Idaho National Laboratory

U.S. Department of Energy - Advanced Vehicle Testing Activity

PHEV Battery Charging Profile and Life Studies, and Field Testing and Demonstration Activities

PHEV Lab Coordination Meeting @ Sentech, November 2007

Jim Francfort (INL)

Electric Transportation Applications

FreedomCAR & Fuel Partnership

U.S. DEPARTMENT OF ENERGY

Presentation

- **INL and AVTA Background and goals**
- **PHEV Battery Charging Profile Studies**
- **PHEV Battery End-of-Life Studies**
- **PHEV Field Testing and Demonstration Studies**
- **Above includes ongoing activities, testing results, and activities being initiated**

AVTA Background & Goal

- **The Advanced Vehicle Testing Activity (AVTA) is part of the U.S. Department of Energy's Office of Vehicle Technologies**
- **The AVTA is primarily conducted by the Idaho National Laboratory (INL) and Electric Transportation Applications (ETA - Phoenix, AZ), with Argonne National Laboratory performing dynamometer testing**

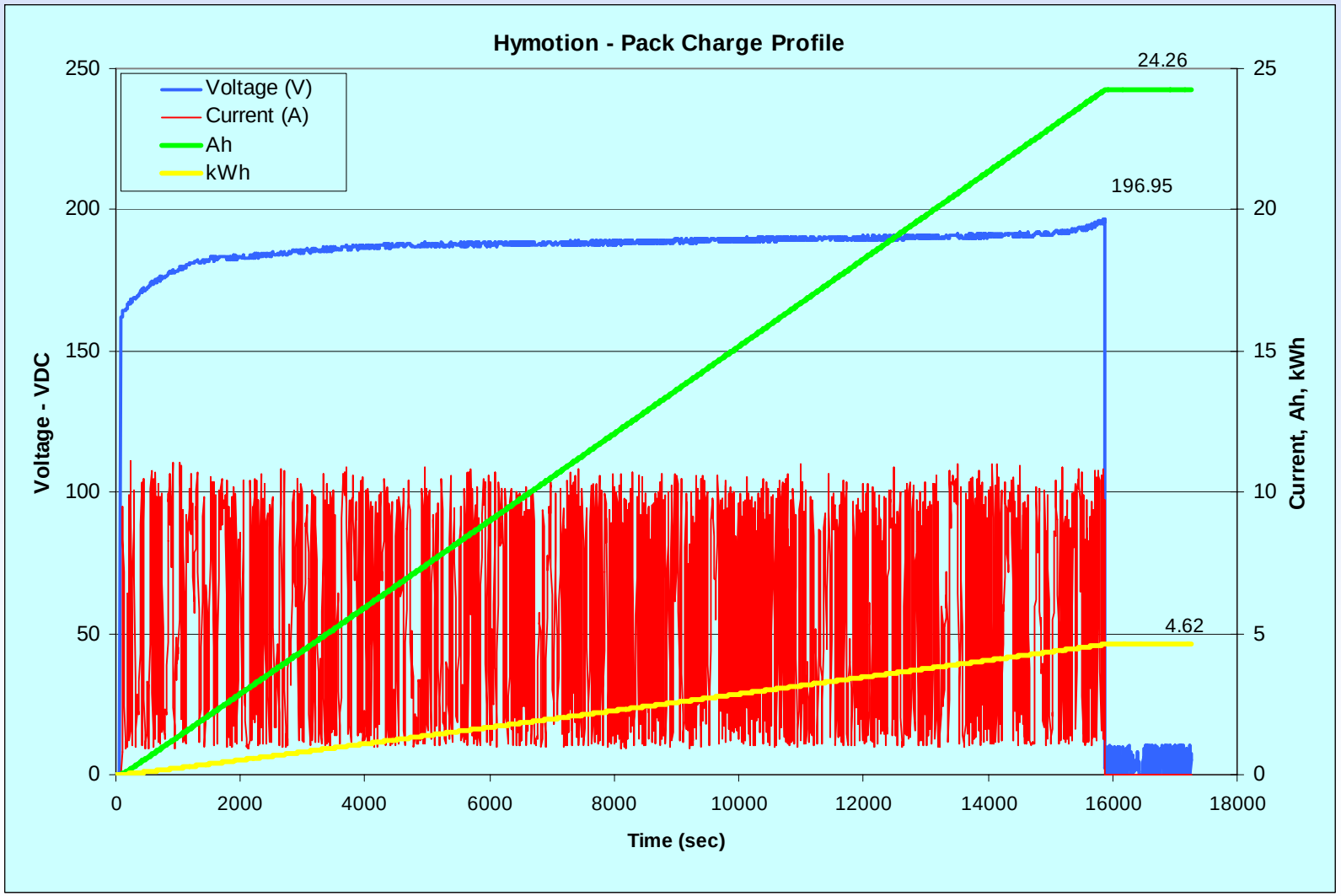
- **AVTA Goal**
  - **Provide benchmark data to technology modelers, and research and development programs**
  - **Assist fleet managers in making informed vehicle purchase, deployment and operating decisions**

PHEV Battery Charging Profile Studies

PHEV Battery Charging Profile Studies

- Document charging profiles in vehicles, both in the lab and in fleets, including:
  - Power and energy demands
  - Human impacts (the third PHEV dimension) on time and length of charging
- Document battery charging profiles for all PHEVs obtained for laboratory and fleet testing
- Document charging profiles in real-world V2Grid use
- Document V2Grid feasibility and battery life impacts
- Document operational and economic life-cycles of chargers, batteries and vehicles in various scenarios
- Provide real-world microscopic data to ORNL and PNL to feed their macroscopic models of grid impacts
- Partner with state and regional governmental entities, and electric utilities to leverage funding

Hymotion Onboard Charge Profile - Battery



A123 Systems Lithium Ion Battery

Electric Transportation Applications

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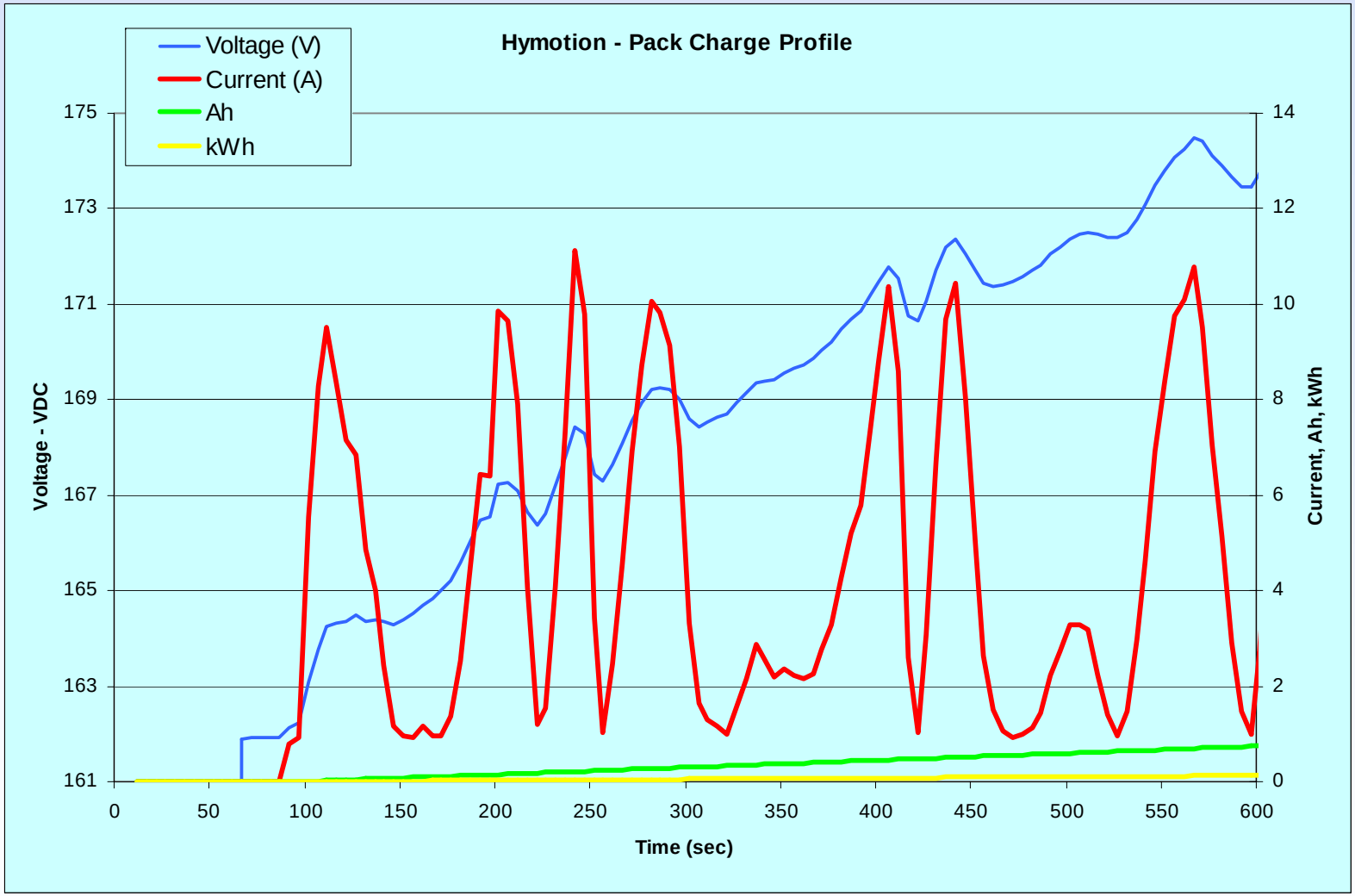
Hymotion Onboard Charge Profile - Battery



