

System Power Determination Validation Program

Status of EPA testing

28th EVE, Ottawa, October 2018

Numbers don't lie!

2.8%



The advertisement banner features the Honda logo and the slogan "NUMBERS DON'T LIE" on the left. In the center, a red Honda CR-V is shown. To its right, a comparison of horsepower is displayed: "184 HORSEPOWER Honda CR-V" versus "179 HORSEPOWER Ford Escape". A yellow double-headed arrow points from the "2.8%" text above to the two horsepower values. On the far right, the text "DETROIT AREA HONDA DEALERS" is accompanied by a city skyline icon and a "SAVE NOW" button. A play button and close button icon are also present in the top right corner of the banner.

Model	Horsepower
Honda CR-V	184
Ford Escape	179

EPA test vehicles



- 2013 Malibu Eco
 - Mild HEV (BAS)
 - Engine: 136 kW @ 6200 rpm (est.)
 - Motor: 11 kW
 - Battery: 0.5 kWh
 - Odometer: 5400 miles (8700 km)



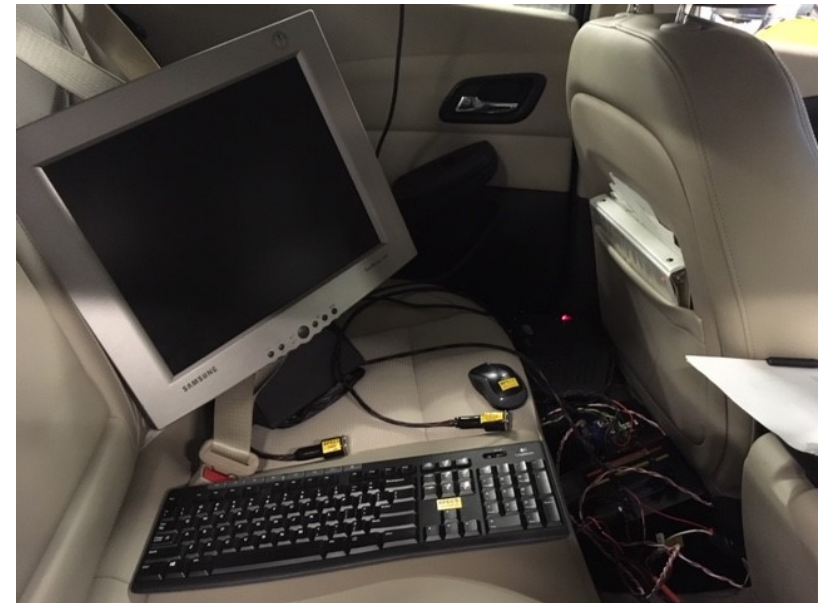
- 2013 Chevrolet Volt
 - OVC-HEV (series with power split)
 - Engine: 63 kW @ 4800 rpm
 - Drive motor: 111 kW; generator: 55 kW
 - Battery: 16.5 kWh
 - Odometer: 11100 miles (17,870 km)

Test protocol - General

- Identify speed of maximum power by conducting speed sweep
 - Day 1: Run constant speeds from 50 to 130 kph in 10 kph increments
 - Perform two 15-second accel pulses at each speed
 - Examine dyno logs to see power delivered to dynamometer rolls at each speed
 - Day 2: Conduct second, finer speed sweep
 - As indicated by Day 1 results
 - The speed of maximum power is likely to be one of the speeds swept
 - The data collected at that speed can then be used to perform TP1 and TP2
- Rate of accel was varied slightly for some pulses (no effect seen)
- Temperatures were monitored to stay within design range
- SOC restored after each pulse by light braking or coasting
 - Attempted to limit charging to 1C but this was difficult to control
 - Often, coasting at constant speed was sufficient to restore SOC

Instrumentation

- EPA utilizes Southwest Research Institute (SwRI) for instrumentation services
- Data collected by Rapid Prototyping Electronic Control System (RPECS)
- SwRI was limited in ability to instrument high voltage battery
 - Lack of standard procedure (SOP) would have added to development time
 - We decided to see if CAN signals for voltage and current would be adequate (10-sec acceleration is relatively steady state)
- For expediency, most signals were collected from CAN except manifold air pressure



Example of signals collected (Malibu Eco)

```
[0]RPECS003 Rev: 3
[1]RPECS003 Rev: 6

PCM[0]
Engine Speed      0.00 [RPM]
MAP Sensor        98.00 [kPa]
Fuel Economy      0.00 [L/hr]
Accel Pedal Pstn 0.00 [%]
Engine Coolant Temp 80.00 [DegC]
IAT Sensor        35.00 [DegC]
MAP Volt          3.84 [V]
Vehicle Speed     60.00 [Kph]
HV Batt SOC       82.35 [%]
HV Batt Temp Max  24.00 [DegC]
HV Batt Temp Min  23.00 [DegC]
Low-volt Circuit Volt 12.70 [V]
Low-volt Circuit Curre 22.00 [Amp]
HV Batt Current   16.20 [Amp]
Drive Motor 1 Temp 25.00 [DegC]
Transmission Oil Temp 54.00 [DegC]
Transmission Mode Comm 65.00 [NONE]
Transmission Mode 65.00 [NONE]
HV Batt Voltage   384.80 [V]
AnInputsCardA[1] 5.45 [Volts]
log_trigger_v     98.13 [kpa]
MAP_Sensor        3.86 [volts]
AnInputsCardBI[2]

NO FULL Sync
Cam1 Slow
Cam1 Noise Warn

Crank Slow
Crank Noise Warn
Crank Insuf Teeth

Gap Not In Wind
Odd Parity

Debug[0] = 0x0000
Debug[1] = 0x0000

CANAct [ 5]
>>No CANB<< [ 0]

OBD Port Tx: Enable
('t' to toggle)

GMLAN: Enabled
```

