# Electric Vehicle Fleet Operations in the United States

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# *Field Operations Program Members*

- *U.S. Department of Energy*
  - *Office of Technology Utilization*
- *Idaho National Engineering and Environmental Laboratory*
  - *U.S. Department of Energy – Idaho Operations Office*
  - *Lockheed Martin Idaho Technologies Co.*
- *Qualified Vehicle Testers*
  - *Southern California Edison*
  - *Electric Transportation Applications (Arizona Public Service, Potomac Electric Power Co., Salt River Project)*

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# *Field Operations Program Mission*

- ***Demonstrate the validity of operating electric vehicles in commercial fleet applications by documenting***
  - ***Performance***
  - ***Costs***
  - ***Support requirements***

# Field Operations Program Testing Methods

- Baseline Performance Testing (EV America)
  - Initial performance
  - Periodic checks
- Fleet testing
  - Viability as fleet vehicle
  - User acceptance issues
- Accelerated reliability testing
  - High mileage
  - Performance over life-cycle
  - Infrastructure support

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# *Baseline Performance (EV America) Testing*

- *Utilities, domestic and foreign car manufacturers, Department of Energy*
- *Stringent testing procedures*
- *Minimum qualification standards*
- *Allows vehicle-to-vehicle and year-to-year comparisons*

# Baseline Performance (EV America) Testing

- Testing parameters
  - Driving cycle range (SAE J1634)
  - (2) constant speed range
  - Maximum speed
  - Acceleration
  - Charge time
  - Charge efficiency
  - Vehicle specifications
  - Braking
  - Handling

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# Baseline Performance (EV America) Testing

- 1998 - Toyota RAV4 (NiMH)
  - Other OEM vehicles
- 1997 - Ford Ranger
  - Chevrolet S-10
- 1996 - GM EV1
  - Toyota RAV4 (lead prototype)
- 1995 - 2 Solectria conversions
  - 1 Baker conversion
- 1994 - 1 Dodge van
  - 3 BAT conversions
  - 2 Solectrica conversions
  - 2 U.S. Electricar conversions
  - 1 Unique Mobility conversion

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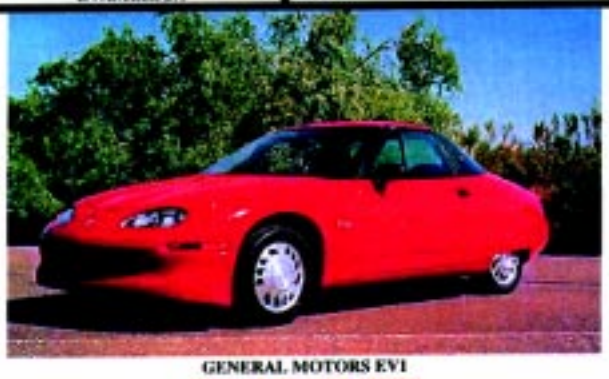
| EVAMERICA | USDOE | Performance Statistics |
|---|---|---|



**GENERAL MOTORS EV1**
**VEHICLE SPECIFICATIONS**

**PURPOSE-BUILT VEHICLE**
Base Vehicle: 1997 EV1
VIN: 4g5pn2250t0100009
Seatbelt Positions: Two

Standard Features:
Heat Pump Climate Control System
Cruise Control
Power Door Locks
Dual Air Bags
Power Windows
Front Disc Brakes
Power Steering
Anti-Lock Brakes
Front Wheel Drive
Regenerative Braking
Daytime Running Lights
AM/FM Stereo w/Cassette and CD Player w/4 Speaker System
ElectriClear Windshield
Check Tire Pressure System
High Voltage Isolation Assurance
Welded & Bonded Aluminum Alloy Body
Electronic Key Pad Entry/Vehicle Activation System
110V 1.2 kW Convenience Charger

**BATTERY**
Manufacturer: Delphi
Type: Valve Regulated Lead Acid
Number of Modules: 26
Weight of Module: 18.8 kg
Weight of Pack(s): 1175 kg

**BATTERY**
Pack Locations: T-Pack Integral
Nominal Module Voltage: 12 V
Nominal System Voltage: 312 V
Nominal Capacity (1C): 53 Ah

**WEIGHTS**
Design Curb Weight: 2970 lbs
Delivered Curb Weight: 2922 lbs
Distribution F/R: 53/47 %
GVWR: 3410 lbs
GAWR F/R: 1705/1705 lbs
Payload: 440 lbs
Performance Goal: 400 lbs

**DIMENSIONS**
Wheelbase: 98.9 inches
Track F/R: 57.9/49.0 inches
Length: 169.7 inches
Width: 69.5 inches
Height: 50.5 inches
Ground Clearance: **4.2 inches at GVWR**
Performance Goal: 5.0 inches at GVWR

**CHARGER**
Location: Off-Board
Type: Delco Electronics Inductive 6.6 kW
Input Voltages: 156 to 260 VAC

**TIRES**
Tire Mfg: Michelin
Tire Model: Proxima RR Radial
Tire Size: P175/65R14
Tire Pressure F/R: 50/50 psi
Spare Installed: No; Self Sealing Tires

**ACCELERATION 0-50 mph**
At 100% SOC: 6.3 sec
At 50% SOC: 6.7 sec
Max. Power: 116.4 kW
Performance Goal: 13.5 sec at 50% SOC

**MAXIMUM SPEED @ 50% SOC**
At 1/4 Mile: 78.9 mph
At 1 Mile: 80.4 mph
Performance Goal: 70 mph in one mile

**CONSTANT SPEED RANGE @ 45 mph**
Range: 135.2miles
Energy Used: 15.58 kWh
Average Power: 5.19 kW
Efficiency: 115 Wh/mile
Specific Energy: 31.9 Wh/kg

**CONSTANT SPEED RANGE @ 60 mph**
Range: 89.1 miles
Energy Used: 14.58 kWh
Average Power: 9.79 kW
Efficiency: 164 Wh/mile
Specific Energy: 29.8 Wh/kg

**DRIVING CYCLE RANGE**
Range per SAE J1634: 78.2 miles
Energy Used: 12.84 kWh
Average Power: 4.06 kW
Efficiency: 164 Wh/mile
Specific Energy: 26.3 Wh/kg
Performance Goal: 60 miles

**BRAKING FROM 60 mph**
Controlled Dry: 171.0 feet
Controlled Wet: 214.8 feet
Panic Wet: 211.9 feet
Course Deviation: 0.0 feet

**HANDLING**
Avg Time @ 90% SOC: 55.8 sec
Avg Time @ 50% SOC: 55.4 sec
Avg Time @ 20% SOC: 55.4 sec
Avg ICE Full Size Time: 54.62 sec

**GRADEABILITY (Calculated)**
Maximum Speed @ 3%: 79.0 mph
Maximum Speed @ 6%: 78.2 mph
Maximum Grade: 53.2%
Time on 3% Grade: 28 min 57 sec
Performance Goal: 15 Min

