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Impact of Drive Cycles on PHEV Component Requirements

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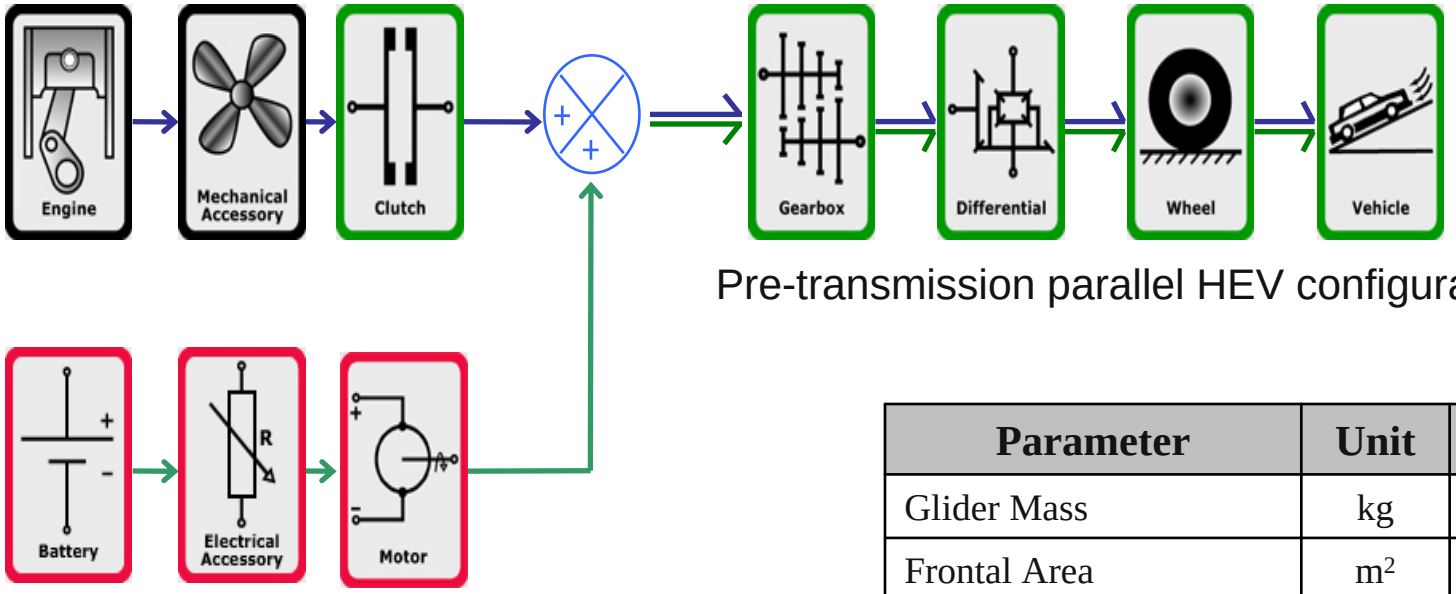
Sponsored by Lee Slezak, U.S. DOE

FreedomCAR & Fuel Partnership

Outline

- PHEV Sizing Based on UDDS for 10, 20 40 AER.
- Control Strategy Options when Engine is ON
- What is the Maximum Share of the Standard Drive Cycle than can be Run in EV?
- What is the Share of the Standard Drive Cycle than can be Run in EV when Engine is Used at Best Efficiency?
- PHEV Sizing Based on Various Driving Cycles.

PSAT Modeling Assumptions

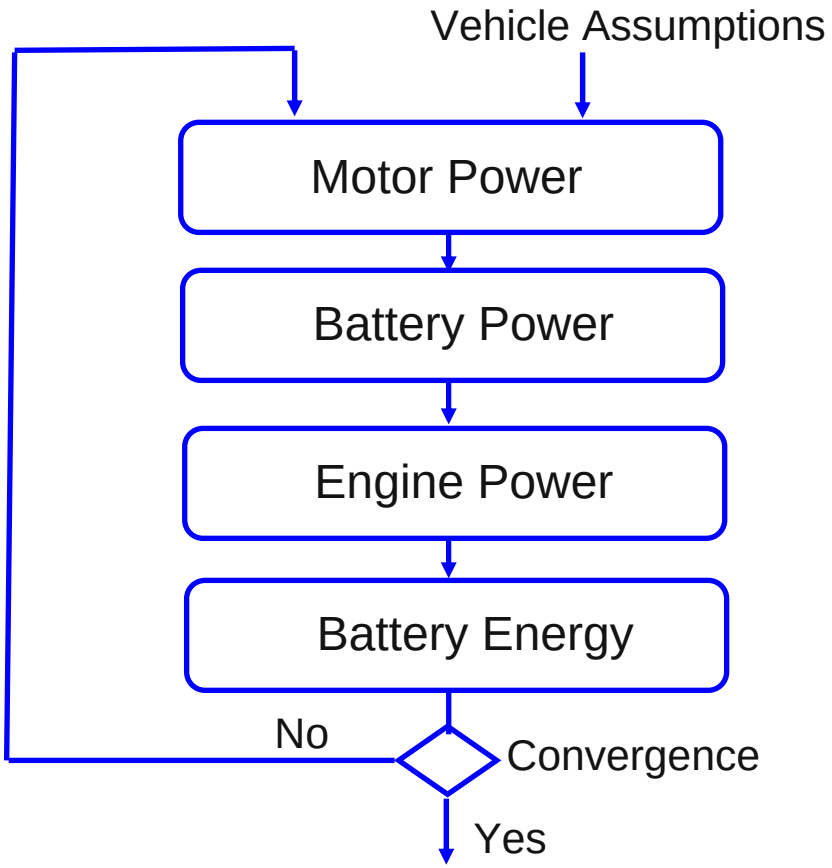


Pre-transmission parallel HEV configuration

Parameter	Unit	Value
0–60mph	s	9 +/- 0.1
0–30mph	s	3
Grade at 60 mph	%	6
Maximum Speed	mph	> 100

Parameter	Unit	Midsize Car
Glider Mass	kg	990
Frontal Area	m^2	2.1
Drag Coefficient		0.31
Wheel Radius	m	0.317
Rolling Resistance		0.008

