Real Driving Emission and Fuel Consumption (for plug-in hybrids)

A3PS Eco-Mobility 2016
Vienna, October 17-18, 2016

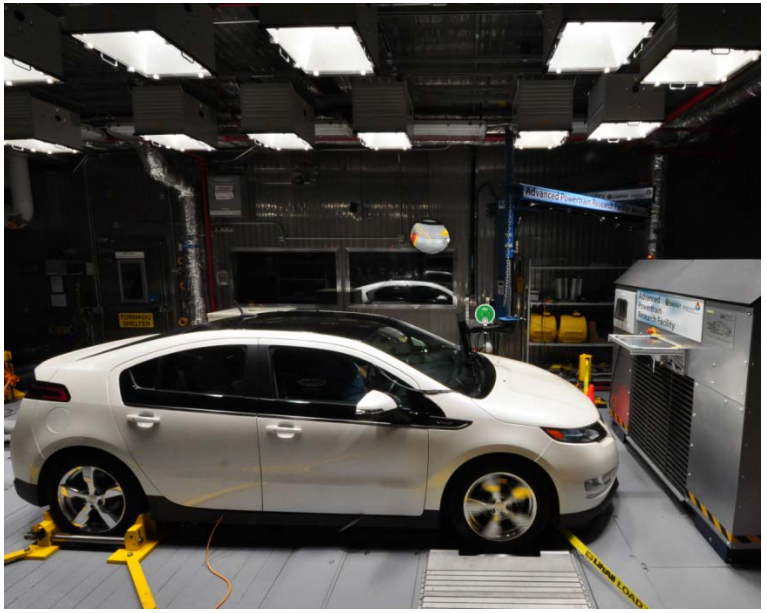
Henning Lohse-Busch, Ph.D.
hlb@anl.gov
Argonne National Laboratory

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Argonne's Advanced Powertrain Research Facility

- Single (**2WD**) and double (**4WD**) axle dynamometers
- **Environmental chamber** for "5-cyle" testing (-18° C to 38° C)
- Focus on **advanced powertrains** and **alternative fuels**
- Energy efficiency and fuel efficiency (fuel displacement)
- Current PHEV and BEV test procedures developed in APRF

2WD chassis dyno

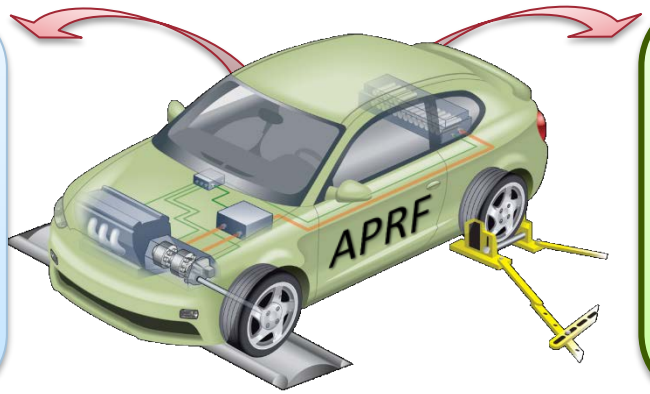


4WD chassis dyno in thermal chamber

Advanced Powertrain Research Facility Serves Two Critical Functions

Technology Assessment

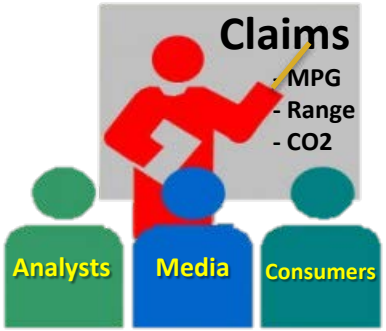
"Provide to DOE and Partners the Best Advanced Vehicle Test Data and Analysis"



Test Procedure Standards

"Leadership in test procedure development with public and independent research and data"

All Technology Claims Come from a **TEST**



Over Predict

- Technology promises too much
- Real experience not matching expectations
- Attention not warranted
- Funds are misdirected
- "Poisoned Well" (diesel in USA '80s)

True Representation

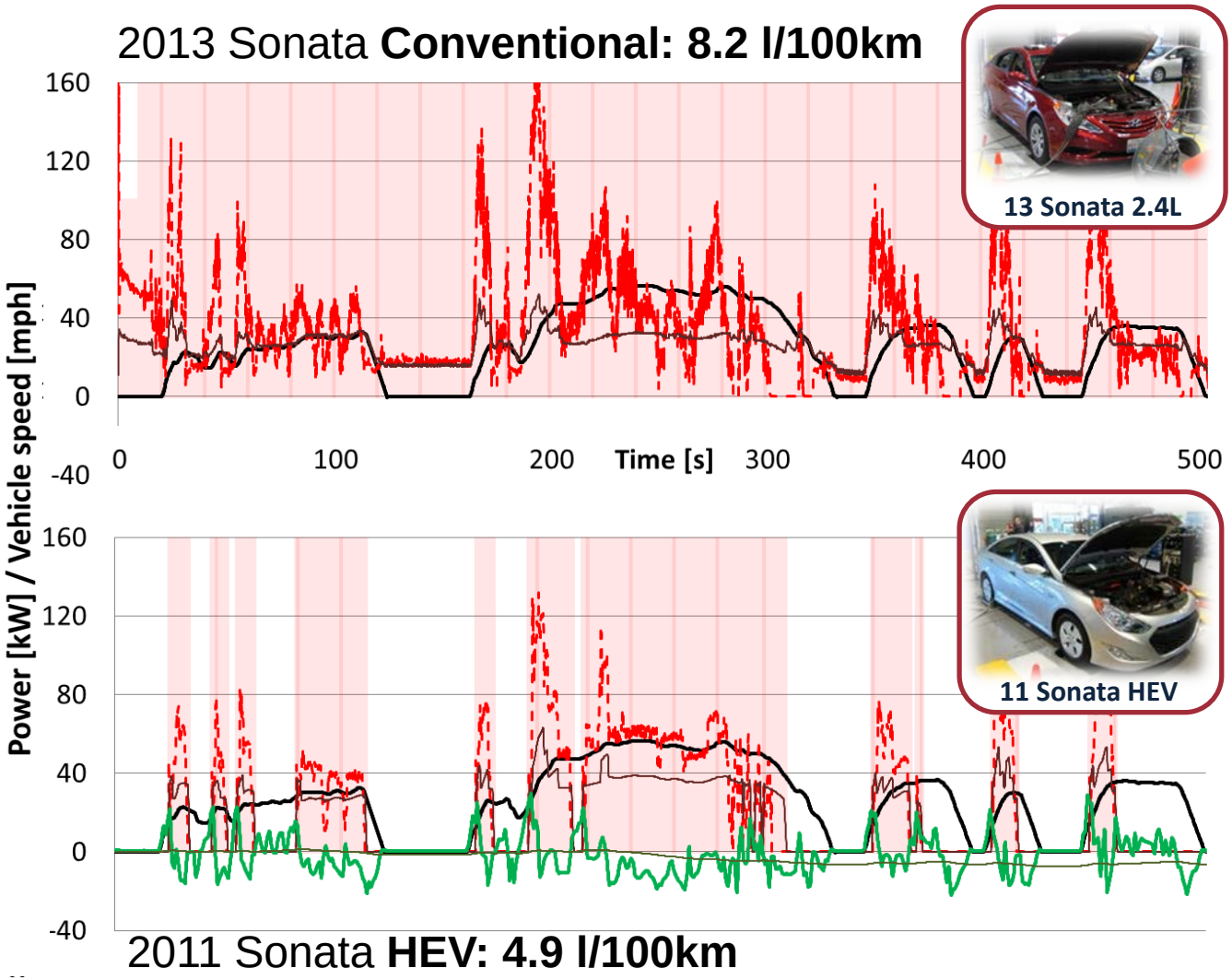
Under Predict

- Technology underrated
- Attention not given
- No adoption, benefits were never predicted
- Missed opportunity by DOE

Why?