**CHARGING EFFICIENCY**
Efficiency: 248 Wh-AC/mile
Energy Cost @ 10 ¢/kWh: 2.48 ¢/mile

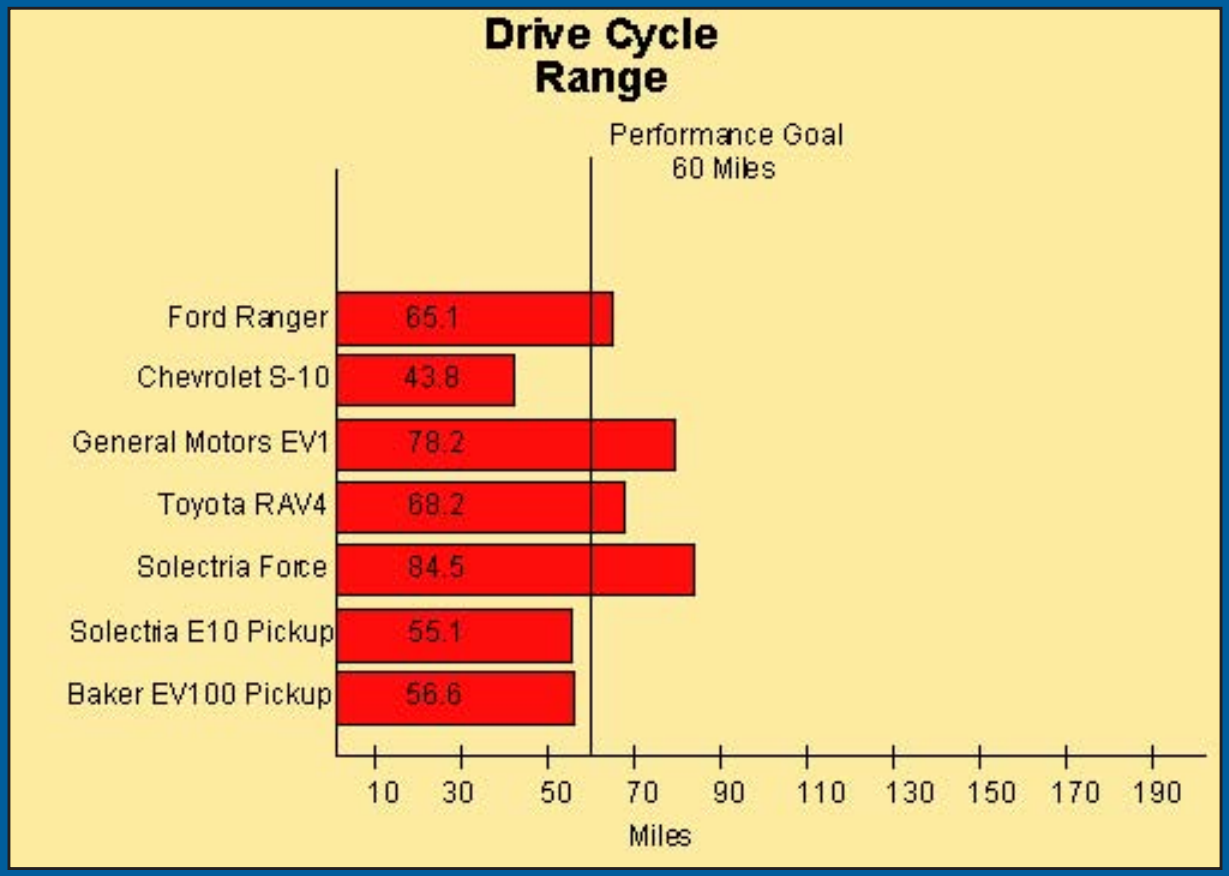
**TEST NOTES:**

1. At various during these range test the Battery Life, Reduced Performance, Service Soon, and Service Now telltales illuminated.
2. Charging time was extended due to high temperature conditions.
3. Specific Energy values were calculated using the number of modules times the module weight.
4. The battery pack data collection voltage signal was reduced 100:1 through a voltage divider installed by General Motors. This was for personnel protection.
5. The Standing Water Test was conducted with a water depth of six inches versus eight inches.

Values in **bold** indicate the Performance Goal was not met. * All Power and Energy values are DC unless otherwise specified.

**CHARGER**
Max Charger Ground Current: <0.01 mA
Max Battery Leakage Current: <0.01 mA mA
Max DC Charge Current: 16.83 Amps
Max AC Charge Current: 28.96 Amps
Pwr Factor @ Max Current: 1.00
THD(V)/(I) @ Max Current: 2.78/4.80 %
Peak Demand: 5.93 kW
Time to Recharge: 5 Hrs 18 min
Performance Goal: 8 hours

# Baseline Performance (EV America) Testing

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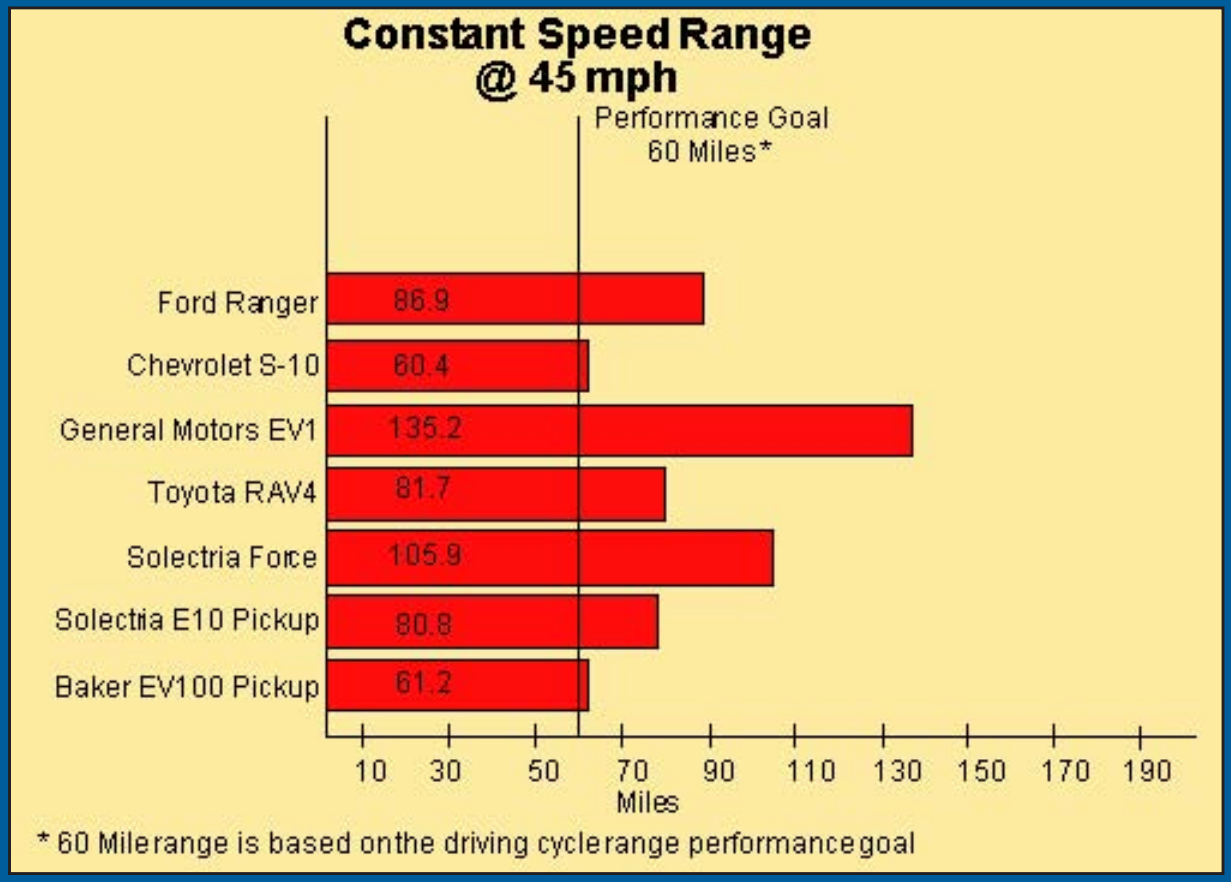


