evs 27

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Impact of Worldwide Test Procedures on Advanced Technology Fuel Efficiency Benefits

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Organized by Fira Barcelona avele

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In collaboration with EVAAP EDTA

Supported by European Commission

Objectives

- To meet future government regulations (i.e., CAFE in the US, CO2 in Europe…), vehicle fuel consumption is critical.
- Different standard test procedures have been developed in EU, Japan and Europe to evaluate if the vehicles meet the regulation.
- Vehicle energy consumption is highly dependent on driving conditions.

- How does each standard driving cycle influence fuel and electrical consumption benefit of different powertrain technologies over conventional vehicles?
- Does the standard cycle choice influence the market and if so, are governments indirectly favoring technologies?

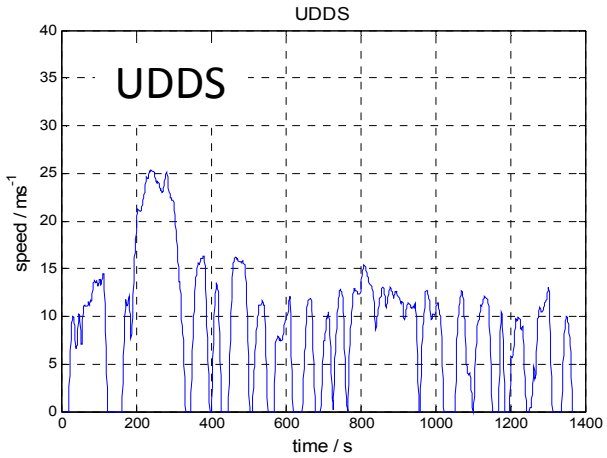
Methodology

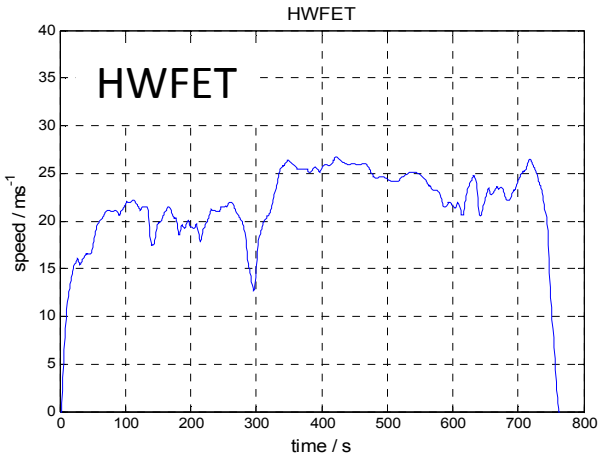
A wide range of powertrain configurations considered for a midsize vehicle

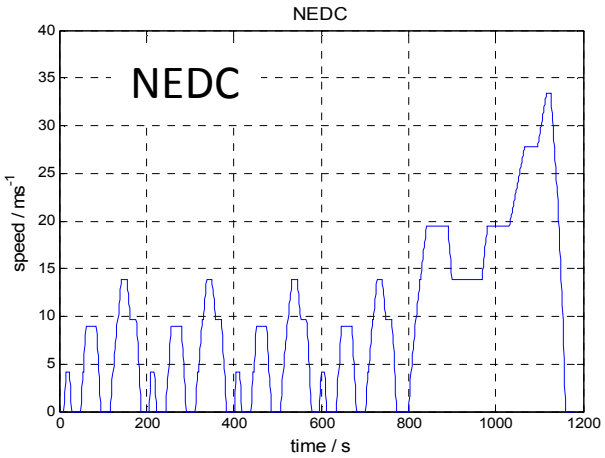
- Conventional gasoline (SI)
- Conventional diesel
- Parallel Micro HEV
- Parallel pre-transimission HEV (Mild
- Split HEV (Full)
- Split PHEV 10miles
- PHEV 40miles (EREV)
- Series Fuel Cell HEV
- Electric single gear 100 mi.
- Electric single gear 300 mi.
- Electric AMT 2spd 100 mi.
- Electric AMT 2spd 300 mi.