2013 Malibu Eco – test configuration

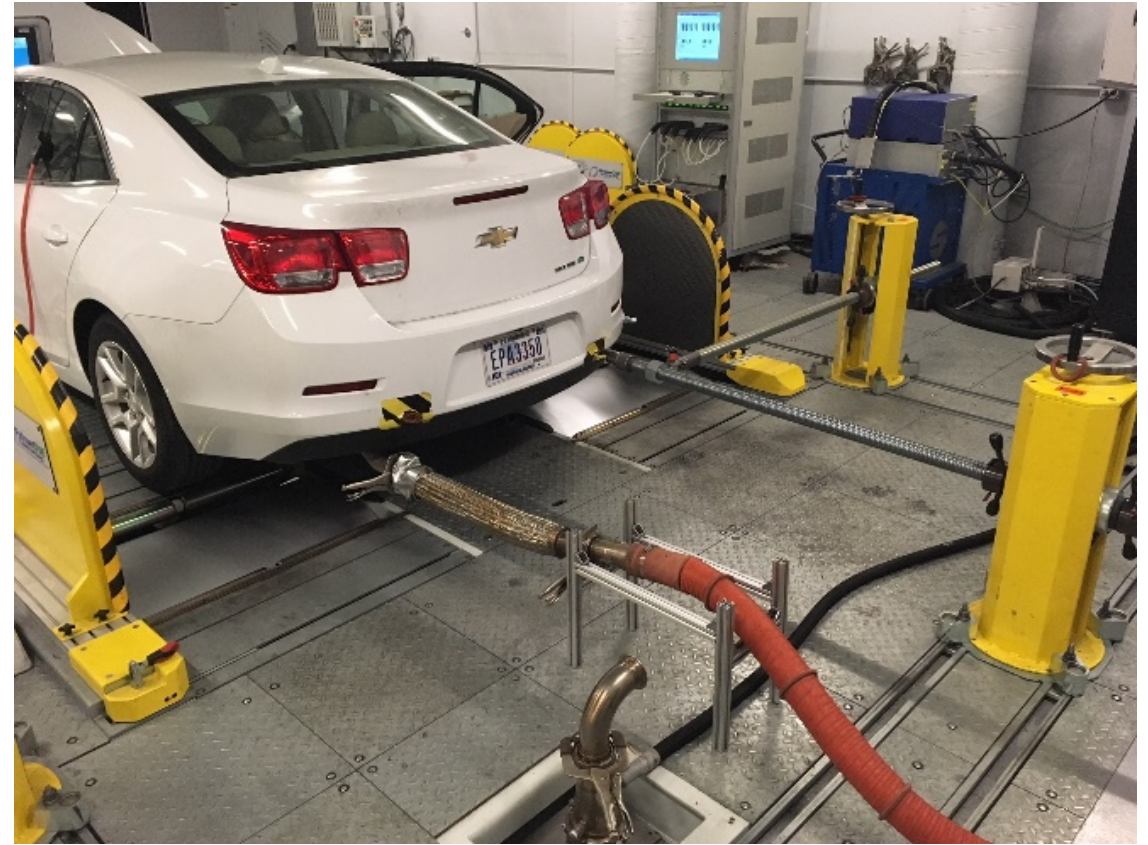
Vehicle ID	GHGMAL		Front: 2250 lb. Rear: 1744 lb. (with 2 occupants as tested)			
Configuration	2WD		ETW	3875 lbs (3994 actual)		
Model Year	MY2013 Manufactured 3/2012		Coefficients	Target		Dyno Set
Manufacturer	GM		A	26.48	lb	lb
Model	Malibu Eco		B	0.2366	lb/mph	lb/mph
VIN	1G11D5RR3DF109037		C	0.01659	lb/mph ²	lb/mph ²
Drive axle	FWD					
Dyno conf.	FWD					
Tire pressure	Front	35 psi		Rear	35 psi	
Tire size:	P225/55R17 (nominal diameter 26.74 inches, radius 0.3396 m)					

