On-road Cold Weather Evaluation of the 2012 Chevrolet Volt

VSATT meeting
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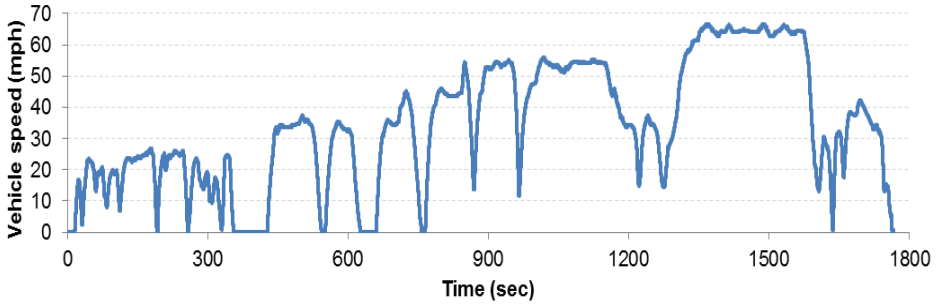
Idaho National Laboratory

On-road testing of a 2012 Chevrolet Volt

- Testing was performed during the winter and spring months to determine the impact of cold temperature on driving and charging efficiency
- A single test vehicle was parked and charged overnight in an unsheltered parking stall and driven by a single driver in the morning along a specified route
- Both the vehicle and the charging equipment were instrumented to record energy consumption and other usage parameters during driving and charging

Test Route

- The 16.9 mile route included a mix of rural, city, and highway roads in the Idaho Falls, Idaho area



A typical profile of vehicle speed versus time for the Idaho Falls cold weather test route

Test Conditions

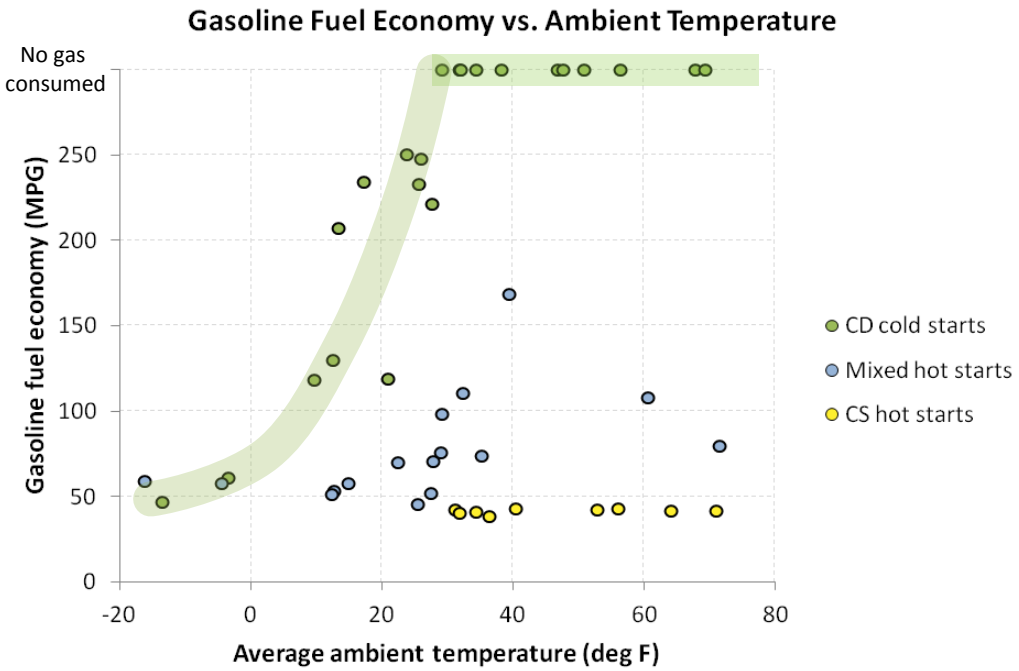
- Ambient temperatures ranged from -17°F to 70°F during testing
- For all tests, the defroster was run at max fan, max heat for 5 min after key-on, after which the climate control was set to ‘Auto’ 72 deg F
- No accessories other than the climate control system were used during testing.
- Cruise control was prohibited for all tests due to the possibility of icy roads on days below freezing and for consistent driving style for tests performed when ambient temperatures were above freezing.
- A single 185-lb driver performed all tests.
- There was no cargo in the vehicle.
- All tests were performed with the vehicle in “normal” mode (as opposed to “sport” or “mountain” modes).
- Prior to the first test in January 2014, tire pressure was set to the manufacturer’s recommended inflation pressure of 38 psi. This was done with ambient and tire temperatures at 39°F.
- Testing was only performed on days when the road was clear of snow or slush.
- The vehicle tested was not equipped with the option that allows the driver to select the temperature at/below which the engine may run to assist heating while in CD mode.