A123 Systems Lithium Ion Battery

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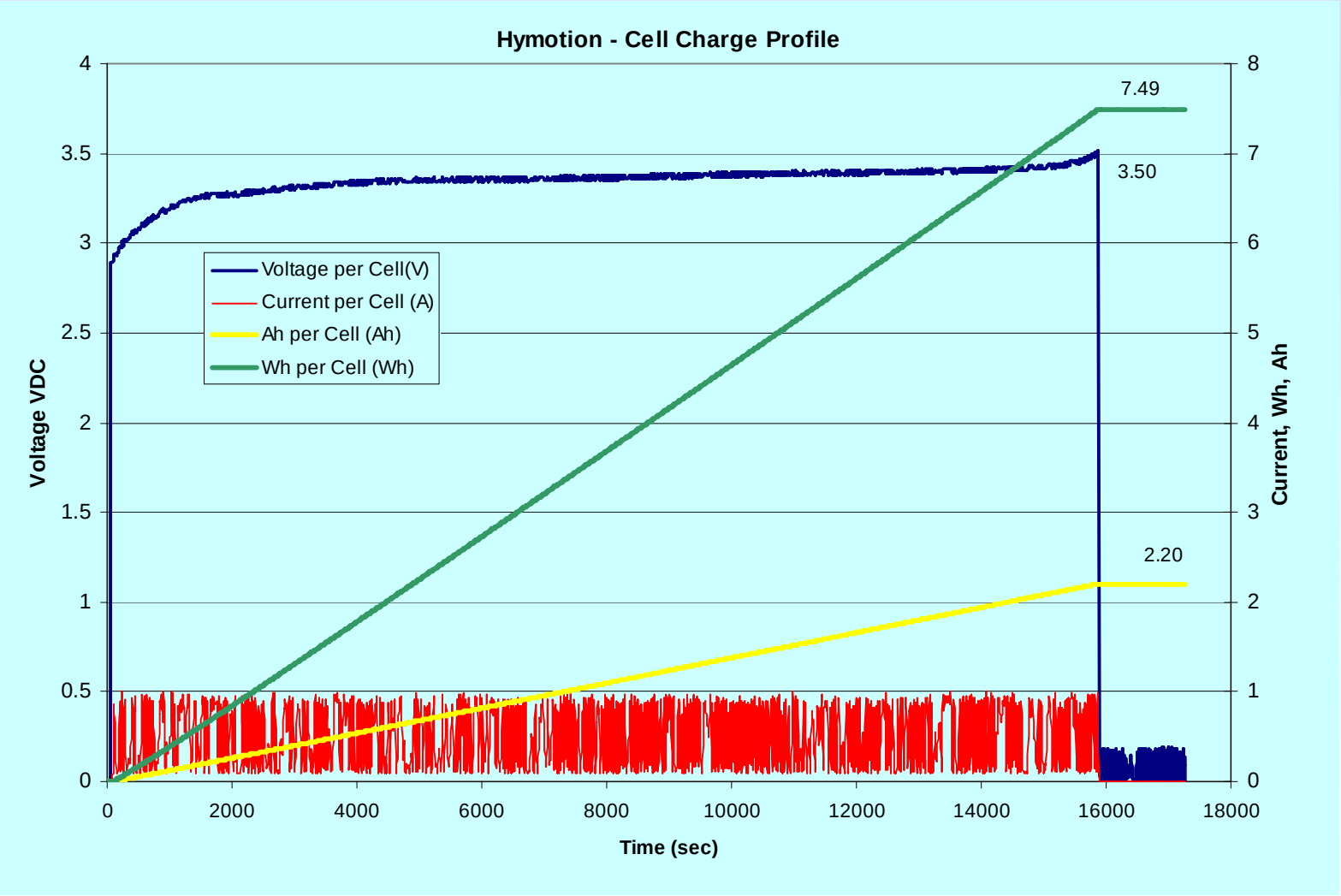
Hymotion Onboard Charge Profile – Cell



A123 Systems Lithium Ion Battery

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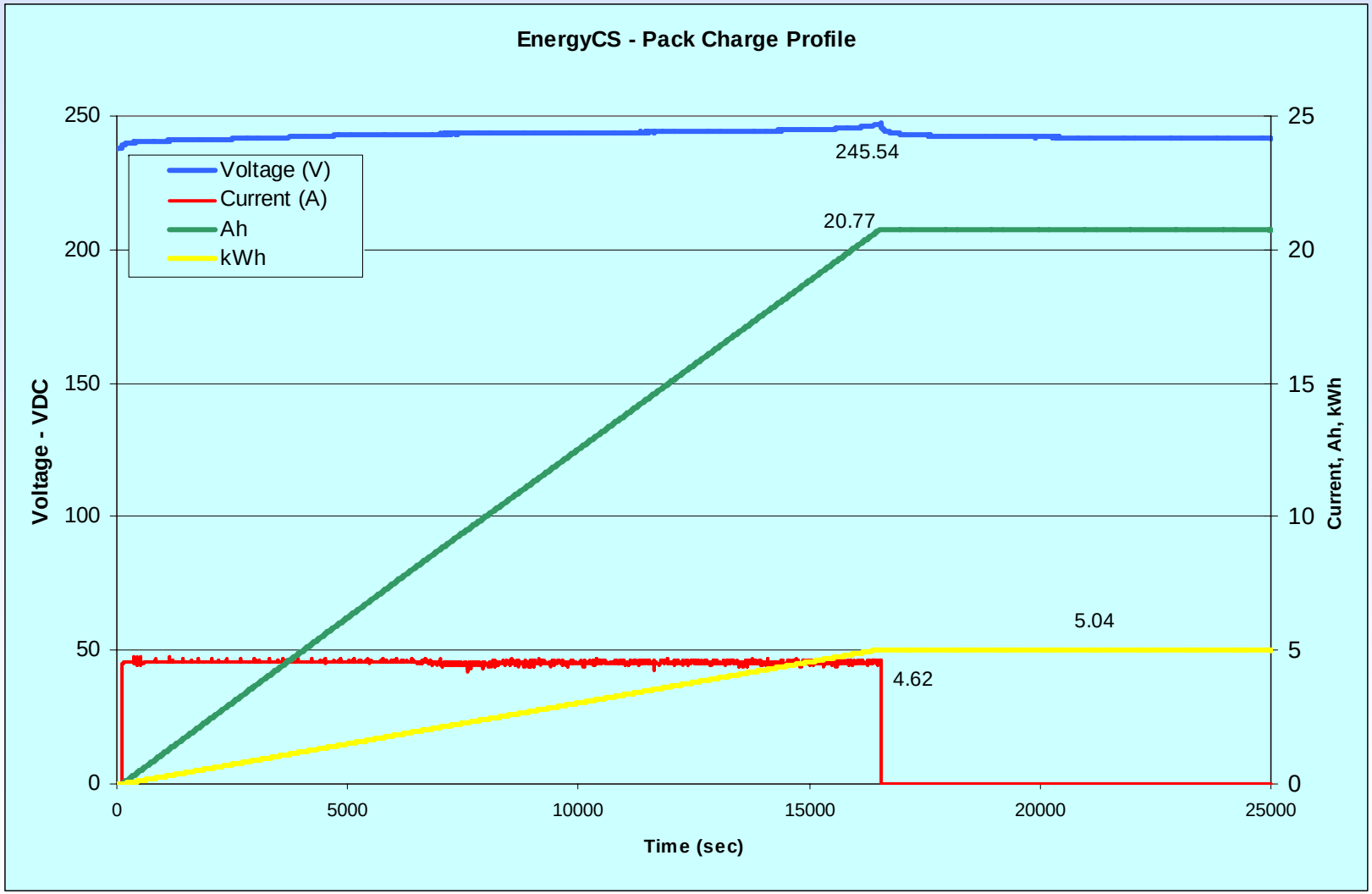
EnergyCS Onboard Charge Profile - Battery



Valence Lithium Ion Battery

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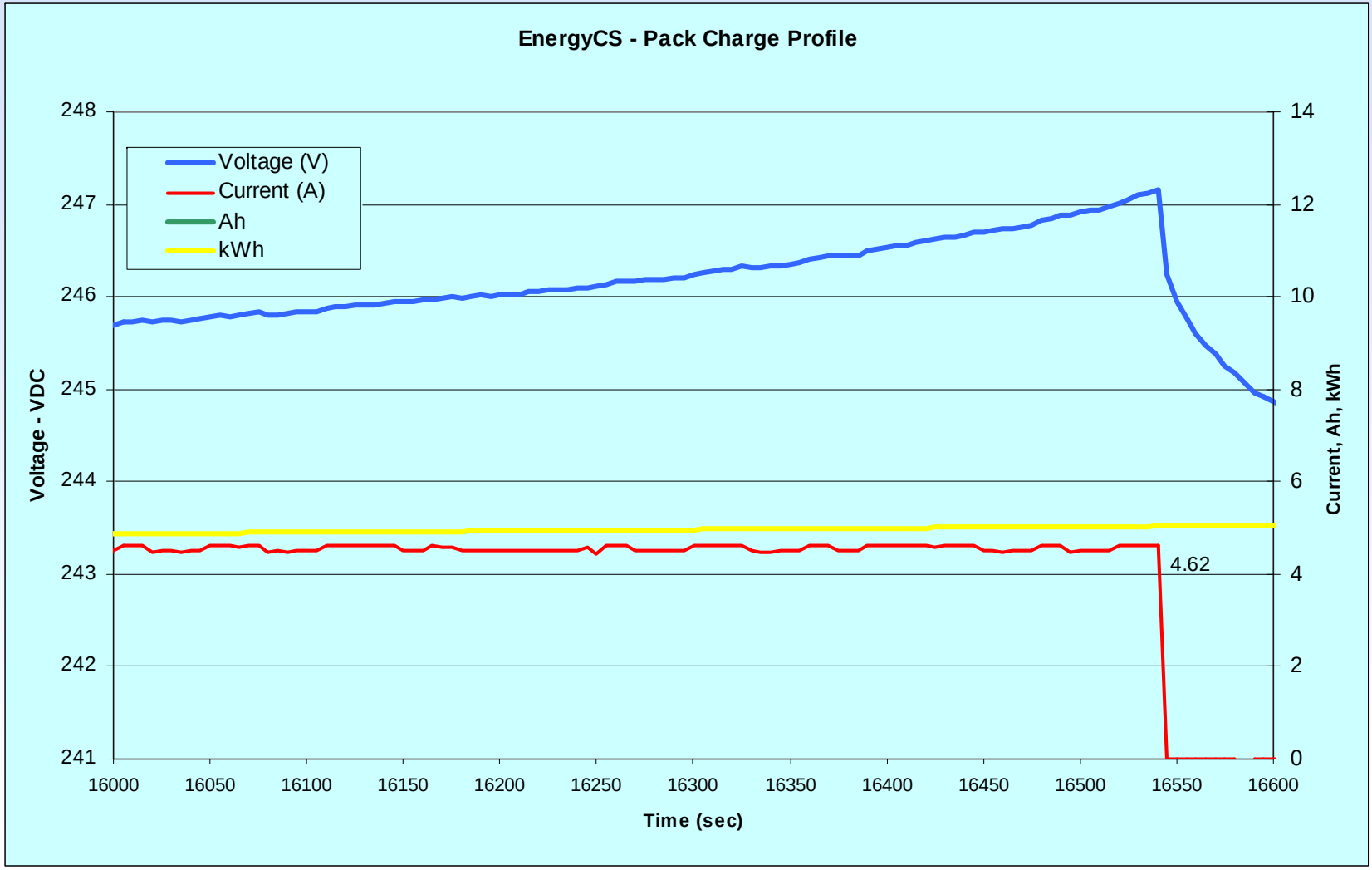
EnergyCS Onboard Charge Profile - Battery



