
The Transient Nature of Particle Emissions from Light Duty Hybrid Vehicles

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The Light Duty Hybrid Project

- Four light duty gasoline-electric hybrid vehicles tested over 5 driving cycles at 20°C and -18°C
- The hybrid vehicles:
 - Honda Civic 2003
 - Honda Insight 2000
 - Ford Escape 2005
 - Toyota Prius 2004
- The 2002 gasoline Smart Car

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The Light Duty Hybrid Project

- 4-phase Federal Test Procedure (FTP)
- 4-phase LA92
 - Represents real-world driving behaviour with more transients and higher speeds than the FTP
- New York City Cycle (NYCCx2)
 - Congested urban driving conditions
- US06x2
 - Aggressive, high speed driving conditions
- Highway fuel consumption test (HWFCT)
 - Free-flow highway driving conditions

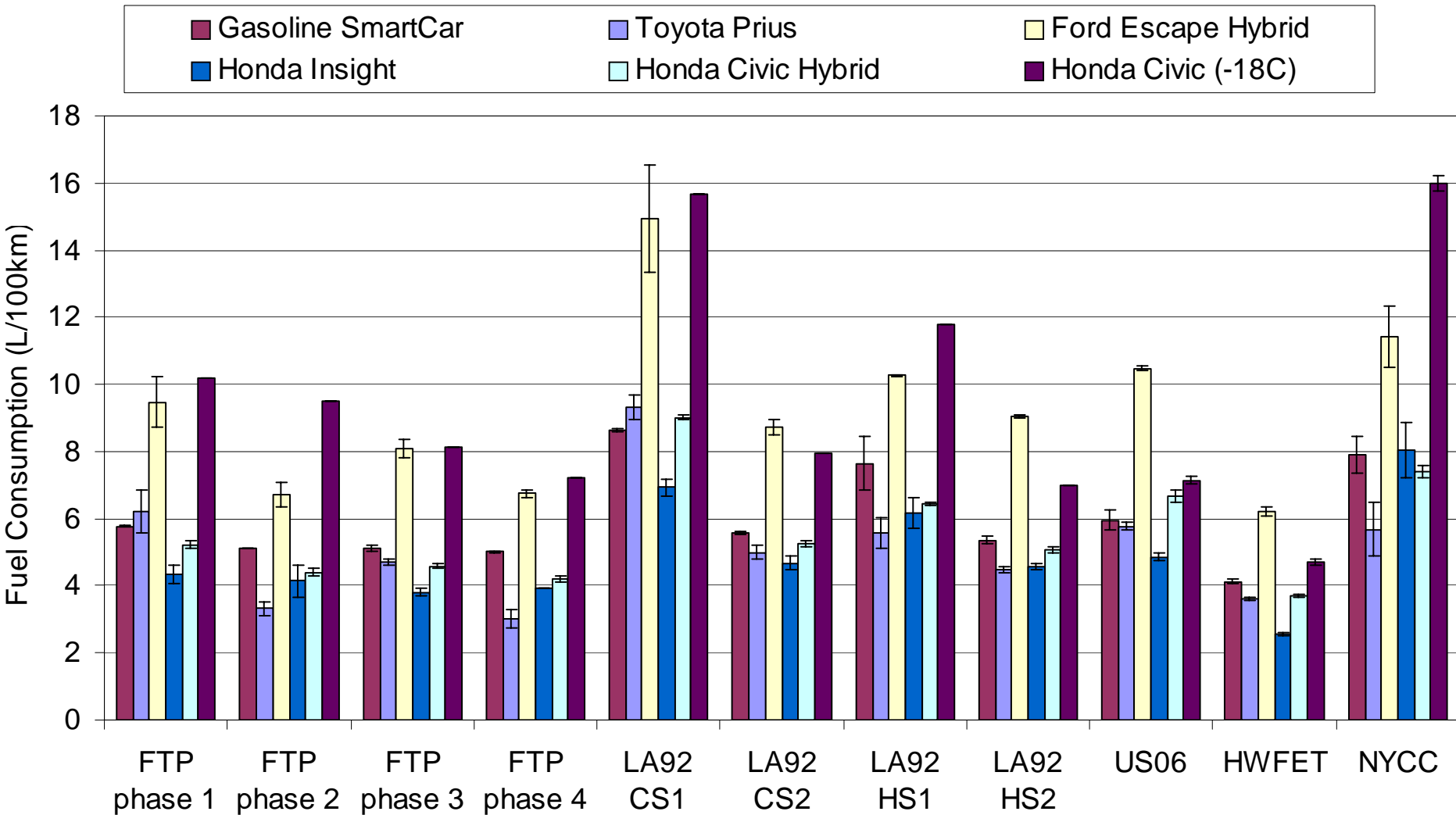
Integrated Sampling

- PM
 - PM_{2.5} mass emissions
 - Teflo filter media
 - PM_{2.5} Organic and elemental carbon emissions
 - Quartz filter media with artifact correction scheme
- Criteria Emissions
 - CO, NO_x, THC, NMHC, NMOG
- Green house gas emissions
 - CO₂, N₂O, CH₄

