

**Electric Drive Transportation Association Conference
Vancouver, Canada
December 2005**

Hybrid Electric Vehicle Testing

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U.S. Department of Energy - FreedomCAR & Vehicle Technologies
Program, Advanced Vehicle Testing Activity

Presentation Outline

- Background & goals
- Testing partners
- Hybrid electric vehicle testing
 - Baseline performance testing (new HEV models)
 - 1.5 million miles of HEV fleet testing (160k miles per vehicle in 36 months)
 - End-of-life HEV testing (rerun fuel economy & conduct battery testing @ 160k miles per vehicle)
 - Benchmark data: vehicle & battery performance, fuel economy, maintenance & repairs, & life-cycle costs
- WWW information location

Background

- Advanced Vehicle Testing Activity (AVTA) - part of the U.S. Department of Energy's FreedomCAR and Vehicle Technologies Program
- AVTA Primary Goal - provide benchmark data for technology modeling, and research and development programs
- AVTA Secondary Goal - help fleet managers and other vehicle purchasers make informed purchase and operations decisions
- These activities are managed by the Idaho National Laboratory (INL also performs data analysis and reporting activities)

Testing Partners

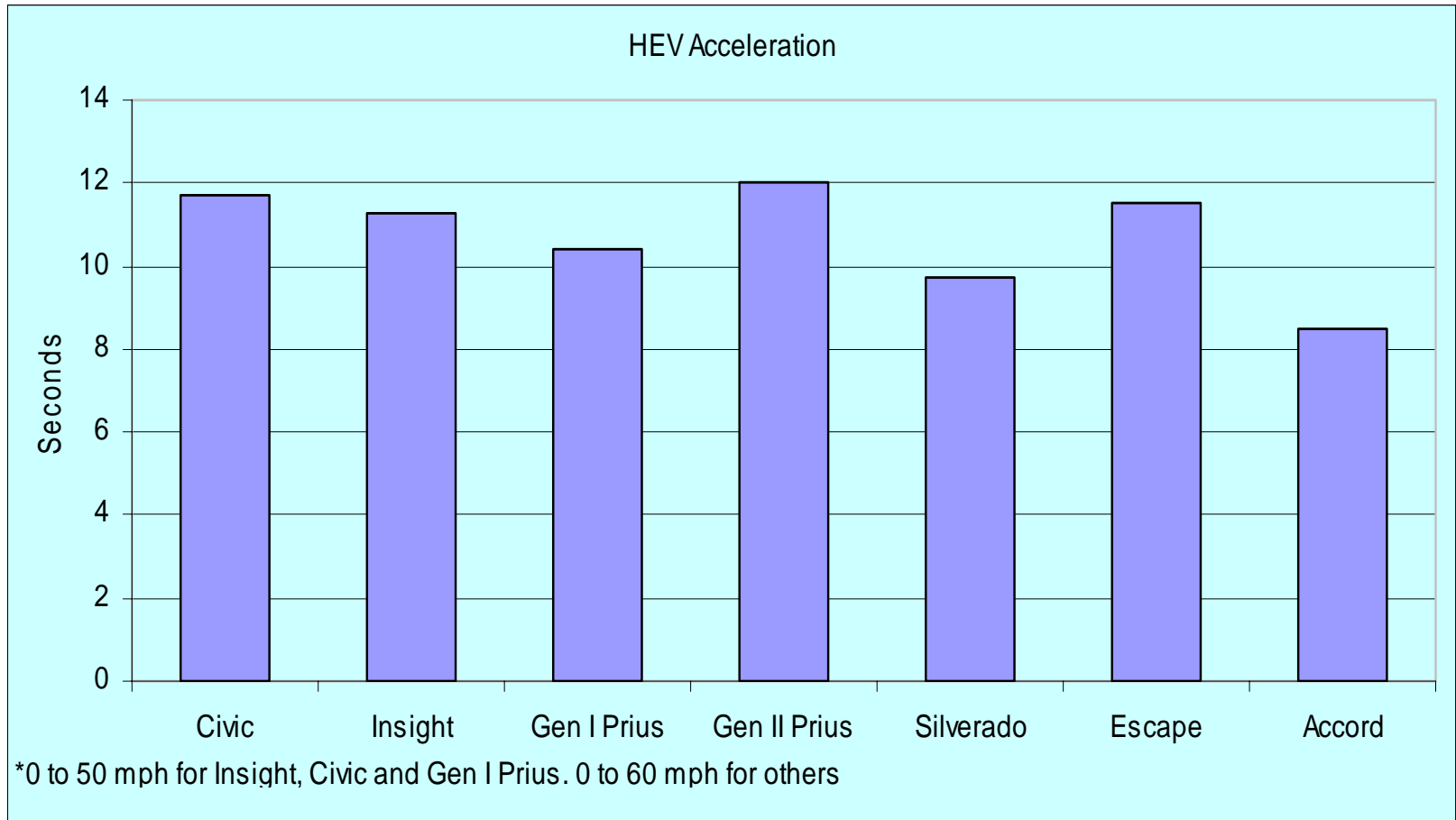
- Qualified Vehicle Testers (50/50 cost share)
 - Electric Transportation Applications (lead)
 - Arizona Public Service
 - Bank One of Arizona
 - Red Cross



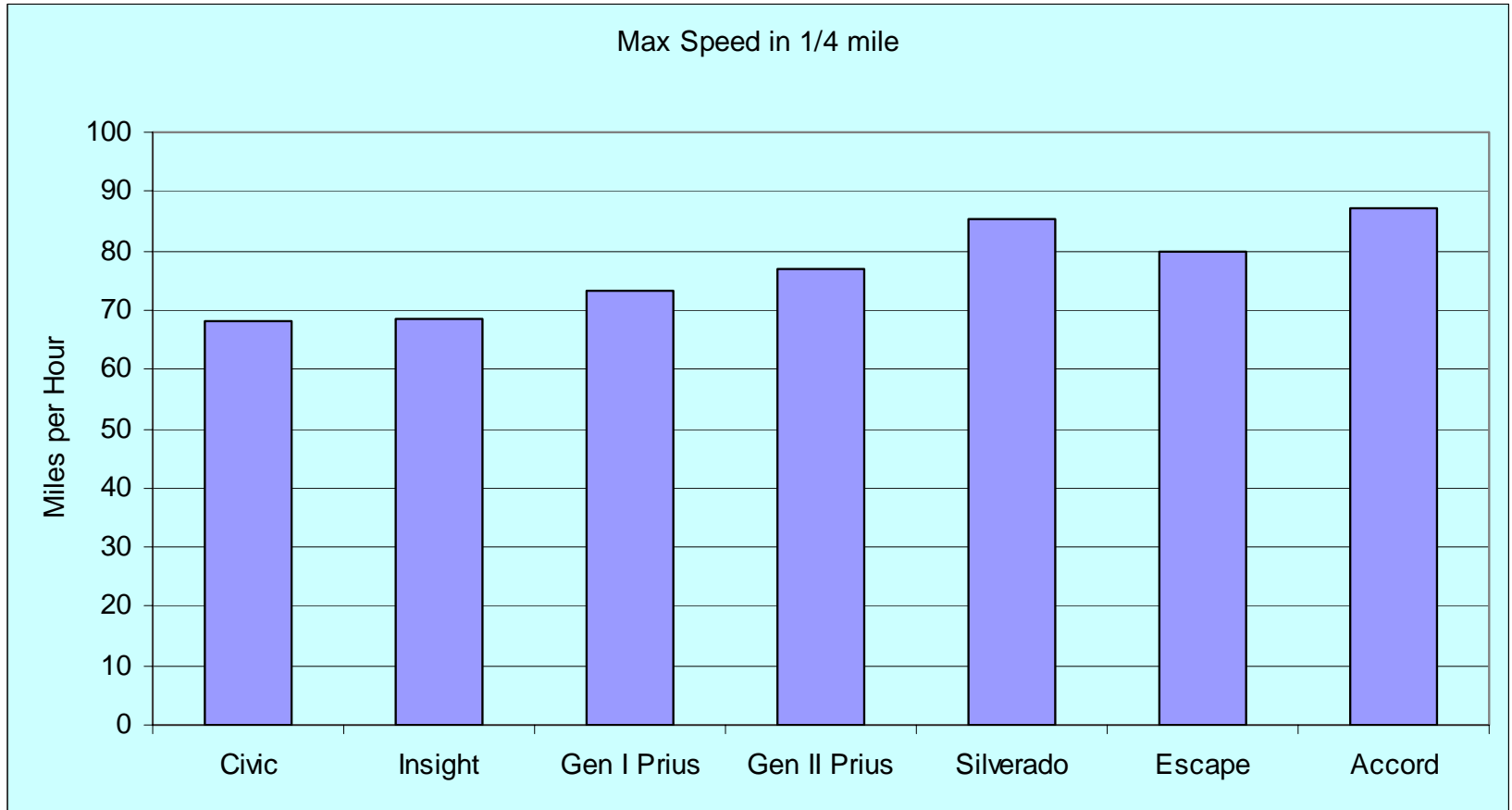
Testing Methods

- Baseline performance testing (dynamometer & closed track testing) – vehicle-to-vehicle comparisons
 - Acceleration, max speed, braking, handling, & two fuel economy tests - SAE J1634 drive cycle - air conditioning (AC) on & off
- Fleet (accelerated reliability) testing
 - Fuel use, miles, maintenance & repairs, & life-cycle costs in fleet operations
 - Two of each HEV model accumulate 160,000 miles
- End-of-life (at 160,000 miles) testing
 - Conduct battery capacity (Hybrid Pulse Power Characterization) & power testing (Static Capacity)
 - Rerun SAE J1634 tests (AC on & off)