Valence Lithium Ion Battery

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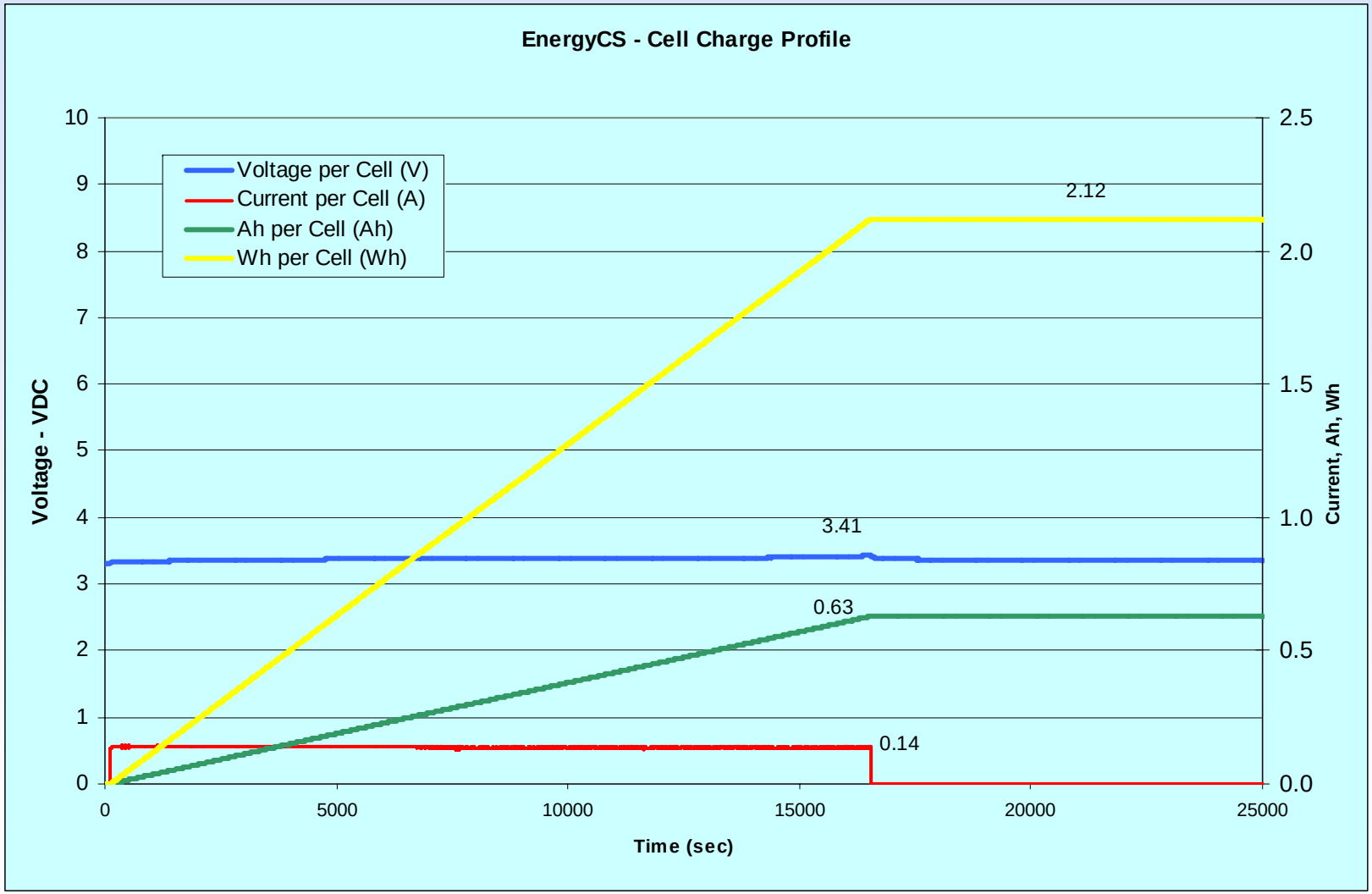
EnergyCS Onboard Charge Profile – Cell



Valence Lithium Ion Battery

Field Charging Profile Studies

- Identify 3 locations with suitable PHEV charging mass
- Measure charging profile impacts on facilities by using:
  - Wireless piggy-backing of building meter
  - Wireless kWh meter on charging branch(s)
- Examine timing and magnitude of facility peak demand and charging profile peak demand
- Document charging profile impacts on facility demand
- Project out if 30 to 50+ PHEVs charged onsite
- How will charging profiles impact demand and cost as well as electrical infrastructure requirements

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V2Grid & Charging Profile Study

- Already identified partners and a remote (isolated) Western U.S. town as full-scale V2Grid test bed
  - 150 electric meters
  - 200 kW hydroelectric plant main generation
  - 3 small diesel generators used for peaking load
  - Brief (seconds) periods of peak load requires diesel generators to run 15 minutes or longer
  - Located in National Park Service unit
- A single PHEV may meet 5% of peak load
- Avoids need for thousands of PHEVs to test V2Grid concept on a large electrical grid
- Documents charging profiles in real-world V2Grid use

V2Grid & Charging Profile Study – cont'd

- Install load control instrumentation on PHEVs' 120 or 240 volt charge circuits to ensure 100% off-peak renewable hydropower charging
- Park Service to provide 1 Escape hybrid for conversion
- Part of larger, mostly rural 20-PHEV planned demonstration with co-funding identified
- Utility has budgeted for automated infrastructure metering upgrades to shed on-peak loads, read meters, and control V2G and G2V
- Opportunity for DOE to leverage funding for V2Grid charging profile demonstration while helping avoid $0.24 per kWh petroleum generated electricity
- Opportunity to demonstrate a positive economic return for a V2Grid project

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PHEV Battery End-of-Life Studies

PHEV Battery End-of-Life Studies

- End of life (EoL) for PHEV batteries in vehicles is unknown and influenced by:
  - Time?
  - Miles?
  - Potholes?
  - Charge cycles?
  - Temperature ranges and swings?
  - Charging patterns: SOC at charging start, partial charges, and number of charges
- Desire to test PHEV batteries when new and at EoL, is balanced against need for healthy batteries in order to test PHEV concept, petroleum reduction, V2Grid, and measure charging profiles
- Experience testing HEV batteries when new and at 160,000 miles

PHEV Battery End-of-Life Studies – cont'd

- AVTA will conduct initial battery testing after 5,440 miles of accelerated testing
- Retest batteries at 25,000 and 50,000 miles, and ? miles
- Identifying vehicle missions that maximize battery discharge for each drive/charge cycle yet economizes on daily number of miles
- Use FreedomCAR Plug-in Hybrid Electric Battery Test Manual, but two-battery designs may require unique battery test plans
- Evaluate batteries in PHEVs to EoL under various conditions:
  - Full discharge cycle with full recharge
  - Partial discharge cycle with full recharge
  - Partial discharge cycle with partial recharge

PHEV Battery End-of-Life Studies – cont'd

- Demonstrate PHEV fast (or just faster) charging
  - Modify PHEV and operate in fleet - charge/discharge
  - Perform Level 2 charging (6 kW for a 1 hour charge)
  - Perform Level 3 charging (15 kW or a 20 minute charge)
- Build a PHEV mule to allow testing of various batteries and charging profiles
  - Possibly Tahoe two-mode PHEV
  - Test large format lithium batteries
  - Advanced lead acid batteries (400,000 cycles in lab)
  - Other battery chemistries, construction designs
- At battery EoL, determine battery life-cycle costs

PHEV Field Testing and Demonstration Studies

Field Testing & Demonstration Objectives

- Independent testing of PHEVs in track, laboratory and onroad environments
- Demonstrate vehicles in regionally diverse fleets
- Collect onboard vehicle operations data
- Collect gasoline and electricity consumption
- Collect vehicle maintenance costs
- Document human influences on fuel use and refueling patterns
- Document requirements and costs of charging and operating PHEVs in real-world environments
- Determine real-world PHEV life-cycle costs

Baseline Performance Testing

- Initial track testing conducted by ETA near Phoenix
  - Testing includes coastdown (determination of dynamometer coefficients), acceleration, top speed, charging, & durability
- Five day dynamometer testing regime performed at Argonne
  - Testing includes at least 26 drive cycle tests
  - Charge depleting & sustaining test cycles
  - UDDS, HWFEDs & US06 cycles
  - Includes air conditioning (AC) off & on cycles

Baseline Performance Testing – cont'd

- If vehicle option, conduct Rechargeable Energy Storage System (RESS) only testing with & without the air conditioning:
  - Day 1, RESS Only mode – A/C off
    - UDDS, UDDS, HWFEDS, HWFEDS
    - UDDS, UDDS, HWFEDS, HWFEDS
    - Repeat as able, than charge traction battery
  - Day 2, RESS Only mode – A/C on
    - UDDS, UDDS, HWFEDS, HWFEDS
    - UDDS, UDDS, HWFEDS, HWFEDS
    - Repeat as able

Baseline Performance Testing Results

PHEVAMERICA

U.S. DEPARTMENT OF ENERGY ADVANCED VEHICLE TESTING ACTIVITY

Base Vehicle Description
Make: Toyota
Model: Prius Year: 2006
VIN: JTDKB20U767508841
Number of Passengers: 5
Hybrid Configuration: Series/Parallel

Energy CS Plug-In Hybrid

VEHICLE SPECIFICATIONS

Weights
Design Curb Weight: 3160
Vehicle Test Weight: 3400 lbs
GVWR: 3795 lbs
GAWR F/R: 2335/2250
Distribution: 54.2%/45.8%
Payload: 635 lbs
Performance Goal: 400 lbs

Engine
Model: 1NZ-FXE
Output: 76 HP @ 5000 RPM
Configuration: 4 Cylinder In-line
Displacement: 1.5L
Fuel Tank Capacity: 11.9 gal
Fuel Types: Unleaded

Electric Drive System
Battery Manufacturer: Valence
Battery Type: Li-Ion
Number of Cells: 2376
Nominal Cell Voltage: 3.2V
Nominal System Voltage: 230.4V
Nominal Pack Capacity: 10 kWh
Measured Useable Capacity: 4.88 kWh

Charge System:
Input Voltages: 120V
Required Breaker Currents: 15 Amp
Charger Power Output: 1.2 kW
Charger Plug Type: NEMA 5-15
Estimated 80% Charge Time: 6.5 Hrs
Estimated 100% Charge Time: 8 Hrs