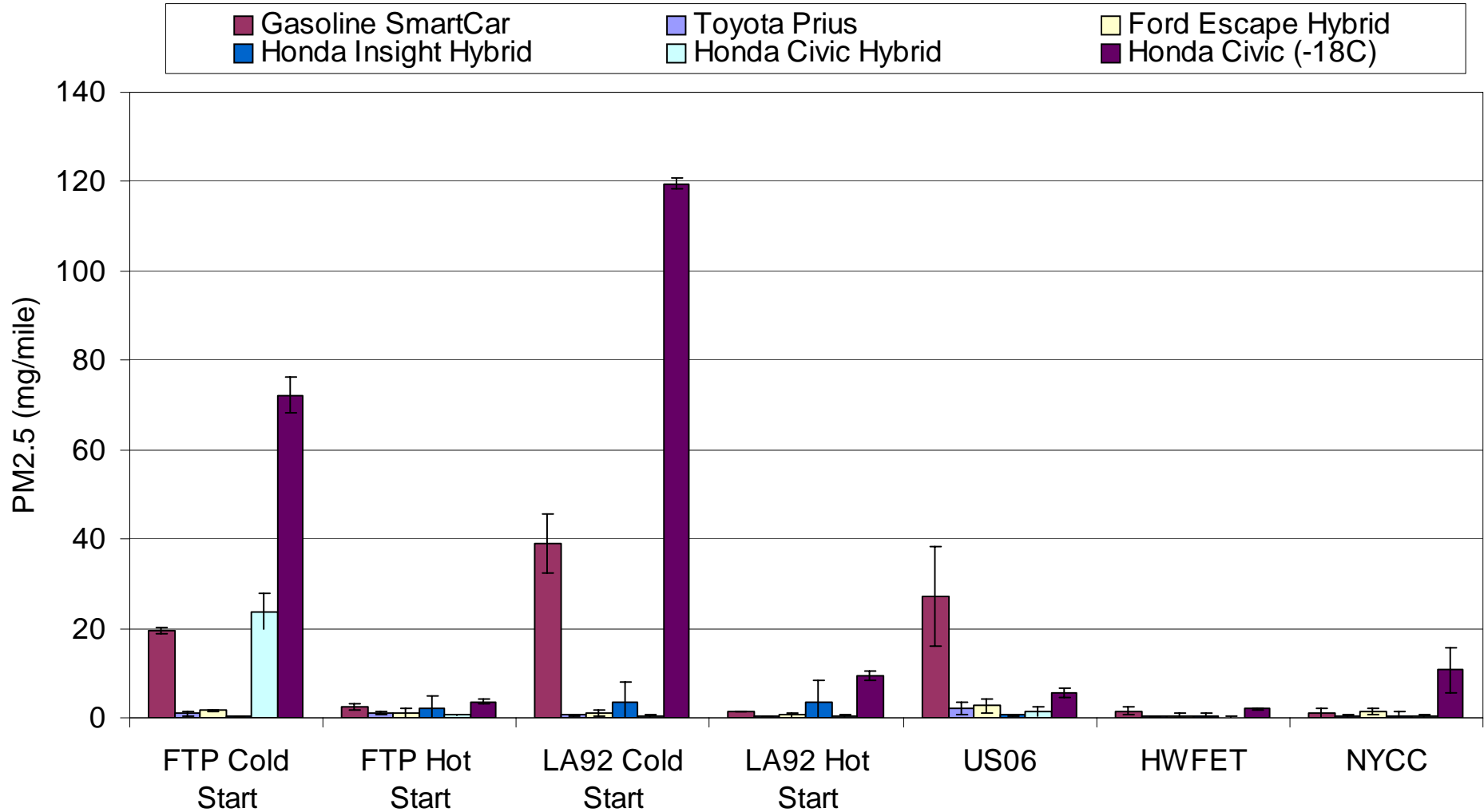
Transient Sampling

- Total particle number emissions
 - Condensation Particle Counter (CPC)
- Particle size distributions
 - Electrical Low Pressure Impactor (ELPI)
- Modal (second by second) gaseous emissions
 - CO₂, CO, NO_x, THC
- Hybrid battery state of charge (SOC)
 - Measured for Civic and Insight using Snap-Link™ OBD scan tool
- Charging current
 - Measured for Prius and Escape