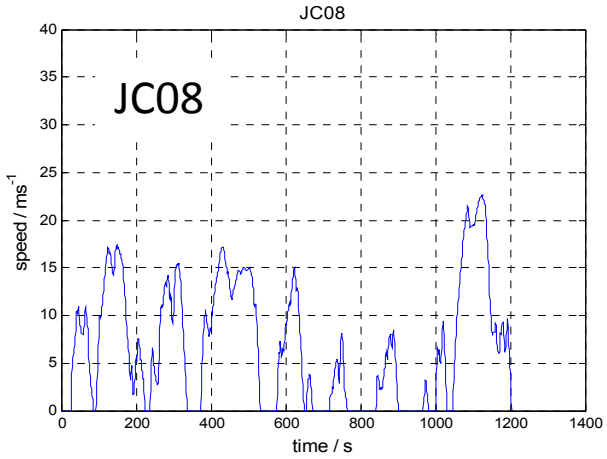
AMT – Automated manual transmission

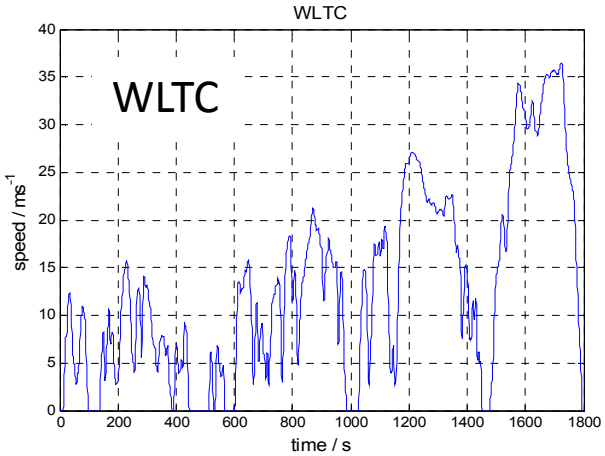
Standard Cycles Considered











Worldwide Standard Cycles Main Characteristics

		JC08	UDDS	NEDC	WLTC	HWFET
Max accel.	m/s^2	1.69	1.48	1.07	1.88	1.43
Mean accel.	m/s^2	0.43	0.50	0.59	0.41	0.19
Max decel.	m/s^2	-1.22	-1.48	-1.43	-1.52	-1.48
Max speed	mph	50.70	56.70	74.60	81.60	59.90
Mean speed	mph	15.21	19.66	20.95	28.85	48.49
Mean running speed	mph	21.55	24.14	27.77	33.06	48.58
Distance	miles	5.09	7.48	6.87	14.43	10.29
Stop frequency	times/mile	2.17	2.28	1.90	0.56	0.10
Mean stop duration	s	32.45	15.18	22.54	29.25	4.00
% stop time	%	29.65%	18.85%	24.83%	13.00%	0.52%
% cruising time	%	0.58%	6.77%	38.51%	0.49%	16.60%
% accel time	%	36.13%	39.71%	20.91%	44.03%	44.18%
% decel time	%	33.64%	34.67%	15.75%	42.48%	38.69%

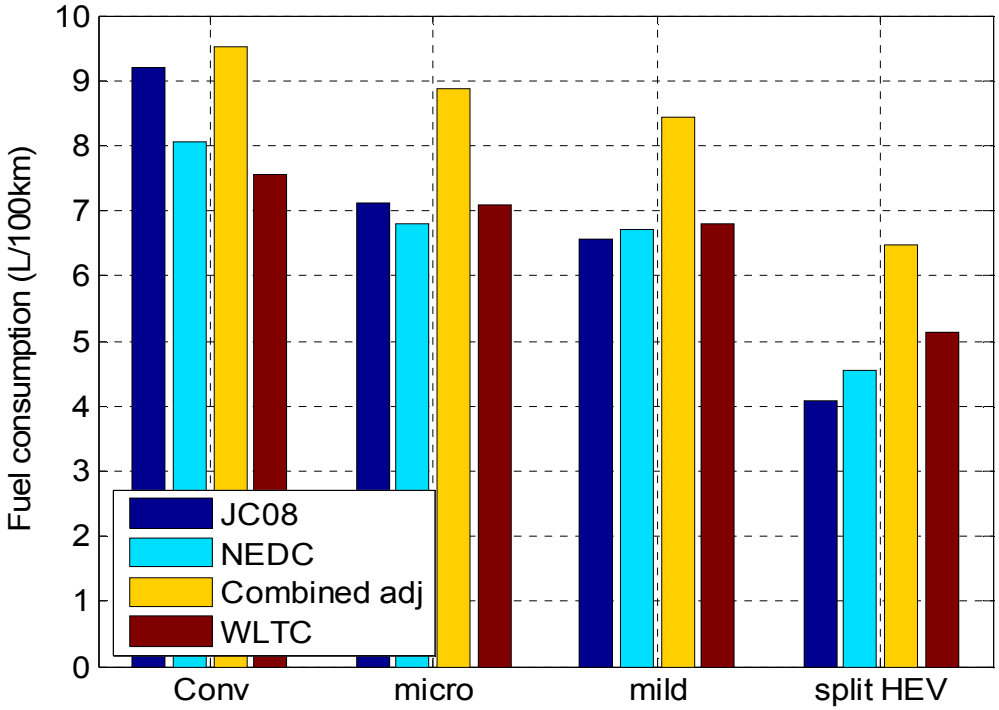
Mean speed increasing

Each Individual Procedures Followed in Simulation

	Combined	JC08	NEDC	WLTC
Conv	2-cycle procs.	Cycle	Cycle	Cycle
HEV	2-cycle procs. w/ SOC corr.	Run drive cycles w/ SOC corr.		
PHEV	J1711	JC08 procs.	NEDC procs.	Cycle
BEV	2-cycle procs.	Cycle	Cycle	Cycle

- US procedure includes adjustment factors
- Analyze the performance of powertrains in terms of
  - Fuel / Energy consumption
  - Fuel consumption ratio compared to conventional vehicles
  - Levelized Cost of Driving (LCOD)