VEHICLE TEST RESULTS

Charge Depleting:
Acceleration 0-60 MPH
Time: 12.96 seconds
Acceleration 1/4 Mile
Time: 20.09 seconds
Maximum Speed: 75.7 MPH
Acceleration 1 Mile
Maximum Speed: 104.9 MPH

Charge Sustaining:
Acceleration 0-60 MPH
Time: 12.82 seconds
Acceleration 1/4 Mile
Time: 19.98 seconds
Maximum Speed: 75.7 MPH
Acceleration 1 Mile
Maximum Speed: 105.0 MPH

Brake Test @ 60 MPH
Distance Required: 126.8 ft

Fuel Economy with A/C Off[1]
Cold Start Charge Depleting[2]:
Fuel Economy: 108.2 MPG
A/C kWh Consumed[3]: .169 kWh/mi
Charge Depleting[4]:
Average Fuel Economy: 149.1 MPG
A/C kWh Consumed[3]: .153 kWh/mi
Charge Sustaining[4]:
Fuel Economy: 60 MPG

Fuel Economy with A/C On[1,5]
Cold Start Charge Depleting[2]:
Fuel Economy: 101.7 MPG
A/C kWh Consumed[3]: .201 kWh/mi
Charge Depleting[4]:
Average Fuel Economy: 139.4 MPG
A/C kWh Consumed[3]: .194 kWh/mi
Charge Sustaining[4]:
Fuel Economy: 43 MPG

UDDS Fuel Economy[6]

Distance (miles)	Fuel Economy (mpg)	A/C Energy Consumed (kWh)[7]
10	118.0	1.83
20	137.6	3.65
40	124.7	5.52
60	105.9	5.65
80	94.7	5.65
100	89.18	5.65
200	77.9	5.65

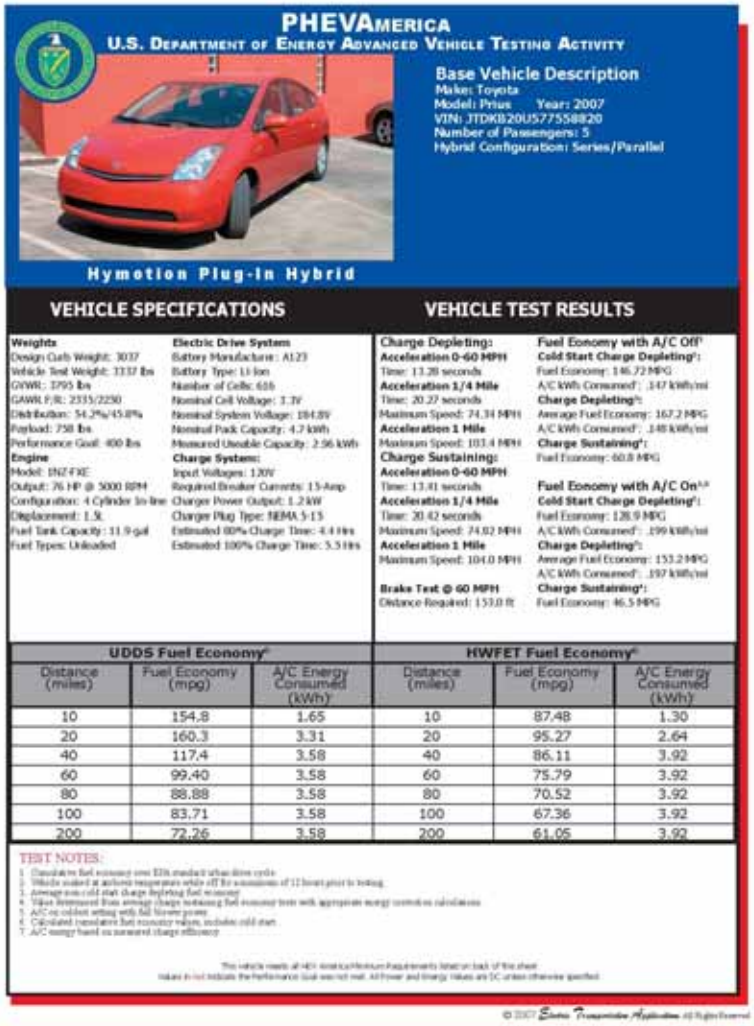
HWFET Fuel Economy[6]

Distance (miles)	Fuel Economy (mpg)	A/C Energy Consumed (kWh)[7]
10	106.6	1.77
20	116.4	3.45
40	99.9	5.46
60	86.7	5.84
80	79.5	5.93
100	75.2	5.93
200	66.6	5.93

TEST NOTES:

1. Cumulative fuel economy over EPA standard urban drive cycle
2. Vehicle soaked at ambient temperature while off for a minimum of 12 hours prior to testing
3. Average non-cold start charge depleting fuel economy
4. Value determined from average charge sustaining fuel economy tests with appropriate energy correction calculations
5. A/C on coldest setting with full blower power
6. Calculated cumulative fuel economy values, includes cold start
7. A/C energy based on measured charge efficiency

This vehicle meets all HEV America Minimum Requirements listed on back of this sheet
Values in red indicate the Performance Goal was not met. All Power and Energy values are DC unless otherwise specified.



PHEVAMERICA

U.S. DEPARTMENT OF ENERGY ADVANCED VEHICLE TESTING ACTIVITY

Base Vehicle Description
Make: Toyota
Model: Prius Year: 2007
VIN: JTDKB20U577558820
Number of Passengers: 5
Hybrid Configuration: Series/Parallel

Hymotion Plug-In Hybrid

VEHICLE SPECIFICATIONS

Weights
Design Curb Weight: 3037
Vehicle Test Weight: 3337 lbs
GVWR: 3795 lbs
GAWR F/R: 2335/2250
Distribution: 54.2%/45.8%
Payload: 758 lbs
Performance Goal: 400 lbs

Engine
Model: 1NZ-FXE
Output: 76 HP @ 5000 RPM
Configuration: 4 Cylinder In-line
Displacement: 1.5L
Fuel Tank Capacity: 11.9 gal
Fuel Types: Unleaded

Electric Drive System
Battery Manufacturer: A123
Battery Type: Li-Ion
Number of Cells: 616
Nominal Cell Voltage: 3.3V
Nominal System Voltage: 184.8V
Nominal Pack Capacity: 4.7 kWh
Measured Useable Capacity: 2.96 kWh

Charge System:
Input Voltages: 120V
Required Breaker Currents: 15 Amp
Charger Power Output: 1.2 kW
Charger Plug Type: NEMA 5-15
Estimated 80% Charge Time: 4.4 Hrs
Estimated 100% Charge Time: 5.5 Hrs

VEHICLE TEST RESULTS

Charge Depleting:
Acceleration 0-60 MPH
Time: 13.28 seconds
Acceleration 1/4 Mile
Time: 20.27 seconds
Maximum Speed: 74.34 MPH
Acceleration 1 Mile
Maximum Speed: 103.4 MPH

Charge Sustaining:
Acceleration 0-60 MPH
Time: 13.41 seconds
Acceleration 1/4 Mile
Time: 20.42 seconds
Maximum Speed: 74.02 MPH
Acceleration 1 Mile
Maximum Speed: 104.0 MPH

Brake Test @ 60 MPH
Distance Required: 153.0 ft

Fuel Economy with A/C Off[1]
Cold Start Charge Depleting[2]:
Fuel Economy: 146.72 MPG
A/C kWh Consumed[3]: .147 kWh/mi
Charge Depleting[4]:
Average Fuel Economy: 167.2 MPG
A/C kWh Consumed[3]: .148 kWh/mi
Charge Sustaining[4]:
Fuel Economy: 60.8 MPG

Fuel Economy with A/C On[1,5]
Cold Start Charge Depleting[2]:
Fuel Economy: 128.9 MPG
A/C kWh Consumed[3]: .199 kWh/mi
Charge Depleting[4]:
Average Fuel Economy: 153.2 MPG
A/C kWh Consumed[3]: .197 kWh/mi
Charge Sustaining[4]:
Fuel Economy: 46.5 MPG

UDDS Fuel Economy[6]

Distance (miles)	Fuel Economy (mpg)	A/C Energy Consumed (kWh)[7]
10	154.8	1.65
20	160.3	3.31
40	117.4	3.58
60	99.40	3.58
80	88.88	3.58
100	83.71	3.58
200	72.26	3.58

HWFET Fuel Economy[6]

Distance (miles)	Fuel Economy (mpg)	A/C Energy Consumed (kWh)[7]
10	87.48	1.30
20	95.27	2.64
40	86.11	3.92
60	75.79	3.92
80	70.52	3.92
100	67.36	3.92
200	61.05	3.92

TEST NOTES:

1. Cumulative fuel economy over EPA standard urban drive cycle
2. Vehicle soaked at ambient temperature while off for a minimum of 12 hours prior to testing
3. Average non-cold start charge depleting fuel economy
4. Value determined from average charge sustaining fuel economy tests with appropriate energy correction calculations
5. A/C on coldest setting with full blower power
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Electric Transportation Applications

