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PHEV Hymotion Prius Model Validation and Control Improvements

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FreedomCAR & Fuel Partnership

Outline

- Vehicle Testing
- Model Validation
- Control Strategy Improvements
- Conclusions

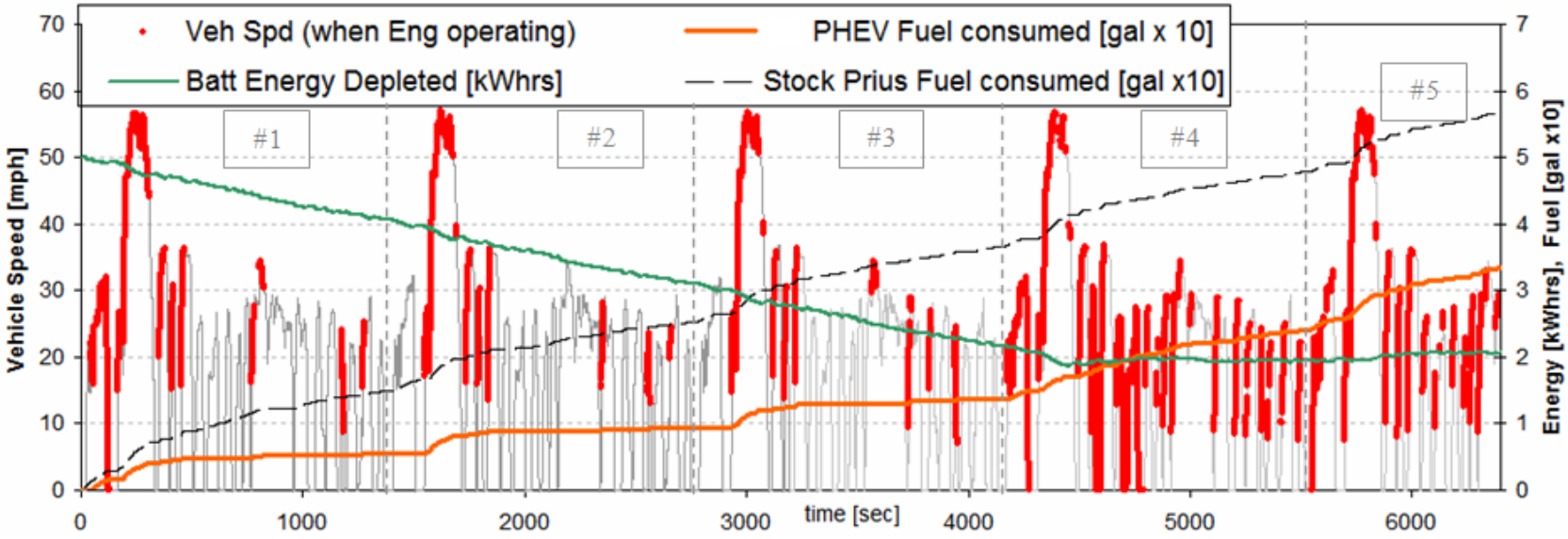
Vehicle Description

5 kWh Li-ion battery system installed in parallel to the production battery

PHEV Prius Dynamometer Coefficients

Coefficients	A	B	C
Target	19.918	0.1393	0.0164
Dyno Set	3.604	-0.1538	0.0179

Vehicle Test Results on UDDS



UDDS	#1	#2	#3	#4	#5
Miles Driven (mi)	7.48	7.48	7.48	7.48	7.47
Fuel Used (gal)	0.051	0.037	0.040	0.101	0.113
Electrical Energy Consumed (DC kWh)	0.93	0.96	0.94	0.23	-0.12
Fuel Economy (mpg)	148	200	187	74.3	66.4
Electrical Consumption (DC Wh/mi)	123	128	125	30.6	15.9