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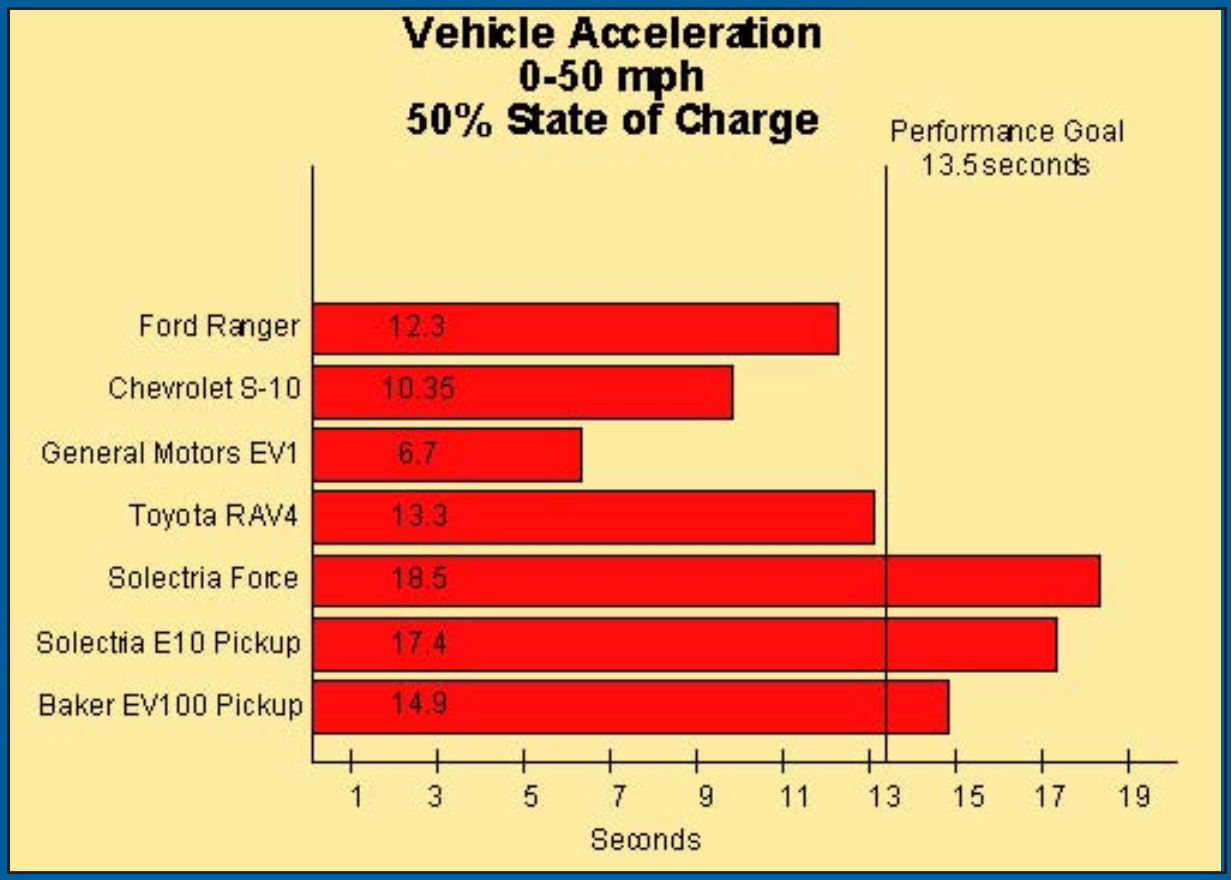


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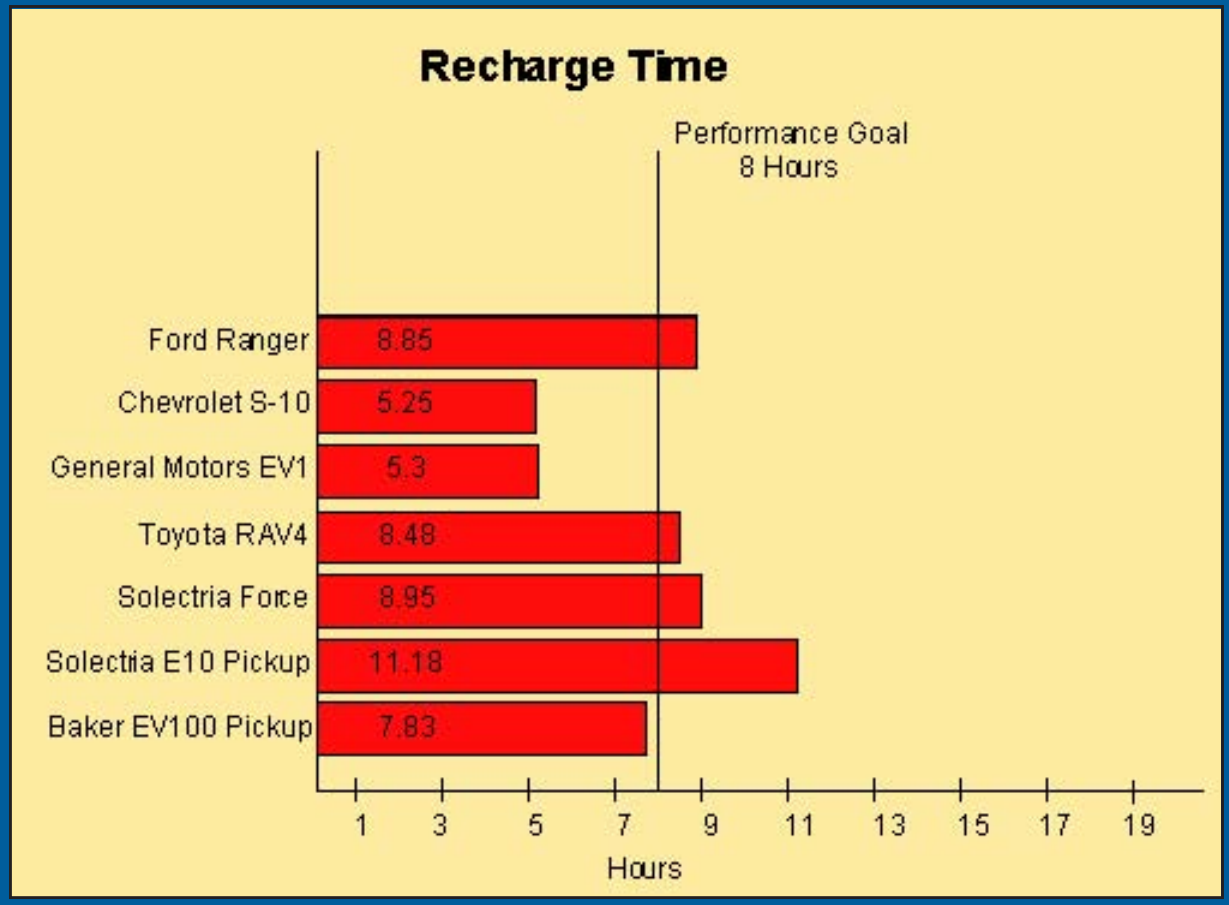