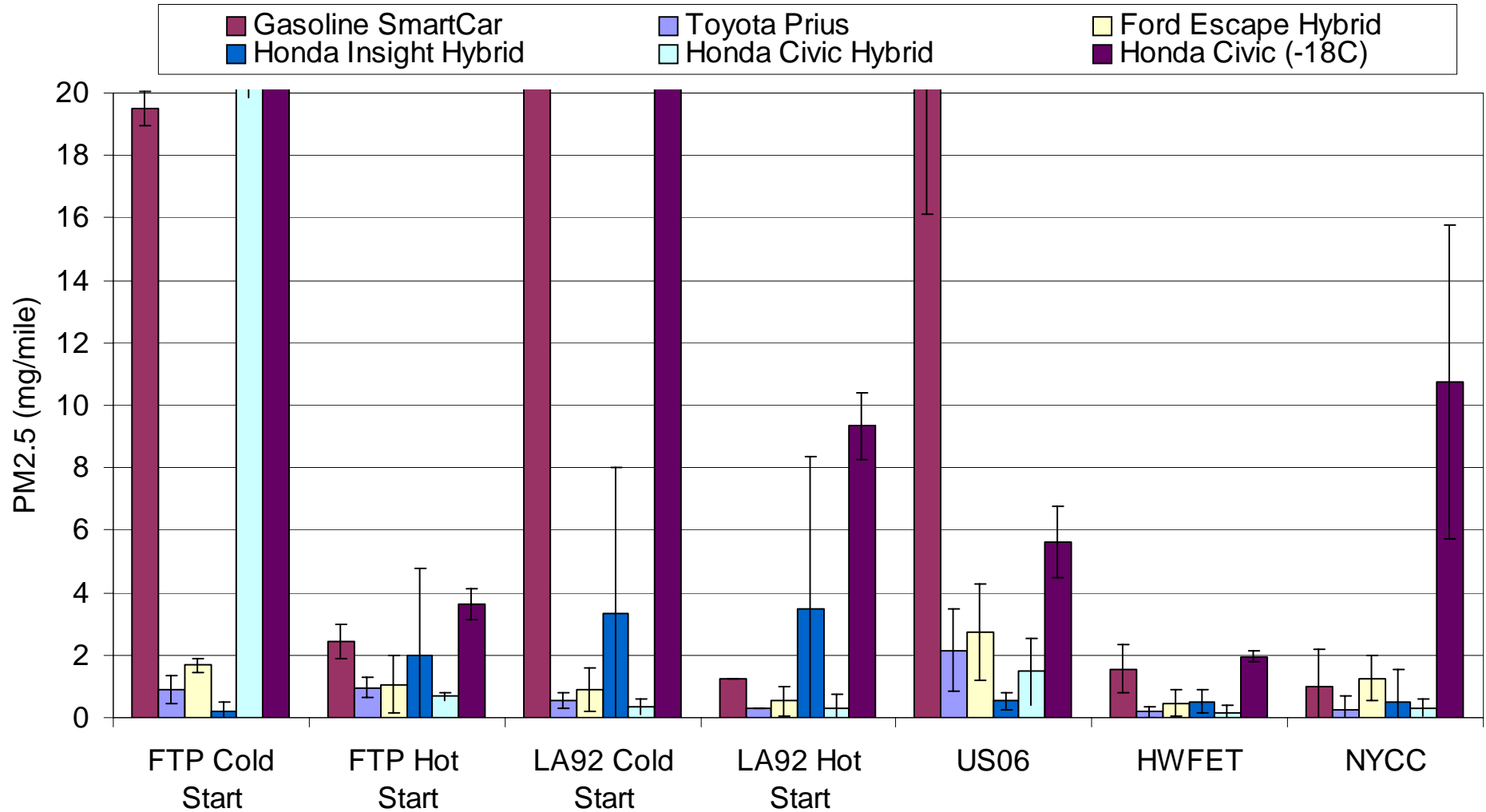
Fuel Consumption



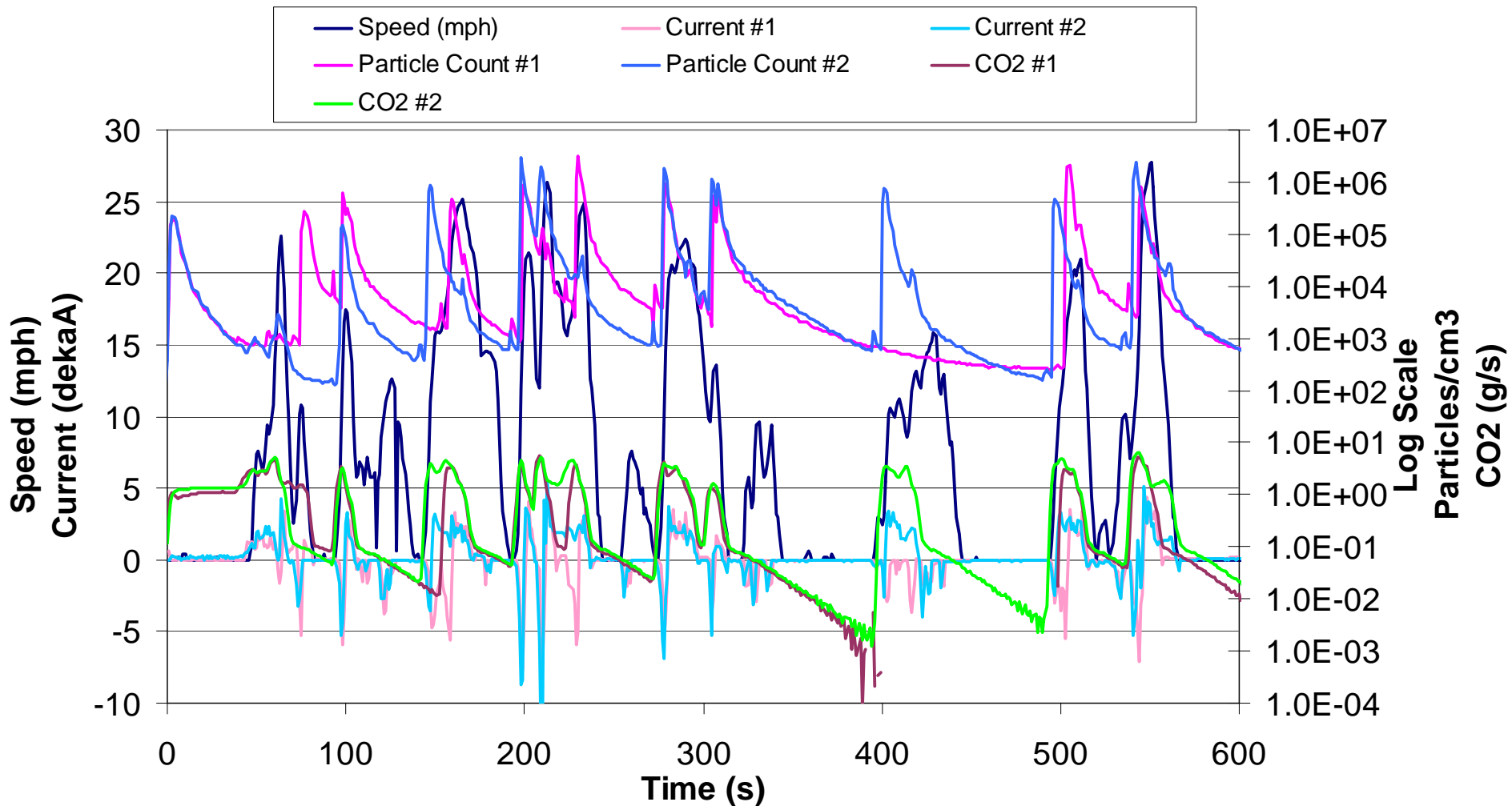
PM_{2.5} Mass Emissions



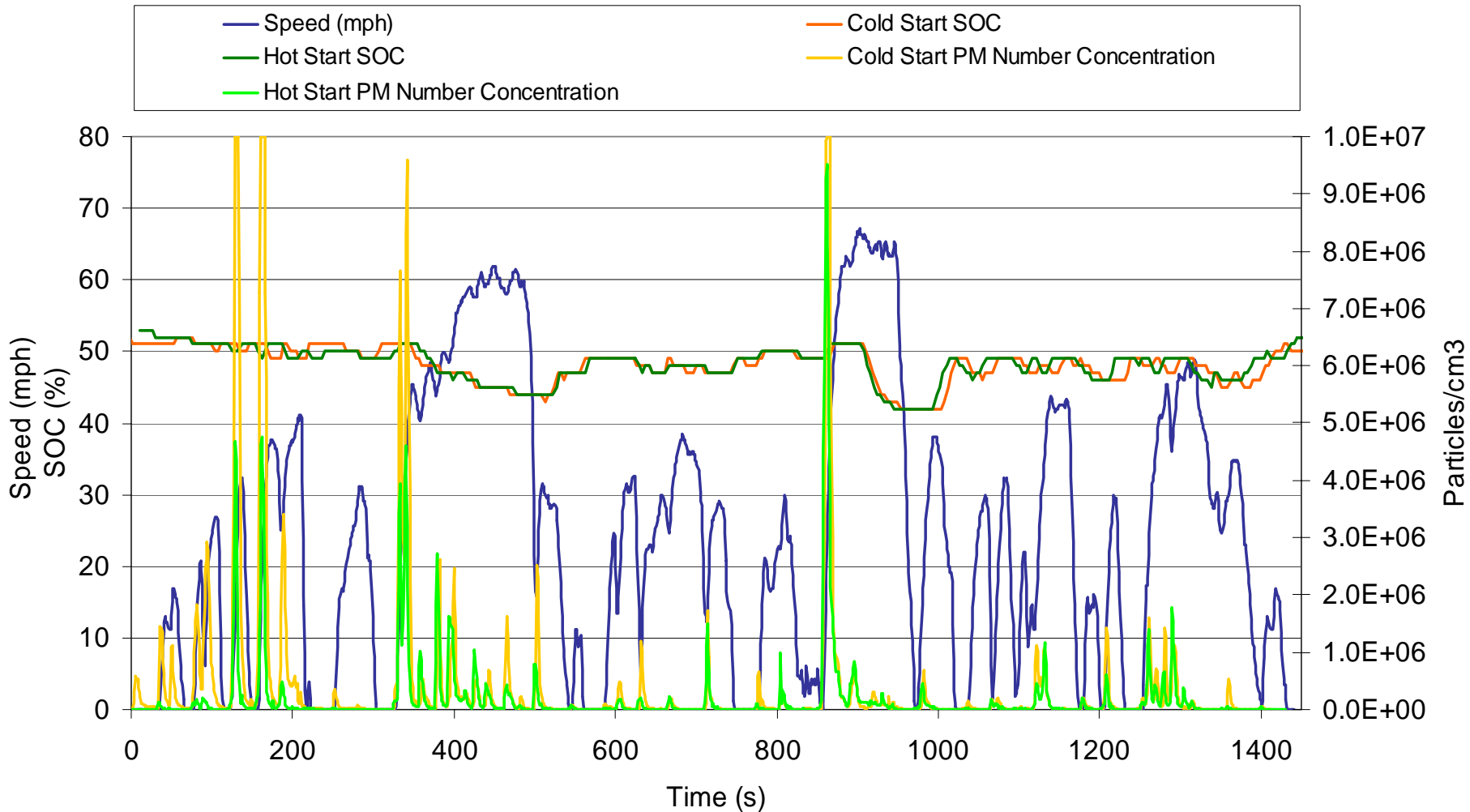
PM_{2.5} Mass Emissions



NYCC – Ford Escape Hybrid