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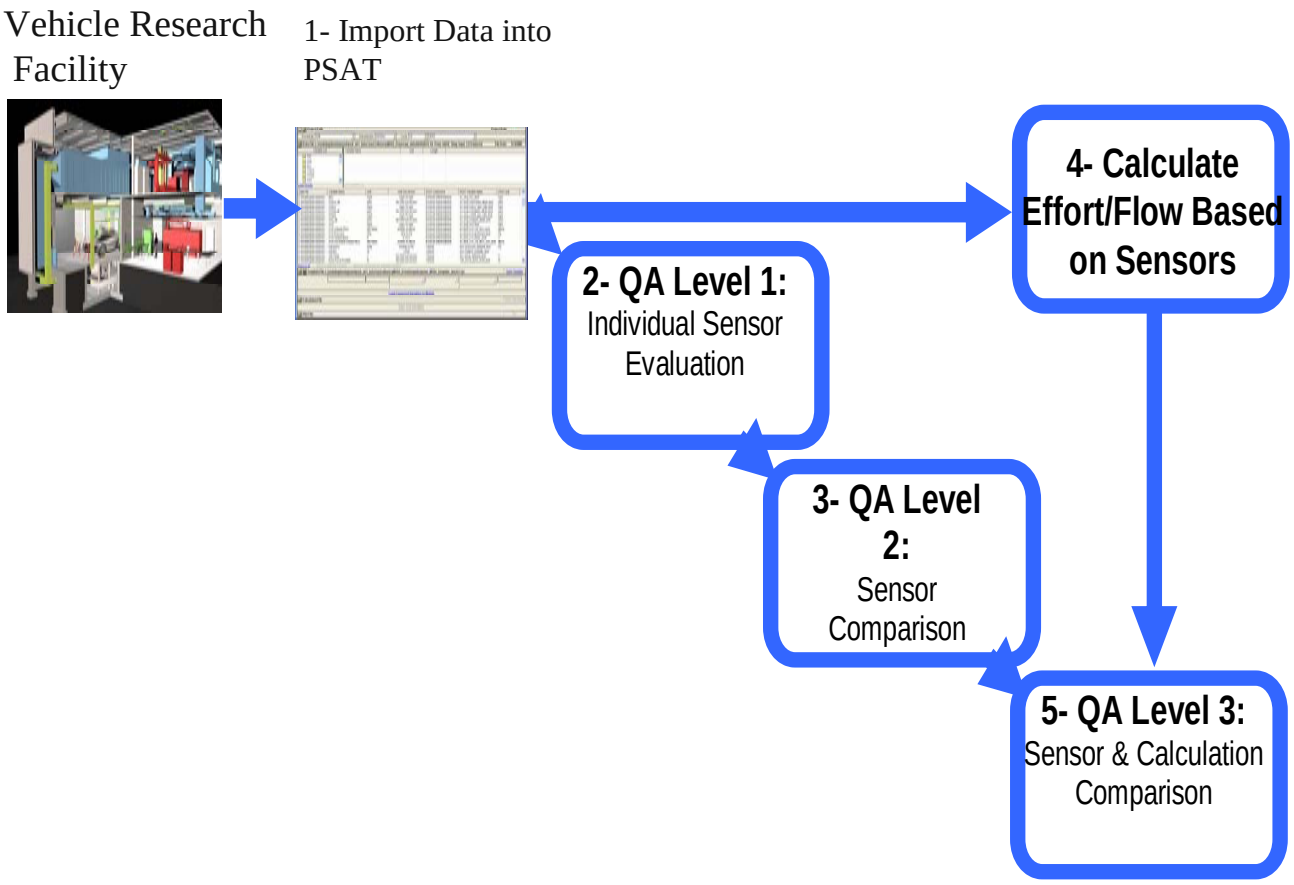
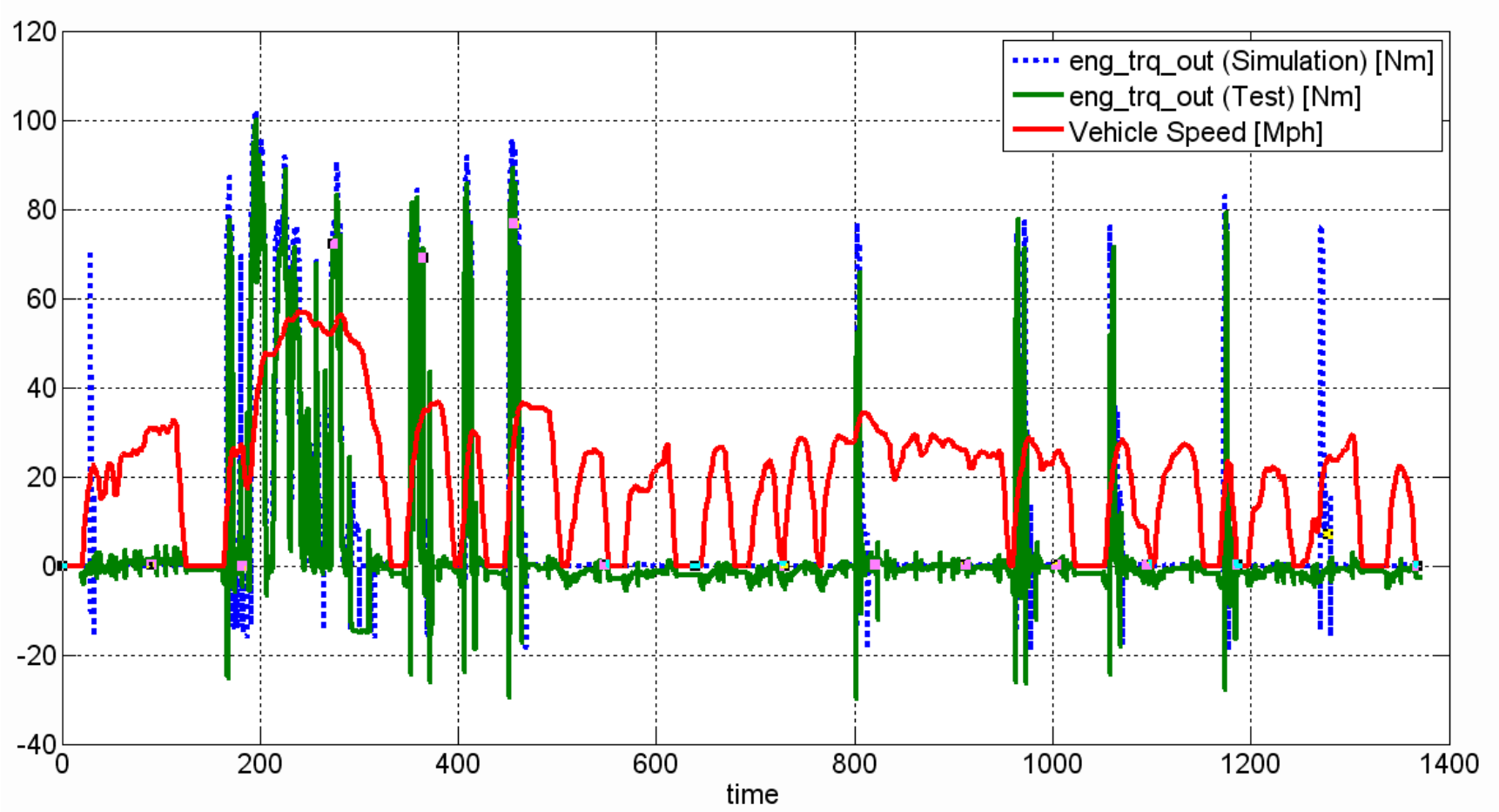
Validation Process