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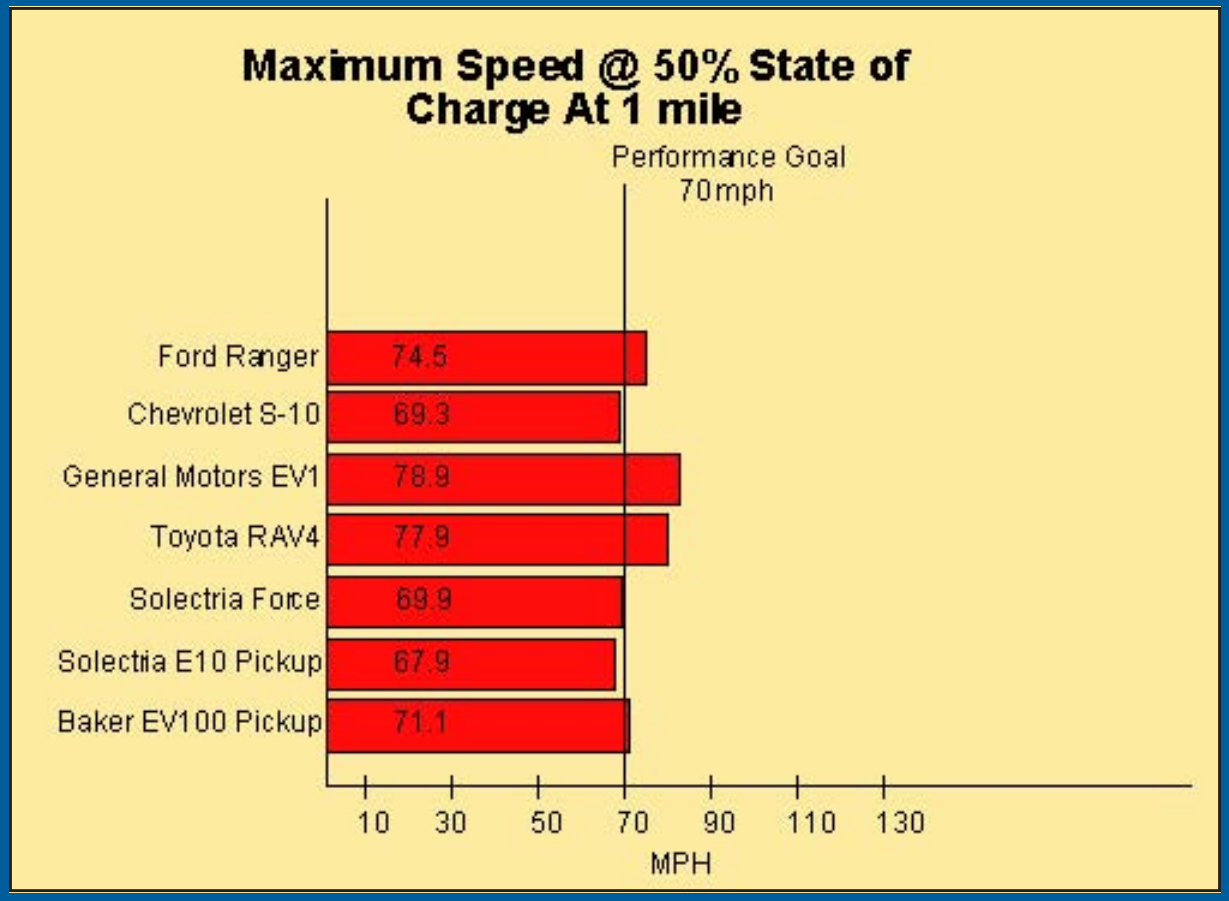


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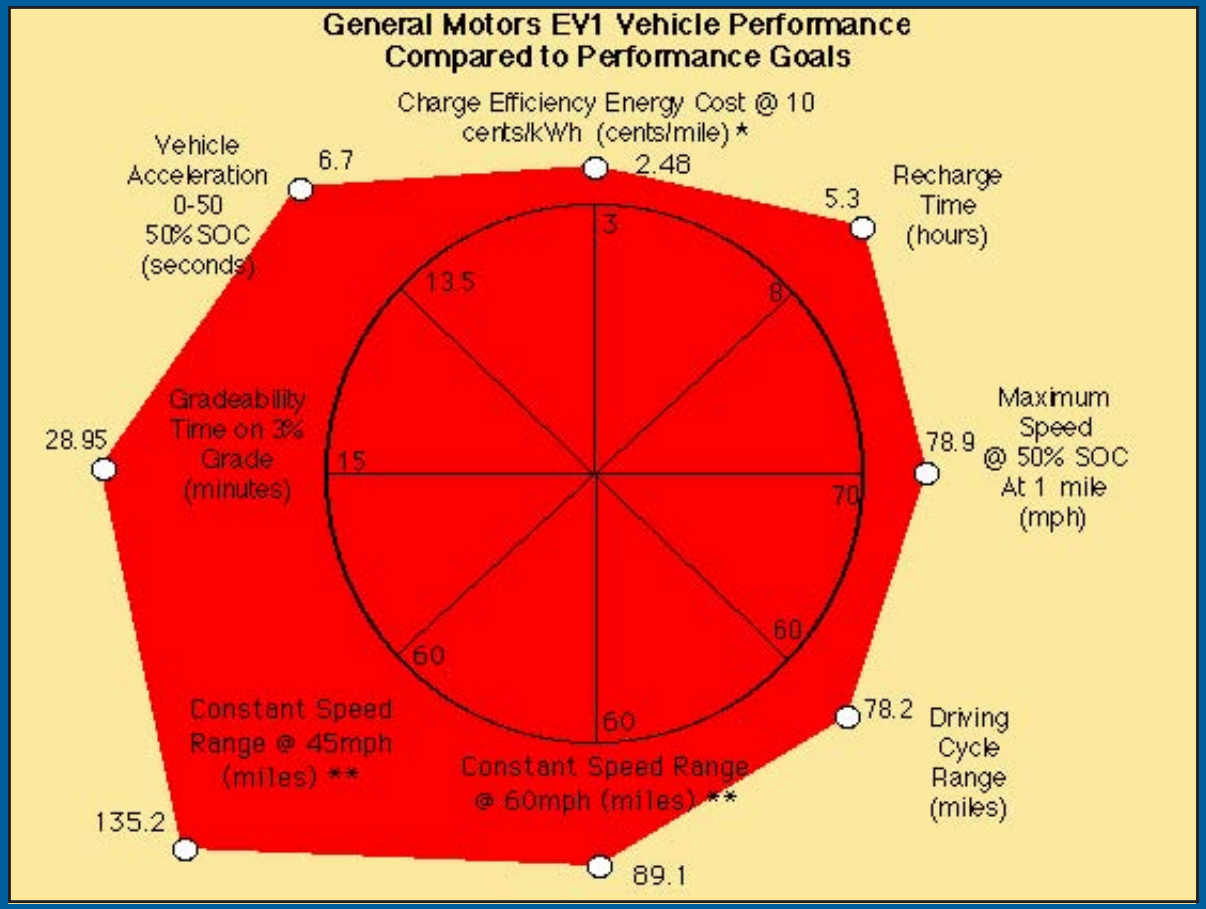


