INEEL/EXT-2000-00866
June 2000

Field Operations Program Toyota RAV4 (NiMH) Fleet Evaluation Final Report

J. Francfort
B. Sanchez
J. Argueta
J. Phung
M. Wehrey

INEEL/EXT-2000-00866

Field Operations Program
Toyota RAV4 (NiMH) Fleet Evaluation
Final Report

J. Francfort[1]
B. Sanchez[2]
J. Argueta[2]
J. Phung[2]
M. Wehrey[2]

Published June 2000

Idaho National Engineering and Environmental Laboratory
Automotive Systems and Technology Department
Idaho Falls, Idaho 83415

Prepared for the
U.S. Department of Energy
Assistant Secretary for Energy Efficiency and Renewable Energy
Under DOE Idaho Operations Office
Contract No. DE-AC07-99ID13727

[1]INEEL/Bechtel BWXT Idaho, LLC.

[2]Southern California Edison

EXECUTIVE SUMMARY

The U.S. Department of Energy's Field Operations Program evaluates electric and other advanced technology vehicles in real-world applications and environments. Information generated by the Program is targeted to fleet managers and others considering the leasing and deployment of advanced technology vehicles. The Program subjects vehicles to several types of performance and operations tests; this report only addresses the Fleet Evaluation testing of 10 electric Toyota RAV4s by Southern California Edison (SCE). Vehicles subjected to Fleet Evaluation are driven in "normal" fleet environments. Most of the data addresses the 1-year test period (4th quarter 1998 through 3rd quarter 1999). The 10 RAV4s were picked randomly from SCE's fleet of 245 RAV4s.

The 10 RAV4s performed well, with only one component failure. Nine hours were required to replace a motor inverter, but the vehicle was out of service for 12 days, waiting for parts. There were a total of 31 maintenance occurrences, with 16 of these relating to problems with the tires. Seven occurrences were related to preventive maintenance or installing backup alarms. The 31 problems required an average of 1.3 hours to correct, but the 31 occurrences included an average of 2.7 days of downtime. However, 21 of the 31 required less than a day of downtime.

The RAV4s were driven 68,440 miles during the test period, traveling 29 miles per charge (despite their test ranges of 76 to 100 miles), averaging 1.9 miles per AC-kWh charged. At the end of the test period, the 10 RAV4s had a total of 122,182 miles on their odometers (includes pre test-period driving), with no battery module failures.

For additional information on testing and other Program activities, visit the Program's web site at http://ev.inel.gov/sop.

CONTENTS

FIGURES

TABLES

ACRONYMS

AC	Alternating current
DOE	U.S. Department of Energy
ETA	Electric Transportation Applications
EVSE	Electric vehicle supply equipment
EVTC	Electric Vehicle Technical Center
F	Fahrenheit
INEEL	Idaho National Engineering and Environmental Laboratory
kWh	kilowatt-hour
mm	Millimeter
NEMA	National Electrical Manufacturers Association
NiMH	Nickel metal hydride (battery)
QVTs	Qualified Vehicle Testers
SCE	Southern California Edison Company
SOC	state-of-charge

Field Operations Program
Toyota RAV4 (NiMH) Fleet Evaluation
Final Report

1. INTRODUCTION

The Field Operations Program was established by the U.S. Department of Energy (DOE) to implement electric vehicle (EV) activities dictated by the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976. In the ensuing years, the Program has evolved in response to new legislation, interests, and technologies. The Program's goals include evaluating electric and other advanced technology vehicles in real-world applications and environments, developing infrastructure elements necessary to support significant advanced technology vehicle use, and increasing the awareness and acceptance of advanced technology vehicles. Personnel of the Idaho National Engineering and Environmental Laboratory (INEEL) manage the Field Operations Program. To support the field evaluation of electric vehicles, during 1996 DOE selected two Qualified Vehicle Testers (QVTs) through competitive bids. One of the QVTs is Southern California Edison Company (SCE). The other QVT is a consortium led by Electric Transportation Applications (ETA), with other members consisting of Arizona Public Service, Salt River Project, and Potomac Electric Power Company. For a more complete description of Program activities, Program reports, and test results, visit the Program's website at http://ev.inel.gov/sop.

One of the tasks of the Program is the fleet evaluation of commercially available electric vehicles. This report summarizes the fleet evaluation of 10 nickel-metal-hydride (NiMH) equipped Toyota RAV4 EVs by the Field Operations Program and its testing partner, SCE. SCE employees operated the RAV4s in normal fleet operations.

SCE's purpose for evaluating EVs, EV chargers, batteries, and related items is to support the safe and efficient use of EVs and to minimize potential utility system impacts. The following supports this purpose:

- As a fleet operator and an electric utility, SCE uses EVs to conduct business.
- In order to make informed decisions in the purchase of EVs, batteries, and charging equipment, SCE must evaluate them.
- SCE must determine if there are safety issues with the related equipment or their usage.
- SCE has a responsibility to educate and advise customers about efficient and safe operation of EVs.

This report summarizes the vehicles' performance during the October 1998 to September 1999 test period. Maintenance records as well as efficiency data are used to document the vehicles' capabilities in a large, fully operational electric utility fleet.

2. TESTING RESULTS

Southern California Edison's (SCE) Fleet of 245 Toyota RAV4 EVs may be the world's largest fleet of RAV4s. Out of the 245, 10 RAV4s were randomly selected to be fleet tested as part of DOE's Field Operations Program. They were operated in coastal, urban, and desert areas to provide data under a variety of climactic conditions. In the 12-month test period, the vehicles logged 68,440 miles (Figure 1) in meter reading applications. (The variance in total miles is due to the different meter reading routes the vehicles were assigned to). This equates to a per vehicle average of 6,844 miles of fleet use during the test year.

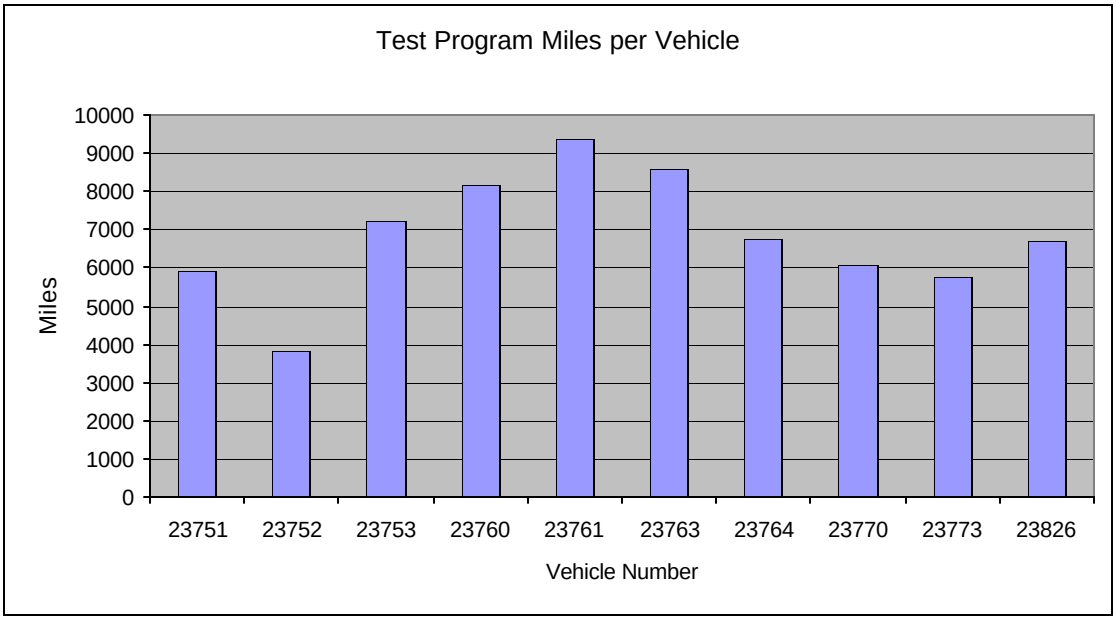

Figure 1. Total miles accumulated during the testing period for the 10 Toyota RAV4s.

Most months, each vehicle was driven between 300 and 900 miles, averaging 570 miles (Figure 2). The highest miles driven for a single vehicle was during December, when vehicle 23761 was driven 1,135 miles. The lowest monthly total was for vehicle number 23760, when it was driven 67 miles. During December, Vehicle 23760 was out of service for 12 days for a controller/power control unit problem. The 12 days were likely spent waiting for parts, as the actual repair only required 9 hours (Table 1). The hours per incident required to correct most problems was fairly low. An average of 1.3 hours was required to fix the 31 incidents. While most (21 of 31) of the incidents involved downtime of a day or less, the average downtime per incident was 2.7 days.

An important part of evaluating an electric vehicle is feedback from the vehicle operators. Surprisingly, the most outstanding concern the drivers had was not range, but

tire performance. As seen in some of the driver questionnaires (see Appendix 1), the low-rolling-resistance tires did not provide the desired traction. Additionally, tire life is another issue that deserves attention, as it was the most troublesome vehicle component (Figure 3); tire repair or replacement was the most frequently performed service on the RAV4s. The rubber compound, softer sidewalls, and higher inflation pressure may all contribute to the shorter tread life and perhaps make them more susceptible to punctures. The need to repair the tires adversely impacted the number of servicing hours required to maintain the RAV4s (Figure 4).

