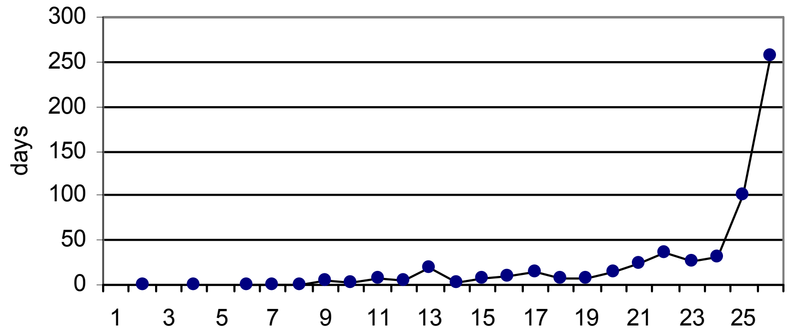
FIGURE ES-6 ECRV AVAILABILITY BY ACCOUNTING PERIOD



ES.5 BATTERIES

There is significant uncertainty in the projected battery life and the cost associated with ECRV battery pack replacements. During the most recent APs, there has been an increase in the number of battery repairs needed, with an increasing number of pack replacements. The time needed by Ford to complete the battery repairs has also increased significantly (Figure ES-7). Data from Ford regarding the costs associated with recent pack replacements indicate that the cost for a pack replacement is now on the order of $14,000. This high cost may be due to the decrease in battery pack demand following the demise of the BEV element of the California Zero Emission Vehicle mandate.

FIGURE ES-7
DAYS NEEDED TO COMPLETE BATTERY REPAIRS



ES.6 CARRIER SATISFACTION

During April and May 2003, a “structured response” type survey was sent to more than 100 Carriers and Managers, with the Carriers selected at random from all sites with ECRVs. The questions in this survey were designed to solicit information on vehicle performance. The ratings for all statements from the Carriers and the Managers were generally favorable or highly favorable. For the Carriers, the two statements that received least favorable responses were concerning the lack of power on hills, and a reluctance to use electrical equipment for fear of draining power from the traction battery. In the responses from the Managers, the two statements that received least favorable responses were on cargo capacity and the reliability of the charging system. Managers noted that the features which Carriers like best are that they do not have to go to the gasoline station and that they are quiet and clean.

ES.7 DATA COLLECTION

Twenty-five ECRVs are equipped with onboard Data Acquisition and Interface Systems (DAIS) to collect and store data on vehicle and battery performance. There are five DAIS vehicles each at the Fountain Valley, La Mirada, Linda Vista, Alameda and Royal Oaks Post Offices. The DAIS collects and records data on the flow of energy into and out of the battery pack, vehicle speed and miles driven, and temperature. Data values are recorded each second when the ECRV is being driven (in Drive files) and each minute when the ECRV is connected to the PCS for charging (in Charge files).

A DAIS database and Report Generator have been created on a Personal Computer in Microsoft Access to store and process the Postal Service ECRV data. The database was populated using approximately one year of data (where available) for each of the 25 DAIS-equipped vehicles. The Report Generator provides the capability to quickly generate reports on vehicle and energy use.

ES.8 CONCLUSIONS

With nearly two years of operating experience now available for the ECRV fleet, a substantial amount of data has been compiled on the performance of these BEVs. Over two million miles have been accumulated by the fleet, using about two million kWh of electricity. This represents a significant utilization of an alternative fuel.

In general, many of the performance issues identified during the course of operating the ECRV fleet are similar to those that may be expected for any new type of vehicle or vehicle technology. However, there is still considerable uncertainty associated with the traction battery cost and life cycle expectancy. Warranty repair and cost data from Ford indicate a relatively high number of battery module and battery pack repairs have been made, and the data indicate the costs for pack replacements have increased dramatically during the last year.

There have been external developments with BEVs at large that have resulted in a decreased demand for this type of vehicle and the batteries they depend on. Of particular relevance are the changes currently being made to the California Zero Emission Vehicle (ZEV) mandate which are expected to decrease demand for BEVs.

The ECRV Program has provided valuable experience for the Postal Service in the acquisition and operation of an AFV fleet. This experience is likely to be helpful as other advanced technologies are tested and demonstrated in the future. The lessons learned may also be helpful to other organizations involved with the operation of a fleet of light duty vehicles in similar applications. Chapter 8 of the main report includes a summary of ECRV Program accomplishments and lessons learned.

UNITED STATES POSTAL SERVICE
ELECTRIC CARRIER ROUTE VEHICLE PROGRAM
500 VEHICLE FLEET DEPLOYMENT REPORT

1. INTRODUCTION

In 1999, the United States Postal Service (Postal Service) contracted with the Ford Motor Company (Ford) for the purchase of Electric Carrier Route Vehicles (ECRVs). An Initial Purchase of 500 ECRVs was called for in the contract, with Purchase Options for additional ECRVs. The first ECRVs were placed in regular service in Southern California in February 2001. By October 2002, all 500 ECRVs had been placed in service, with most vehicles in California and a small number at two locations on the East Coast.

To support the Postal Service ECRV test program and the development of the electric vehicle industry, the United States Department of Energy (DOE) entered into a testing support agreement with the Postal Service. One of the conditions of the agreement was to prepare a 500 Fleet Deployment report after all of the ECRVs were placed in service. In support of this testing agreement, the Postal Service contracted with Ryerson Master and Associates (RMA) to prepare this report.

This report has eight main chapters including this introduction. Chapter 2 includes an overview of the Postal Service carrier fleet operations and the ECRV deployment within the fleet. Chapter 3 is an evaluation of vehicle performance based on energy efficiency, repair and maintenance, reliability and battery performance. Chapter 4 discusses user (Letter Carrier) satisfaction, and Chapter 5 is a review of data collection systems. Chapter 6 covers infrastructure and the electric charging systems, and Chapter 7 discusses other ECRV program activities. Chapter 8 presents the main conclusions from this report, and Chapter 9 includes the references.

The appendices provide a list of preparers and persons contacted (Appendix A), supporting information on ECRV electricity use and mileage (Appendix B), maintenance and repair (Appendix C), battery issues (Appendix D), the Carrier satisfaction survey (Appendix E), and analysis of the ECRV Data Acquisition and Integration System data collected to date (Appendix F).

The following two sections in this introductory chapter describe the purpose and scope of this study, with a summary of some of the limitations.

1.1 PURPOSE AND SCOPE OF STUDY

The purpose of this report is to report on the performance of the ECRVs during the first two years of deployment. This is one of the largest Battery Electric Vehicle (BEV) demonstration programs ever to take place, so it presents a unique opportunity to gather detailed information of how well a BEV fleet can perform in a delivery service environment. Some of the key topics addressed in the report are:

- Energy efficiency of the vehicles
- Carrier satisfaction
- Maintenance and repairs
- Availability and reliability
- Battery performance
- Infrastructure and charging system
- On-board data collection

The period covered by this study is from initial deployment date (for each vehicle) through the beginning of calendar year 2003. Depending on when the vehicles were deployed to each site, the period of service ranges from just over one year (San Jose Station Post Office) to more than two years (Fountain Valley Station Post Office). All data are based on averages (or totals) for each deployment location, and on all deployment locations combined. The report does not include data on each individual vehicle.

Most of the data and results presented in this report were collected and analyzed in previous reports for the Postal Service. However, additional data on energy use, maintenance and repairs, and battery performance were collected to evaluate the performance of the entire fleet of 500 ECRVs. Most of this information was obtained from the Postal Service Vehicle Maintenance and Accounting System (VMAS) and directly from Ford. A limited number of site visits were made to the Postal Service Vehicle Maintenance Facilities (VMFs) in whose service areas the ECRVs are deployed, and to a few key deployment sites. A survey of Letter Carriers and Post Office Managers was also conducted to obtain feedback from the Post Offices on how well the vehicles are performing.

The Postal Service considers the 500 vehicle ECRV program to be a demonstration program with three main objectives:

- Demonstration of the maturity of electric vehicle technology
- Demonstration of cost effectiveness
- Demonstration of reliability and maintainability

This report includes information and analysis to evaluate how well the ECRVs have performed to date against the first and third of these program objectives. The report also includes some limited data on electricity and battery costs.

1.2 LIMITATIONS

Though there are now 500 ECRVs in service at 22 Post Office locations, the amount of information available for evaluating performance is still limited given the relatively short period over which the vehicles have been in service. The operating experience database (6,000 vehicle months of data per year of operation) is small when compared with the vast amount of information accumulated by the Postal Service every year for the nationwide Long Life Vehicle (LLV) fleet of gasoline vehicles (over one million vehicle-months of data for each year of operation).

While the operational data from the first two years do provide an indication of ECRV performance, they do not yet provide sufficient operational and maintenance data to determine how well the ECRVs will perform over the long term or at sites other than the deployment locations. Only a small number of the vehicles have been placed on the East Coast where cold weather could affect vehicle performance. It is expected that differences in route distances, terrain, and climate at the various deployment sites will affect the ECRV operational performance.

2. CARRIER VEHICLE MISSION AND ECRV DEPLOYMENT

This chapter includes an overview of the Postal Service Carrier Vehicle Fleet operations (including a discussion of the need for Alternative Fuel Vehicles, AFVs), a brief description of how the Electric Carrier Route Vehicle (ECRV) deployment strategy was developed, and the current status of the deployment.

2.1 OVERVIEW OF CARRIER VEHICLE FLEET OPERATIONS

The Postal Service operates a fleet of over 169,000 light-duty mail delivery vehicles called Carrier Route Vehicles (CRVs). The CRVs are used for city delivery routes and rural routes. These routes provide daily mail delivery directly to residential and business customers. The mail delivery vehicles are usually half-ton or quarter-ton gasoline vehicles, manufactured specifically for the Postal Service. In addition to the CRVs, the Postal Service also operates a large fleet of one-ton and two-ton cargo vehicles, and trucks for regional distribution.

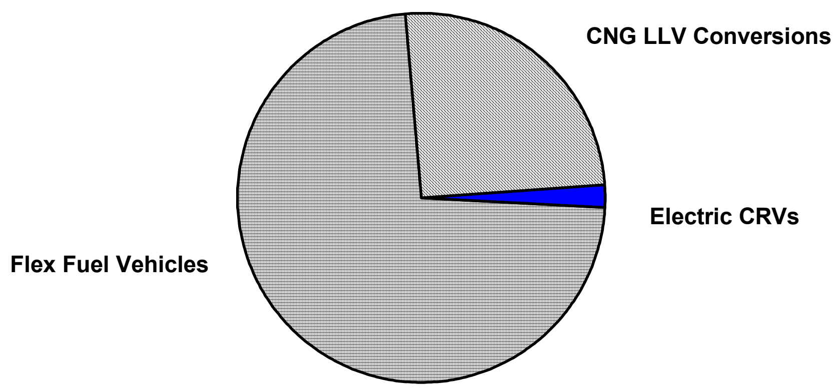
The Postal Service has an ongoing need to purchase new CRVs either to replace older CRVs or to increase the fleet to accommodate expanding services. When new vehicles are purchased or leased, the Postal Service must comply with the legislative requirements of the Energy Policy Act (EPACT), administered by the U.S. Department of Energy, and the Clean Air Act (CAA), administered by the U.S. Environmental Protection Agency. The preference for right-hand drive vehicles for mail delivery and collection means that the Postal Service often makes large acquisitions of specialized fleet vehicles directly from the vehicle manufacturers.

EPACT requires the Postal Service and other federal agencies to purchase a specified percentage of AFVs. Under EPACT mandates, 75% of light-duty vehicle purchases and leases (up to 8,500 pounds gross vehicle weight [GVW]) must be AFVs within designated Metropolitan Statistical Areas (MSAs). Allowable fuels under the EPACT mandate include natural gas, liquefied petroleum gas, alcohol fuels, hydrogen, coal, biological material derived fuels, and electricity.

The CAA, as modified by the Clean Air Act Amendments of 1990, established new mandates for fleet operators in certain MSAs designated as non-attainment for ozone (serious, severe or extreme) or carbon monoxide (design value greater than 16 parts per million). The EPA has developed a Clean Fuel Fleet Program (CFFP) which applies in the designated MSAs. The CFFP applies to all light duty vehicles up to 8,500 pounds gross vehicle weight, and heavy duty vehicles from 8,500 to 26,000 pounds gross vehicle weight. New vehicles purchased in these MSAs must meet Low Emission Vehicle (LEV) standards or better. Under the CFFP of the CAA, the fleet operators may meet the LEV emission standard using reformulated gasoline or alternative fuels.

The Postal Service voluntarily complies with the EPACT purchase percentages nationwide to avoid geographic restrictions on their assignment and usage of vehicles across the country. All new CRVs purchased by the Postal Service in recent years have been Alternative Fuel Vehicles (AFVs). The Postal Service has purchased more than 20,000 Flex Fuel Vehicles (FFVs) from Ford, designed to operate on gasoline or ethanol. Several thousand gasoline carrier vehicles (called Long Life Vehicles or LLVs) have been converted to run on Compressed Natural Gas (CNG). The composition of AFVs within the Postal Service fleet is shown in Figure 2-1.

FIGURE 2-1
POSTAL SERVICE CARRIER VEHICLE FLEET
ALTERNATIVE FUEL VEHICLES



Prior to the acquisition of the 500 ECRVs, the Postal Service conducted a test program of BEV technology for carrier vehicles in which ten LLVs were converted to Electric Long Life Vehicles (ELLVs) in collaboration with US Electricar (Chobotov et. al, 1996). For this test program, the LLVs were equipped with lead acid batteries, and five were placed in service at the Harbor City Post Office in the Los Angeles area. Subsequently, 13 Chrysler EPIC vehicles were added to the Harbor City fleet to make this the first "all-electric" postal delivery fleet in the country. These pilot programs provided valuable information for the Postal Service prior to the acquisition of a larger number of electric vehicles. A performance study of the Harbor City electric vehicles was conduced by the Postal Service Pacific Area (LeMay, 2000).

2.2 CARRIER VEHICLE ROUTES

For mail delivery, the Carrier routes are differentiated in terms of the type of route. There are three main route types at each Post Office:

1. A ***curbline or mounted route*** is one where the predominant method of Carrier delivery is to mailboxes along the curb (e.g., the driver drives from box to box and delivers the mail without leaving the vehicle).
2. A ***park and loop route*** is one where the predominant method for Carrier delivery is to park at a designated location, exit the vehicle and walk a "loop", delivering mail to the individual homes and businesses. Frequently, multiple "loops" are designed from a single park point.
3. The ***express delivery route*** refers to expedited delivery and collection activities. The employee delivers express mail, packages and makes on-demand or scheduled pick-ups of mail, throughout the postal delivery area.

The type of route is an important consideration for AFVs, because it may affect the performance of the vehicles. For example, the miles driven for the express delivery routes are usually much higher than for the other two routes. The route types could also affect the fuel economy and vehicle maintenance costs. For the ECRVs, the ideal route is on level terrain with a distance that can be comfortably covered twice on a single charge.

In this study, a limited assessment was conducted of ECRV performance at different locations to compare performance under different operating conditions. This type of comparison can provide valuable information to fleet managers as they make decisions about future acquisitions. Prior to the large scale deployment of electric vehicles, the terrain, climate, route distance and route type at the deployment location need to be carefully considered, given the range limitations of these vehicles.

For refueling, Postal Service Carriers using gasoline vehicles typically refuel by driving to a fuel station offsite. Depending on the route distance and other local factors, the gasoline LLVs are usually refueled about once every one or two weeks. The daily use of the vehicles depends on the type of route, but the majority of vehicles used for mail delivery are on the route from late morning to late afternoon. Vehicles are usually parked at the Post Office location overnight. For electric vehicles that need to be charged daily, the ability to use off-peak electricity at night is an important factor.