Vehicle Sized to Meet Requirements



Associated Requirements

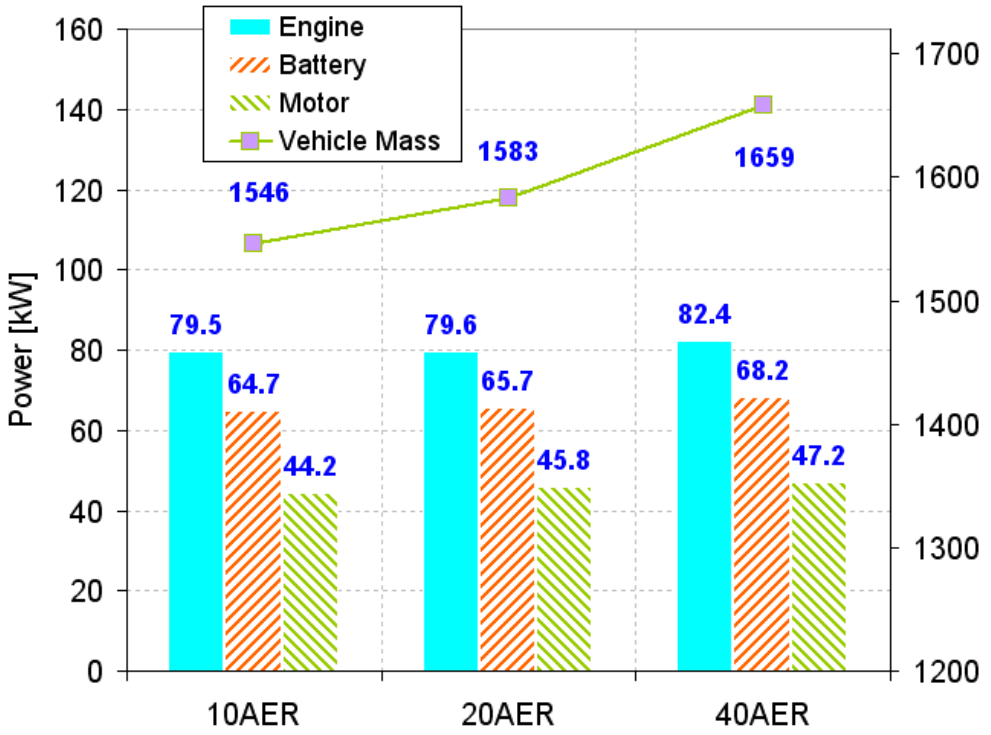
Drive Cycle in EV Mode

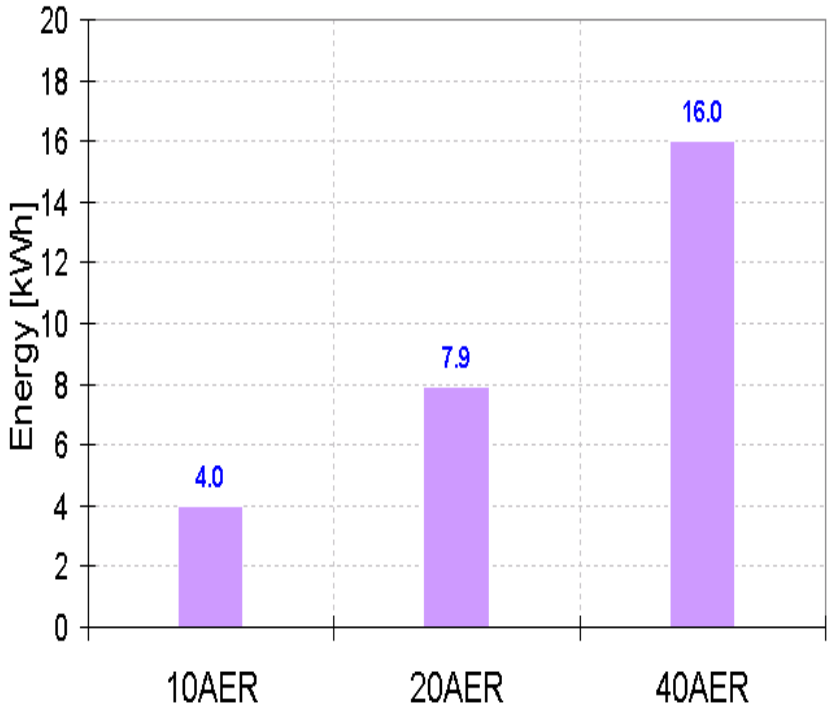
Perfo:
IVM-60 mph

Grade:
60 mph 6% grade

Range

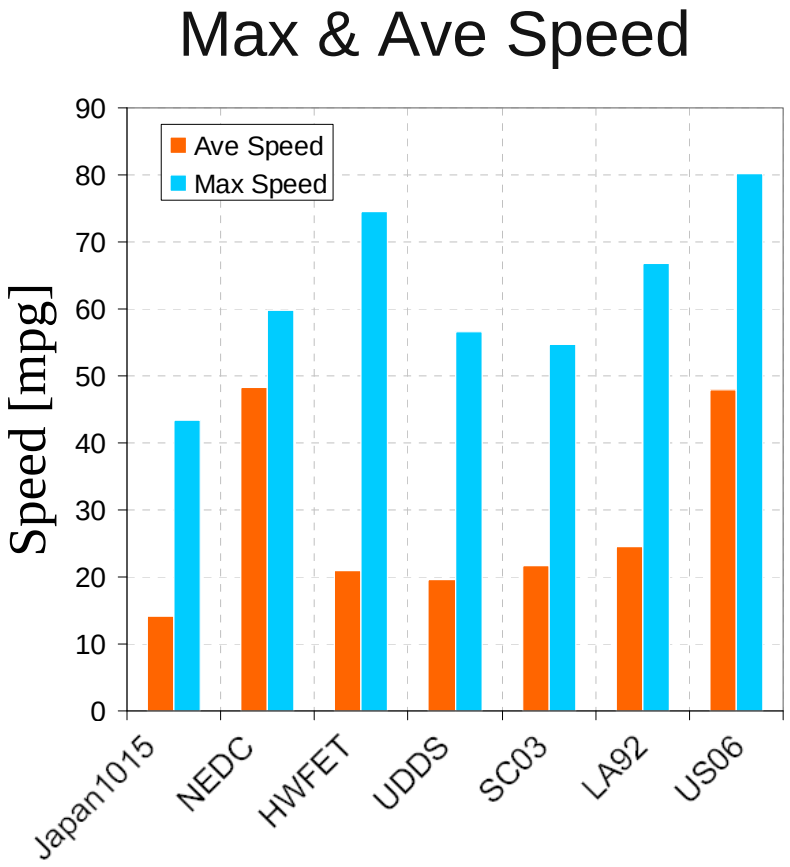
Component Sizing on UDDS

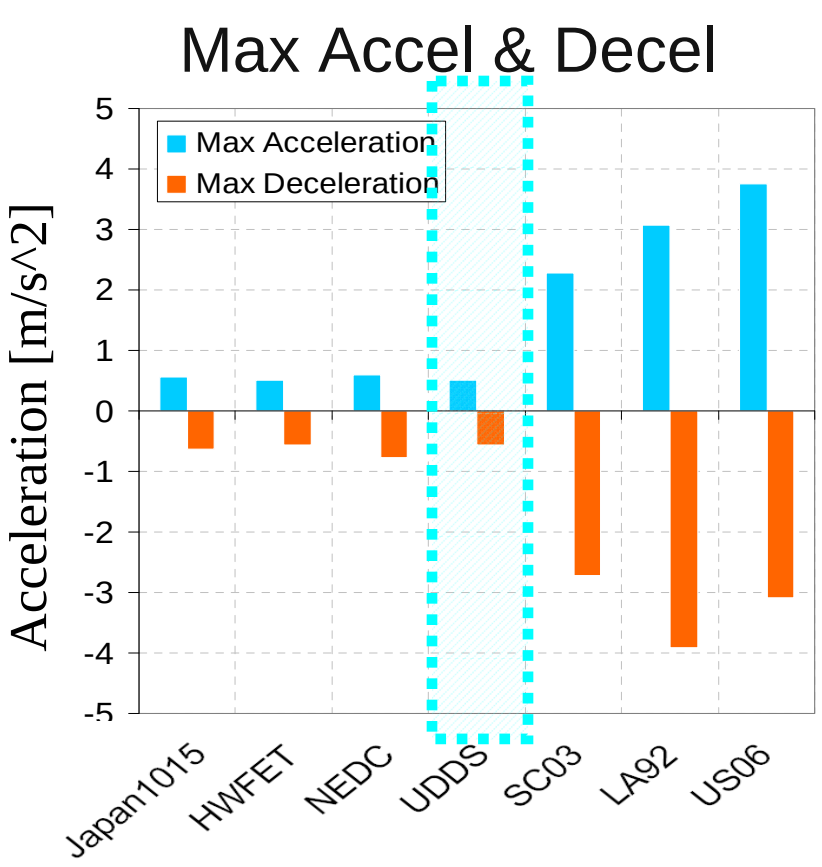




- Battery power slightly increases due to vehicle mass
- Battery capacity changed to maintain acceptable battery pack voltage (~200V)

Cycle Characteristics : SC03, LA92 and US06 are More Aggressive