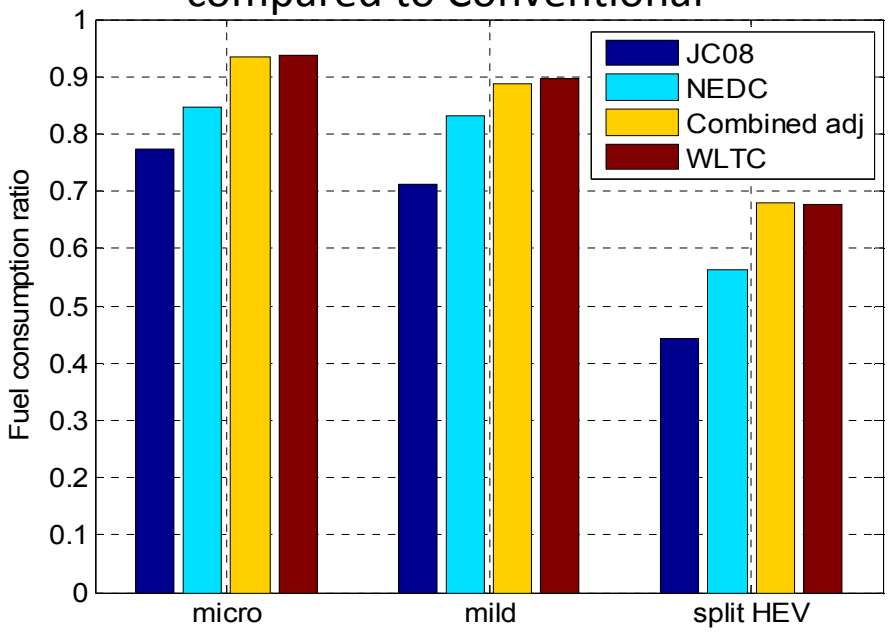
Conventional/Micro/Mild/Full Hybrid Fuel Consumption



- US combined procedure leads to the highest fuel consumption; (adjustment factors play a significant role)
- For NEDC and JC08, the drop in fuel consumption is especially high for the micro-HEV

Micro/Mild/Full Hybrid Fuel Consumption Ratio Comparison

Fuel consumption ratio compared to Conventional

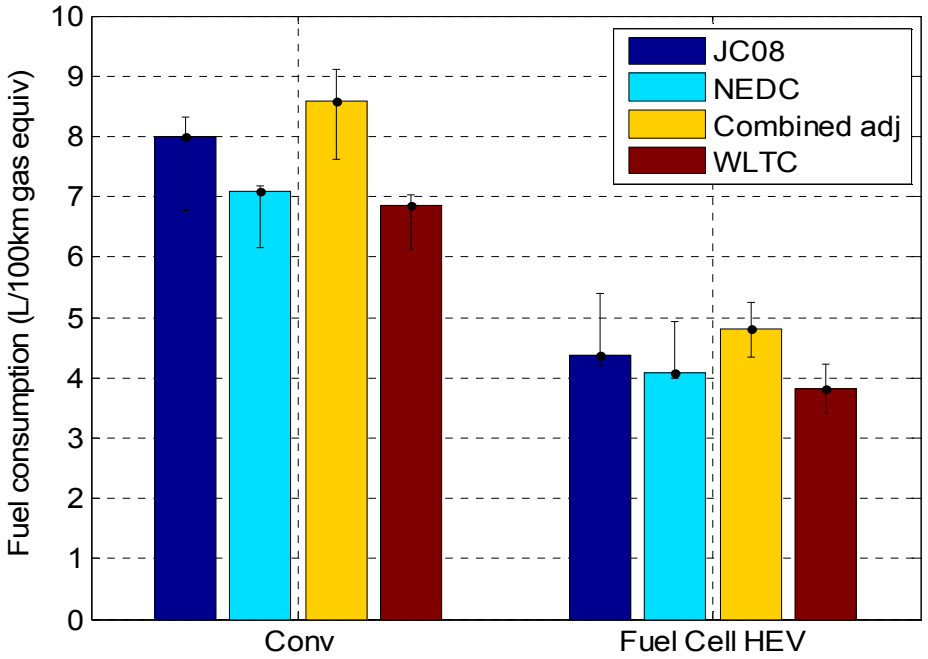


- Micro hybrids offer fuel savings ranging from 8% to 25%.
- The improvement from micro to mild hybrid is not significant.
- Full hybrids improve fuel economy considerably, especially for low-speed driving cycles such as the JC08.

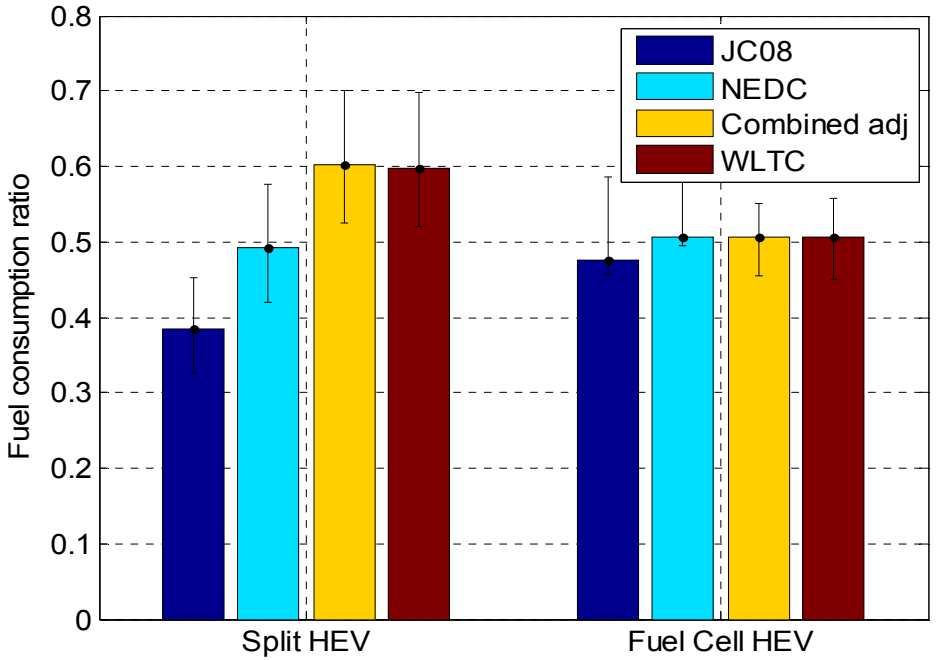
⇒ JC08 > NEDC > Combined ~ WLTC

Fuel Cell Hybrids Favors the Same Cycles as Conventional, Unlike Power Split HEVs