Performance Metrics

- The following metrics were tracked:
  - Gasoline fuel economy (mpg)
  - Electrical energy consumption (Wh/mi)
  - Electric-only (EV) mode range (mi)
  - Charge depleting (CD) mode range (mi)
- All varied significantly as ambient temperature varied

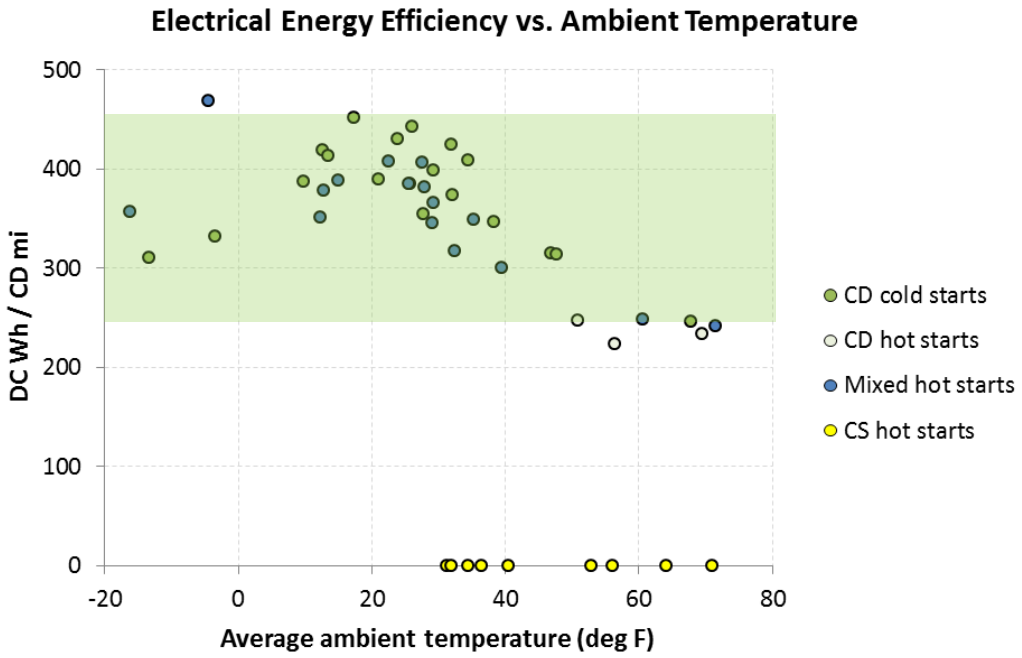
Vehicle Driving Efficiency: Gasoline Fuel Economy

- As an all-electric capable vehicle, the Volt was able to complete the test route without consuming any gasoline, until the ambient temperature fell to 27°F
- At 27°F, the vehicle's control system commands the engine to cycle on
- At even lower temperatures, the engine cycled on more frequently and fuel economy dropped further
- At -15°F, test fuel economy was 47 mpg, which approached charge sustaining operation fuel economy