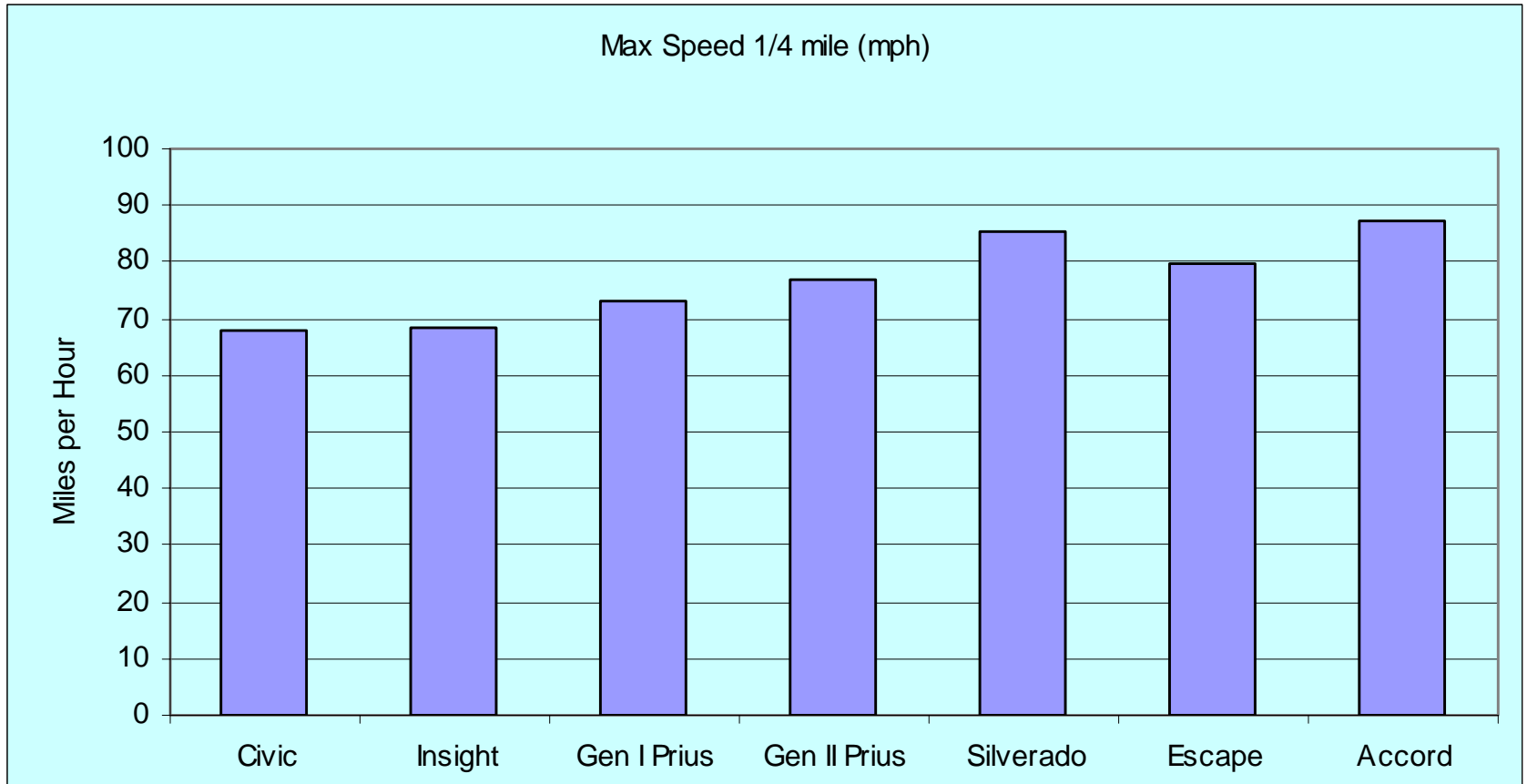
Acceleration



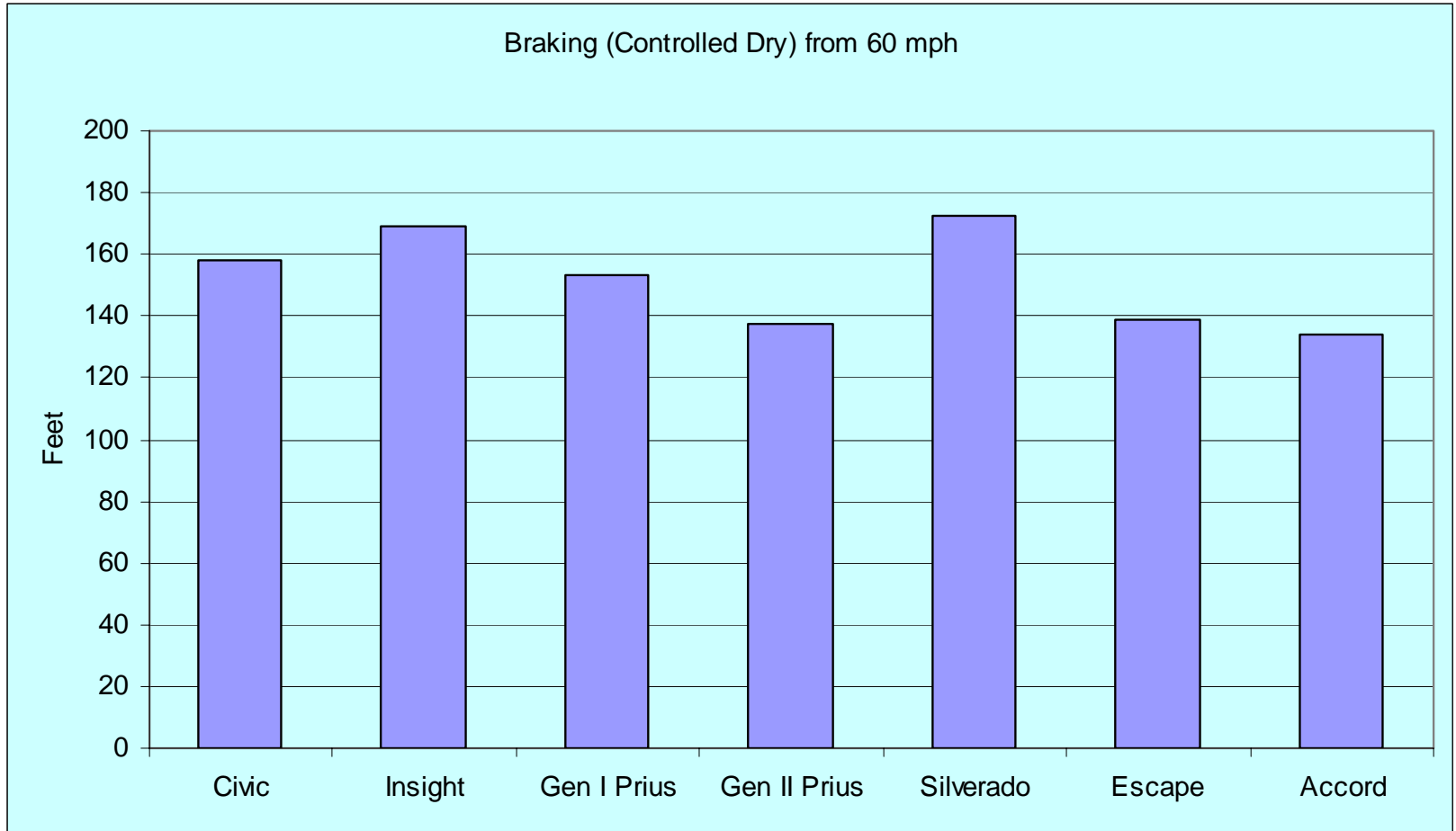
Maximum Speed in ¼ Mile



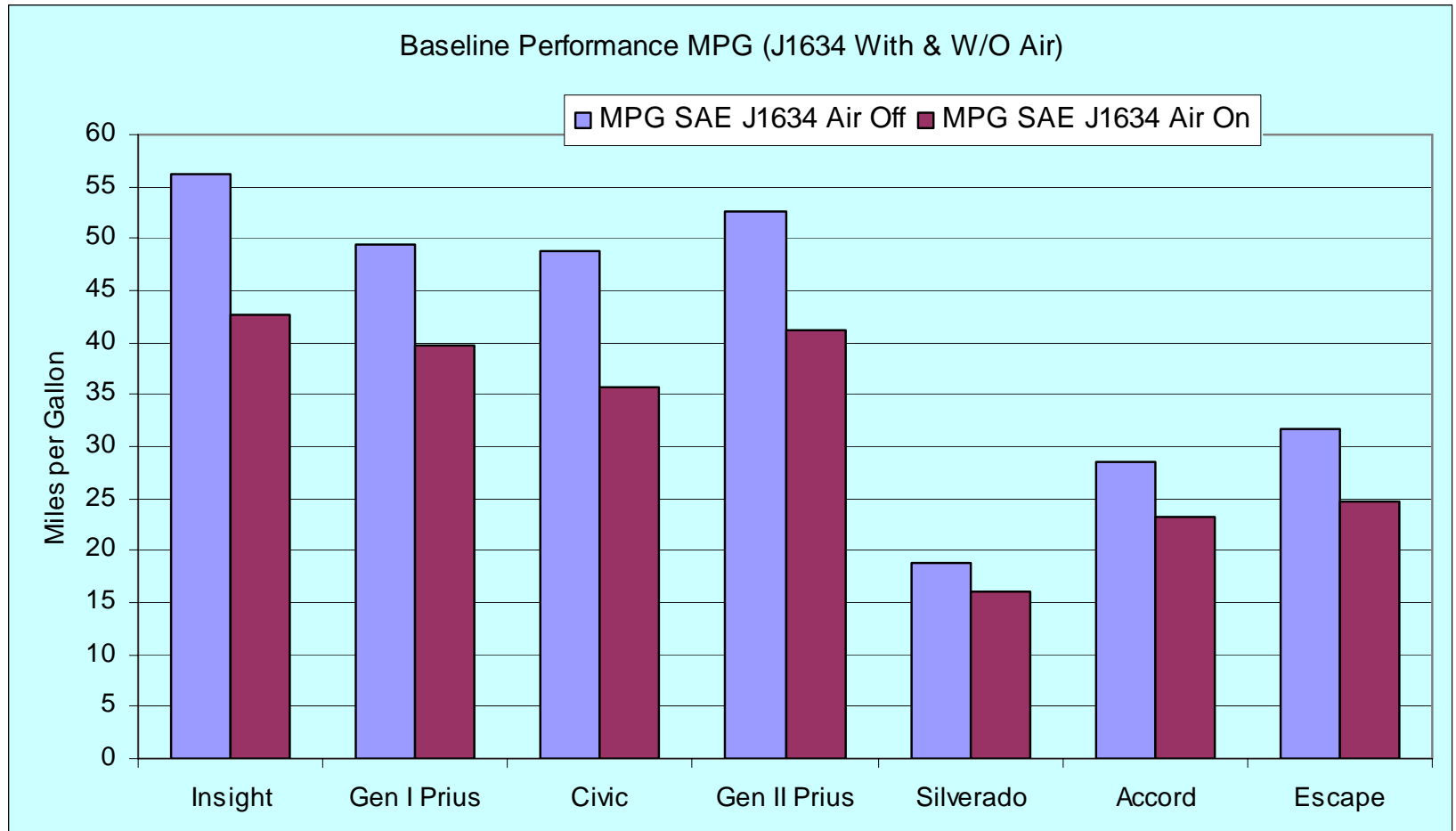
Max Speed @ 6% Grade



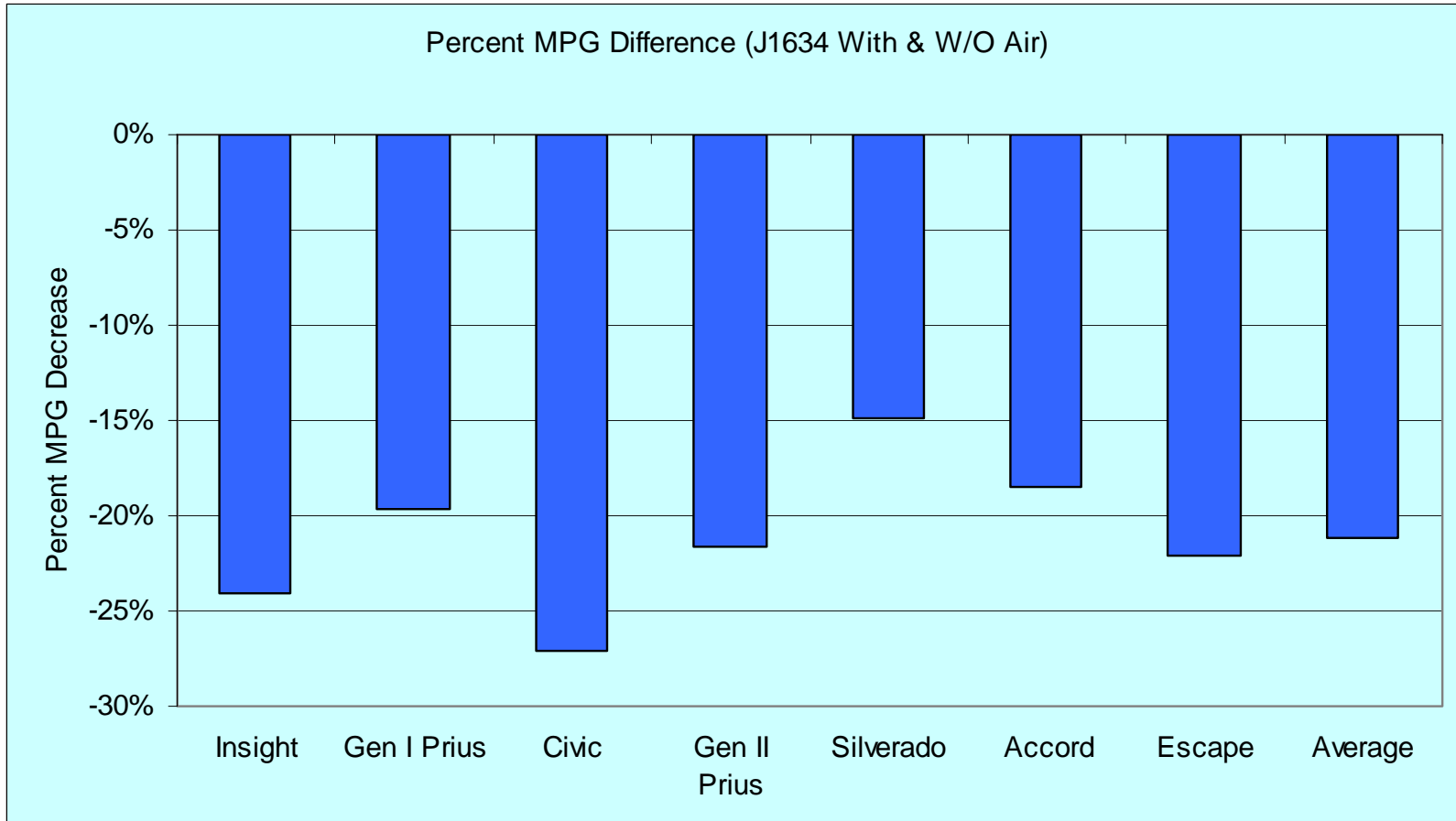
Braking



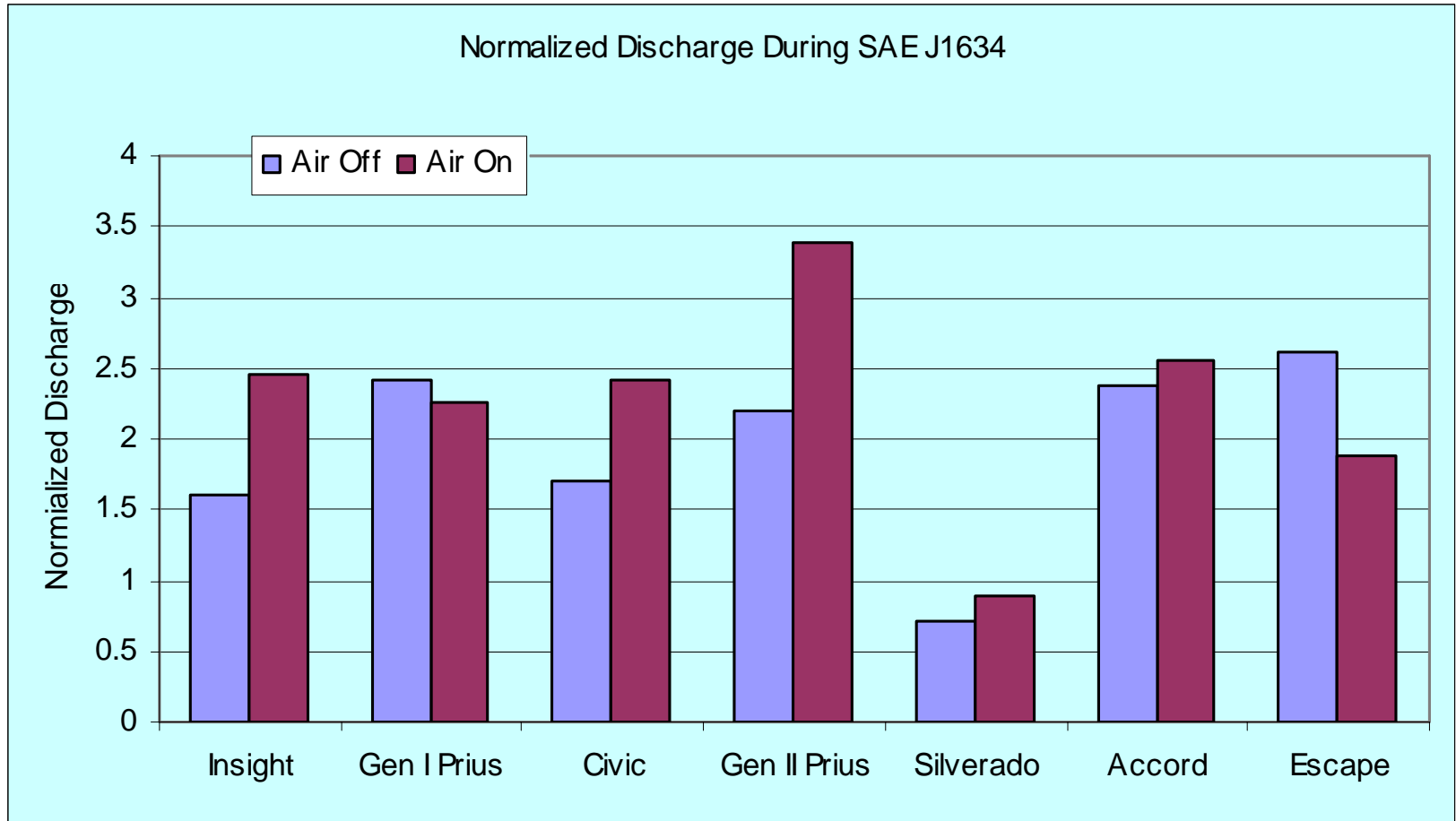
Baseline Performance MPG



MPG (SAE J1634) - Air on/off Decrease



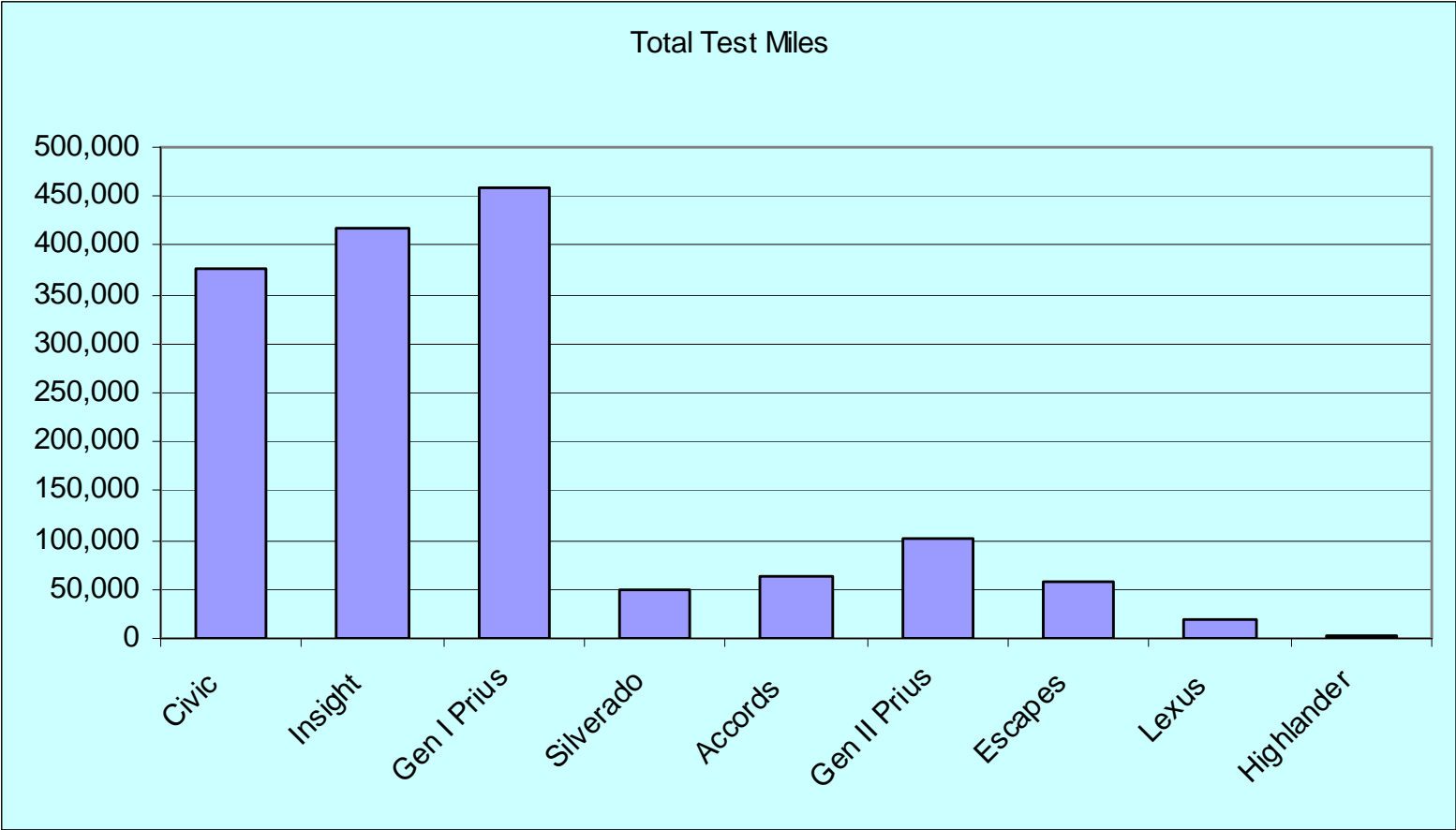
Normalized Discharge (SAE J1634)



28 HEVs - Fleet Testing Status

- 6 - 2001 Honda Insights: Aug/01 - March/05
- 6 - 2002 Gen I Toyota Prius: Nov/01 - April/05
- 4 - 2003 Honda Civics: May/02 - April/05
- 2 - 2004 Gen II Toyota Prius: Nov/03 - ongoing
- 2 - 2004 Chevrolet Silverado: Sept/04 - ongoing
- 2 - 2005 Honda Accord: Jan/05 - ongoing
- 2 - 2005 Ford Escape: April/05 - ongoing
- 2 - 2005 Lexus RX400h SUVs: May/05 - ongoing
- 2 - 2006 Toyota Highlander SUVs: Oct/05 - ongoing

1.5 Million HEV Fleet Testing Miles



Fleet Testing Fact Sheets

- Summarize real-world use:
 - Vehicle use
 - Major maintenance & repair events
 - Mileage profile
 - Cumulative fuel economy
 - Life cycle operating costs

HEV Fleet Testing Advanced Vehicle Testing Activities



**2002
Toyota Prius**
VIN #
JTEBBA120420043883

Fleet Performance

Description:
This vehicle was operated throughout the State of Arizona by Bank One of Arizona's courier pool. It was operated 24 hours a day, six days a week, transferring documents between branches and a central processing center located in Phoenix on city streets and urban freeways as well as intrastate courier routes, with typical high-

> 300 miles.