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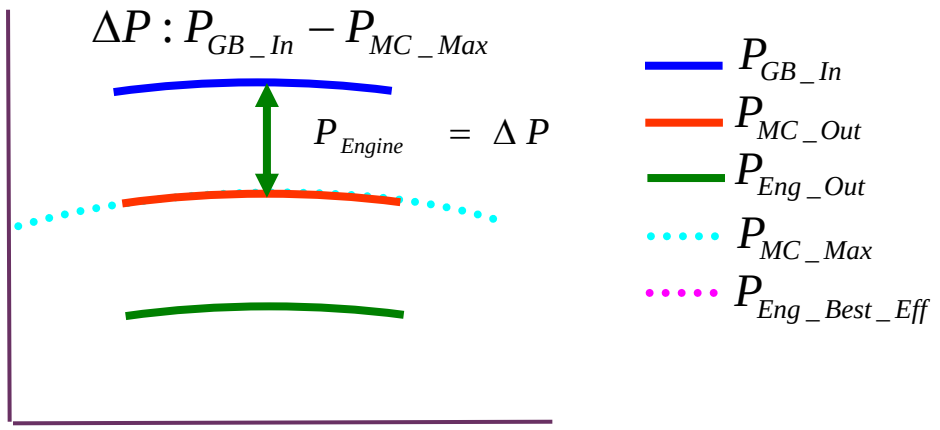
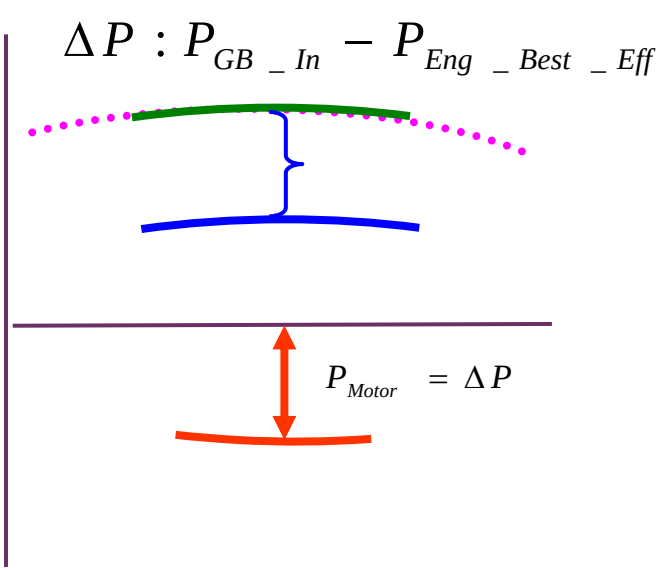
Two PHEV Controls Were Considered





- Engine Minimum Assist :

  Engine is turned on when Motor torque reaches its maximum power curve. Engine provides the delta power between required power at the gearbox input and maximum motor power

- Engine Assist at Best Efficiency :

  Engine is turned on when Motor power reaches its maximum power curve. The engine operates at the best efficiency region. The surplus power from the engine is used to charge the battery.