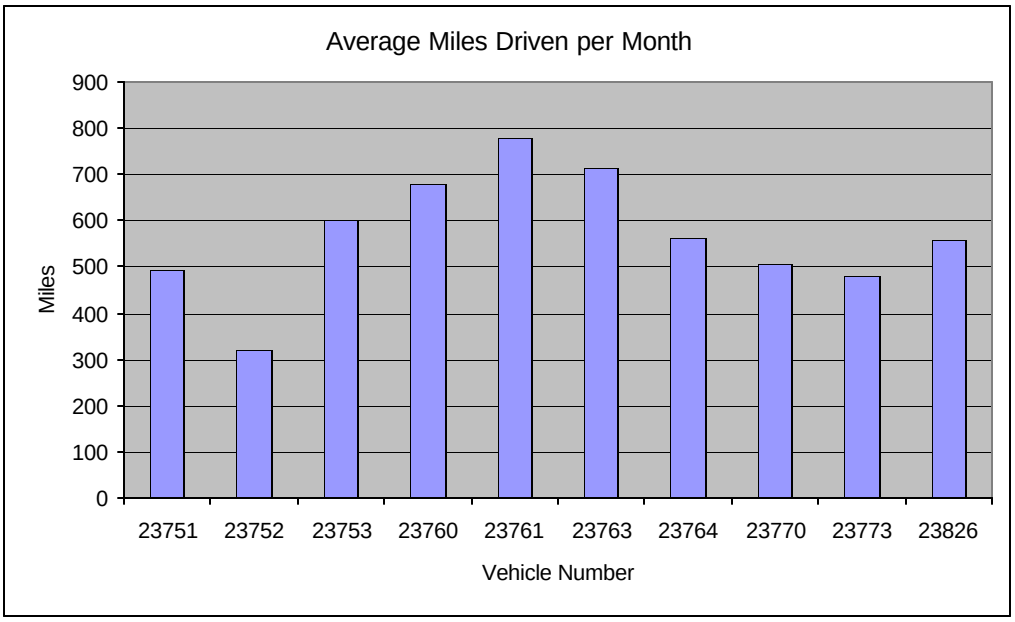

Figure 2. Average miles driven per month for the 10 RAV4s.

Tire-related issues accounted for 16 of the 31 maintenance items reported (Table 1). Seven items were for either preventive maintenance or installing backup alarms; five were for things like burned-out light bulbs, a windshield crack, and a misadjusted door. One occurrence involved recharging the air conditioner and one involved the ABB kWh meter installed by SCE to monitor the energy use. The final occurrence involved Vehicle 23760's power control unit (PCU), which required the previously mentioned twelve days to repair. The PCU problem could arguably be considered the only EV-specific component that required maintenance. While the ABB kWh meter is EV-specific, it was added by SCE for testing purposes only.

Table 1. Maintenance performed on the 10 RAV4s during the test period.

Veh. No.	Component Name	Odometer Reading	Reported Problem	Date Reported	Date Repaired	Downtime (Days)*	Hours	Corrective Action
4th Quarter 1998								
23751	Tires / wheels	4,576	Front tires need to be replaced	10/29/98	10/29/98	0	1	R&R front tires
23773	Tires / wheels	NA	Right front tire flat	11/16/98	11/20/98	4	1	R&R tire
1st Quarter 1999								
23751	Tire	6,233	Nail in left front tire	03/04/99	03/05/99	1	0.5	Repaired tire
23760	ABB meter	N/A	ABB meter bad	01/11/99	01/12/99	1	1.5	R&R ABB meter
23760	Controller/ PCU	8,521	Vehicle quit on road	01/13/99	01/29/99	12	9	R&R motor inverter
23761	Tire	11,345	Nail in left front tire	01/04/99	01/05/99	1	0.5	Repaired tire
23761	Tire	12,601	Right front tire flat	02/03/99	02/08/99	3	1.5	R&R tire
23761	Tire	13,755	Rear tires flat	03/15/99	03/17/99	2	1	Repaired rear tires
23763	Tire	11,291	Right front tire has a slow leak	02/01/99	02/08/99	5	1.25	Repaired tire
2nd Quarter 1999								
23751	Tire	7,075	Front tire worn	05/03/99	05/03/99	1	0.75	R&R front tires (2)
23751	Backup alarm	7,111	Install backup alarm	05/05/99	05/05/99	1	0.75	Installed backup alarm
23751	Tire	7,734	Right front tire flat	06/14/99	06/14/99	1	0.5	R&R tire
23751	Preventive maintenance	7,734	Service due	06/14/99	06/14/99	1	1.5	Service completed
23752	Backup alarm	4,564	Install backup alarm	05/05/99	05/05/99	1	2	Installed backup alarm
23752	A/C system	5,065	A/C not cold enough	06/18/99	06/18/99	1	1.5	Recharged by vendor

Veh. No.	Component Name	Odometer Reading	Reported Problem	Date Reported	Date Repaired	Downtime (Days)*	Hours	Corrective Action
23753	Tire	12,896	Front tires wearing out	04/19/99	04/23/99	5	2	R&R front tires (2)
23753	Backup alarm	13,517	Install backup alarm	05/13/99	05/13/99	1	1.5	Installed backup alarm
23760	Tire	12,091	Nail in left rear tire	06/17/99	06/19/99	3	1	Repaired tire
23764	Backup alarm	5,969	Install backup alarm	05/06/99	05/06/99	1	0.75	Installed backup alarm
23773	Tire	8,477	Right front and right rear tires flat	04/06/99	04/14/99	7	1.75	Repaired both tires
23773	Non EV related	9,548	Right rear brake light burned out	06/24/99	06/24/99	1	2.5	R&R brake light bulb
3rd Quarter 1999								
23751	Non EV related	7,734	Right front turn lens damaged	06/21/99	07/01/99	9	1	R&R right front turn lens
23751	Tire	9,424	Left front tire worn	09/02/99	09/02/99	1	0.5	R&R tire
23760	Tire	12,561	Left front tire flat	07/06/99	07/06/99	1	0.5	Repaired tire
23761	Tire	14,162	Flat tire	07/02/99	07/02/99	1	1	Repaired tire
23763	Brakes	16,308	Left brake light out	08/26/99	08/26/99	1	0.5	R&R brake light bulb
23764	Preventive maintenance	9,263	Service due	07/28/99	08/27/99	1	1	Service completed
23764	Non EV related	9,263	Crack in windshield	09/10/99	09/29/99	14	1	R&R windshield
23770	Preventive maintenance	8,240	Service due	07/28/99	08/27/99	1	1	Service completed
23773	Tire	10,098	Nail in right rear tire	08/04/99	08/04/99	1	N/A	R&R tire by parkhouse
23826	Non EV related	9,168	Fuel door bent \ out of adjustment	08/16/99	08/16/99	1	1	Repaired

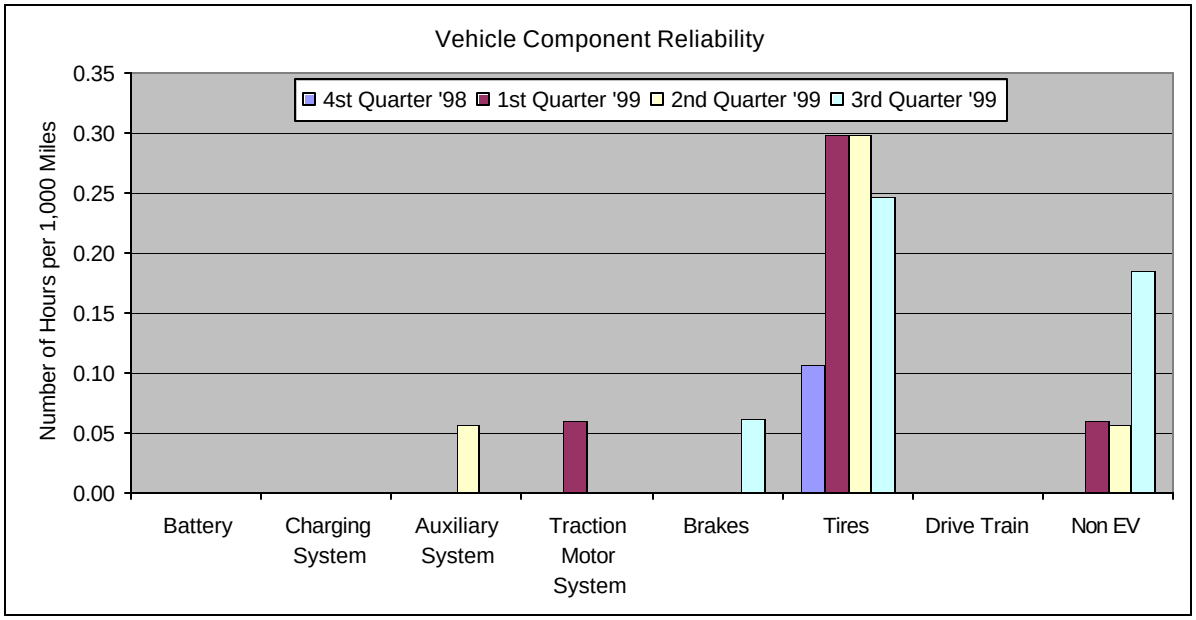

Figure 3. Vehicle component failure per 1,000 miles for the 10 RAV4s during the fourth quarter of 1998 and the first, second and third quarters of 1999 test period.

