

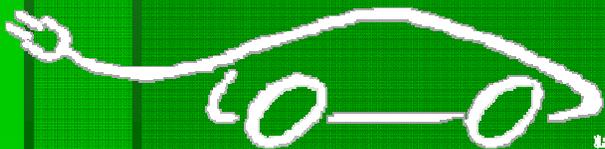
Toyota RAV4-EV Driver Experience

A Survey of Capability, Reliability, and Failures

Ron Freund, EAA Chairman

Presented to the CARB Technical Review
Sacramento, September 27, 2006

<http://www.eaaev.org>

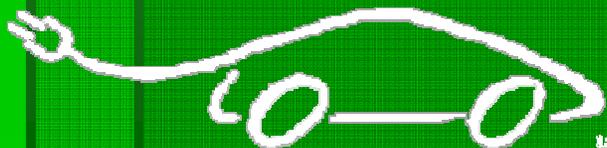


Electric Auto Association

Results: Usage Patterns



- **Surveyed: 132 vehicles**
 - **(incl. 16 fleet) 2001, 2002, 2003**
 - **Total ZEV miles: 5,051,064**
 - **Average Annual Miles: 10,000**
 - **Car purpose:**
 - **Commuter: 24%**
 - **Primary: 66%**
 - **Sole vehicle: ~10%**
 - **Even when ICE is available – avg. use: 80.4% of all miles driven**
 - **High mileage: 105,135**
Low Mileage: 4,100
 - **Locations: Initially all in CA, now in FL, MD, PA, IL, LA, CO, NJ, Nova Scotia etc.**
- Range: 103.1 mi,**
11.6 mi. standard deviation
- Average odometer: 37,978 miles**



Results: Power sources used

- Regular home-based grid charging: more convenient
- Solar: 48% of respondents drive Solar Powered Vehicles (SPV)
- BEVs can use renewables today.
 - Solar, Wind, Green Certificates, Methane
- Public infrastructure is enjoyed by >90%
- Extended driving horizon: 34.6 X/yr, avg.



Results: Failure/Defect Analysis (1 of 2)

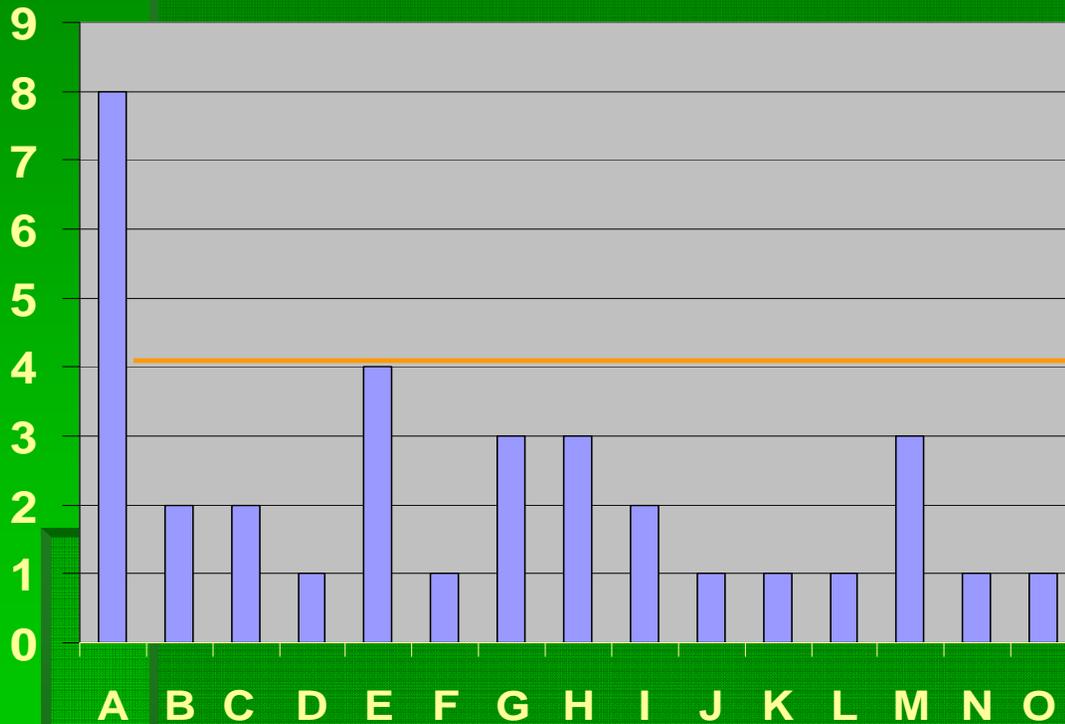
- **Failure defined:**
Anything that was not expected and that resulted in inability to continue without outside assistance
- **BEV Technology related versus routine:** nothing remarkable noted
- **Significant is 10-year-old design, well executed, mature technology**
- **No repeated BEV technology related failures, only routine maintenance issues noted**



Results: Failure/Defect Analysis (2 of 2)

Defect counts from 132 samples

FRU Frequency of Occurrence



A	Charge port fan
B	Traction pack
C	Heat pump
D	Electric Pwr. Steering
E	Rectifier
F	Rear Wiper motor
G	Traction Motor inverter
H	Battery Mgmt ECU
I	Motor seal leak
J	Main relay
K	Regen caused cut-out
L	Dash Brake Lamp on
M	Tires misaligned
N	Master cylinder
O	Overcharging