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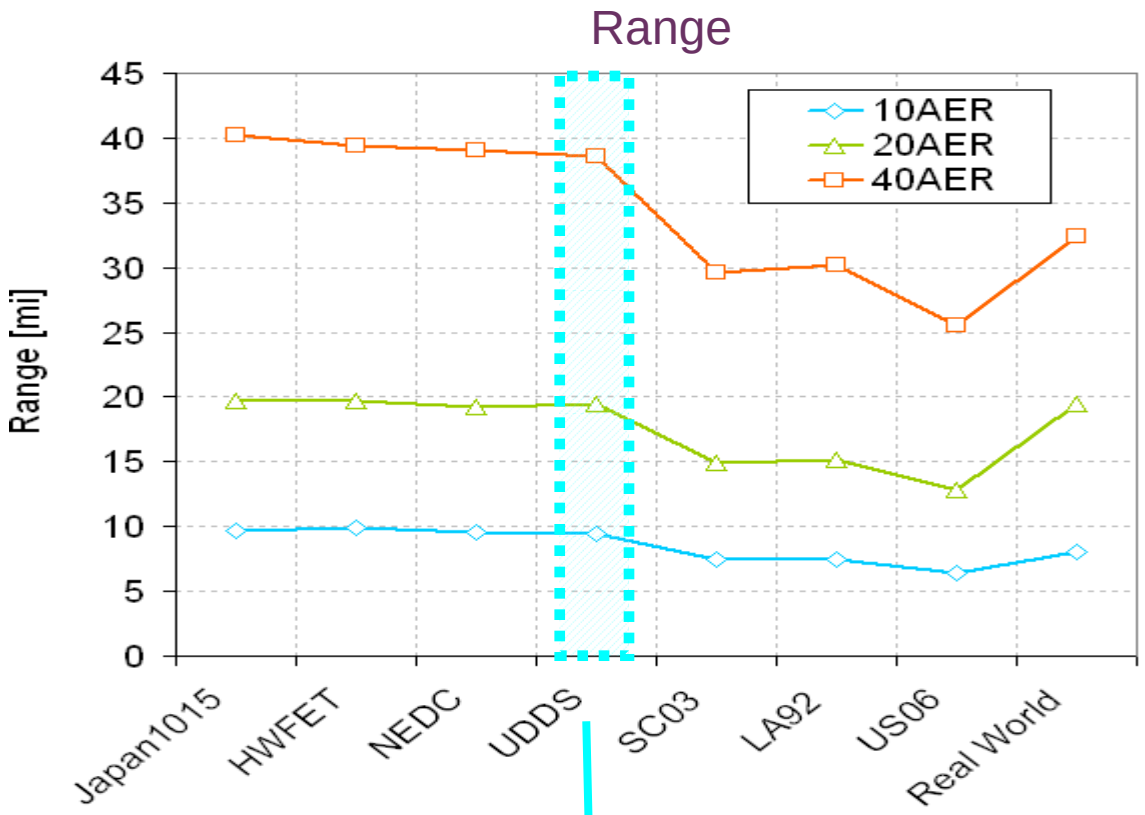
Charge Depleting (CD) Capability Decreases as Drive Cycle Aggressiveness Increases



Aggressiveness Decreases

Aggressiveness Increases

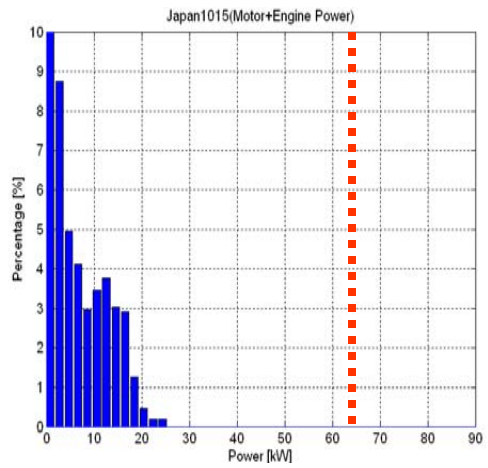
CD Increases

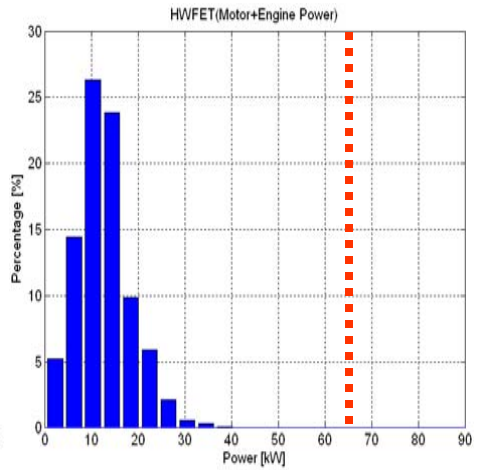
CD Decreases

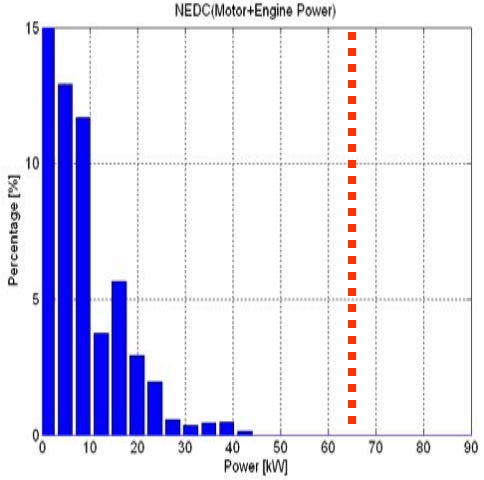
Engine Minimum Assist

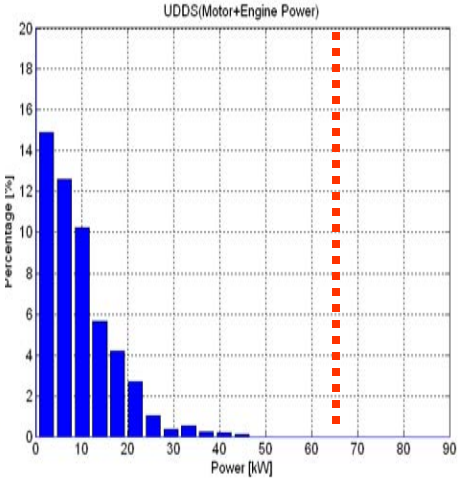
Engine Used Only When Electric Machine Reaches its Limit

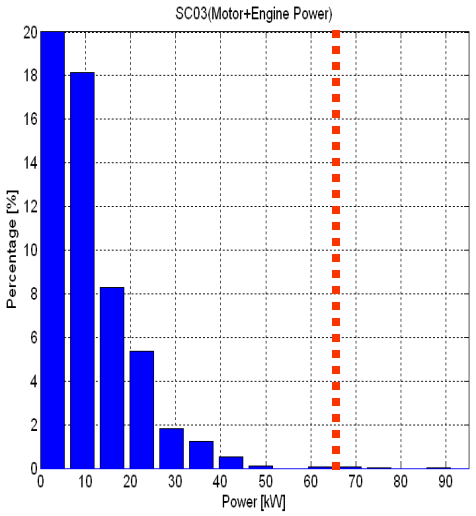
.... Maximum Power Required at Gearbox Input for UDDS (~67.4kW)