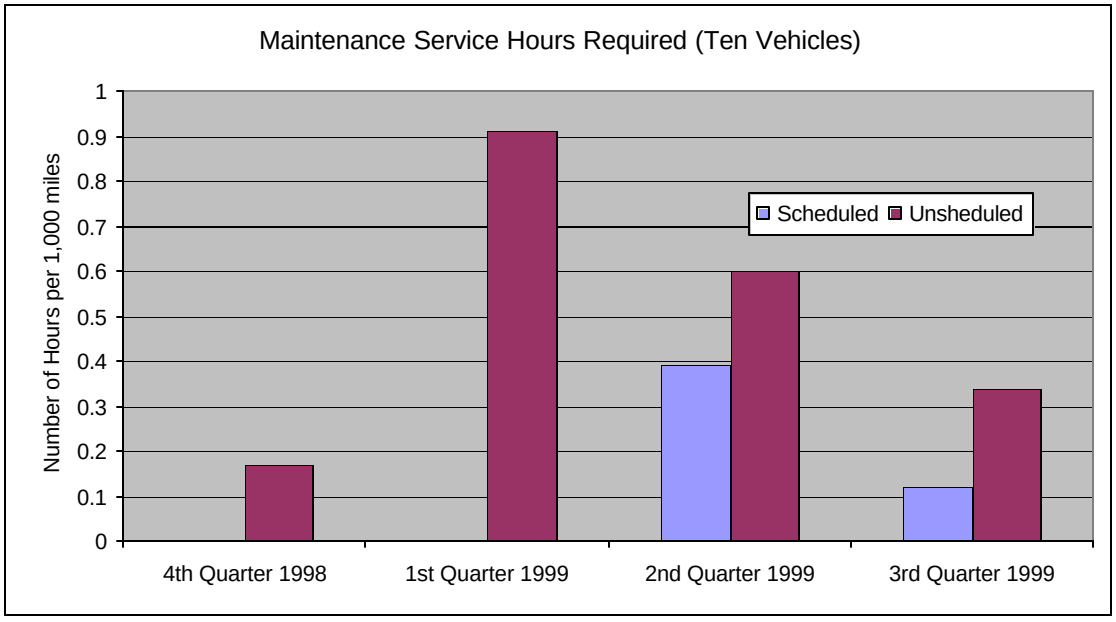

Figure 4. Number of hours (per 1,000 miles of operation) required for scheduled and unscheduled maintenance on the 10 RAVs.

The Toyota RAV4s accumulated 68,440 miles (Table 2) during the fleet evaluation testing period and each had previously accumulated an average of 5,400 miles before the start of testing. Thus, at the conclusion of the testing, they had accumulated a total of 122,182 miles (Table 3). All of the RAV4s were equipped with Panasonic NiMH batteries and conductive connectors for charging.

Table 2. Monthly and total mileage accumulated for each RAV4 during the test period.

Vehicle No.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Totals
23751	622	420	394	227	395	478	449	399	639	517	794	608	5,942
23752	249	272	364	323	110	309	268	302	585	320	417	323	3,842
23753	874	551	843	896	665	842	892	378	413	251	301	321	7,227
23760	518	654	722	67	686	863	830	787	796	685	739	813	8,160
23761	921	1,080	1,135	831	900	883	627	586	586	634	479	700	9,362
23763	630	690	760	485	545	926	739	752	701	821	633	910	8,592
23764	955	651	725	509	582	474	663	276	509	449	535	429	6,757
23770	619	320	590	431	425	638	729	268	570	501	654	328	6,073
23773	515	430	584	707	486	532	533	461	260	408	380	482	5,778
23826	533	552	578	524	502	517	607	567	565	460	719	583	6,707
Totals	6,436	5,620	6,695	5,000	5,296	6,462	6,337	4,776	5,624	5,046	5,651	5,497	68,440

Table 3. Vehicle status at the conclusion of the Fleet evaluation testing. The Pomona Urban Loop was used to determine the Range as Tested.

SCE Vehicle #	Range as Tested (Date)	Delivery Date	Assigned Garage	Assigned Application	Status	Odometer as of 09/30/99
23751	90 (01/98)	12/97	Arrowhead	Meter Reading	In Use	10,032
23752	93 (12/97)	12/97	Santa Monica	Meter Reading	In Use	6,422
23753	86 (12/97)	12/97	Santa Monica	Meter Reading	In Use	14,975
23760	88 (12/97)	12/97	Covina	Meter Reading	In Use	14,720
23761	76 (12/97)	12/97	Covina	Meter Reading	In Use	17,859
23763	95 (12/97)	12/97	Covina	Meter Reading	In Use	17,318
23764	100 (12/97)	12/97	San Jacinto	Meter Reading	In Use	9,768
23770	98 (12/97)	12/97	San Jacinto	Meter Reading	In Pomona for preventive maintenance	8,639
23773	84 (01/98)	12/97	Montebello	Meter Reading	In Use	10,893
23826	80 (12/97)	12/97	Montebello	Meter Reading	In Use	11,556
Total						122,182

Table 4 shows the total number of miles driven and charge cycles for the 122,182 miles driven before and during the test cycle. The average miles driven per charge cycle in Table 4 is only 20 miles, while during the test period the vehicles averaged 29 miles per charge cycle (Figures 5 – 8). (While an organizational theorist might be able to explain the influence of being tested on the drivers' behaviors, this report will limit itself to simply identifying the average miles driven per charge cycle). The RAV4s averaged a cumulative 1.9 miles per AC-kWh charged (Figures 9 – 12) during the test period.

Table 4. Number of cycles, miles, and average miles per cycle placed on the 10 RAV4s and their Panasonic MHB-100 NiMH batteries at the conclusion of the testing. The manufacturer rated capacity is 100 Amp-hour at C/3. All of the RAV4s were placed in service during December 1997. The data includes miles accumulated before and during the test period. The data reflects the test fleet status as of September 3l 1999.

Vehicle No.	Total number of charge cycles	Total miles	Battery modules replaced	Average miles per charge cycle
23751	502	10,032	0	19.98
23752	320	6,422	0	20.07
23753	749	14,975	0	19.99
23760	736	14,720	0	20.00
23761	893	17,859	0	20.00
23763	866	17,318	0	20.00
23764	488	9,768	0	20.02
23770	432	8,639	0	20.00
23773	545	10,893	0	19.99
23826	578	11,556	0	19.99
Totals	6,109	122,182	0	20.00

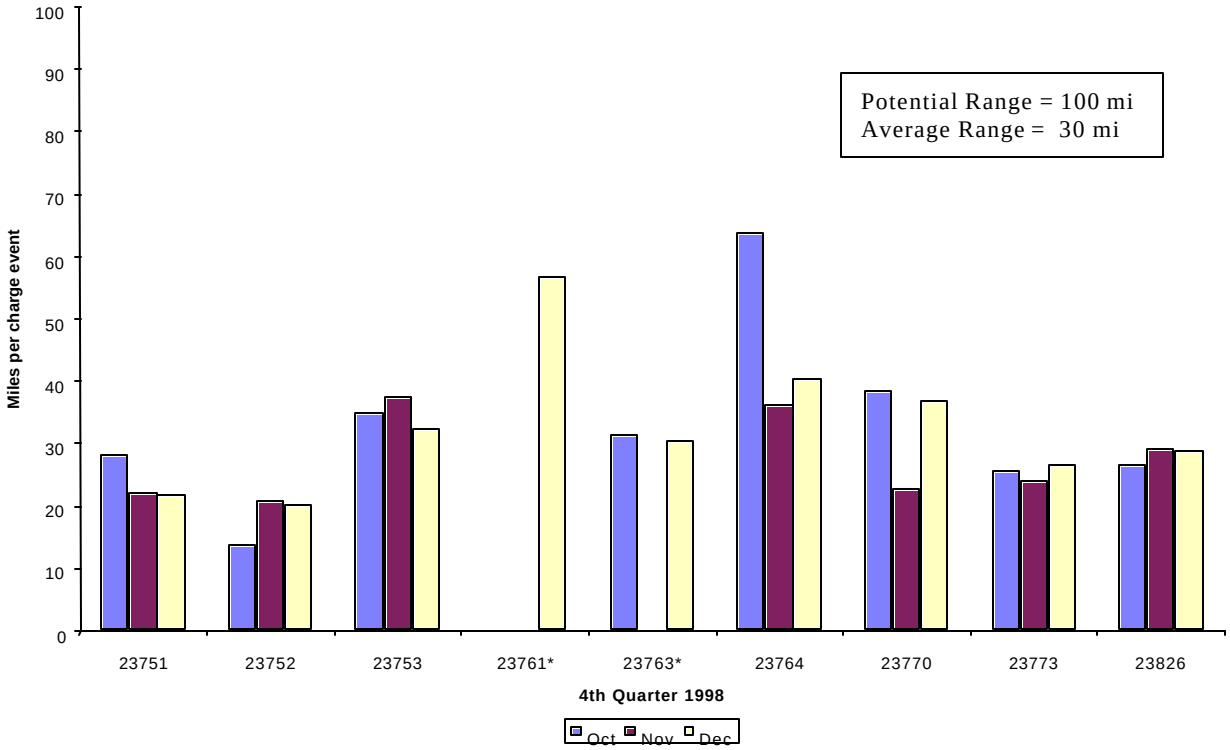

Figure 5. Average miles per charge event during the 4th Quarter 1998. (*Problems with the ABB meter programming led to missed or incorrect data).