2.3 ECRV SITE SELECTION AND VEHICLE DEPLOYMENT

Prior to deployment of the ECRVs, the Postal Service conducted a detailed assessment of potential deployment locations. A site selection study was performed to help develop a deployment plan for the first 500 vehicles (Ryerson, Master and Associates, Inc., January 1999). During the course of the study, over 800 Postal Service sites were screened, and more than 220 were analyzed in detail.

The prioritized list of sites was used by the Postal Service to select the sites for deployment of the 500 Initial Purchase ECRVs. A list of 22 sites was developed with the total number of vehicles at each site ranging from about 20 to 40 vehicles. The evaluation process considered a wide range of siting factors, including potential impacts on mail delivery operations, local support and incentive funding for AFV programs, size of the vehicle fleet at each site, proximity to the Postal Service's Vehicle Maintenance Facility (VMF), topography and climate, degree of support available from the electric utility, and other factors. Prior to construction, additional studies were conducted to describe the ECRV infrastructure needed for each site, and to document VMF and Fleet Information pertaining to the ECRVs.

During deployment, a few minor changes were made to the list of sites initially selected. These were due to changes in operational details and engineering constraints that were identified during the planning process. With many back-up sites identified during the site selection process, this did not result in any delays to the overall fleet deployment.

The final list of deployment sites is shown in Table 2-1. Twenty of the Post Office sites are in California with 15 in the Los Angeles area, two in San Diego, one site each in San Jose, Sacramento and Alameda. The other two sites are in New York State (White Plains Post Office), and in Washington D.C. (Lamond Riggs Post Office). Figures 2-2 through 2-5 show the deployment locations.

TABLE 2-1 ECRV DEPLOYMENT INFORMATION

Post Office	Address	VMF	Number of Vehicles	Deployment Date
Alameda Main	2201 Shoreline Dr., Alameda, CA 94501-6200	Oakland	20	Jan-02
Bicentennial Station	7610 Beverly Blvd., Los Angeles, CA 90048-9996	Los Angeles North	57	Feb-02
Blossom Hill Station	5706 Cahalan Ave., San Jose, CA 95123-3008	San Jose	20	Oct-02
Bostonia Station	867 N. Second St., El Cajon, CA 92021-5805	San Diego Midway	20	Aug-01
Costa Mesa Main	1590 Adams Ave., Costa Mesa, CA 92628-9001	Huntington Beach	20	Jun-01
Covina Main	545 Rimsdale Ave., Covina, CA 91722-9200	La Puente	20	Jan-02
Dockweiler Station	3585 S. Vermont Ave., Los Angeles, CA 90007-3977	Los Angeles Central	39	Apr-01
El Monte Main	11151 Valley Blvd., El Monte, CA 91734-9000	La Puente	30	Oct-01
Fountain Valley	17227 Newhope, Fountain Valley, CA 92728-9005	Huntington Beach	28	Jan-01
Glendora Main	255 S. Glendora Ave., Glendora, CA 91740-9000	La Puente	20	Jan-02
Harbor City	25690 Frampton Ave., Harbor City, CA 90710-2979	Torrance	5	Aug-01
Ida Jean Haxton Station	9151 Atlanta Ave., Huntington Beach, CA 92615-9000	Huntington Beach	25	May-01
Irvine Harvest Station	17192 Murphy Ave., Irvine, CA 92623-9000	Huntington Beach	24	Jun-01
La Mirada	14901 Adelfa Dr., La Mirada, CA 90638-4749	Long Beach	15	Aug-01
Lamond Riggs, DC	6200 N. Capital St, N.W., Washington, DC 20011-4108	Brightwood	14	Mar-02
Linda Vista Station	2150 Comstock St., San Diego, CA 92111-9998	San Diego Midway	22	Aug-01
Los Feliz Station	1825 N. Vermont Ave., Los Angeles, CA 90027-4212	Los Angeles North	32	Aug-01
Norwalk	14011 Clarkdale Ave., Norwalk, CA 90650-8112	Long Beach	26	Sep-01
Pico Rivera	6320 Passons Blvd., Pico Rivera, CA 90660-3300	Long Beach	16	Sep-01
Royal Oaks Station	2000 Royal Oaks Dr., Sacramento, CA 95813-9998	Sacramento Main	20	Nov-01
San Gabriel Main	120 S. Del Mar Ave., San Gabriel, CA 91778-9000	La Puente	20	Dec-01
White Plains, NY	100 Fisher Avenue, White Plains, NY 10606-1919	West Chester	7	Mar-02
Total			**500**	

FIGURE 2-2 ECRV DEPLOYMENT SITES IN CALIFORNIA

FIGURE 2-3 ECRV DEPLOYMENT SITES IN THE LOS ANGELES AREA

FIGURE 2-4 ECRV DEPLOYMENT SITE IN NEW YORK

FIGURE 2-5 ECRV DEPLOYMENT SITE IN WASHINGTON DC

3. ECRV PERFORMANCE

This chapter addresses the performance of the 500 ECRVs from deployment through March 2003. The first part provides a brief description of the physical characteristics of the ECRV and comments on the overall design. The second part addresses energy efficiency expressed in terms of the miles driven and the electricity used. The third part provides a brief discussion of vehicle reliability expressed in terms of days in service, days unused and days in shop. The third and fourth parts address maintenance and repair issues; and the fifth part discusses battery performance and cost.

The period of ECRV performance covered in this report is from initial deployment through March 2003. The data presented are generally shown as the averages or totals for each deployment location, and for all deployment locations combined. Performance data are not presented for each individual vehicle. Much of the data used in preparing this report were collected and analyzed in previous reports for the Postal Service. Applicable references are cited where this is the case.

Additional data were collected to evaluate the performance of the entire fleet of 500 ECRVs, including vehicle miles driven, electricity used, and maintenance and repair data. These data were obtained from readily available VMAS reports, from the electric utilities, and from Ford.

3.1 VEHICLE DESCRIPTION AND SPECIFICATIONS

This section includes a description of the ECRV based on the Postal Service vehicle specifications and bulletins, and on field measurements and observations taken during the time the ECRVs have been in service.

Ford selected a vehicle design for the ECRV that has been in commercial service for a number of years. The vehicle body is supplied by Grumman Allied, and is very similar to the LLV body. The chassis of the ECRV is similar to the Ford Ranger Electric Pickup Truck chassis. The Postal Service Make Model code for the ECRVs is MM 12-80.

The ECRVs are designed to operate on routes similar to gasoline-fueled Carrier route vehicles. ECRVs are designed to travel at speeds up to 60 miles per hour and to travel about 40 miles on a single electrical charge, depending on weather and road conditions. The ECRVs are right-hand drive vehicles with similar mail-carrying capacity as LLVs.

The vehicle's gear selector has the normal options, including "P" for park, "R" for reverse, "N" for neutral, and "D" for drive, plus "E" for Economy Mode. The Economy Mode, which has a top speed of about 50 miles per hour, conserves energy and should be used for most mail delivery operations. The vehicles are equipped with regenerative braking.

The 312-volt traction battery pack includes 39 eight-volt lead acid batteries with optional heater for cold weather climates. The pack is rated at 23 kWh and weighs 2,000 pounds. The pack is located underneath the vehicle between the wheelbase and frame rails to give the vehicle a low center of gravity. The pack assembly contains the battery modules, wiring, a fan for ventilation and cooling, and a control system. The ECRV utilizes an on-board, conductive charging system. The off-board charging infrastructure is described in Chapter 6.

The ECRV has a number of unique gauges. The battery State of Charge (SOC) gauge is equivalent to a fuel gauge on a gasoline-powered vehicle. The Distance to Empty (DTE) gauge estimates the remaining distance that the vehicle can travel before requiring a battery pack recharge. The gauge reading is based on remaining energy, driving conditions, and recent vehicle usage. The Economy gauge provides information about the vehicles energy usage. Economical usage of the vehicle is indicated by the gauge reading on the plus side and maximizes the vehicle's range.

The Motor Enabled gauge indicates the vehicle is ready to drive, and the Temperature Gauge indicates the temperature of the vehicle's components. Unlike a conventional temperature gauge, this gauge does not start cold and move to normal. It starts normal, and moves to hot or cold when there is problem. The panel also includes a Vehicle Malfunction warning light (often referred to as a Wrench light).

The dimensions of the ECRV are shown in Table 3-1, together with selected design specifications. Compared with the Postal Service LLV, the ECRV is longer (187 inches vs. 175.5 inches), wider (79 inches vs. 76 inches), and higher (88 inches vs. 85 inches). The driver step is much higher for the ECRV (17 inches vs. 12.5 inches), as is the driver seat (46 inches vs. 38.5 inches). The top of the seatbelt latch from the floor is shorter than for the LLV (11.5 inches vs. 14.5 inches). At the rear, the height of the back door strap is 87 inches for the ECRV compared with 76 inches for the LLV; and the back bumper reach is 13.5 inches for the ECRV compared with 5 inches for the LLV. The Gross Vehicle Weight Rating (GWVR) for the ECRV is 6,250 pounds, compared with 4,450 pounds for the LLV.

3.2 ENERGY USE AND EFFICIENCY

Energy efficiency is an important performance measure for the ECRV. This is based on the miles driven for a given amount of electricity. Preliminary estimates of ECRV energy efficiency were developed by RMA during the first months of ECRV deployment. These were included in the "Life Cycle Cost and Performance Evaluation" study (RMA 2001a), and the subsequent update report (RMA, 2003). The early estimates were in the range 0.85 to 0.90 miles per kWh range. These figures were based on operational data obtained from the ECRV vehicles first deployed at the Fountain Valley, Dockweiler Station, and Ida Jean Haxton Station Post Offices.

In this study the energy efficiency estimates were updated using readily available data from all sites with ECRVs. For most sites, the vehicles were placed in service by March 2002, so there was about one year of operating data available for this study.

TABLE 3-1 ECRV VEHICLE DIMENSIONS AND DESIGN SPECIFICATIONS

External dimensions	
Length	187 inches
Width	79 inches
Height	88 inches
Cab step to ground	17 inches
Ground to top of seat cushion	46 inches
Ground to back door strap	87 inches
Back bumper horizontal "depth"	13.5 inches
Floor to top of seatbelt latch	13 inches (angle) 11.5 inches (vertical)
Curb Weight	5,000 lb
Payload Weight	1,250 lb
Gross Vehicle Weight Rating	6,250 lb
Range (approximate)	40 miles
Emission Certification	ZEV
Battery Capacity	23 kWh

Section 3.2.1 provides an overview of the ECRV energy requirements, Section 3.2.2 summarizes the approach used to obtain the fleet miles driven. Section 3.2.3 includes a summary of the approach used to obtain electricity use and cost data, and to calculate the energy efficiency for the 500 vehicle ECRV fleet.

3.2.1 ECRV Energy Requirements

In the ECRV Life Cycle and Performance Evaluation report (RMA, 2001a), it was estimated that the energy use for an ECRV over a one week period amounts to about 65-80 kWh (Table 3-2). This includes the energy required for driving the vehicle and the energy required to maintain the battery. This assumes the vehicle is driven six days a week and left parked and connected to the Power Control System (PCS) unit on the seventh day. In developing these estimates it was assumed that it takes about two hours to charge the battery (at 20 amps, 4.2 kW) and about one hour for the charge to return to 1 kW or less (assuming an average current of 6 amps).
Table 3-2, shows that, over the course of a week, the electricity needed for vehicle and battery maintenance is about 12 to 24 kWh, which is approximately 18-30% of the total energy use.

TABLE 3-2 ESTIMATED WEEKLY ENERGY REQUIREMENTS (kWh) FOR ONE ECRV

	Energy (kWh)	Energy (Percent)
On-Peak Maintenance	1.4 - 5.6	2 - 7%
Off-Peak Maintenance	10 – 18	16 - 23%
Off-Peak Charge	55	70 - 82%
Total	**67 - 79**	**100%**

The numbers presented in Table 3-2 were found to be in reasonable agreement with the energy use measured at the electricity meter for a fleet of vehicles. The daily energy use and demand for the 28 vehicles at the Fountain Valley Post Office during June 2001 was is in the range 320 to 420 kWh on the six days that the ECRVs were driven, and about 50 to 80 kWh on the one day a week when the vehicles were not driven (Figure 3-1).

The peak power demand for a single ECRV on charge was found to range from about 3.6 kW to 4.3 kW. On Sundays, when the vehicles were not driven, the maximum power demand for a site with 28 vehicles was found be about 3 kW total.

FIGURE 3-1
FOUNTAIN VALLEY P.O.
DAILY ECRV ENERGY USE
24-HOUR INCREMENTS FROM 7 a.m. to 7 a.m.

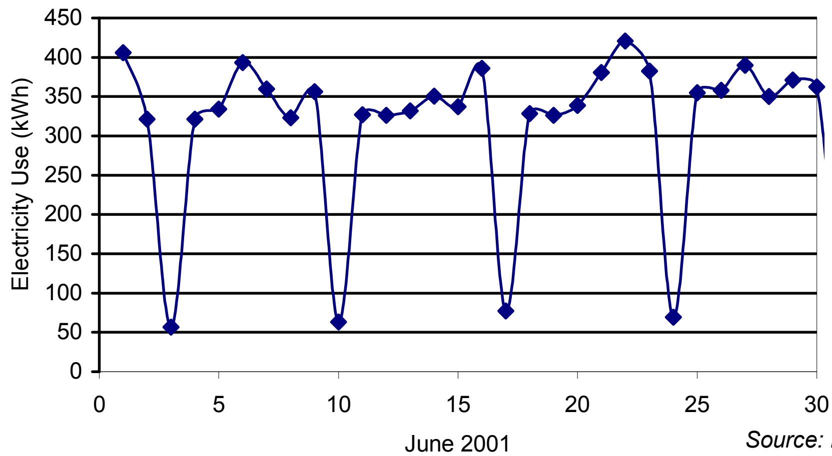


Chart 2

Source: Edison Amicos

On-peak and off-peak electricity use does not affect energy efficiency, but it can significantly affect costs. Following the charging procedure recommended by Ford, the vehicles are always connected to the PCS units (on-hook) when they are not being driven. This means that at all locations there will be at least some on-peak charging whenever they are not being driven. However, on-peak charging can also occur if the charging system timers are set incorrectly, or if the vehicle users press the “Charge-Now” feature on the PCS to activate charging at any time during on-peak hours.

Having the timers set for automatic adjustment for Daylight Savings can also help to avoid possible inadvertent on-peak charging when the clocks are set back an hour in the fall. This was an issue during the early period of vehicle deployment.

The Charge-Now button on the PCS overrides the timer so that the vehicle can be charged immediately. This feature may be used if an ECRV is brought in during the day with a low battery and the vehicle is needed for further mail deliveries or collections later the same day. However, having the Charge-Now button prominently placed on the PCS front panel makes it easy to activate this feature during the day, especially by someone who doesn’t know that it shouldn’t be used under normal circumstances.

Figure 3-2 shows the electricity demand for the Fountain Valley Post Office for three selected days during June, 2001. In Figure 3-2(a) the chart shows an "ideal charging scenario," where there is no increase in demand during the evening hours prior to when the off-peak rates begin. In Figures 3-2(b), and 3-2(c), there are distinct "shoulders" in the curve that show an increase in demand during the on-peak hours between 5:00 pm and 9:00 pm, indicative of vehicles being charged at that time.

With the present arrangement of the charging system timers at the Post Office locations, all vehicles at a site begin charging within a few minutes of each other. This results in a high power demand during the period soon after the onset of charging. The electricity use data indicate that the charging period for the site is limited to the first two or four hours after the timer activates battery pack charging. There is an opportunity to reduce the peak power demand by at least 50% by spreading the charging load over a longer period of time during the night. This is important for sites served by utilities that have a demand charge for off-peak energy use.