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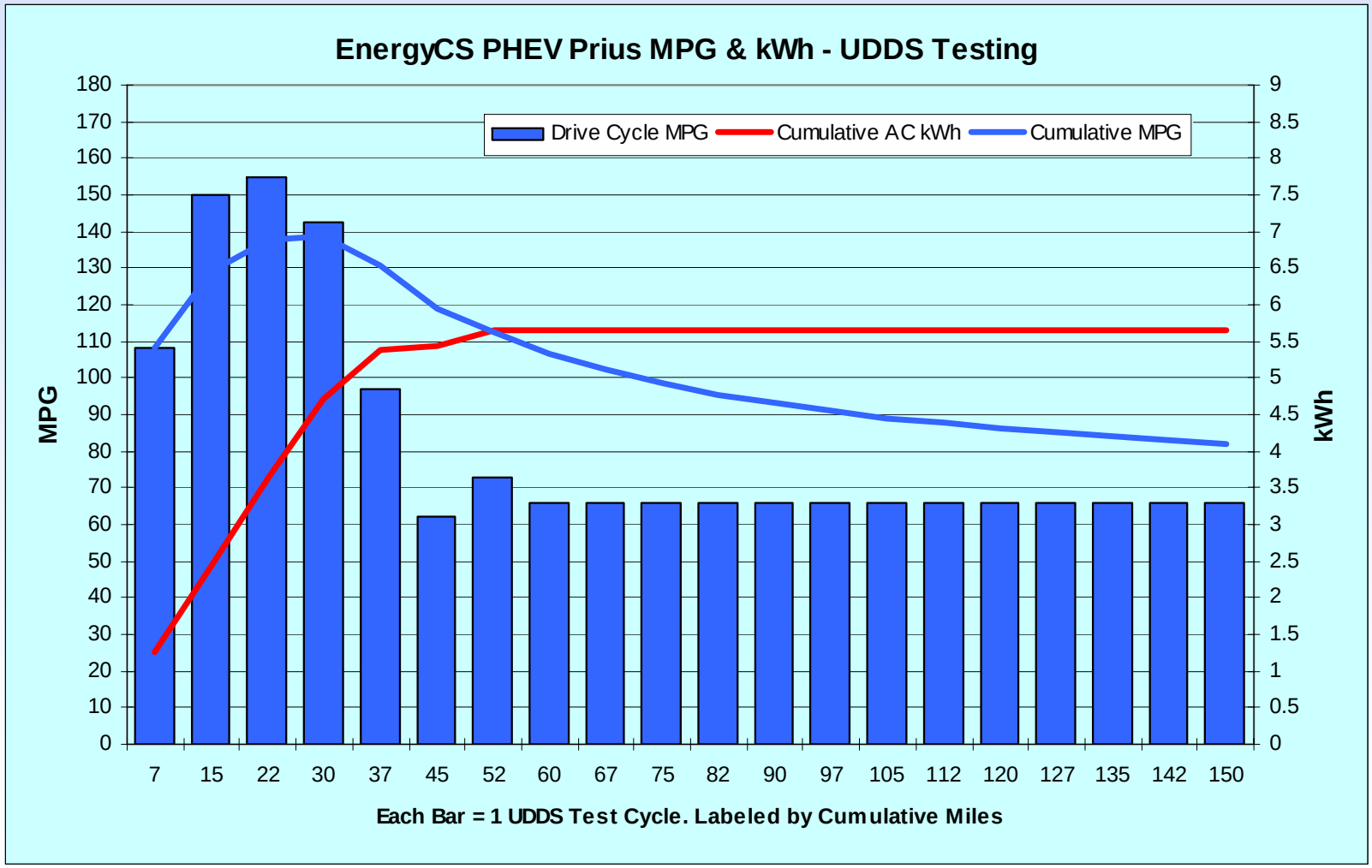
U.S. DEPARTMENT OF ENERGY

EnergyCS Prius – UDDS Fuel Use

- **9 kWh Valence lithium pack – A/C kWh**



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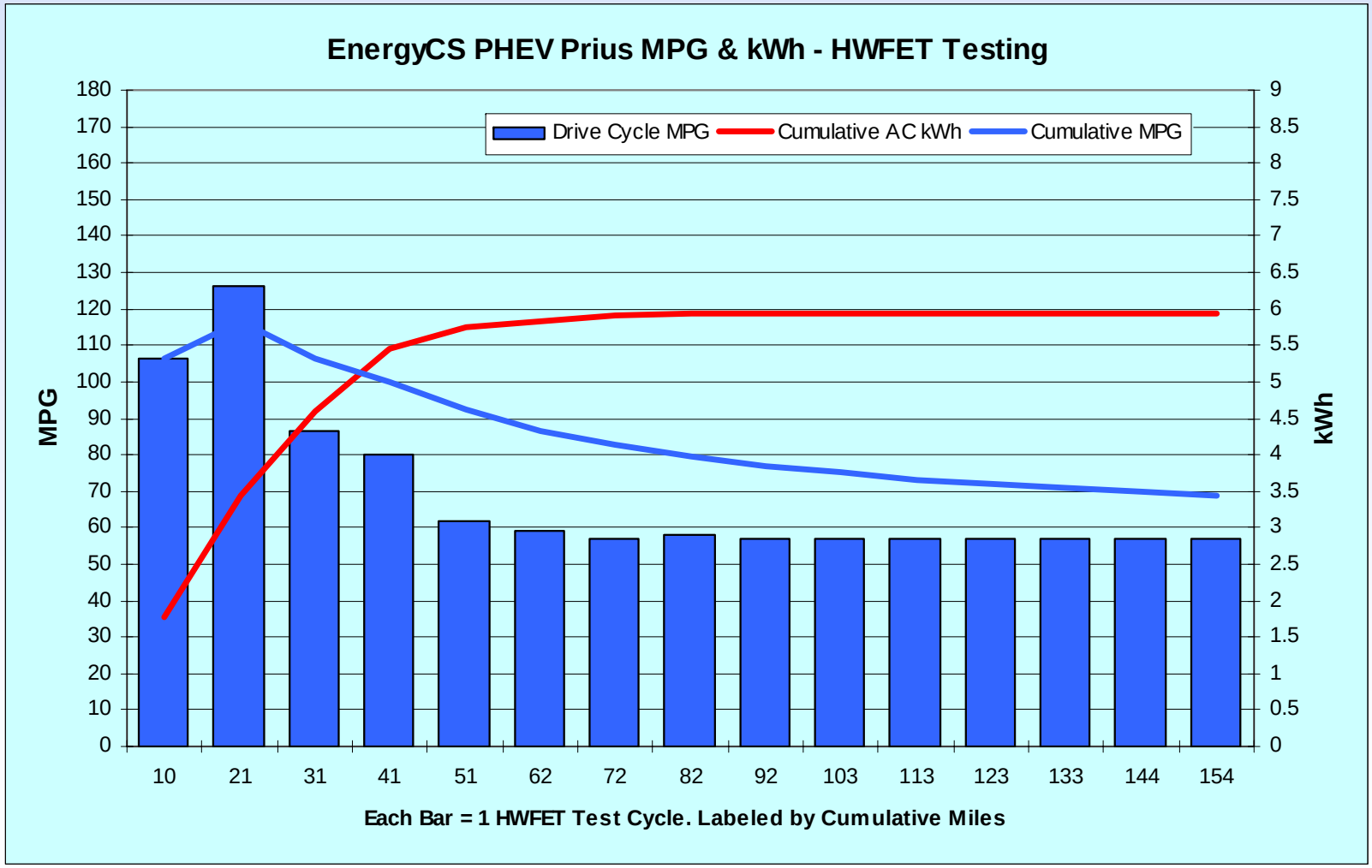
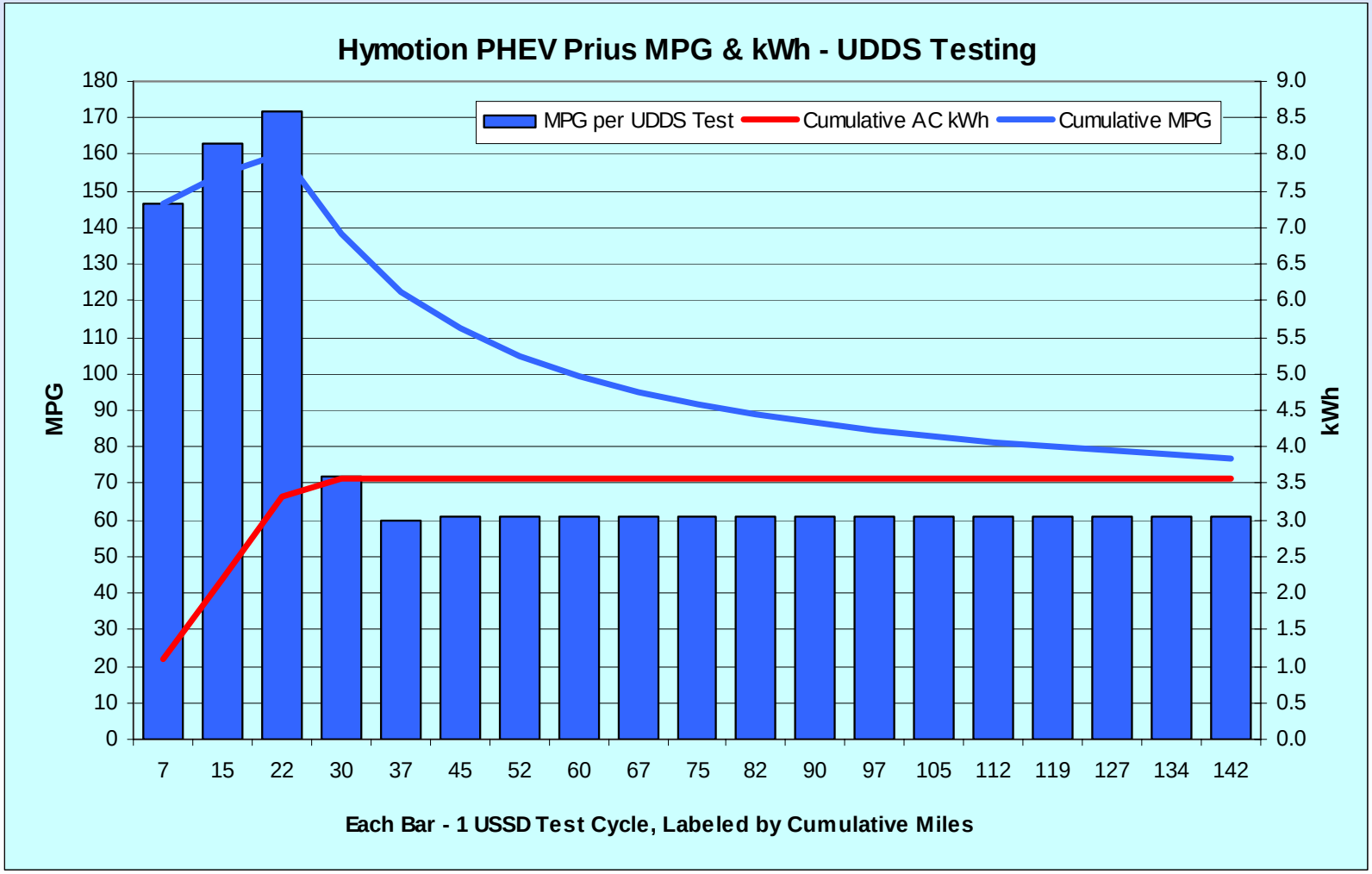
EnergyCS Prius – HWFET Fuel Use