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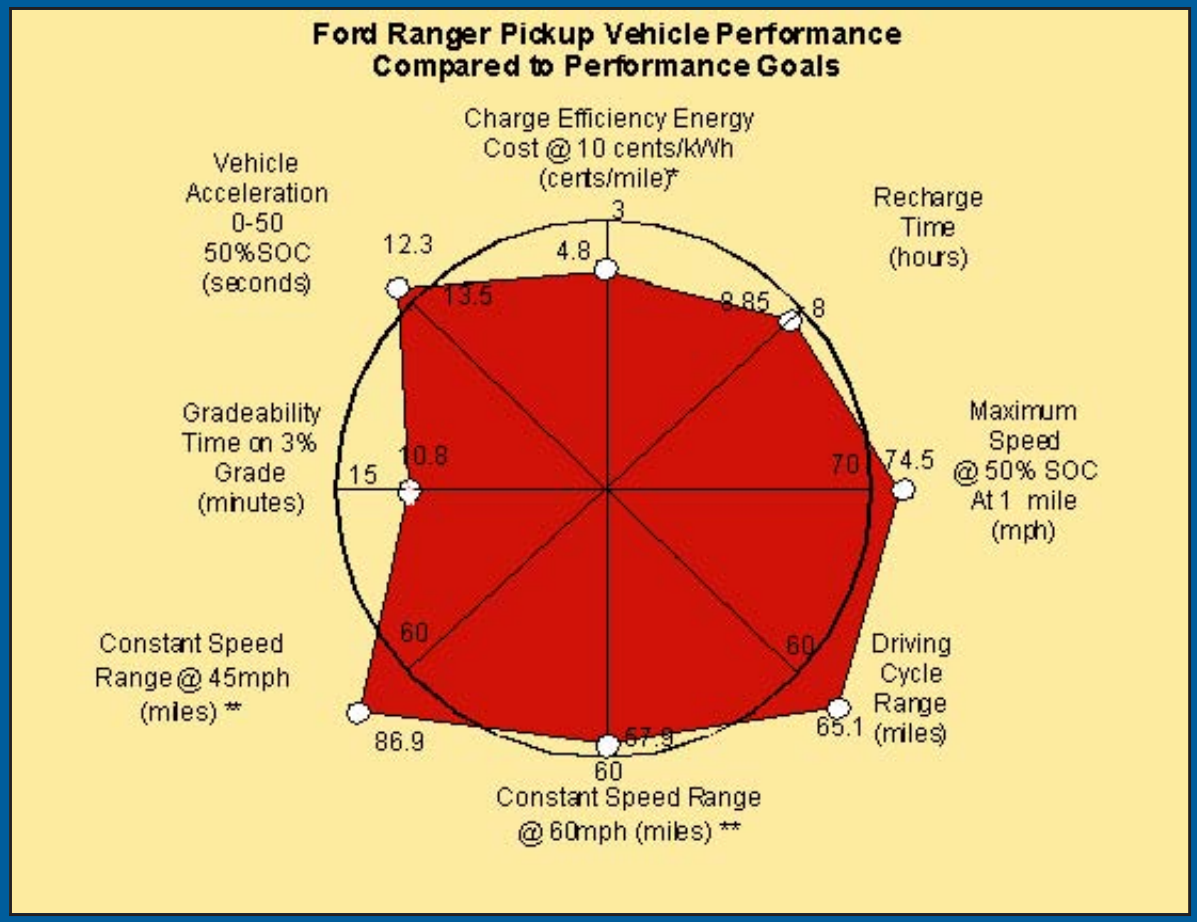


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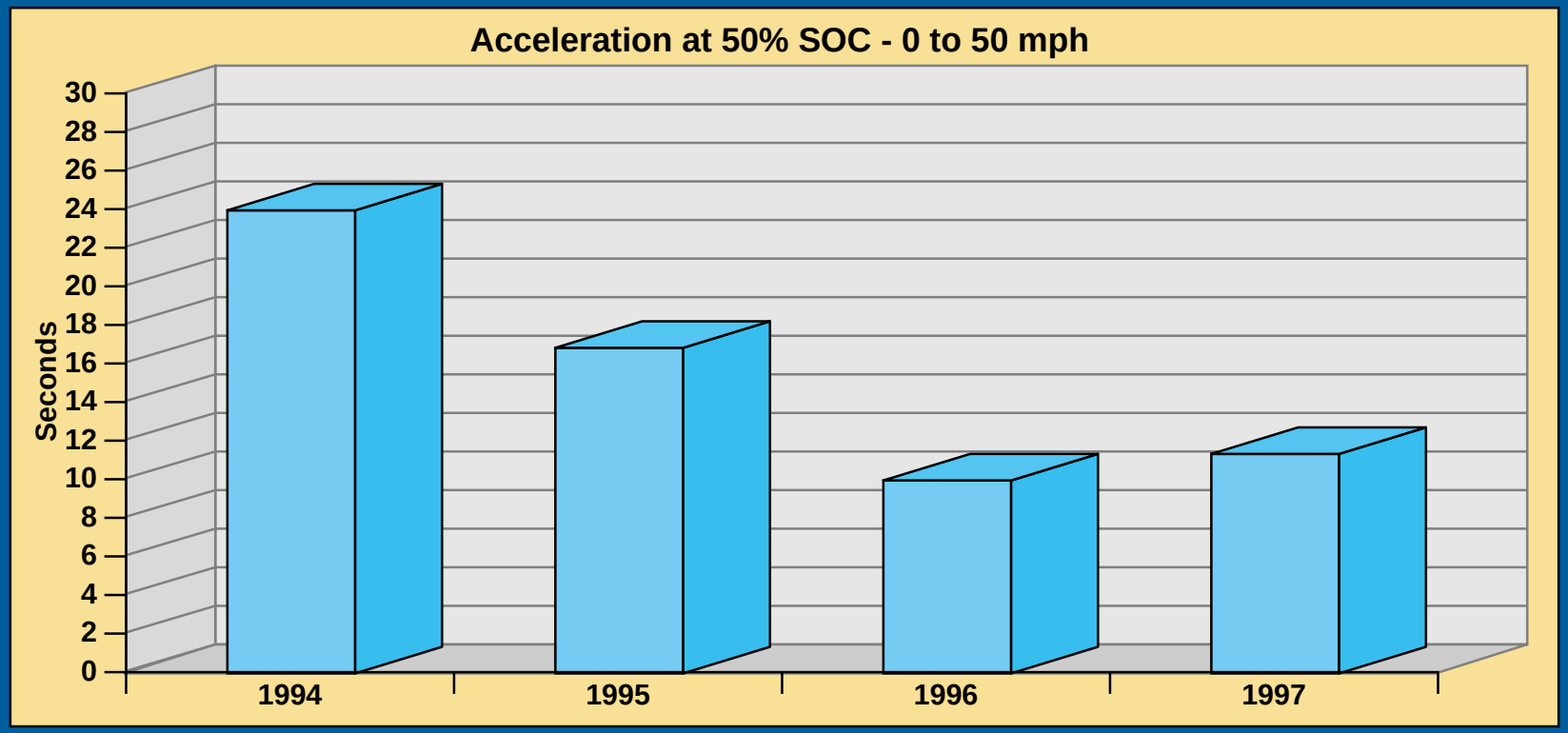