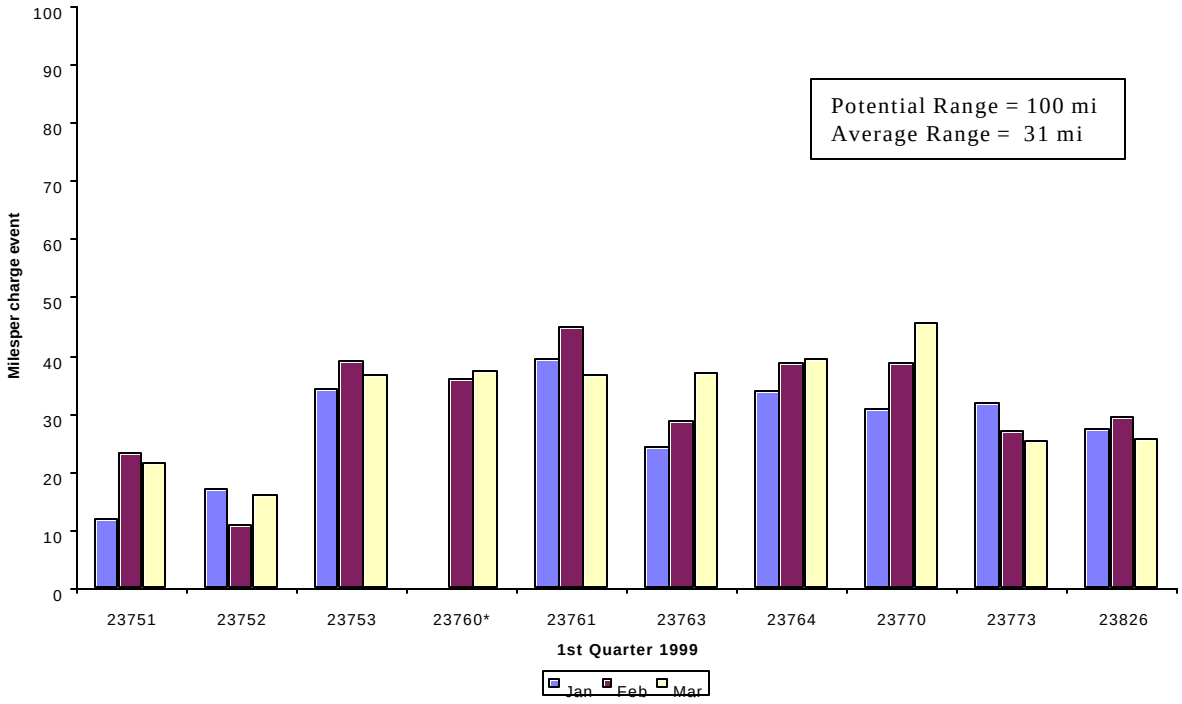

Figure 6. Average miles per charge event during the 1st Quarter 1999. (*Problems with ABB meter programming led to missed or incorrect data).

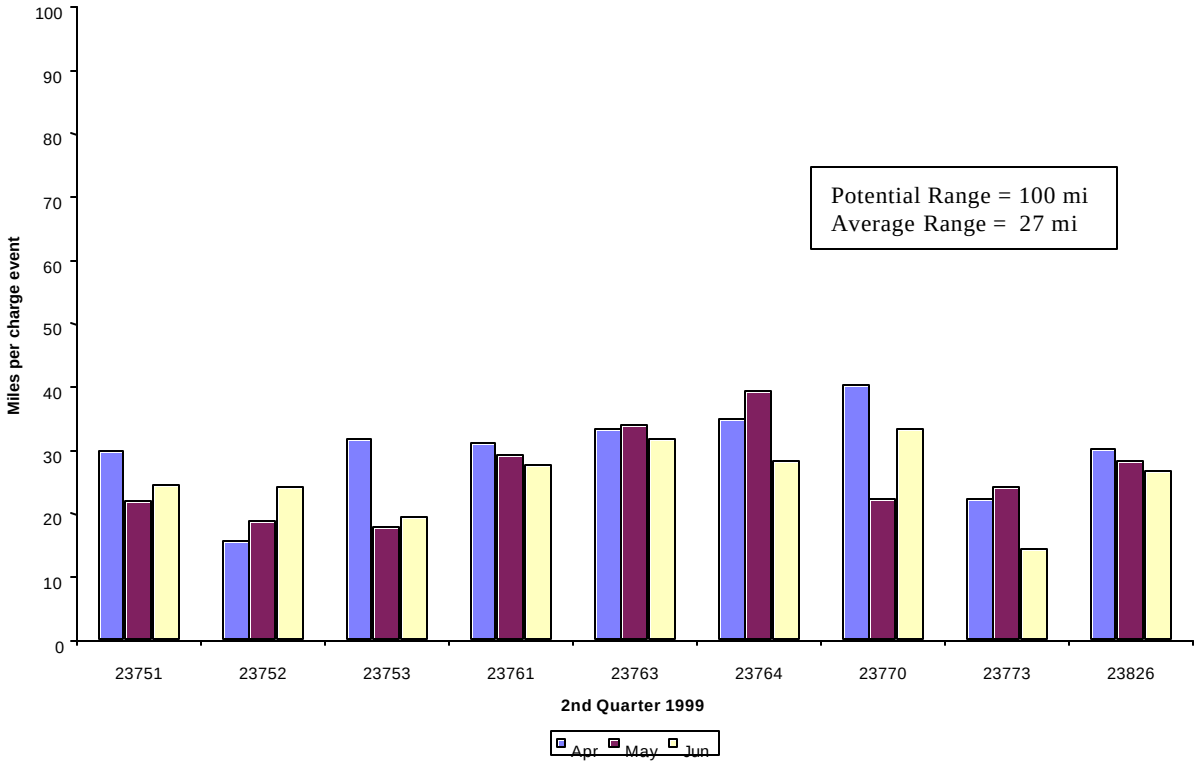

Figure 7. Average miles per charge event during the 2nd Quarter 1999.

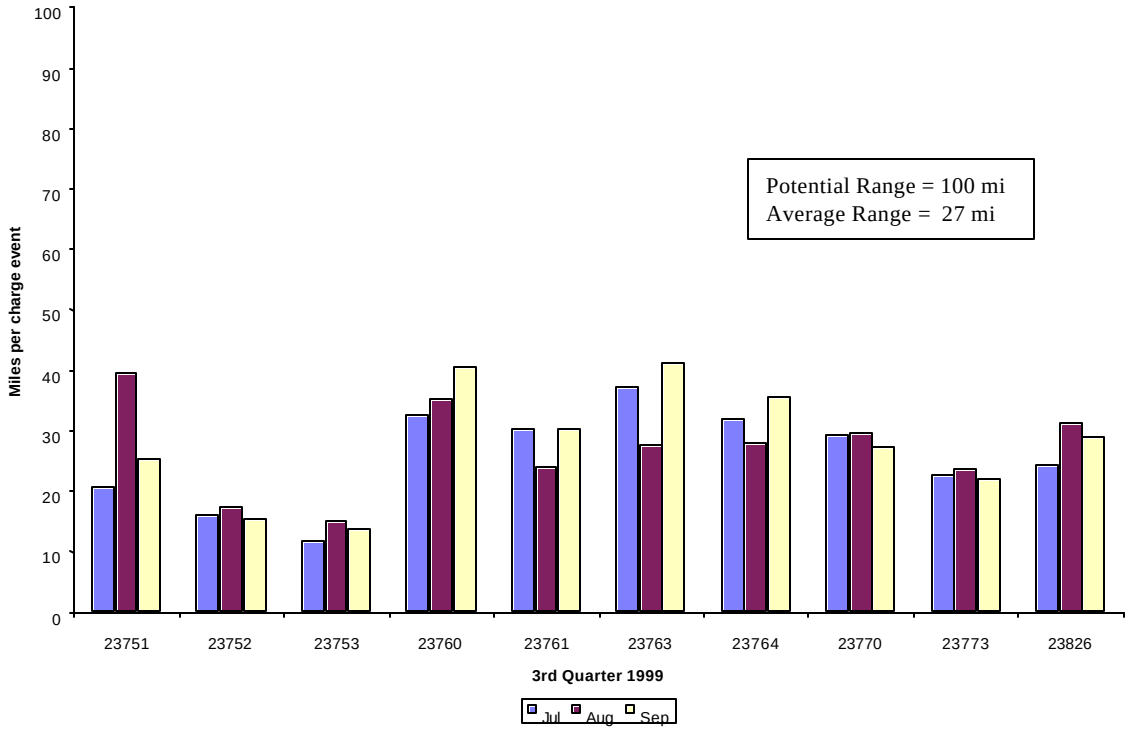

Figure 8. Average miles per charge event during the 3rd Quarter 1999.