- **9 kWh Valence lithium pack – A/C kWh**



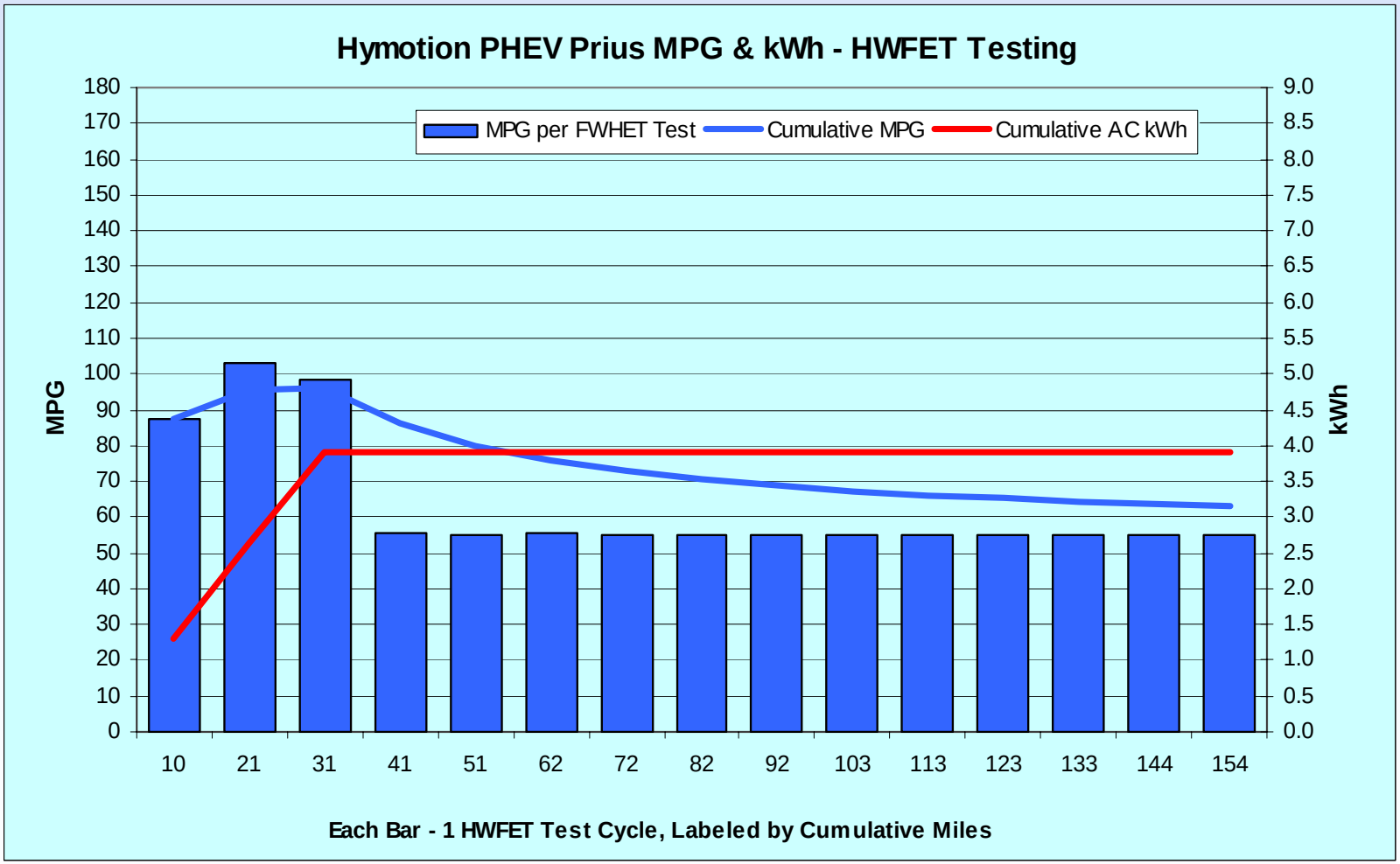
Hymotion Prius – UDDS Fuel Use

- **5 kWh A123 lithium & Prius packs – A/C kWh**

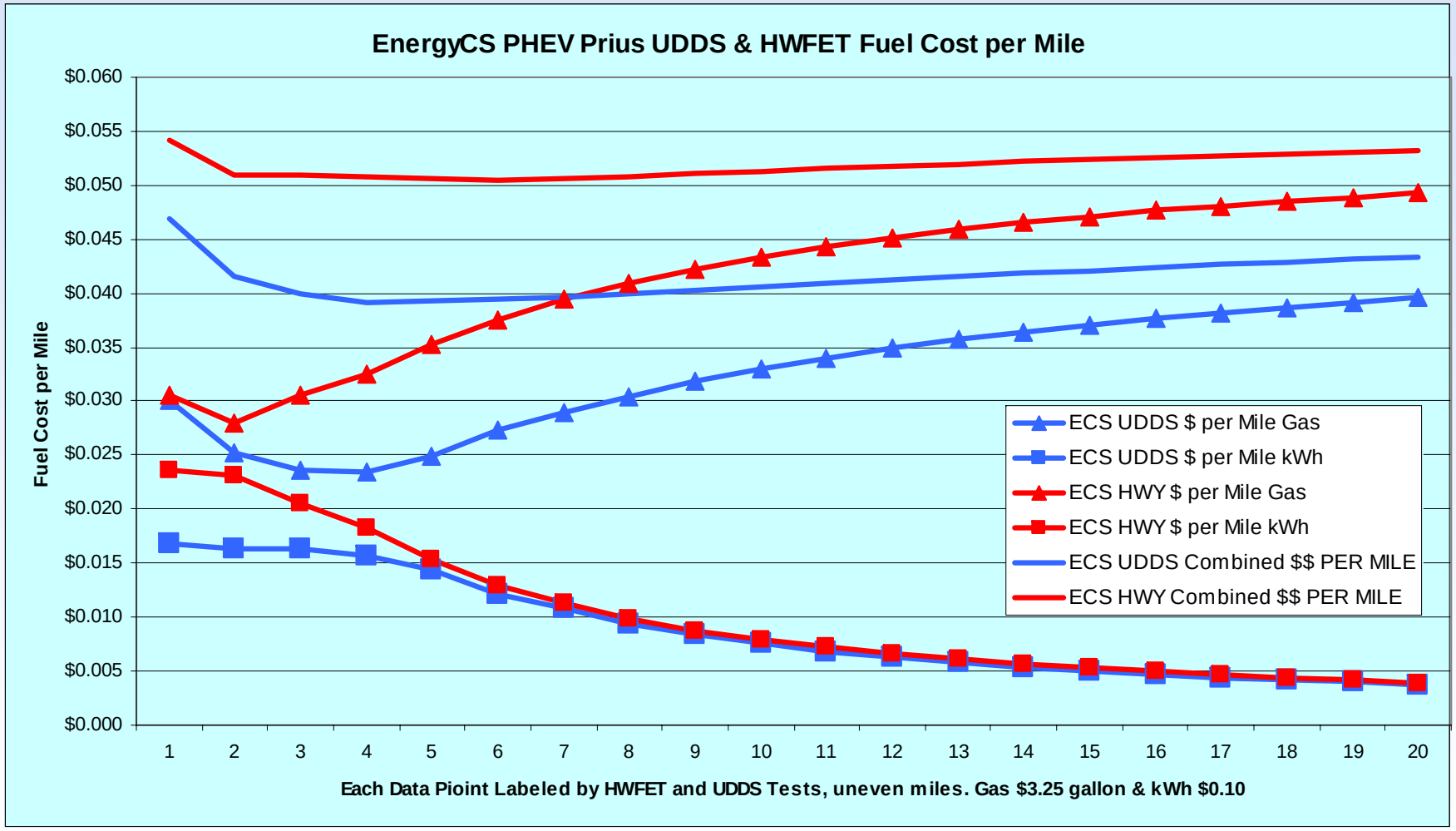


Hymotion Prius – HWFET Fuel Use

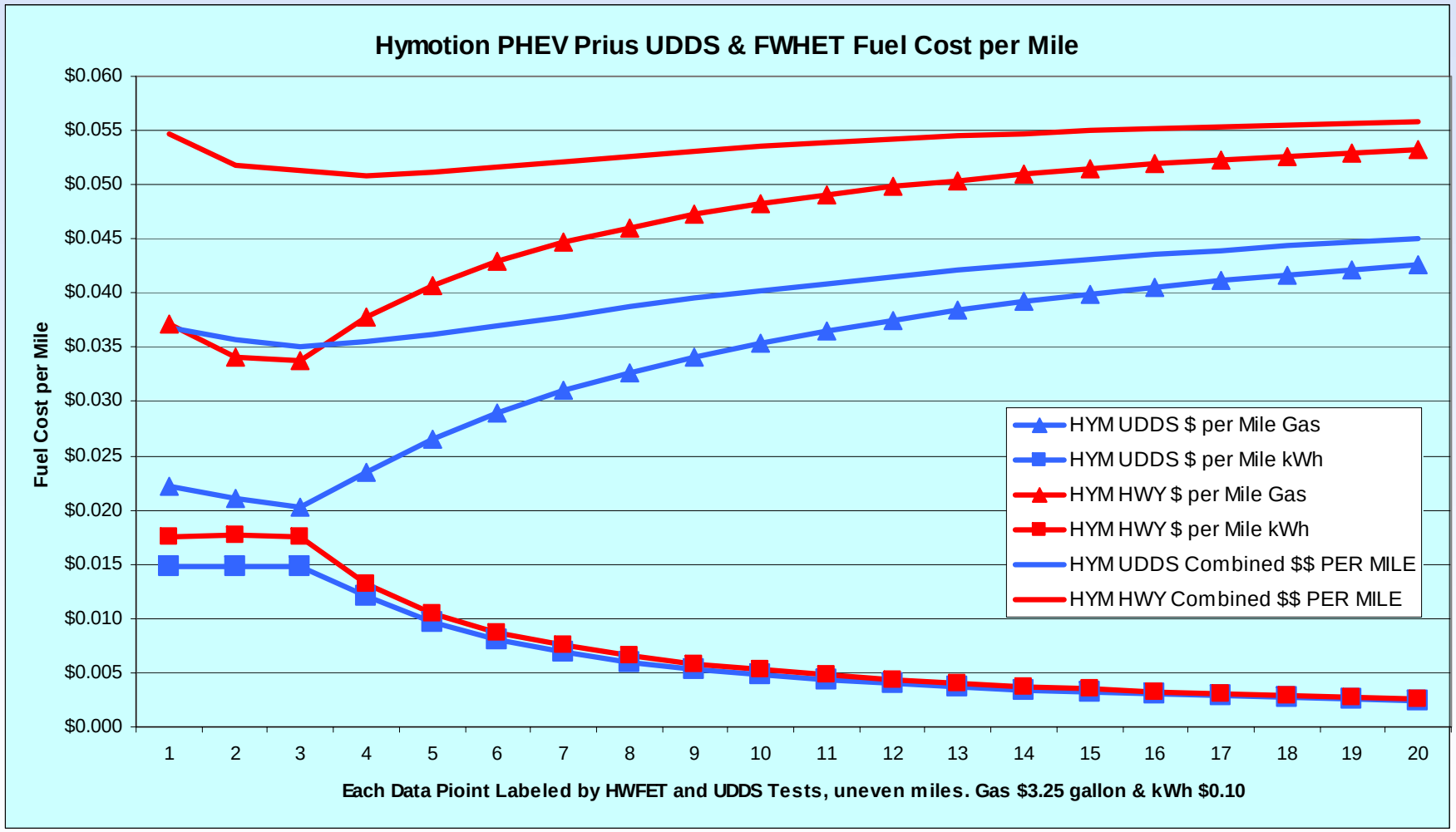
- **5 kWh A123 lithium & Prius packs – A/C kWh**