Fuel consumption (gas equiv)



Fuel ratio compared to Conv



Fuel savings:

- Split HEV SI : JC08 > NEDC > Combined ~ WLTC
- Fuel cell HEV : JC08 ~ NEDC ~ Combined ~ WLTC

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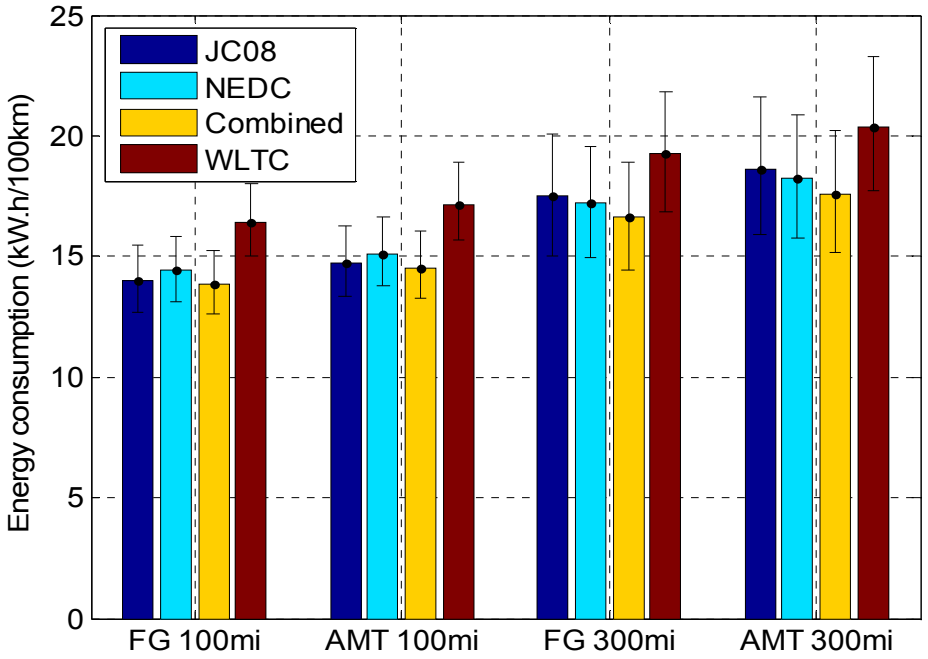
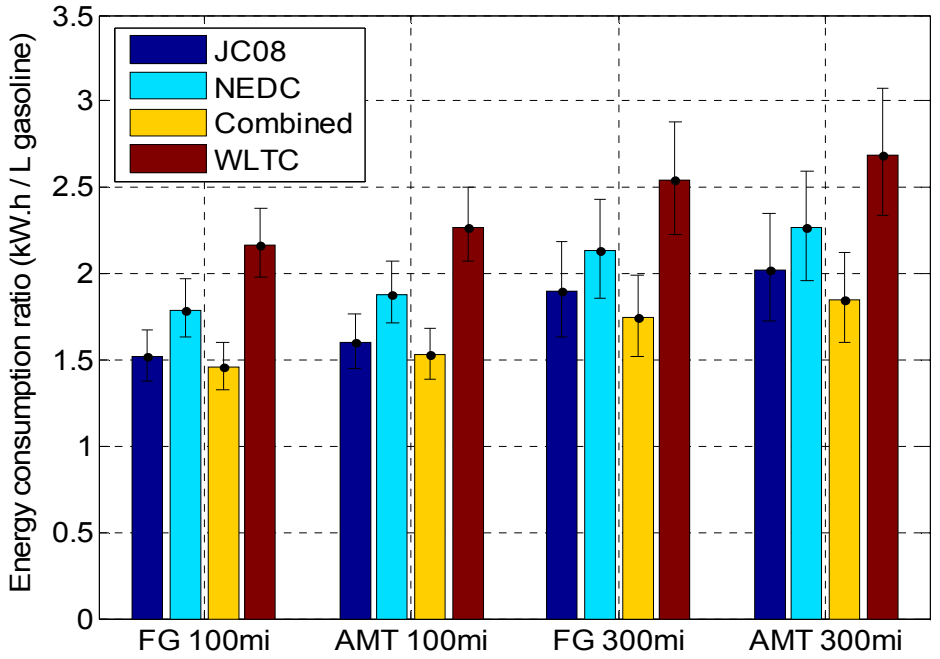
BEVs are Moderately Sensitive to Driving Cycles