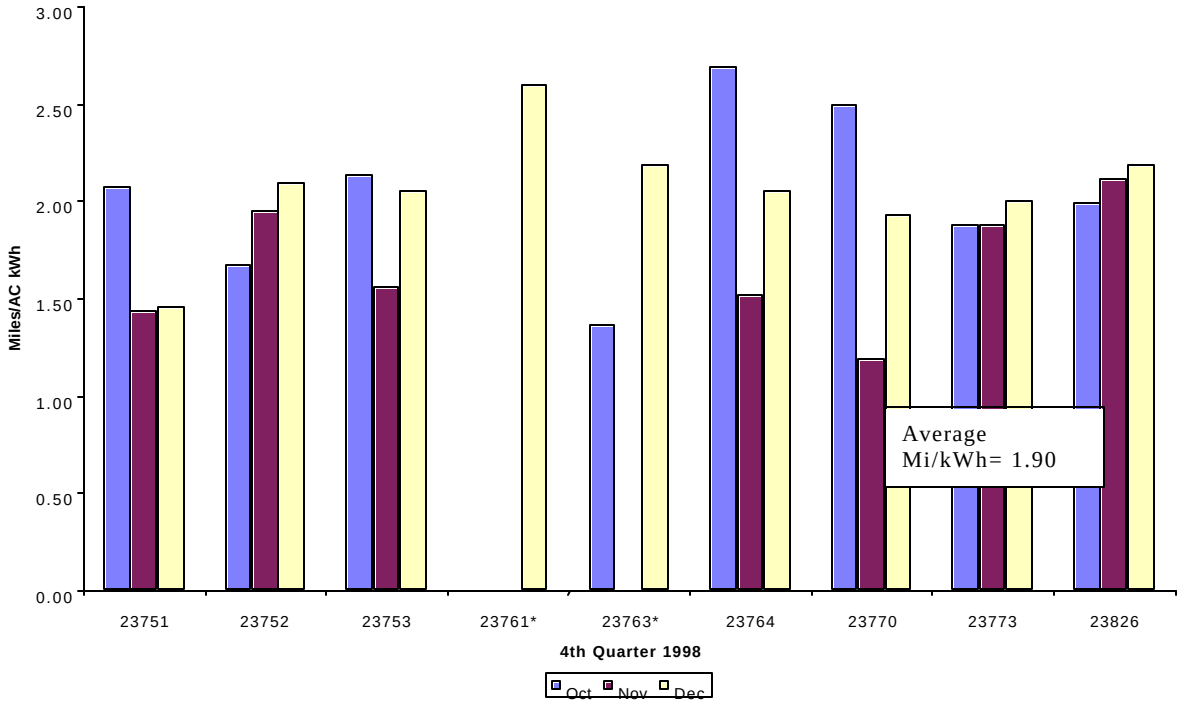

Figure 9. Average miles per AC kWh charged during the 4th Quarter 1998. (*Problems with ABB meter programming led to missed or incorrect data.)

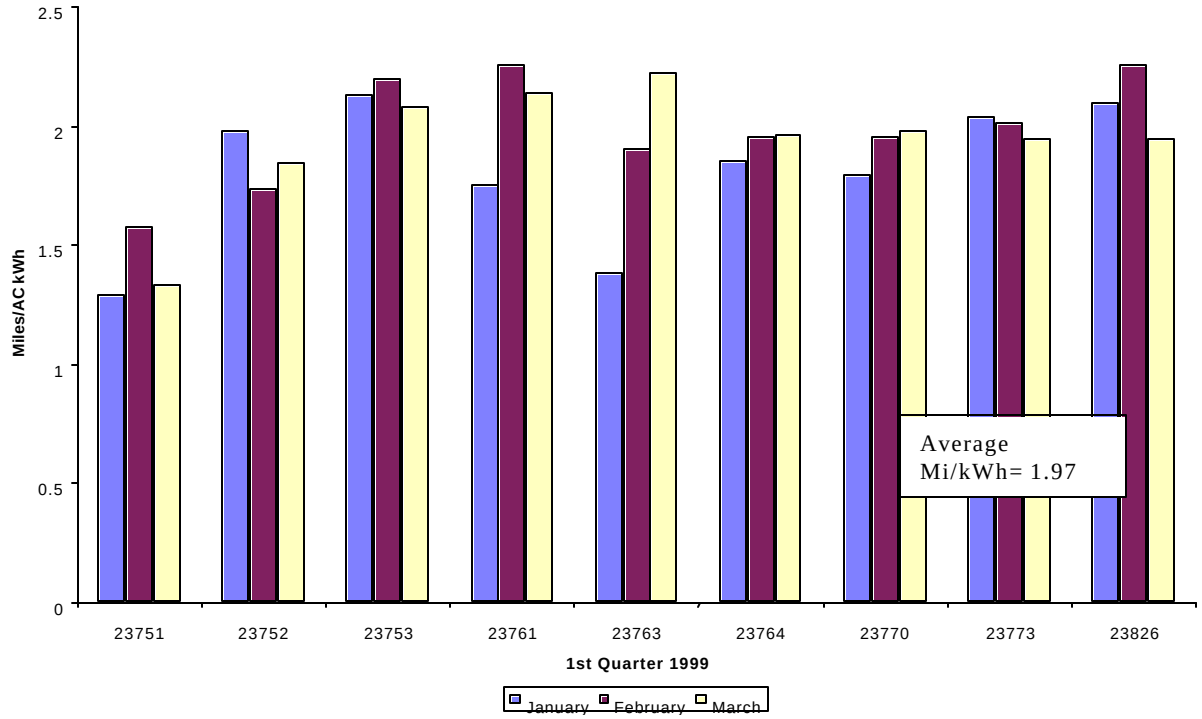

Figure 10. Average Miles/AC kWh 1st Quarter 1999. (*Problems with ABB meter programming led to missed or incorrect data.)

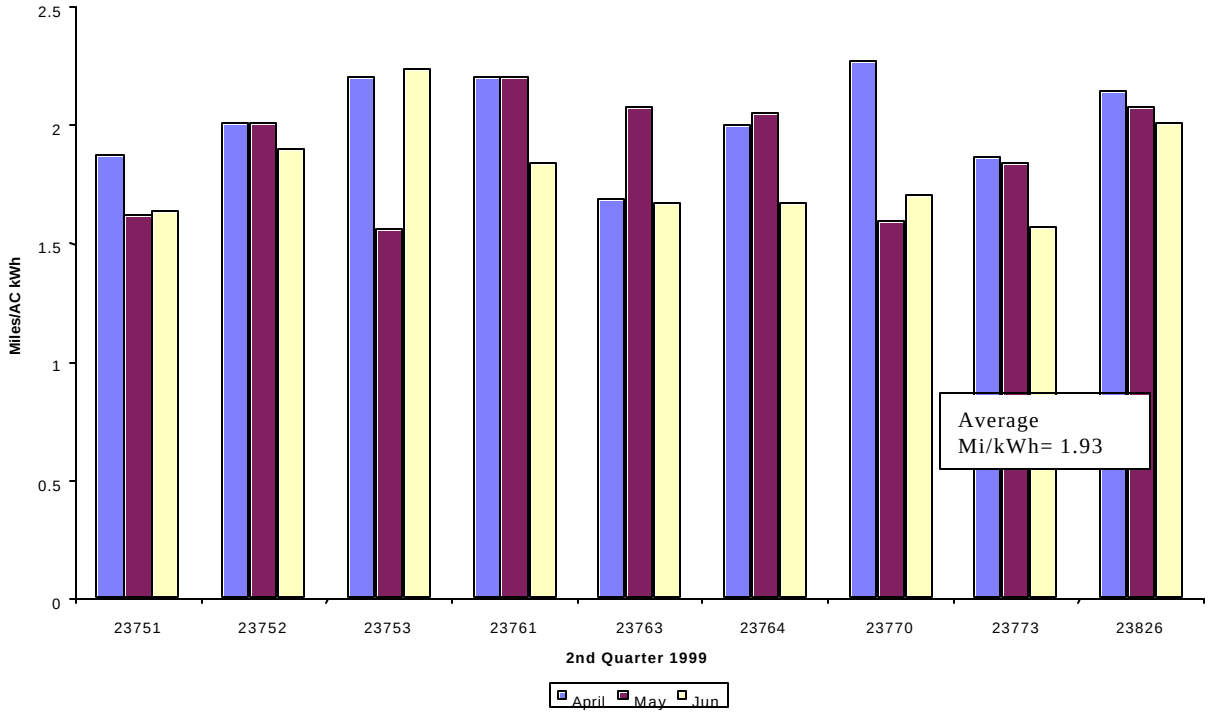

Figure 11. Average Miles/AC kWh 2nd Quarter 1999.

