



**GT-Suite Users International Conference
Frankfurt a.M., October 8th 2007**



Diesel hybrid for passenger cars: analysis of different degrees of hybridization

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Presentation overview

- Introduction
- The vehicle model
- Vehicle model validation
- Use of simulation for the analysis of different degrees of hybridization
- Conclusions

INTRODUCTION (1/3)

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Although in light duty applications all hybrid engine vehicles currently commercially available are based on gasoline internal combustion engines, hybridization of Diesel engines is believed to have a considerably higher potential in terms of fuel consumption reduction, due to the higher peak efficiency values of the diesel internal combustion engine as well as to the more favourable trend of engine efficiency vs. engine load. A wide penetration of hybrid diesel technologies could obviously be expected in the EU market, due to high fuel prices (making fuel savings more attractive), high diesel share and also to a different approach of the legislation to emission limits, not yet fuel neutral.

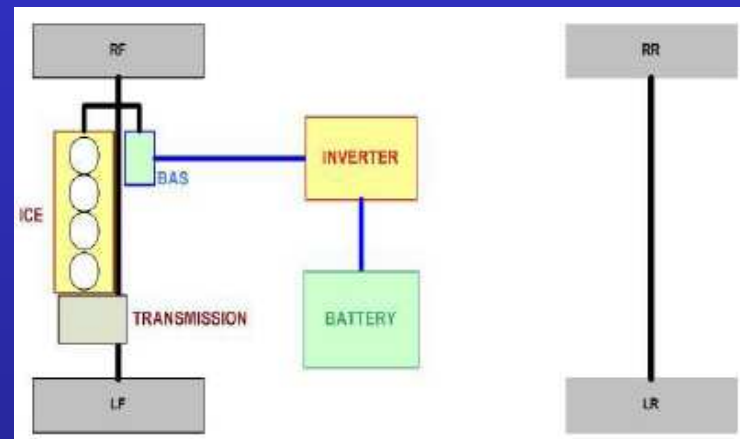
INTRODUCTION (2/3)

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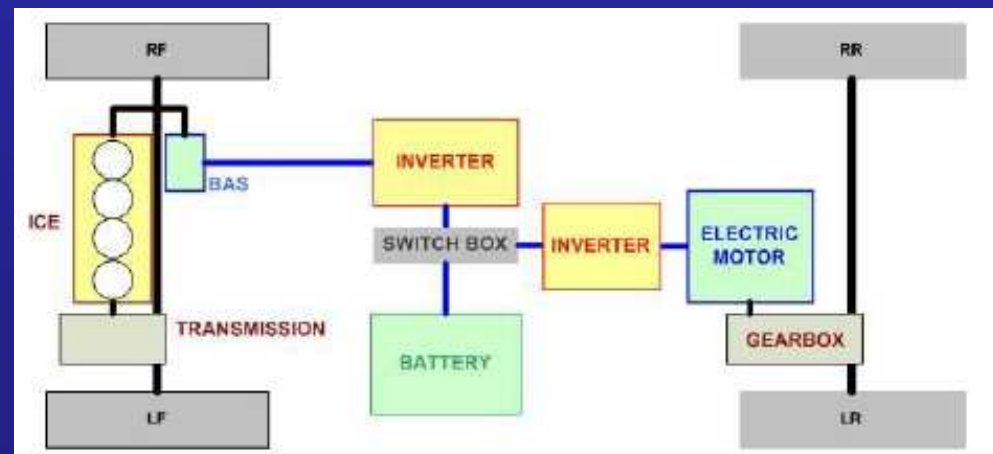
However, although diesel propulsion systems could undoubtedly add further benefits to HEVs and offer complementary advantages, such as for instance higher efficiencies in extra-urban driving conditions, the high values of efficiencies that can be already attained by conventional diesel vehicles may make more difficult to achieve further improvements in a cost effective way. Moreover the trade-off between fuel consumption saving potential and the emissions constraints must be carefully considered in the hybrid strategy to avoid unexpected penalties in terms of NOx emissions that could jeopardize diesel HEVs advantages.

INTRODUCTION (3/3)

The hybrids architectures analyzed in this work are based on a BAS (Belt Alternator Starter) system, which can be complemented with a second EM (Electric Motor) connected to the rear axis, thus enabling pure electric drive and e-AWD operation modes.