Energy consumption

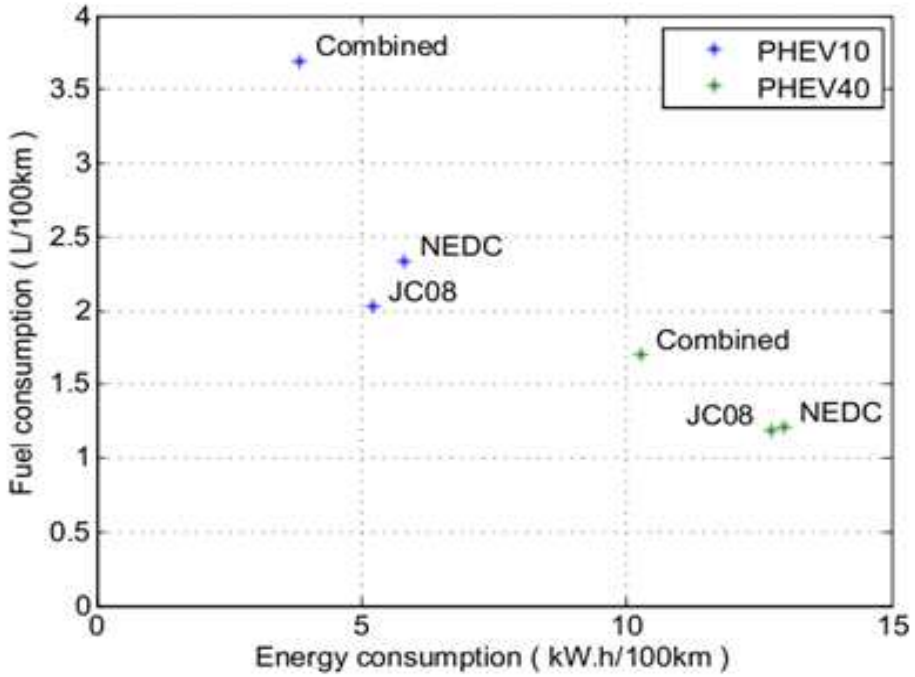


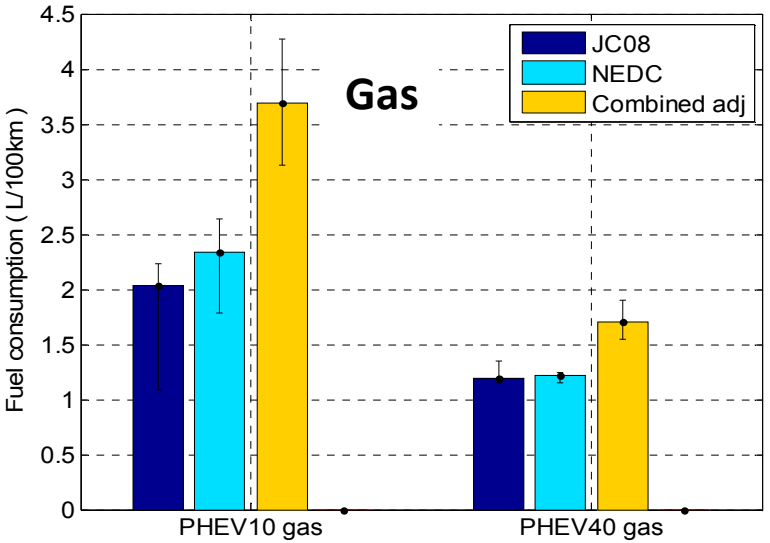
Fuel ratio compared to Conventional

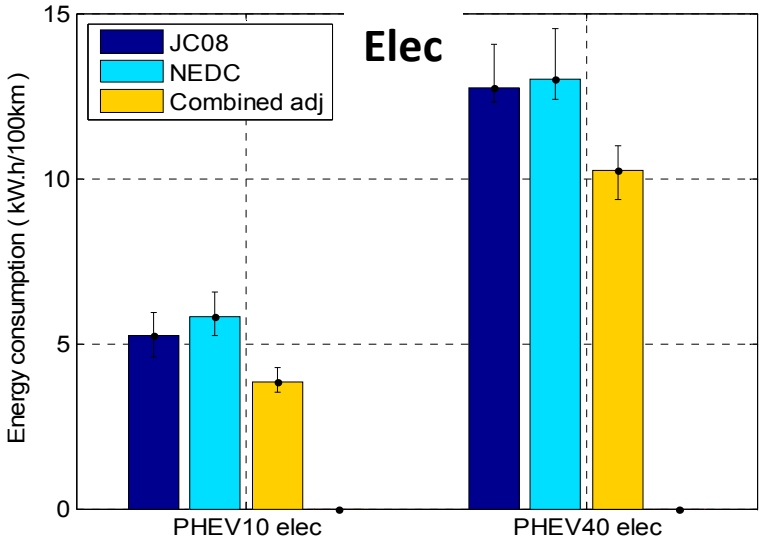


- Energy consumption : JC08 ~ Combined < NEDC < WLTC