Department of Energy should care about test procedures?

Conventional and Hybrid Vehicle in City Driving



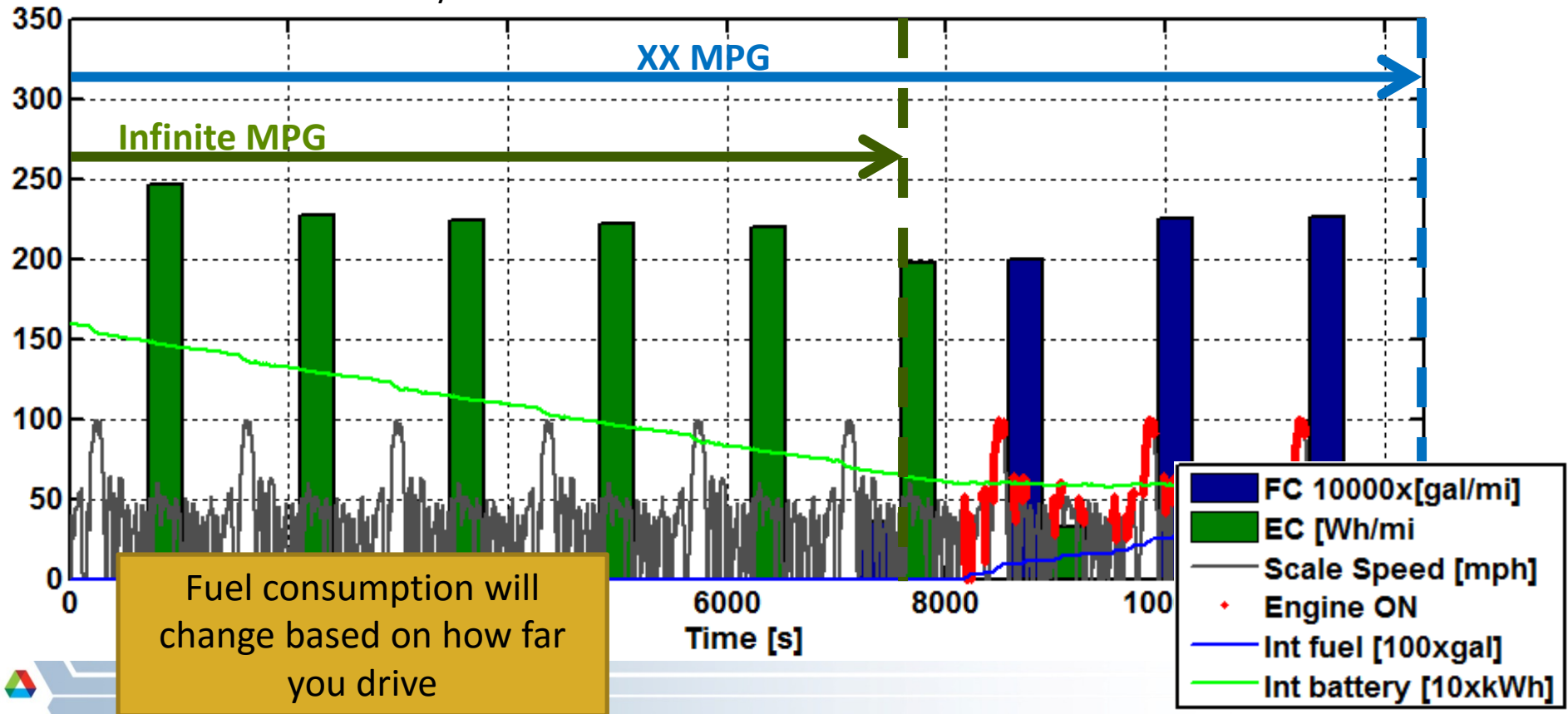
Hybrid system enables:

- Engine Start-Stop
- EV Operation
- Engine Load Optimization
- Regenerative braking
- Accessory HV electrification (AC, PS,…)