Vehicle Specifications

Engine: 4-cylinder, 52 kW @ 4000 rpm
Electric Motor: 33 kW
Battery: Nickel Metal Hydride
Seating Positions: Five
Payload: 955 lbs
Features: Regenerative Braking
CVT Transmission

See HEVAmerica Baseline Performance Fact Sheet for more information.

Distance Events:
Total distance:
more
106,153 miles

**2002*
MPG:** 51.2, 100 (40/4)

**Mileage
per
100miles**

5

100% gasoline
100% electric
50% gasoline
50% electric
or delivery fee costs



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FREEDOMCAR & VEHICLE TECHNOLOGIES PROGRAM

HEV Fleet Testing Advanced Vehicle Testing Activities



**2003
Civic Hybrid**
VIN #
JHM3E2664230083463

Fleet Performance

Description:
This vehicle was operated throughout the State of Arizona by Bank One of Arizona's courier pool. It was operated 24 hours a day, six days a week, transferring documents between branches and a central processing center located in Phoenix on city streets and urban freeways as well as intrastate courier routes, with typical high-speed round trips of 100 to 300 miles.

Major Operations & Maintenance Events:
CVT transmission failed @ 99,102 miles
Cost: \$2,500
Catalytic converter failed @ 100,715 miles
Cost: \$1,164
Transmission failed @ 157,209 miles
Cost: \$2,438

Operating Cost:
Purchase Cost: \$23,174 (5/02)*
NADA Used Vehicle Price: \$10,045 (3/05)
Sale Price: In operation
Maintenance Cost: \$0.07/mile
Operating Cost: \$0.07/mile
Total Ownership Cost: \$0.22/mile

Operating Performance:
Total miles driven: 161,075
Cumulative MPG: 37.32

* Purchase includes dealer price with options plus taxes. It does not include title, license, registration, extended warranty or delivery fee costs.

Vehicle Specifications

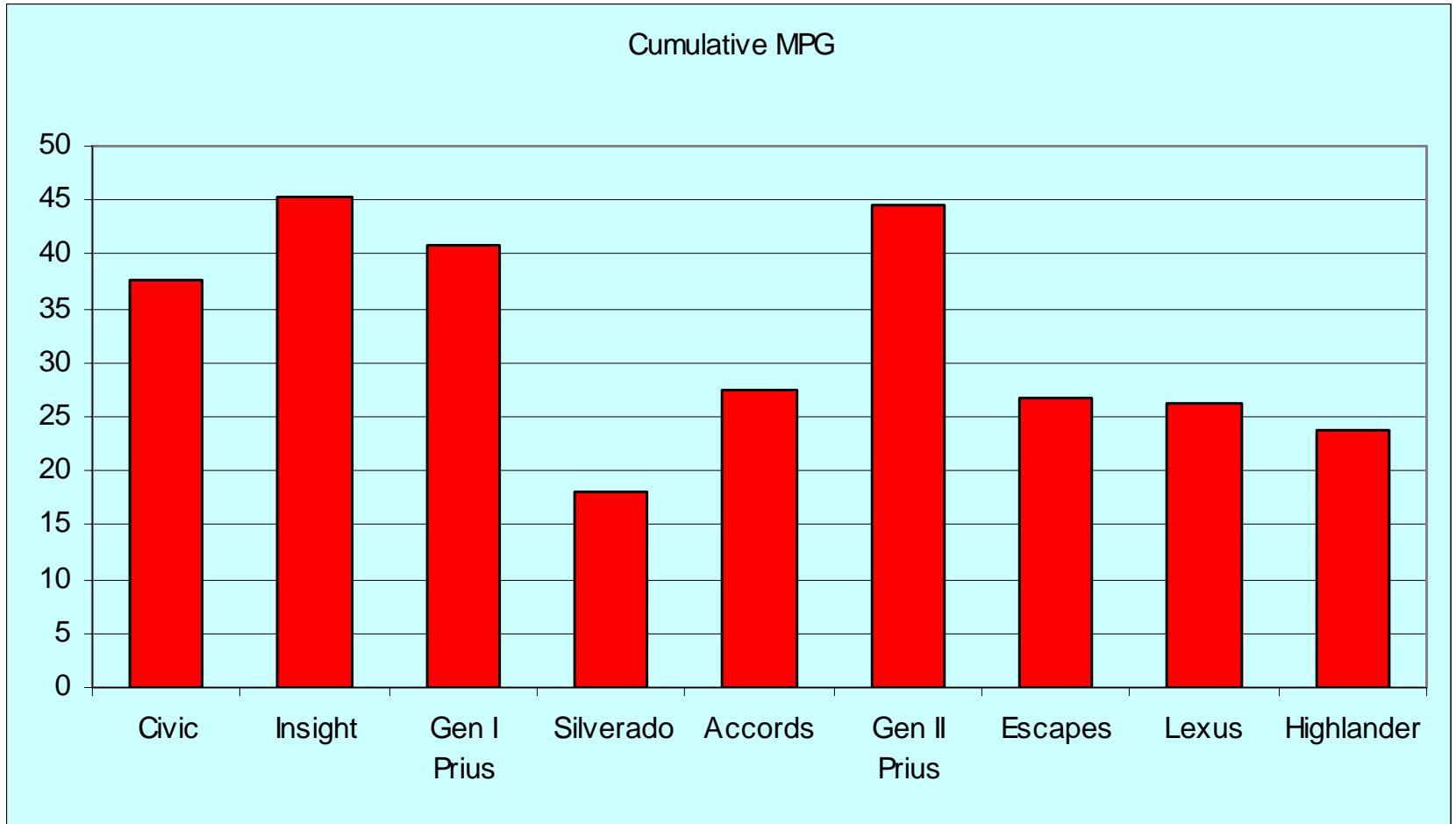
Engine: 4-cylinder, 70 kW @ 5700 rpm
Electric Motor: 10 kW
Battery: Nickel Metal Hydride
Seating Positions: Five
Payload: 882 lbs
Features: Regenerative Braking
CVT Transmission

See HEVAmerica Baseline Performance Fact Sheet for more information.

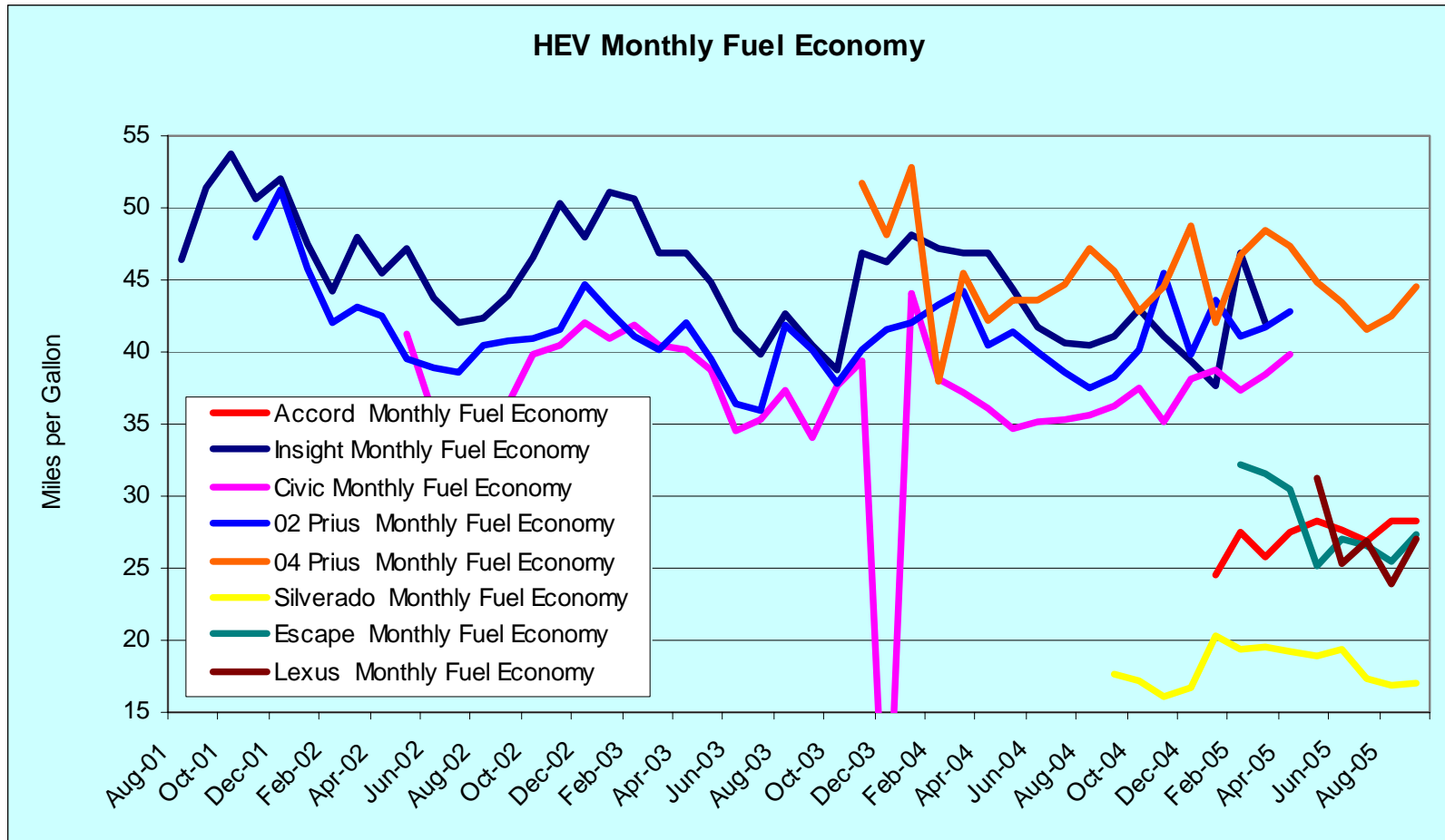


For more information contact:
EERE Information Center
1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov