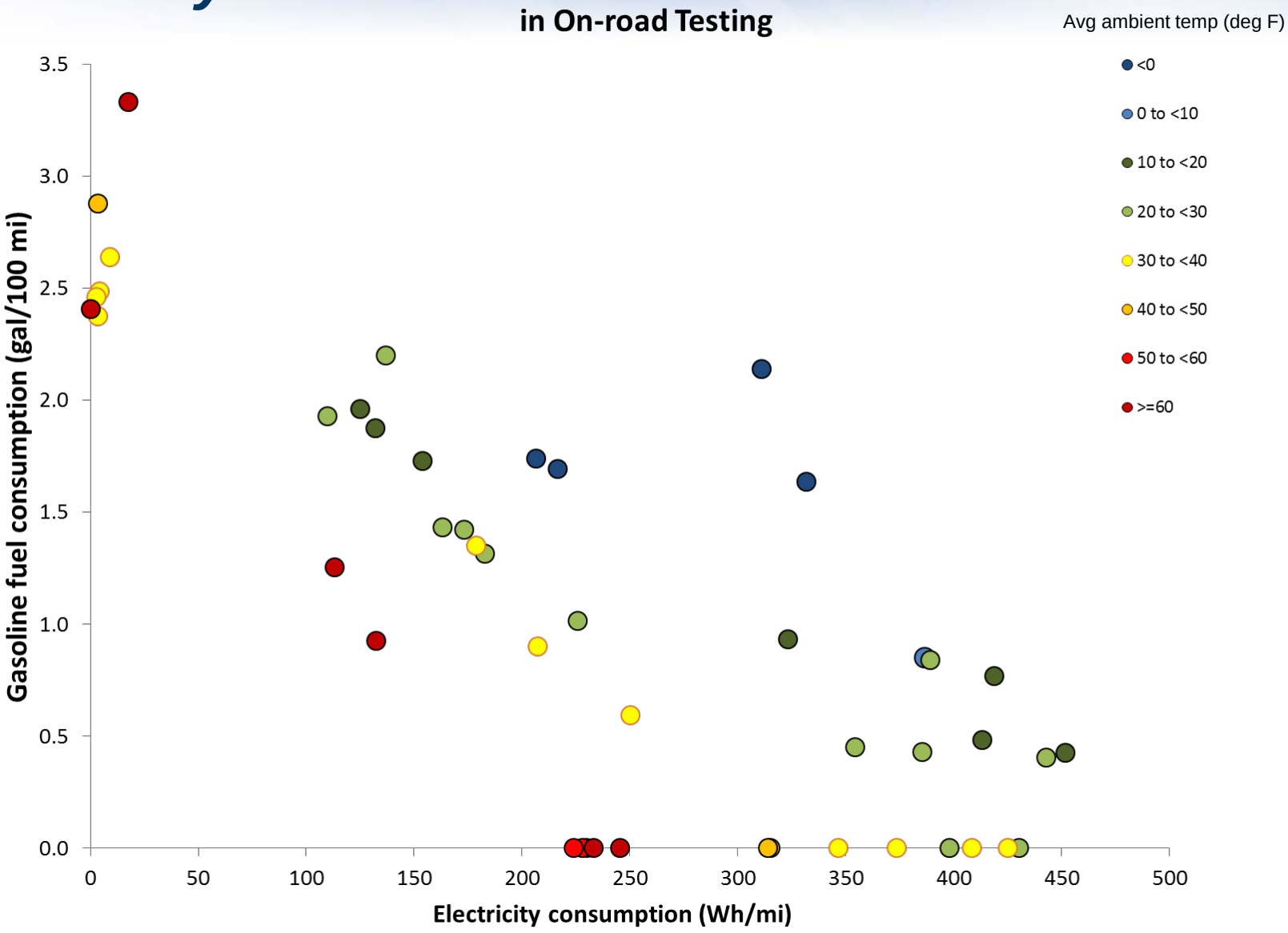


Vehicle Driving Efficiency: Electrical Energy Consumption

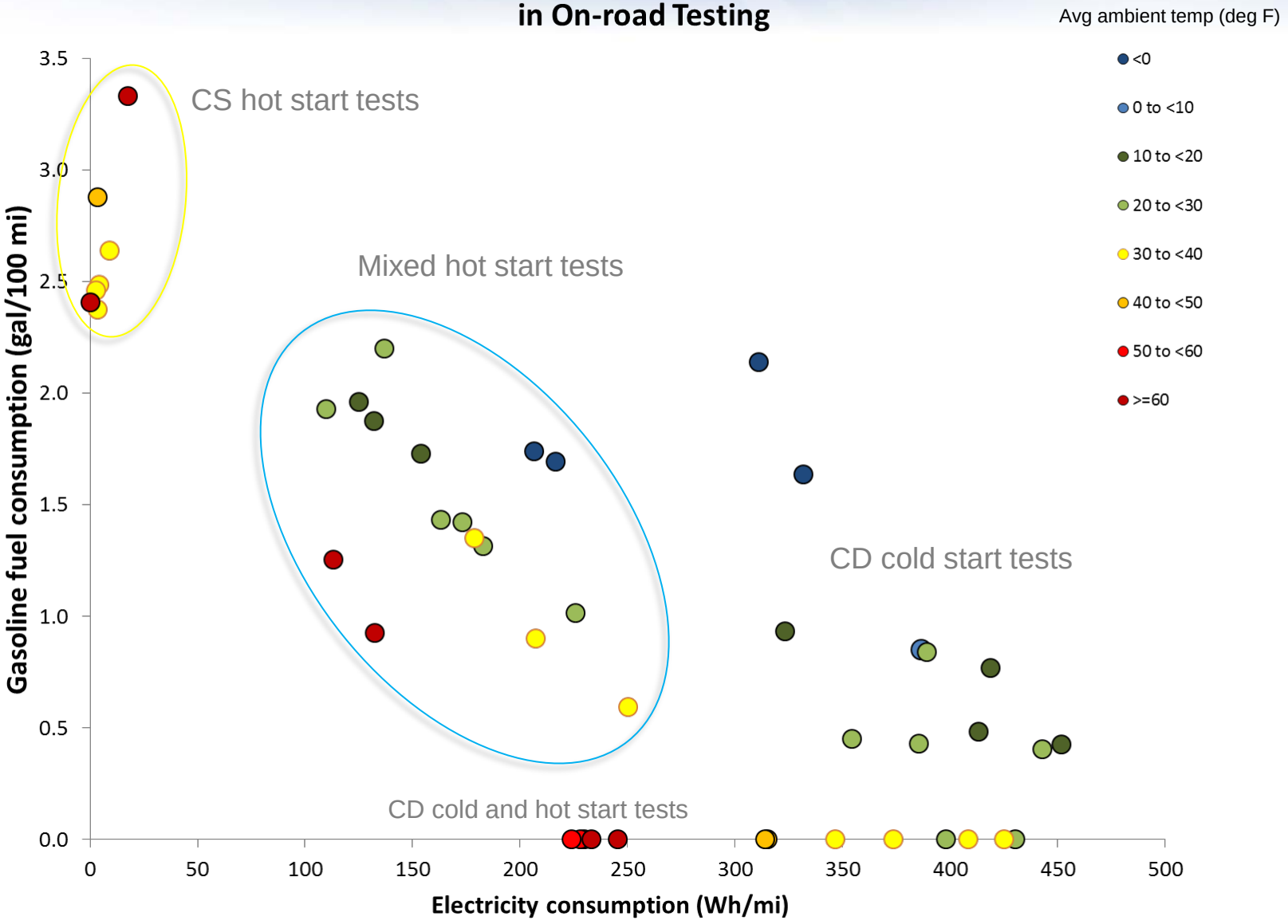
- Electrical energy efficiency across all CD tests with cold starts ranged from 246 DC Wh/mi to 452 DC Wh/mi
- This 84% increase in consumption can be attributed to the effects of cold temperature and climate control load
- During the coldest CD test, electrical energy efficiency during this test was 311 DC Wh/mi
- Cold start tests consumed less electrical energy than hot start tests below 0°F because the engine was on for a greater portion of the test and offset electrical power consumption from the battery