Plug-In Hybrids: "Split-Personality Vehicle" (Fuel and Electricity) - SAE J1711

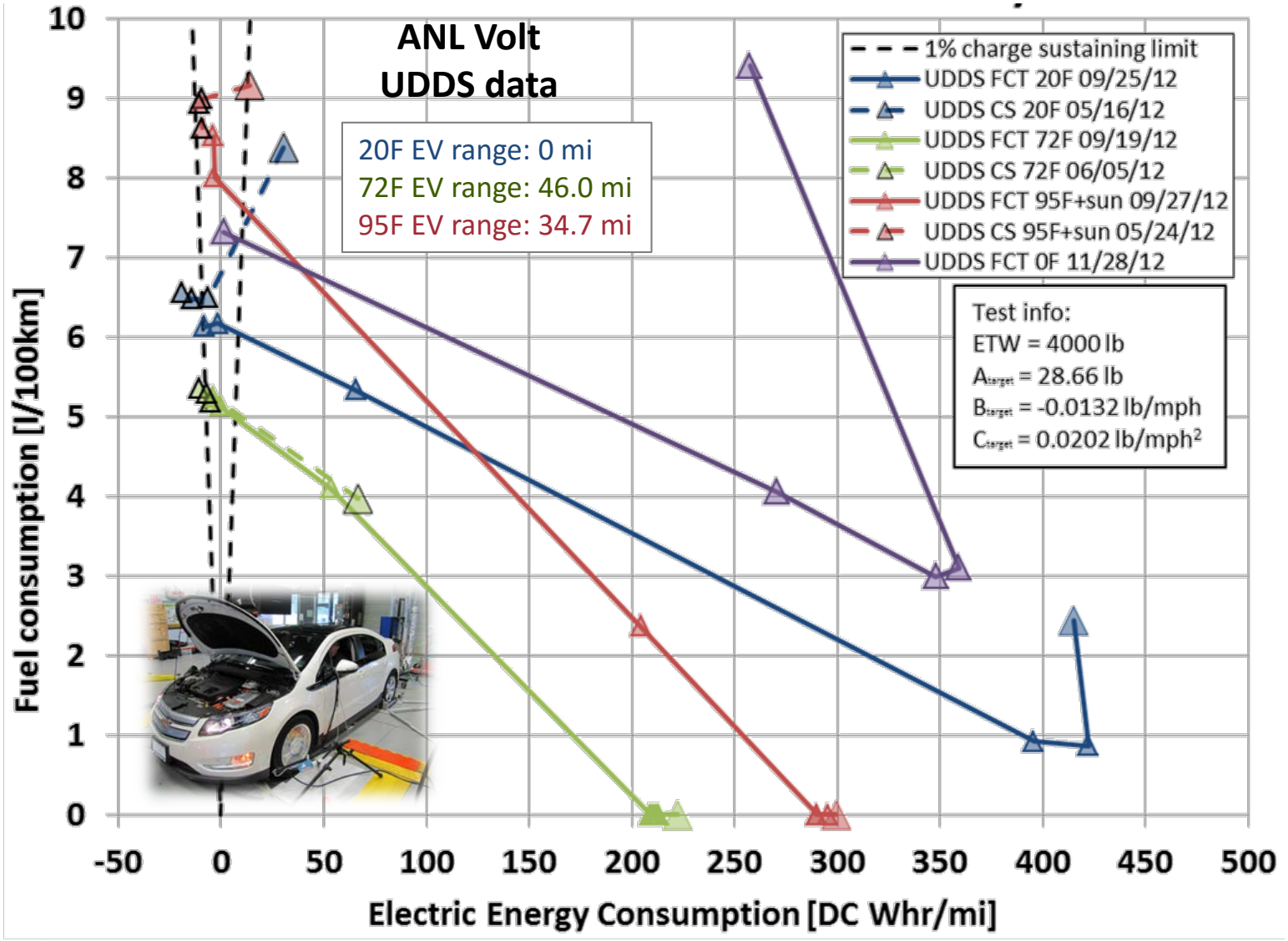
Test data from:
2012 Chevy Volt

- Plug-in hybrids use energy from
  - Fuel (tank)
  - Electricity (battery pack)
- First the vehicle will deplete the battery energy and thus displace fuel. Once the battery is depleted the vehicle operates in a charge sustaining mode like a 'normal' hybrid

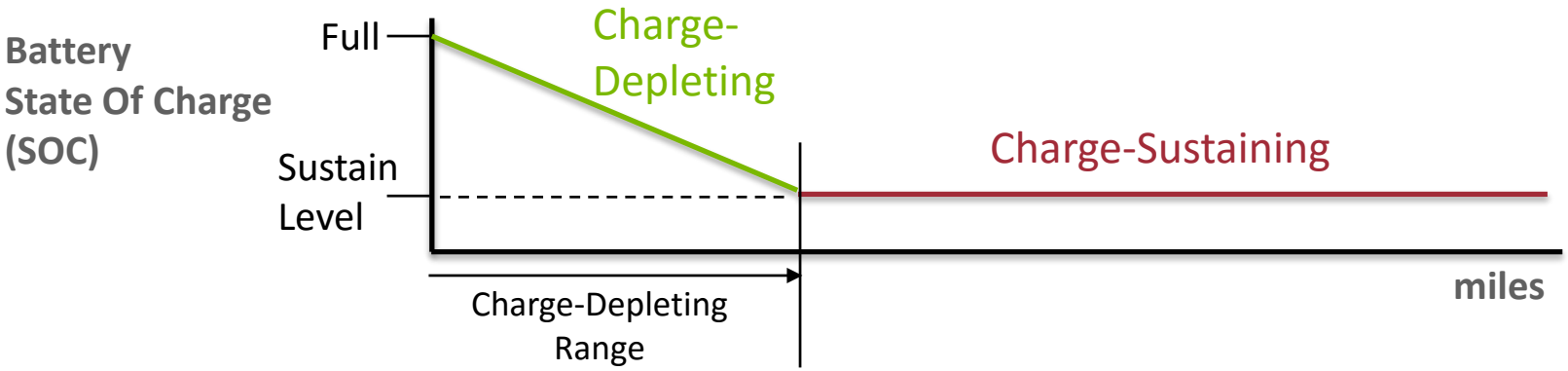


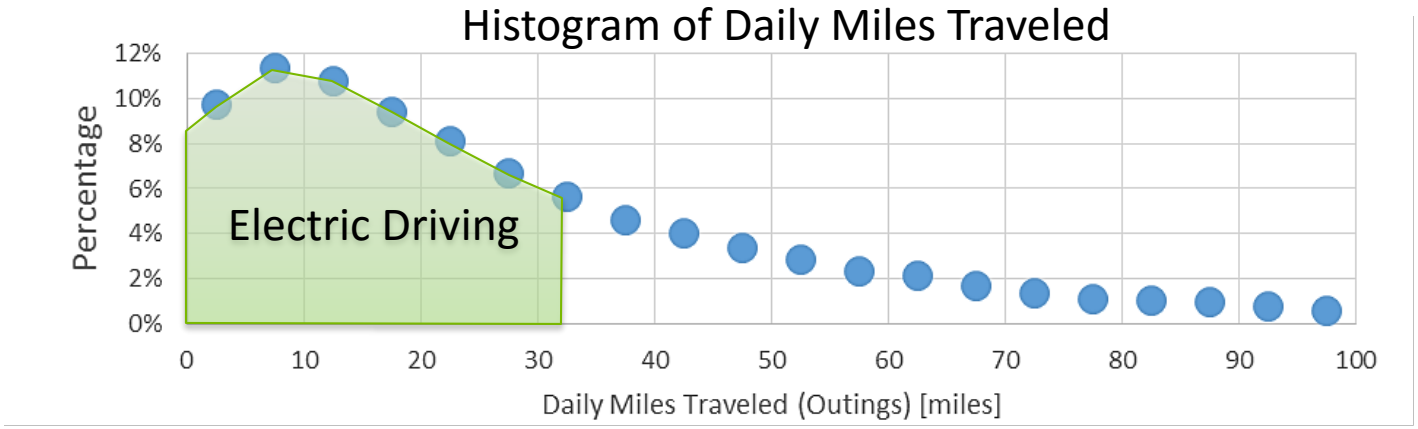
Fuel consumption will change based on how far you drive