Based on previous studies (RMA, 2001a), some of the main observations from the ECRV program relevant to on-peak charging and minimizing electricity costs are as follows:

- The vehicle maintenance mode results in an inevitable need for electricity whenever the vehicle is on-hook. While the percentage of on-peak energy required is relatively low, it is proportionately higher at sites with short mail delivery routes.
- It is important to ensure the time clock for the charging system is set-up correctly to avoid on-peak charging. The times for on-peak and off-peak charging need to be reviewed for each utility when setting up the timer clocks.
- A relatively high on-peak demand will occur if the Charge-Now button is activated for one or more vehicles during the on-peak electricity hours. Modifying the accessibility of this feature would help to limit the amount of on-peak charging.
- For utilities that include an off-peak demand charge in the electricity bill, the demand could be significantly reduced by sequencing the chargers evenly throughout the off-peak period at night.

3.2.2 ECRV Miles Driven

To estimate the energy efficiency of the 500 vehicle ECRV fleet, vehicle miles driven were obtained for each site and for each Accounting Period (AP) from the Postal Service Vehicle Maintenance Accounting System (VMAS). The data were obtained for each site from deployment date through February, 2003. An AP is a four-week period used by the Postal Service for accounting purposes, and it is used as the basis for tracking vehicle operating and maintenance costs and utilization. The start and end dates for each AP from January 2001 through April 2003 are shown in Table 3-3.

Since the ECRVs were delivered in groups, the start dates are not exactly the same for all vehicles at each site. However, the total miles traveled, the number of vehicles, and the days used are all tracked in VMAS, so the data provide a reliable basis for estimating miles per day and average miles driven per vehicle.

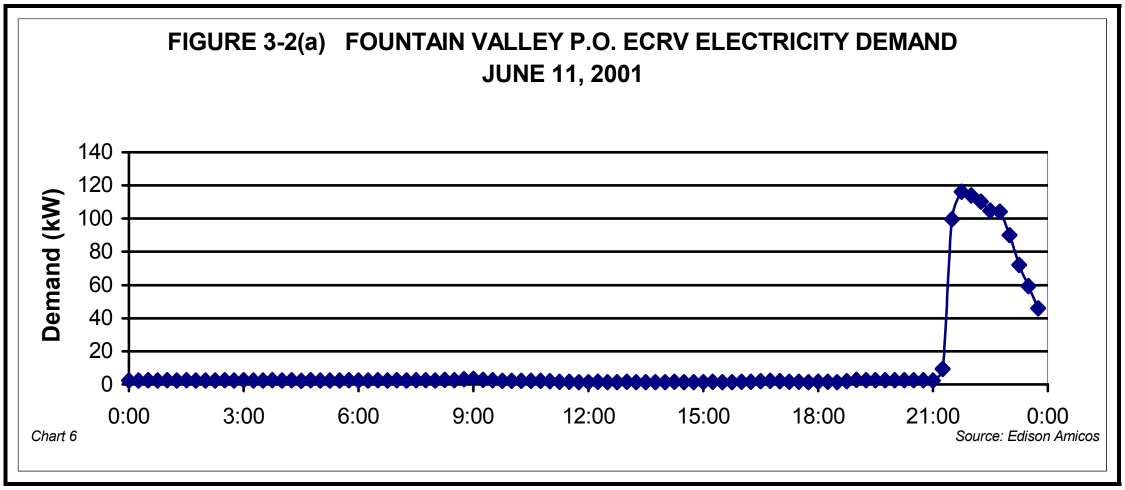


FIGURE 3-2(a) FOUNTAIN VALLEY P.O. ECRV ELECTRICITY DEMAND
JUNE 11, 2001
Demand (kW)
140
120
100
80
60
40
20
0
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
0:00
Chart 6
Source: Edison Amicos

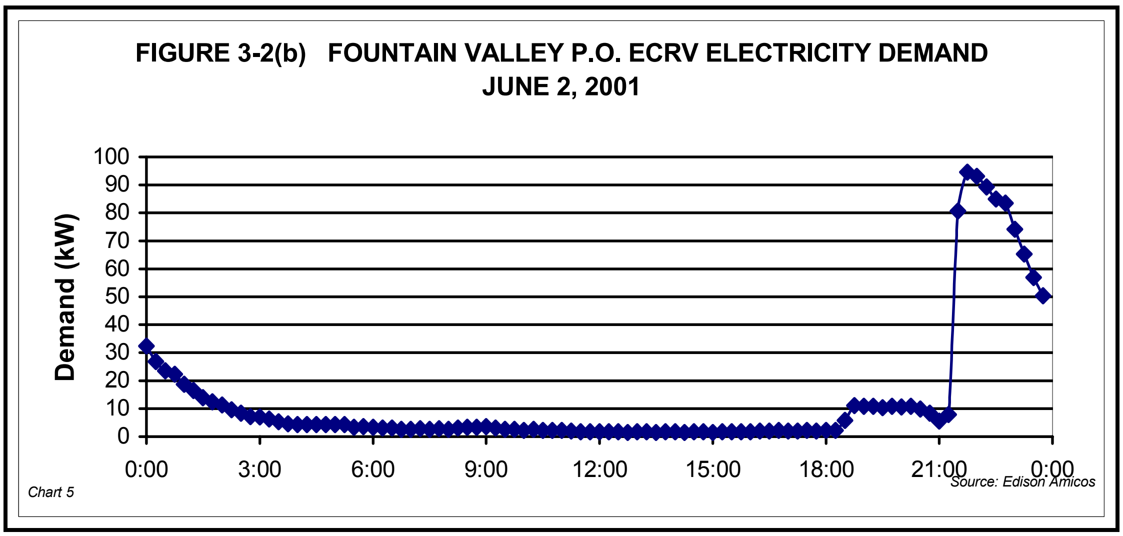


FIGURE 3-2(b) FOUNTAIN VALLEY P.O. ECRV ELECTRICITY DEMAND
JUNE 2, 2001
Demand (kW)
100
90
80
70
60
50
40
30
20
10
0
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
0:00
Chart 5
Source: Edison Amicos

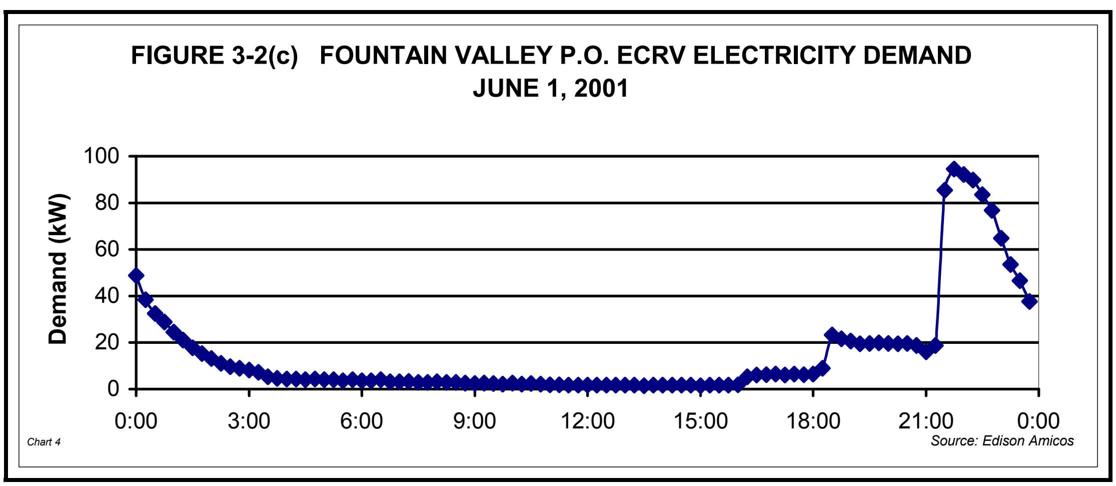


FIGURE 3-2(c) FOUNTAIN VALLEY P.O. ECRV ELECTRICITY DEMAND
JUNE 1, 2001
Demand (kW)
100
80
60
40
20
0
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
0:00
Chart 4
Source: Edison Amicos

TABLE 3-3 POSTAL SERVICE ACCOUNTING PERIODS

Fiscal Year	Accounting Period	Begin Date	End Date
FY01	05	12/30/00	1/26/01
	06	1/27/01	2/23/01
	07	2/24/01	3/23/01
	08	3/24/01	4/20/01
	09	4/21/01	5/18/01
	10	5/19/01	6/15/01
	11	6/16/01	7/13/01
	12	7/14/01	8/10/01
	13	8/11/01	9/7/01
FY02	01	9/8/01	10/5/01
	02	10/6/01	11/2/01
	03	11/3/01	11/30/01
	04	12/1/01	12/28/01
	05	12/29/01	1/25/02
	06	1/26/02	2/22/02
	07	2/23/02	3/22/02
	08	3/23/02	4/19/02
	09	4/20/02	5/17/02
	10	5/18/02	6/14/02
	11	6/15/02	7/12/02
	12	7/13/02	8/9/02
	13	8/10/02	9/6/02
FY03	01	9/7/02	10/4/02
	02	10/5/02	11/1/02
	03	11/2/02	11/29/02
	04	11/30/02	12/27/02
	05	12/28/02	1/24/03
	06	1/25/03	2/21/03
	07	2/22/03	3/21/03
	08	03/22/03	04/18/03
	09	4/19/03	5/16/03

The miles driven and days used for each Post Office are included in Section B.1 of Appendix B (Section B.1). The totals are summarized by site in Table 3-4, and by AP in Table 3-5. Average miles per day for the fleet are shown by site in Figure 3-3, and by AP in Figure 3-4.

TABLE 3-4 MILES DRIVEN AND DAYS USED – POST OFFICE TOTALS DEPLOYMENT THROUGH FY03, AP08

Station Name	Number of Vehicles	Sum of Days Assigned	Sum of Days Not Used	Sum of Days Used	Sum of Days In Shop	Sum of Miles Driven	Avg Miles/Day
Alameda Main PO	20	7,460	1,219	6,205	36	72,577	11.7
Bicentennial Station PO	57	18,914	4,303	14,216	581	10,8101	7.6
Blossom Hill Station PO	20	2,365	688	1,659	16	20,492	12.4
Bostonia Station PO	20	10,700	708	9,764	242	98,015	10.0
Costa Mesa Main PO	20	11,448	2,069	9,371	8	102,183	10.9
Covina Main PO	20	7,924	933	6,969	26	78,942	11.3
Dockweiler Station PO	39	24,492	2,633	21,818	41	178,362	8.2
El Monte Main PO	30	14,245	1,947	12,091	207	156,906	13.0
Fountain Valley PO	28	19,672	2,321	17,194	161	199,654	11.6
Glendora Main PO	20	8,420	1,882	6,512	26	90,203	13.9
Harbor City PO	5	2,555	145	2,410	0	22,878	9.5
Ida Jean Haxton PO	25	14,895	2,618	12,036	241	118,662	9.9
Irvine Harvest Station PO	24	13,968	1,309	12,457	204	151,265	12.1
La Mirada PO	15	7,665	1,244	6,310	111	63,711	10.1
Lamond Riggs PO	14	4,204	704	3,431	69	28,244	8.2
Linda Vista Station PO	22	11,650	794	10,659	197	99,454	9.3
Los Feliz Station PO	32	15,526	2,425	12,753	378	80,651	6.3
Norwalk PO	26	12,662	972	11,686	4	105,353	9.0
Rico Rivera PO	16	7,792	765	6,970	57	65,346	9.4
Royal Oaks Station PO	20	7,084	783	6,209	92	74,104	11.9
San Gabriel Main PO	20	8,860	921	7,938	1	65,492	8.3
White Plains PO	7	2,590	493	2,097	0	19,970	9.5
Totals	**500**	**235,091**	**31,876**	**200,755**	**2,698**	**2,000,565**	**10.0**

From a review of these figures and tables, it can be seen that the total distance driven by the fleet to date exceeds two million miles. The average miles per day (mpd) varies from a low of 6.3 mpd at Los Feliz to a high of 13.9 mpd at Glendora. The average for the 500-vehicle fleet is 10.0 mpd. From Figure 3-4, it can be seen that the average distance driven per day for the 500-vehicle fleet has been consistently between 9 mpd and 11 mpd since the end of Fiscal Year 2001. Prior to that, the miles per day average was higher. During the early period when the ECRVs were being deployed, the sample size was less. Also, the VMAS data (Appendix B.1) show that ECRVs are typically driven for longer distances during the first one or two months in service.

3.2.3 ECRV Electricity Use and Energy Efficiency

The electricity use for the ECRVs at the 22 Post Office locations was obtained from the electricity utilities during the period from deployment through March 2003. There are six utilities in California that have ECRVs in their service areas, and two utilities on the East Coast. The utilities and the list of ECRV sites served by each utility are shown in Table 3-6.

TABLE 3-5 MILES DRIVEN AND DAYS USED – ALL SITES

FY	AP	Number of Vehicles	Sum of Days Assigned	Sum of Days Not Used	Sum of Days Used	Sum of Days In Shop	Sum of Miles Driven	Average Miles/Day
2001	01	2	48	48	0	0	0	
	02	4	96	49	47	0	1,320	
	03	2	48	21	27	0	1,968	
	04	2	48	2	46	0	2	
	05	22	528	526	2	0	2	
	06	27	648	522	126	0	1,564	12.4
	07	30	856	369	487	0	7,687	15.8
	08	67	1,608	1,151	457	0	6,624	14.5
	09	82	1,968	961	1,007	0	14,134	14.0
	10	128	3,005	1,300	1,705	0	17,046	10.0
	11	136	3,182	1,098	1,870	214	21,512	11.5
	12	173	4,152	1,145	2,983	24	25,290	8.5
	13	198	4,616	897	3,715	4	39,760	10.7
2002	01	285	6,840	2,073	4,759	8	50,813	10.7
	02	301	6,984	1,499	5,441	44	54,078	9.9
	03	323	7,182	1,154	5,973	59	60,340	10.1
	04	343	7,930	1,125	6,777	28	68,120	10.1
	05	374	8,306	1,775	6,492	39	63,122	9.7
	06	397	9,139	1,530	7,567	42	79,486	10.5
	07	448	10,756	2,232	8,469	55	81,570	9.6
	08	454	10,900	1,722	9,096	82	95,489	10.5
	09	482	11,572	1,331	9,627	614	104,007	10.8
	10	478	11,006	1,164	9,789	53	95,046	9.7
	11	478	10,959	809	10,109	45	93,515	9.3
	12	478	11,426	622	10,753	47	105,971	10.0
	13	478	10,948	413	10,499	36	101,698	9.8
2003	01	478	11,472	384	11,073	15	115,319	10.6
	02	478	10,994	409	10,627	68	98,986	9.3
	03	478	10,516	323	10,141	132	91,562	9.0
	04	478	10,996	225	10,558	211	99,624	9.4
	05	498	10,956	300	10,576	80	98,157	9.3
	06	498	11,454	1,379	9,861	222	97,099	9.8
	07	498	11,952	1,494	10,181	315	108,577	10.8
	08	500	12,000	1,824	9,915	261	101,077	10.2
		500	**235,091**	**31,876**	**200,755**	**2,698**	**2,000,565**	**10.0**