PHEV10 / PHEV40 Results

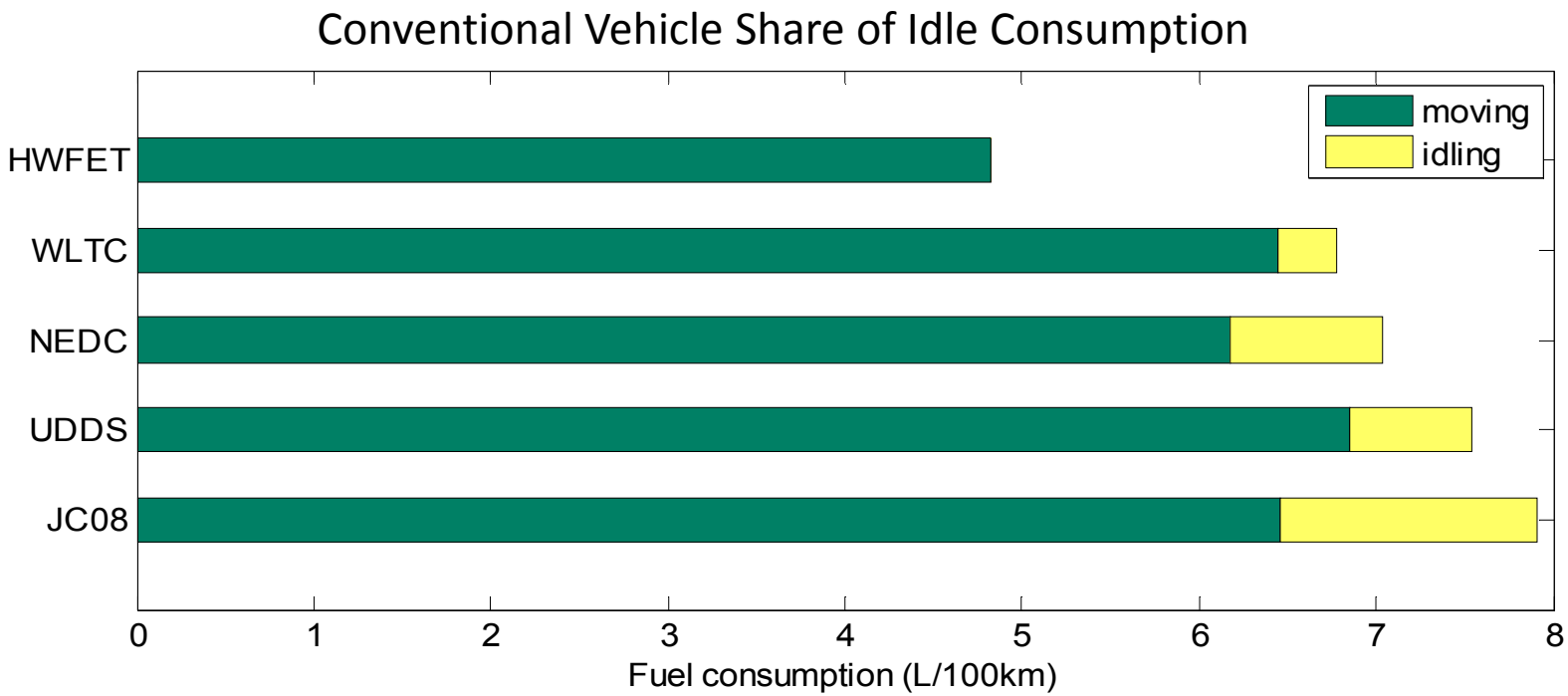






- PHEV 10 behaves similarly to HEVs
- PHEV 40 behaves similarly to BEVs

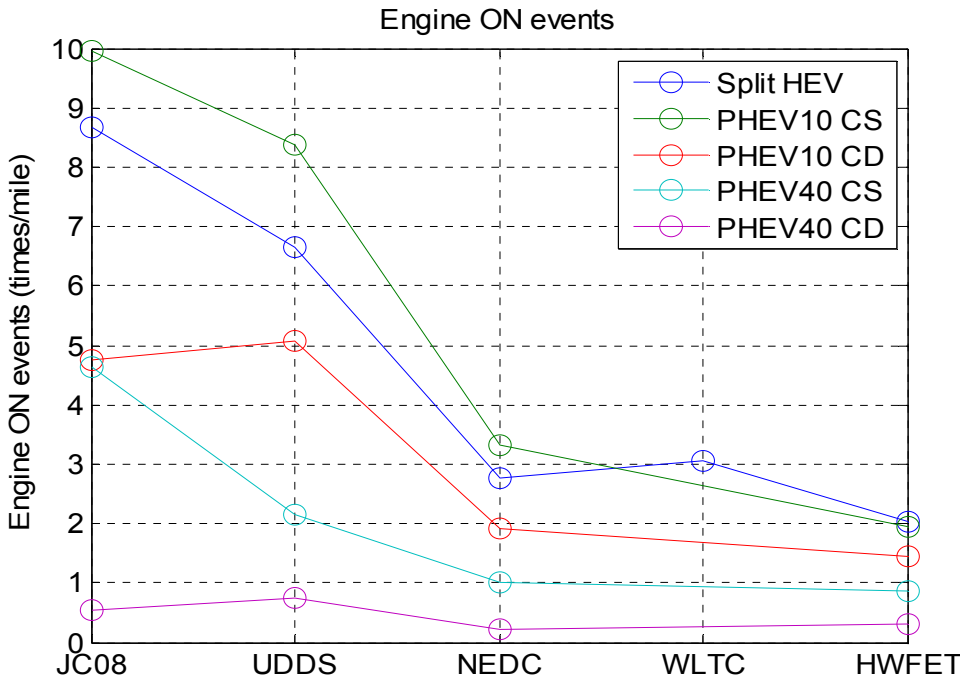
Fuel Saving Origins
Idle Fuel Consumption