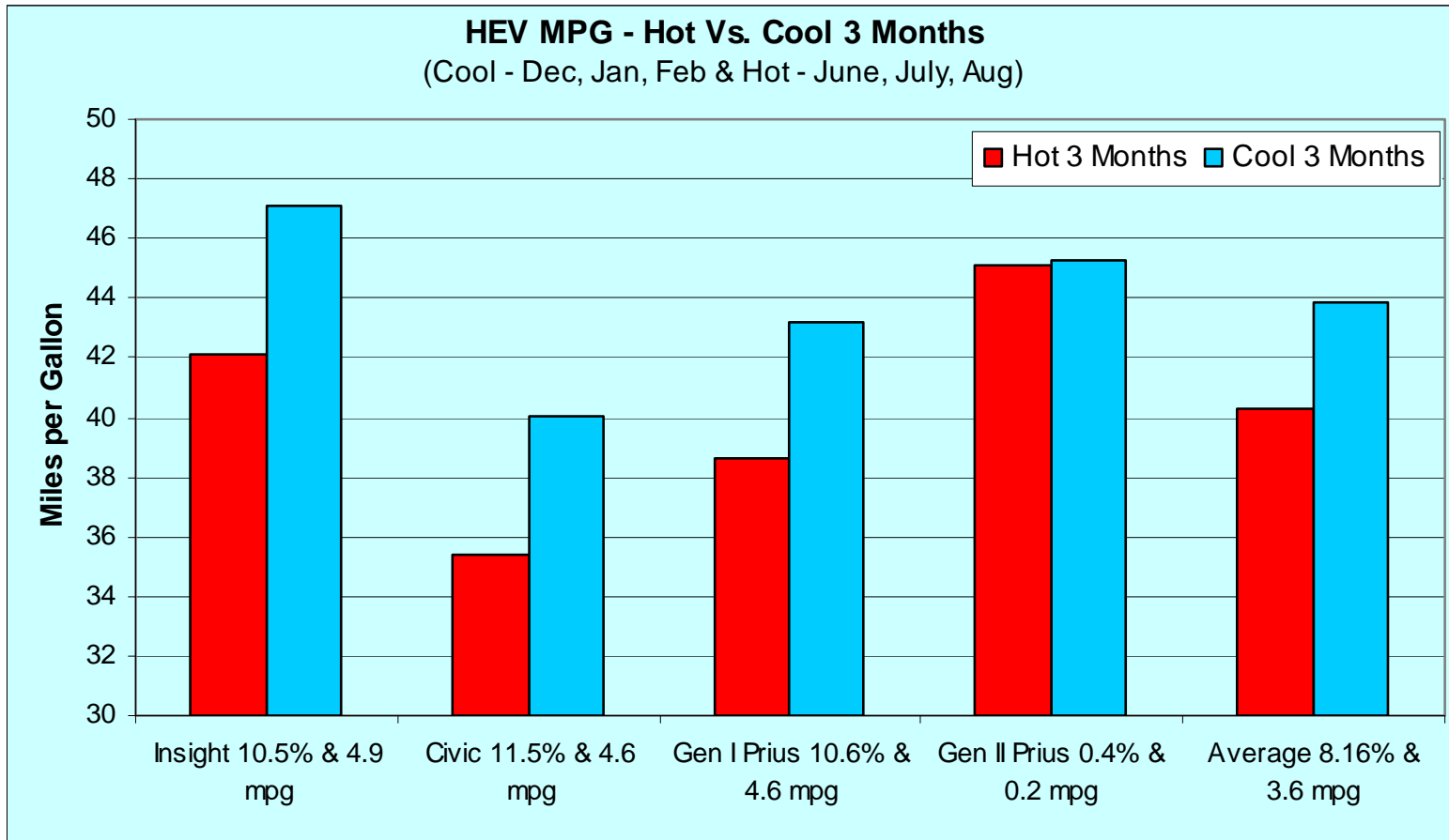
Fleet Testing Average MPG



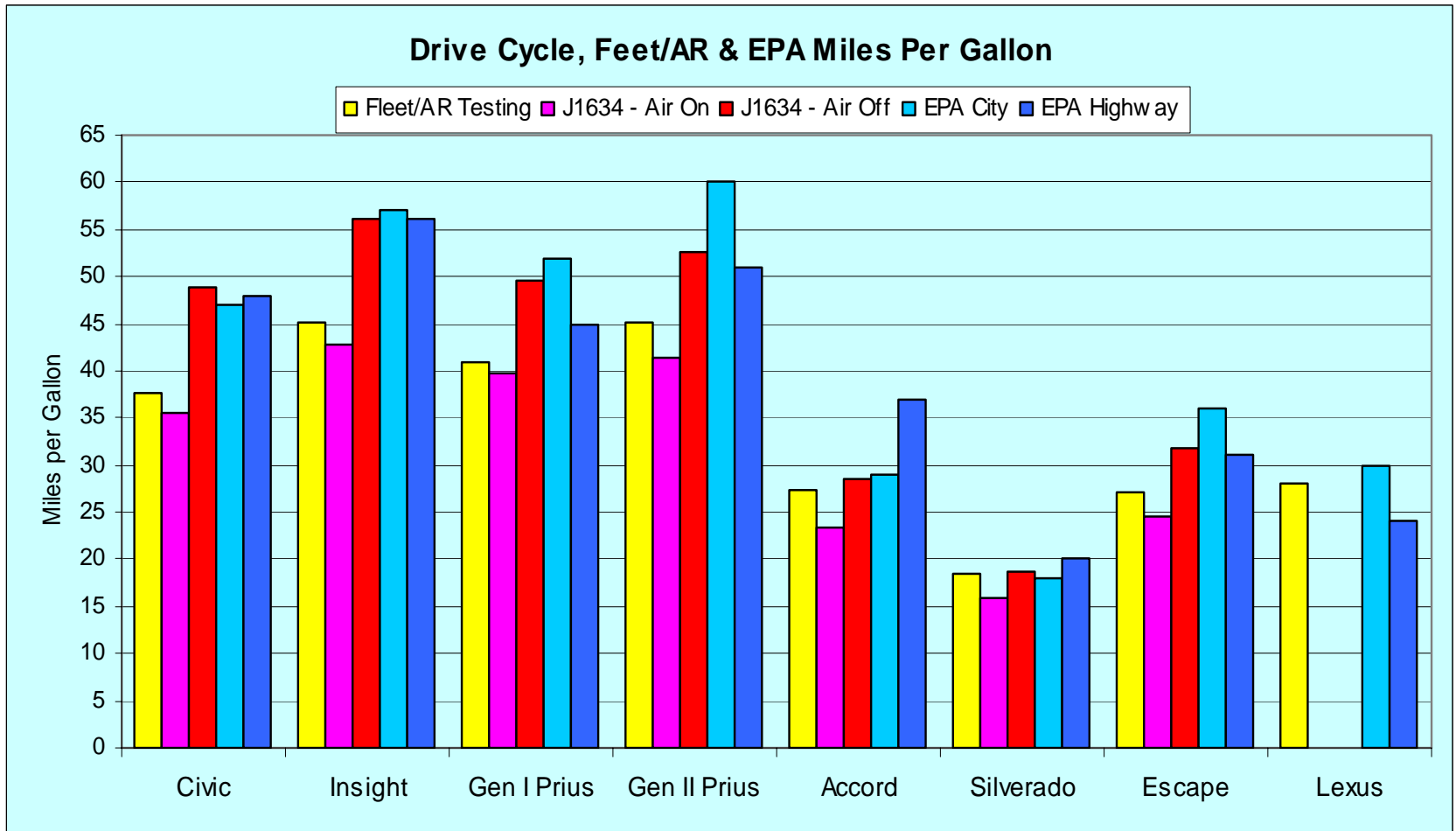
Fleet Testing Monthly MPG



Fleet Testing MPG Hot & Cool Months



MPG – Fleet, SAE J1634 & EPA



Maintenance & Repairs

- All events - date, mileage, description & cost/warranty

HEV Fleet Testing - Maintenance Sheet 2003 – Honda Civic Hybrid



Advanced Vehicle Testing Activity

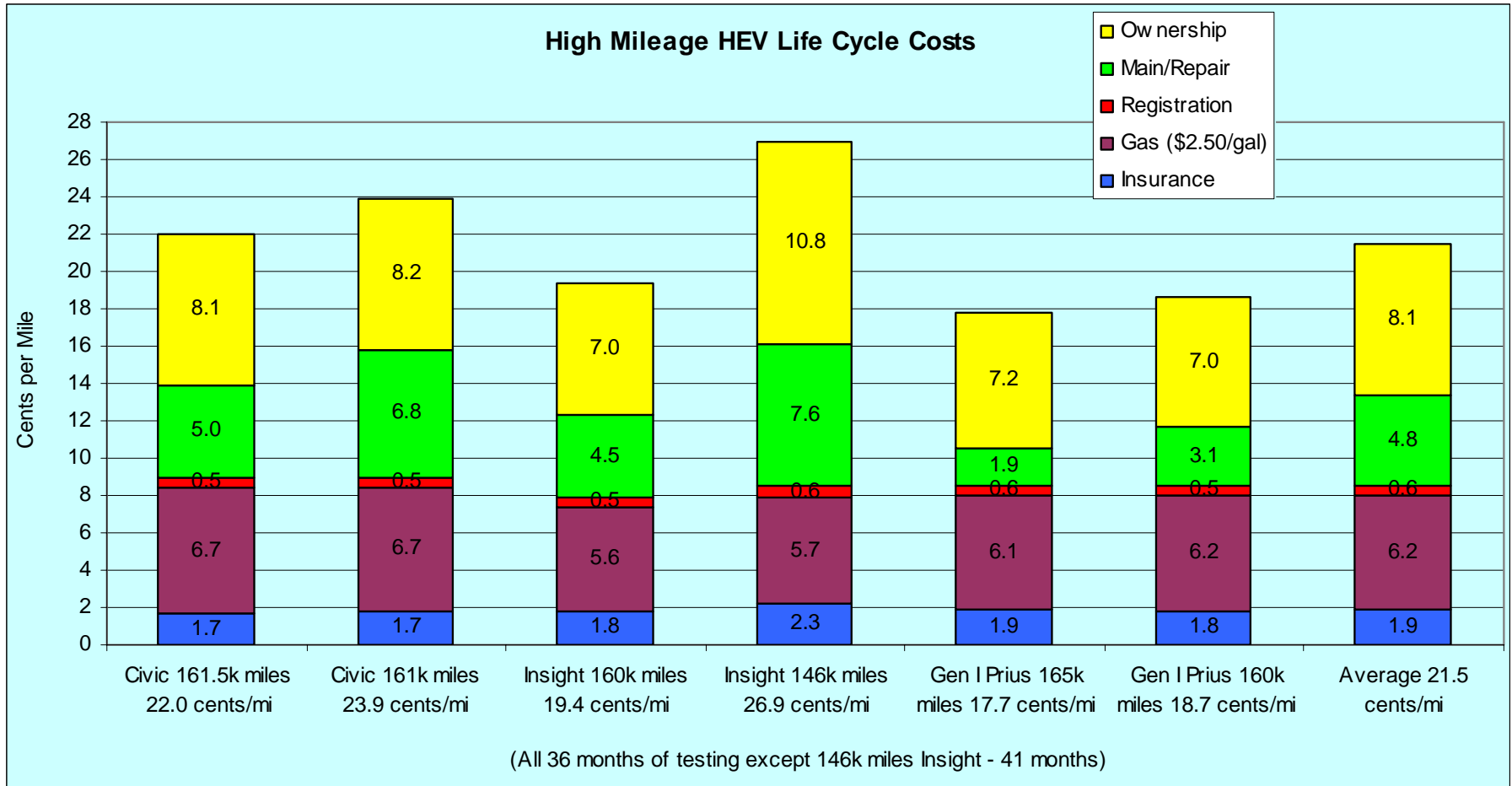
VIN #JHMES96663S003864

Date	Mileage	Description	Cost
7/10/2002	5,041	Change oil and rotate tires	\$ 27.00
8/6/2002	9,979	Change oil and rotate tires	\$ 28.62
9/5/2002	15,023	15,000 mile service	\$ 231.38
9/24/2002	18,706	Repair accident damage to left front (not included in maintenance costs)	\$ 1,222.34
10/8/2002	20,142	Change oil and rotate tires	\$ 28.99
10/29/2002	25,147	Change oil and rotate tires	\$ 30.87
12/20/2002	33,270	Change oil and rotate tires	\$ 31.07
2/10/2003	43,290	45,000 mile service	\$ 341.58
2/13/2003	43,500	Repair accident damage to rear bumper (not included in maintenance costs)	\$ 834.42
3/18/2003	53,381	Change oil and rotate tires	\$ 30.67
4/22/2003	62,573	Change oil and rotate tires	\$ 30.67
5/23/2003	69,932	Change oil and rotate tires	\$ 30.67
6/6/2003	74,353	30,000 mile service	\$ 324.18
6/24/2003	77,828	Replace four tires and align front wheels	\$ 185.33
6/19/2003	77,589	Check Engine trouble light illuminated. Dealer reset, no problem found.	warranty
7/7/2003	80,425	Change oil and rotate tires	\$ 31.09