Results: Support services

- **Problems with Toyota**

While a few dealerships gave exemplary service, some had not seemed fully on-board

- **Problems with Toyota obtaining parts**

Yes = 24%, 76% said “not needed or no”

Many parts had long lead times, 4-6 weeks after crash/impacts

- **Problems with the home charger (included with vehicle)**

None = 77% 4 roll-aways; generally CFC Inc. repaired; once they refused for a known problem



RAV4-EV Traction battery

- Panasonic EV-95 NiMH performs admirably, 26 kWh capacity
- Specs: Three rows, ~1000 lbs., 26 kWh >100 freeway miles
- Regeneration: 20-33% additional energy recaptured and available thru use of 'B', 'EB' and anticipation

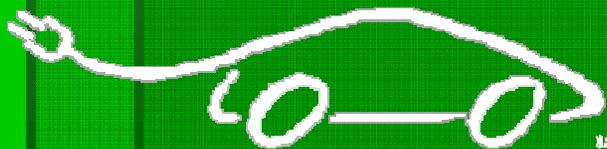
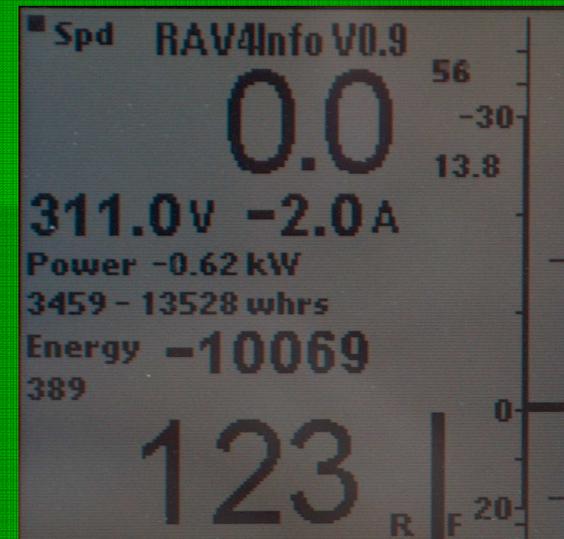
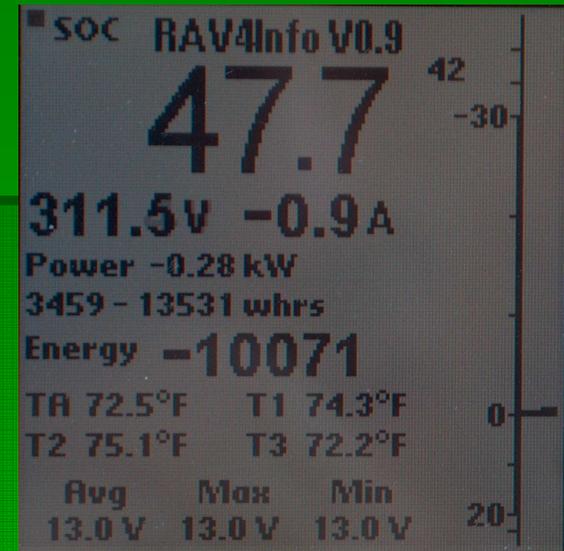


- 91% reported no change in capability, 9% reported some range loss. Of those 9%, the loss was less than 10%.
- No long term self-discharge noted.



Tool employed: RAV4Info S/W on PDA

- 3rd party development
- Taps into OBD-II data stream on car
- Software: protocol emulator, data interpretation, presentation
- How well do people drive?
 - DC energy used per mile driven
245 wH/mile average, A/C largest secondary load
 - High: 340, Low: 112
- Regeneration provides range boost (>20%)
- Driving for efficiency becomes a goal



Drivers' Overall Perception of RAV4-EV

- Owners overwhelmingly appreciate:
 - vehicle functionality and reliability
 - predictability and durability of the NiMH battery technology
 - measurably lower fuel cost, time saved by home charging
 - not buying gasoline
 - no tailpipe emissions; lower carbon footprint
 - unexpected investment asset
 - very short learning curve - extremely simple to operate
- No technology limitations seen in this implementation example
- All failures and defects are significantly less, or in rare cases, at worst - very comparable to the gasoline version of car



RAV4 EV Drivers' Survey Conclusions

- RAV4-EV provides drivers w/ good value and pleasant driving experience.
- The manufacturing process demonstrated by Toyota is mature and well executed
- As natural and easy to use as a gas car
- Textbook example of manufacturing quality control; failures below 3% maximum for worst component
- Technology is over 10 years old, over 100,000,000 ZEV miles in real-world consumer use
- Frequent comments: “best car ever owned”, etc.



RAV4 EV Drivers' Survey Backup slides



Biographical overview

RAV4 EV Driver Survey

- Professional Hardware Design Engineer
- Actively employed as engineer in tech. industry
- Driver of electric vehicles since Feb. 1998
- Renter of GM EV-1 from EV-Rentals at LAX in 2001
- Purchased 5th RAV4-EV from Toyota in Palo Alto, 2002
- Lead EAA since Feb. 2001, CA 501(c)(3) w/ >1000 members in 43 states and 10 foreign countries
- EAA represents drivers as a public benefit education organization with several special interest groups
- Details on website <http://www.eaaev.org>



Electric Auto Association

RAV4 EV Drivers' Survey

Approach used

- Decided what data to collect
- Created an email survey
Requirement < 10 minutes to fill out and return
- >132 vehicles represented (of ~330 privately held)
- Tabulated responses via spreadsheet