ICE + BAS

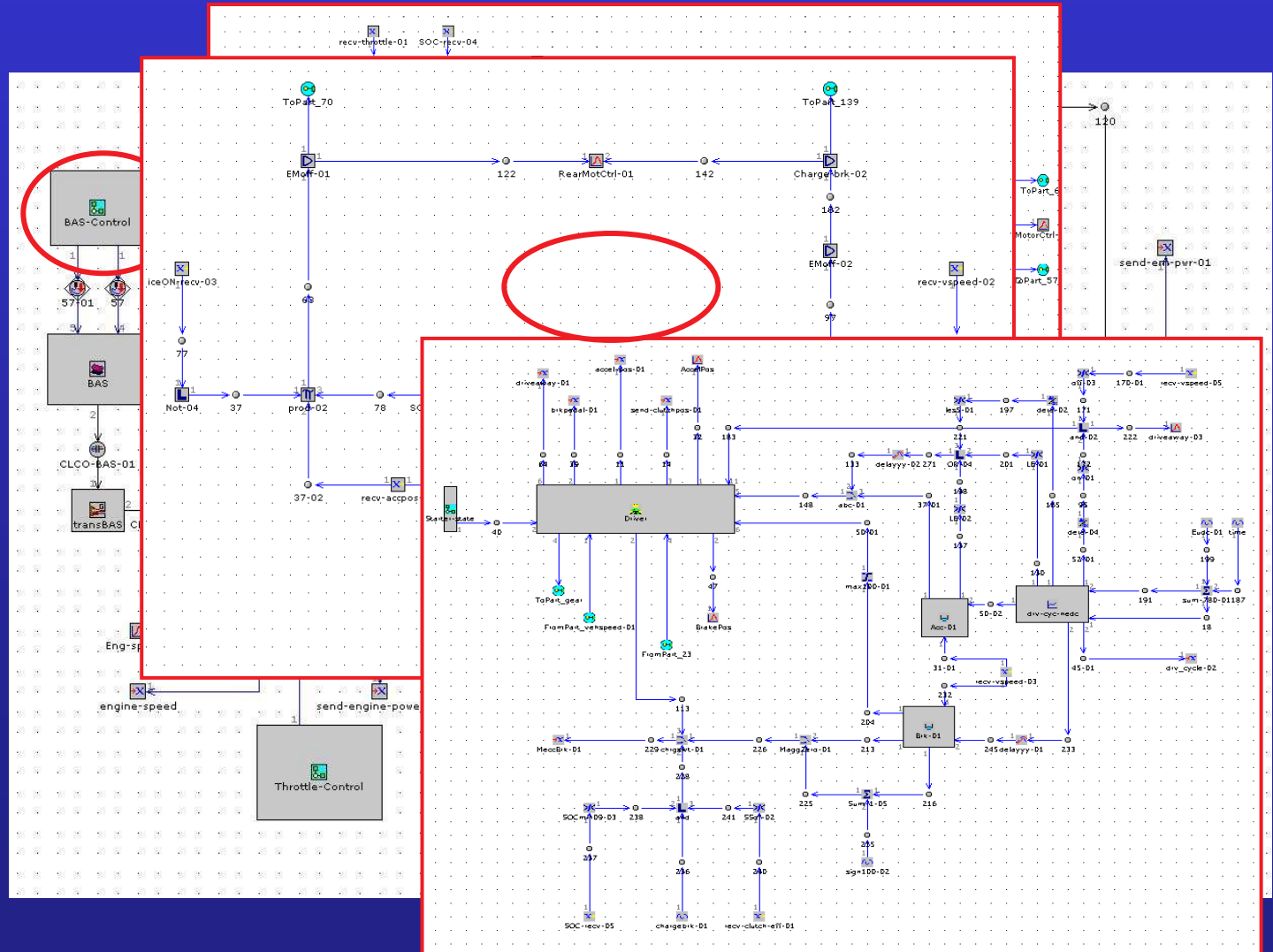


ICE +
BAS +
EM

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THE VEHICLE MODEL

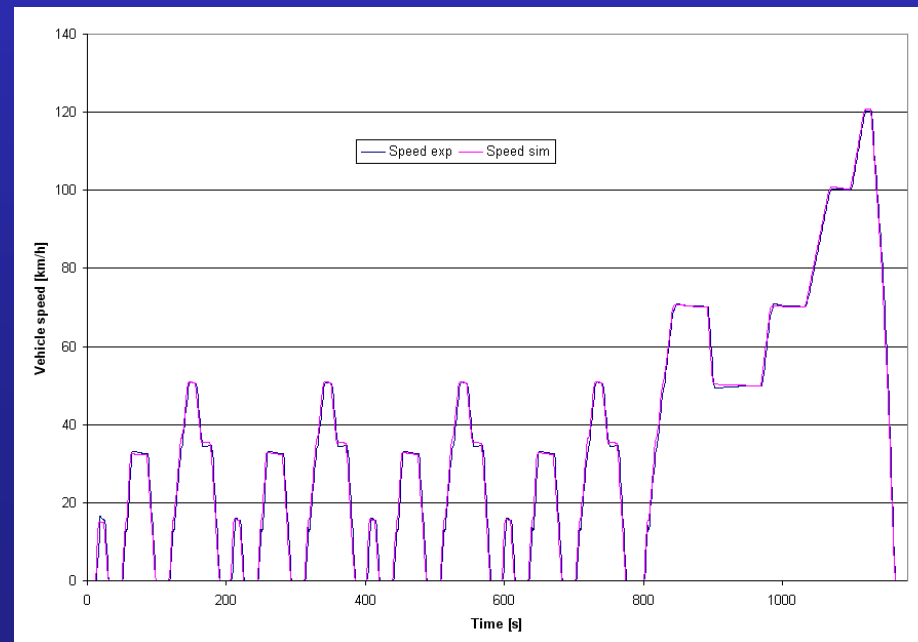
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VEHICLE MODEL VALIDATION

The model has been validated comparing the results of a simulation on an “hot” NEDC cycle with some available experimental data, referred to an European Sedan equipped with 2.0L Diesel engine and a standard driveline configuration.