7/8/2003	80,434	Check Engine light illuminated. Dealer repaired an intermittent problem with a valve sticking.	warranty
8/27/2003	89,304	90,000 mile service	\$ 324.13
8/4/2003	86,353	Change oil and rotate tires	\$ 31.09
9/12/2003	90,507	Check Engine trouble light illuminated. Updated PCM software installed by dealer.	\$ 50.00
10/14/2003	93,616	Ignition switch replaced	\$ 50.00
10/24/2003	93,912	Change oil and replace brake pads	\$ 146.22
11/20/2003	96,556	Check Engine light illuminated. Dealer replaced the Purge System pressure sensor	\$ 50.00
1/15/2004	96,802	Transmission shifting erratically. Transmission replaced	\$ 3,503.82
1/26/2004	97,750	Check Engine trouble light illuminated. Catalytic converters replaced.	\$ 1,124.38
2/24/2004	103,901	15,000 mile service	\$ 260.83
4/6/2004	113,685	30,000 miles service and accessory 12 volt battery replacement	\$ 464.09
4/15/2004	115,649	Replace front tires	\$ 112.38
5/3/2004	119,570	Change oil and rotate tires	\$ 31.92

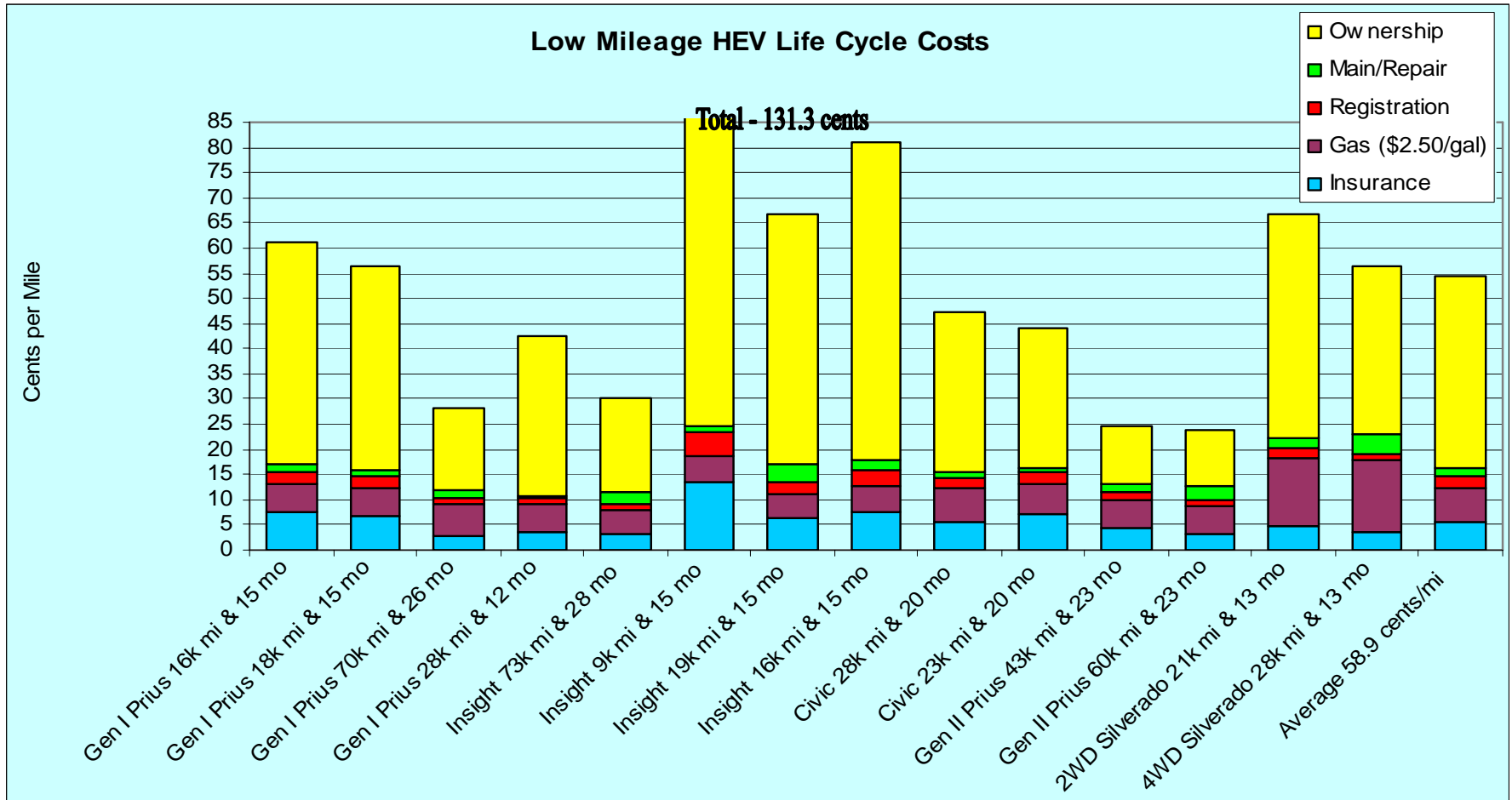
Maintenance & Repairs Summary

- Civic & Insight - 6 continuously variable transmission (CVT) failures in 4 vehicles @ 97k, 99k, 89k & 77k miles. Again @ 157k & 146k miles
- Insight battery control module & traction battery replaced @ 72k miles
- Insight & Civic - 7 software upgrades & 3 catalytic converters replaced
- Gen I Prius - rack & pinion replacements 1st Prius @ 106k, & 2nd Prius @ 25k & 32k miles
- Other HEVs – normal maintenance @ lower mileages

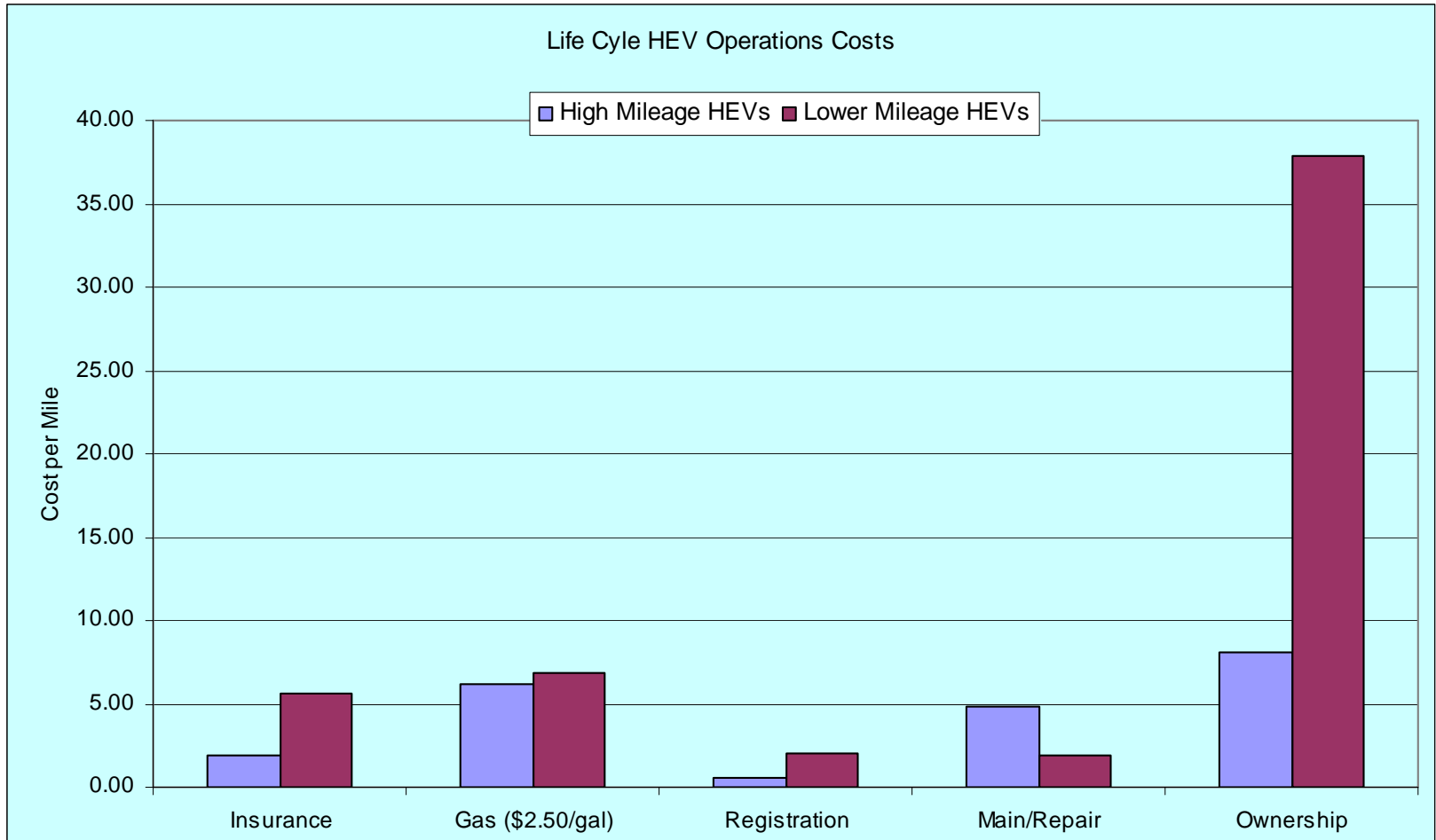
Life-Cycle Costs (high mileage HEVs)



