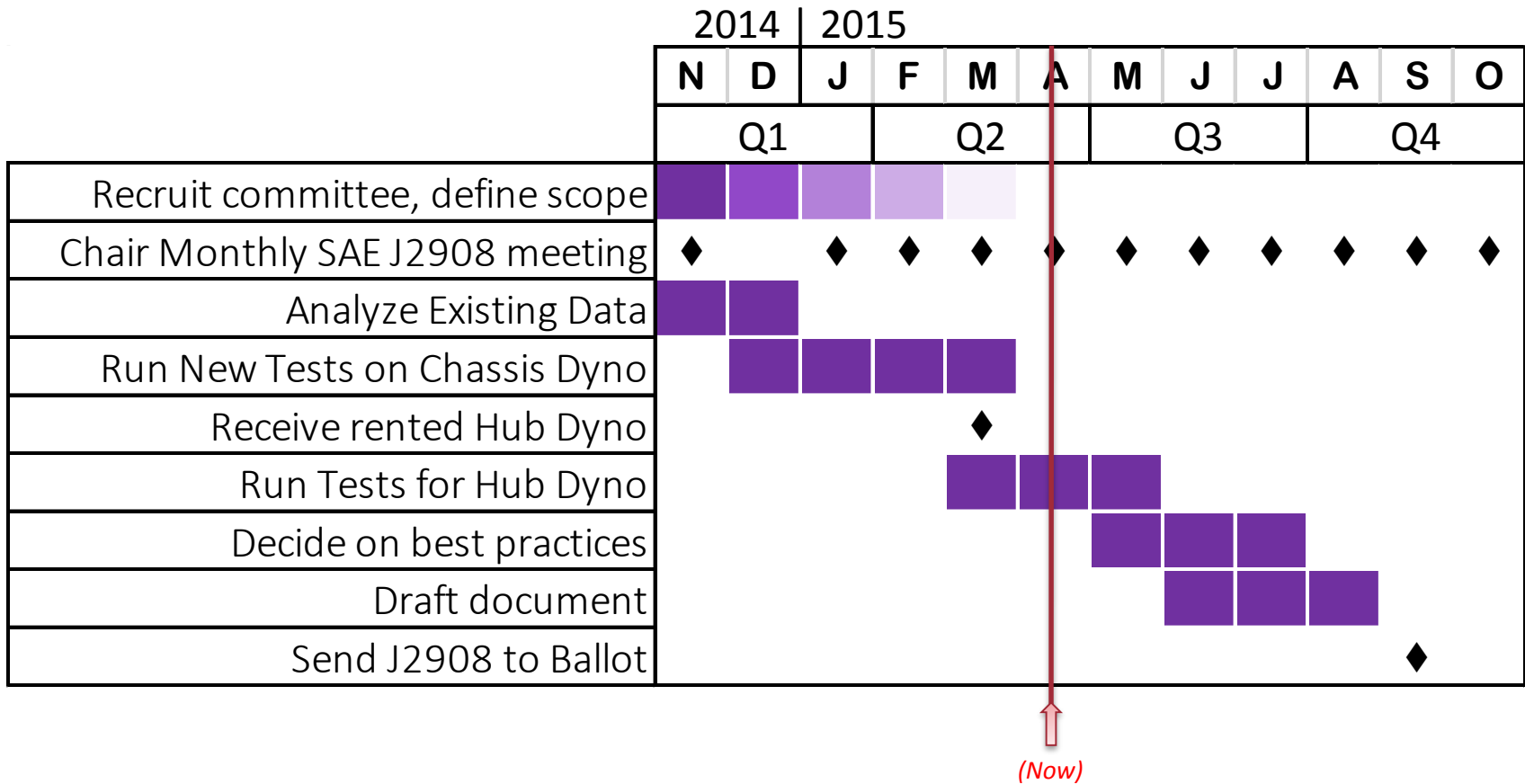


SAE J2908: Hybrid System Power Rating

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SAE J2908 Timing, Milestones



J2908 Must Satisfy a Challenging List of Objectives

1. Describe **Hybrid System Power** in clear, unambiguous terms
2. Avoid **creative interpretation** of procedure → “horsepower wars”
3. If we use **wheel power**, what about current **Engine Flywheel power**?
 - The same “200 HP” car could rate at “162 System HP”
4. Avoid requirement to buy **expensive new dynamometer equipment**
5. Target the needs and perspectives of **both audiences**:
 - **Consumers**
 - **Vehicle Systems Engineers**
6. Provide a procedure **robust** enough to succeed in any powertrain configuration
 - Power-split, series, step transmission, belt CVT, mild HEV, full PHEV, (even BEV?)