Fuel tank volume	15.8 gallons	
Fill amount	100%	

Fuel Type	Tier 2 test fuel	
FTAG	26864	

Fan Type and position:
a) US06 fan on engine (40 mph).
Hood: Hood open

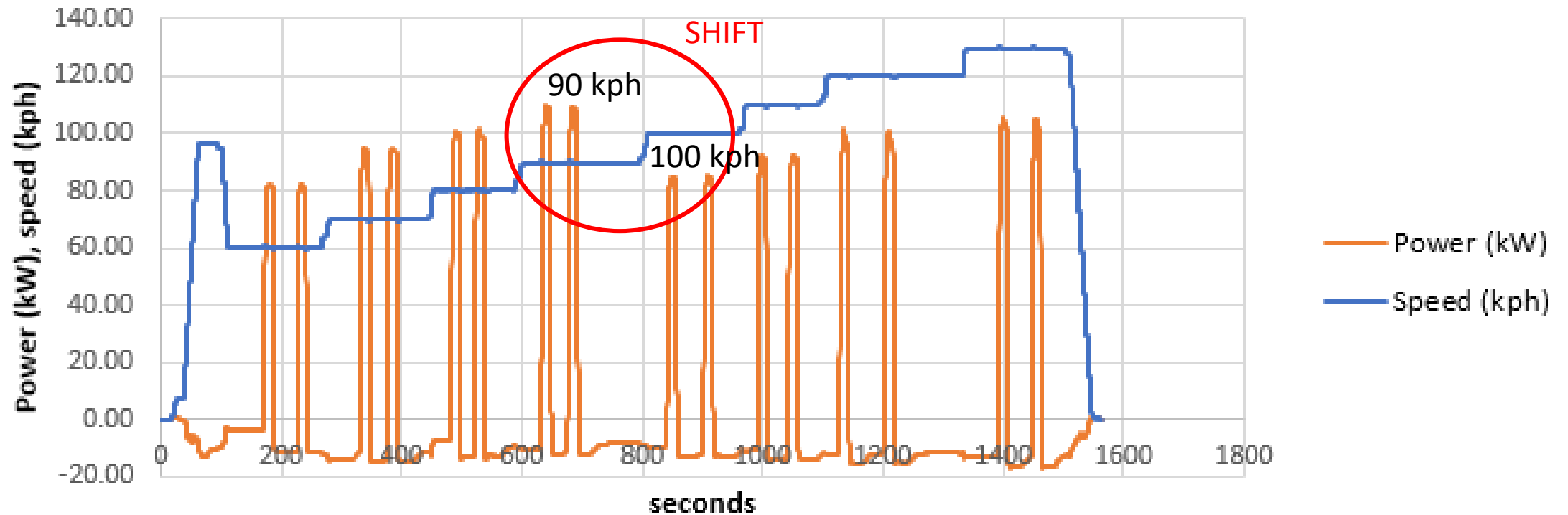
2013 Malibu Eco – Test cell setup



Identifying speed of maximum power

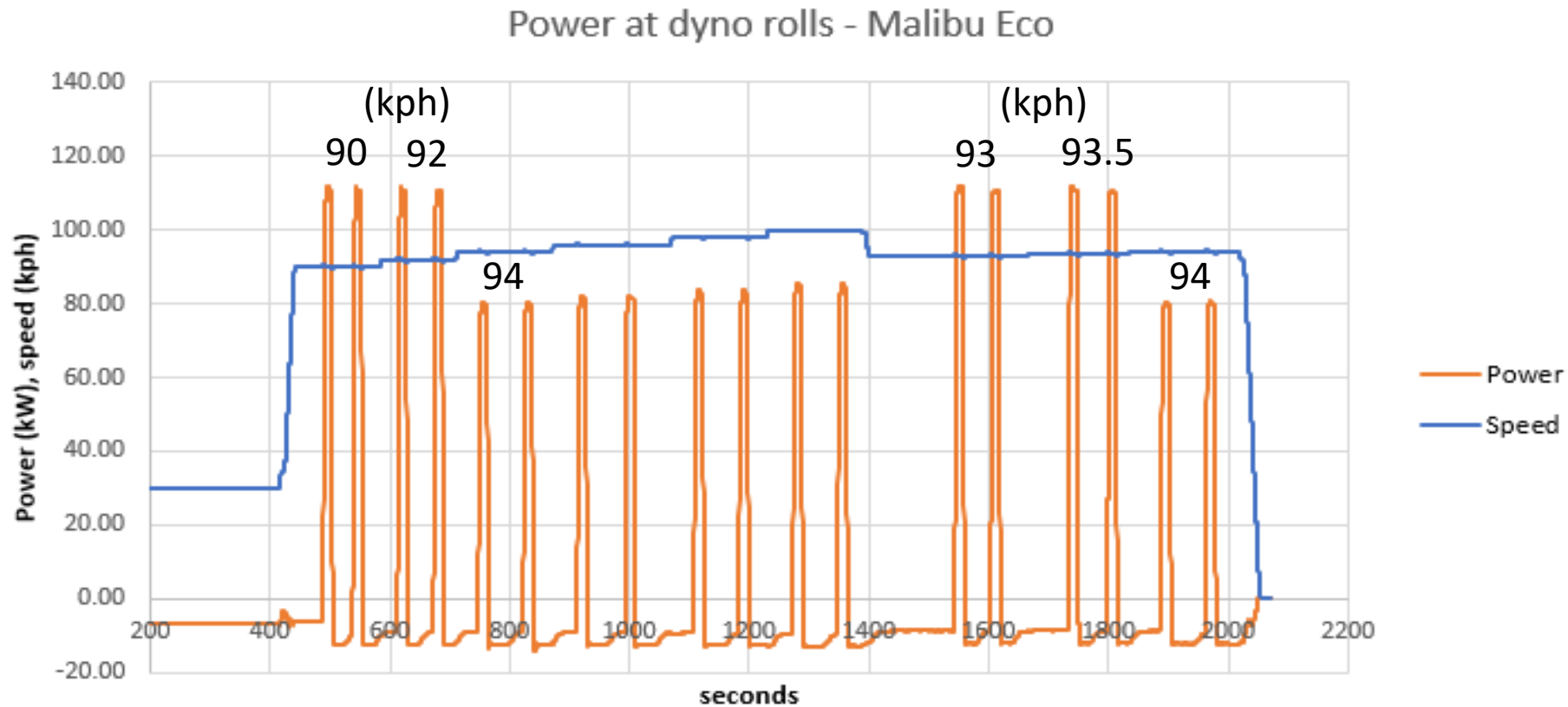
Day 1: Initial speed sweep – 60 to 130 kph