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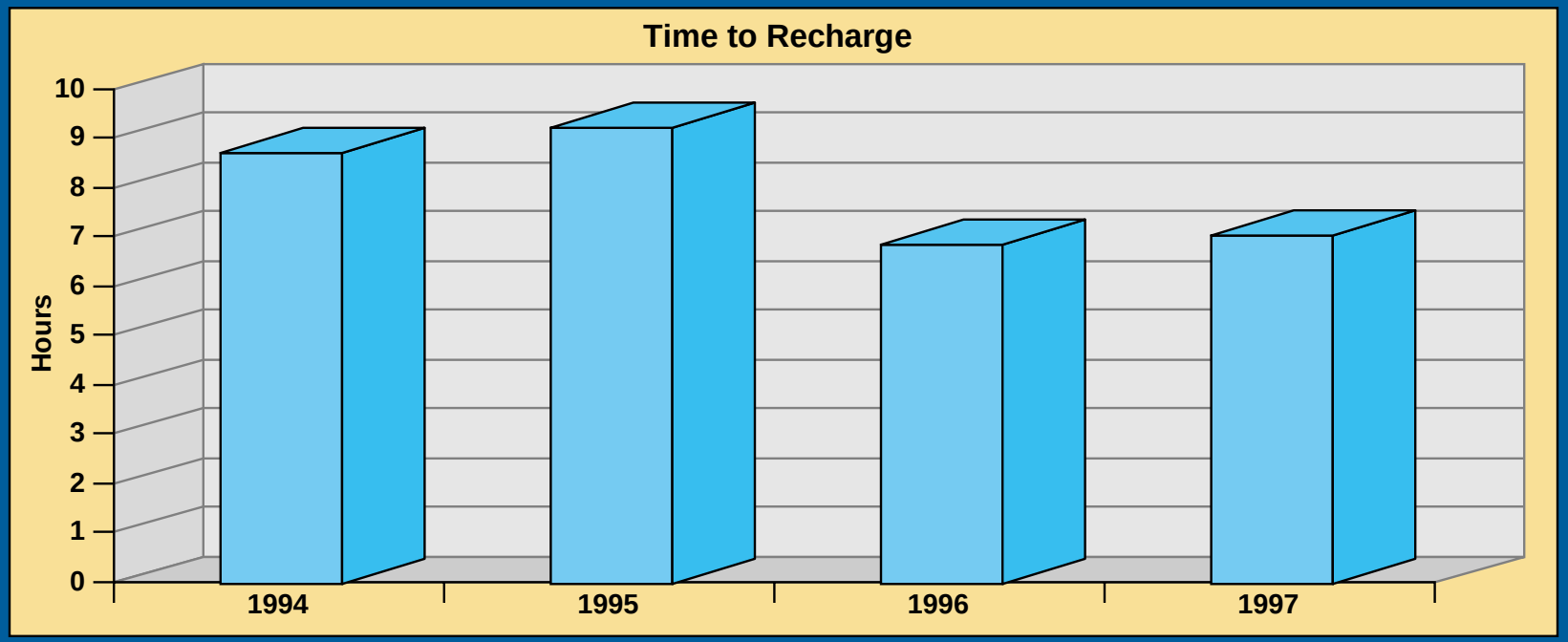


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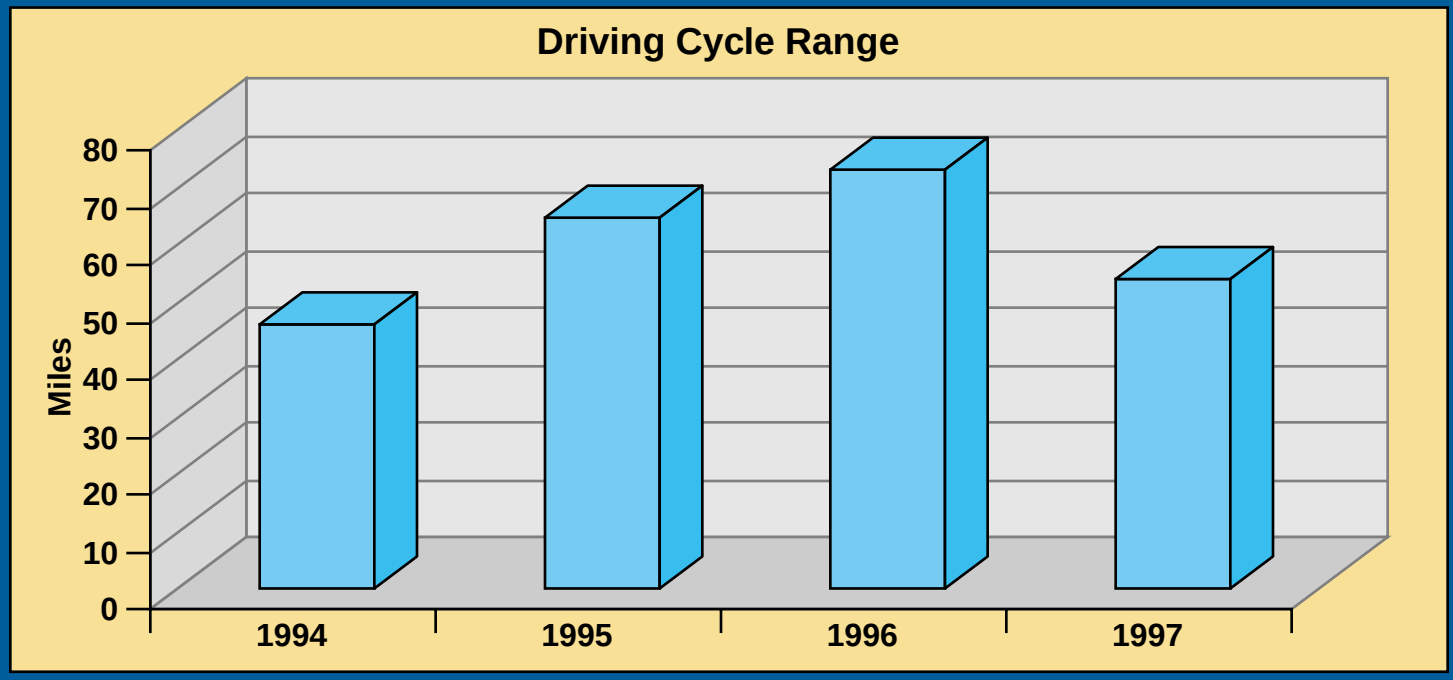


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# *Fleet Testing Activities*

- *Data acquisition*
  - *kWh meter onboard, for onboard conductive chargers*
  - *kWh meter offboard, for inductive chargers*
  - *kWh data stored in 15 minute segments*
  - *Odometer readings*
  - *Location, vehicle identification, time/date*

# Fleet Testing Activities

- Information Calculated
  - Charging profiles for 24 hours by fleets, models, and individual vehicles
  - Average and maximum charging rates
  - Range in miles per kWh
  - Daily distance based on charging patterns
  - Range per charge
  - Energy efficiency; mileage; and energy use by fleet, model, and vehicle