Two System Power Approaches

A. Nominal System Power **Rating**

- Based upon component-level power(s)
- Similar to current engine power rating, “Catalog Rating”

B. System Power **Test**

- Based upon dyno test
- Verifiable test for engineers to communicate power levels

Additional Hybrid System Metrics in J2908

Ratings Will Provide Common Data Benchmarks

1. Electric Assist

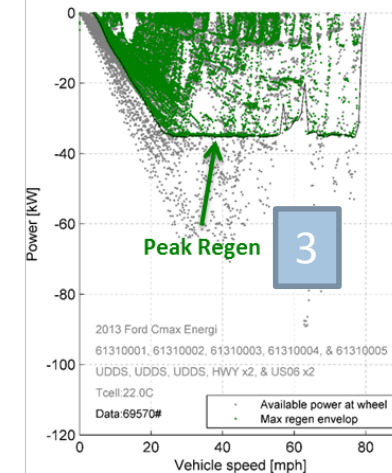
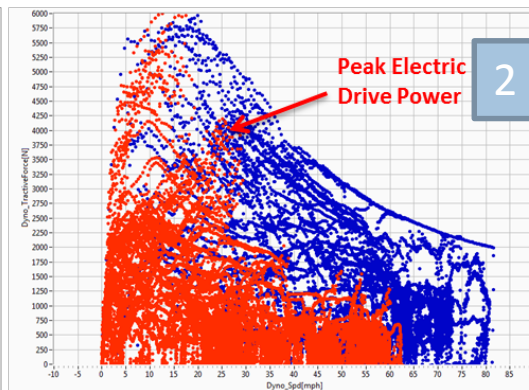
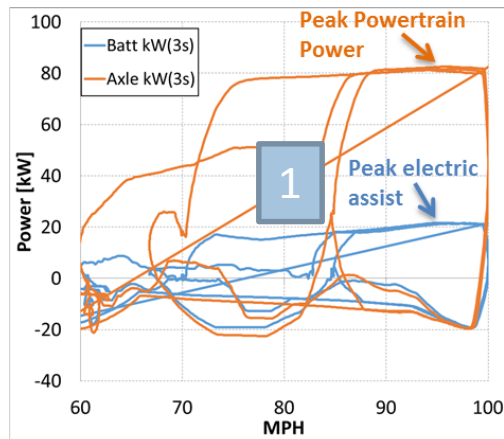
- How much electric power assist is given during maximum total power?
- Provides an input needed for **Nominal System Power Rating**

2. Electric-only Drive Power (mostly for PHEVs)

- Maximum electric traction power assist in “EV Mode”

3. Regen Power

- Maximum electric power going to battery during braking



A. Nominal System Power Rating

- This approach parallels current engine power ratings
 - Rating look at sum of “upstream” component power
 - Powertrain losses downstream of the engine do not diminish peak power.
- Current OEM catalog ratings use this approach. However:
 - There are **no rules or standards** in how, or in what condition ratings are given.
 - Added components not consistent: **Motor + Engine? Battery + Motor?**
 - Claims can not be traced back to standard test for validation

2015 Dodge
Challenger Hellcat

Engine: 707 HP



Photo: Wikipedia

2015 Ford Focus
1.0L EcoBoost

Engine: 123 HP



Photo: Wikipedia

2010 Toyota Prius

Engine: 98 HP
Motor: 80 HP
Battery: 36 HP
System Net: 134 HP



Photo: Argonne
Specs: “Toyota Prius Product Information”