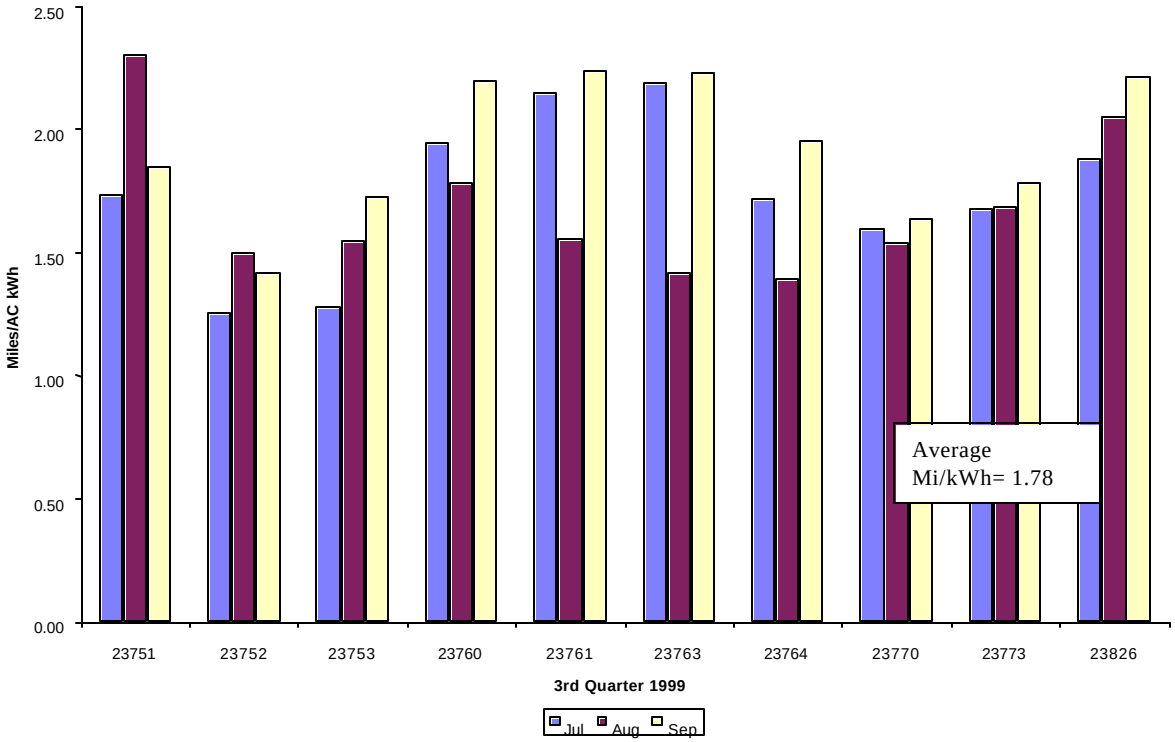

Figure 12. Average Miles/AC kWh 3rd Quarter 1999.

3. CONCLUSION

While a vehicle's appeal will vary from person to person, the majority of the RAV4 drivers surveyed preferred electric vehicles to internal combustion engine (ICE) vehicles in their job applications. SCE's fleet of 245 RAV4s has an approval rating of over 70% amongst drivers.

There are environmental as well as financial benefits when incorporating electric vehicles into a fleet. 16,426 pounds of pollutants were reduced while driving the RAV4s instead of driving 10 ICE vehicles for the same amount of time. Thirteen oil changes were avoided, saving 65 quarts of oil, nor did the vehicles have to undergo smog checks every 2 years. 34,220 kWh of electricity were consumed, saving 2,738 gallons of gasoline, netting savings of over $1,700 in fuel costs.

The RAV4s were leased for 3 years at a cost of $16,000 per vehicle. The lease includes a 3-year bumper to bumper warranty, which covers all necessary repairs not resulting from driver negligence or abuse. In addition, subsidizing funds exist in California, which lowers the lease cost of an electric vehicle, making it comparable to an ICE vehicle. EVs have 10 times fewer moving parts than an ICE vehicle, which results in fewer component failures.

Assuming a 1-year lease cost of $5,333, an energy cost of 8.2 cents per kWh, an average of 3,422 kWh per vehicle year, and an average of 6,844 miles driven per year, the cost to operate the RAV4s averaged 82 cents per mile.

Southern California Edison has made a strong commitment to incorporate electric vehicles into its fleet. Original equipment manufacturers continue to advance EV technology, in turn increasing the applications that electric vehicles could be assigned for. This report shows that EVs are not only capable of being matched to a mission successfully, they also have the ability to reduce the overall cost of operating a utility fleet.

Appendix A
Driver Questionnaires

SCE Electric Vehicle Driver Questionnaire

DRIVER NAME: Jon Price LOCATION: Arrowhead

VEHICLE #: 23751 VEHICLE MAKE & MODEL: Toyota RAV 4

VEHICLE APPLICATION: Meter Reading DATE: 5/24/99

DRIVEABILITY	SA	A	NS	D	SD	NA
1. The vehicle feels stable and safe	X					
2. The vehicle steering is responsive	X					
3. The vehicle acceleration is adequate	X					
4. The vehicle braking is responsive and safe		X				
DRIVING CONTROLS AND GAUGES						
1. The cabin temperature controls are easy to operate		X				
2. The "state-of-charge" gauge is helpful and easy to read		X				
3. The "range remaining" gauge is helpful and easy to read		X				
CHARGING CONTROLS AND GAUGES						
1. The charging controls are easy to operate		X				
2. The charging connector (plug) is easy to use		X				
3. The charging cord is easy to manage		X				
4. The vehicle charges adequately (full in the morning)		X				
5. The charger is reasonably quiet		X				

6. Do you know the differences between Inductive and Conductive charging? ___ **Yes** X **No**

If yes, which do you prefer? ___ **Inductive** ___ **Conductive** ___ **No preference**

7. Did you have any problems charging? ___ **Yes** X **No**

If yes, please describe* _____

INTERIOR							
1. The heater provides adequate heat		X					having to use air yet
2. The air conditioner provides adequate cooling			X				
3. The vehicle is quiet		X					

4. Did you use electronic equipment (cell phone, radio, etc.) inside the EV? X **Yes** ___ **No**

If yes, please list equipment(s) and describe any problems encountered* Radio, it would Drain Battery - until they took it to the key.

GENERAL						
1. The vehicle has adequate payload		X				
2. The vehicle has adequate range				X		
3. The vehicle is easy to operate		X				
4. The vehicle is suited for your job application				X		
5. The vehicle meets your expectations			X			

6. If you had to choose between this vehicle or a similar gasoline vehicle ***for use in your work***, which one would you select? **(Circle One)** **Electric Vehicle** **Gasoline Vehicle** **Either**

COMMENTS*

What did you like best? The vehicle is comfortable, easy to Drive, easy to get in & out of places.

What did you like least? The range is not good Because if you run heater, lights, wiper, & Radio then Drive we only get about 10-15 mile per charge, without these things you are lucky to get 30 miles to a charge.

SA: *Strongly Agree;* ***A:*** *Agree;* ***NS:*** *Not Sure;* ***D:*** *Disagree;* ***SD:*** *Strongly Disagree;* ***NA:*** *Not Applicable*

Electric Vehicle Driver Questionnaire

Participant _____

DRIVER NAME: MARK RODRIGUEZ LOCATION: SANTA MONICA

VEHICLE NUMBER: 23752 VEHICLE MAKE & MODEL: TOYOTA RAV

VEHICLE APPLICATION: METER READING DATE: 5/20/99

	SA	A	NS	D	SD	NA
DRIVEABILITY						
1. The vehicle feels stable and safe	✓					
2. The vehicle steering is responsive	✓					
3. The vehicle acceleration is adequate	✓					
4. The vehicle braking is responsive and safe		✓				
DRIVING CONTROLS AND GAUGES						
1. The cabin temperature controls are easy to operate	✓					
2. The "state-of-charge" gauge is helpful and easy to read	✓					
3. The "range remaining" gauge is helpful and easy to read	✓					
CHARGING CONTROLS AND GAUGES						
1. The charging controls are easy to operate	✓					
2. The charging connector (plug) is easy to use	✓					
3. The charging cord is easy to manage	✓					
4. The vehicle charges adequately (full in the morning)	✓					
5. The charger is reasonably quiet	✓					

6. Do you know the differences between Inductive and Conductive charging? ✓ **Yes** ___ **No**

   If yes, which do you prefer? ___ **Inductive** ✓ **Conductive** ___ **No preference**

7. Did you have any problems charging? ___ **Yes** ✓ **No**

   If yes, please describe* _____

	SA	A	NS	D	SD	NA
INTERIOR						
1. The heater provides adequate heat			✓			
2. The air conditioner provides adequate cooling			✓			
3. The vehicle is quiet			✓			

4. Did you use electronic equipment (cell phone, radio, etc.) inside the EV? ✓ **Yes** ___ **No**

   If yes, please list equipment(s) and describe any problems encountered* NO PROBLEMS - CELL PHONE

	SA	A	NS	D	SD	NA
GENERAL						
1. The vehicle has adequate payload	✓					
2. The vehicle has adequate range		✓				
3. The vehicle is easy to operate	✓					
4. The vehicle is suited for your job application	✓					
5. The vehicle meets your expectations	✓					

6. If you had to choose between this vehicle or a similar gasoline vehicle ***for use in your work***, which one would you select? **(Circle One)** **Electric Vehicle** **Gasoline Vehicle** **Either**

COMMENTS*

What did you like best? CLEAN - NO EMISSIONS.