Vehicle Driving Efficiency



Gasoline and Electricity Consumption in On-road Testing



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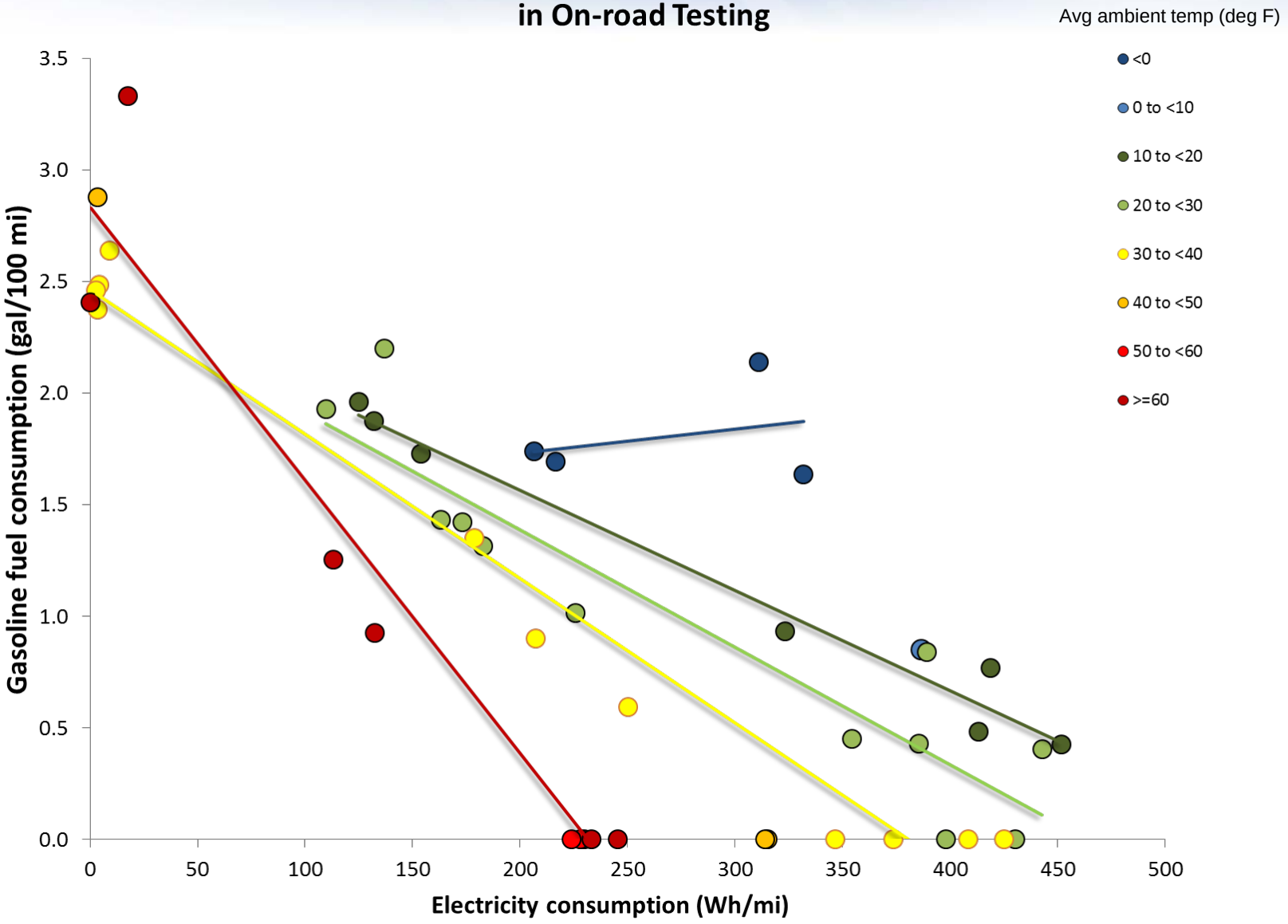
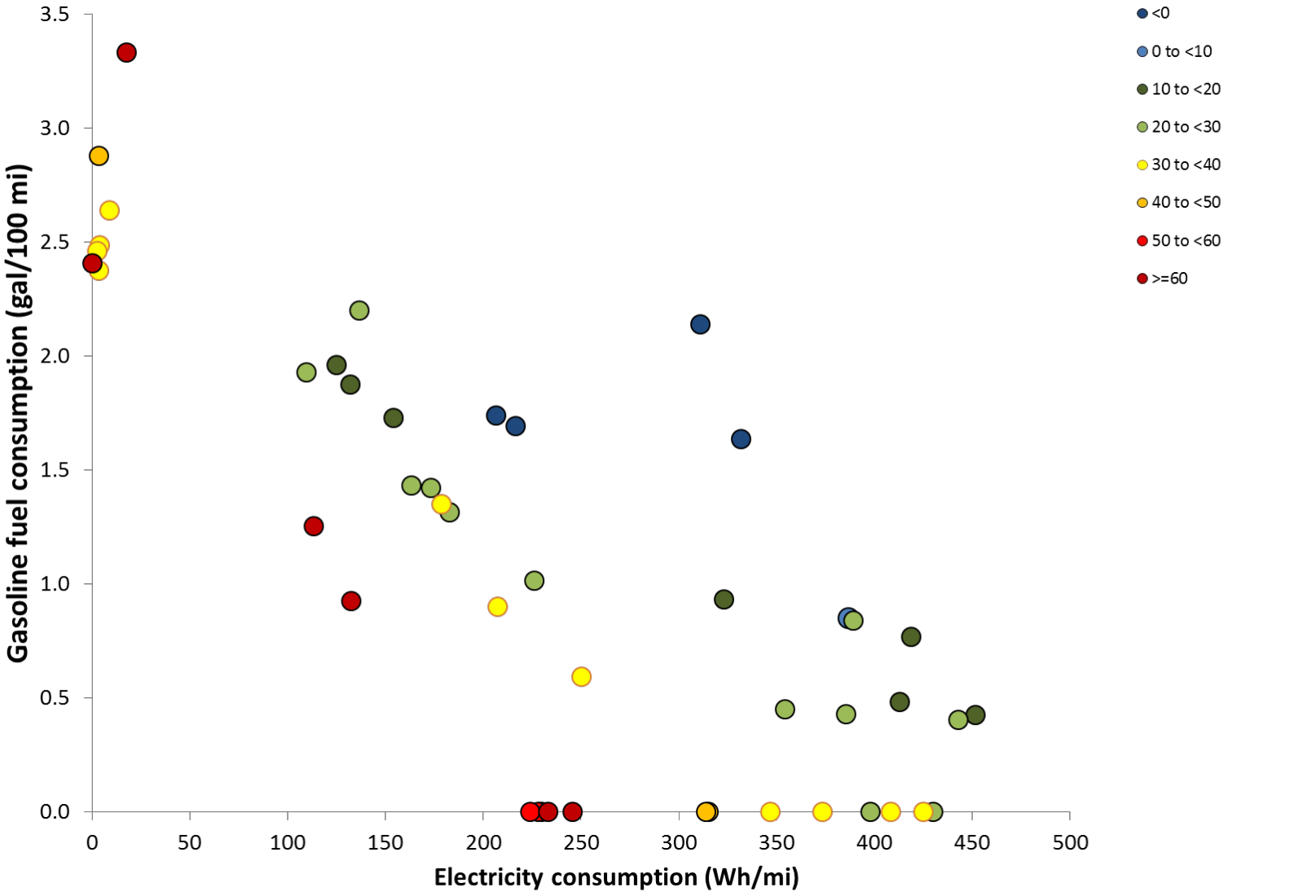