Power at dyno rolls, for various speeds - Malibu Eco

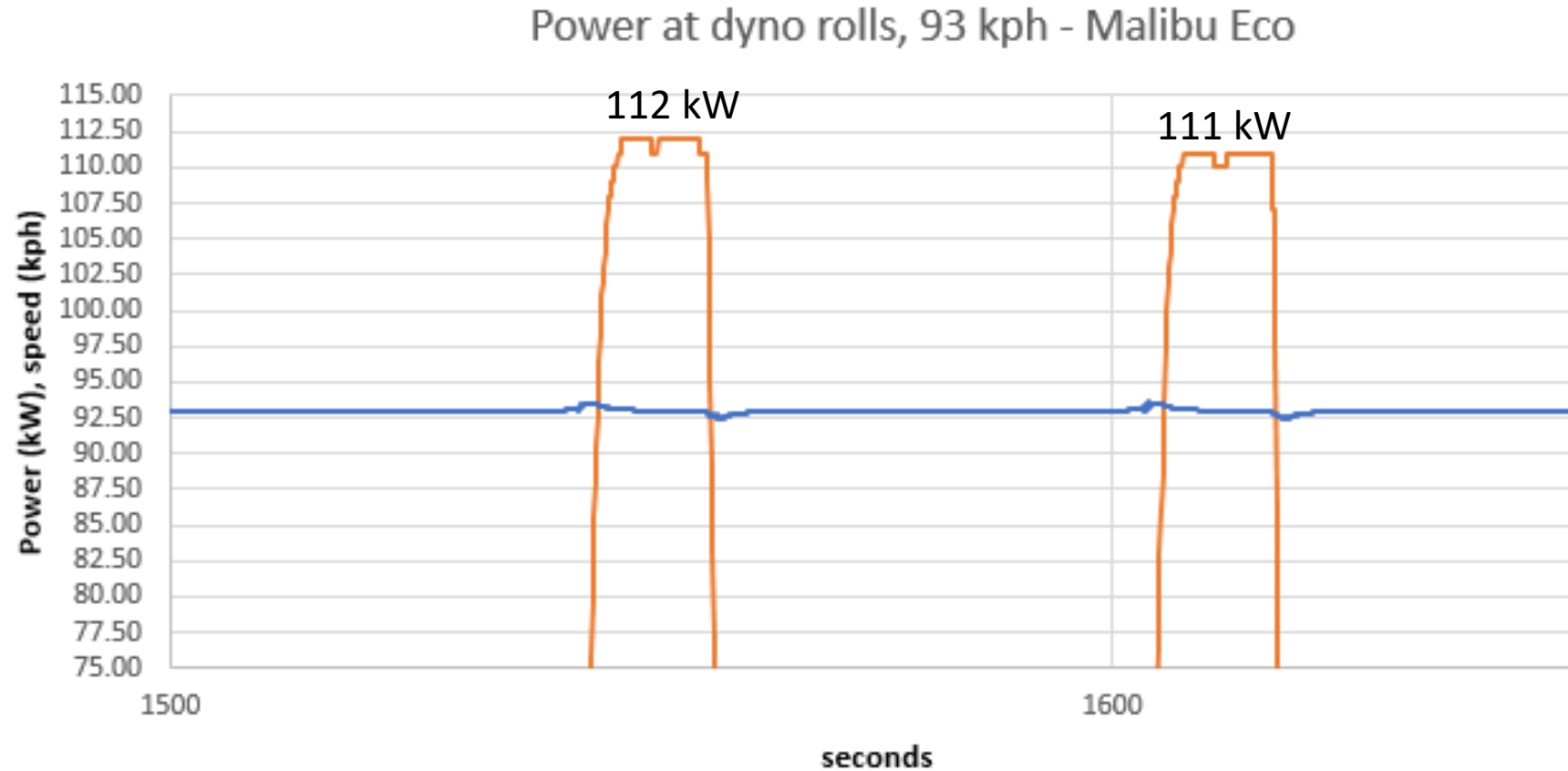


Identifying speed of maximum power

Day 2: Second speed sweep – 90 to 100 kph



Wheel power at 93.0 kph - Malibu

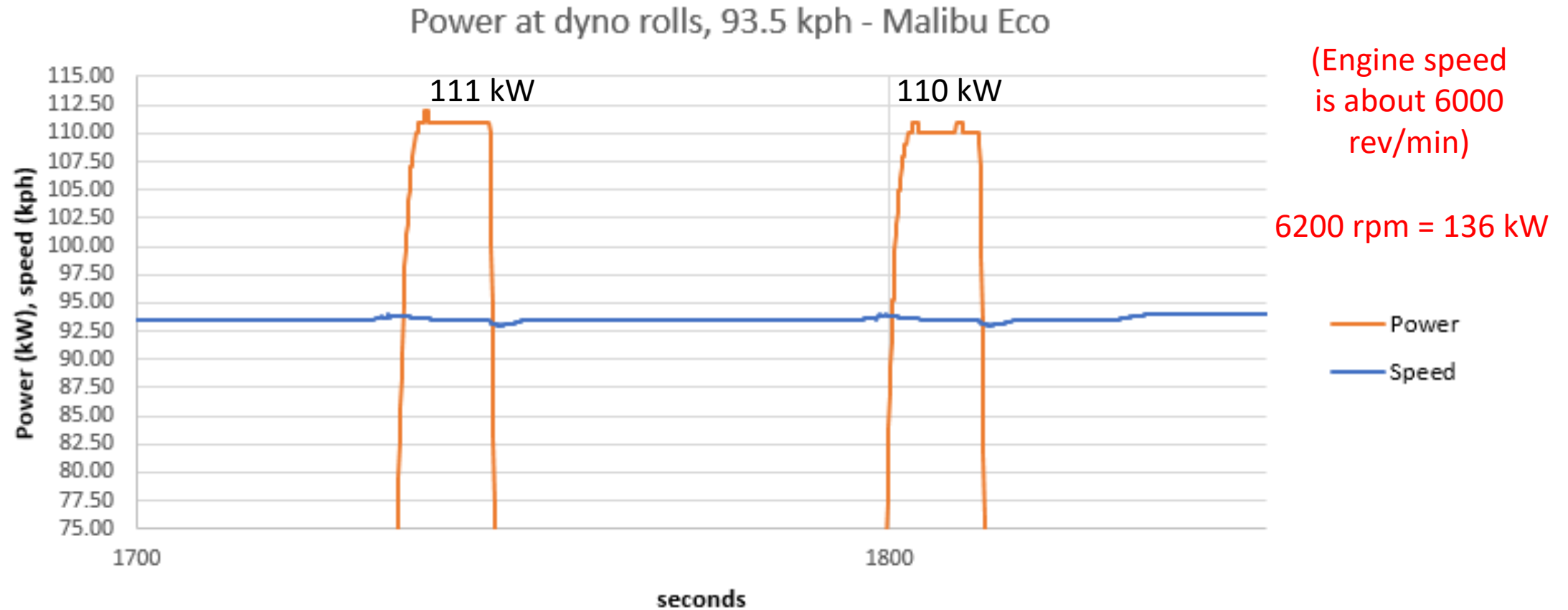


(Engine speed is about 6000 rev/min)

6200 rpm = 136 kW

— Power
— Speed

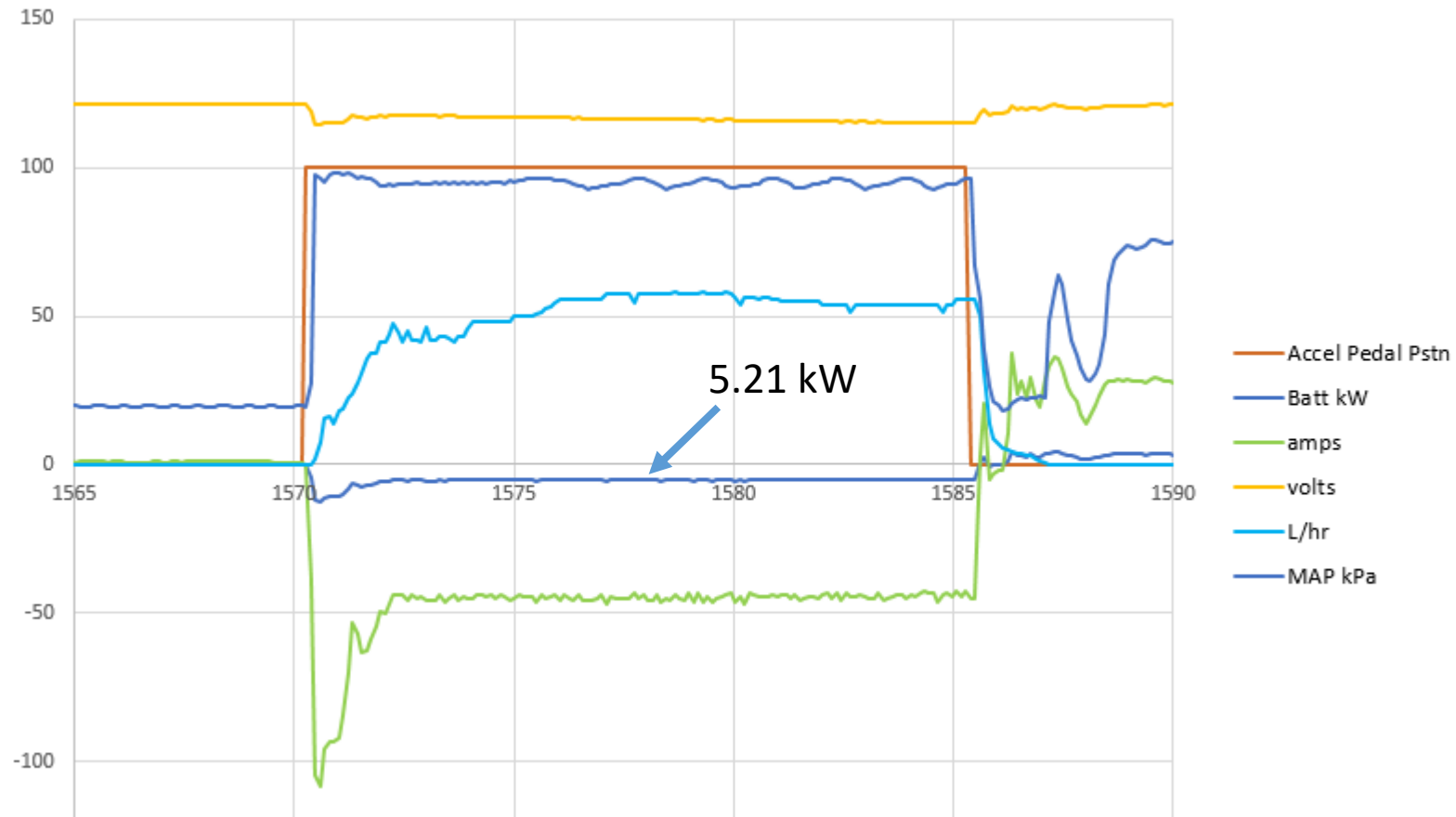
Wheel power at 93.5 kph - Malibu



Measured battery power – 93 kph



Measured battery, fuel, MAP – 93 kph



111 kW at road / (135 kW + 5 kW) at engine/battery = $\sim 80\%$ downstream efficiency