What did you like least? MILAGE ON A CHARGE

SA: *Strongly Agree;* ***A:*** *Agree;* ***NS:*** *Not Sure;* ***D:*** *Disagree;* ***SD:*** *Strongly Disagree;* ***NA:*** *Not Applicable*

Electric Vehicle Driver Questionnaire

Participant _____

DRIVER NAME: LEVI HENRY LOCATION: SANTA MONICA

VEHICLE NUMBER: 23753 VEHICLE MAKE & MODEL: TOYOTA, EV RAV

VEHICLE APPLICATION: METER READING DATE: 5/20/99

	SA	A	NS	D	SD	NA
DRIVEABILITY						
1. The vehicle feels stable and safe		✓				
2. The vehicle steering is responsive		✓				
3. The vehicle acceleration is adequate		✓				
4. The vehicle braking is responsive and safe			✓			
DRIVING CONTROLS AND GAUGES						
1. The cabin temperature controls are easy to operate		✓				
2. The "state-of-charge" gauge is helpful and easy to read		✓				
3. The "range remaining" gauge is helpful and easy to read		✓				
CHARGING CONTROLS AND GAUGES						
1. The charging controls are easy to operate		✓				
2. The charging connector (plug) is easy to use		✓				
3. The charging cord is easy to manage		✓				
4. The vehicle charges adequately (full in the morning)	✓					
5. The charger is reasonably quiet	✓					

6. Do you know the differences between Inductive and Conductive charging? ✓ **Yes** ___ **No**

   If yes, which do you prefer? ✓ **Inductive** ___ **Conductive** ___ **No preference**

7. Did you have any problems charging? ___ **Yes** ✓ **No**

   If yes, please describe* _____

INTERIOR						
1. The heater provides adequate heat				✓		
2. The air conditioner provides adequate cooling					✓	
3. The vehicle is quiet	✓					

4. Did you use electronic equipment (cell phone, radio, etc.) inside the EV? ✓ **Yes** ___ **No**

   If yes, please list equipment(s) and describe any problems encountered* no problems w/ cell phone

GENERAL						
1. The vehicle has adequate payload	✓					
2. The vehicle has adequate range		✓				
3. The vehicle is easy to operate	✓					
4. The vehicle is suited for your job application		✓				
5. The vehicle meets your expectations		✓				

6. If you had to choose between this vehicle or a similar gasoline vehicle ***for use in your work***, which one would you select? **(Circle One)** **Electric Vehicle** **Gasoline Vehicle** **Either**

COMMENTS*

What did you like best? quiet, smooth

What did you like least? braking over speed bumps - not linear

SA: *Strongly Agree;* ***A:*** *Agree;* ***NS:*** *Not Sure;* ***D:*** *Disagree;* ***SD:*** *Strongly Disagree;* ***NA:*** *Not Applicable*

SCE Electric Vehicle Driver Questionnaire

DRIVER NAME: Baynham **LOCATION:** Covina
VEHICLE #: 23760 **VEHICLE MAKE & MODEL:** R-4
VEHICLE APPLICATION: _____ **DATE:** 5-14-99

	SA	A	NS	D	SD	NA
DRIVEABILITY						
1. The vehicle feels stable and safe	✓					
2. The vehicle steering is responsive	✓					
3. The vehicle acceleration is adequate	✓					
4. The vehicle braking is responsive and safe	✓					
DRIVING CONTROLS AND GAUGES						
1. The cabin temperature controls are easy to operate	✓					
2. The "state-of-charge" gauge is helpful and easy to read	✓					
3. The "range remaining" gauge is helpful and easy to read	✓					
CHARGING CONTROLS AND GAUGES						
1. The charging controls are easy to operate	✓					
2. The charging connector (plug) is easy to use	✓					
3. The charging cord is easy to manage	✓					
4. The vehicle charges adequately (full in the morning)	✓					
5. The charger is reasonably quiet	✓					

6. Do you know the differences between Inductive and Conductive charging? ___ Yes ___ No
   If yes, which do you prefer? ___ Inductive ___ Conductive ___ No preference
7. Did you have any problems charging? ___ Yes ✓ No
   If yes, please describe* _____

INTERIOR						
1. The heater provides adequate heat	✓					
2. The air conditioner provides adequate cooling	✓					
3. The vehicle is quiet					✓	

4. Did you use electronic equipment (cell phone, radio, etc.) inside the EV? ✓ Yes ___ No
   If yes, please list equipment(s) and describe any problems encountered* (Radio) No Problems

GENERAL						
1. The vehicle has adequate payload	✓					
2. The vehicle has adequate range	✓					
3. The vehicle is easy to operate	✓					
4. The vehicle is suited for your job application	✓					
5. The vehicle meets your expectations	✓					

6. If you had to choose between this vehicle or a similar gasoline vehicle ***for use in your work***, which one would you select? **(Circle One)** (Electric Vehicle) Gasoline Vehicle Either

COMMENTS*
What did you like best? Something different than gasoline.

What did you like least? The breaks for some reason always "Squeak" makes alot of noise when breaking. Thats about it - To many Questio All day, from peo

SA: *Strongly Agree;* ***A:*** *Agree;* ***NS:*** *Not Sure;* ***D:*** *Disagree;* ***SD:*** *Strongly Disagree;* ***NA:*** *Not Applicable*

SCE Electric Vehicle Driver Questionnaire

DRIVER NAME: JUSTIN VAN TASSEL **LOCATION:** COVINA
VEHICLE #: 23761 **VEHICLE MAKE & MODEL:** TOYOTA RAV 4
VEHICLE APPLICATION: _____ **DATE:** 5/13/99

DRIVEABILITY	***SA***	***A***	***NS***	***D***	***SD***	***NA***
1. The vehicle feels stable and safe	X					
2. The vehicle steering is responsive	X					
3. The vehicle acceleration is adequate	X					
4. The vehicle braking is responsive and safe		X				
DRIVING CONTROLS AND GAUGES						
1. The cabin temperature controls are easy to operate	X					
2. The "state-of-charge" gauge is helpful and easy to read		X				
3. The "range remaining" gauge is helpful and easy to read	X					
CHARGING CONTROLS AND GAUGES						
1. The charging controls are easy to operate	X					
2. The charging connector (plug) is easy to use	X					
3. The charging cord is easy to manage	X					
4. The vehicle charges adequately (full in the morning)	X					
5. The charger is reasonably quiet	X					
6. Do you know the differences between Inductive and Conductive charging?			___ **Yes**	✓ **No**		
If yes, which do you prefer? ___ **Inductive** ___ **Conductive** ___ **No preference**						
7. Did you have any problems charging? ___ **Yes** X **No**						
If yes, please describe* _____						
INTERIOR						
1. The heater provides adequate heat			X	X		
2. The air conditioner provides adequate cooling		X				
3. The vehicle is quiet	X					
4. Did you use electronic equipment (cell phone, radio, etc.) inside the EV?			X **Yes**	___ **No**		
If yes, please list equipment(s) and describe any problems encountered* CELL PHONE/NONE						
GENERAL						
1. The vehicle has adequate payload		X				
2. The vehicle has adequate range		X				
3. The vehicle is easy to operate	X					
4. The vehicle is suited for your job application	X					
5. The vehicle meets your expectations	X					
6. If you had to choose between this vehicle or a similar gasoline vehicle ***for use in your work*** which one would you select? **(Circle One)** **Electric Vehicle** **Gasoline Vehicle** **Either**						

COMMENTS*

What did you like best? ITS QUIET AND COMFORTABLE

What did you like least? THE HEATER DOESN'T WORK WELL.

SA: *Strongly Agree;* ***A:*** *Agree;* ***NS:*** *Not Sure;* ***D:*** *Disagree;* ***SD:*** *Strongly Disagree;* ***NA:*** *Not Applicable*

SCE Electric Vehicle Driver Questionnaire

DRIVER NAME: Tyrone Chamois **LOCATION:** Covina
VEHICLE #: 23763 **VEHICLE MAKE & MODEL:** Toyota Rav 4 EV
VEHICLE APPLICATION: _____ **DATE:** 5/13/99

	SA	A	NS	D	SD	NA
DRIVEABILITY						
1. The vehicle feels stable and safe		✓ on streets not Freeway				
2. The vehicle steering is responsive		✓				
3. The vehicle acceleration is adequate		✓				
4. The vehicle braking is responsive and safe		✓				
DRIVING CONTROLS AND GAUGES						
1. The cabin temperature controls are easy to operate	✓					
2. The "state-of-charge" gauge is helpful and easy to read	✓					
3. The "range remaining" gauge is helpful and easy to read	✓					
CHARGING CONTROLS AND GAUGES						
1. The charging controls are easy to operate			✓			
2. The charging connector (plug) is easy to use		✓				
3. The charging cord is easy to manage		✓				
4. The vehicle charges adequately (full in the morning)		✓				
5. The charger is reasonably quiet		✓				

6. Do you know the differences between Inductive and Conductive charging? ___ Yes ✓ No
   If yes, which do you prefer? ___ Inductive ___ Conductive ✓ No preference
7. Did you have any problems charging? ___ Yes ✓ No
   If yes, please describe* _____

	SA	A	NS	D	SD	NA
INTERIOR						
1. The heater provides adequate heat						
2. The air conditioner provides adequate cooling		✓				
3. The vehicle is quiet		✓				

4. Did you use electronic equipment (cell phone, radio, etc.) inside the EV? ✓ Yes ___ No
   If yes, please list equipment(s) and describe any problems encountered* Radio No Problems

	SA	A	NS	D	SD	NA
GENERAL						
1. The vehicle has adequate payload		✓				
2. The vehicle has adequate range		✓				
3. The vehicle is easy to operate		✓				
4. The vehicle is suited for your job application		✓				
5. The vehicle meets your expectations		✓				

6. If you had to choose between this vehicle or a similar gasoline vehicle ***for use in your work***, which one would you select? **(Circle One)** **Electric Vehicle** **(Gasoline Vehicle)** **Either**

COMMENTS*
What did you like best? Car has good power for E.V.
What did you like least? The breaks squeak loud. Ride a little unstable on freeways.