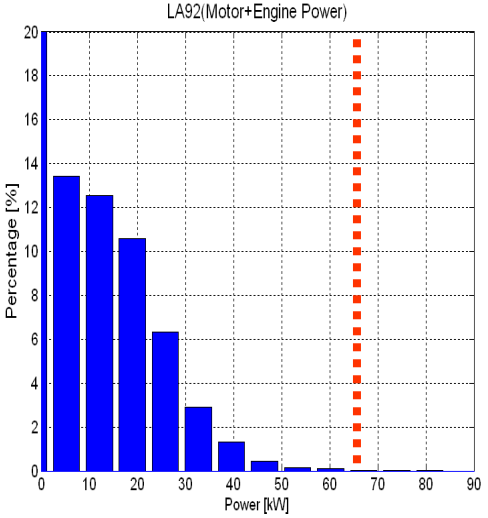


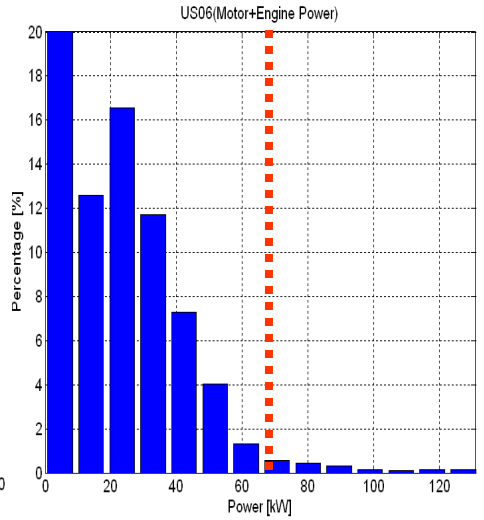


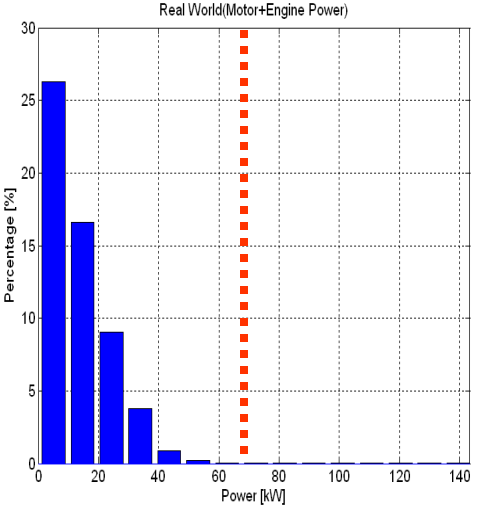






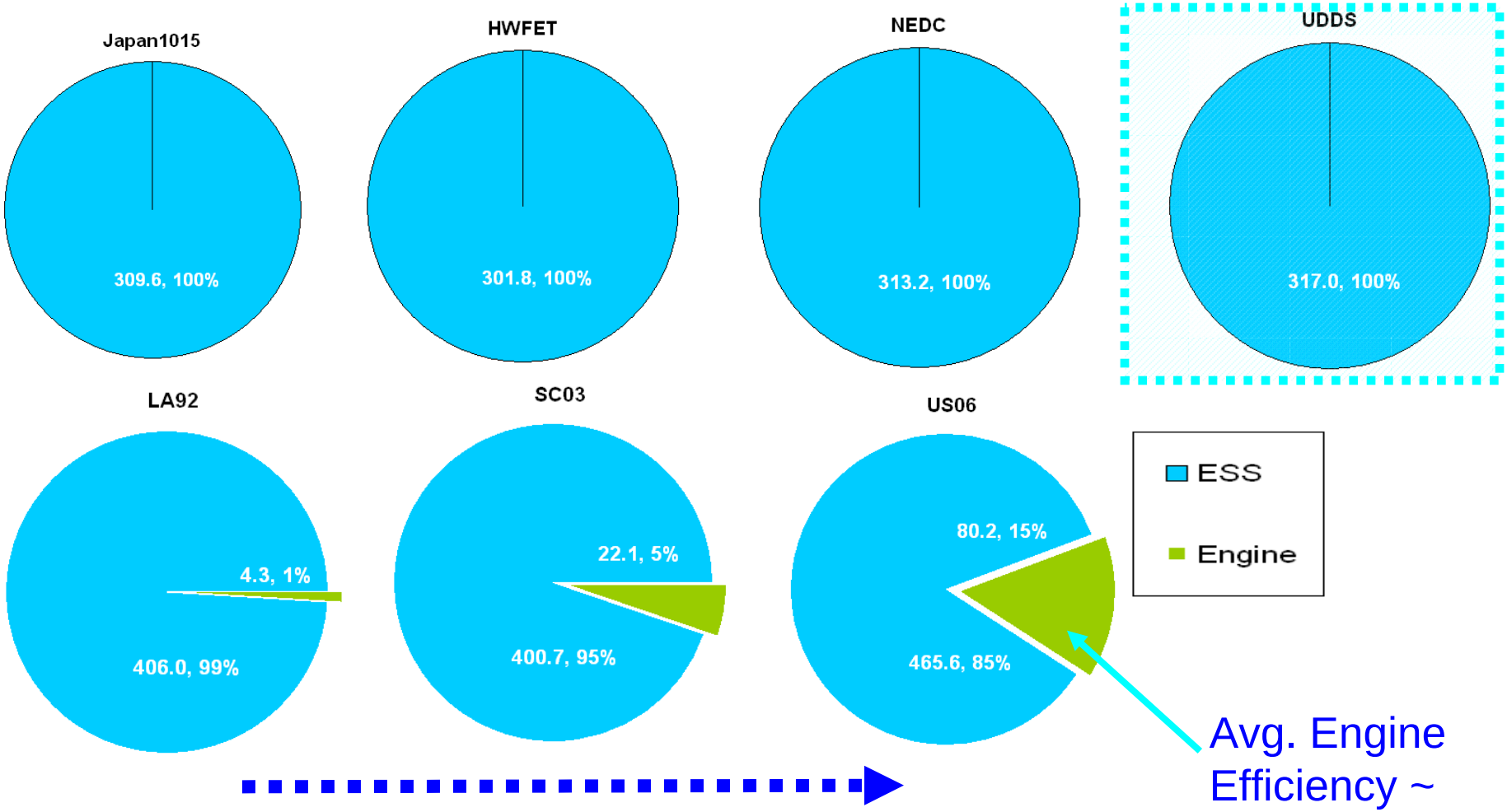






Engine Minimum Assist

Energy Consumption of Engine Increases as the Aggressiveness of Cycle Increases