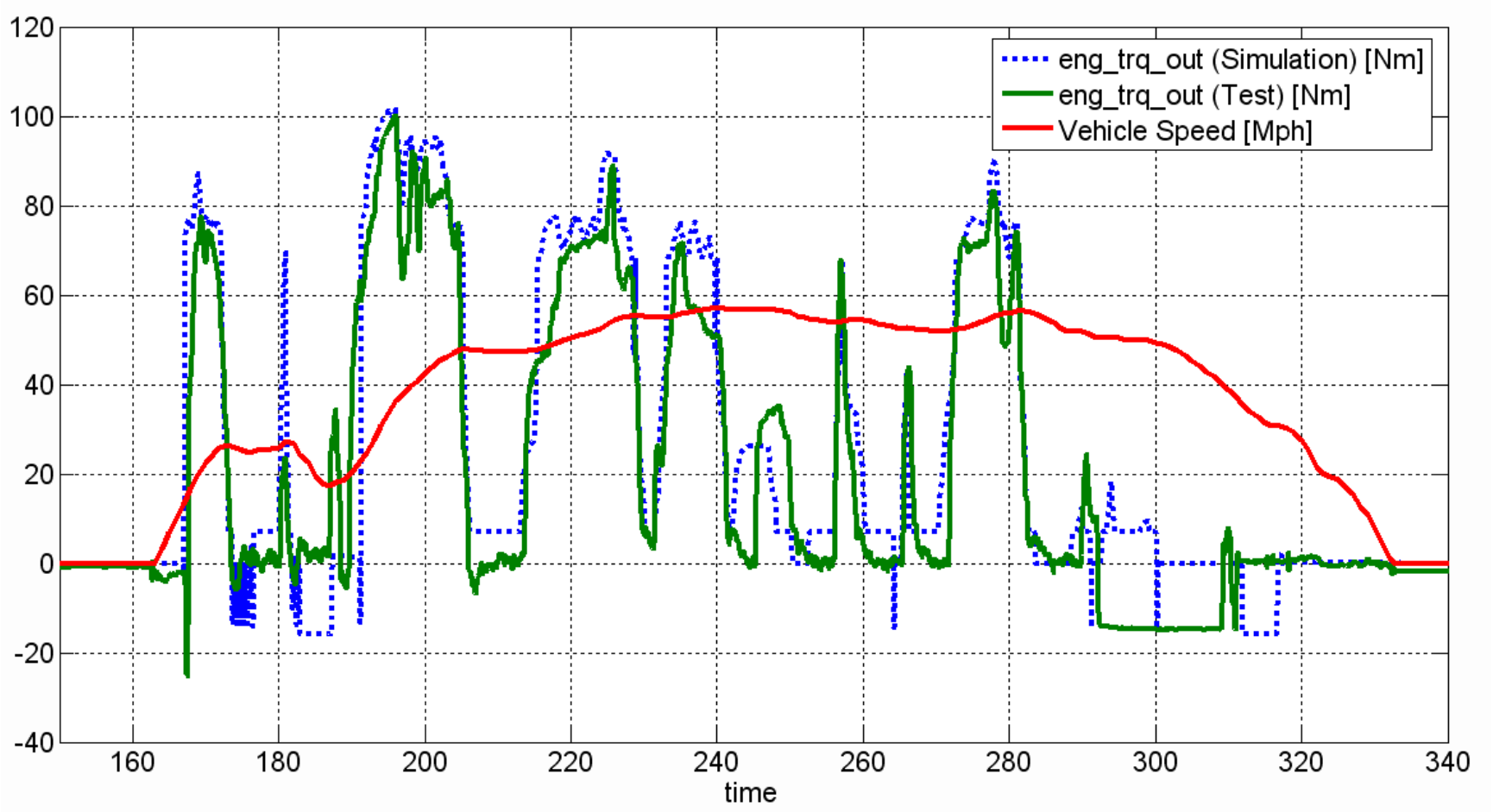


Engine Torque Comparison



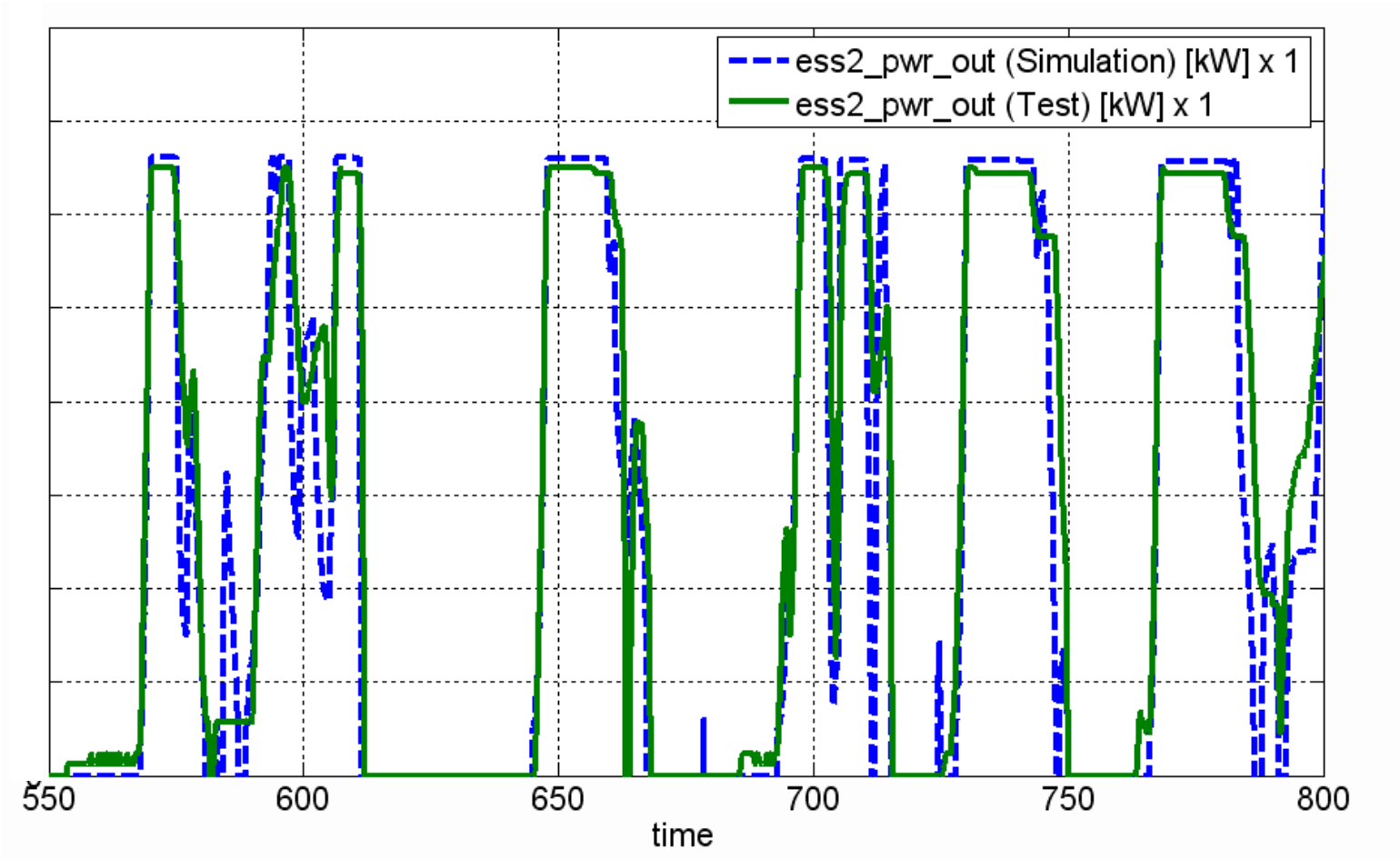
UDDS – during CD Mode

Engine Torque Comparison (Zoom)



UDDS – during CD Mode

High Capacity Battery Power



UDDS – during CD Mode

Model Validation Results

UDDS during CD Mode (Test #60610104)

Parameter	Units	Test	Simulation	Absolute Difference	Relative Difference
Fuel Consumption	l/100 km	1.33	1.22	0.11	8.8%
Elec. Consumption	Wh/km	86.3	83.8	2.5	2.8%
SOC Initial	%	62	62	0	0
SOC Final	%	62	62.8	0.8	1.3%

UDDS during CS Mode (Test #60610106)

Parameter	Units	Test	Simulation	Absolute Difference	Relative Difference
Fuel Consumption	l/100 km	3.64	3.58	0.06	1.7%
SOC Initial	%	62	62	0	0
SOC Final	%	62	61.8	0.2	0.3%