Thus, the model has been set up so that the hybrid components were not active during the simulation.

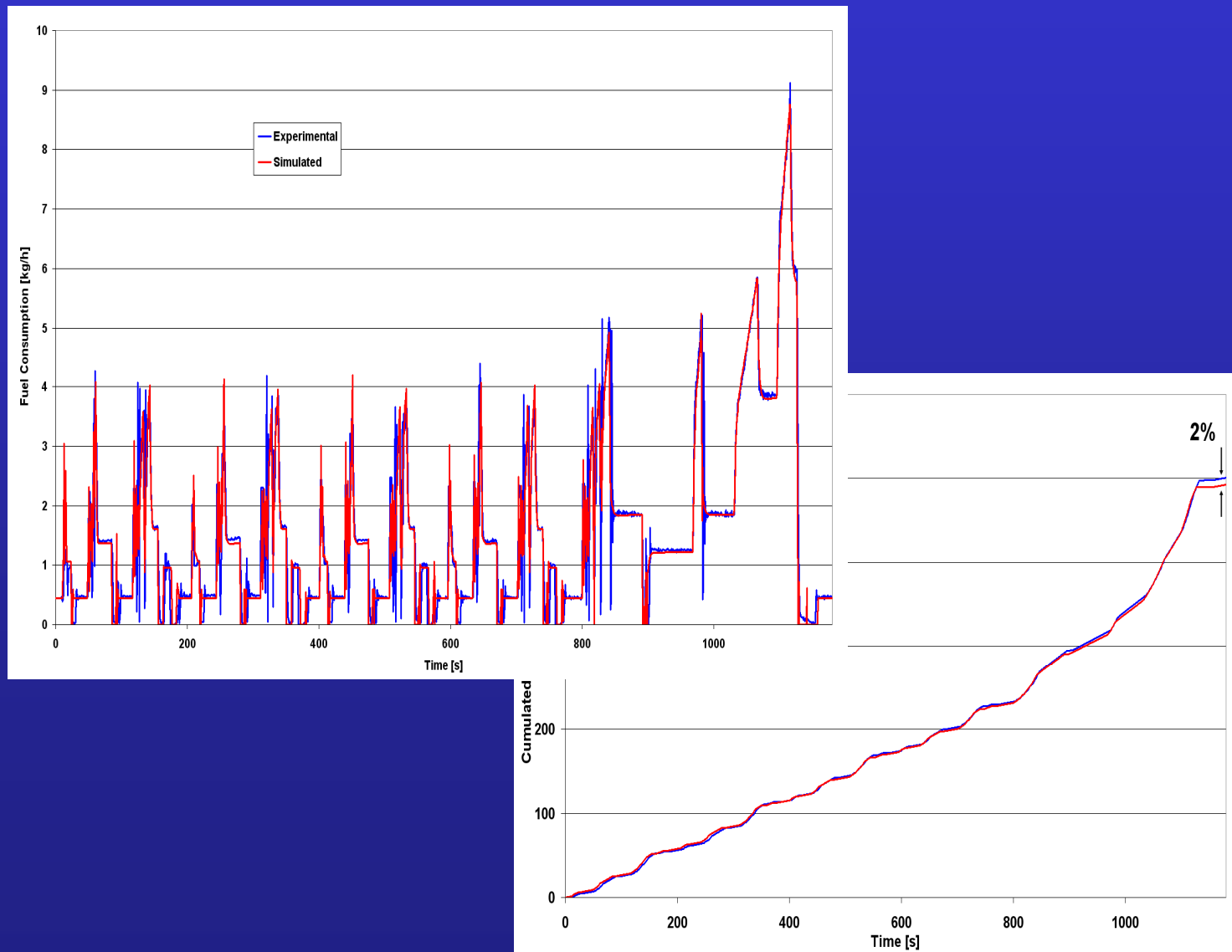


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VEHICLE MODEL VALIDATION

FUEL CONSUMPTION

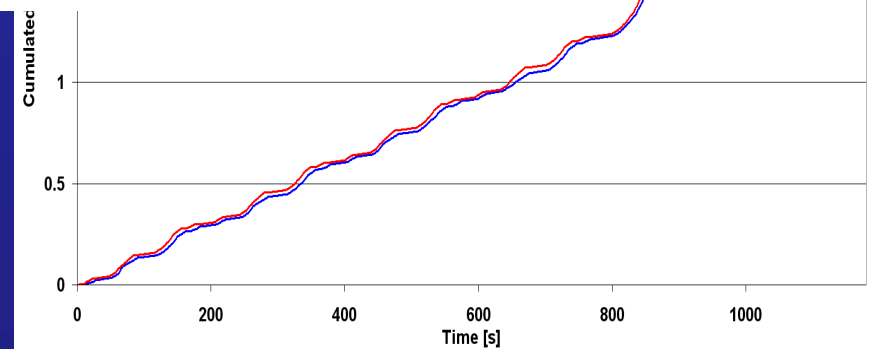