Gasoline and Electricity Consumption in On-road Testing and Standard Dyno Cylces



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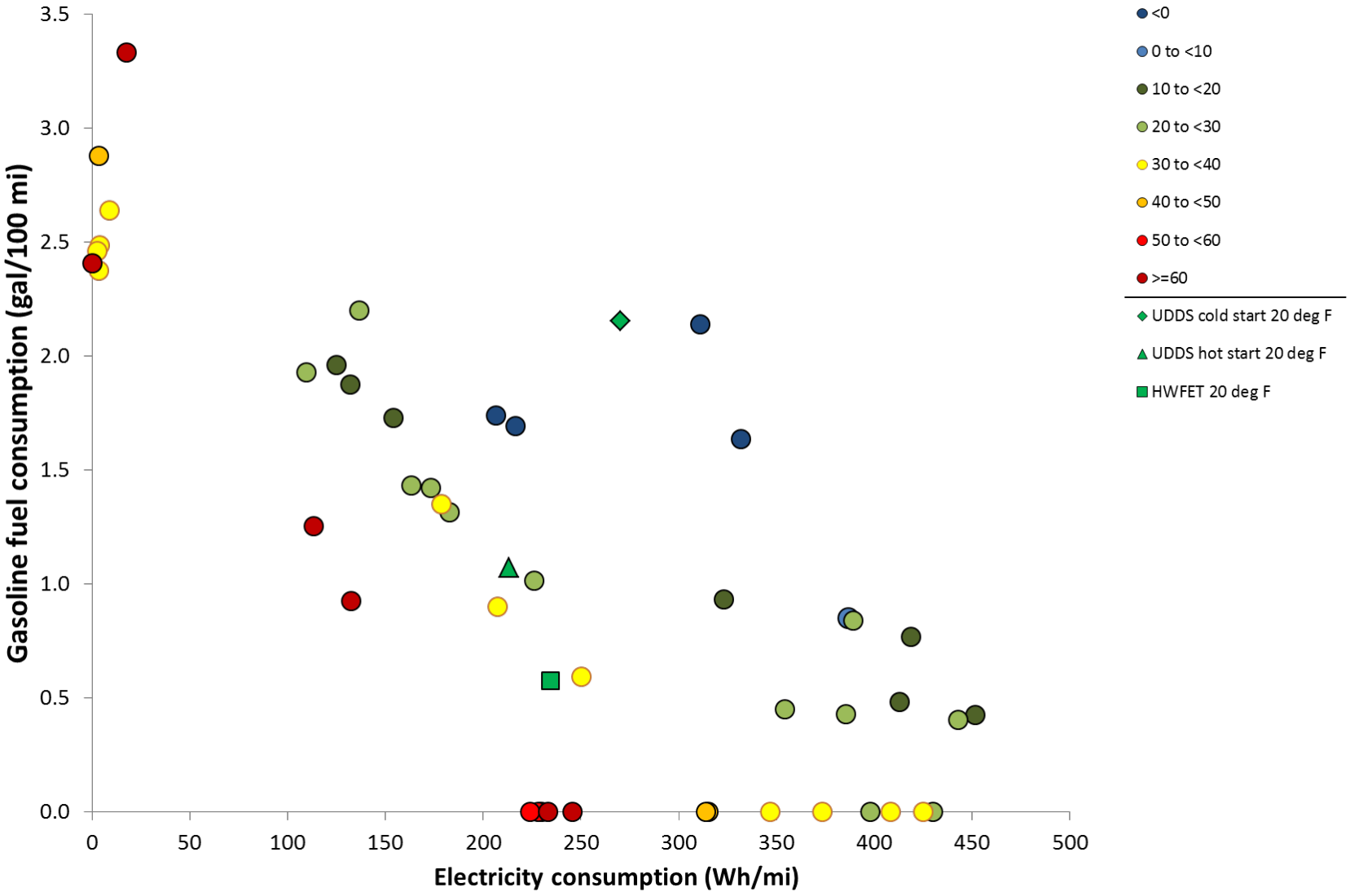