FIGURE 3-3 ECRV AVERAGE DAILY MILES DRIVEN

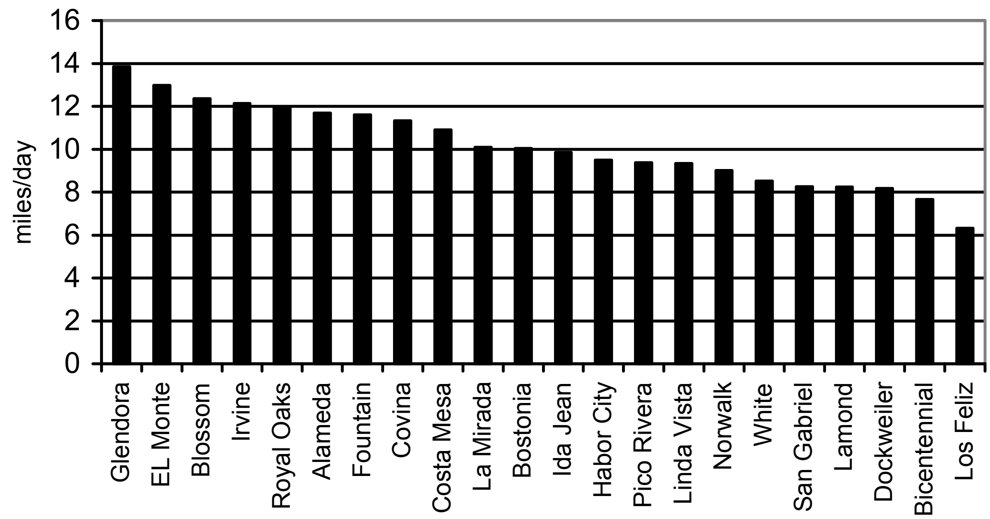


FIGURE 3-4 AVERAGE MILES PER DAY (ALL ECRVs)

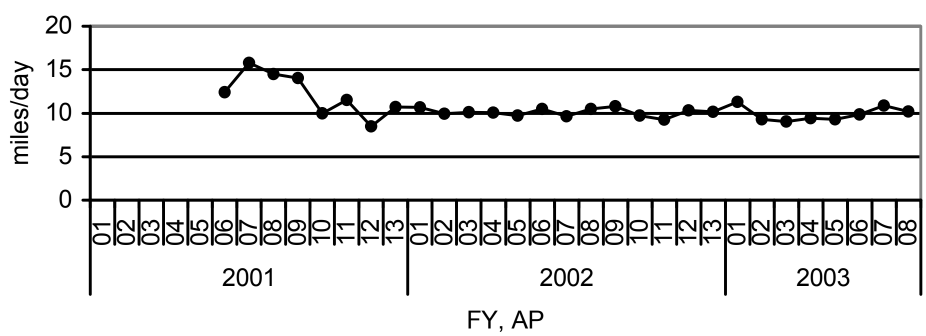


TABLE 3-6 LIST OF ELECTRIC UTILITIES FOR RESPECTIVE ECRV DEPLOYMENT LOCATIONS (AS OF APRIL 2003)

CALIFORNIA

Southern California Edison
- Costa Mesa Main P.O.
- Covina Main P.O.
- El Monte Main P.O.
- Fountain Valley P.O.
- Glendora Main P.O.
- Ida Jean Haxton Station P.O.
- Irvine Harvest Station P.O.
- La Mirada P.O.
- Norwalk P.O.
- Pico Rivera P.O.
- San Gabriel Main P.O.

Sacramento Municipal Utility District
- Royal Oaks Station P.O.

Los Angeles Department of Water and Power
- Bicentennial Station P.O.
- Dockweiler Station P.O.
- Harbor City P.O.
- Los Feliz Station P.O.

San Diego Gas and Electric
- Bostonia Station P.O.
- Linda Vista Station P.O.

Pacific Gas and Electric
- Blossom Hill Station P.O.

City of Alameda
- Alameda Main P.O.

WASHINGTON DC

Potomac Electric Power Company (PEPCO)
- Lamond Riggs P.O.

NEW YORK STATE

Consolidated Edison Company of New York (ConEdison)
- White Plains P.O.

The eight utilities were contacted and requested to provide monthly electricity use and cost data for the ECRV sites from deployment through February 2003. Electricity use data were available by month for all ECRV sites in California. For the Lamond Riggs Post Office, electricity data were not available by month. For the White Plains Post Office, no reliable electricity use data were available. Tables summarizing the electricity use data are included in Appendix B (Section B.2).

The cost data include facility charges, meter charges, demand charges, energy use charges, and any special energy cost charges. This was done to assure that the energy efficiency calculations accounted for all costs rather than just the electricity unit costs.

The electricity use totals are summarized for each site in Table 3-7, and by month in Table 3-8. In both these tables, the data are for the 20 sites in California and Lamond Riggs. The daily average electricity use (kiloWatt hours, kWh) is shown for the entire fleet in Figure 3-5. The average electricity use per vehicle per day is shown by month in Figure 3-6 and by site in Figure 3-7.

It should be noted that all daily average electricity use data presented in this report were calculated by dividing electricity use (kWh) by the number of days in the billing period, and then adjusting the result by a factor of 7/6 to account for the 6-day work week.

Figure 3-5 shows that, over the period from February 2001 through May 2002, the electricity use gradually increased as more ECRVs were placed in service. For most of the last year (March 2002 through February 2003), the average daily electricity use for the fleet was in the range 4,000-5,300 kWh. This equates to between 9 and 10.5 kWh per vehicle per day. For all California vehicles, the average daily use is 9.2 kWh per vehicle (Table 3-7).

TABLE 3-7 ELECTRICITY USE TOTALS FOR EACH POST OFFICE (FROM DEPLOYMENT THROUGH FEBRUARY 2003)

Post Office	Days	Total kWh	Daily Avg kWh	Bill $ Amount	Average Cost ($/kWh)	Number of Vehicles	KWh/day/ Vehicle
Alameda Main PO	422	78,360	217	$11,616	$0.15	20	10.8
Bicentennial Station PO	365	122,560	392	$16,119	$0.13	57	6.9
Blossom Hill Station PO	116	26,400	266	$3,909	$0.15	20	13.3
Bostonia Station PO	609	119,960	230	$23,587	$0.20	20	11.5
Costa Mesa Main PO	640	105,695	193	$23,638	$0.22	20	9.6
Covina Main PO	459	83,276	212	$11,332	$0.14	20	10.6
Dockweiler Station PO	810	213,920	308	$32,417	$0.15	39	7.9
El Monte Main PO	526	181,571	403	$31,423	$0.17	30	13.4
Fountain Valley PO	965	225,238	272	$39,708	$0.18	28	9.7
Glendora Main PO	497	87,197	205	$22,479	$0.26	20	10.2
Harbor City PO [1]	122	9,520	91	$2,695	$0.28	5	18.2
Ida Jean Haxton PO	703	127,112	211	$21,041	$0.17	25	8.4
Irvine Harvest Station PO	738	173,682	275	$26,510	$0.15	24	11.4
La Mirada PO	581	71,202	143	$12,783	$0.18	15	9.5
Lamond Riggs PO	246	44,320	210	$4,297	$0.10	14	10.5
Linda Vista Station PO	610	94,080	180	$20,746	$0.22	22	8.2
Los Feliz Station PO	599	126,480	246	$12,482	$0.10	32	7.7
Norwalk PO	549	100,865	214	$18,066	$0.18	26	8.2
Rico Rivera PO	568	68,141	140	$9,687	$0.14	16	8.7
Royal Oaks Station PO	419	83,240	232	$13,906	$0.17	20	11.6
San Gabriel Main PO	491	78,565	187	$19,179	$0.24	20	9.3
All Sites - Total		**2,221,384**	**235**	**$371,615**	**$0.17**	**500**	**9.5**

Note: No data were available for White Plains.

[1] For Harbor City, the kWh/day/vehicle total is for the last four billing periods. (Prior to that, electricity use includes that for the 12 Chrysler EPIC electric vehicles also.

TABLE 3-8 ELECTRICITY USE TOTALS BY MONTH (JANUARY 2001 THROUGH FEBRUARY 2003)

Month	Days	Total kWh	Daily Avg kWh	Bill $ Amount	Average Cost ($/kWh)	Vehicles Deployed	kWh/day /Vehicle
Jan-01	31	12278	462	$1,785	$0.15	28	
Feb-01	28	16972	707	$2,476	$0.15	28	
Mar-01	31	18943	713	$2,763	$0.15	28	
Apr-01	30	20310	790	$3,011	$0.15	68	
May-01	31	22346	841	$3,274	$0.15	93	9.0
Jun-01	30	20212	786	$4,515	$0.22	137	5.7
Jul-01	31	30620	1152	$6,108	$0.20	194	5.9
Aug-01	31	47514	1788	$9,569	$0.20	231	7.7
Sep-01	30	59049	2296	$11,777	$0.20	273	8.4
Oct-01	31	69934	2632	$11,190	$0.16	303	8.7
Nov-01	30	84694	3294	$12,610	$0.15	323	10.2
Dec-01	31	91792	3455	$14,110	$0.15	343	10.1
Jan-02	31	96216	3621	$15,419	$0.16	383	9.5
Feb-02	28	111873	4661	$22,474	$0.17	460	10.1
Mar-02	31	117086	4406	$19,650	$0.16	465	9.5
Apr-02	30	119755	4657	$17,660	$0.16	480	9.7
May-02	31	128633	4841	$25,121	$0.21	480	10.1
Jun-02	30	121862	4739	$22,644	$0.19	480	9.9
Jul-02	31	120990	4553	$23,239	$0.19	480	9.5
Aug-02	31	124872	4699	$23,930	$0.19	480	9.8
Sep-02	30	124436	4839	$22,624	$0.18	480	10.1
Oct-02	31	120919	4551	$19,177	$0.16	500	9.1
Nov-02	30	133482	5191	$19,260	$0.14	500	10.4
Dec-02	31	140570	5290	$20,492	$0.15	500	10.6
Jan-03	31	129905	4889	$19,761	$0.15	500	9.8
Feb-03	31	127425	4796	$19,656	$0.15	500	9.6

FIGURE 3-5
ECRV DAILY AVERAGE ELECTRICITY USE
ALL VEHICLES, ALL SITES

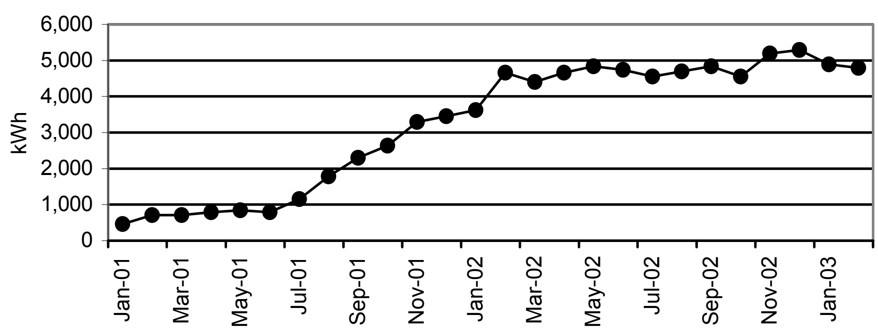


FIGURE 3-6 ECRV AVERAGE ELECTRICITY USE PER DAY

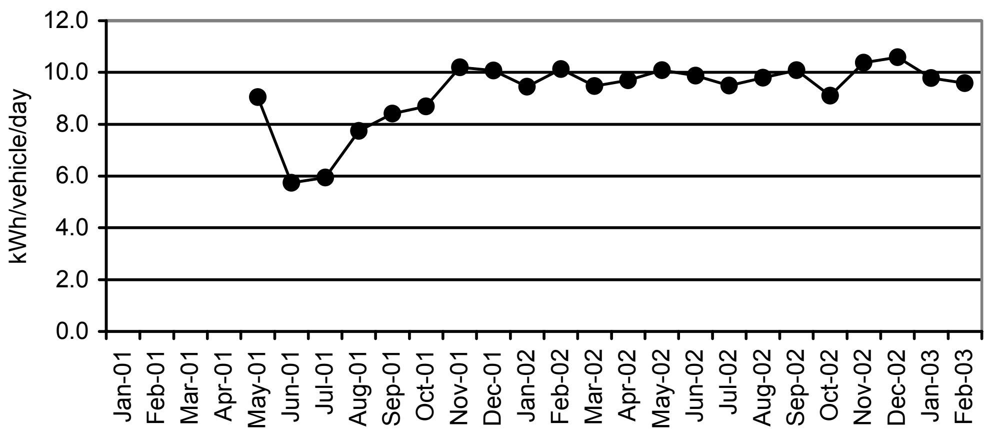
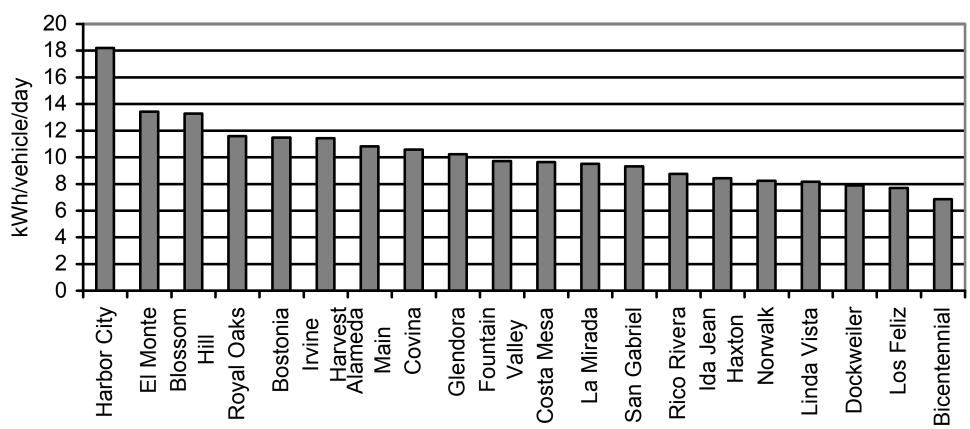


FIGURE 3-7 ECRV AVERAGE ELECTRICITY USE PER VEHICLE PER DAY



Using the data presented above for vehicle miles driven and electricity used, estimates of energy efficiency were developed (miles per kWh). The results are shown in Table 3-9, and Figure 3-8 (by site) and Figure 3-9 (by month). With the exception of Lamond Riggs, Los Feliz and Harbor City, all sites show energy efficiency in the range 0.8 miles per kWh to just over 1.0 miles per kWh, with an average of 0.85 miles/kWh for the fleet. This compares with an estimate of 0.87 miles per kWh which was derived in the performance evaluation using the first few months of data at three sites (RMA, 2001a). Plotting the average energy efficiency data against average miles per day for each site suggests that energy efficiency improves by about 10-15% as the distance driven increases from 7 to 14 miles per day (Figure 3-10).

TABLE 3-9 ECRV ENERGY EFFICIENCY

Read Date	Number of Vehicles	Vehicle Days Used	Sum of Miles Driven	Total kWh	Miles/kWh	Miles/Day
Alameda Main	20	6,205	72,577	78,360	0.93	11.7
Bicentennial Station	57	14,216	108,101	122,560	0.88	7.6
Blossom Hill Station	20	1,659	20,492	26,400	0.78	12.4
Bostonia Station	20	9,764	98,015	119,960	0.82	10.0
Costa Mesa Main	20	9,371	102,183	105,695	0.97	10.9
Covina Main	20	6,969	78,942	83,276	0.95	11.3
Dockweiler Station	39	21,818	178,362	213,920	0.83	8.2
El Monte Main	30	12,091	156,906	181,571	0.86	13.0
Fountain Valley	28	17,194	199,654	225,238	0.89	11.6
Glendora Main	20	6,512	90,203	87,197	1.03	13.9
Harbor City [1]	5	517	4,867	9,520	0.52	9.4
Ida Jean Haxton Station	25	12,036	118,662	127,112	0.93	9.9
Irvine Harvest Station	24	12,457	151,265	173,682	0.87	12.1
Lamond Riggs	14	3,431	28,244	44,320	0.64	8.2
La Mirada	15	6,310	63,711	71,202	0.89	10.1
Linda Vista Station	22	10,659	99,454	94,080	1.06	9.3
Los Feliz Station	32	12,753	80,651	126,480	0.64	6.3
Norwalk	26	11,686	105,353	100,865	1.04	9.0
Pico Rivera	16	6,970	65,346	68,141	0.96	9.4
Royal Oaks Station	20	6,209	74,104	83,240	0.89	11.9
San Gabriel Main	20	7,938	65,492	78,565	0.83	8.3
All Sites - Total	**493**	**196,765**	**1,962,584**	**2,221,384**	**0.88**	**10.0**

[1] Data for Harbor City are for December 2002 through March 2003.