Conclusions – Malibu Eco

- Speed of maximum power: ~93 kph (expect 111-112 kW at wheels)
- Shape and magnitude of each power pulse are similar
- CAN data for current and voltage is stable and repeatable during steady state portion of pulse
- Fuel flow and MAP signals appear reasonable
- Power calculations should be achievable with this data
 - TP1 depends on availability of engine test data (equivalent to ISO 1585)
 - TP2 depends on availability of tire data (equivalent to RRC class in WLTP)

2013 Chevy Volt – test configuration

Vehicle ID	EPA3047		Front: 2465 lb. Rear: 1704 lb. (with 2 occupants as tested)			
Configuration	2WD		ETW	3750 lbs (4169 actual)		
Model Year	MY2013		Coefficients	Target		Dyno Set (4WD dyno)
Manufacturer	GM		A	26.05	lb	2.88 lb
Model	Chevy Volt		B	-0.0120	lb/mph	-0.072 lb/mph
VIN	1G1RA6E41DU102286		C	0.01820	lb/mph ²	0.0171 lb/mph ² 2
Drive axle	FWD					
Dyno conf.	4WD					
Tire pressure	Front	38 psi	Rear	38 psi		
Tire size:	P215/55R17 (nominal diameter 26.31 inches, radius 0.33414 m)					

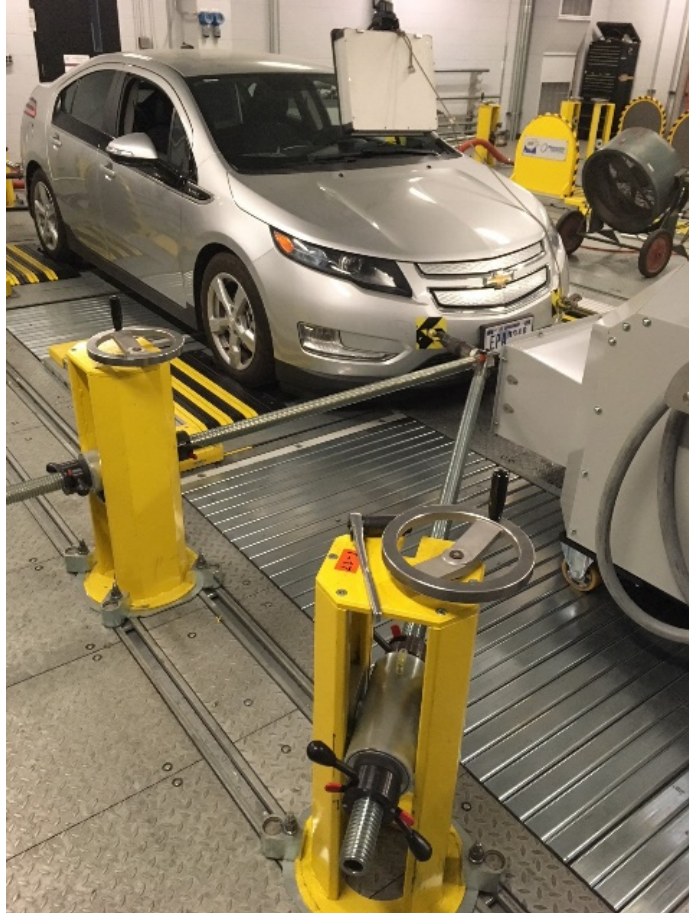
Fuel tank volume	11 gallons	
Fill amount	100%	

Fuel Type	Tier 2 test fuel	
FTAG	26967	

Fan Type and position:
a) Road speed fan on engine.
Hood: Hood closed

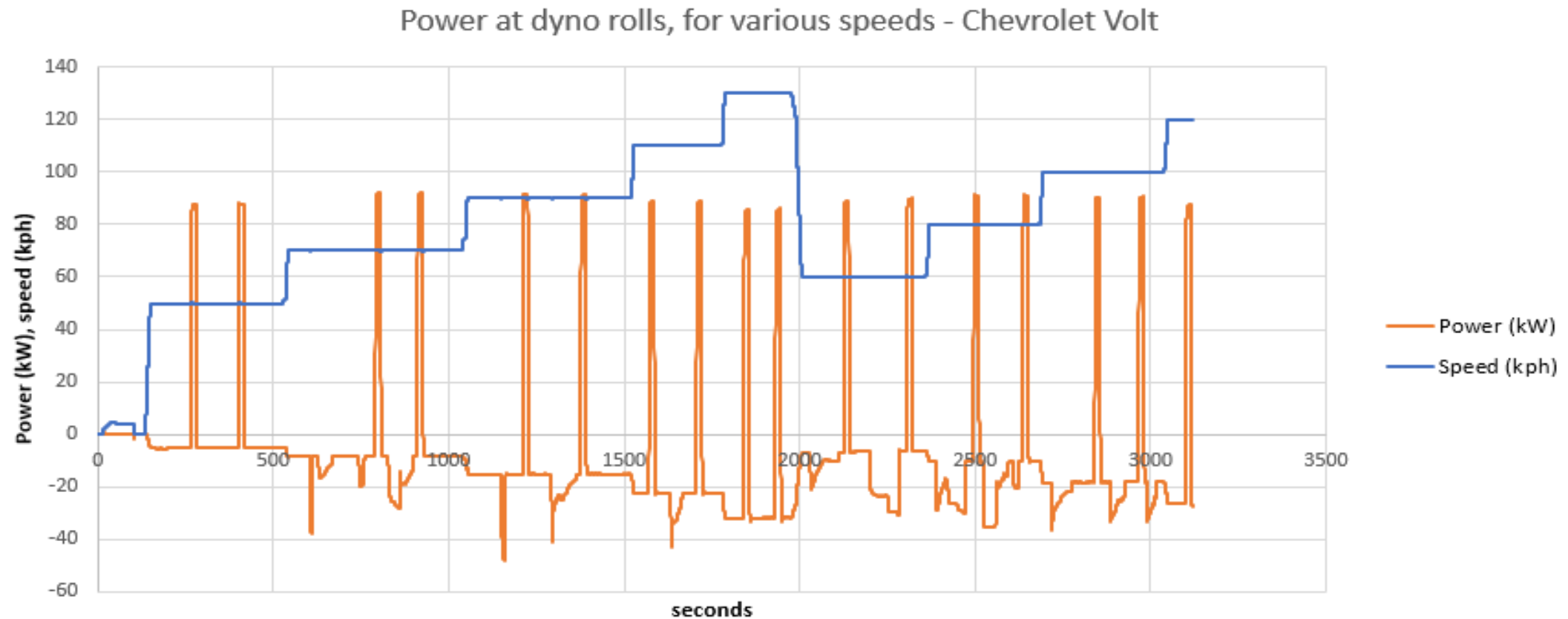
Conditioning cycle: "Hold Mode"
Power cycle: "Normal Mode"