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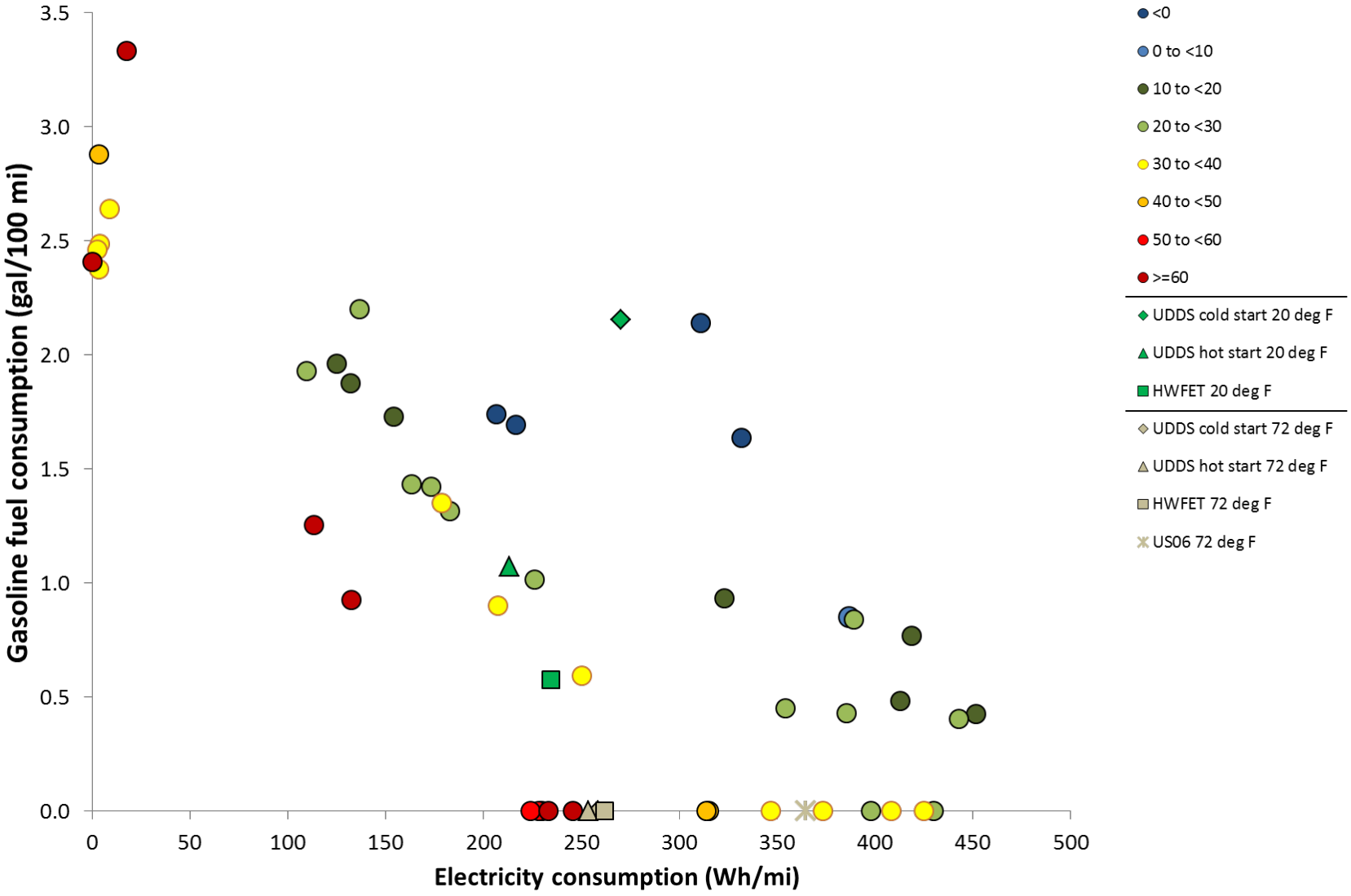