2011 Sonata HEV

Engine: 166 HP
Motor: 40 HP

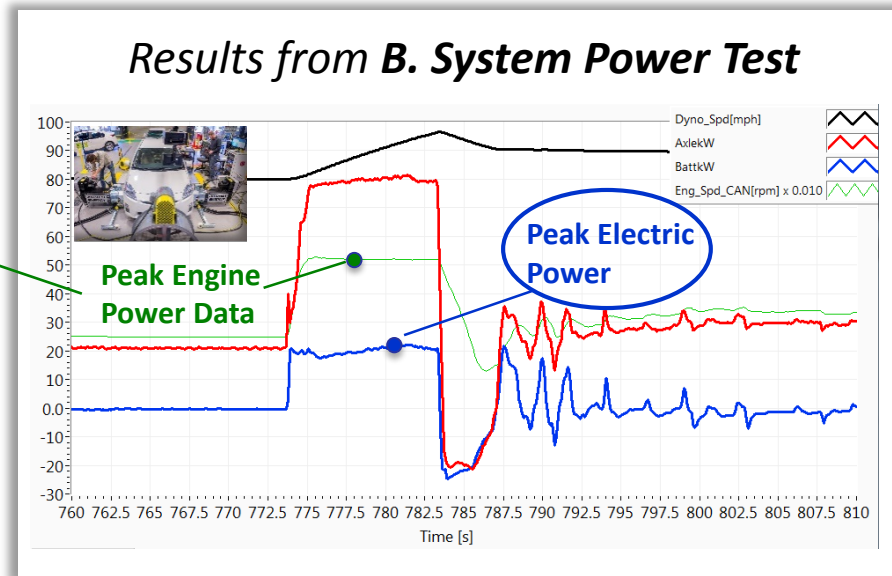
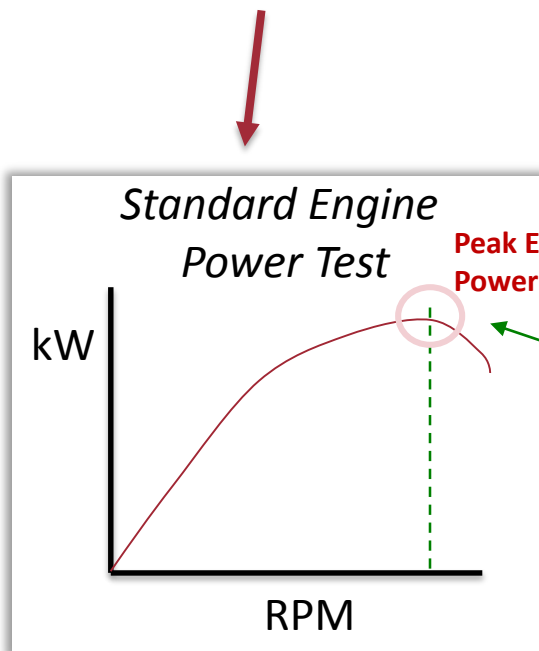
System Net: 206 HP



Photo: Argonne

Progress on Defining A. Nominal Rating

$$\text{Engine Power} + \text{Electric Power} = \text{Hybrid System Power}$$



(goal is to agree with JARI/ISO method)



B. System Power Test

- Only valid approach to measure net power is at wheel/hub
 - HEV configurations are too varied
 - Unique system controls regulate component powers for each configuration
- Either Chassis or Hub dyno for test
 - Many labs already own chassis dynamometer
 - Chassis dynamometer** could limit wheel torque in some tests
 - Hub dynamometer** allows high torque and less expensive for new installations

Draft procedure notes for System Power Test

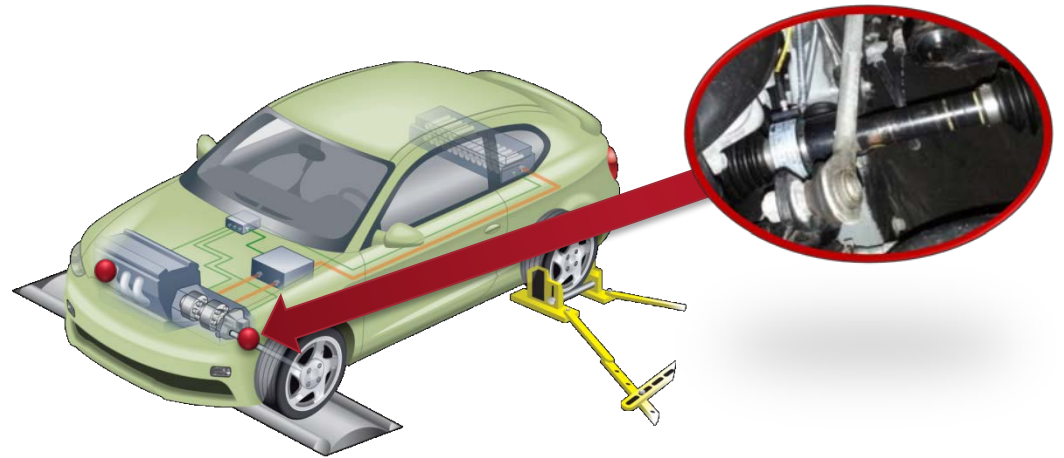
The image displays three columns of draft procedure notes for system power tests. Each column includes a title, a list of test steps, and a graph illustrating the test results.