FIGURE 3-8 ECRV ENERGY EFFICIENCY

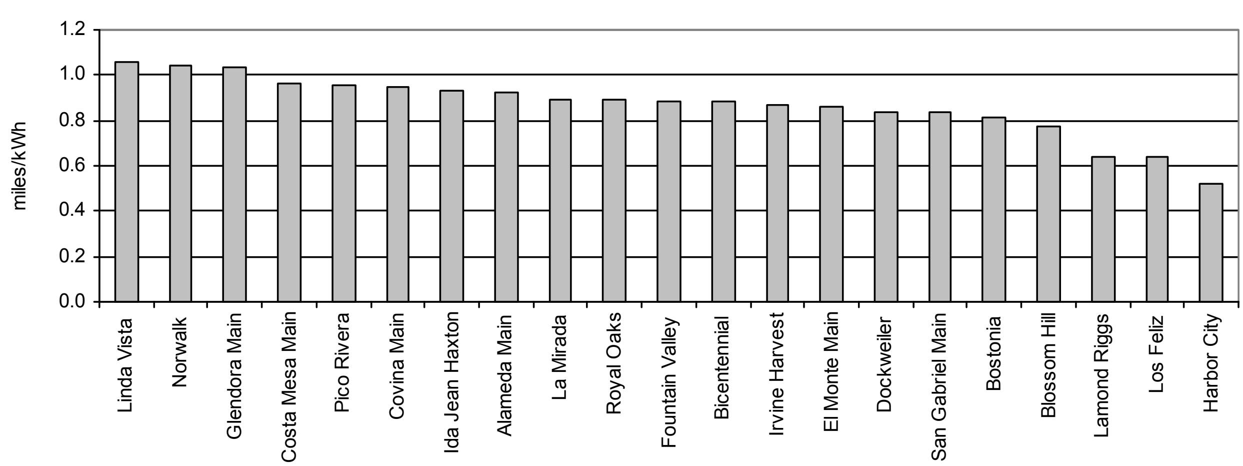


FIGURE 3-9
AVERAGE ENERGY EFFICIENCY BY MONTH
POST OFFICES IN CALIFORNIA

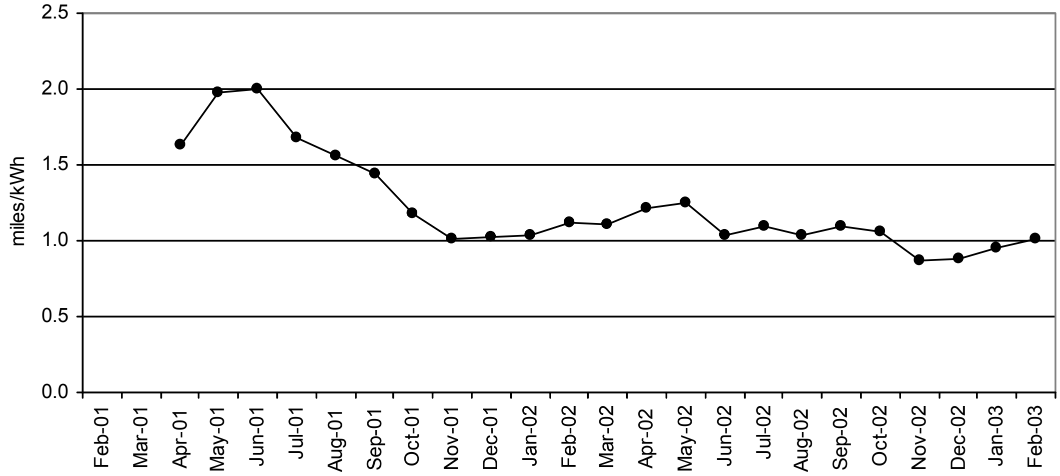
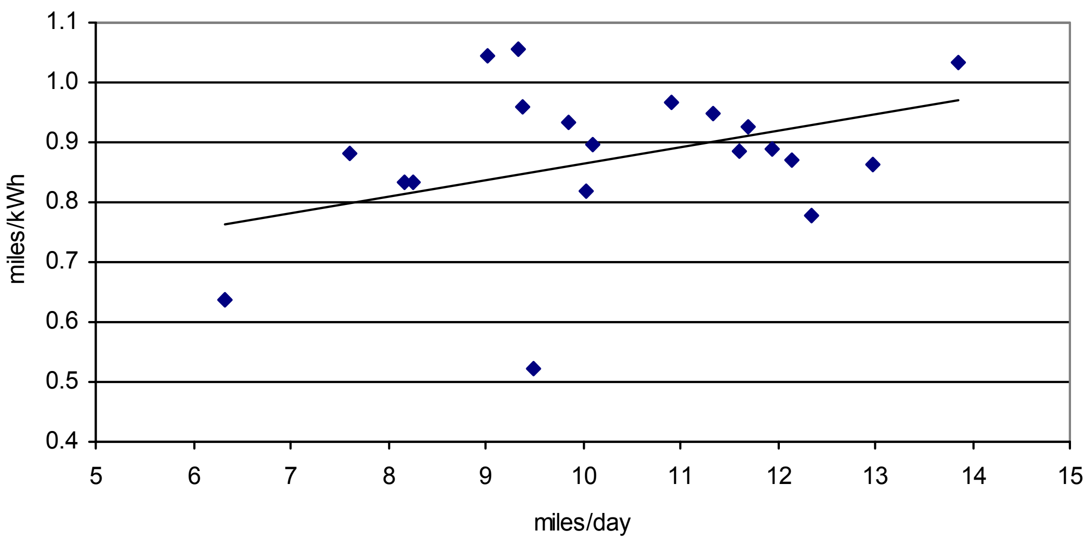


FIGURE 3-10
ECRV ENERGY EFFICIENCY vs. MILES DRIVEN



The average cost of electricity ($/kWh) for each site is shown in Figure 3-11. The data shown in this figure and in Table 3-7 indicate that the average cost of electricity for sites in California ranges from less than $0.15c per kWh to more than $0.25c per kWh. This wide range is likely due to the availability of favorable utility rates at some sites (low cost per kWh), and a relatively high use of on-peak electricity at other sites (high cost per kWh). Further analysis of the data would be needed to provide a more explicit explanation of the differences. The average for all sites and all vehicles is $0.17c per kWh (Table 3-7). (For the Life Cycle cost analysis, a value of $0.14 per kWh was used for the electricity cost (RMA, 2001a)). It is likely that the average electricity cost could be decreased if the charging practices were optimized at all sites to minimize use of on-peak electricity.

The monthly cost for electricity at all sites in California is shown in Figure 3-12. This figure shows that, with all vehicles in operation (April 2002 through February 2003), the monthly cost of electricity for all sites in California (479 vehicles) was on the order of $20,000 to $25,000. From this limited duration of data, there is some indication of an increase in the monthly electricity cost in summer, which would be expected given that most of the utilities have higher rates during the summer months, especially for on-peak electricity use. Insufficient data were available for the Lamond Riggs and White Plains Post Offices to evaluate whether the colder ambient temperatures have any adverse affect on the ECRV energy efficiency at those sites.

FIGURE 3-11
AVERAGE COST OF ELECTRICITY - POST OFFICES IN CALIFORNIA

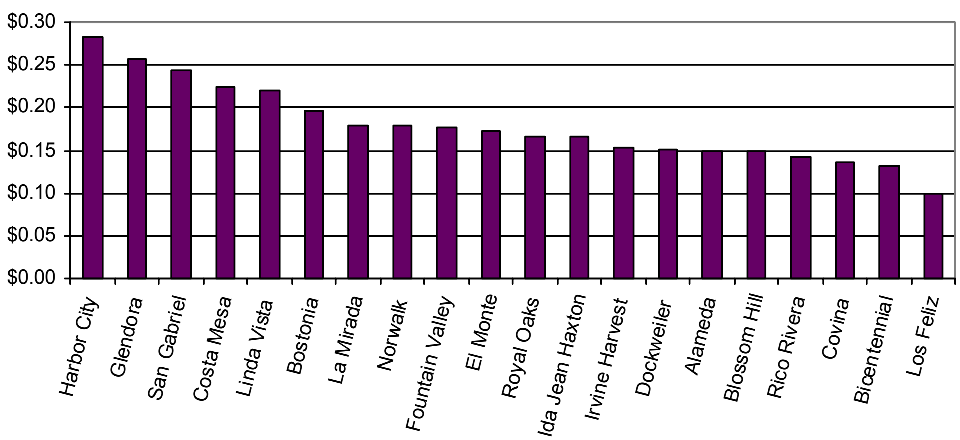
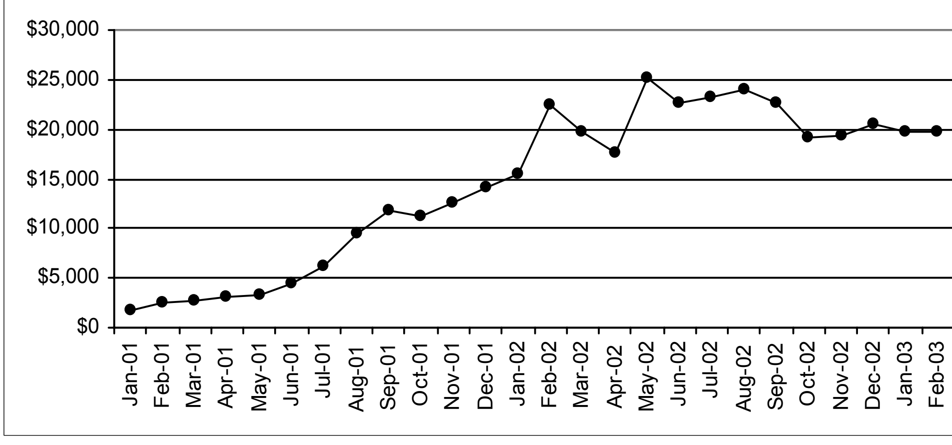


FIGURE 3-12
MONTHLY COST FOR ELECTRICITY - CALIFORNIA POST OFFICES



3.2.4 Air Emission Reductions

Estimates of air emission reductions for the ECRV deployment were developed by assuming the ECRVs are Zero Emission Vehicles, and the level of emission reductions would be based on the emissions of the vehicles being displaced. Though there were some Carrier Route Vehicle transfers at the Post Offices to accommodate the ECRVs, the vehicles which were retired from service were the Postal Service AMG Jeeps with Model Year 1978-1983. The emission estimates were not adjusted to account for any power plant emissions associated with electricity generation.

Emissions associated with the AMG Jeeps were estimated using the EMFAC2002 program available from the California Air Resources Board. Details of this program are available in the EMFAC Users Guide (CARB, 2003a). A 1983 vehicle model year was assumed, with emission factors for the South Coast Air Quality Management District. Emission Factors were obtained for running emissions, cold starts, hot starts, hot soak, diurnal evaporation and running losses (Table 3-10). An average vehicle speed of 20 mph was used, and it was assumed there would be 10 hot starts, and 1 cold start each day.

TABLE 3-10 EMISSIONS FACTORS USED FOR 1983 AMG JEEP

Running Emissions	Carbon Monoxide(CO)	25.668 g/mi
	Reactive Organic Compounds (ROC)	0.982 g/mi
	Oxides of Nitrogen ($NO_{x)}$	2.832 g/mi
Cold Start Emissions	CO	45.148 g/trip
	ROC	3.426 g/trip
	NO_x	1.383 g/trip
Hot Start Emissions	CO	4.263 g/trip
	ROC	0.313 g/trip
	NO_x	0.351 g/trip
Hot Soak Emissions	ROC	0.582 g/trip
Diurnal Evaporation Emissions [1]	ROC	1.38 g/day
Running Losses [2]	ROC	6.84 g/day

Source: California Air Resources Board, EMFAC2002
Notes: [1] Assumes 12 hours of diurnal losses; [2] Assumes one hour of driving per day.

Total emission reductions for the period from deployment to date were estimated using the total vehicle miles and days used for each Air District. The emissions were also pro-rated by calendar year based on the number of miles driven in each Air District each year. The results are presented in Table 3-11.

TABLE 3-11 ESTIMATE OF EMISSION REDUCTIONS

		BAAQMD	SCAQMD	SDCAPCD	SMAQMD	Other	Total
Number of Vehicles		40	377	42	20	21	500
Miles Driven		108,257	1,587,709	197,469	74,104	69,827	2,037,366
Days Used		8,304	160,731	20,423	6,209	5,530	201,197
Total Emission Reductions (pounds)	CO	7,733	120,950	15,127	5,395	5,022	154,226
	ROC	516	8,879	1,119	371	338	11,223
	NO_x	765	11,647	1,453	530	496	14,891
2001 Emission Reductions (pounds)	CO	0	29,369	3,782	635	0	33,930
	ROC	0	2,156	280	44	0	2,469
	NOX	0	2,828	363	62	0	3,276
2002 Emission Reductions (pounds)	CO	5,422	73,147	9,076	3,808	3,863	95,620
	ROC	361	5,370	671	262	260	6,958
	NOX	537	7,044	872	374	381	9,232
2003 Emission Reductions (pounds)	CO	2,311	18,434	2,269	952	1,159	24,676
	ROC	154	1,353	168	65	78	1,796
	NOX	229	1,775	218	93	114	2,383

Notes
Vehicle miles driven and days used obtained from Postal Service VMAS data.
BAAQMD = Bay Area Air Quality Management District
SCAQMD = South Coast Air Quality Management District
SDCAPCD = San Diego County Air Pollution Control District
SMAQMD = Sacramento Metropolitan Air Quality Management District
Other = Lamond Riggs and White Plains Post Offices

3.3 MAINTENANCE AND REPAIR

During the time the ECRVs have been in service, over a thousand warranty repairs have been completed by Ford. While the Postal Service Vehicle Maintenance Facilities (VMFs) have conducted some repairs on the ECRVs, these have mostly been body and cab repairs, tire and wheel repairs, and for lighting (changing bulbs). The repairs have been made by the VMFs when needed to keep vehicles in service (personnel communication with Gerard Koontz, Huntington Beach VMF, May 2, 2003).

Most of the information in this section is based on analysis of the ECRV Concern Reports (CRs) that Ford has been using to document ECRV incidents and repairs. A detailed listing of the CRs was obtained from Ford in the form of a log (see Appendix C). Ford also provided the actual Concern Reports for battery module and pack repairs. Additional information and explanation of the data on warranty repairs was provided directly by Ford staff involved in maintaining the ECRVs in the field (personal communication with Ken Stwertnik, April 25, 2003).

Figure 3-13 presents a summary of the ECRV warranty repairs showing the incident categories used by Ford and the number of Concern Reports issued for each type of repair. An explanation of the repair categories is included in Table 3-12. It can be seen that, apart from clear codes and miscellaneous non-electrical repairs, the categories that have occurred most frequently are the 12-volt components (28 %) and battery modules (18 %). These two repair categories have considerably more incidents than the remaining categories. Incidents in the battery module category include battery module and pack replacements.