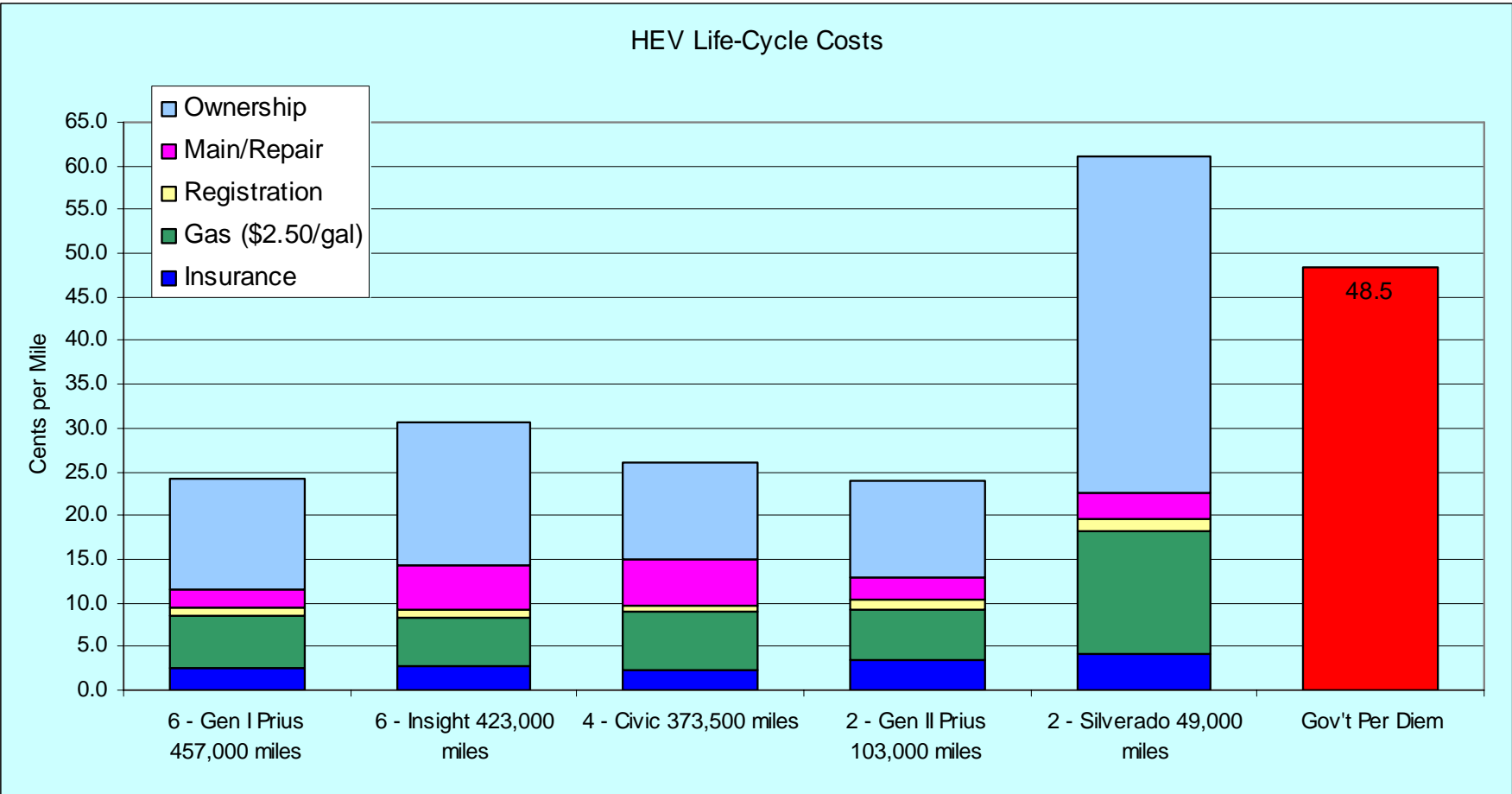
Life-Cycle Costs (low mileage HEVs)



Cost Components – High & Low mileage

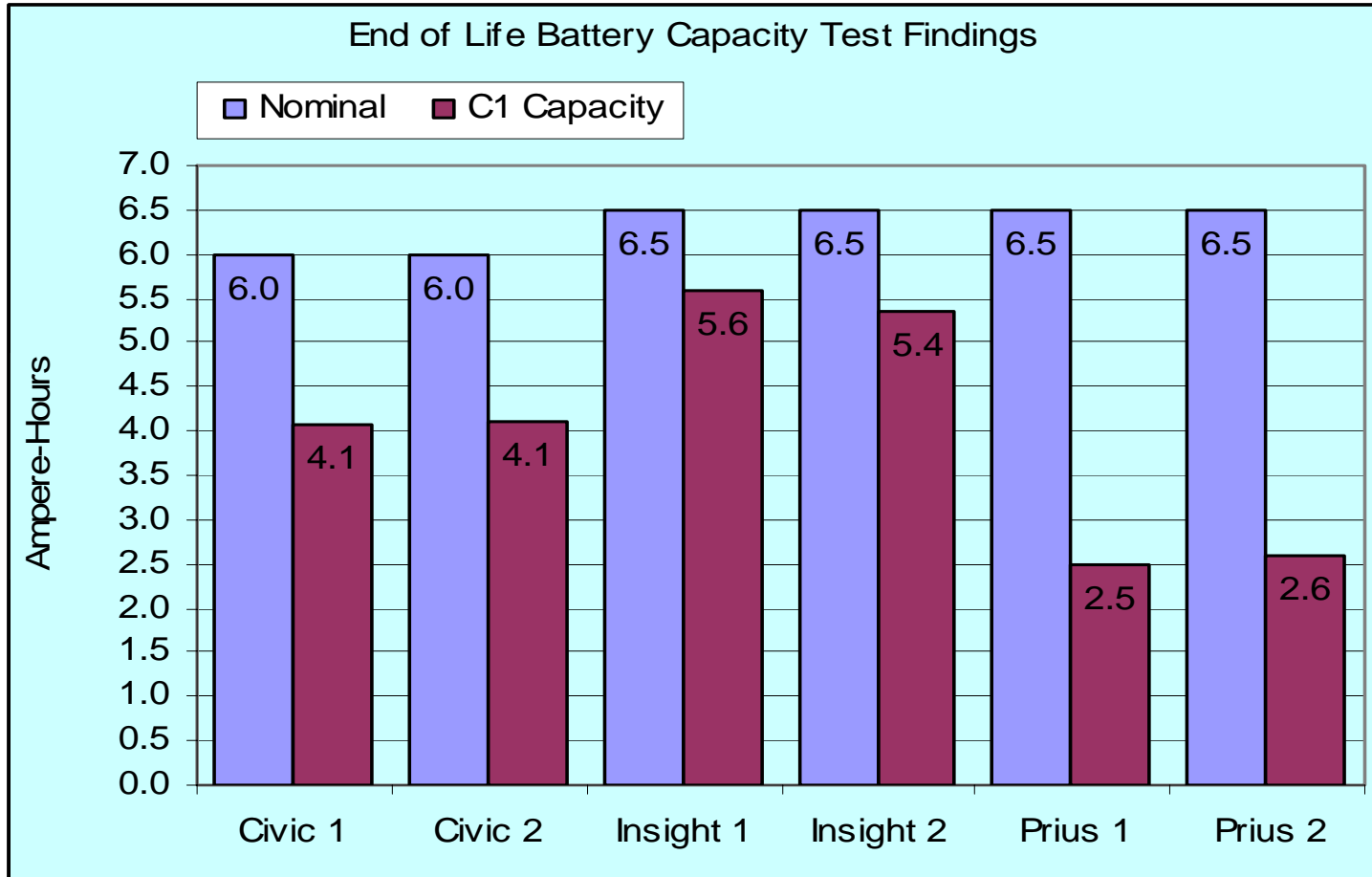


HEV Life-Cycle Costs (Weighted by Miles)



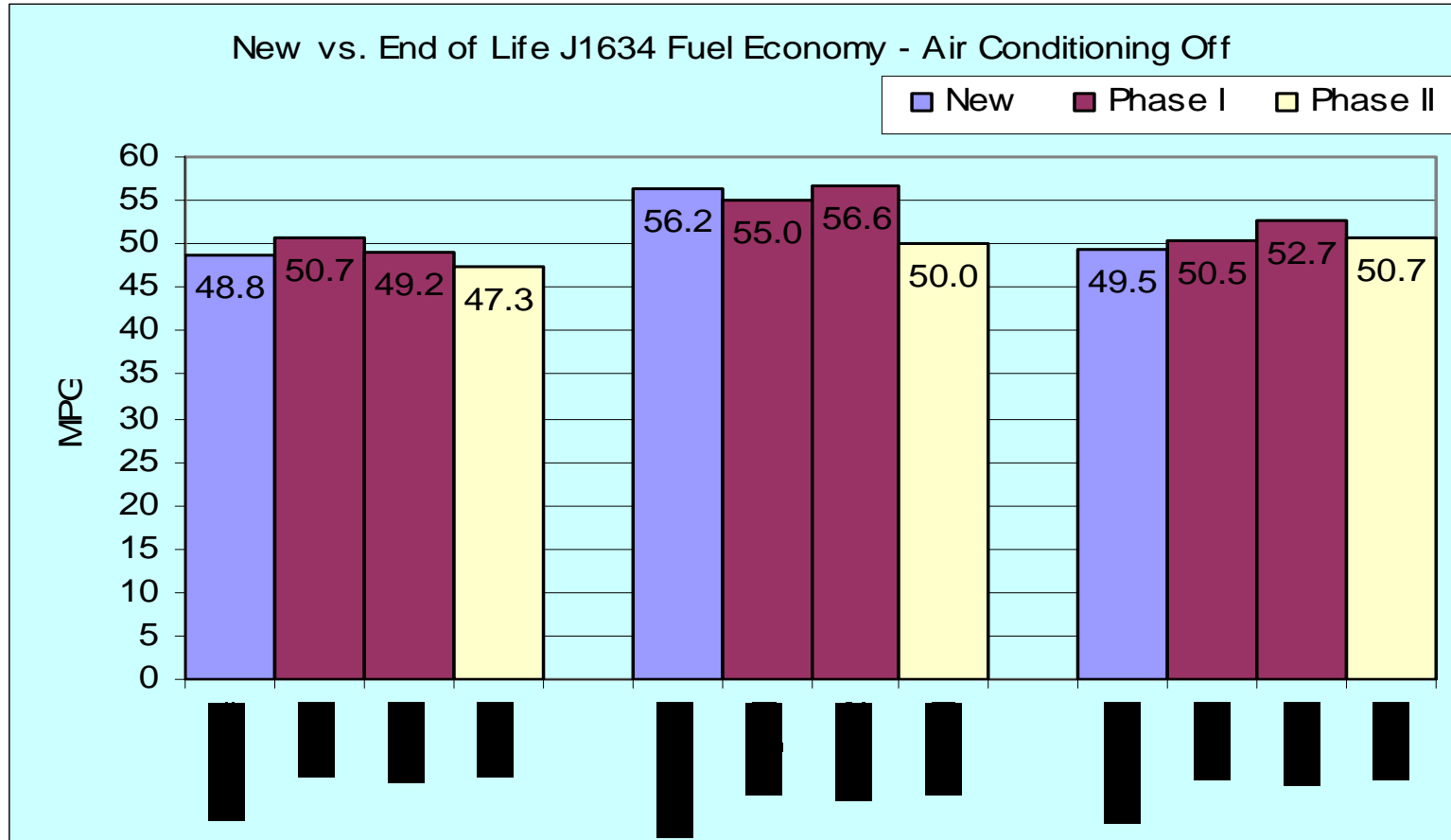
Costs include: Insurance, maintenance & repairs (excludes any collision costs), fuel @ \$2.50 gallon, registration, & purchase – sales cost (or lease cost for Silverado)