- Test: I.8.2.1a – System Power: Discrete Passing Tests**
This test involves discrete passing maneuvers. The steps include: Run I.8.2.1.a (0-100% in road load), Find power at 100%, Find absolute peak power at 100%, Repeat 5 speeds (1.4, 1.2, 1.0, 0.8, 0.6), Show at 100% (10), Engage FCMD (10) (100% in road load), Show in EV mode until SOC drops around 4-6 SOC% points (10) before the running target SOC%, Brake to neutral to 0 MPH, Engage FCMD (10) (100% in road load), Place in vehicle in Drive, EV accel point, Engage one of 5 target speeds (1.4, 1.2, 1.0, 0.8, 0.6), Observe SOC% until target is reached, Show absolute SOC% for 5 seconds (10), Tap out to 0% accel, 100% in EV mode until SOC drops around 4-6 SOC% points (10) before the running target SOC%, Repeat 10 times at the speed where highest load point was found (10).
A graph titled "EV PWS 'OVERLAPPING PASSING ACCELERATIONS'" shows power (kW) vs. speed (MPH) with multiple overlapping curves representing different target speeds.
- Test: I.8.2.1a – System Power: Fixed Dyno Mode, 0-100% Accel**
This test involves a fixed dyno mode with 0-100% acceleration. The steps include: Run I.8.2.1.a (0-100% in road load), Find power at 100%, Find absolute peak power at 100%, Repeat 5 speeds (1.4, 1.2, 1.0, 0.8, 0.6), Show at 100% (10), Engage FCMD (10) (100% in road load), Show in EV mode until SOC drops around 4-6 SOC% points (10) before the running target SOC%, Brake to neutral to 0 MPH, Find the EV accel point power/brake point, Place in vehicle in Drive, Engage FCMD (10) (100% in road load), Engage one of 5 target speeds, Observe SOC% until target is reached, Tap in accel to roughly 10% maximum load found in "open road" (10) (10), Hold SOC% for 5 seconds, Tap accel to full for 5 seconds (10), Tap out (10), Repeat 10 times more times, 10 times (10).
A graph shows power (kW) vs. speed (MPH) with a single curve representing the 0-100% acceleration test.
- Test: I.8.2.1b – System Power: Fixed Dyno Mode, w/ 100% Accel**
This test involves a fixed dyno mode with 100% acceleration. The steps include: Run I.8.2.1.b (0-100% in road load), Find power at 100%, Find absolute peak power at 100%, Repeat 5 speeds (1.4, 1.2, 1.0, 0.8, 0.6), Show at 100% (10), Engage FCMD (10) (100% in road load), Show in EV mode until SOC drops around 4-6 SOC% points (10) before the running target SOC%, Brake to neutral to 0 MPH, Find the EV accel point power/brake point, Place in vehicle in Drive, Engage FCMD (10) (100% in road load), Engage one of 5 target speeds, Tap in accel to roughly 10% maximum load found in "open road" (10) (10), Hold SOC% for 5 seconds, Tap accel to full for 5 seconds (10), Tap out (10), Repeat 10 times more times, 10 times (10).
A graph shows power (kW) vs. speed (MPH) with a single curve representing the 100% acceleration test.

System Power Test Hardware

Chassis Dyno

Using axle torque sensors to directly measure powertrain power



Hub Dyno

Using two hub dynos to directly measure powertrain power
(*very small losses in wheel bearings*)



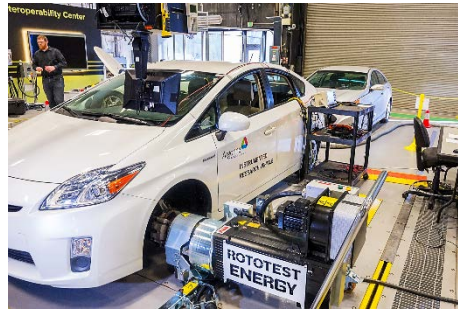
Photo: Argonne

Several Vehicles in Validation Study at Argonne

- Tested on both Hub and Chassis dynos
- HEVs (power-split, step transmission, mild HEV CVT), Conventional, BEV
- All vehicle have axle torque sensors for chassis dynamo testing