EnergyCS Prius – Fuel Costs



Hymotion Prius – Fuel Costs



Accelerated Onroad Testing

- Uses dedicated drivers
- Predetermined and repeatable drive cycles
- Combinations of urban and highway loops
- 5,440 total onroad test miles per PHEV model
- 162 drive and charging cycles that include 1,344 hours of charging - can not economically be performed on a dynamometer
- Not as controlled as dynamometer, but compliments controlled dynamometer testing by allowing a broader view of fuel use over many more miles and charging events
- Gives PHEV conversions extended opportunity to fail before being placed into fleets

PHEV Accelerated Testing

- Accelerated testing in Phoenix over 5,440 miles
- GPS units track distance, average & maximum speeds

Cycle (mi)	Urban (10 mi)	Highway (10 mi)	Charge (hr)	Reps (N)	Total (mi)	Reps (%)	Miles (%)
10	1	0	4	60	600	37%	11%
20	1	1	8	30	600	19%	11%
40	4	0	12	15	600	9%	11%
40	2	2	12	15	600	9%	11%
40	0	4	12	15	600	9%	11%
60	2	4	12	10	600	6%	11%
80	2	6	12	8	640	5%	12%
100	2	8	12	6	600	4%	11%
200	2	18	12	3	600	2%	11%
Total	2,340	3,100	1,344	162	5,440		
Average	43%	57%	8.3	18			

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EnergyCS Prius – Accelerated Testing

Cycle	Urban	Highway	Charge	Reps	Total	Electricity	Gasoline	
(mi)	(10 mi)	(10 mi)	(hr)	(N)	(mi)	kWh	Gals	MPG
10	1	0	4	60	600	115.58	4.78	125.6
20	1	1	8	30	600	86.21	7.95	77.9
40	4	0	12	5	200*	17.37	1.61	126.4
40	2	2	12	5	200*	29.00	1.42	145.1
40	0	4	12	5	200*	30.00	2.43	85.5
60	2	4	12	10	600	65.00	5.90	103.7
80	2	6	12	8	640	39.04	10.09	65.8
100	2	8	12	6	600	22.67	8.81	70.8
200	2	18	12	3	600	12.98	10.46	57.8
Total	1740	2500	984	132	4240	Weighted Ave		88.4

*** Being rerun to 600 miles**

Electric Transportation Applications

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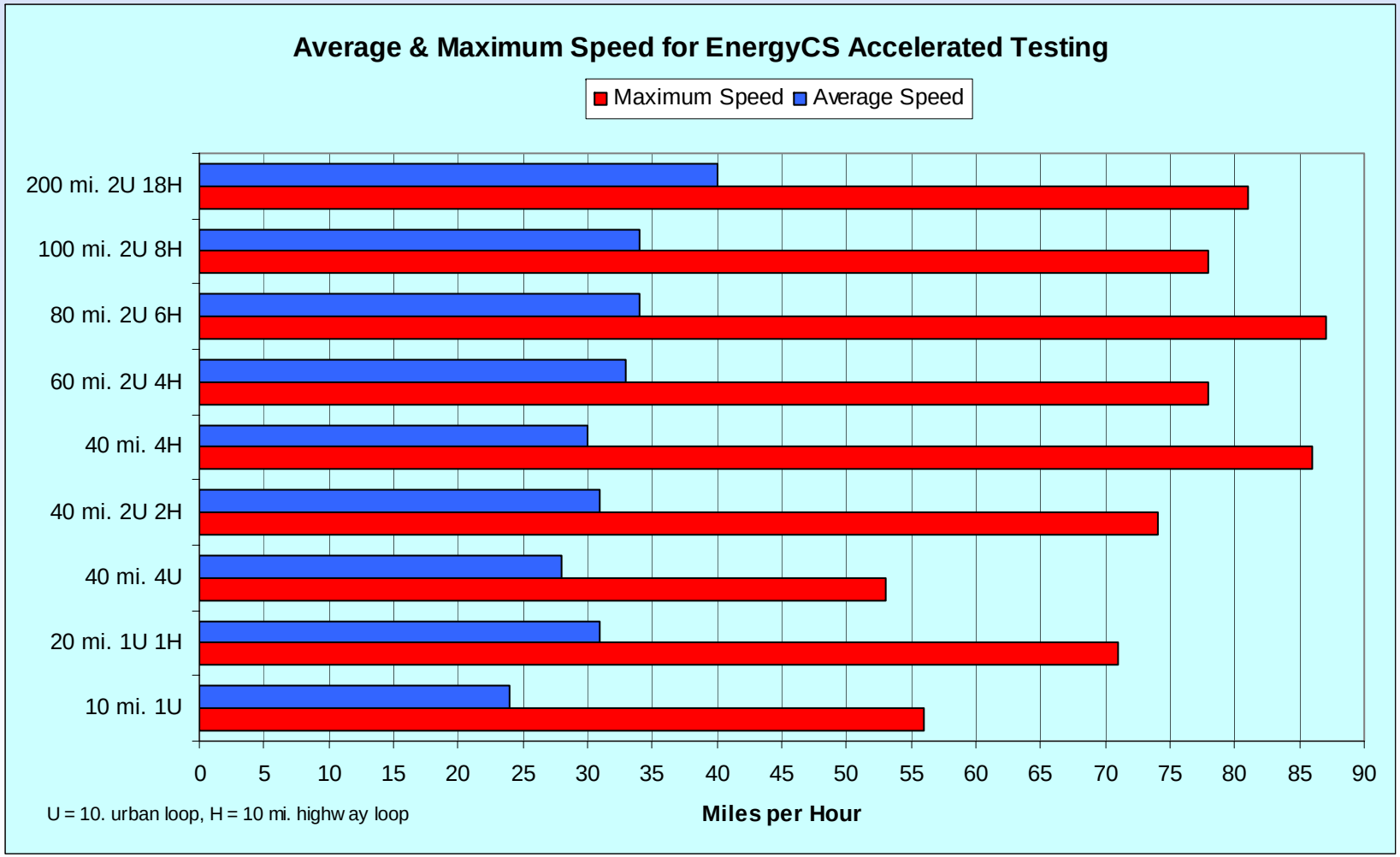
EnergyCS Prius – Accelerated Testing



Hymotion Prius – Accelerated Testing

Cycle	Urban	Highway	Charge	Reps	Total	Electricity	Gasoline	
(mi)	(10 mi)	(10 mi)	(hr)	(N)	(mi)	kWh	Gals	MPG
10	1	0	4	60	600			
20	1	1	8	30	600	122.02	5.37	115.9
40	4	0	12	5	200*	29.84	1.87	108.9
40	2	2	12	5	600			
40	0	4	12	5	600			
60	2	4	12	10	600			
80	2	6	12	8	640			
100	2	8	12	6	600	35.98	8.43	73.23
200	2	18	12	3	600			
Total	1740	2500	984	132	4240	Weighted Ave		

* Being rerun to 600 miles

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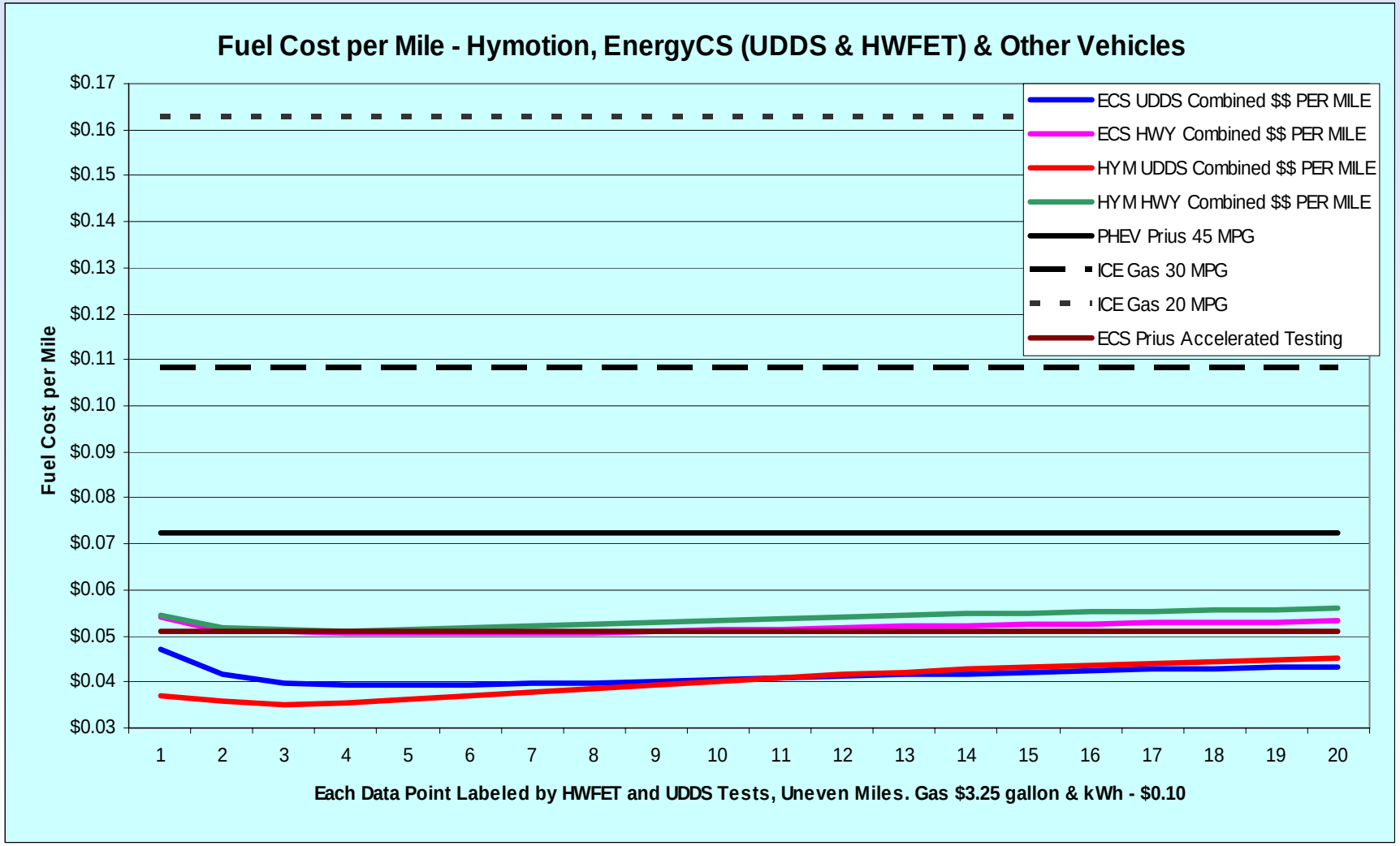
Combined ECS & Hymotion Fuel Costs