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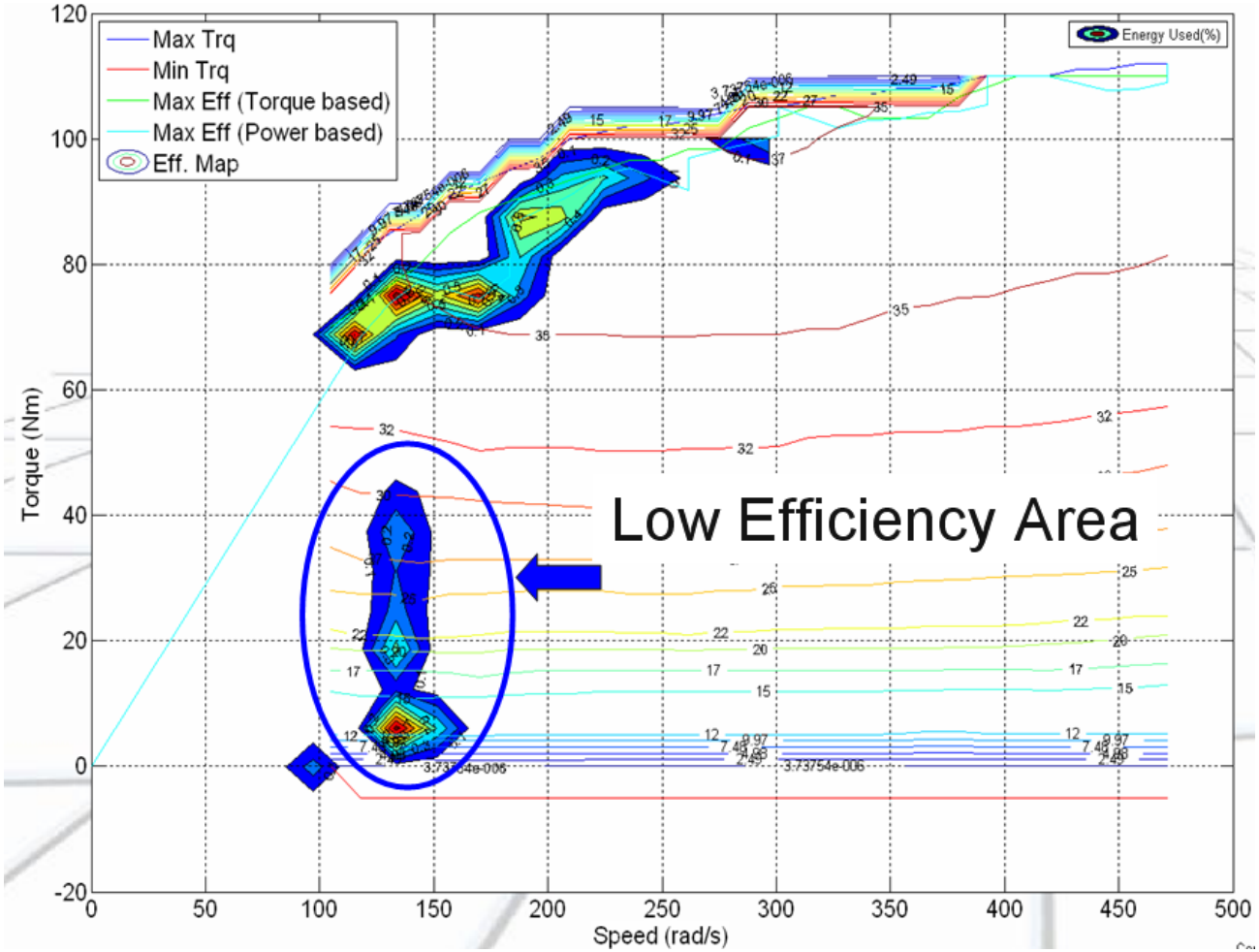