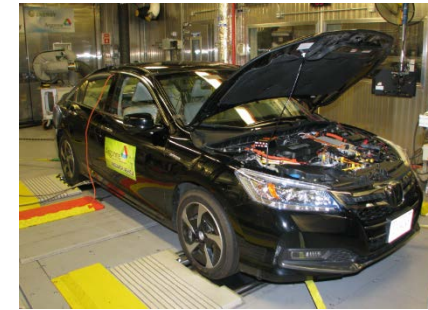
Sonata HEV



Prius HEV



Volt PHEV



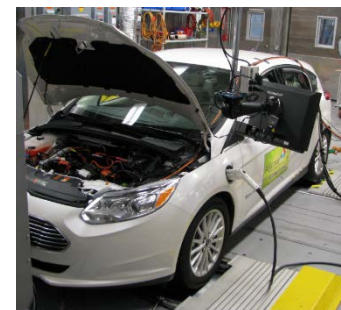
Accord PHEV



Gen 2 Insight HEV



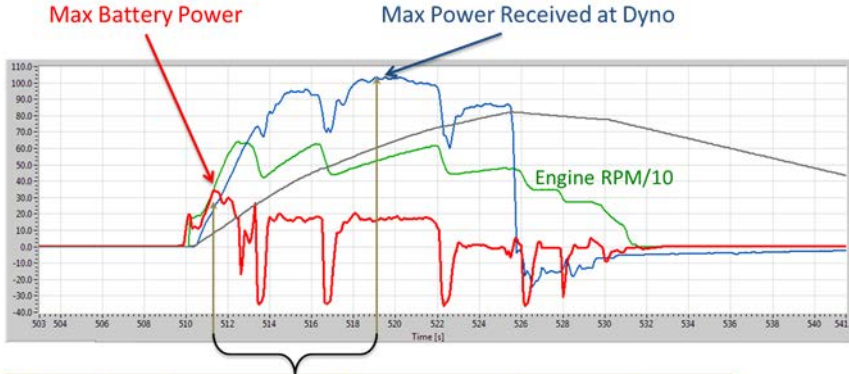
Fusion Conventional



Focus BEV

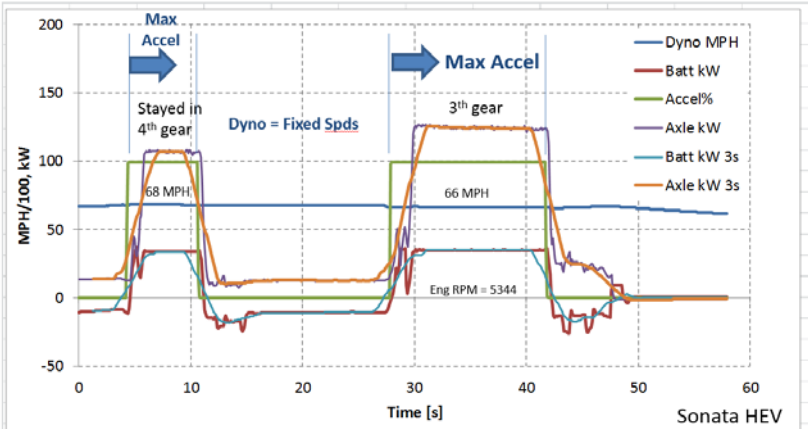
Findings Are Ensuring Test Works for All HEV Types

Peak battery power not always during peak total power



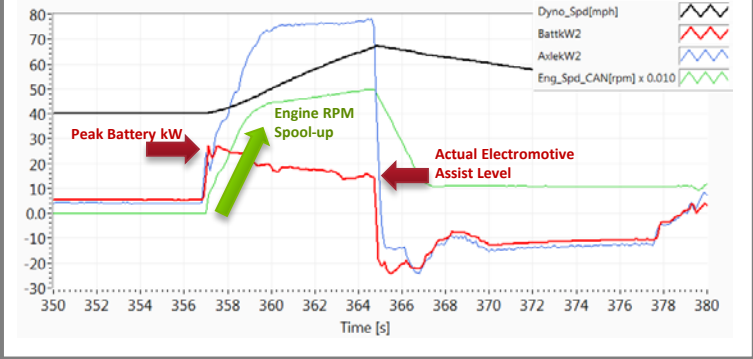
Observed peak motor power did not occur at peak powertrain power