2013 Chevy Volt – Test cell setup

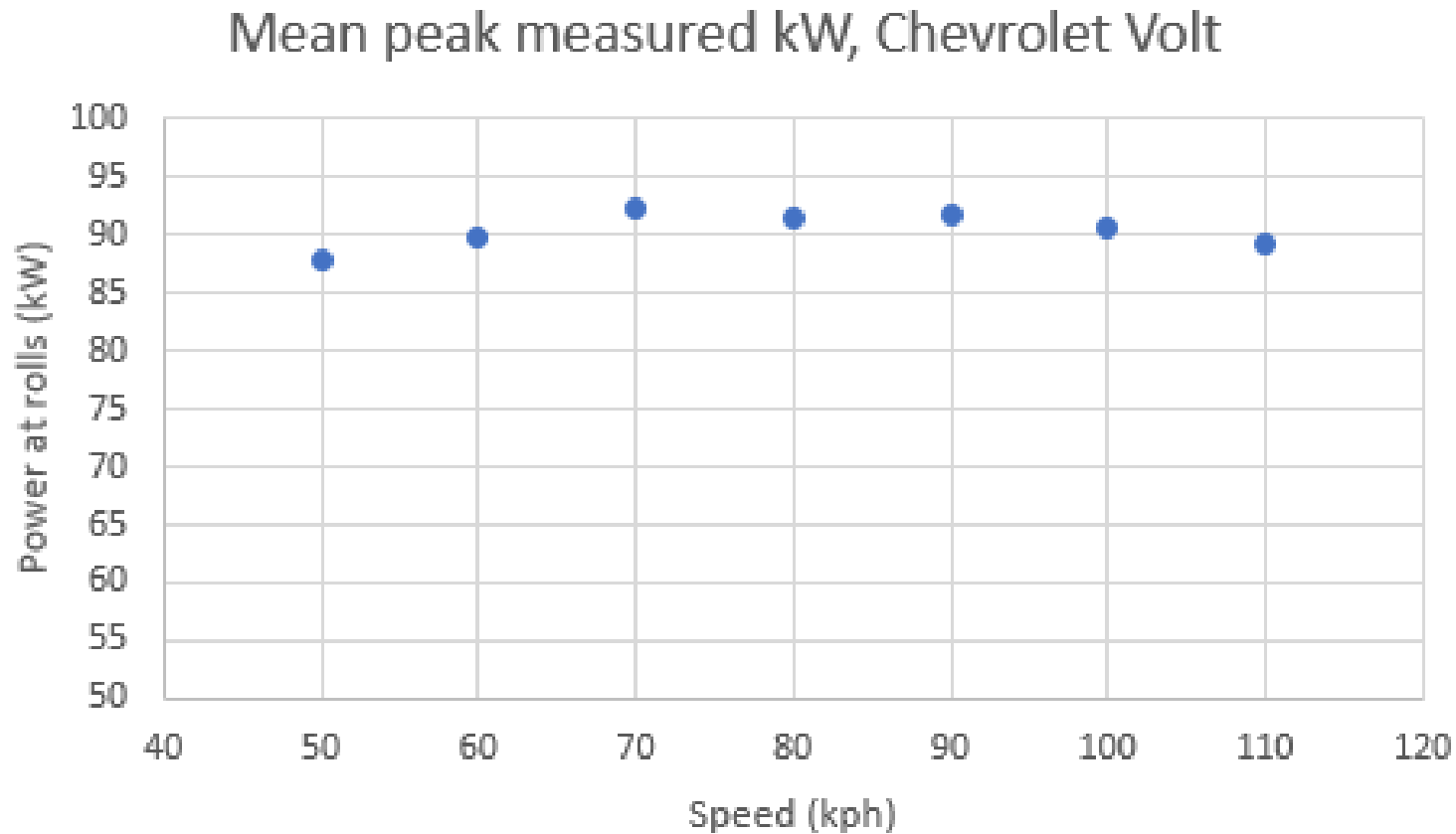


Identifying speed of maximum power

Day 1: Initial speed sweep – 50 to 130 kph



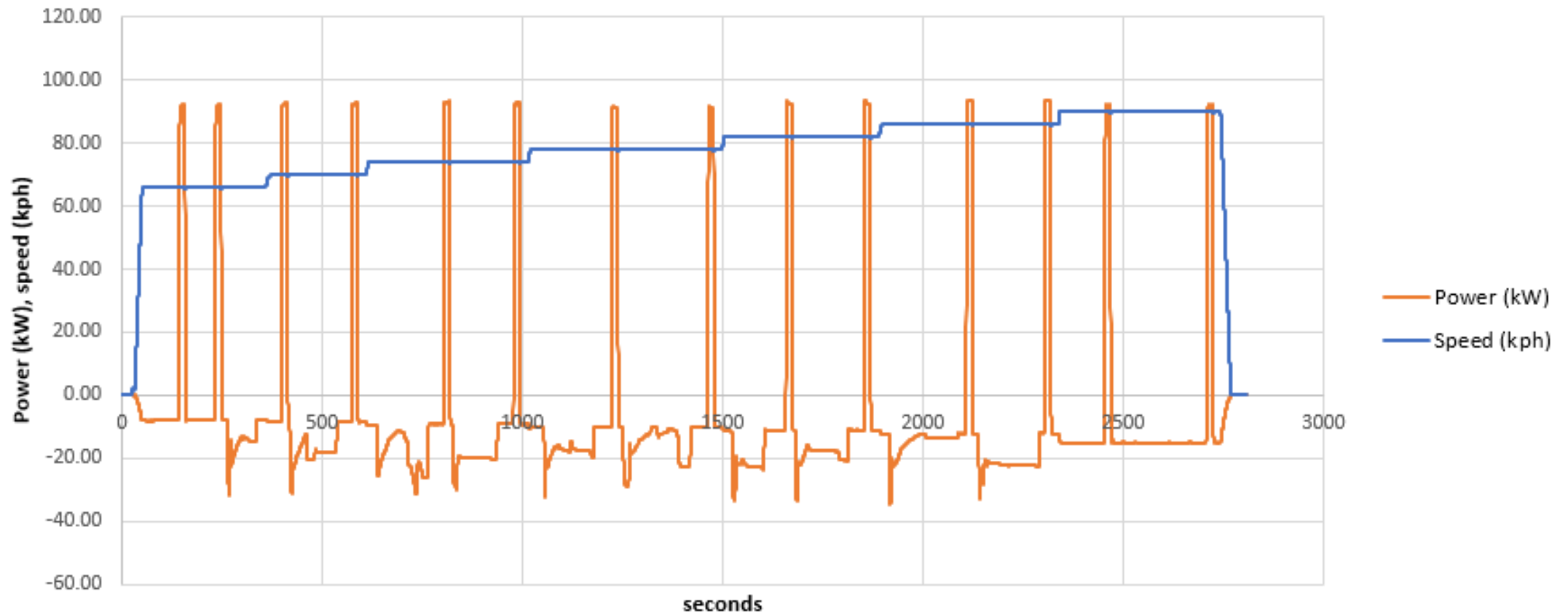
Power at wheels varies little with speed