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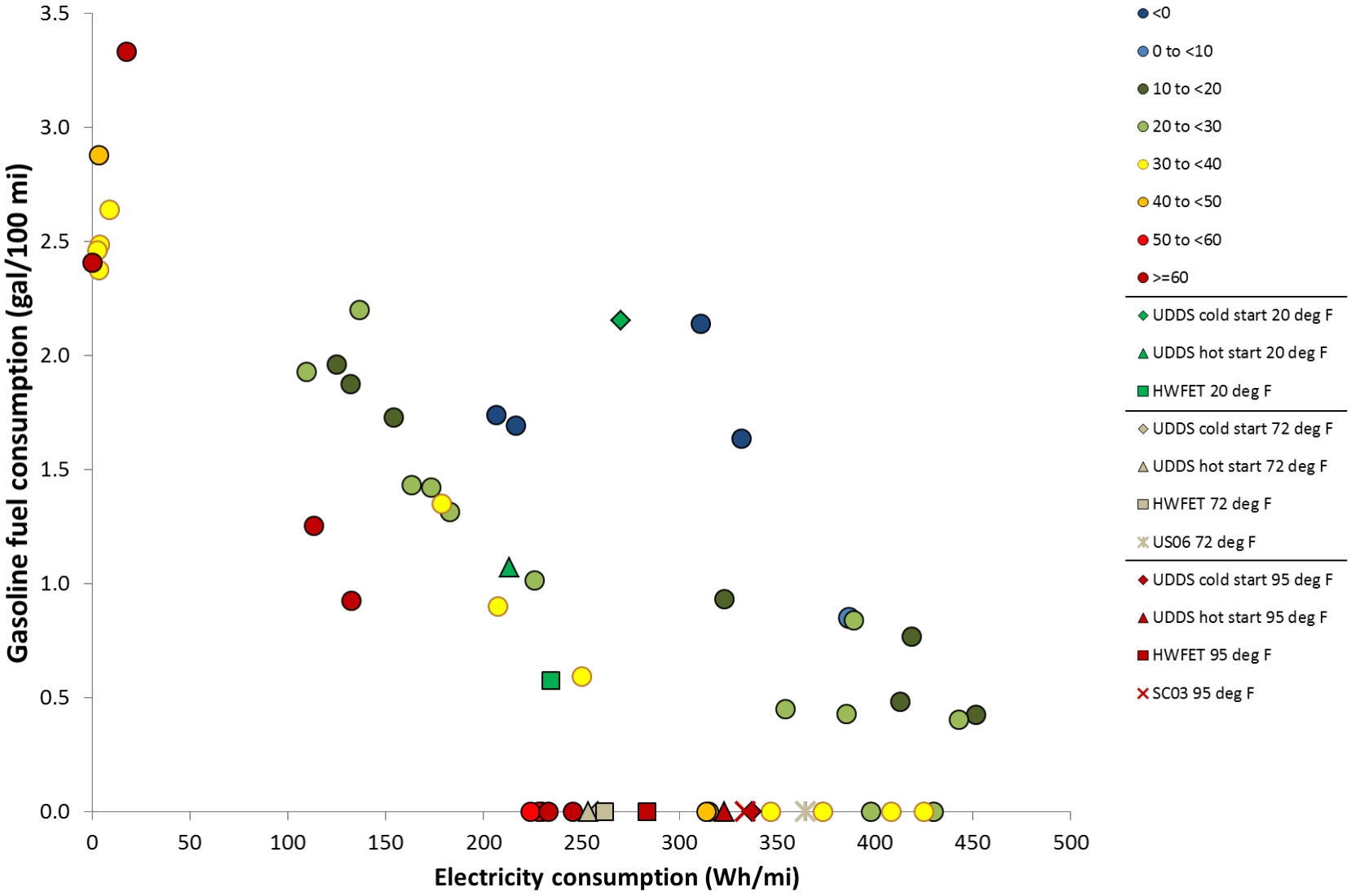
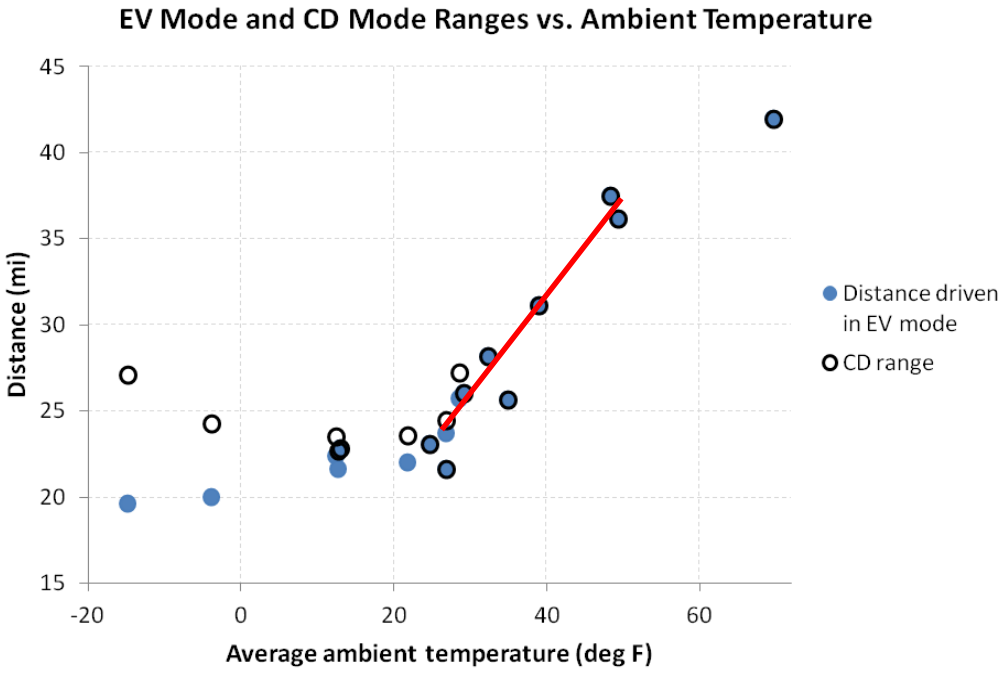