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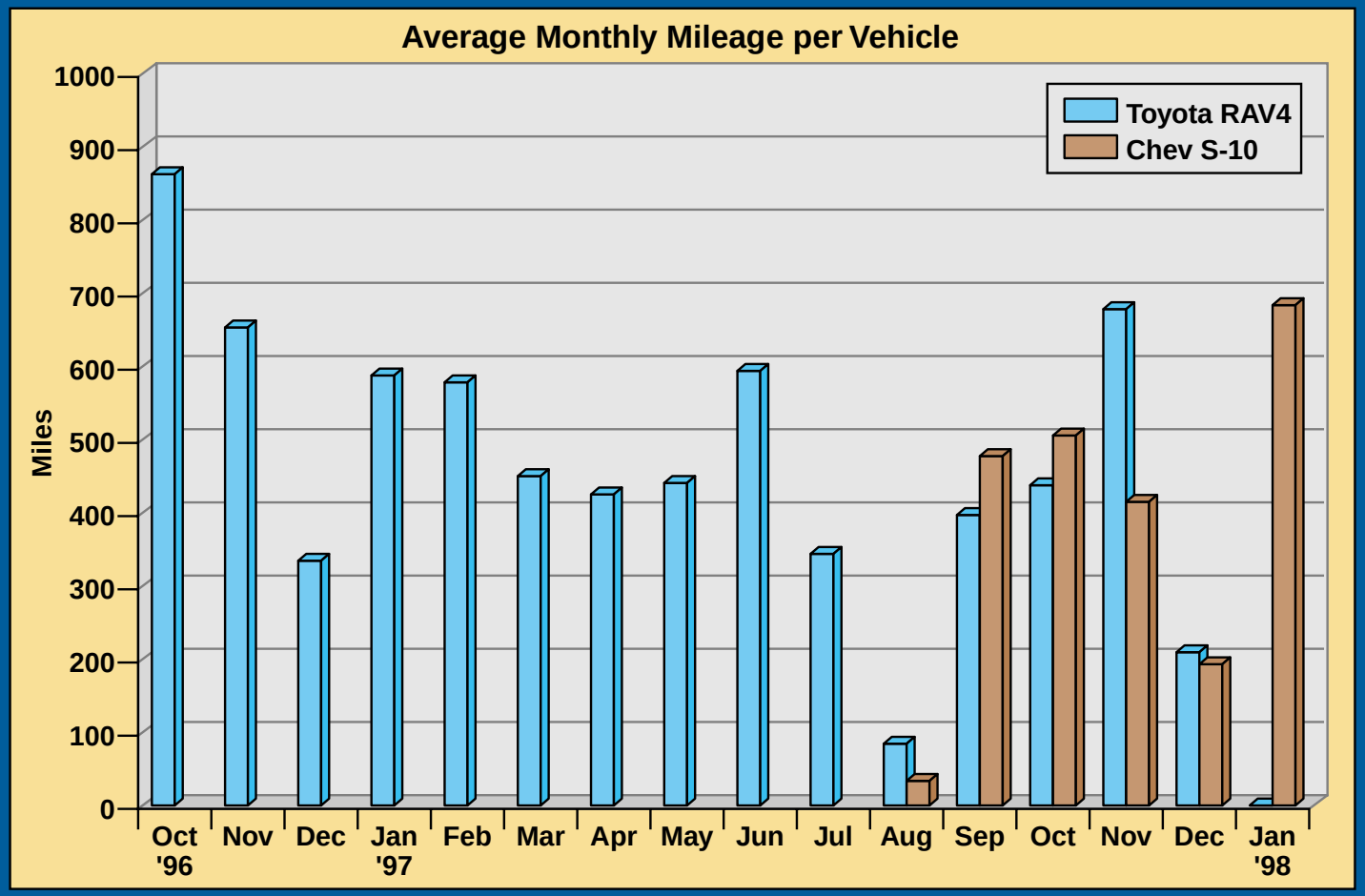
# Fleet Testing Activities

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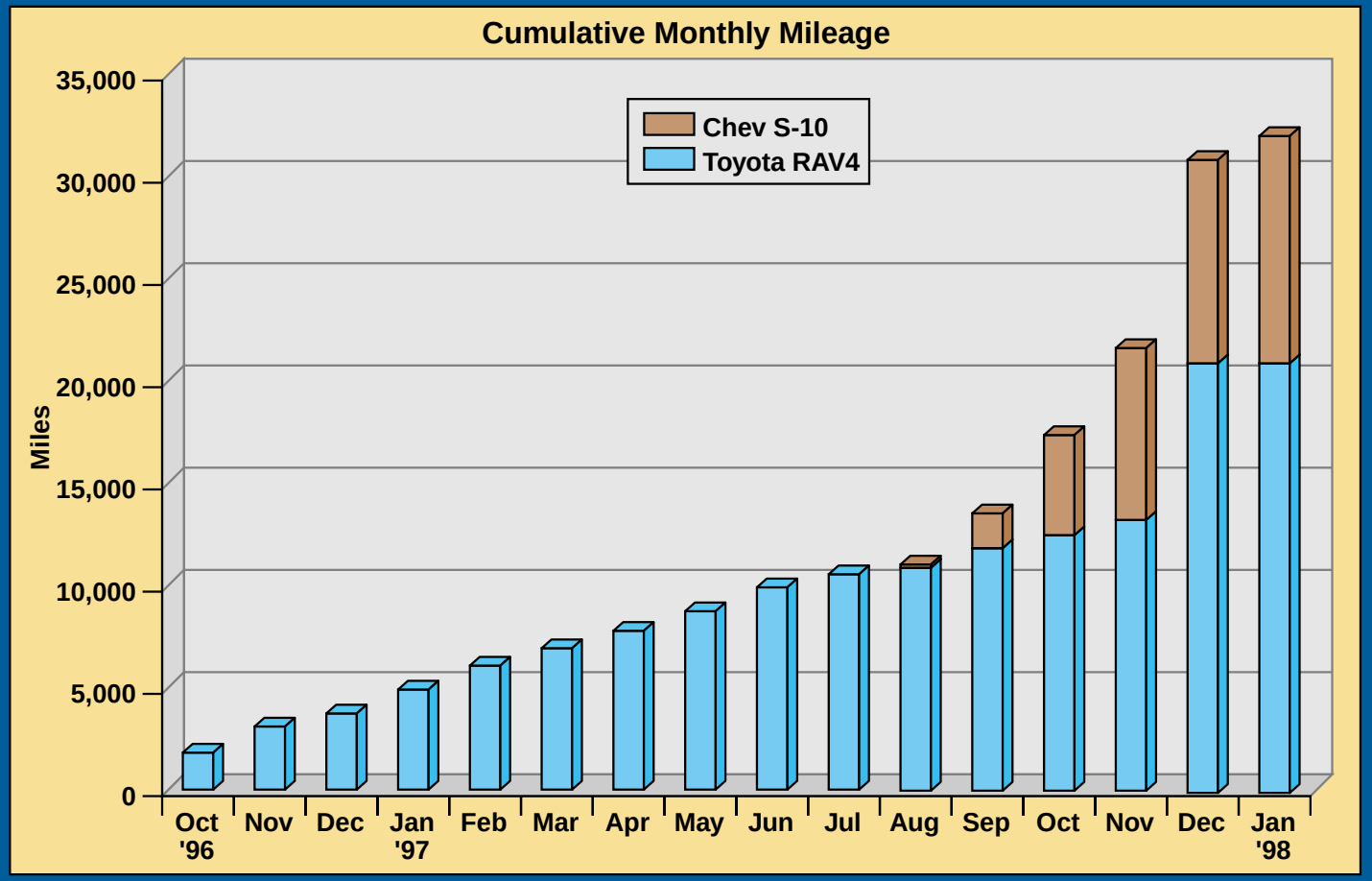
# Fleet Testing Activities