Plug-in Hybrids are a Two Dimensional Challenge



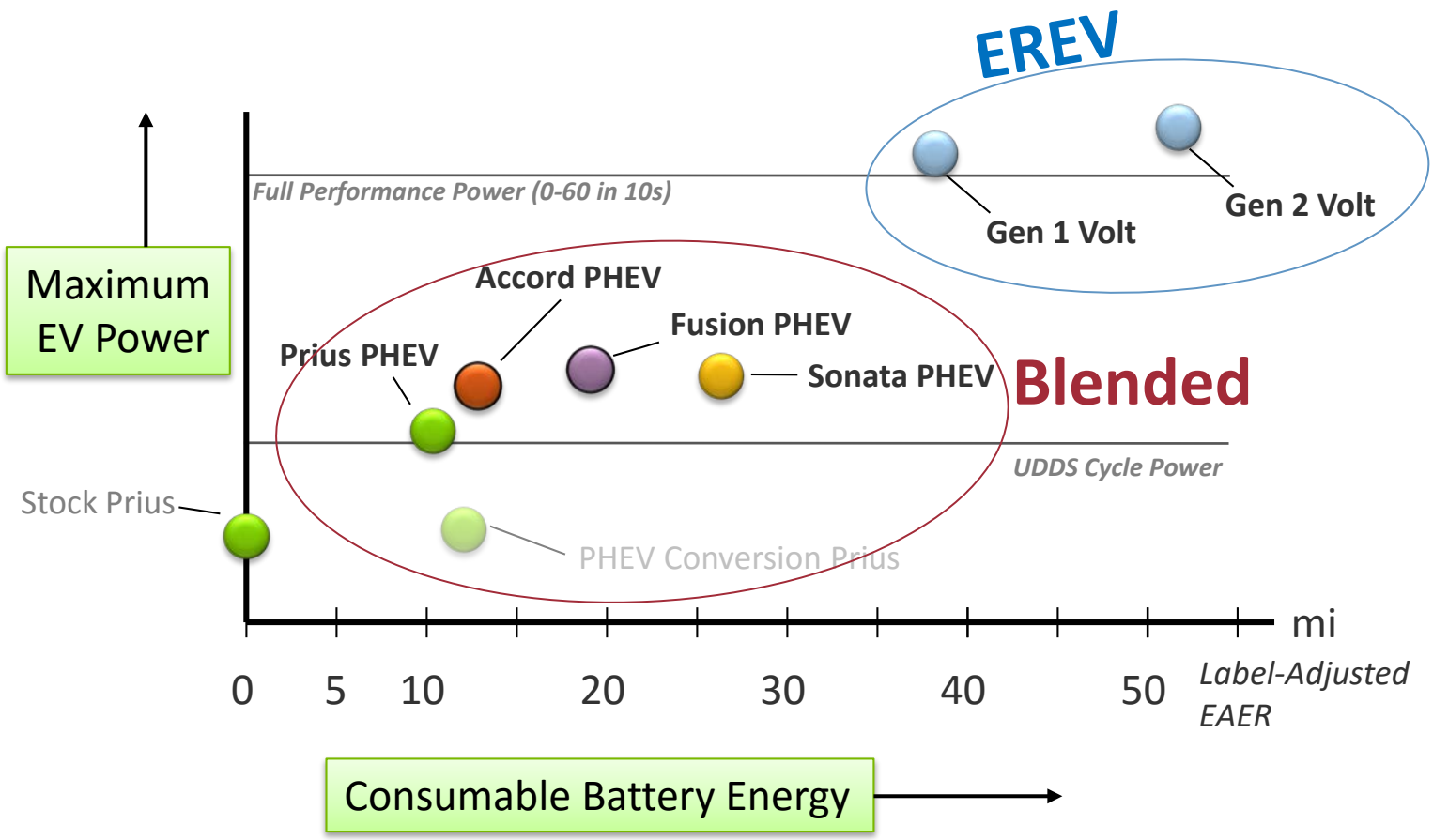
Q: Benefit of PHEVs?
A: Displace petroleum fuel with electric energy