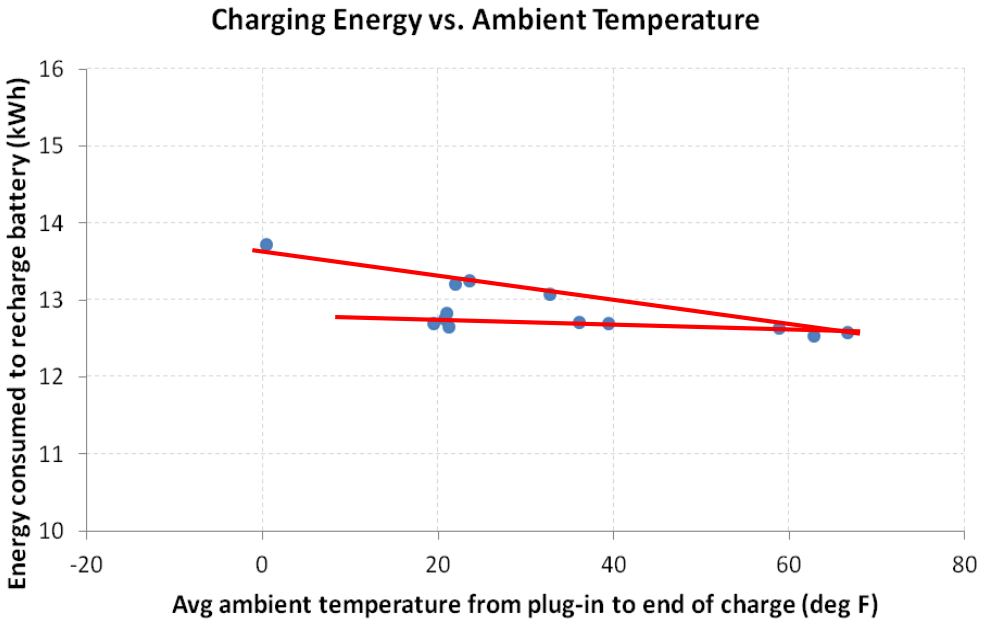
EV and CD Mode Range

- The Volt's full-charge EV range dropped from 42.0 miles at 70°F to 19.7 miles at -15°F, a reduction of 53%
- EV range fell off fairly linearly in tests averaging 50 to 25°F at a rate of 0.6 miles per deg F
- CD range diverged from EV range in tests when temperatures were 27°F or less, because engine operation due to cold temperature also slowed the rate of battery depletion



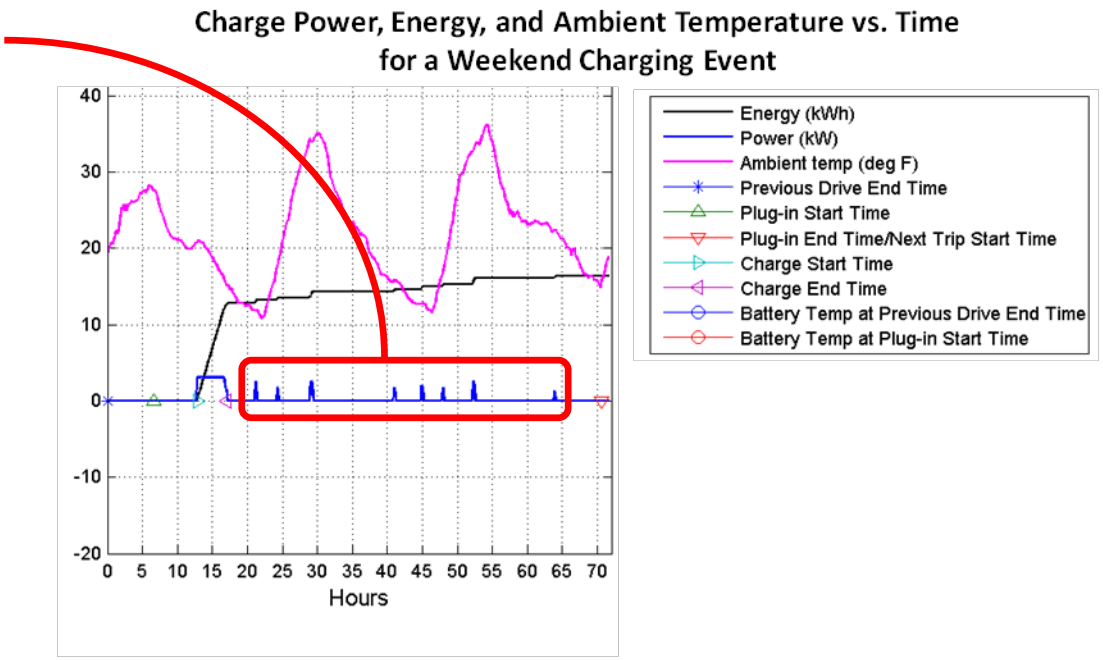
Vehicle Charging Efficiency

- Energy consumption during overnight charging ranged from 12.53 to 13.73 AC kWh (10% increase)
- Energy consumption increased with decreasing temperature, but not at a consistent rate
- Additional instrumentation is required to determine the cause of this variation



Vehicle Charging Efficiency (cont.)

- The Volt draws power after charging to heat the battery
- This post-charge power draw resulted in additional energy consumption of 3.56 AC kWh for the charging event shown
- Naturally, the energy consumed due to post-charge power draw is a function of how long the vehicle remains plugged in
- The short power spikes peaked between 1.8 to 2.6 kW and lasted for 10 to 25 minutes



Time history data for a charging event when the vehicle was left plugged-in over the weekend.

To access the full report on the INL website, go to:
avt.inl.gov/pdf/phev/2012VoltColdWeatherTestReport.pdf