Fixed speed test fails with step transmissions

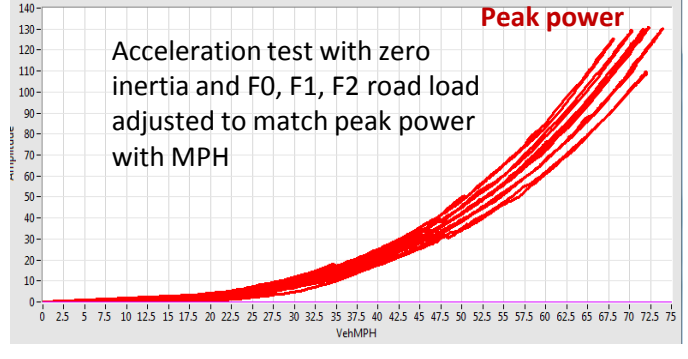


Batt kW max = 34.85967 125.5083 = Axle kW max
 Batt HP max = 46.74764 168.3096 = Axle HP max

Peak battery power ≠ peak electric assist (lost power in engine spool-up)

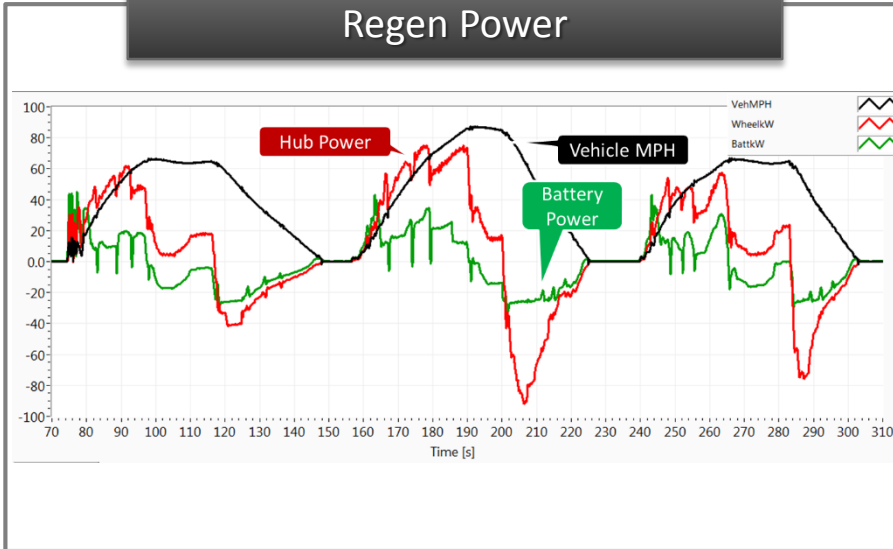


New Terminal Velocity test method invented- very promising



Additional Tests for J2908 Accomplishments

Developed test cycle for finding Regen Power



Successful Fixed-Speed EV Drive Power Procedure

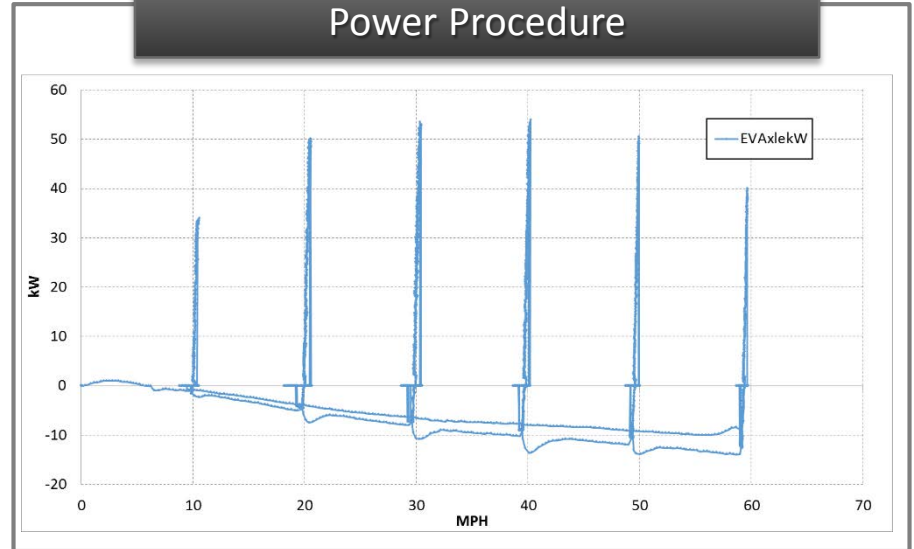


Photo: Argonne



Photo: Argonne



Photo: Argonne





The End