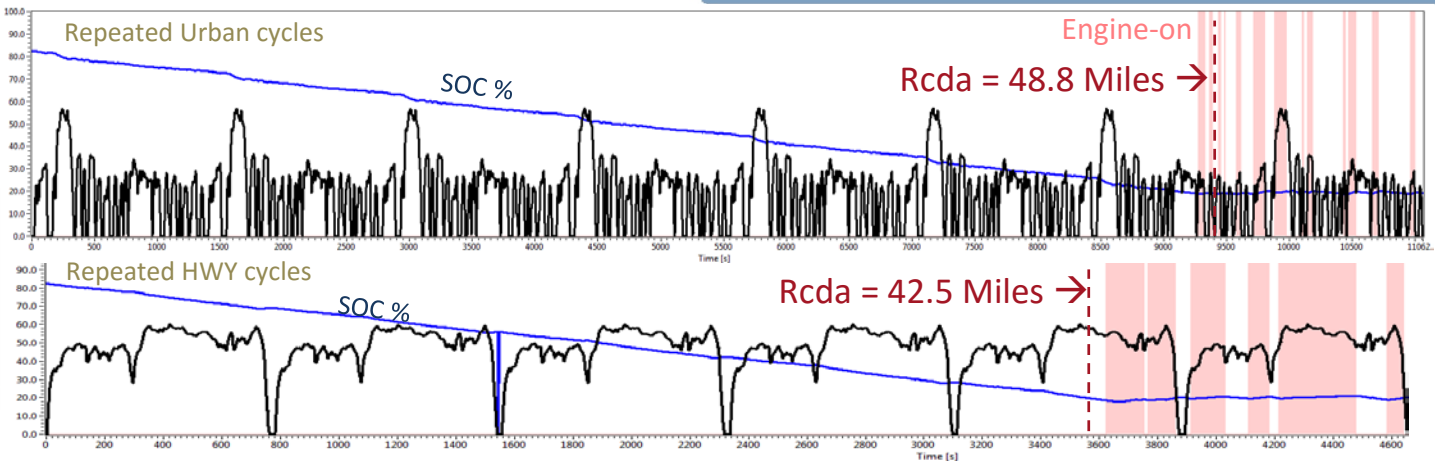
PHEV Design Space – Energy and Power

→ Both have affect on electric utilization

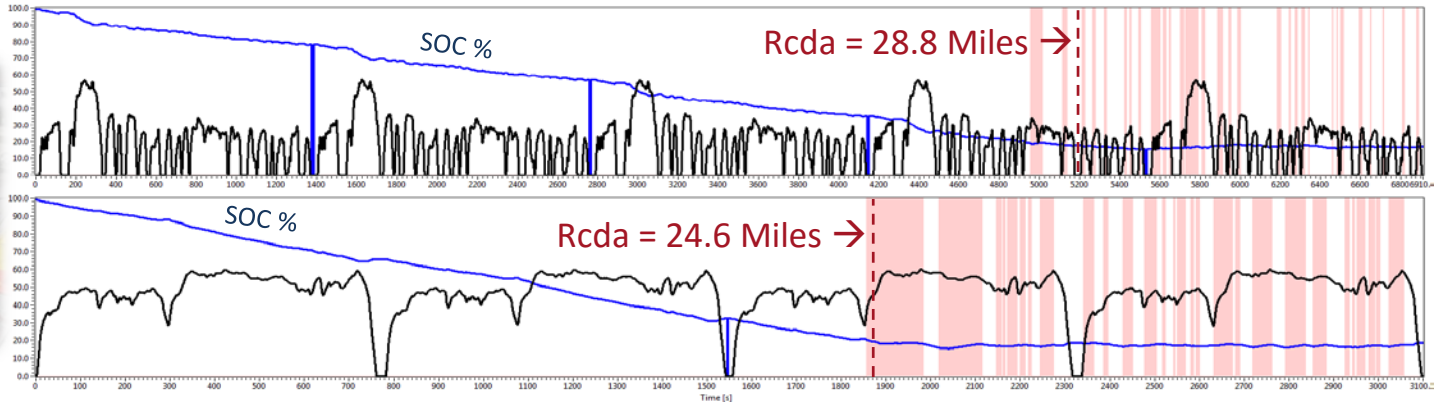


UDDS & Highway Depleting mode testing

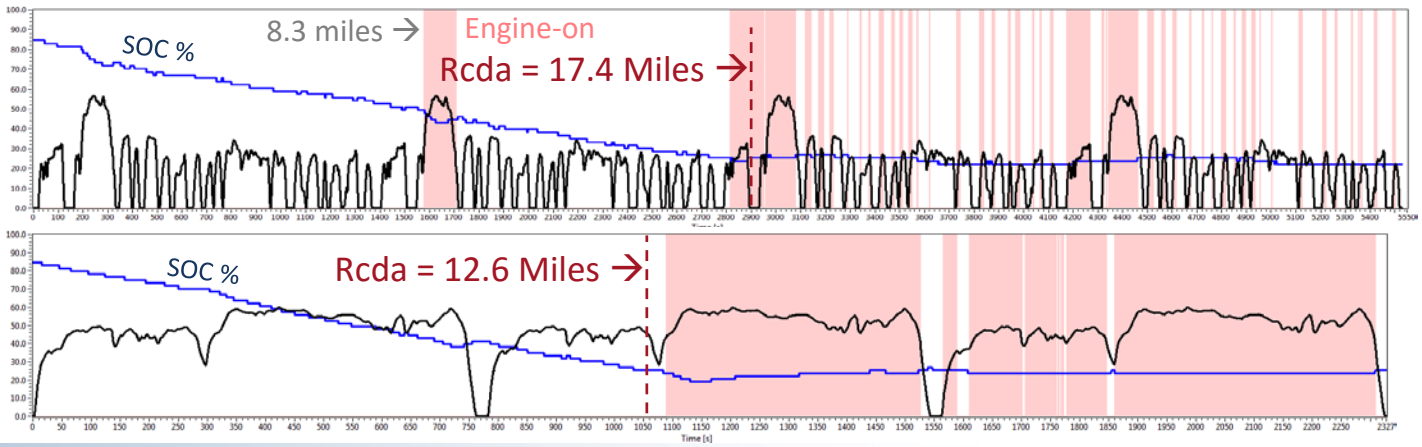