End of Life (160k miles) Battery Capacity



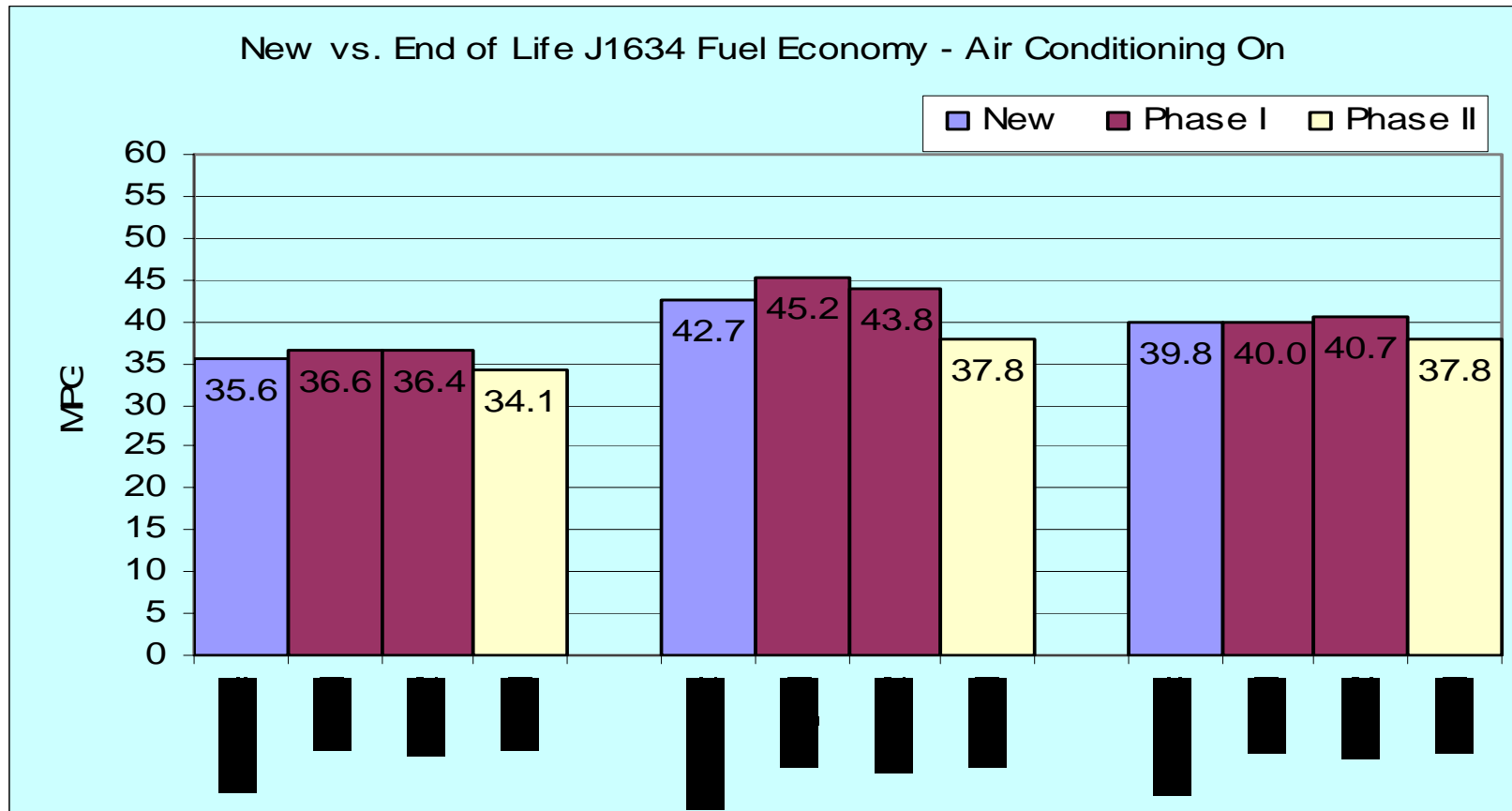
*Gen I Prius

End-of-Life (160k miles) MPG - AC Off



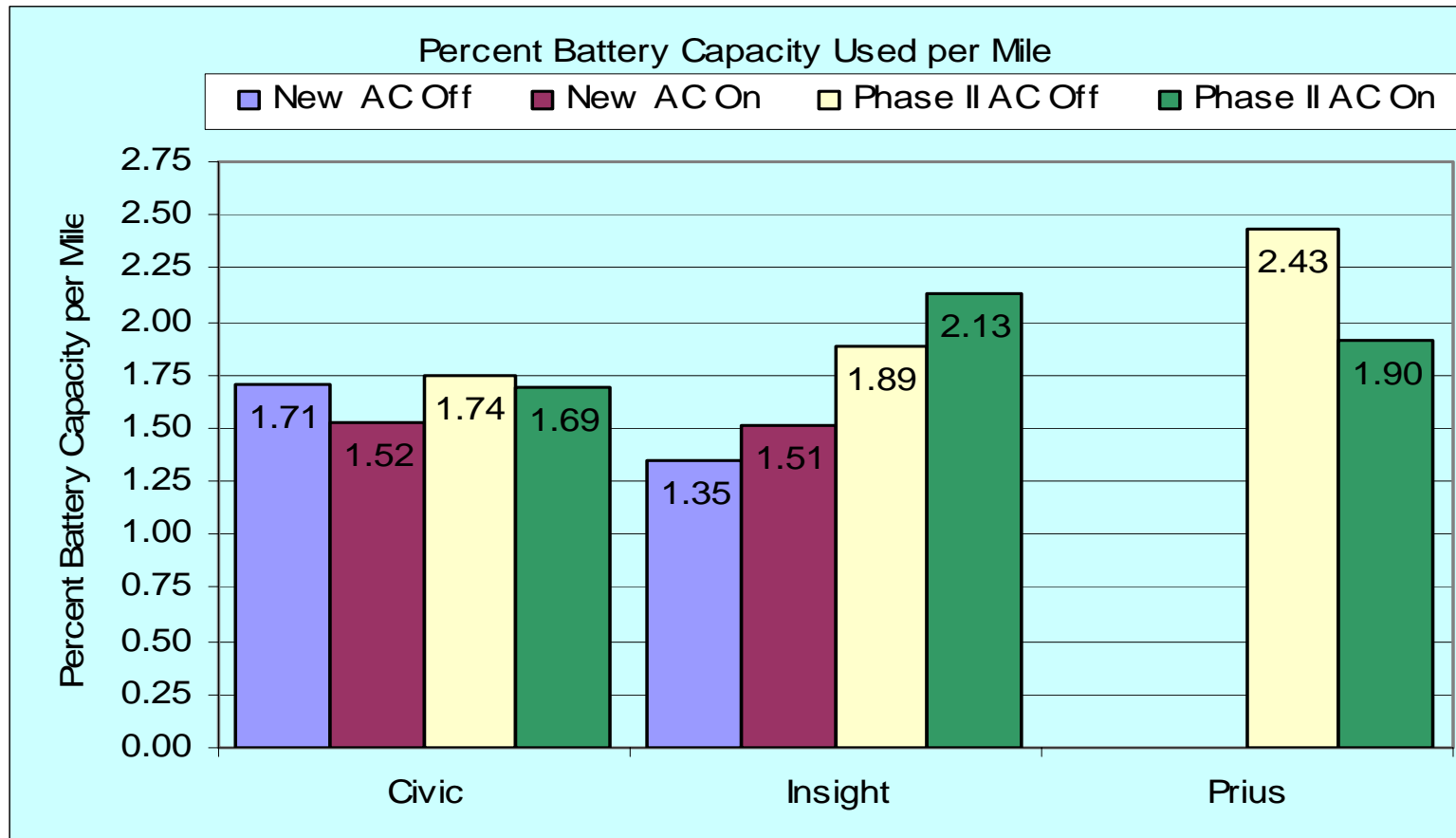
*Gen I Prius

End-of-Life (160k miles) MPG - AC On



*Gen I Prius

Percent Battery Capacity Used per Mile



*Gen I Prius

End-of-Life Phase II (SAE J1634) Vs. Onboard-Vehicle-Computer MPG

End-of-life Phase II HEV MPG Testing	Onboard computer fuel economy percentage above Phase II SAE J1634 fuel economy
Civic 1 AC off	+21.7%
Civic 1 AC on	+21.0%
Insight 1 AC off	+11.0%
Insight 1 AC on	+11.7%
Gen I Prius AC off	+15.7%
Gen I Prius AC on	+14.7%

Additional Near-term HEV Testing

- Hydrogen ICE HEV (HICEHEV) Hydrogen Prius from SCAQMD/Quantum
- Plug-in Diesel or Gas HEV (PIDHEV or PIGHEV) Dodge Sprinter (lithium) from Dodge
- PIGHEV Escape (lithium or lead) from vehicle converter Energy CS
- PIGHEV Gen II Prius conversion (Valence Li-Ion) from vehicle converter Energy CS
- Azure HEVs used by Purolator?
- Other OEM HEVs and/or Plug-ins?

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