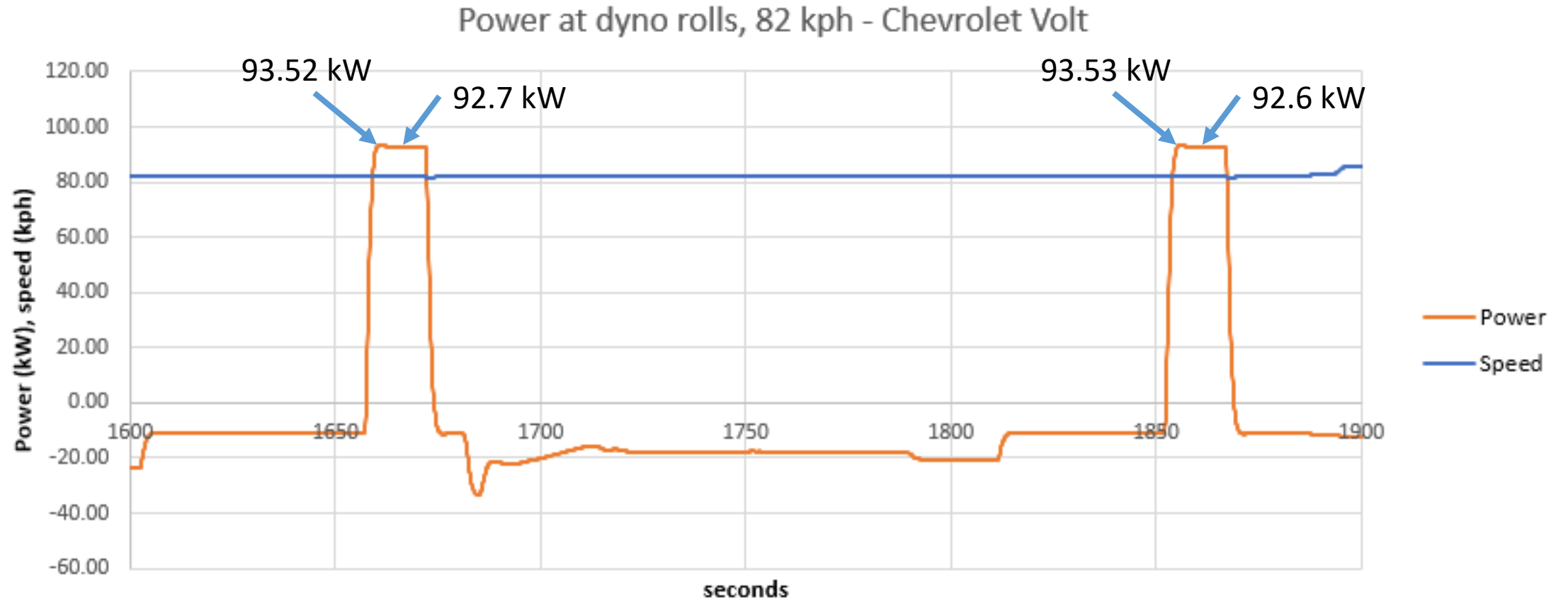
Identifying speed of maximum power

Day 2: Speed sweep from 66 to 90 kph @ 4 kph

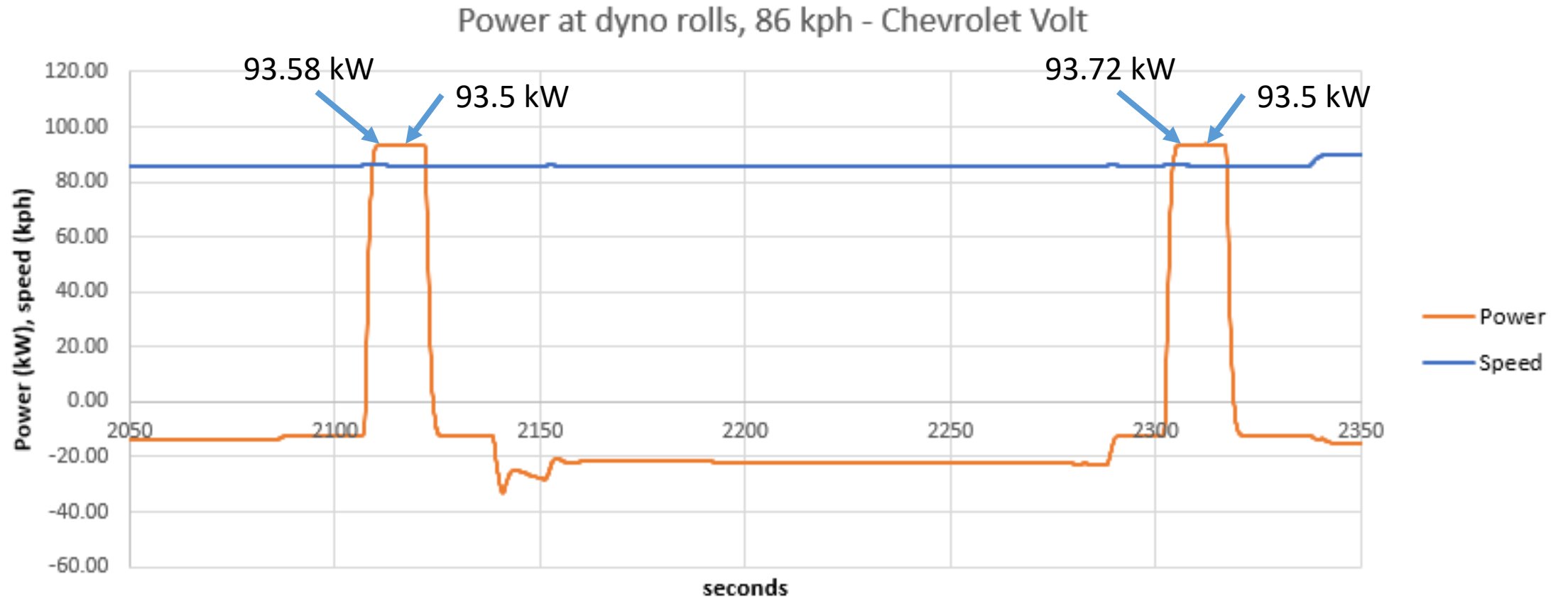
Power at dyno rolls, for various speeds - Chevrolet Volt