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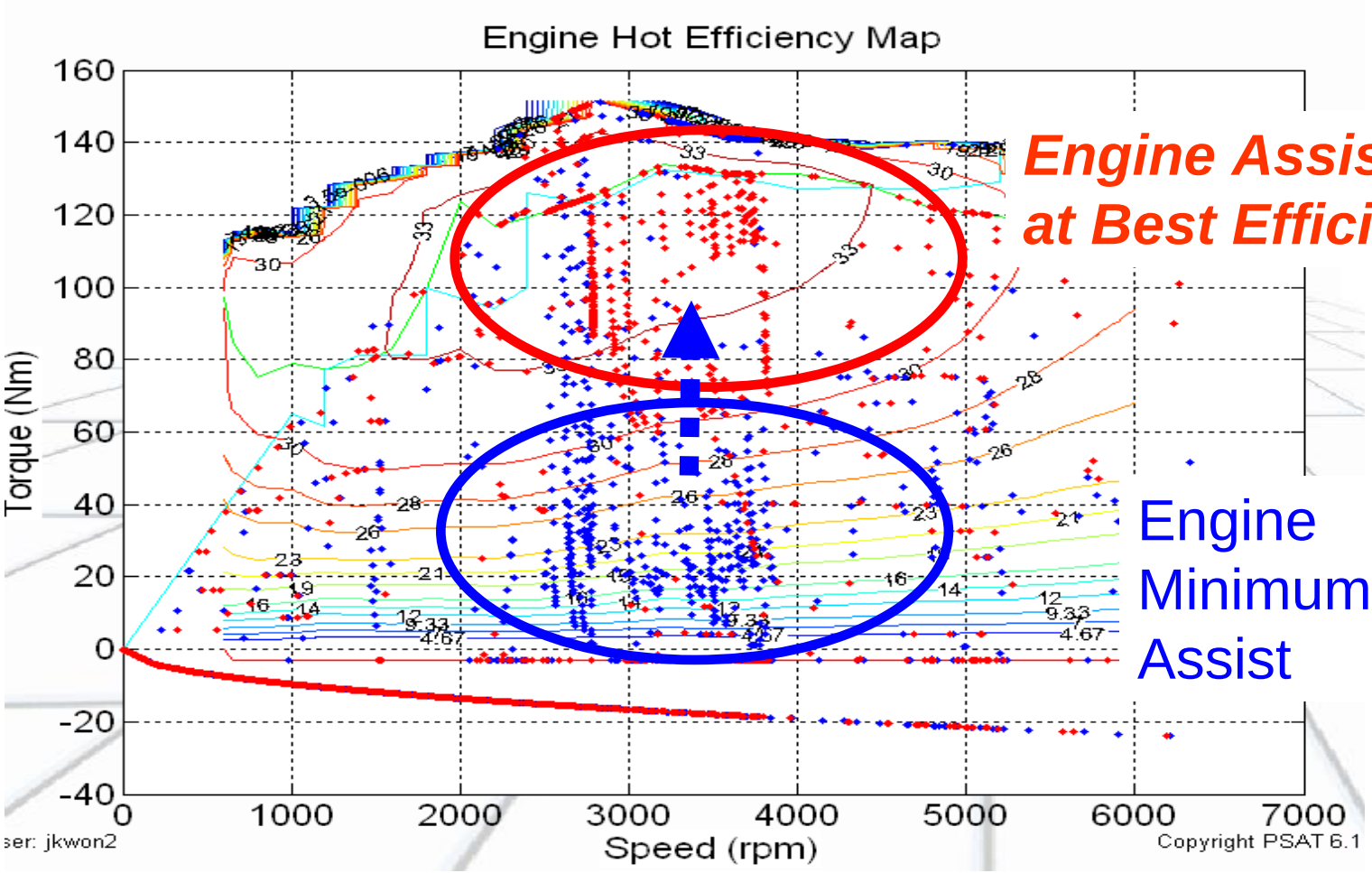
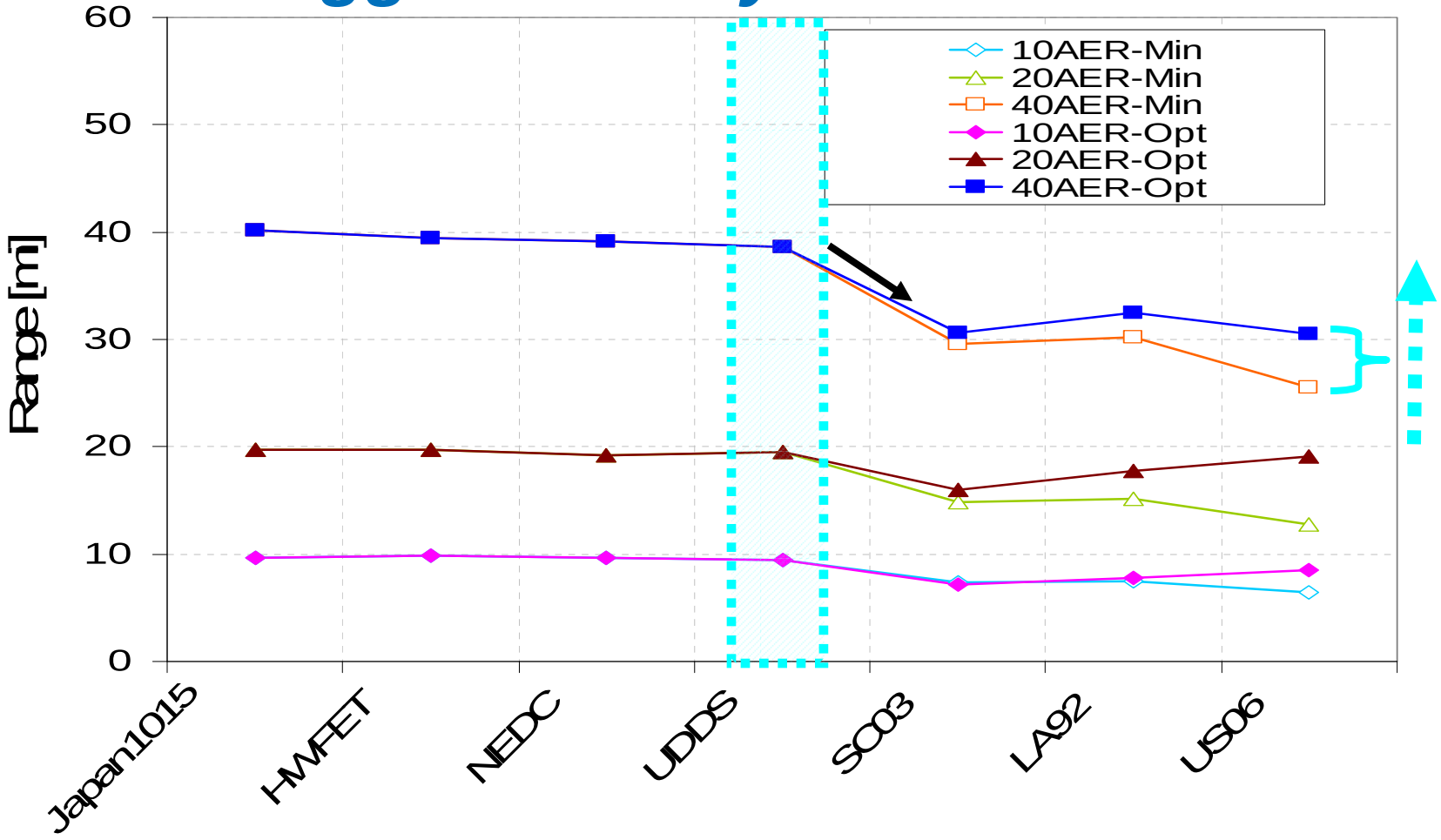
How does Engine Assist at Best Efficiency Control Strategy Affects Energy Consumption?