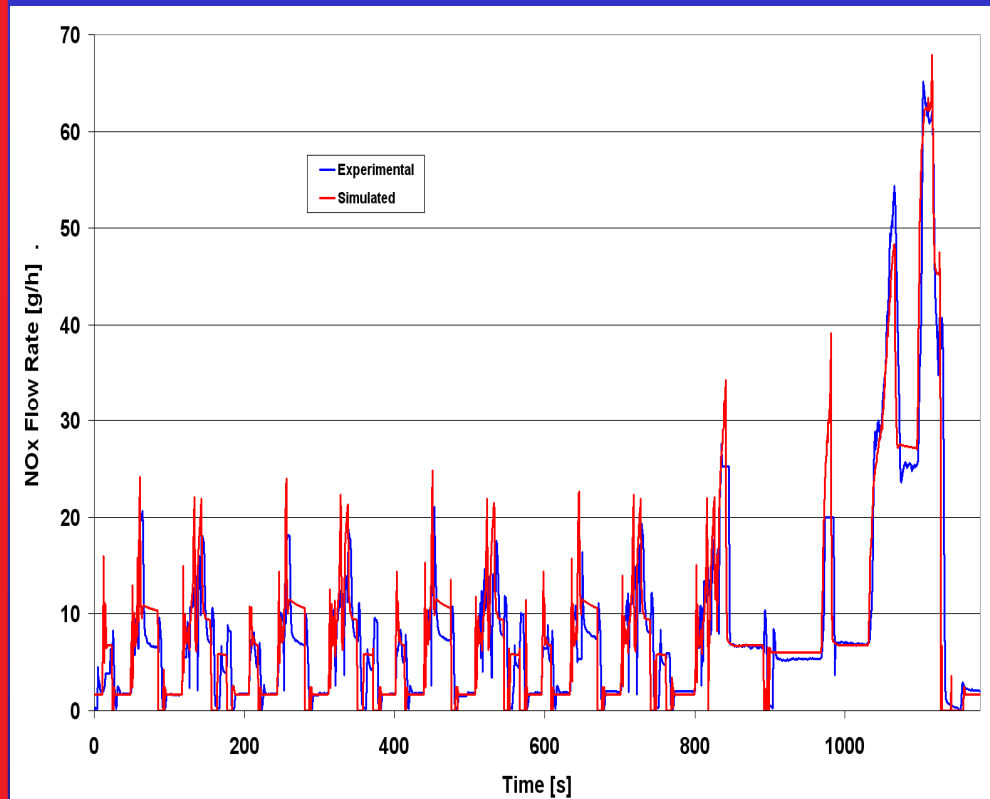
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VEHICLE MODEL VALIDATION

NO_x EMISSIONS

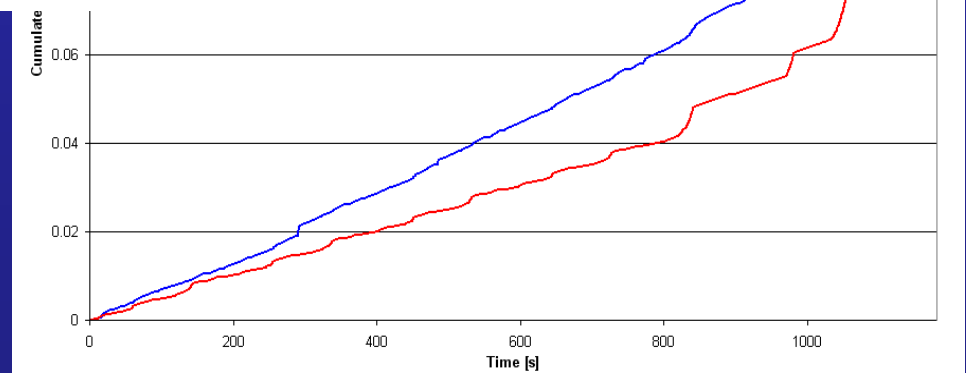
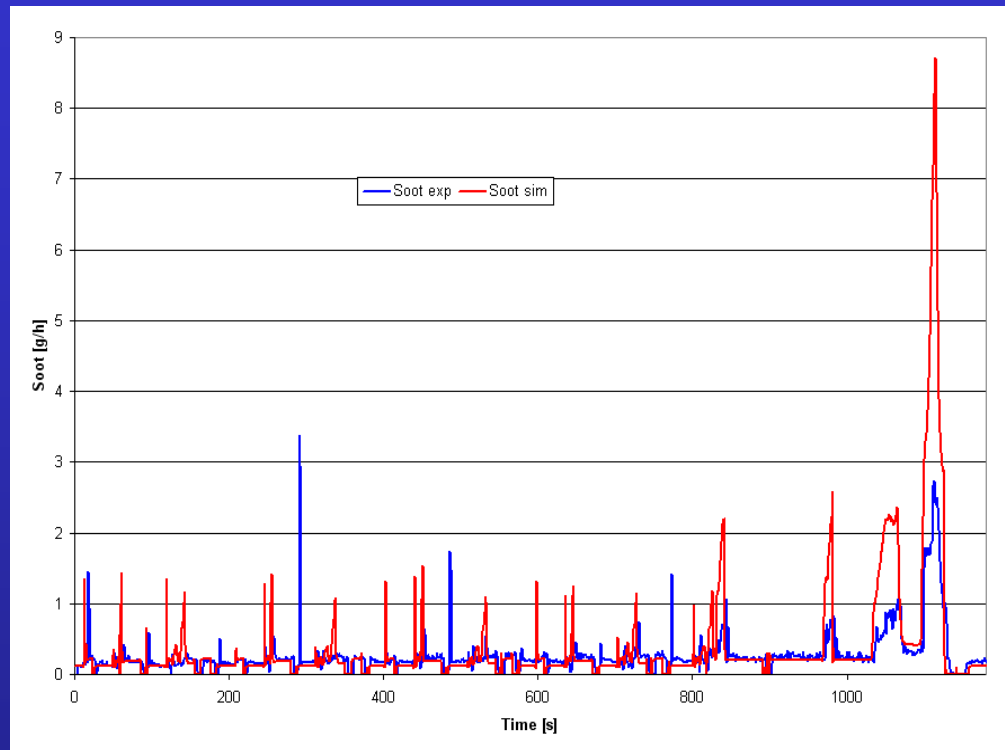
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VEHICLE MODEL VALIDATION