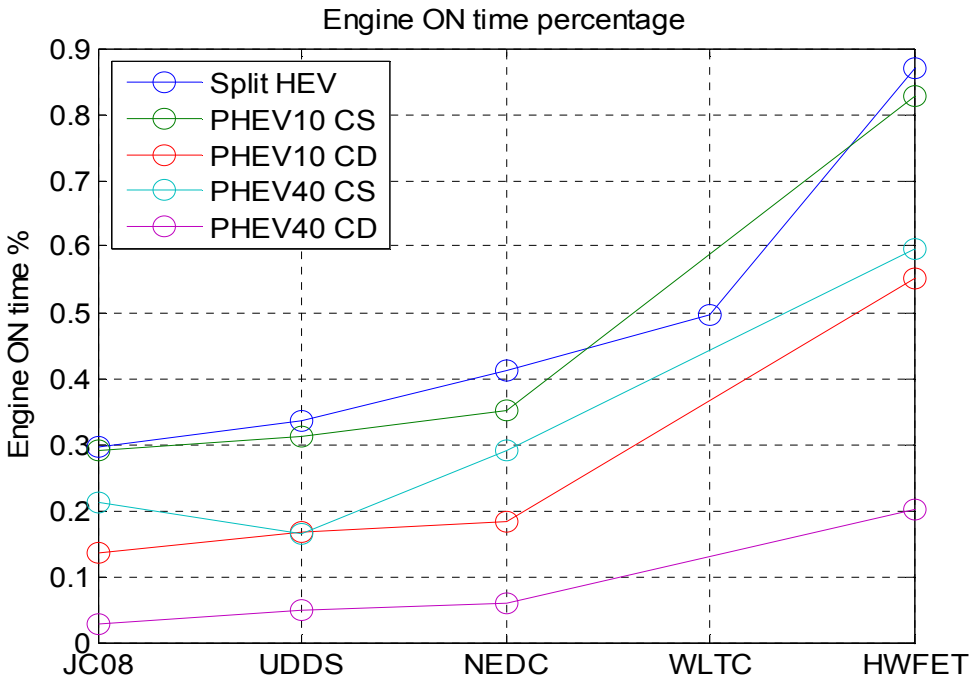


- Start-stop and mild HEV will show greater benefits on JC08 and NEDC

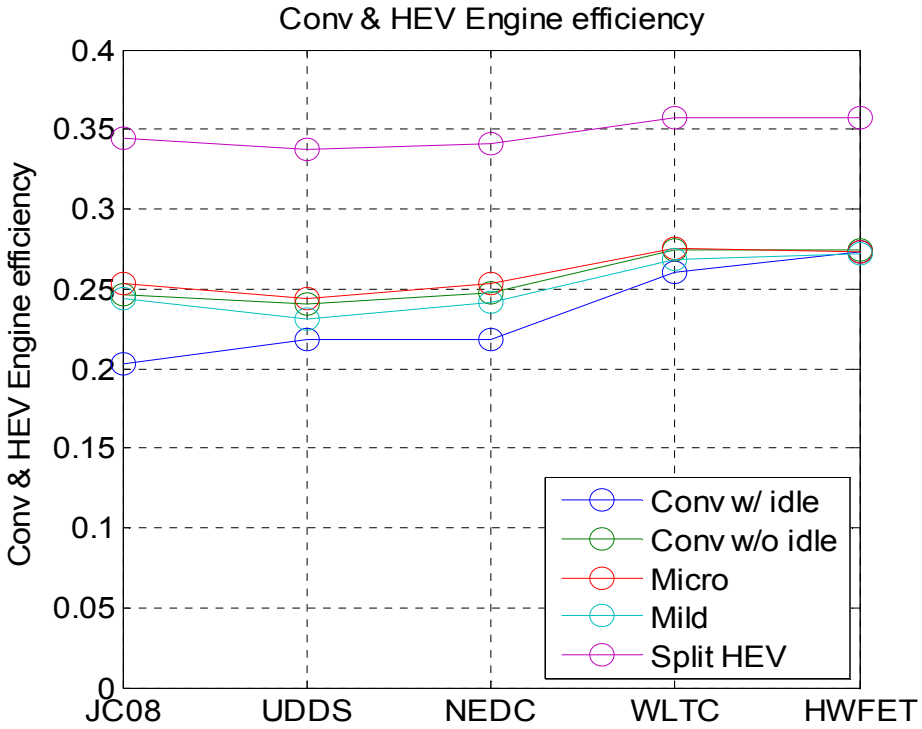
Fuel Saving Origins
Engine ON/OFF

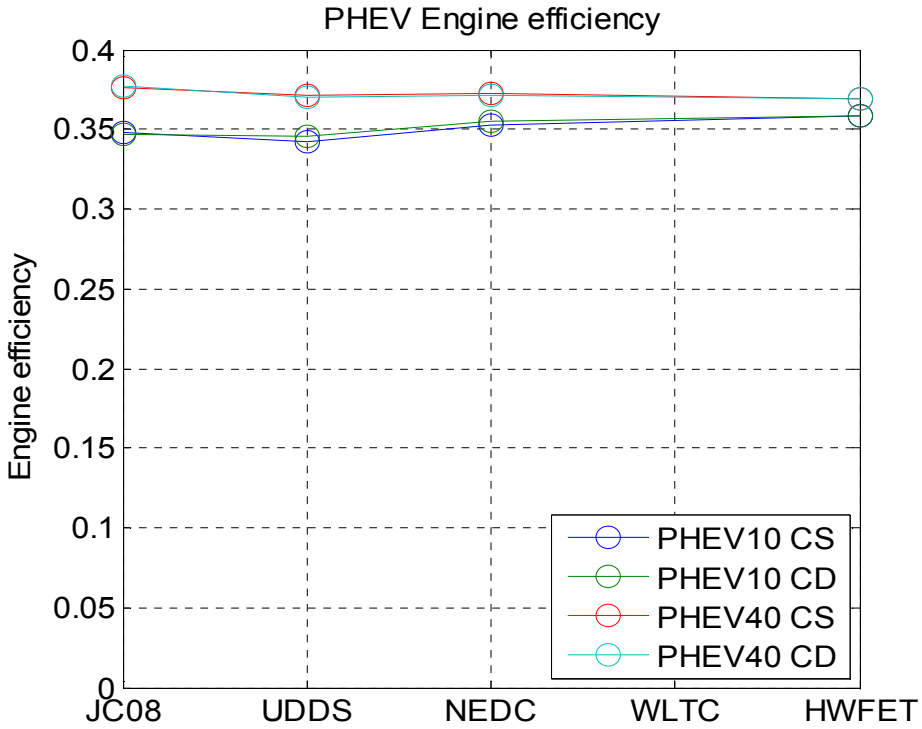
When cycle speed increases: less ON/OFF events but longer operation time