2012 Chevy Volt



2013 Cmax PHEV

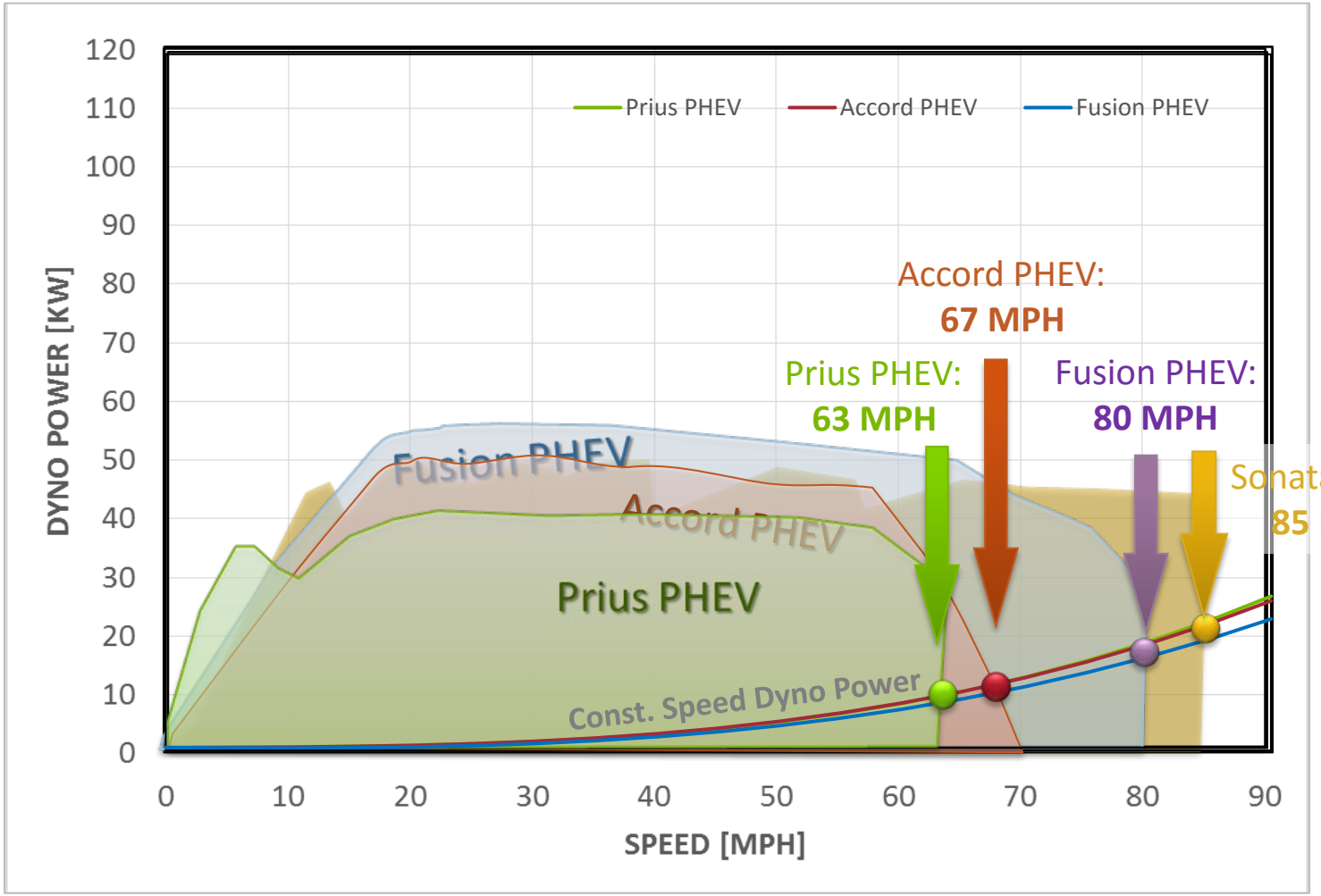


2013 Prius PHV

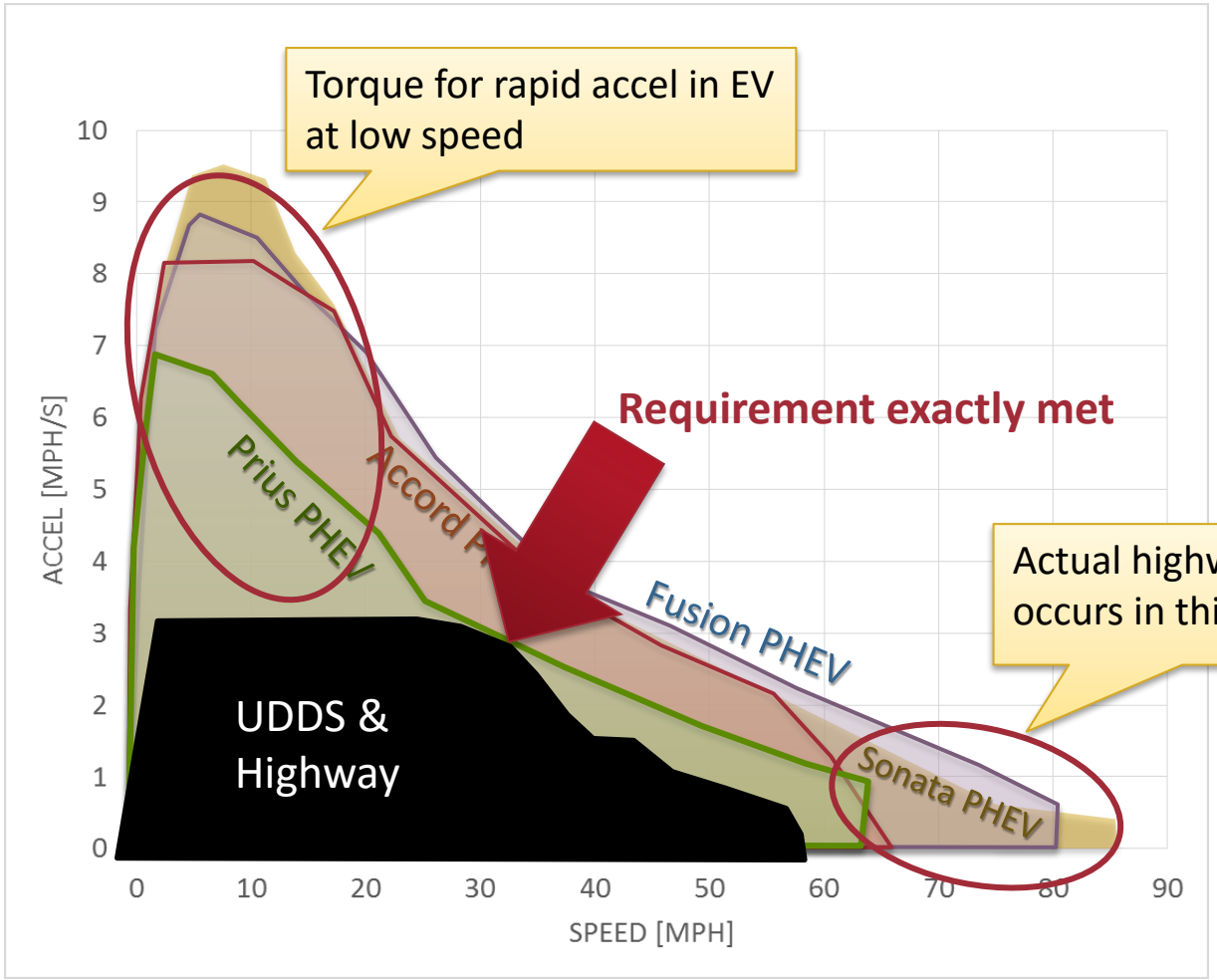


EV Power Envelope Summary

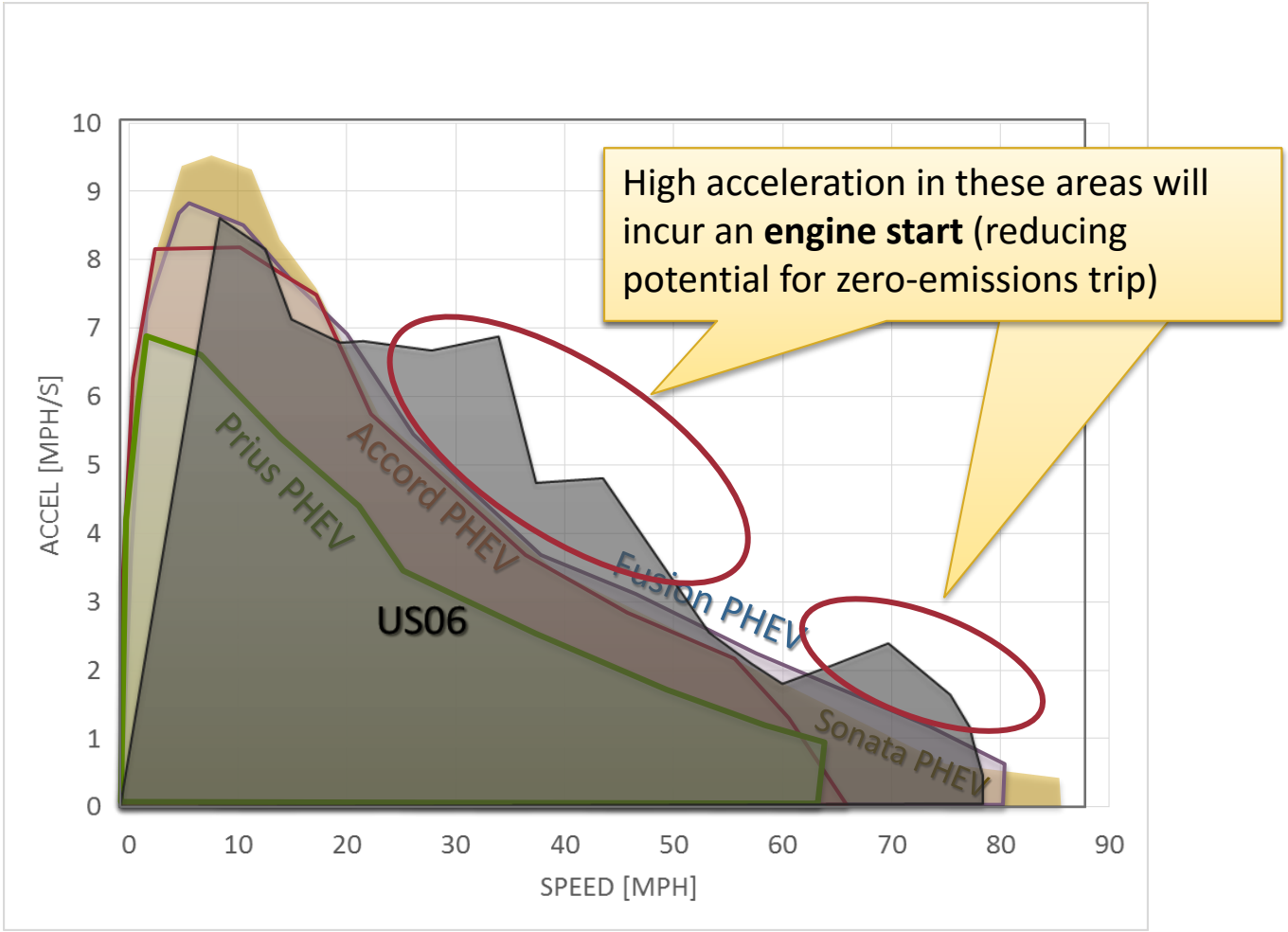
→ EV Power and EV Speed provide EV envelope