Engine Assist at Best Efficiency Increases AER for Aggressive Cycles



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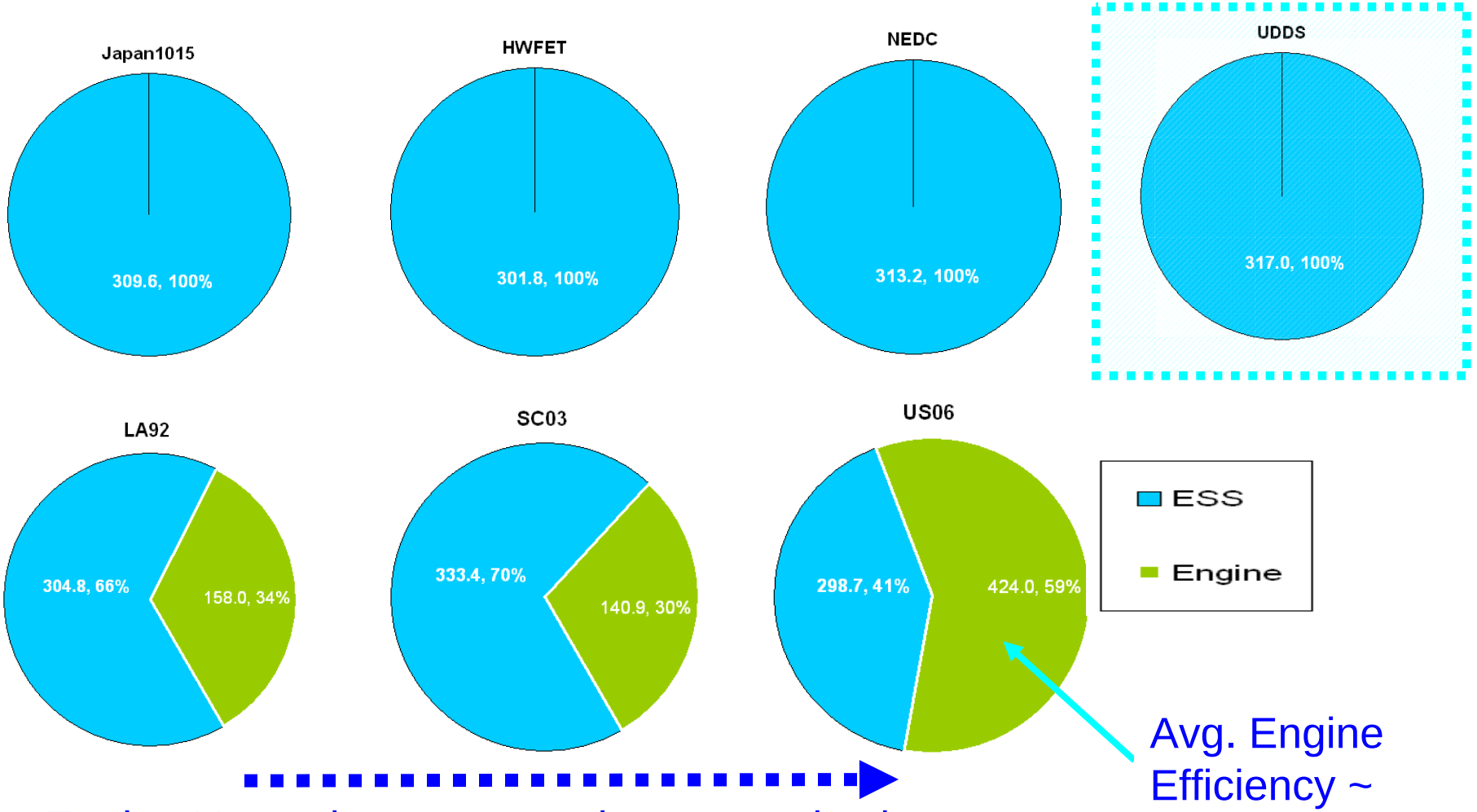