FIGURE 3-13
NUMBERS OF ECRV CONCERN REPORTS BY CATEGORY
(Excluding Pre-Delivery CRs)

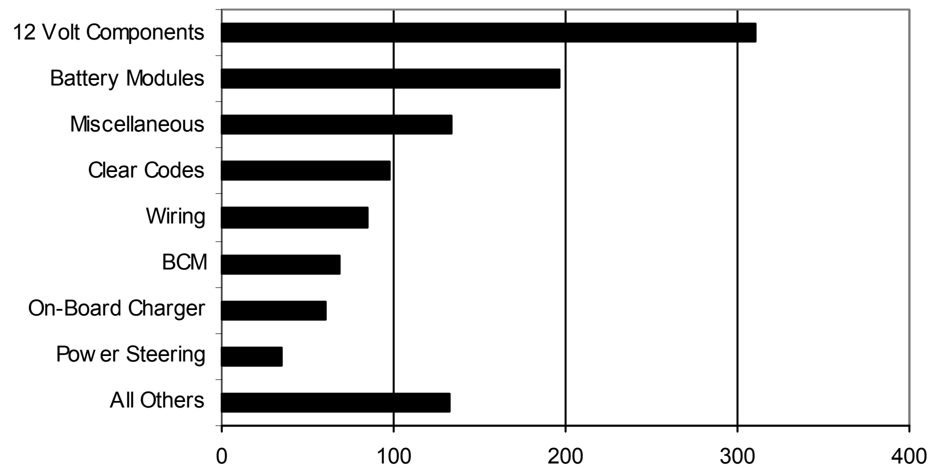


TABLE 3-12 EXPLANATION OF CONCERN REPORT CATEGORIES (FORD MOTOR COMPANY)

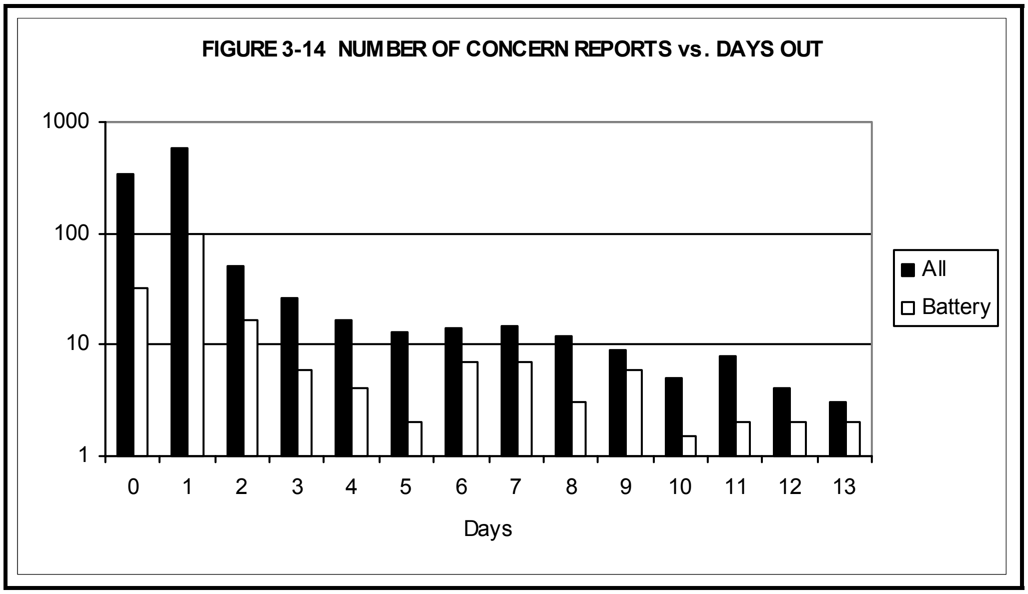
- **Clear Codes:** Clear codes are used when the technician could not identify a specific vehicle problem. This call is usually in response to the vehicle malfunction (wrench) warning light being on, or that the vehicle did not recharge.
- **Auxiliary Battery:** The auxiliary battery is a 12-volt battery that provides power for the network system on the vehicle and normal automotive functions. It is charged via the DC to DC converter. The EV puts a greater usage on this battery than a typical gasoline vehicle so it is more prone to failure. When voltage is below 11.5 volts the vehicle will not charge or start.
- **BCM:** The Battery Control Module (BCM) manages the battery pack and charging process. Problems with the BCM are related to vehicle range and charging. The driver is notified of a problem when warning light(s) are on.
- **Battery Modules:** There are 39 battery modules in the battery pack. Failure of just one module will reduce range and/or not allow the vehicle to be driven. As more miles are accumulated on the modules, the greater the potential for range reduction. Most repairs are related to decreased vehicle range caused by worn module(s).
- **On-Board Charger:** This component charges the battery pack as directed by the BCM. Failure results in the vehicle not being recharged.
- **Contactor Box:** This component is controlled by the BCM and opens and closes various high voltage circuits. Failure results in the wrench (malfunction) warning light turning on and/or the loss of power steering, charging, heater, and/or vehicle operation.
- **Charger Inlet:** This component provides the connector for the Power Control System (PCS) and supplies wall current to the On-Board Charger. Failure results in loss of charging.

TABLE 3-12 EXPLANATION OF CONCERN REPORT CATEGORIES (FORD MOTOR COMPANY) (CONTINUED)

- **Heater Components:** This category covers the Heater Switching Module and the heater core resistors. Failure may be indicated by warning light(s) being on and/or loss of power steering, charging and heater function.
- **12-Volt Components:** Most failures have been with the side brake lights, horn contact "clock-spring", headlamp switch, and ignition switch.
- **Power Steering:** The power steering unit is unique to this vehicle. Failure results in loss of power steering and possible failure of the contactor box.
- **TIM/Motor/Transaxle:** The Traction Inverter Module (TIM) and Motor/Transaxle assembly are connected and together provide power to the rear wheels. Failure of these components may result in turning on warning light(s), and/or a loss of power.
- **Wiring Harness/Misc:** This category covers blown fuses, connector pin problems, and/or wiring defects. Most of the failures are blown fuses related to vehicle complexity.
- **Vacuum Pump:** This component supplies vacuum for the power brake booster and for the climate control system. Most replacements are due to a noisy pump.
- **Non Electrical/Misc:** This category covers all other systems steering and brakes. The majority of failures have been broken guide pins in the parking brake handle.

One reason why the number of incidents for 12-volt components is high is that this category includes the water pump, a component that has experienced recurring problems. In April 2003, Ford committed to replacing all ECRV water pumps (Ken Stwertnik, April 25, 2003). Ford indicated that a number of 12-volt failures were due to the higher usage of parts (such as the ignition switch) on an electric vehicle than compared with a comparable internal combustion engine vehicle.

Figure 3-14 is a histogram showing the number of incidents and the time taken to complete the repairs ("days out"). (Note that a logarithmic scale is used in this figure.) The data for "all CRs" are included in this figure together with the battery module data. While the overall profile shows a tail distribution with the number of incidents decreasing with time needed for repair, the battery module profile shows a bimodal distribution with a peak at one day, and a secondary peak at 6-8 days. The two peaks are likely associated with the module repairs and the pack replacements Not shown in this figure are the 15 CRs that took longer than 14 days or more, including seven for battery repairs, and four for 12-volt component repairs.



Note: logarithmic scale on y axis

The number of CR incidents per month from February 2001 through March 2003 is shown in Figure 3-15. The total number per month increased through 2002 as all ECRVs were phased into service. The number of CR incidents per vehicle per month is shown in Figure 3-16. Based on this data, it appears that the frequency of incidents increased through late 2002, with an average repair frequency for the ECRV fleet to date of 0.12 per vehicle per month (1.47 repairs per vehicle per year).

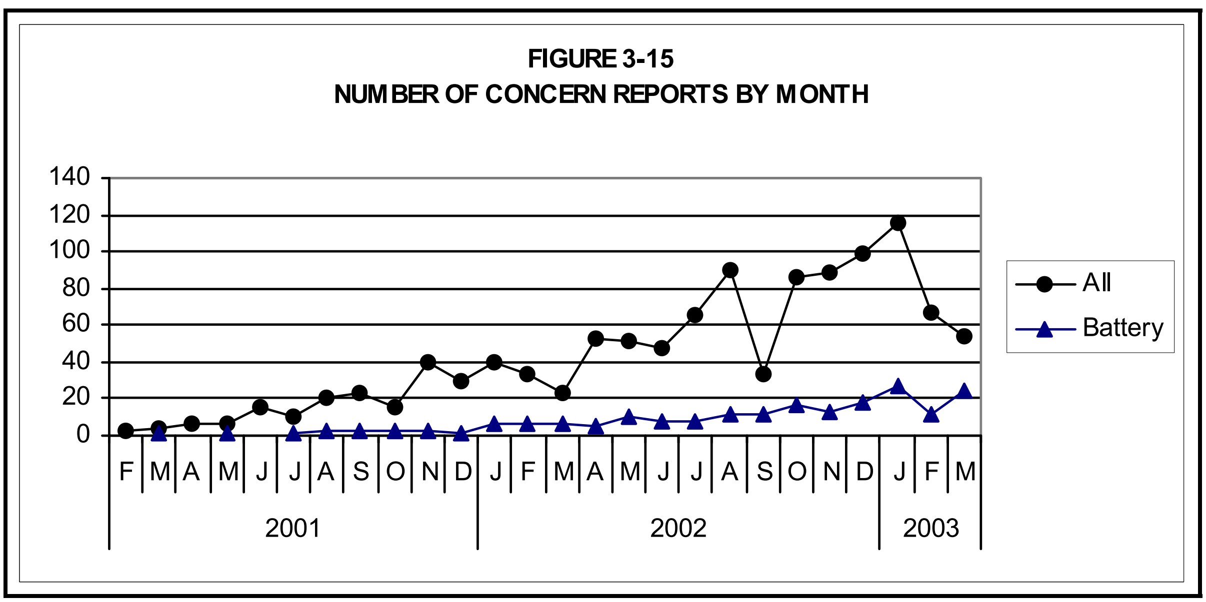
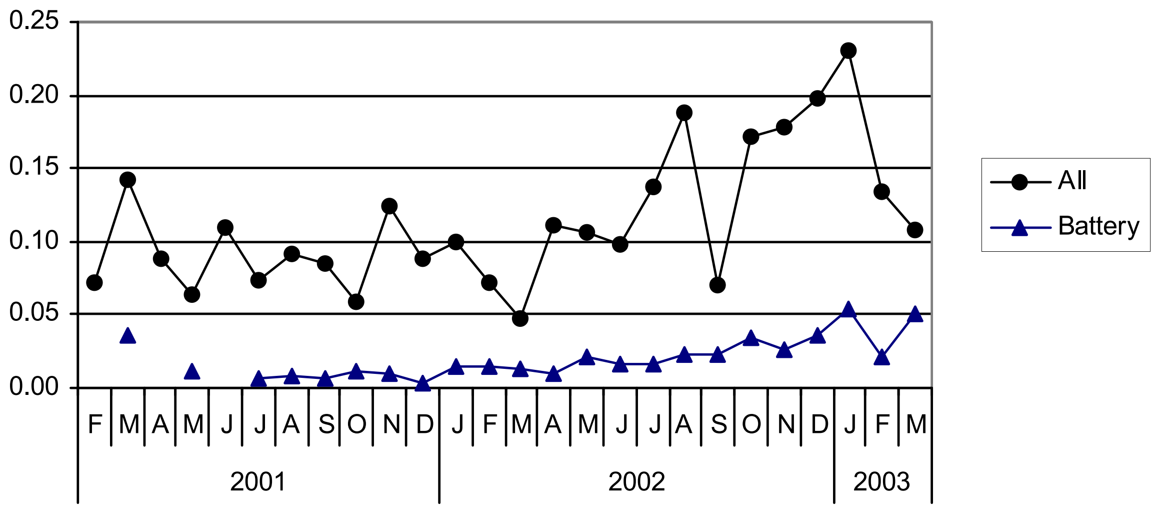


FIGURE 3-16
NUMBER OF CONCERN REPORTS PER VEHICLE PER MONTH



Based upon the information included in the CR logs and from discussions with Ford personnel, RMA developed independent estimates of the time taken (labor hours) to complete each type of repair. In most cases, it was assumed that the actual time to accomplish the repair would be on the order of an hour or less. However, it was assumed that a service technician would need time to travel to the ECRV in the field and/or to bring the ECRV into the shop, so even for the simplest kinds of repair the minimum labor time required was assumed to be three (3) hours.

The two repair categories that have consistently needed more time to complete are the battery module repairs, and some of the wiring harness repairs. For a technician to investigate battery module incidents, it is often necessary to completely discharge the battery prior to diagnosis, and this may require the vehicle to be driven for several hours. For these types of repair, the CR data indicate that the time between the initiation of the repair and the date of completion is often many days (three days on average, with 12% taking more than a week). In the case of extended repairs, for at least some of this time, the service technician could be waiting for parts or a replacement battery. For this analysis it was assumed that battery module repairs take 10 hours of technician time and battery pack repairs 24 hours.

Some of the wiring harness repairs have been especially challenging because of the complexity of the wiring system in the ECRV. Engineering assistance is frequently needed, and it may take many hours of mechanic time to complete this type of repair (personal communication, Ken Stwertnik with Ivor John. April 25, 2003). It was assumed that the labor time for wiring harness repairs would be 14 hours on average, based on information from Ford.

Using the above assumptions, estimates were developed for the total labor hours and the total labor hours per month per vehicle to complete the ECRV repairs. The calculations were made for all repair categories, and for battery modules separately as this category has dominated the need for technician repair time. The monthly labor totals and the labor totals per vehicle per month are shown in Figures 3-17 and 3-18, respectively. These figures show that, since mid-2001, the time needed for maintenance has increased steadily. The average labor time for all repairs has increased from about 0.3 to over 1.1 hours per vehicle per month, and the average labor time for battery repairs has increased from 0.1 to more than 0.6 hours per vehicle per month during the same period. The average time spent for all repairs was about 0.7 hours per vehicle per month.