Cycle Requirements vs EV Capability

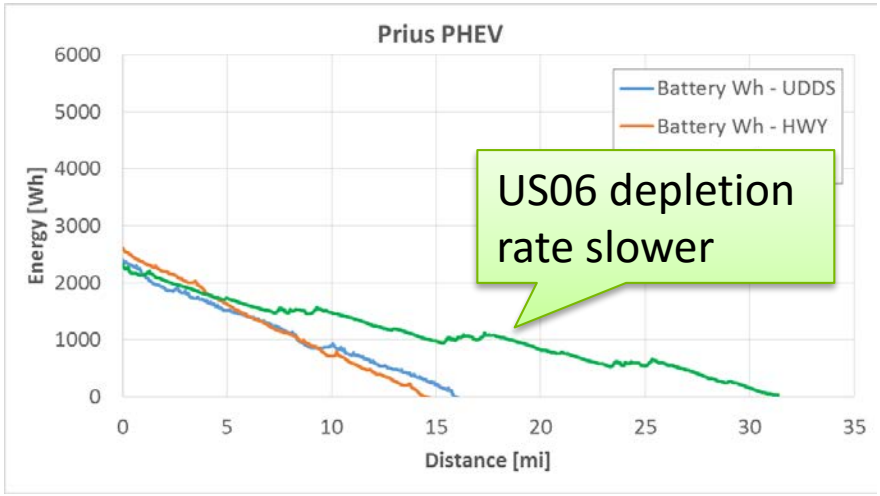


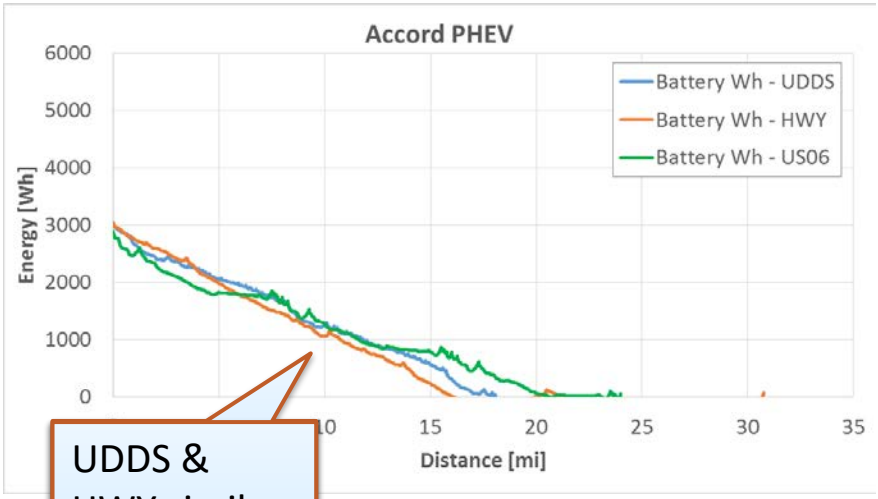
EV Capability: Speed / Accel Summary

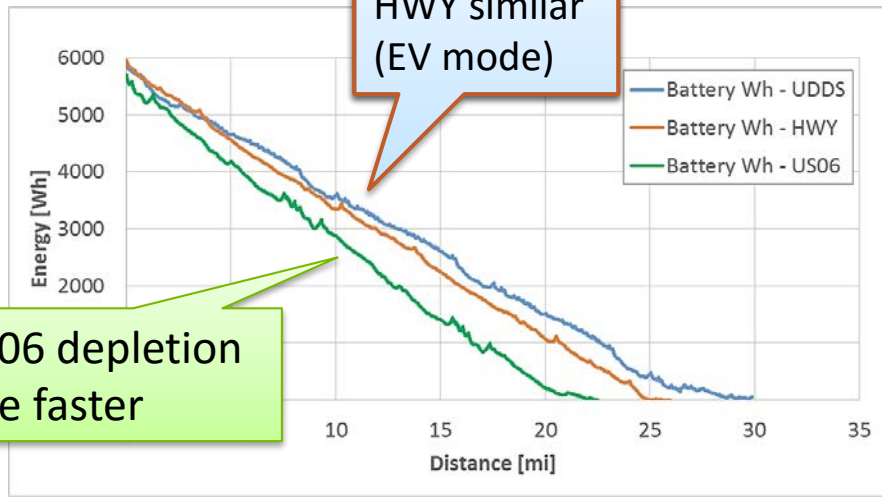


→ Important: criteria pollution can be dramatically decreased if engine starts are avoided in daily travel

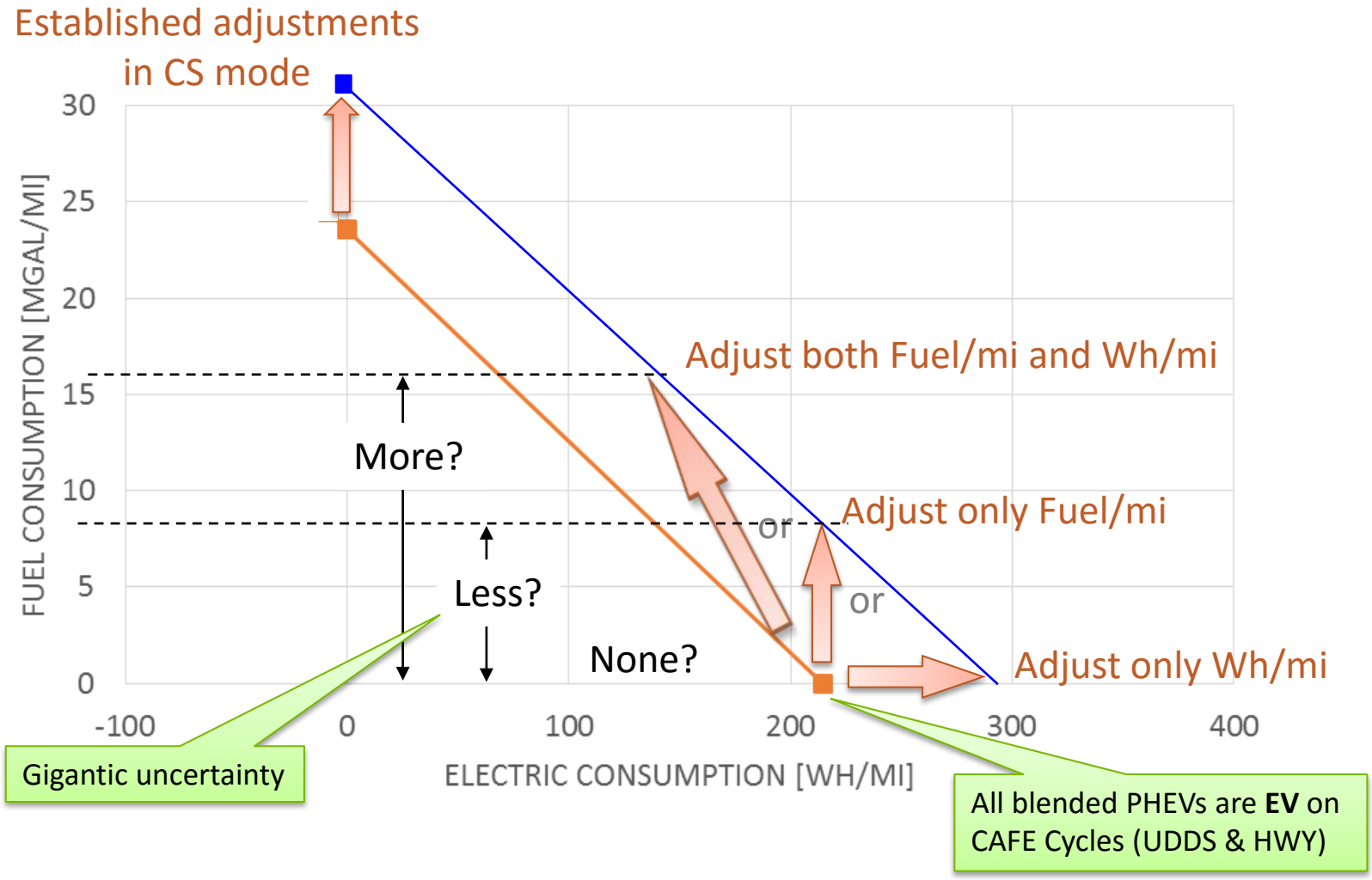
Depletion Rate: Key Factor in Fuel Displacement





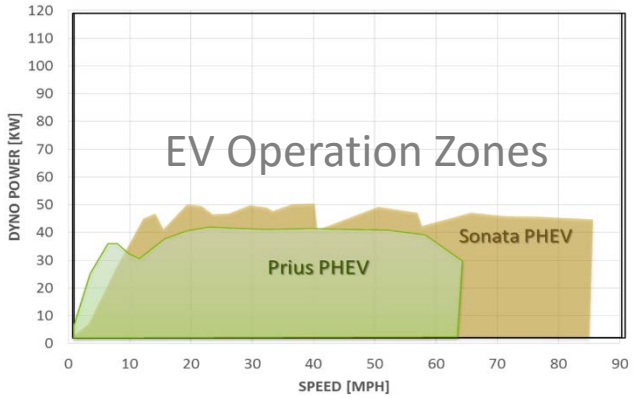


Using "Established Adjustments" for In-Use Driving? Not Possible with Blended PHEVs – Which Direction?