SOOT EMISSIONS

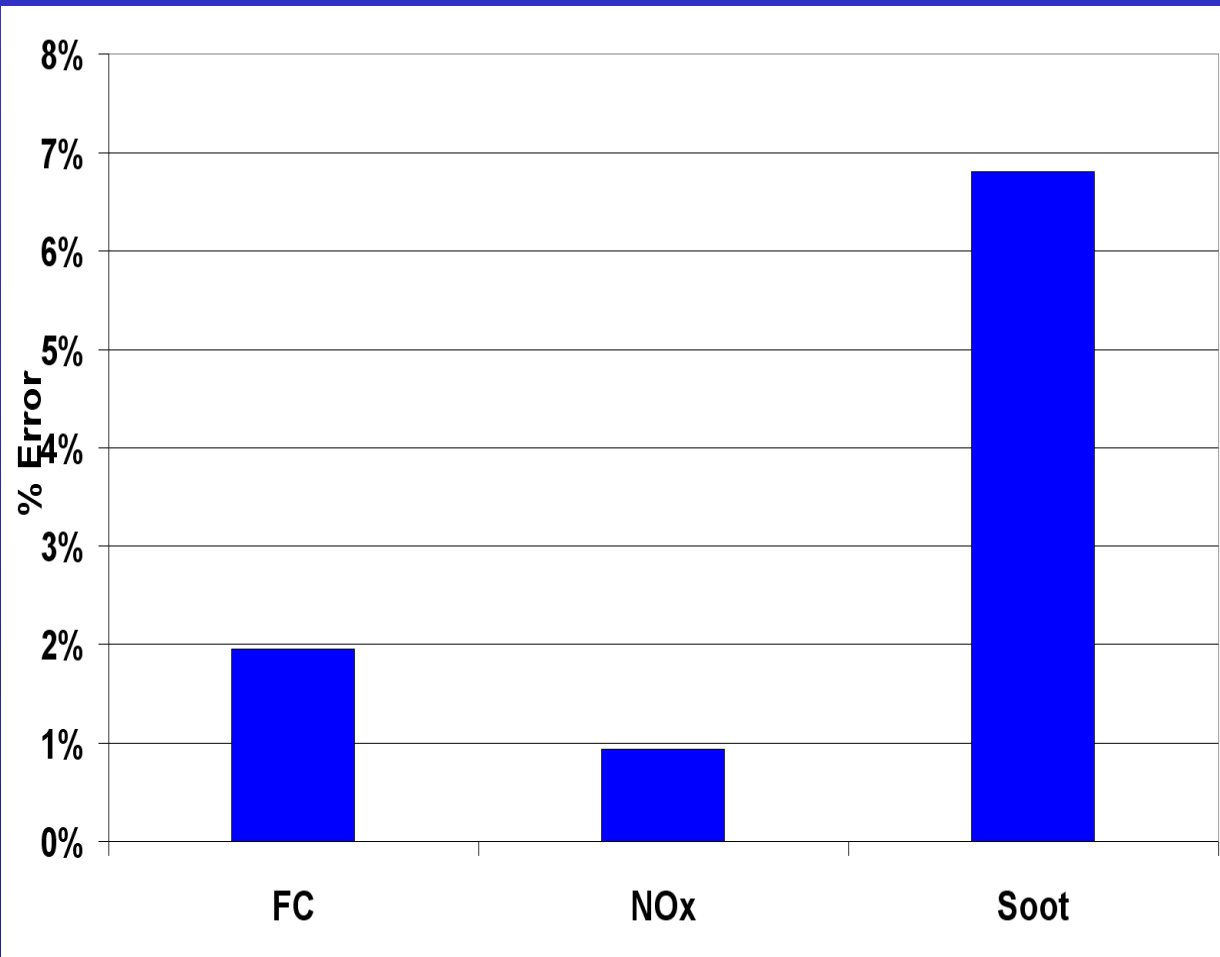
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VEHICLE MODEL VALIDATION