FIGURE 3-17
TOTAL LABOR TIME FOR REPAIRS

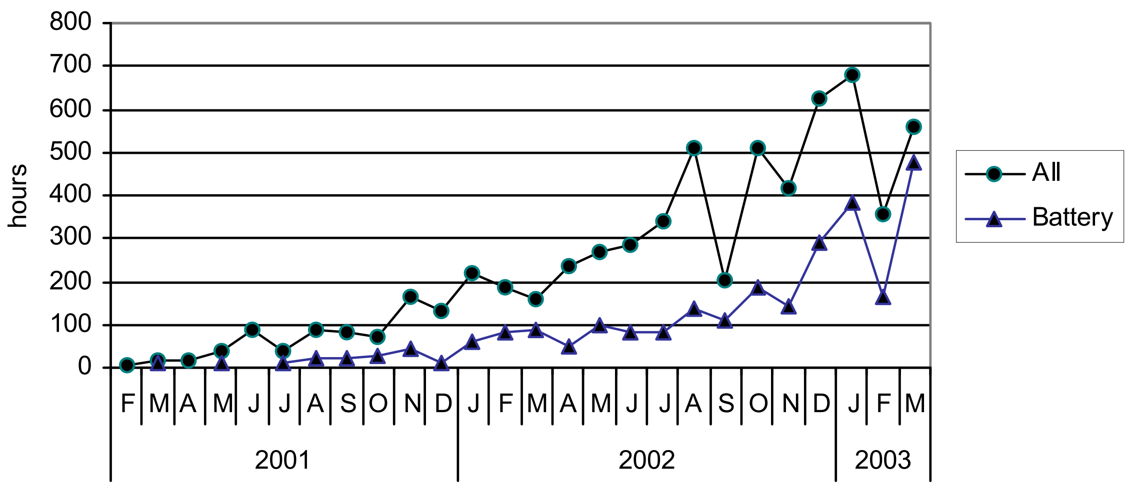
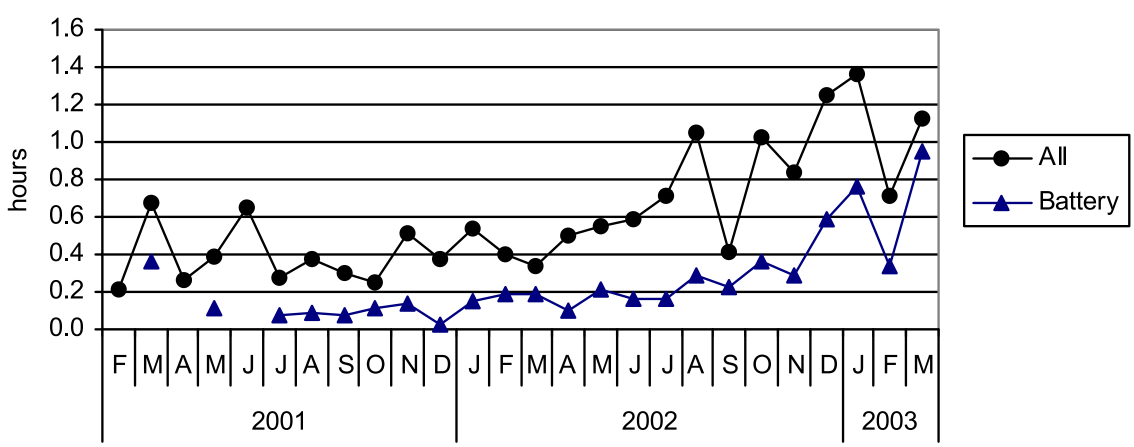


FIGURE 3-18
AVERAGE LABOR TIME FOR REPAIRS PER VEHICLE



It is important to emphasize that these estimates are based on information provided by Ford for warranty repairs. At the end of the warranty, the time taken by Postal Service mechanics and the types of repairs may well vary from these estimates. Also, this analysis provides no information on the cost of parts needed to complete these repairs.

In addition to the Ford Concern Reports, the Postal Service VMAS data for the ECRVs were obtained to investigate the types of repairs the Postal Service mechanics have been involved with, and the typical costs incurred through the warranty period to date. This was done for a sample of the ECRVs at the eight Post Offices served by the Huntington Beach and La Puente VMFs. Brief phone interviews were also conducted with a small number of VMF personnel. The results are presented in Table 3-13. The data in this table confirm that, apart from the “all others” component category, very little time has been spent by the VMFs on the ECRVs, and this has been mostly for work on cab and body repairs (12.2%), tire repairs and replacements (8.6%), wheels (2.4%) and lighting (2.5%). All VMF repairs (including the “all other” category) have incurred an average cost (for parts and labor) of approximately $400 per vehicle since deployment (or about $200 per vehicle per year).

TABLE 3-13 SUMMARY OF VMAS DATA COMPONENT COSTS FOR ECRVS (HUNTINGTON BEACH AND LA PUENTE VMFs)

Component Category	Total Cost (Parts and Labor	Percent
Heating	$680	0.9%
Cab Body	$9,233	12.2%
Instrument Gauges	$48	0.1%
Brakes	$577	0.8%
Suspension	$379	0.5%
Tires	$6,499	8.6%
Wheels	$1,847	2.4%
Front axle	$92	0.1%
Rear axle	$32	0.04%
Transmission	$38	0.1%
Charging System	$30	0.0%
Cranking System	$352	0.5%
Ignition System	$364	0.5%
Lighting System	$1,855	2.5%
Cooling System	$58	0.1%
Exhaust System	$90	0.1%
Fuel System		
Engine	$35	0.05%
Trailer		
All Others	$53,396	70.6%
Total	**$75,604**	**100.0%**

Source: VMAS AEL302P9, FY01 through FY03, Q02. Total of 187 ECRVs.

The main conclusions from this analysis on ECRV maintenance and repair are as follows:

- A high number of warranty repair issues has been addressed by Ford. The trend is upward in recent months.
- The battery module repair category has been one of the most prevalent and time consuming problems. These failures require extended service time to diagnose and repair. (Refer to Section 3.5 for further discussion on this item.)
- The wiring harness repair category has also required extended service time. Because of the extensive wiring on the ECRV, the repairs are often very complex. Ford Engineering has often been needed to help diagnose and repair these problems.
- The 12-volt component category is the category with the highest number of incidents. Many of the vehicle systems that are mechanical on a gasoline vehicle are electrical on the ECRV (e.g., the water pump). This places a higher demand on the ECRV 12-volt system. The 12-volt component repairs have not been as time-consuming or complicated as those for battery modules and wiring harnesses.
- Problems have occurred with the water pumps (categorized as a 12-volt component) and the power steering units in many of the ECRVs. Ford has addressed these problems by replacing many of the components and establishing improved quality standards with suppliers. Water pumps may have exacerbated battery performance problems because failures may have resulted in overheating of the battery pack.
- On-road failures have occurred, and some vehicles have been towed in for repairs (mainly by Ford). However, results from the Carrier survey (Chapter 4) indicate this issues has not been pervasive.
- Postal Service has been involved to a minimal extent in service and repairs through the warranty period to date. Repairs conducted by the Postal Service have been mostly for the body and cab, tires, wheels, and lighting systems.

Reliability and battery performance are discussed in more detail in the next two sections.

3.4 RELIABILITY AND AVAILABILITY

3.4.1 Vehicle Reliability and Availability

Due to the limited period that the ECRVs have been operating, it is difficult to predict long-term reliability and availability with confidence. However, the available data do give a preliminary indication of the overall trend during the first two years since vehicles were first deployed.

Two approaches were used to develop an indication of the ECRV availability. The first approach was to use the Postal Service VMAS data to derive a percentage of lost time for the fleet to date. The second approach was to estimate the lost time from an assessment of the Ford Concern Reports, previously discussed

Applicable data from the VMAS AEL302P9 reports (summarized in Appendix B, Section B.1) were used to provide availability index values for the ECRV fleet by subtracting the “days in shop" from the "days assigned" and dividing by the "days assigned". The availability to date for each Post Office is shown in Figure 3-19. Overall the availability index value for the ECRV fleet using this approach is on the order of 98.8%, with most sites above 98%. Availability over time is shown in Figure 3-20. This figure indicates that availability to date has been high (above 99%), but there has been a deterioration in the last seven APs. This methodology does not account for ECRV "days not used", but when those days are included, a similar trend is observed.

For comparison, the availability index values for Postal Service gasoline LLVs is typically in the range from 98% to 99% for the newer LLVs (vehicle age of 6 or 7 years), and from 97% to 98% for older vehicles (RMA, 2001a).

FIGURE 3-19 ECRV AVAILABILITY BY POST OFFICE

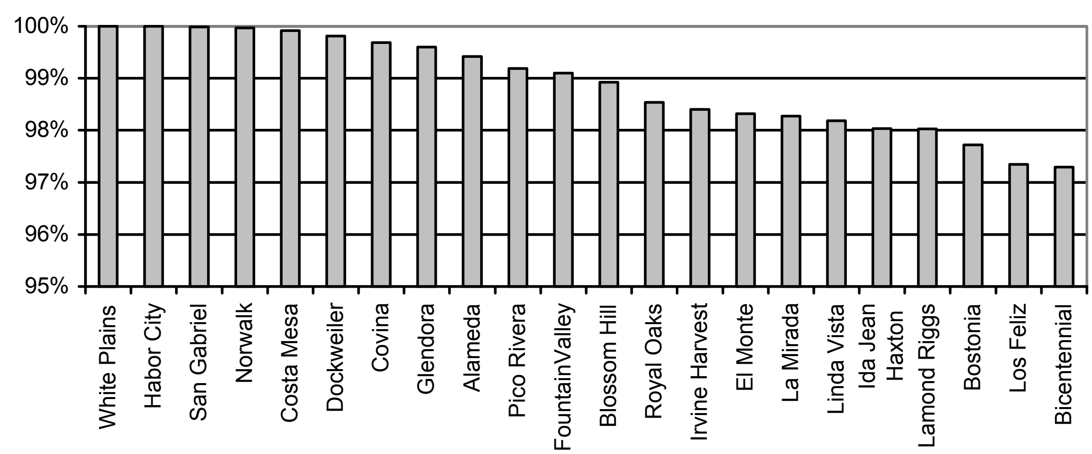
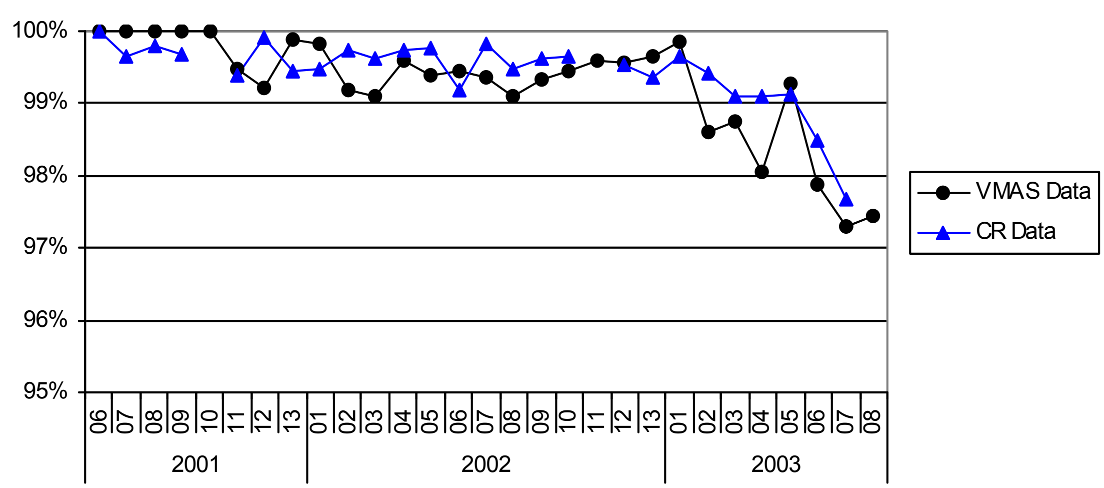


FIGURE 3-20 ECRV AVAILABILITY BY AP

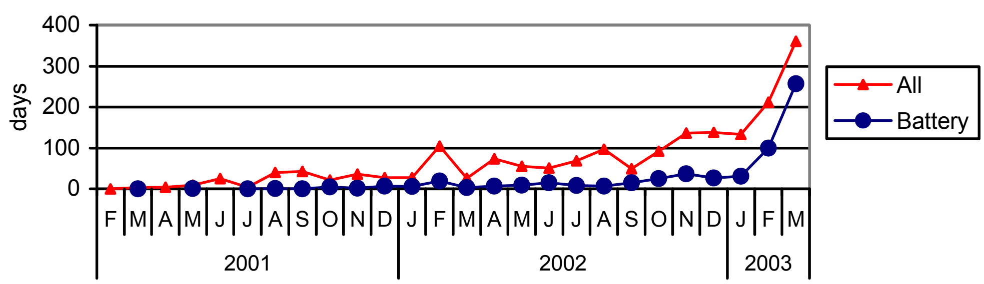


In the second approach, Concern Reports (CRs) were reviewed to develop a separate availability index. This estimate was based on the CRs provided by Ford covering the period from February 2001 through April 2003. The time elapsed between the report date and the repair completion date was used as an estimate of vehicle lost days, similar to “days in shop” in the previous approach. This assumes the vehicles are not available for operations during the time the CR remains open.

The availability index in this case was estimated by calculating the total number of vehicle-days by month), and using the CRs to estimate total time the ECRVs were unavailable. This provided an average value of 99.3% for the ECRV fleet. This figure compares reasonably well with the estimate from the first approach using VMAS data, and the overall trend also shows the downward trend in the last few months (also shown Figure 3-20).

The downward trend in the availability index during the last few months coincides with the increased need for repairs during the same period (Figure 3-17). Figure 3-21 shows that repairs during the last five months took longer to complete than those previously. Again, this is consistent with the need for more complex battery repairs often involving pack replacements. This trend may indicate that batteries are approaching their end of life, and the need for pack replacements.

FIGURE 3-21 REPAIR DAYS BY MONTH



In summary, the Postal Service has experienced considerable reliability problems with the ECRV fleet during recent months. These have mostly been due to battery pack replacements. In addition to these battery performance issues, the warranty repair data show that there have also been high failure levels with water pumps, wiring harnesses and other 12-volt components.

It appears that the availability of the ECRV fleet to date has been comparable with that for the Postal Service gasoline LLVs, but the data suggest that reliability and availability have been deteriorating during the last few months, mainly because of battery problems. Battery performance is discussed further in Section 3.5.

3.4.2 Reliability of the Electricity Supply

During the late 1990s, power supply problems in California raised concerns about the reliability of electricity supply and the potential for cost increases. In the summers of 1999 and 2000, there were periodic disruptions to the supply, and users throughout the state faced uncertainty about electricity prices and supply reliability.

For electric vehicles that rely on wall current for charging, it is critical that electricity supply be reliable and cost-effective. While the power supply problems during that period did impact cost and reliability of the supply, most of the problems were related to peak demand periods during the day. Since EVs tend to be charged during the off-peak period, they are sheltered to some degree from power supply disruptions. However, the off-peak rates have been subject to cost increases as a result of California's power supply problems. During the last few years, the price per kiloWatt for off-peak electricity in the Southern California Edison service area has increased from $0.06c/kWh (without taxes and other facility/service charges) to $0.09c/kWh in 2003.

Since the year 2000, the State of California has made progress in stabilizing the electricity supply, providing additional supply during times of peak demand. New plants have been built to assist the state in overcoming the shortfalls.

Many of the ECRV deployment sites are served by the municipal utilities, including the Los Angeles Department of Water and Power. The municipal utilities have not been subject to the power supply and cost instability problems to the same extent as the publicly owned utilities.

Since 1999, the publicly owned utilities have been approved to increase rates to cover the higher wholesale power supply costs, however, the increases have remained moderate to date. The ongoing working sessions with the Governor, the power suppliers and the utilities are attempting to stabilize both the supply and the costs of the power. They are focusing on the use of long-term supply contracts, establishment of a State Power Authority, reducing demand through conservation, and other measures. To date, there has been considerable progress on these issues.

3.5 BATTERY PERFORMANCE AND COST

3.5.1 Battery Performance

As the first ECRVs were placed in service, the uncertainties associated with battery performance, battery life, and battery replacement cost were known to be significant concerns. Some of the contributing factors to this are summarized below:

- Ford experienced a "battery power reduction without warning" on some of the early ECRVs going through end of production line range testing. This was a result of battery module voltage drop-out which was later attributed to poor acid diffusion.
- The two ECRVs tested by Southern California Edison (SCE) in the Accelerated Reliability Testing program both experienced battery problems, and the battery packs in both vehicles were replaced before the end of the test program.

- Uncertainties over battery life and cost in an incipient BEV market were singled out as one of the main issues in the ECRV Life Cycle Cost and Performance Evaluation (RMA, 2001a).

A significant concern was raised with the battery pack in 2001 when several ECRVs going through the end of production line range testing experienced "module voltage dropout". After a detailed investigation, Ford attributed this to poor acid diffusion in the battery because of plate pore size and porosity (Taenaku, 2001). Ford concluded this problem would not adversely affect the Postal Service because the vehicles operate at shallow depth of discharge and they are in warm climates.