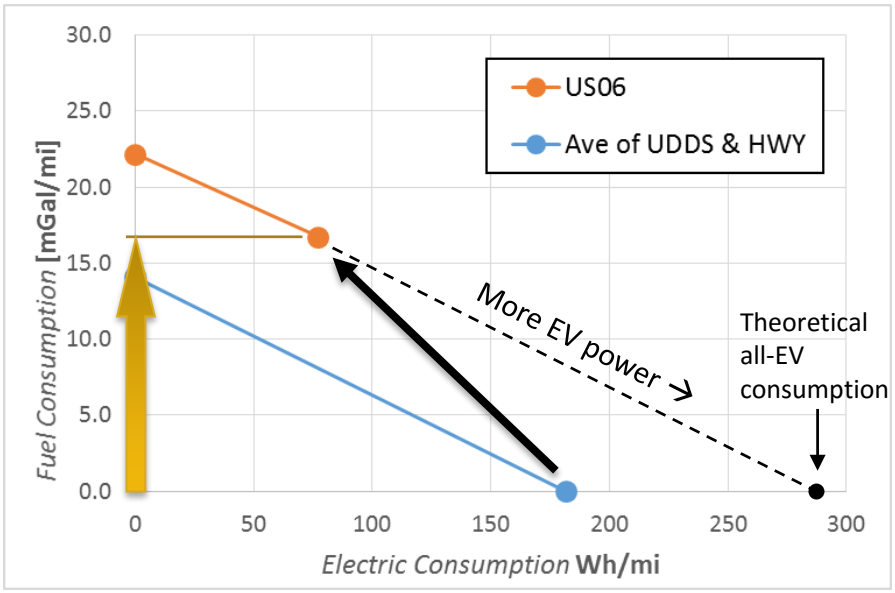


For Aggressive Driving (US06):

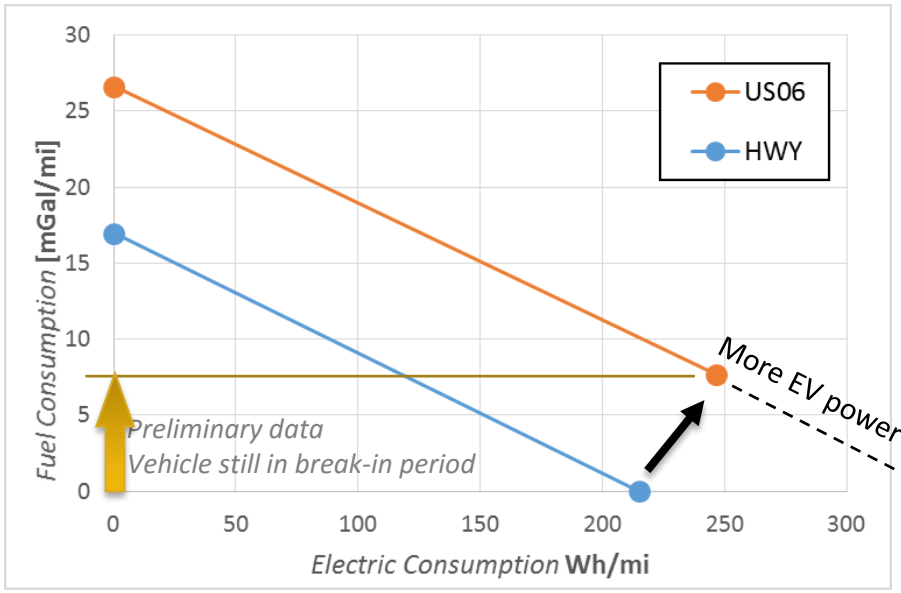
Vast Difference in Fuel Displacement with Small Changes in EV Power Capability



Prius PHEV

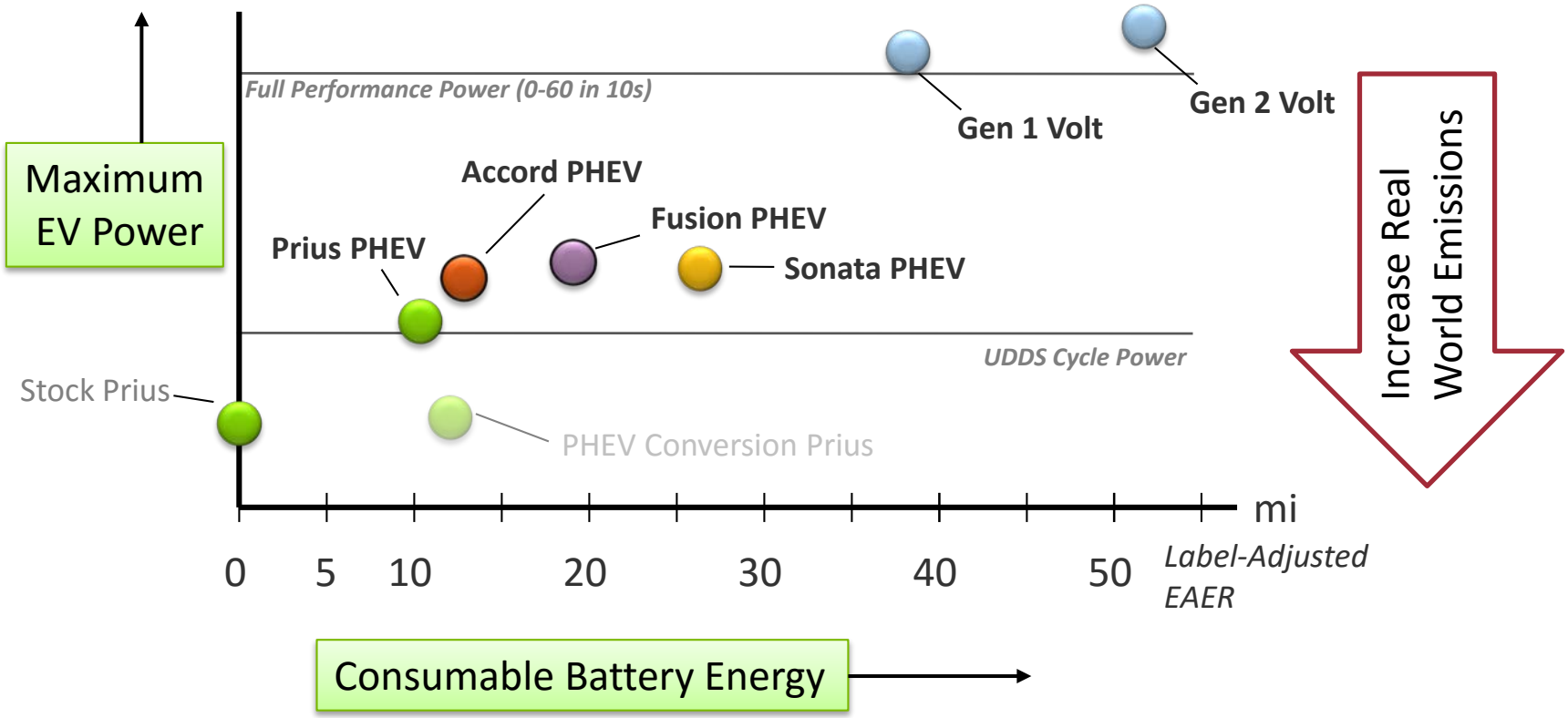


Sonata PHEV



→Prius: Because EV power and speed are low,
nearly 3x increase in fuel consumption compared to Sonata

Real World Driving Emissions and Fuel Consumption for Blended Plug-in Hybrids Will Be Defined by the Match Between their Electric Operation Envelop and Their Usage



The End