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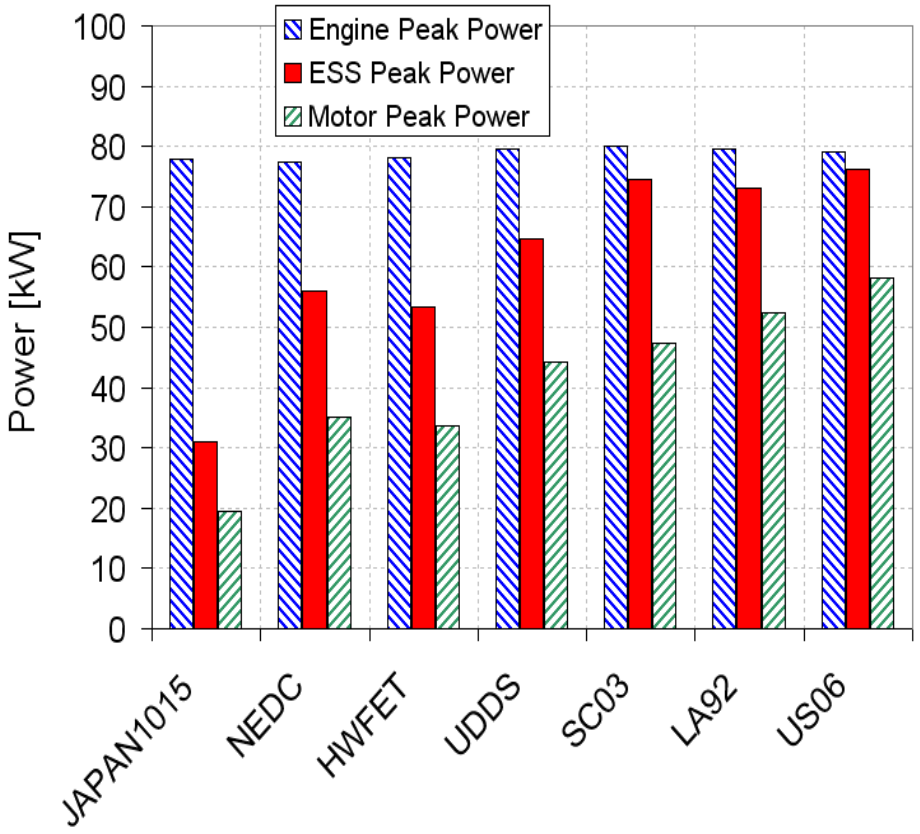
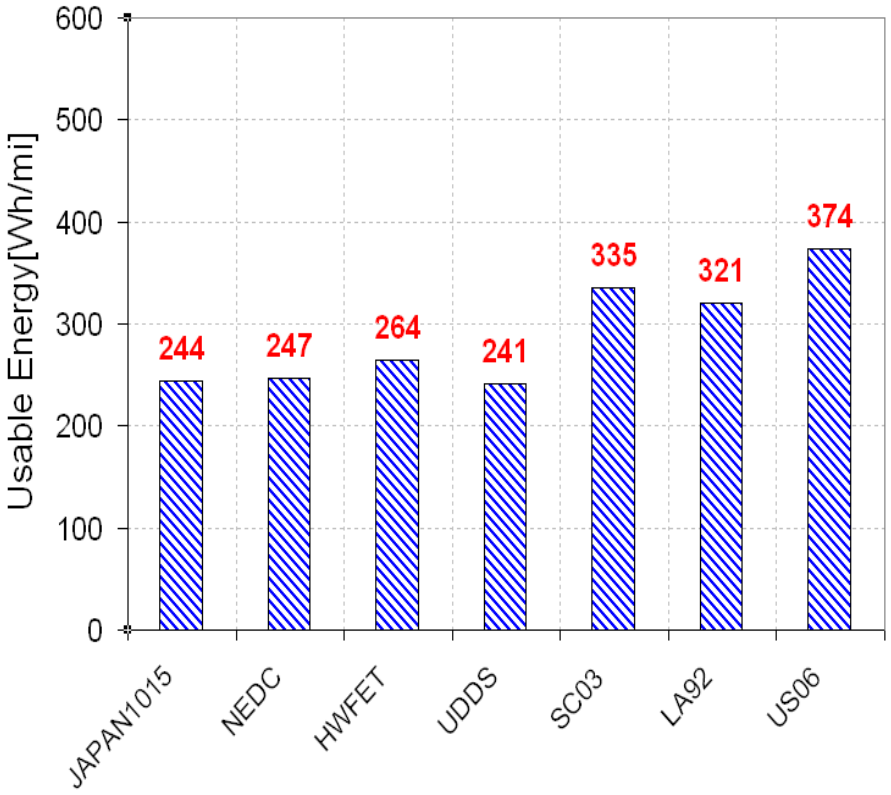
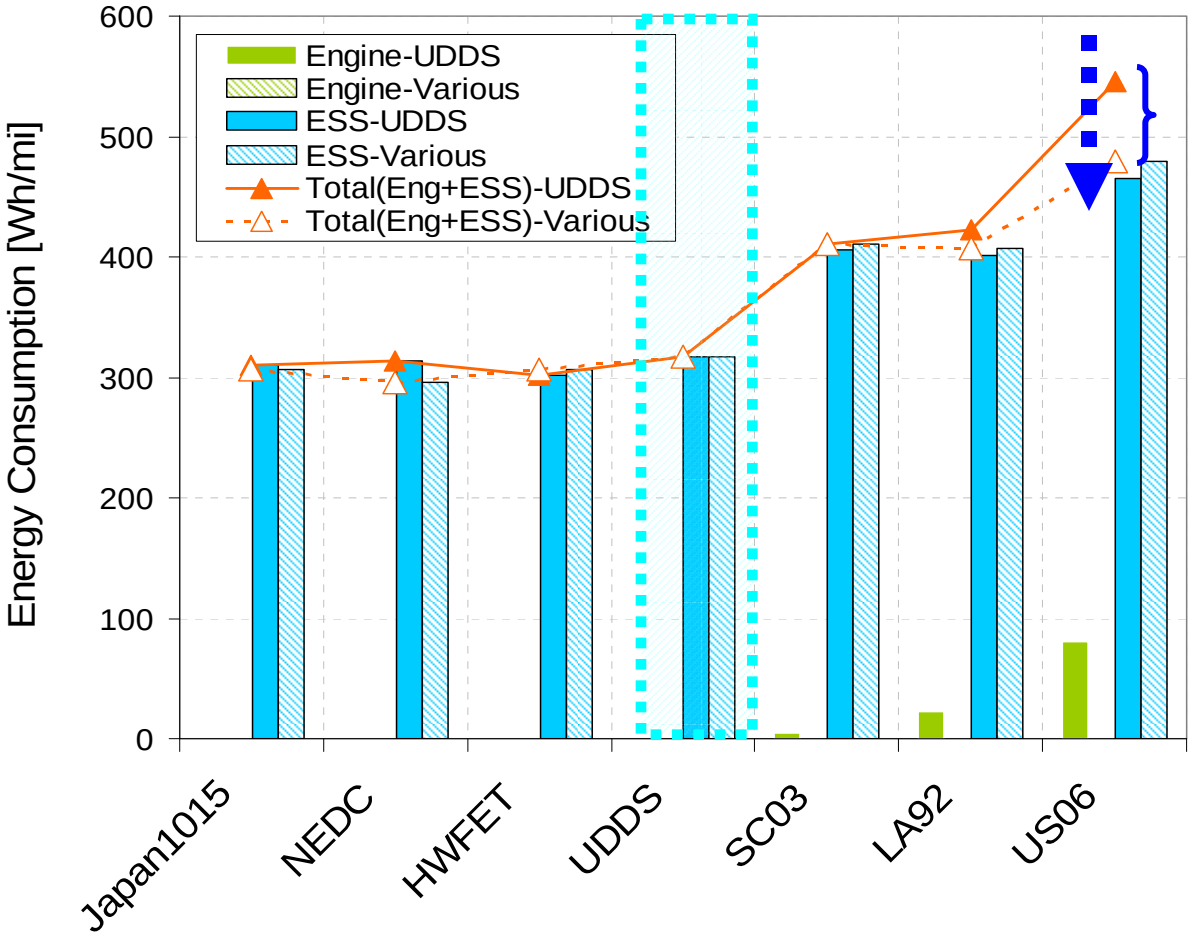
When Battery Sized for Each Cycle, its Power Increases With Cycle Aggressiveness





Sizing based on Each Driving Cycle Decreases Energy Consumption for Aggressive Cycles



The greater impacts are shown on more aggressive cycles, such as SC03, LA92, and US06

10 AER

Conclusion

- The choice of driving cycles influences PHEV design decisions.
- All standard drive cycles considered are less aggressive than real-world driving conditions.
- All electric operation can be achieved on aggressive drive cycles with small additional battery power (10 to 15 kW) compared to the UDDS. However, considering Li-ion technology, available power might not be an issue.
- Should the batteries be designed on UDDS to satisfy CARB requirements when it is not representative of real-world driving conditions?