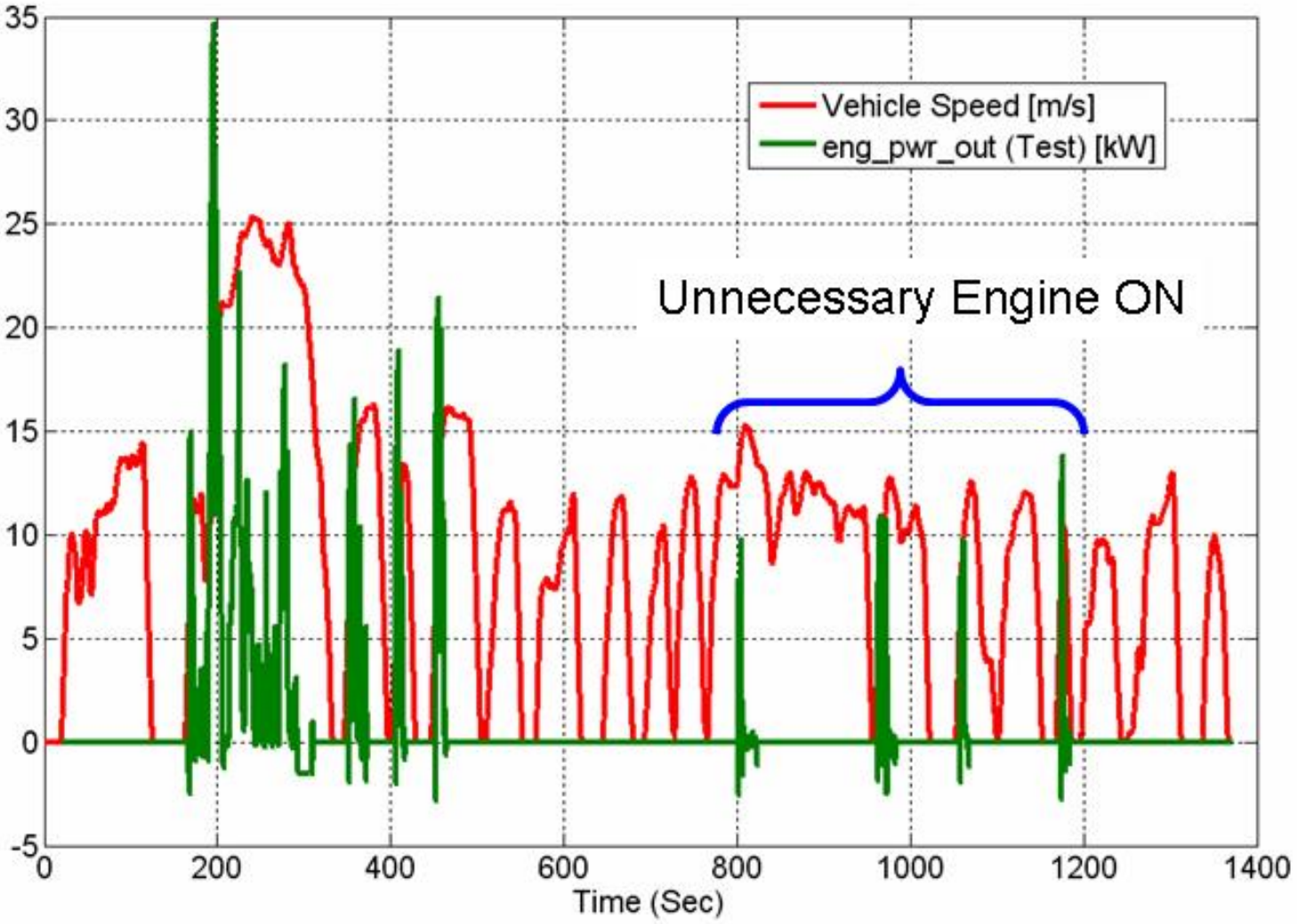
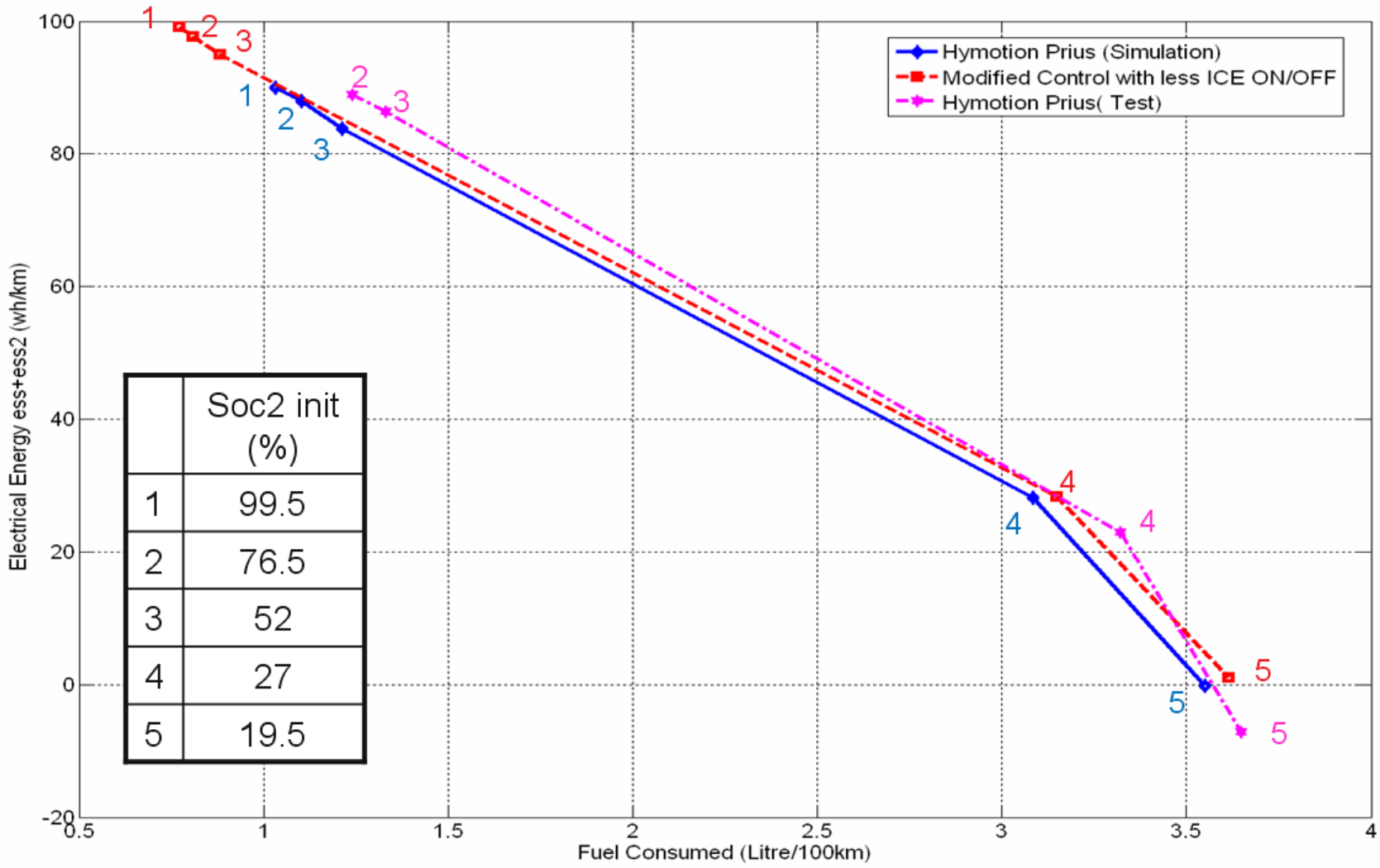
Hymotion Uses Engine at Low Efficiency Areas