Fuel Saving Origins
Engine Average Cycle Efficiency



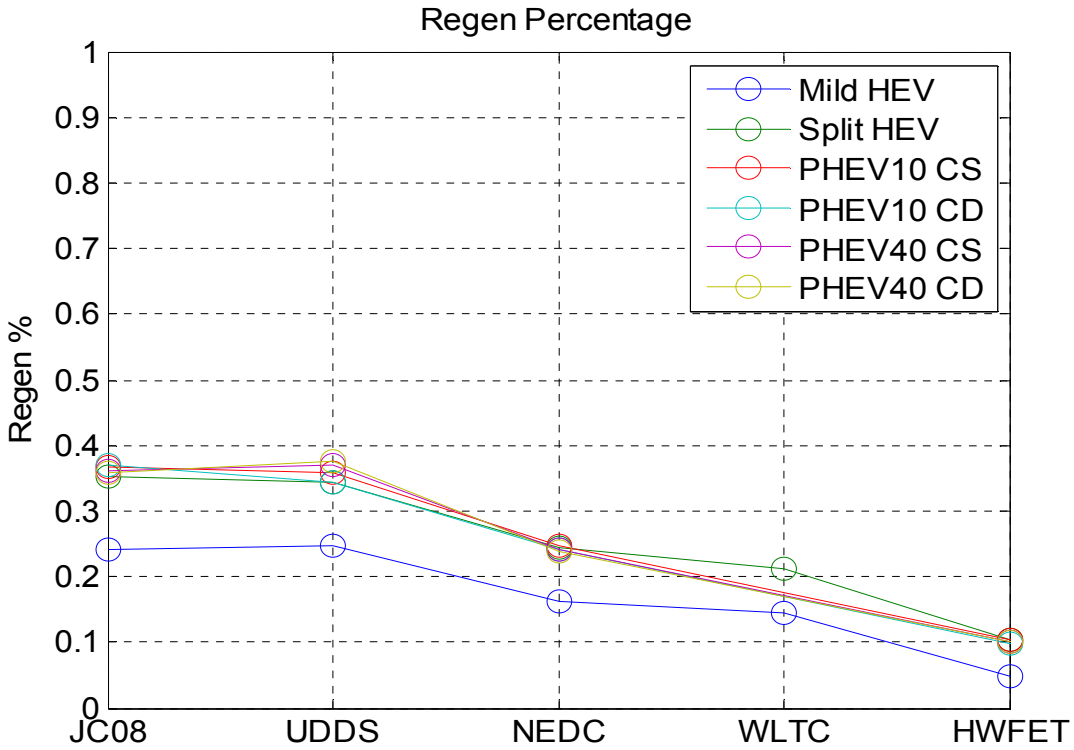


- Conv : 20% ~ 27% depending on cycles
- Micro & Mild : 23% ~ 27% , slightly higher than conv
- HEV/PHEV : 34% ~ 38% , PHEV40 > PHEV10/HEV

Fuel Saving Origins
Regenerative Braking

- To exclude the impact of powertrains, the regen percentage is defined as

$$\frac{Energy\ recovered\ at\ wheel}{Total\ energy\ sent\ to\ the\ wheel\ to\ propel\ the\ vehicle}$$



- HEV and PHEVs will show greater benefits on JC08 and UDDS
- Regen benefits are higher under transient cycles with frequent accel/decel like JC08 and UDDS

Standard Cycle Impact on Vehicle Technology Market Penetration

- In 2010, HEV constituted 3.9% of total sales in the US, while in the European Union the share was only 0.6%.
- Start-stop systems have however penetrated the European market, but there are few in the United States.
- In Japan, sales of full HEVs have significantly increased in the past 2 years.
- The choice of the standard drive cycle is of critical importance.
  - HEVs benefit the JC08 much higher than other cycles, partially explaining the volume of sales in Japan.
  - Micro and mild HEVs show very good gains on the NEDC. The benefits of full HEVs are not as large, partially explaining the technology choices in Europe.

=> One might expect a change of technology in the near future with the introduction of the WLTC as a replacement of some (if not all) the standard cycles

Conclusions

- Standard driving cycles significantly impact fuel and electrical consumption.
  - Conventional and series FC HEVs favor high speed with little idling,
  - Power-split full HEVs offer higher fuel benefits on low-speed cycles.
  - PHEV40s and BEVs are not significantly impacted by drive cycles.
- To understand the differences between cycles, a selected number of parameters were analyzed, including idle consumption, component efficiency, and ICE ON/OFF events.
- When looking at the current market share of the technologies worldwide, it appears that there is a correlation between technology choice and current standard drive cycles.

=> With a new drive cycle soon to be adopted by some countries, future studies will need to look at its impact on future technology market penetrations.

Acknowledgments

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