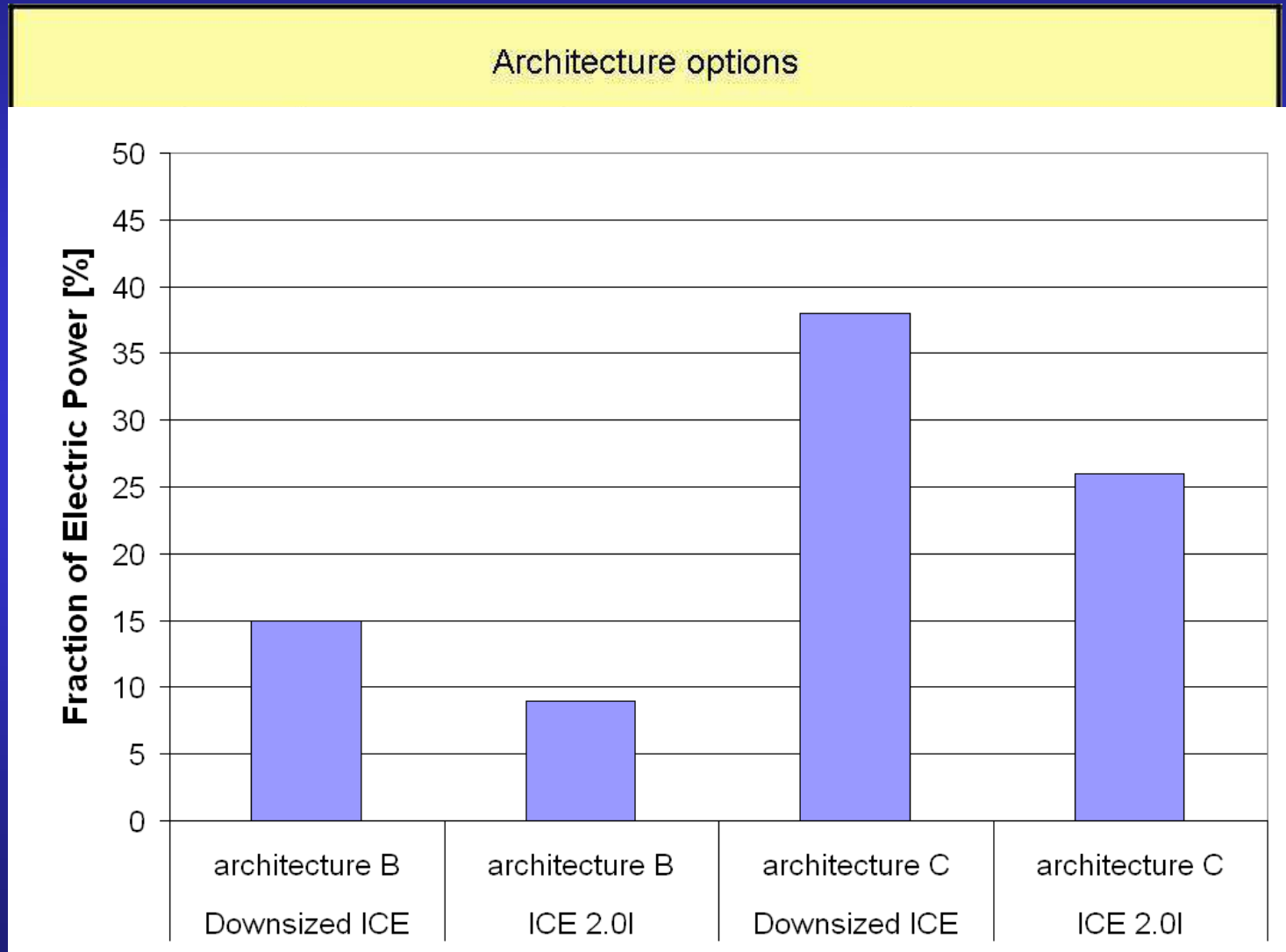
% ERROR FOR FUEL CONSUMPTION, NOx AND SOOT EMISSIONS