Change #1 – Minimize Engine ON/OFF

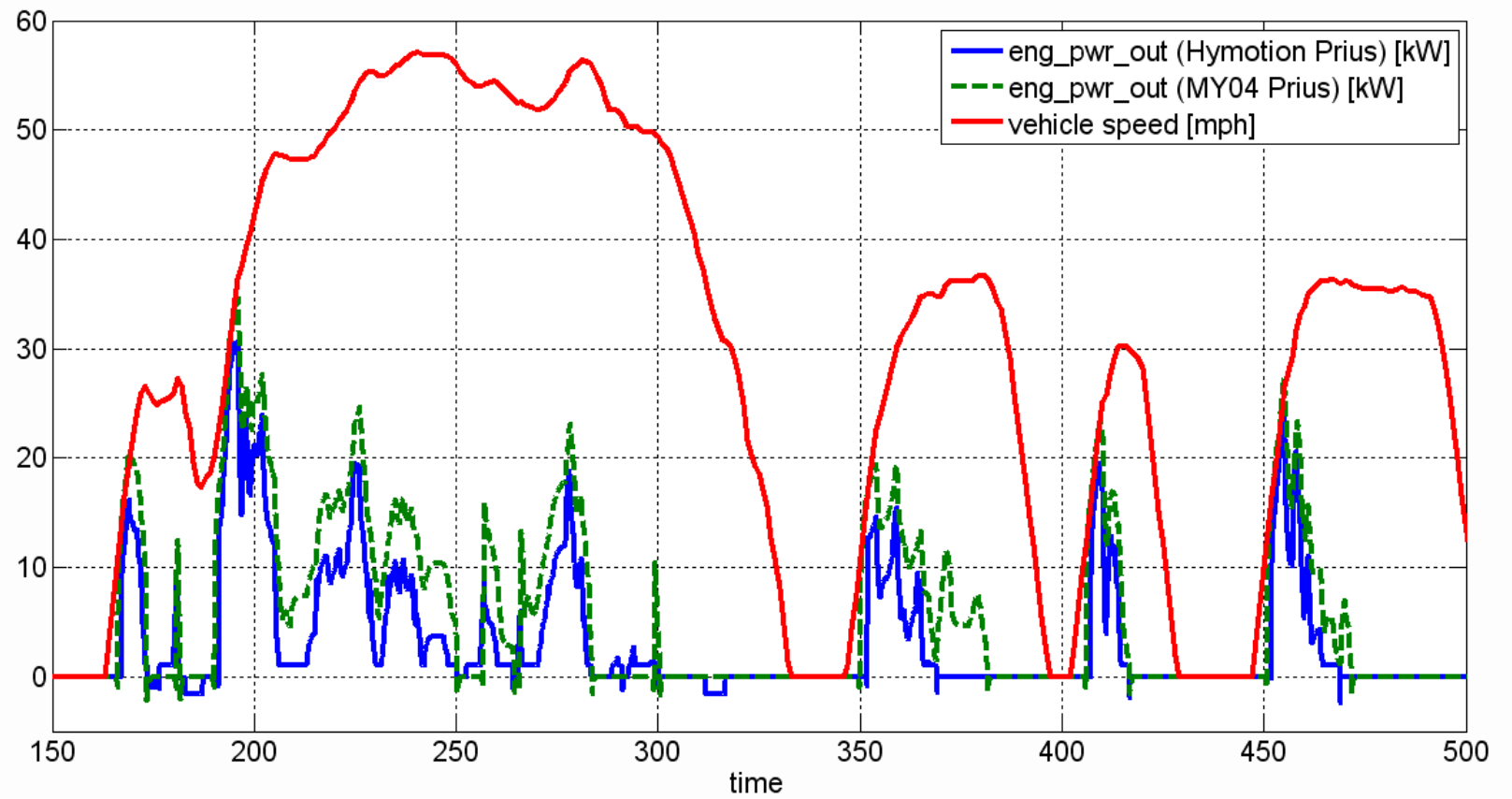


Change #1 – Fuel Economy Impact



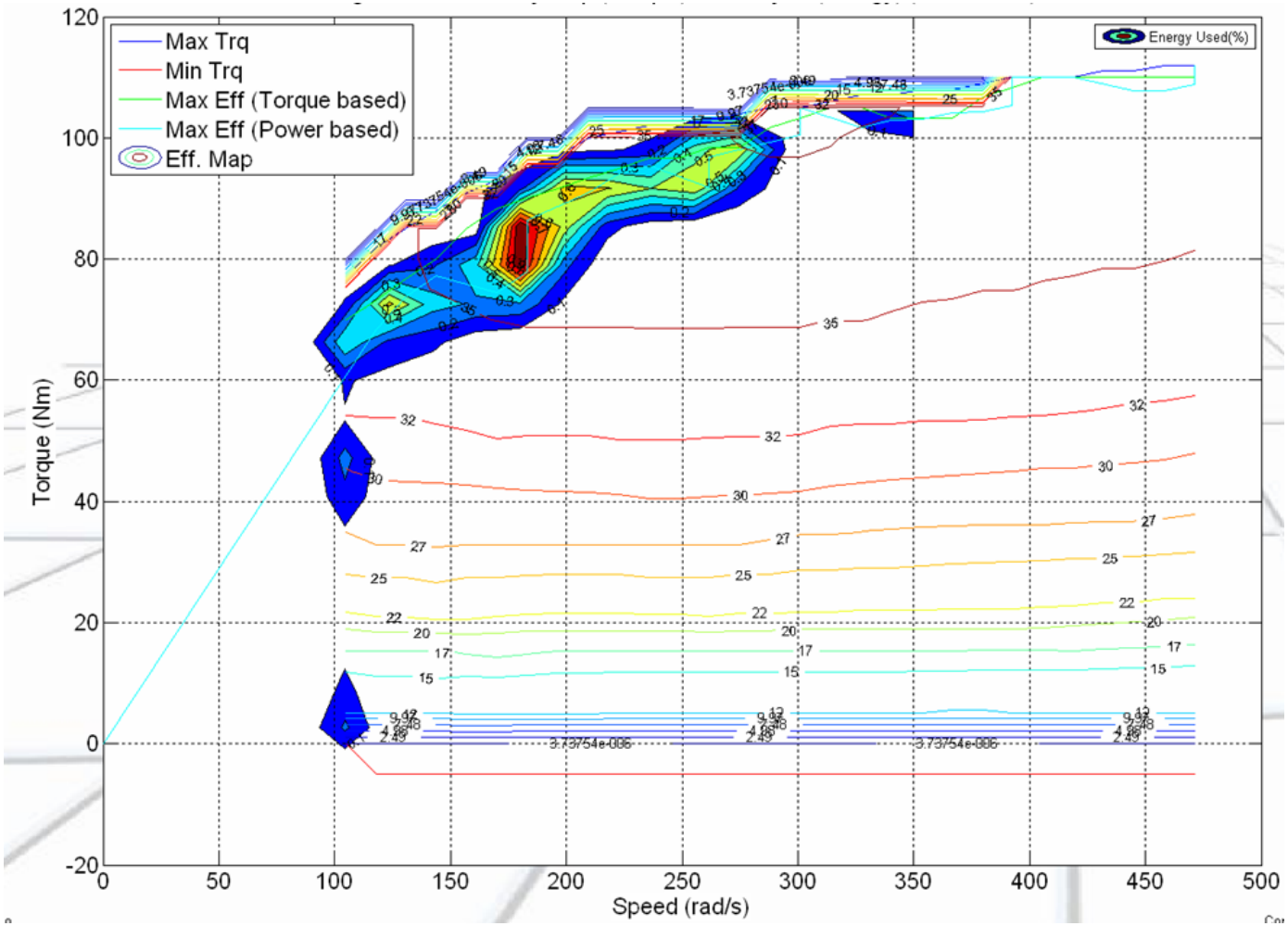
	Soc2 init (%)
1	99.5
2	76.5
3	52
4	27
5	19.5