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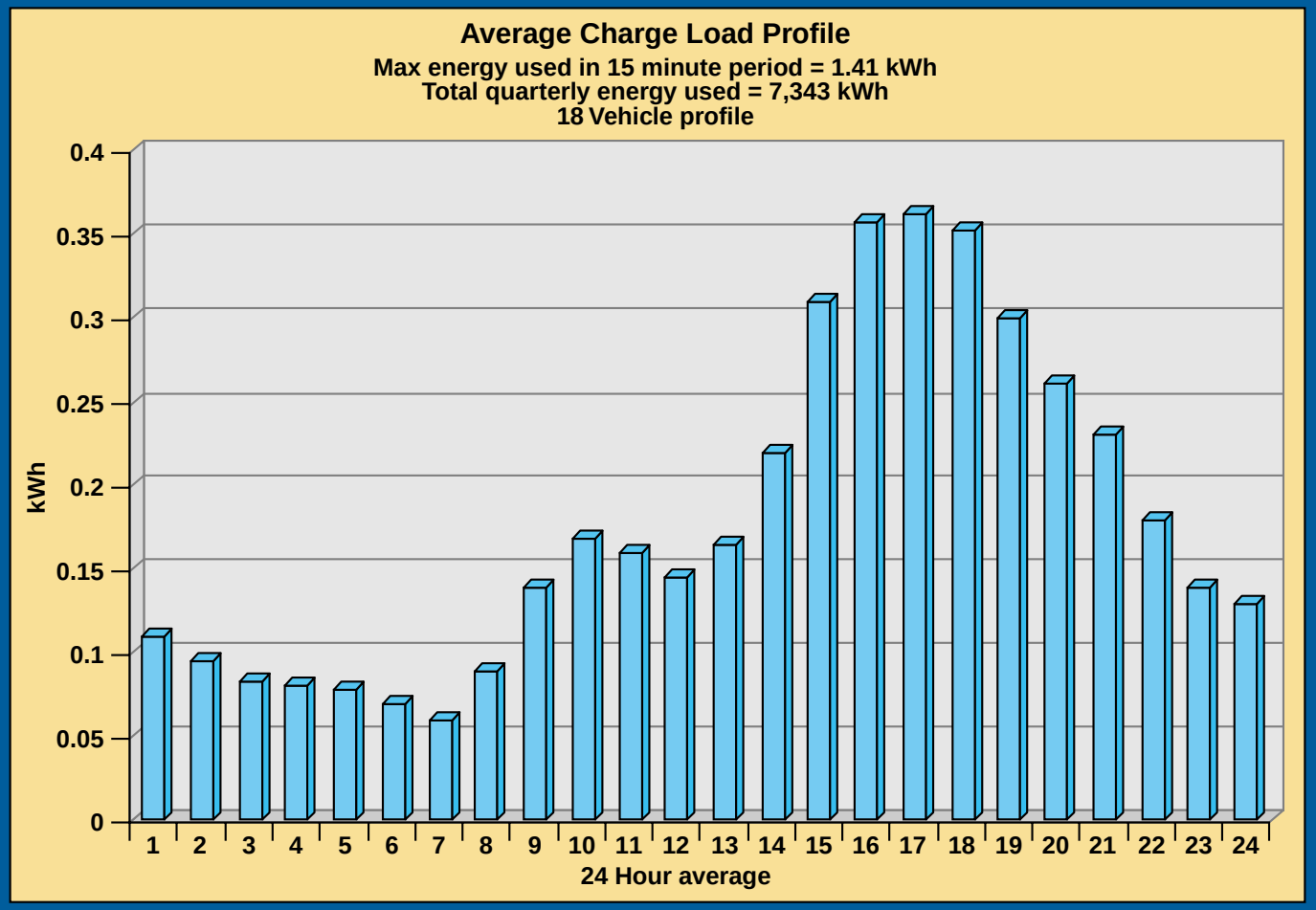
# Fleet Testing Activities

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# Accelerated Reliability Testing

- Chrysler EPIC (lead acid) 4,000+ miles
- Chevrolet S-10 - several vehicles, 12,000+ miles per vehicle
- Toyota RAV4 and Ford Ranger now entering testing
- KWh, mileage, and maintenance requirements collected
- Topical reports

# Infrastructure Development

- Infrastructure Working Council
  - Health and Safety
  - Load Management, Distribution, and Power Quality
  - Data Interface
  - Bus/Non Road
  - Connector & Connecting Stations
    - Defining Level 1, 2, and 3 charging standards
    - Developing connector hardware

# *Charging Connectors*

- ***Conductive - direct wire-to-wire "traditional" connection. Both offboard and onboard chargers.***
  - ***Chrysler, Ford, Honda, Toyota***
- ***Inductive - transfer power by magnetic coupling between the windings of two separate coils, one in the paddle and one in the vehicle receptor. Offboard charger.***
  - ***General Motors, Nissan***

# *Chargers - Level of Power Classification*

- ***Level 1 - Common household type of circuit, rated to 120 volts/AC and rated to 15 amps, standard household 3-prong connection, portable equipment, often results in low miles/AC kWh efficiencies***
- ***Level 2 - Permanently wired EVSE used specially for electric vehicle charging, rated up to 240 volts/AC, up to 60 amps, and up to 14.4 KW***
- ***Level 3 - Permanently wired EVSE used specially for electric vehicle charging, rated greater than 14.4 KW***

# *Chargers - Fast Charging*

- ***Fast chargers are rated as Level 3 chargers. However, not all Level 3 chargers are considered as fast chargers. This depends on the size of the battery pack to be charged and how much time is required to charge the battery pack. A charger generally can be considered a fast charger if it is capable of charging an average electric vehicle battery pack in about 20 to 30 minutes or less***

# Summary

- *Leaving vehicles charging over weekends/nights results in low miles/AC kWh efficiencies*
- *Early vehicles often failed to meet performance goals*
- *Average annual performance results are improving*
- *New vehicles are OEM manufactured and include warranties*
- *Performance test results suggests that vehicle quality is significantly increasing as OEMs provide vehicles*

# *Summary (cont'd)*

- *Vehicles in fleet and reliability testing*
  - *Chevrolet S-10s (Lead acid)*
  - *RAV4s (NiMH)*
  - *Ford Rangers (Lead acid)*
  - *Chrysler EPIC (Lead acid)*
- *Vehicles in baseline performance testing (1998)*
  - *Toyota RAV4 (NiMH)*
  - *3 OEM vehicles with advanced (NiMH) battery packs*

# *Field Operations Program - Web Homepage*

- ***Operations, performance, and maintenance results disseminated through formal reports and the World-Wide-Web***

  ***http://ev.inel.gov/sop/***