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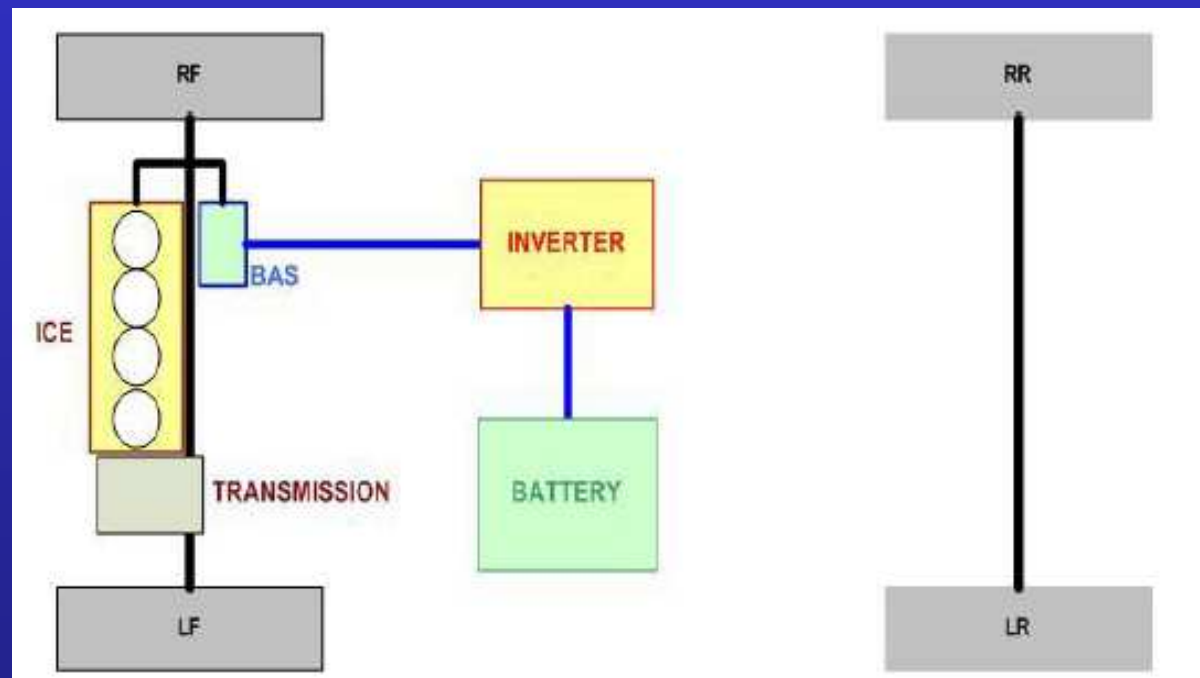
USE OF SIMULATION FOR THE ANALYSIS OF DIFFERENT DEGREES OF HYBRIDIZATION

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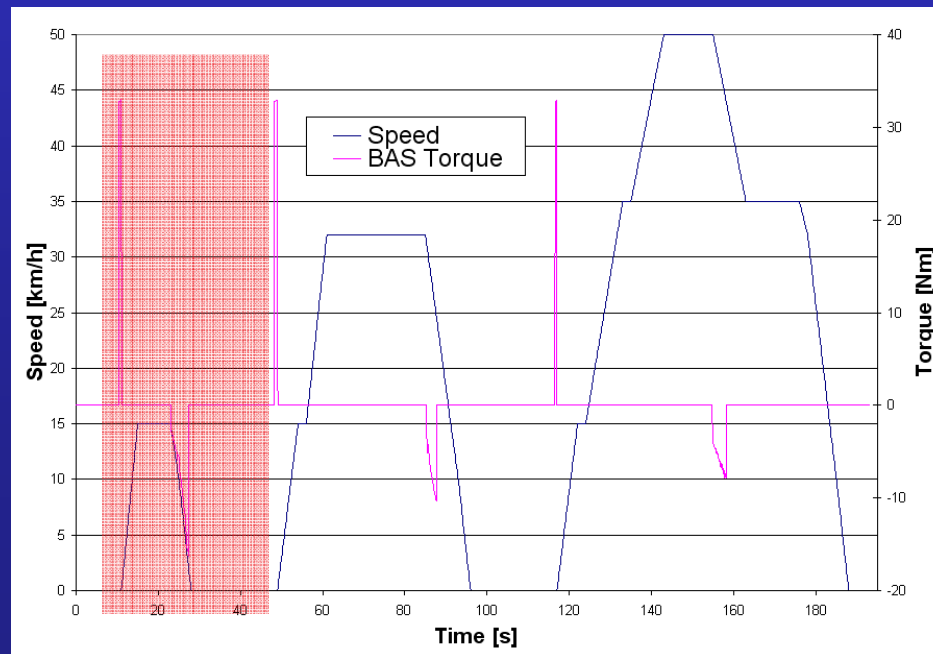
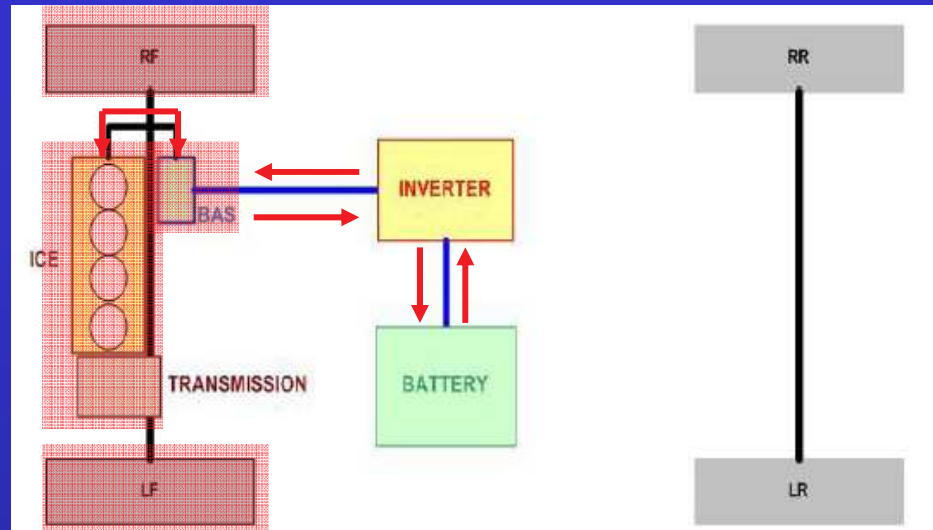
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START & STOP STRATEGY