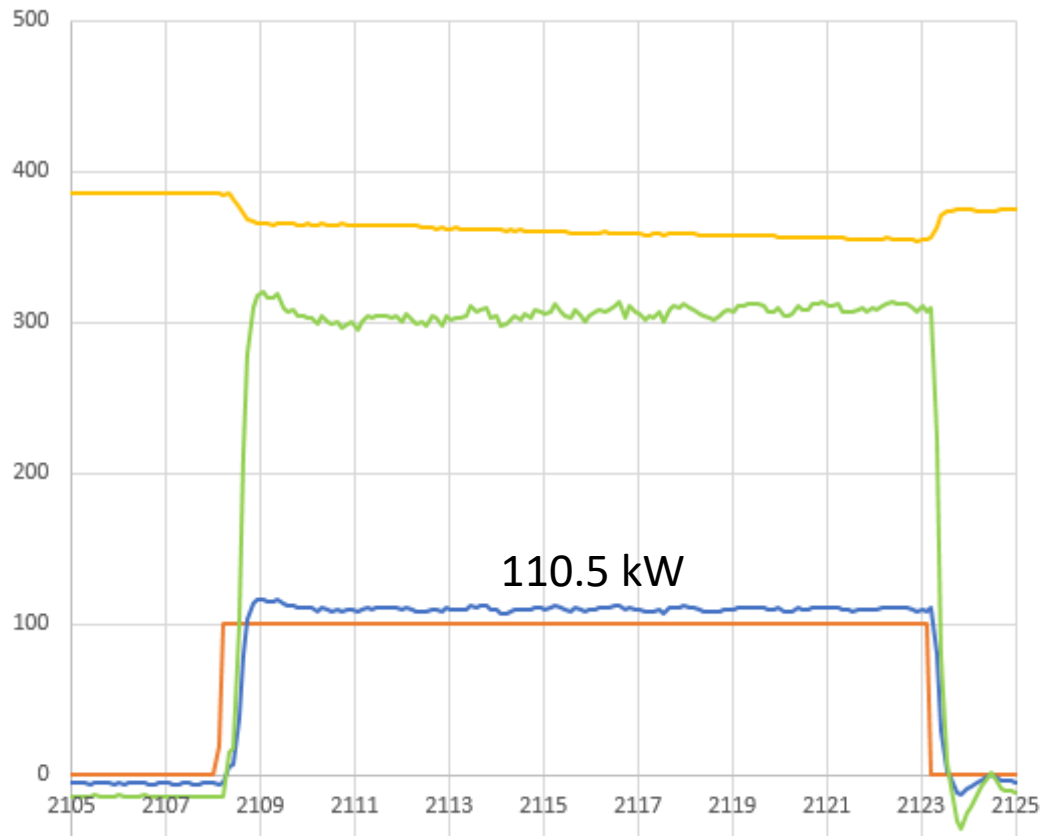
Wheel power at 82 kph – Chevy Volt



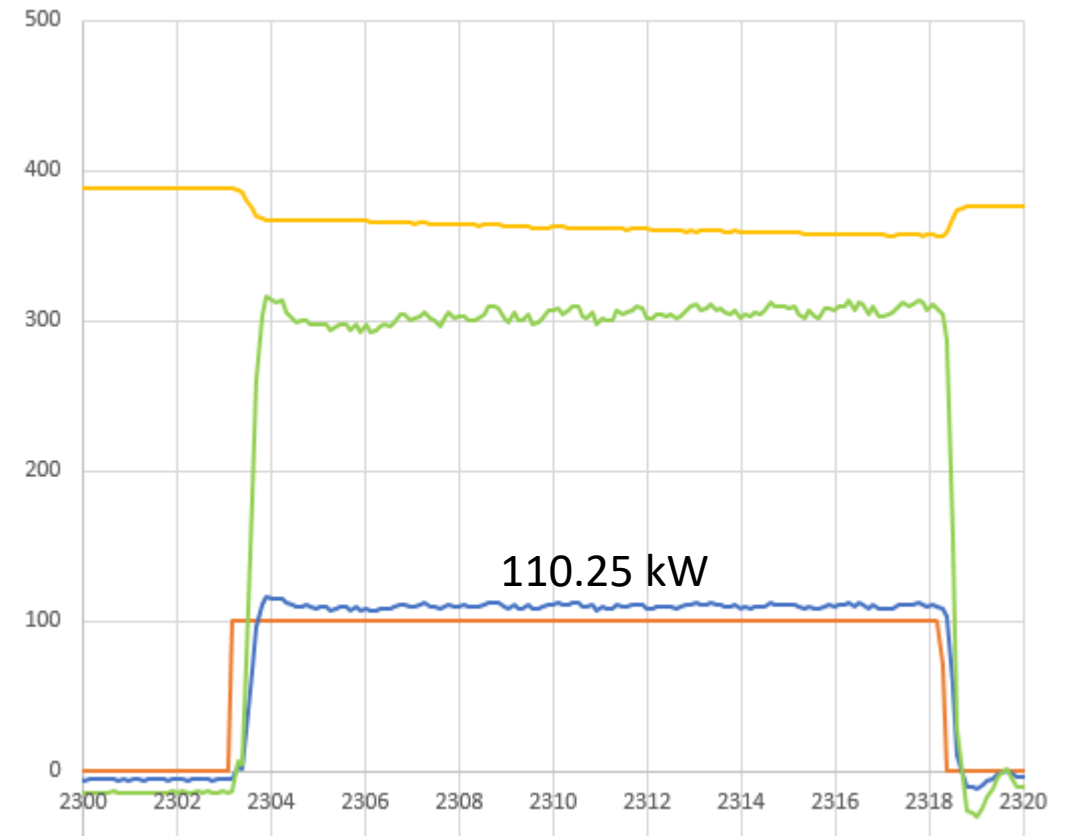
Wheel power at 86 kph – Chevy Volt



Measured battery power - 86 kph



— Accel pedal pos
— Batt kW
— amps
— volts



93.5 kW at road / 110.25 kW at battery = **84.8%** battery-to-road efficiency

Conclusions – Chevy Volt

- Speed of maximum power: ~ 86 kph (expect 93.5 kW at wheels)
- Shape and magnitude of each power pulse are similar
- CAN data for current and voltage is stable and repeatable
- Fuel flow and MAP signals not needed (CD = no engine operation)
- Power calculations should be achievable with this data
 - TP2 depends on availability of tire data (equivalent to RRC class in WLTP)

Other observations

- Canada, JRC, and EPA found that constant speed mode is rarely used
 - Dynamometer staff needed to review how to operate in constant speed mode
 - Controlling speed in response to sudden loading requires some attention
 - EPA found that speed control under loading was not a difficulty (+/- 0.5 kph)
- 20 min conditioning cycle was not sufficient for transmission oil temperature to fully stabilize
 - Temperature continues to creep up during testing
 - Temperature is still within design range, just higher than at end of conditioning
 - Strict interpretation of test procedure would require a return to conditioning cycle, but this is not effective at reducing oil temperature