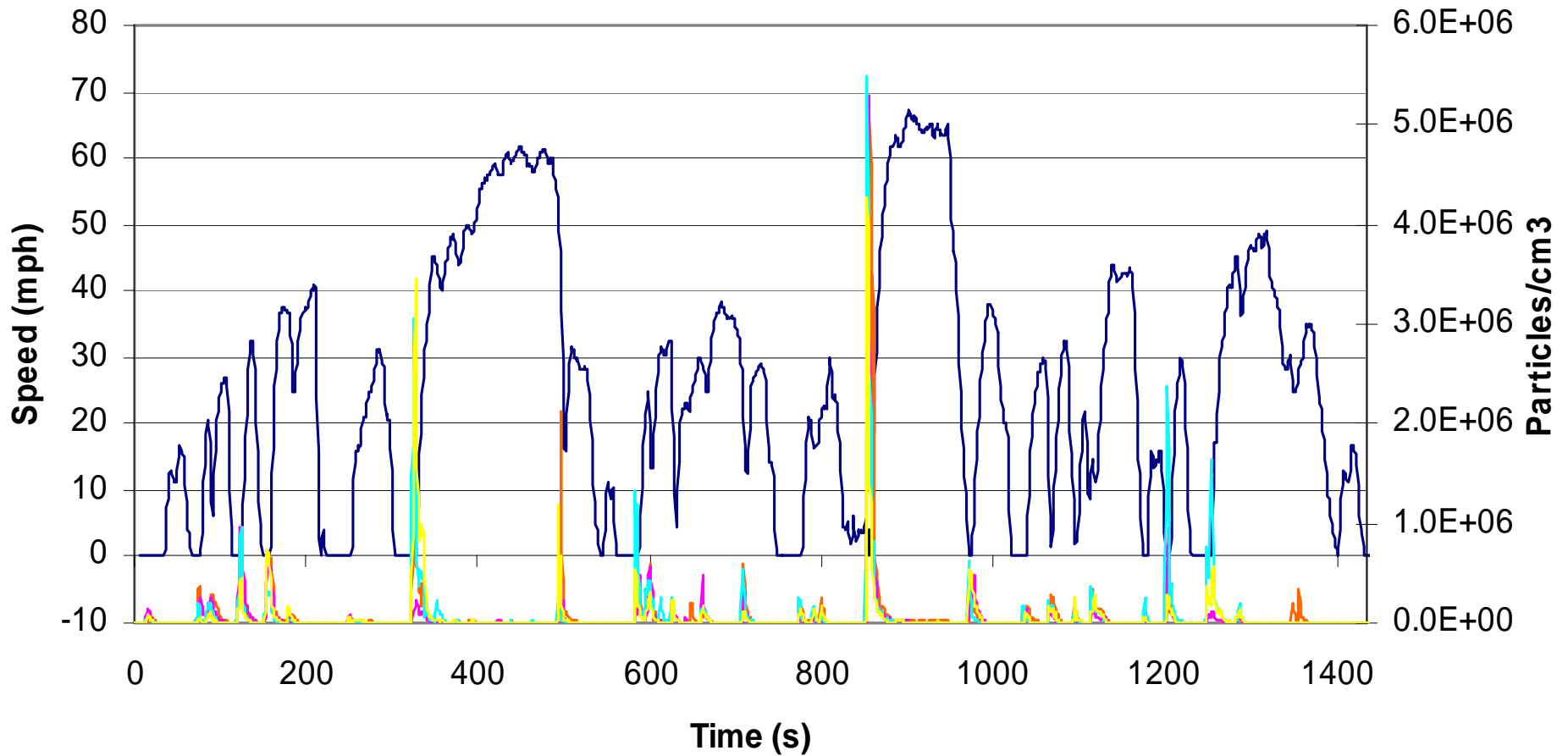


LA92 - Honda Civic Hybrid

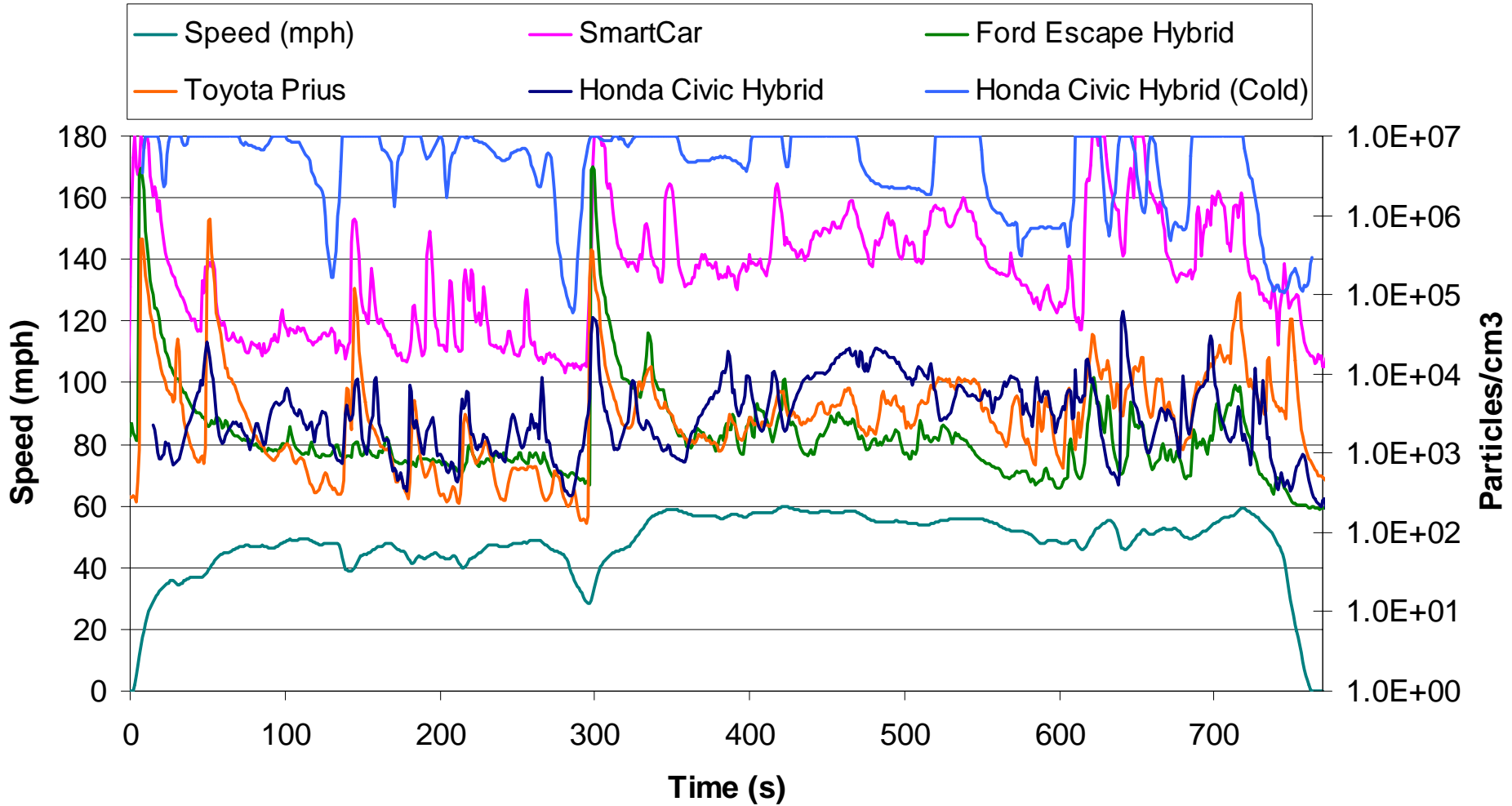


LA92 – Toyota Prius

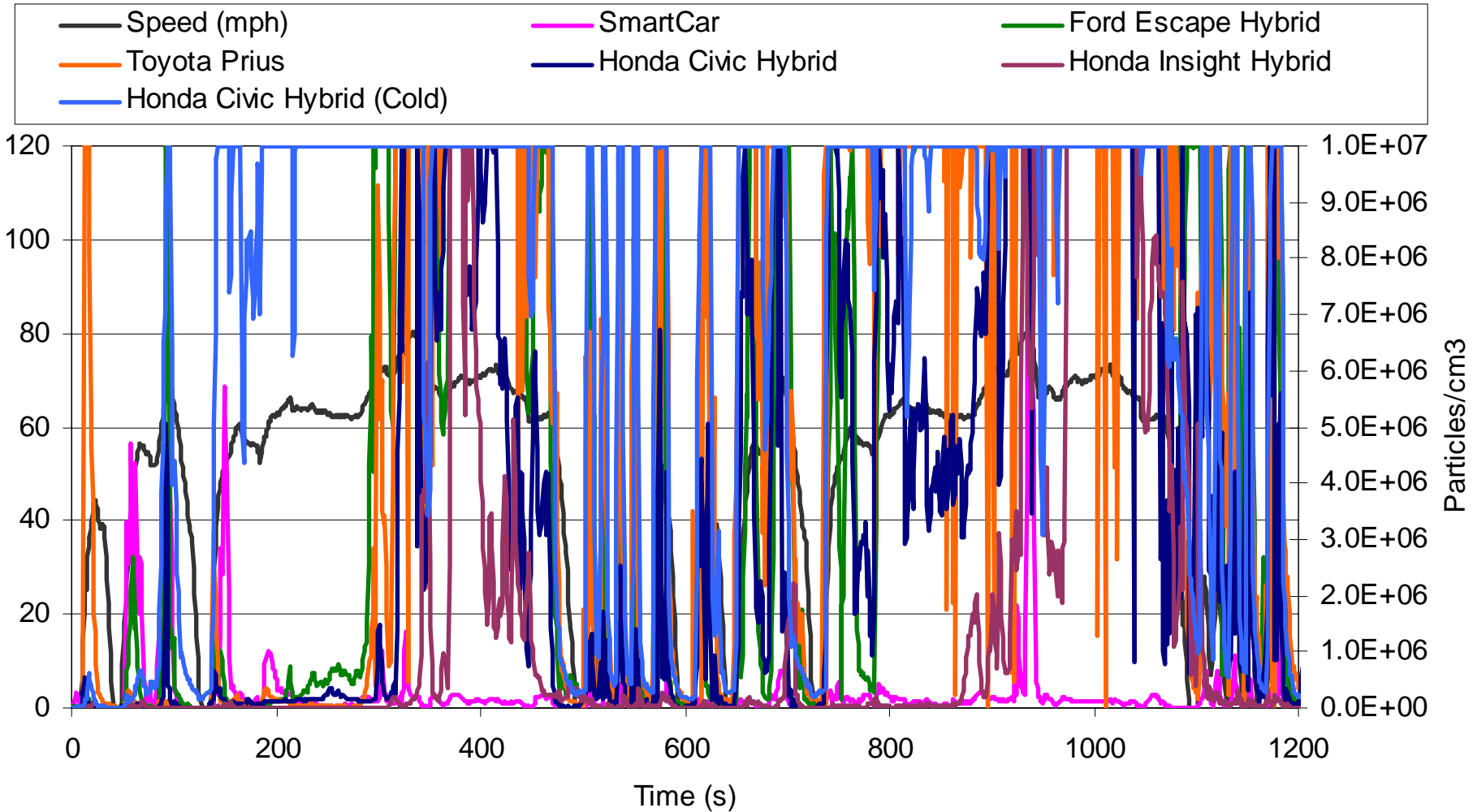
— Speed (mph) — Cold Start #1 — Cold Start #2 — Hot Start#1 — Hot Start #2



HWFCT – Particle Emissions



US06 – Particle Emissions



Concluding Remarks

- Patterns in total particle number concentrations from the hybrid vehicles are in some ways similar to conventional vehicles with large increases in concentration on accelerations.
- Different patterns are observed under driving conditions where the engine is turned off, or the electric drive assists in accelerations.
- Patterns can vary from one repeat of a test to another depending on battery state of charge.

Concluding Remarks

- Cold temperatures result in higher mass and number emission rates of particulate matter as compared to standard temperature
- Cold temperatures influence the transient nature of particle emissions from hybrid vehicles
- The transient and variable behaviour of light duty hybrid vehicle emissions have implications in emission inventory development

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