In late 2001-early 2002, Ford and East Penn Manufacturing Company, Inc. (EPM) – the ECRV battery pack manufacturer – jointly identified battery modules delivered to Ford that were outside the production control specification. Ford and EPM have subsequently taken steps to ensure that production controls are implemented as designed. They have also changed to cast-metal plate electrodes in the battery in place of the original expanded-metal plates. Ford has not seen any evidence of the voltage dropout problem reappearing.

Prior to full-scale deployment of the ECRVs, two vehicles went through an Accelerated Reliability testing program with SCE (SCE EVTC, December 2001). For Vehicle 124001, the battery pack was replaced at 8,818 miles, 10,069 miles and 11,323 miles. For Vehicle 124002, the pack replacement occurred at 16,293 miles. However, it is unclear if these battery packs had served their full useful life before being replaced, and whether or not the second and third replacements on Vehicle 124001 were completely new packs. This early experience (especially with Vehicle 124001) served to raise awareness about potential problems with the batteries for vehicles deployed in Postal Service operations.

To date, the ECRV fleet has experienced a high number of battery-related incidents requiring lengthy and costly repairs. The battery module repair category has been one of the most prevalent and time consuming problems. These failures require extended service time to diagnose and repair, they lead to a relatively high degree of vehicle lost time, and in some cases they have affected the drivers' confidence about vehicle range and reliability.

From deployment through April 2003, there were 243 CRs involving battery modules out of a total of 1,215. About 63 of these were termed "pre-delivery", so there have been 180 battery repairs for vehicles in the field. These have involved 122 vehicles (24% of the fleet). Many vehicles have needed battery repairs more than once. For 41 vehicles, there has been a need to replace the entire battery pack (8% of fleet), and this has been needed more than once for five vehicles. These numbers are based on data available through the end of March 2003, which represents a weighted average of 1.5 years for the fleet.

The CRs for the battery module incidents, provided by Ford, were carefully reviewed to develop a better understanding of the implications of these numbers. Appendix D includes a limited sample of battery repair CRs for the 25 most recent repairs, and the incidents associated with the vehicles equipped with Data Acquisition and Interface Systems (DAIS).

Figure 3-22 shows the number of battery module and pack repairs by month since deployment. This figure shows there has been a growing number of repairs over time. While some of this increase may be attributable to the steady increase in vehicles deployed between 2001 and

2002, the figure shows a large increase in the number of pack replacements in recent months. Figure 3-23, also derived from the CR data, shows that the number of defective modules per repair has also increased steadily over time, and nearly all module repairs (excluding pack replacements) involved five or less modules.

**FIGURE 3-22
NUMBER OF MODULE AND PACK REPLACEMENTS OVER TIME**

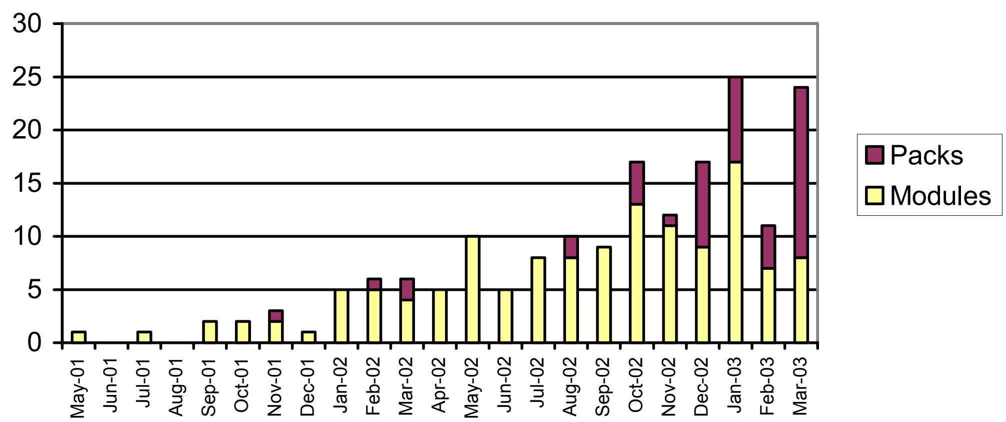
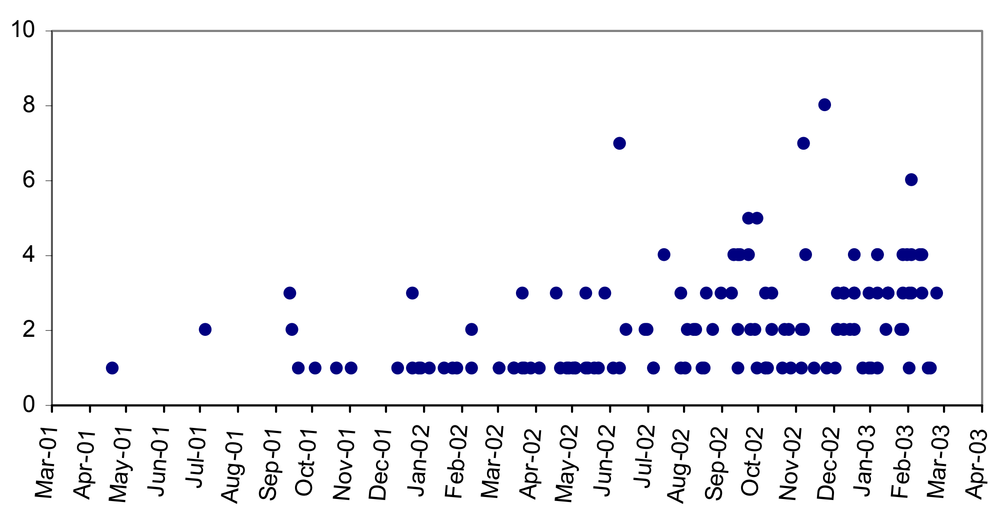


FIGURE 3-23 NUMBER OF MODULES REPLACED

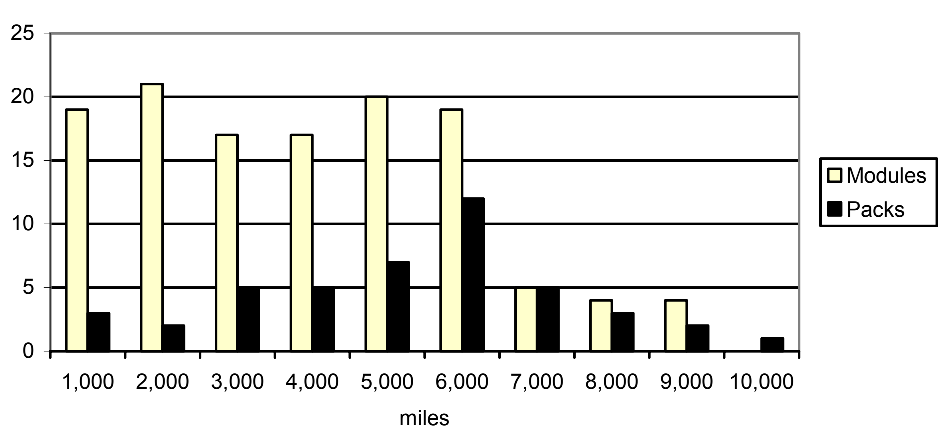


The Postal Service contract with Ford was not specific in defining how the battery condition would be evaluated over time, nor what conditions would constitute the need for an entire pack replacement. However, Ford has developed the following criteria for deciding when a battery needs to be repaired, rebuilt or replaced. All battery pack modules are first checked for open circuit voltage, SOC, and capacity (the latter two calculated by the battery control module). If there is a significant deviation of any of these values from normal ranges, those modules are flagged for replacement. The entire pack is replaced either (1) if replacements are needed and the amp-hour throughput exceeds a certain value (generally 8,000 kWh); or (2) if there are more than five modules that need to be replaced. Ford's standard service does not generally attempt to rejuvenate modules that vary significantly from the rest of the pack.

Figure 3-14 (included in Section 3.3.3), showed the number of battery CRs plotted as a function of "days out". (This is the difference between the date when the incident was first reported and the date when the repair was completed.) Most of the battery repairs were completed in two days or less, but there is a secondary cluster of repairs that took about 6-7 days. Also, of the 15 repairs that took 14 days or more to complete, seven were for batteries. The average times to complete the module and pack repairs were 2.0 and 6.1 days, respectively, and 3.0 days combined. These figures compare with an average of 1.4 days for all other repairs.

Examination of battery repairs against odometer reading (Figure 3-24) shows that the repairs in each 1,000 mile increment up to 6,000 miles has been consistently between 17 and 21. However, the number of pack replacements has increased steadily by odometer reading. Since the average vehicle odometer reading at the time of this study was only about 4,000 miles, the number of battery repairs and replacements for odometer readings greater than 4,000 miles is expected to increase over time. The fleet would have to travel many more miles to ascertain where the median point (in miles) would be for battery pack replacements, thereby indicating the battery pack life expressed in terms of vehicle miles driven.

FIGURE 3-24 BATTERY REPAIRS BY ODOMETER READING



For the ECRVs that have been in service the longest, the battery performance has been mixed. The 28 vehicles at Fountain Valley have traveled more than 7,000 miles on average, and there have been no pack replacements to date. However, at Dockweiler and Ida Jean Haxton, the packs have been replaced on eleven out of 65 vehicles (17% of the vehicles), and at Irvine Harvest, there have been seven pack replacements out of 24 (29%). These results highlight the relatively high frequency of battery replacements to date in the oldest vehicles, and also the significant differences in battery longevity from site to site.

Ford has indicated that the warranty data gathered to date indicate that the battery life is about 30 months. However, these data do not reflect the efforts made by the Postal Service to re-deploy vehicles with low range into routes that require a limited drive range. Also, some vehicles that experienced low range after a period of time have been kept on their original route as long as the vehicle met the required range for that route. These practices may have raised the apparent battery life artificially. Ford has not attempted to predict the battery life in the absence of these actions. The data in Figure 3-24 suggest there is likely to be a wide spread in the battery life across the fleet.

Obtaining early detection of impending battery problems has been a challenge. Detecting battery deterioration as early as possible is important to help minimize serious battery damage. Ford Engineering considers the SOC change rate and the DTE gauges as early warning indicators for encroaching battery problems, particularly for vehicles that are driven to the limits of the battery capacity (low states of charge).

From the CRs, it is clear that the initial indicators of battery problems are almost always the Malfunction Indicator (Wrench) Lamp coming on (84 CRs) or Low Range (71 CRs). However, in practice, it is usually the operator's observances of less-than-expected DTE that is the initial cause for requests for service. The ability to provide service at the most opportune time is dependent on having all ECRV drivers aware of this and the need to report unusual observations. The DAIS data for these vehicles were also reviewed, where available, for the times when battery problems occurred. However, no clear indicators of battery deterioration were apparent. (Refer to Section 5.3 of the report for further details).

In the Carrier satisfaction survey conducted in April, 2003, the Carriers' feedback on battery performance was mostly favorable (Chapter 4). There was no indication in the responses that suggested a major concern about battery performance or reliability. One related statement that received a less favorable response was that the Carriers are concerned about using the electrical ancillary equipment for fear of draining the battery. In the performance data collected for this report, there is no evidence that there have been weather-related energy efficiency or availability issues.

The Battery Control Module (BCM) software code was modified in late 2002 to accommodate both the expanded-metal plate battery modules and the cast metal plate electrodes. The code change consisted of an adjustment to the voltage limit temperature compensation applied during a charge. During the validation of this change it was also seen that the new algorithm reduced charge time and improved charge acceptance for the existing expanded-metal battery modules. Also, gassing was reduced which is expected to help reduce battery failures due to electrolyte dry-out.

3.5.2 Battery Costs

From the outset of the ECRV Demonstration Program, battery costs were recognized as being a significant contributor to the life cycle cost for electric vehicles. The life cycle costs are impacted by the battery cost (manufacturing and installation) and battery life.

Over time, there has been a considerable range in the cost estimates for repairing and replacing the battery packs. In the initial contract between Ford and the Postal Service, the estimated cost for a battery pack replacement provided by Ford was $4,700, though it is unclear whether this amount included installation. During the initial production phase, Ford indicated that the cost to replace a battery pack could be on the order of $9,600, including the cost for the battery from the manufacturer, Original Equipment Manufacturer (OEM) mark-up and installation cost (email from Jeffrey Stroven to Judy Beigbeder, September 21, 2001).

The uncertainty surrounding battery replacement cost was highlighted in the ECRV Life Cycle Cost and Performance Evaluation study (RMA, 2001a). In that study, a base case scenario was developed using a battery replacement cost of $5,238. It was also assumed there would be two battery replacements – one after four years, and the other after eight years. After discounting, the total present value cost for the two replacements was $7,900. The present value battery replacement cost was estimated to be $3,922 for one replacement, and $11,983 for three replacements. However, using the $9,600 figure provided by Ford, it was estimated the present value cost for three replacements could be as high as $21,798. Since that time, Ford has stated their actual cost for replacing battery packs in 2003 was $14,000 (email from David Wagner to Jacqueline Johnson, April 29, 2003)

The ECRV Life Cycle Cost and Performance Evaluation included a review of a wide range of data sources on battery costs (RMA, 2001a). One of the main sources referenced in this report was the Battery Technology Advisory Panel (BTAP) report for the California Air Resources Board (CARB, 2000). An addendum to this report was recently released which indicates there has been no significant change in the specific energy, cost or life for lead acid battery technology during the last three years. The following conclusions are included in the update. *"Lead acid battery life is still limited to about 600-800 cycles at 70% depth of discharge which, depending on the usage profile, is equivalent to a service life of 2-5 years at best. . . . There is no fundamental change in the cost projections published in the 2000 BTAP report – i.e. $150 to $200 per kWh at moderate production volumes. This is equivalent to about $4,500-$6,000 for a 30 kWh pack."* (Anderman, 2003).

3.5.3 Recent Developments

During the latter part of 2002, the Postal Service received notice from Ford that they would be ending their Ranger EV program and canceling the "Think City" BEV program. Ford's program decisions mirrored the recent industry and regulatory shifts away from development of dedicated battery electric technology and a shift toward hybrid electric vehicles and fuel cell technology. At the same time, Ford notified the Postal Service that EPM – the ECRV battery pack manufacturer – was making a business decision to end production of the Postal Service ECRV battery packs. Price increases could thus be expected for interim battery pack orders. No suitable replacement batteries were located, and no alternative supplier was found.

In 2003, the California Zero Emission Vehicle mandate is also expected to be changed in a way that places far less demand on the OEMs to produce BEVs (CARB, 2003). As this change is implemented, the future demand for BEVs and BEV batteries is uncertain. While in the past it was possible to predict that battery costs would go down because of increased demand related to the ZEV mandate, it is difficult to determine how BEV technology and battery performance will change without the BEV provisions in the ZEV mandate, and as hybrid electric vehicles start to place a higher demand for different kinds of batteries.

Coupled with the deteriorating battery performance of the ECRV fleet and the high failure levels of many ECRV components, these developments in the industry and in Ford's position on BEV technology presented a significant challenge to the Postal Service. Clearly, it would be increasingly difficult to maintain and support the ECRV fleet in the face of a deteriorating ECRV support structure at Ford and in the industry. To the extent that Postal Service relied upon receiving maintenance support for the ECRVs from authorized Ford dealerships, cancellation of the Ranger EV program means that those dealerships could be less able to provide the needed support over time.

With these prospects, the Postal Service determined that the risks and costs of attempting to operate the ECRV fleet through a normal delivery vehicle's life cycle would be excessive. An agreement was negotiated with Ford to end the ECRV Program with a Ford buy-out of the ECRV contract. Under the terms of the new agreement, the 500 ECRVs will be replaced by 500 Windstars which are operationally viable ULEV-certified vehicles. The ECRVs will be dismantled and returned to Ford for disassembly.