SA: *Strongly Agree;* ***A:*** *Agree;* ***NS:*** *Not Sure;* ***D:*** *Disagree;* ***SD:*** *Strongly Disagree;* ***NA:*** *Not Applicable*

Electric Vehicle Driver Questionnaire
Participant _____

DRIVER NAME: _____ **LOCATION:** SAN JACINTO

VEHICLE NUMBER: 23764 **VEHICLE MAKE & MODEL:** TOYOTA RAV4

VEHICLE APPLICATION: METERING **DATE:** _____

DRIVEABILITY	***SA***	***A***	***NS***	***D***	***SD***	***NA***
1. The vehicle feels stable and safe				X		
2. The vehicle steering is responsive	X					
3. The vehicle acceleration is adequate	X					
4. The vehicle braking is responsive and safe	X					
DRIVING CONTROLS AND GAUGES						
1. The cabin temperature controls are easy to operate		X				
2. The "state-of-charge" gauge is helpful and easy to read			X			
3. The "range remaining" gauge is helpful and easy to read		X				
CHARGING CONTROLS AND GAUGES						
1. The charging controls are easy to operate	X					
2. The charging connector (plug) is easy to use	X					
3. The charging cord is easy to manage	X					
4. The vehicle charges adequately (full in the morning)	X					
5. The charger is reasonably quiet	X					

6. Do you know the differences between Inductive and Conductive charging? ____ **Yes** __X__ **No**
   If yes, which do you prefer? ____ **Inductive** ____ **Conductive** __X__ **No preference**
7. Did you have any problems charging? ____ **Yes** ____ **No**
   If yes, please describe* _____

INTERIOR						
1. The heater provides adequate heat		X				
2. The air conditioner provides adequate cooling		X				
3. The vehicle is quiet	X					

4. Did you use electronic equipment (cell phone, radio, etc.) inside the EV? __X__ **Yes** ____ **No**
   If yes, please list equipment(s) and describe any problems encountered* Radio no

GENERAL						
1. The vehicle has adequate payload				X		
2. The vehicle has adequate range		X				
3. The vehicle is easy to operate		X				
4. The vehicle is suited for your job application				X		
5. The vehicle meets your expectations			X			

6. If you had to choose between this vehicle or a similar gasoline vehicle ***for use in your work***, which one would you select? **(Circle One)** **Electric Vehicle** **Gasoline Vehicle** **Either**

COMMENTS*

What did you like best? not Sure But People Like To Talk about it

What did you like least? wind moves it Around To much and Don't feel it would Be Safe in an accident

SA: Strongly Agree; A: Agree; NS: Not Sure; D: Disagree; SD: Strongly Disagree; NA: Not Applicable

Electric Vehicle Driver Questionnaire
Participant _____

DRIVER NAME: _____ LOCATION: SAN JACINTO

VEHICLE NUMBER: 23720 VEHICLE MAKE & MODEL: TOYOTA RAV4

VEHICLE APPLICATION: METERING DATE: _____

DRIVEABILITY	***SA***	***A***	***NS***	***D***	***SD***	***NA***
1. The vehicle feels stable and safe		X				
2. The vehicle steering is responsive		X				
3. The vehicle acceleration is adequate		X				
4. The vehicle braking is responsive and safe		X				
DRIVING CONTROLS AND GAUGES						
1. The cabin temperature controls are easy to operate		X				
2. The "state-of-charge" gauge is helpful and easy to read		X				
3. The "range remaining" gauge is helpful and easy to read		X				
CHARGING CONTROLS AND GAUGES						
1. The charging controls are easy to operate		X				
2. The charging connector (plug) is easy to use		X				
3. The charging cord is easy to manage		X				
4. The vehicle charges adequately (full in the morning)		X				
5. The charger is reasonably quiet		X				

6. Do you know the differences between Inductive and Conductive charging? ___ Yes X No
   If yes, which do you prefer? ___ Inductive ___ Conductive ___ No preference
7. Did you have any problems charging? ___ Yes X No
   If yes, please describe* _____

INTERIOR	***SA***	***A***	***NS***	***D***	***SD***	***NA***
1. The heater provides adequate heat			X	X		
2. The air conditioner provides adequate cooling		X				
3. The vehicle is quiet		X				

4. Did you use electronic equipment (cell phone, radio, etc.) inside the EV? X Yes ___ No
   If yes, please list equipment(s) and describe any problems encountered* RADIO

GENERAL	***SA***	***A***	***NS***	***D***	***SD***	***NA***
1. The vehicle has adequate payload		X				
2. The vehicle has adequate range					X	
3. The vehicle is easy to operate		X				
4. The vehicle is suited for your job application		X				
5. The vehicle meets your expectations		X				

6. If you had to choose between this vehicle or a similar gasoline vehicle ***for use in your work***, which one would you select? **(Circle One)** **Electric Vehicle** **Gasoline Vehicle** **Either**

COMMENTS*

What did you like best? QUIETNESS OF VEHICLE

What did you like least? NOT LONG ENOUGH RANGE

SA: Strongly Agree; A: Agree; NS: Not Sure; D: Disagree; SD: Strongly Disagree; NA: Not Applicable

SCE Electric Vehicle Driver Questionnaire

DRIVER NAME: CARLOS MUNGUIA **LOCATION:** MONTEBELLO
VEHICLE #: 23773 **VEHICLE MAKE & MODEL:** Toyota Rav 4
VEHICLE APPLICATION: METER READER **DATE:** 5/13/94

	SA	A	NS	D	SD	NA
DRIVEABILITY						
1. The vehicle feels stable and safe	✓					
2. The vehicle steering is responsive	✓					
3. The vehicle acceleration is adequate		✓				
4. The vehicle braking is responsive and safe	✓					
DRIVING CONTROLS AND GAUGES						
1. The cabin temperature controls are easy to operate	✓					
2. The "state-of-charge" gauge is helpful and easy to read	✓					
3. The "range remaining" gauge is helpful and easy to read	✓					
CHARGING CONTROLS AND GAUGES						
1. The charging controls are easy to operate	✓					
2. The charging connector (plug) is easy to use	✓					
3. The charging cord is easy to manage	✓					
4. The vehicle charges adequately (full in the morning)	✓					
5. The charger is reasonably quiet	✓					

6. Do you know the differences between Inductive and Conductive charging? ___ Yes ✓ No
   If yes, which do you prefer? ___ Inductive ___ Conductive ___ No preference
7. Did you have any problems charging? ___ Yes ✓ No
   If yes, please describe*_____

INTERIOR						
1. The heater provides adequate heat	✓					
2. The air conditioner provides adequate cooling	✓					
3. The vehicle is quiet						

4. Did you use electronic equipment (cell phone, radio, etc.) inside the EV? ___ Yes ✓ No
   If yes, please list equipment(s) and describe any problems encountered*_____

GENERAL						
1. The vehicle has adequate payload	✓					
2. The vehicle has adequate range	✓					
3. The vehicle is easy to operate	✓					
4. The vehicle is suited for your job application	✓					
5. The vehicle meets your expectations.	✓					

6. If you had to choose between this vehicle ~~or a similar~~ gasoline vehicle ***for use in your work***, which one would you select? **(Circle One)** **Electric Vehicle** **Gasoline Vehicle** **Either**

COMMENTS*
What did you like best? I like the quietness and smoothness of the car.
What did you like least? I didn't like driving uphills in this car.

SA: *Strongly Agree;* ***A:*** *Agree;* ***NS:*** *Not Sure;* ***D:*** *Disagree;* ***SD:*** *Strongly Disagree;* ***NA:*** *Not Applicable*

SCE Electric Vehicle Driver Questionnaire

DRIVER NAME: Michael Villa **LOCATION:** Montebello

VEHICLE #: 23926 **VEHICLE MAKE & MODEL:** Rav Toyota

VEHICLE APPLICATION: Motor Rev. II **DATE:** 5/13/99

	SA	A	NS	D	SD	NA
DRIVEABILITY						
1. The vehicle feels stable and safe		✓				
2. The vehicle steering is responsive		✓				
3. The vehicle acceleration is adequate		✓				
4. The vehicle braking is responsive and safe					✓	
DRIVING CONTROLS AND GAUGES						
1. The cabin temperature controls are easy to operate		✓				
2. The "state-of-charge" gauge is helpful and easy to read		✓				
3. The "range remaining" gauge is helpful and easy to read		✓				
CHARGING CONTROLS AND GAUGES						
1. The charging controls are easy to operate		✓				
2. The charging connector (plug) is easy to use		✓				
3. The charging cord is easy to manage		✓				
4. The vehicle charges adequately (full in the morning)		✓				
5. The charger is reasonably quiet		✓				

6. Do you know the differences between Inductive and Conductive charging? ___ Yes ✓ No

   If yes, which do you prefer? ___ Inductive ___ Conductive ___ No preference

7. Did you have any problems charging? ___ Yes ___ No

   If yes, please describe* _____

	SA	A	NS	D	SD	NA
INTERIOR						
1. The heater provides adequate heat		✓				
2. The air conditioner provides adequate cooling		✓				
3. The vehicle is quiet		✓				

4. Did you use electronic equipment (cell phone, radio, etc.) inside the EV? ✓ Yes ___ No

   If yes, please list equipment(s) and describe any problems encountered* _____

	SA	A	NS	D	SD	NA
GENERAL						
1. The vehicle has adequate payload		✓				
2. The vehicle has adequate range		✓				
3. The vehicle is easy to operate		✓				
4. The vehicle is suited for your job application		✓				
5. The vehicle meets your expectations		✓				

6. If you had to choose between this vehicle or a similar gasoline vehicle ***for use in your work***, which one would you select? **(Circle One)** **Electric Vehicle** **Gasoline Vehicle** **Either**

COMMENTS*

What did you like best? It's quiet I like driving it

What did you like least? Brake system along with the slick tires I don't like

SA: Strongly Agree; A: Agree; NS: Not Sure; D: Disagree; SD: Strongly Disagree; NA: Not Applicable