Change #2 – Engine Operating Condition Improvements

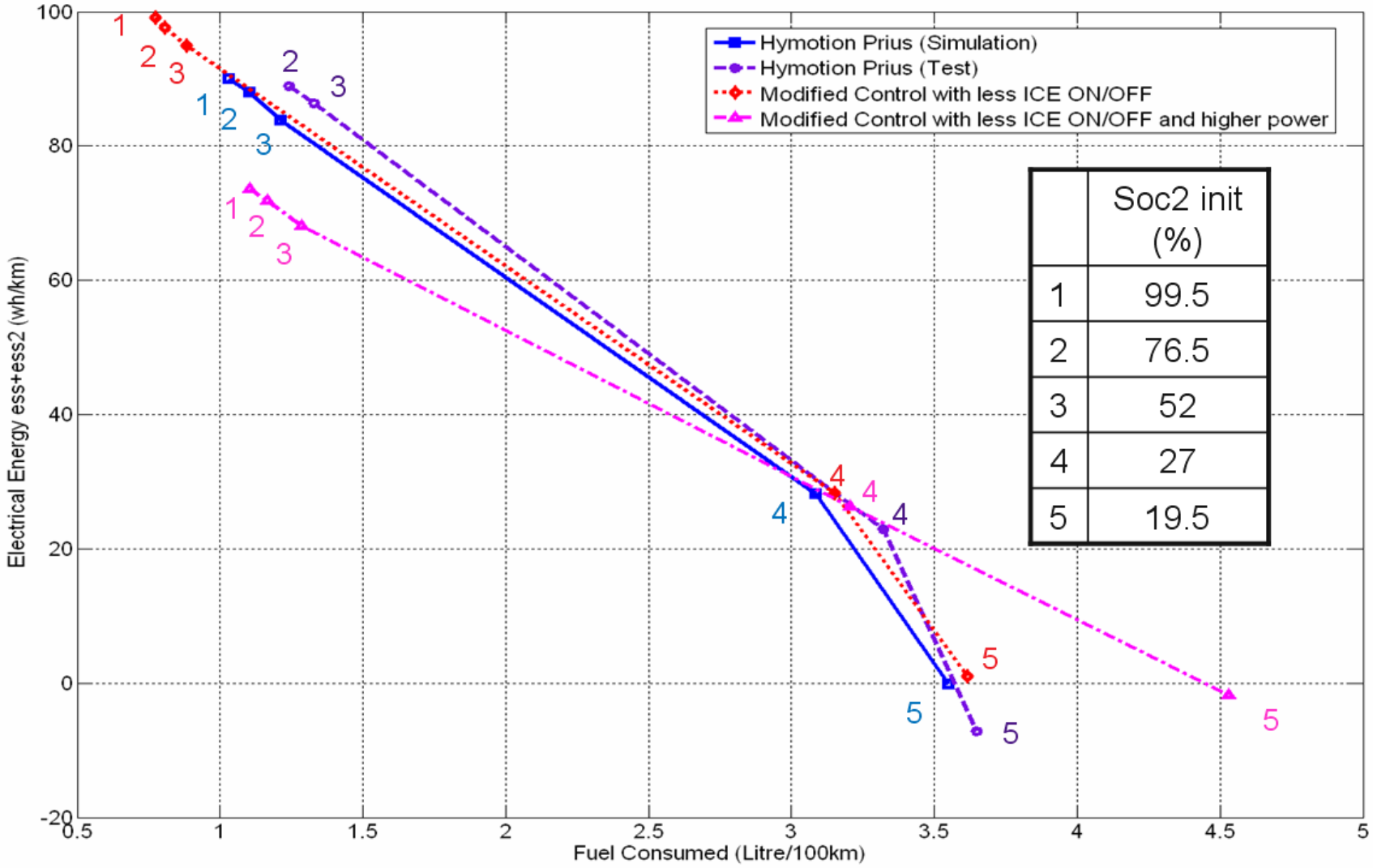


Hymotion operates at lower engine power than the Prius HEV

Change #2 – Changes Lead to Higher Engine Efficiencies



Change #2 – Fuel Economy Impact



	Soc2 init (%)
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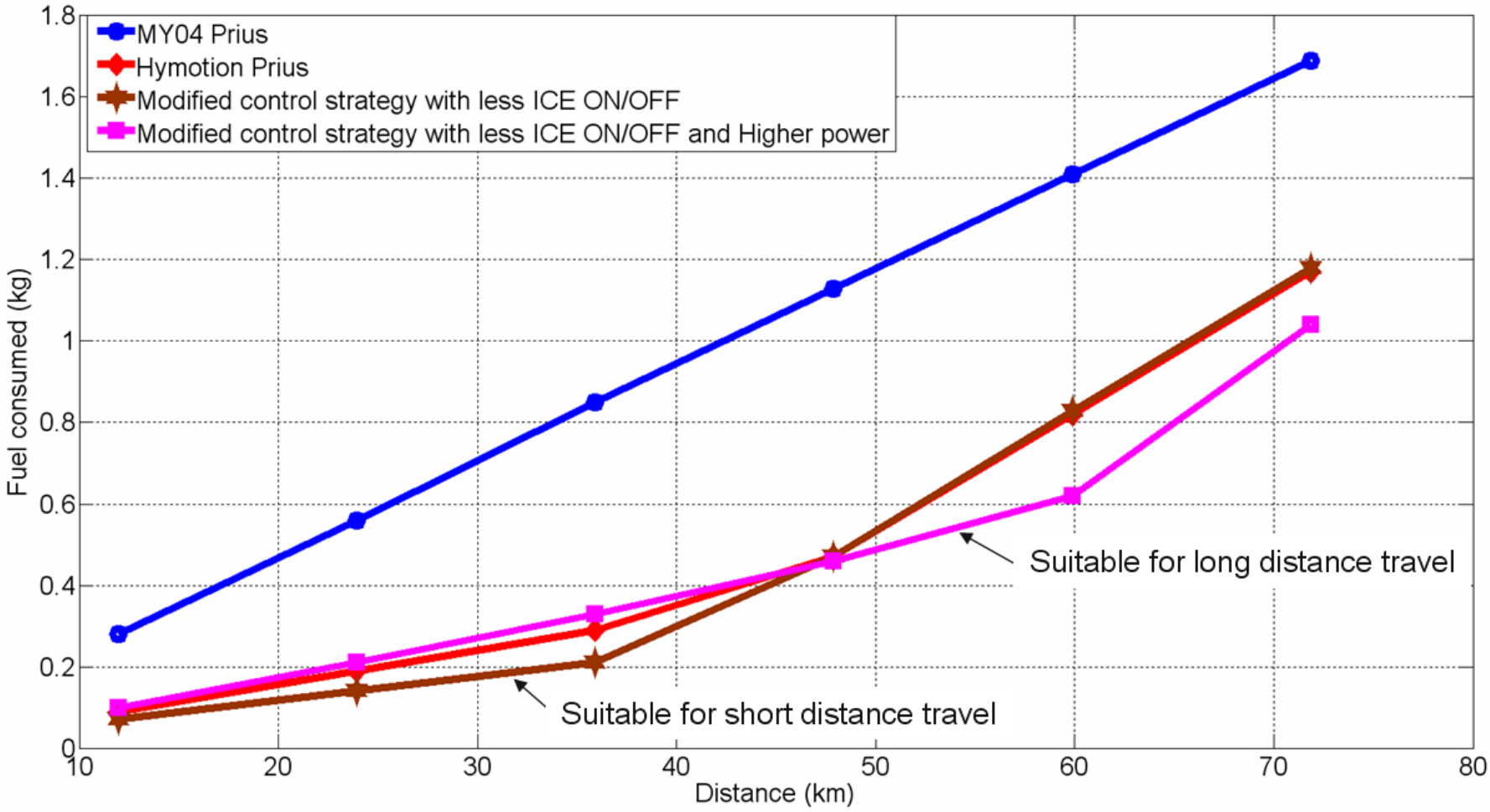
2	76.5
3	52
4	27
5	19.5

Control Options Comparison for Different Distances



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Conclusions

- On the basis of vehicle test data collected in Argonne's four-wheel-drive dynamometer, the 5-kWh Hymotion Prius model was validated in PSAT. The engine ON logic and its operating points were correlated with test data.
- Several changes were proposed to minimize the number of engine ON/OFF events and maximize the engine's efficiency throughout the drive cycle.
- The study demonstrated that it is preferable to operate the engine at low power during short trips and higher power during longer trips to maximize the efficiency of the entire system.