Kangoo – Test Results

- **Renault Kangoo – Series hybrid with 9.6 kWh (usable) NiCad pack & 650cc gasoline engine**

Test Cycle	A/C kWh per Mile	Miles per Gallon
Battery Only - UDDS	0.268	
Battery Only - HWFET	0.155	
Battery Only @ Constant 45 mpg	0.271	
Battery & Gas Cold UDDS	0.144	42.3
Battery & Gas Hot UDDS	0.110	39.4
Battery & Gas Hot HWFET	0.042	40.9
60 Battery Only 10-mile Accelerated Cycles	0.481	

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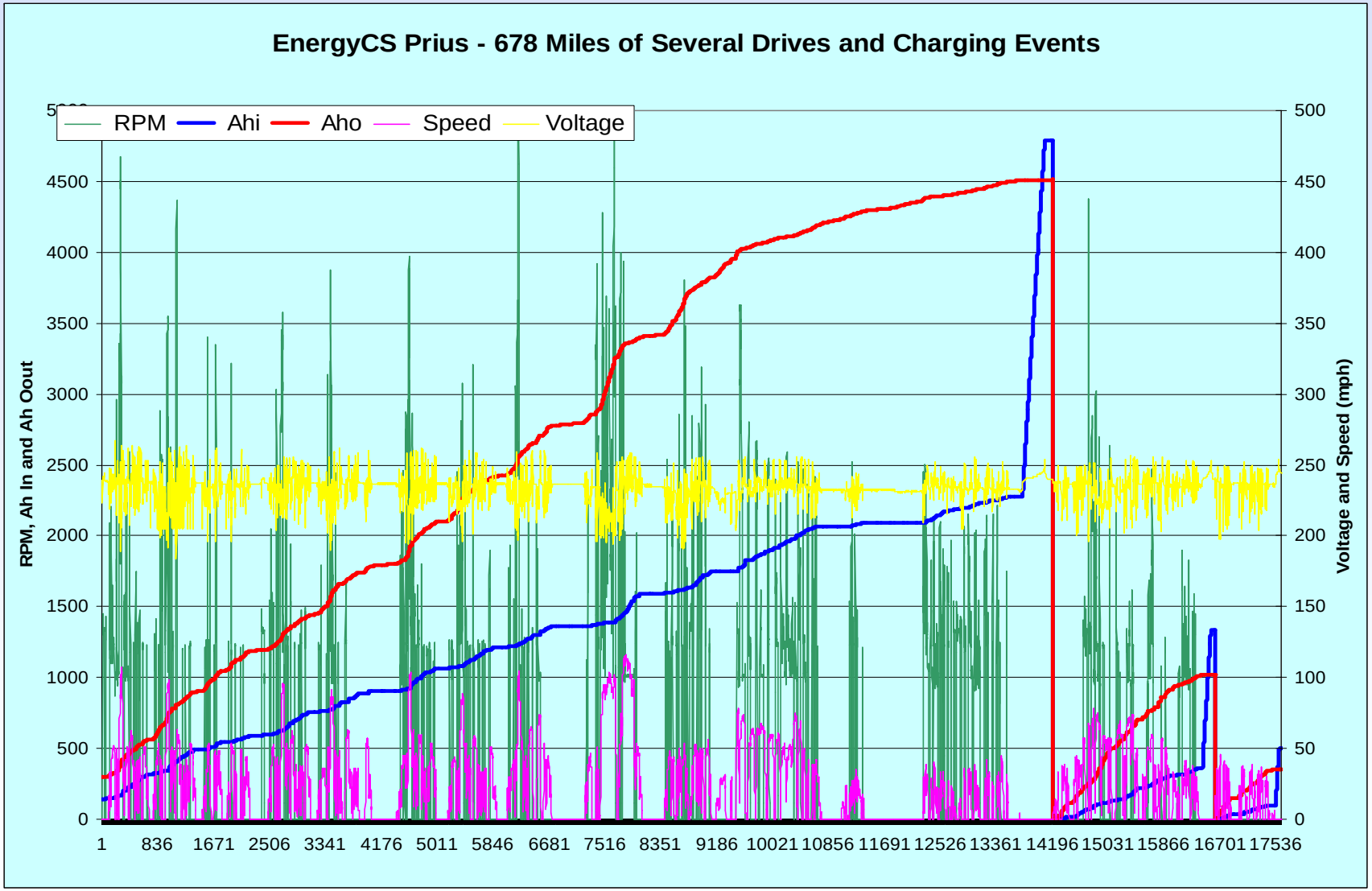
Hymotion

- Data loggers installed on most of 50 PHEVs in 25 North America locations, with plans to actively collect data on 100 vehicles during 2008
- New battery version available in 1st quarter 2008, is in crash testing and will have SULEV certification
- Testing will include charging and driving profiles as well as charging infrastructure analysis
- The AVTA signed agreement with Hymotion and is initiating Hymotion fleet testing support by:
  - On a monthly basis, collecting data from fleets via an ftp site or regular mail
  - Performing DOE, operating fleet, and Hymotion required data reduction, and analysis
  - Reporting testing results monthly

EnergyCS

- **The AVTA and EnergyCS have signed and initiated a data collection, dissemination and reporting agreement**
- **EnergyCS has provided historical PHEV operations onboard data for 7 vehicles operating in fleets in Canada, Arizona, and California**
- **Data collection methods being modified to allow the AVTA to collect fleet operators data directly and to handle all aspects of PHEV onboard data collection**

EnergyCS Onboard Data



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NYSERDA

- **The AVTA is testing all 6 (probably 5) of the New York State Energy Research and Development Agency's PHEV conversions. Models and test statuses:**

Model	Baseline Testing	Accelerated Testing	Delivery Status
EnergyCS Prius	Completed	Near completion	
Hymotion Prius	Completed	ongoing	
Hymotion Civic			Not yet delivered
Hymotion Escape	Starting	After baseline	
Electovaya Escape	Starting	After baseline	4 deliveries required
HybridsPlus Escape			Delivered once, sent back

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Seattle-Area Demonstration

- 13 Hymotion Prius PHEV demonstration with:
  - The City of Seattle (4)
  - King County (4)
  - Port of Seattle (2)
  - Puget Sound Clean Air Agency (3)

- 1 Green Car Co. lead acid Prius at King County
- Fleets will operate the vehicles in various missions
- AVTA will collection onboard data from the fleets and individual operators, process the data, and provide individual vehicle and fleet summary operations data
- Testing will include charging and driving profiles as well as charging infrastructure analysis
- Start late 1st quarter CY2008

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City of Tacoma

- The City of Tacoma has obtained 1 lead acid battery Prius PHEV from the Green Car Company with 1 more on order, and 1 Hymotion Prius is on order
- Tacoma and the AVTA to conduct cooperative testing of vehicles and charging infrastructure
  - Tacoma is following the NEC for PHEV charging
  - Each branch circuit is metered
- Lead acid PHEVs are supposed to be the first PHEVs deployed with an all-electric range of 10 to 15 miles
- Testing will include charging and driving profiles as well as charging infrastructure analysis
- Considering swapping PHEV for lead acid PHEV baseline performance testing
- Started 4th quarter CY2007

National Rural Electric Cooperative Association (NRECA)

- Developing PHEV data collection effort between the AVTA and the NRECA
- Total of 7 Prius and Escape PHEVs from Hymotion, EnergyCS, and HybridsPlus will be operated by rural electric coop utilities in Florida, Georgia, Indiana, Minnesota, North Carolina, Oregon, and South Carolina
- The AVTA will collection and process onboard data from the fleets, and provide individual vehicle and fleet operations data
- Testing will include charging and driving profiles as well as charging infrastructure analysis

Southern California Edison (SCE)

- The Idaho National Lab (INL) and SCE have jointly conducted vehicle testing for 20+ years
- INL and SCE have been negotiating PHEV cooperative testing, as the AVTA was invited by SCE to partner in the Ford/SCE Escape PHEV demonstration
- Twenty Ford PHEV Escapes planned for demonstration, with first one starting very late 2007
- Testing will include charging and driving profiles as well as charging infrastructure analysis, as SCE has significant interest in PHEVs providing at-home backup power
- AVTA will obtain a SCE Escape for baseline performance testing

International Truck Cooperative Testing

- Conduct baseline performance testing of 40-foot PHEV school bus from International Truck with lithium pack
- Perform coastdown and dynamometer testing
- No specific PHEV bus testing protocol exists. Likely use either or both the Manhattan driving cycle or the Orange County cycle
- With PHEV option on, 1st day of testing will include:
  - Cold start in charge deleting mode
  - Followed by hot starts in charge depleting modes
  - Followed by at least 2 hot starts in charge sustaining modes
- In diesel engine only mode, 2nd day of testing will include 1 cold start, followed by several hot starts
- Three dynamometer testing facilities being considered

Accessory Load Study for PHEV Modelers

- Prius and Escape HEV accessory load testing to provide exact power levels to PHEV modelers
- Power steering with no steering input and at lock stop
- Air conditioning at full compressor load and defrost compressor load
- DC/DC converter
  - All optional accessories off at idle with engine running (initial condition)
  - Initial condition plus maximum blower speed
  - Initial condition plus all optional accessory loads
  - Initial condition plus power window operation
  - Initial condition plus service brake operation
- Engine start

Data Logger Testing

- Document data logger selections in order to respond to "inquires"
  - Use Hymotion's Kvaser Memorator data logger on Hymotion ~50 Prius PHEVs
  - Use EnergyCS logger on seven EnergyCS PHEVs
  - Testing V2Green cellular data logger on an EnergyCS Prius. Will likely use on at least some of the PHEVs in the Tacoma and Seattle fleets, and possibly other remote locations
  - Supported ARDAQ testing
  - Have used HEM Data's Drewtech Cardeq on HEVs, may use on PHEVs with no integrated sensors
- Ideally use a single data logger

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Additional Information

http://avt.inl.gov
or
http://www1.eere.energy.gov/vehiclesandfuels/avta/

INL/CON-07-13005

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