START & STOP STRATEGY

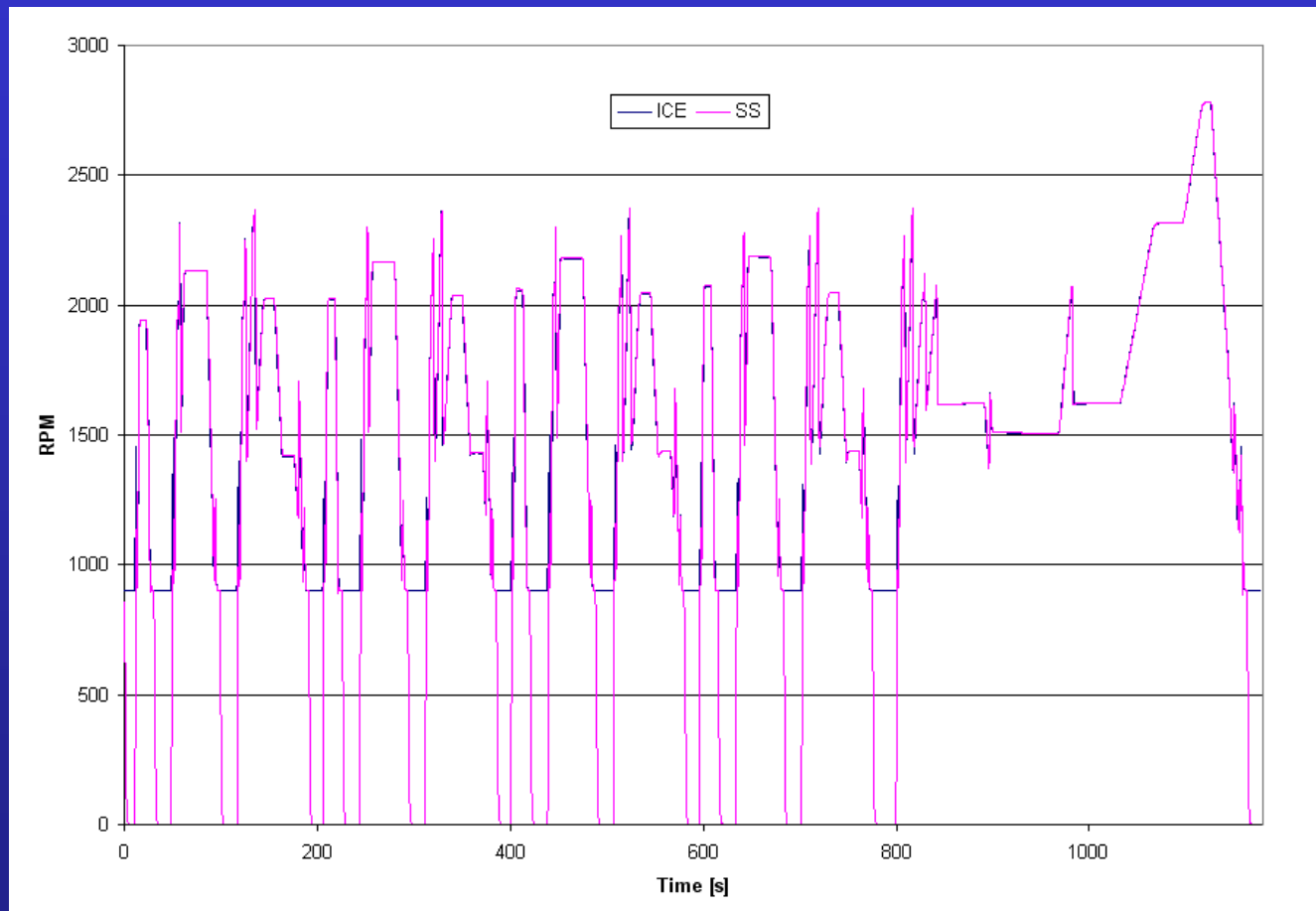
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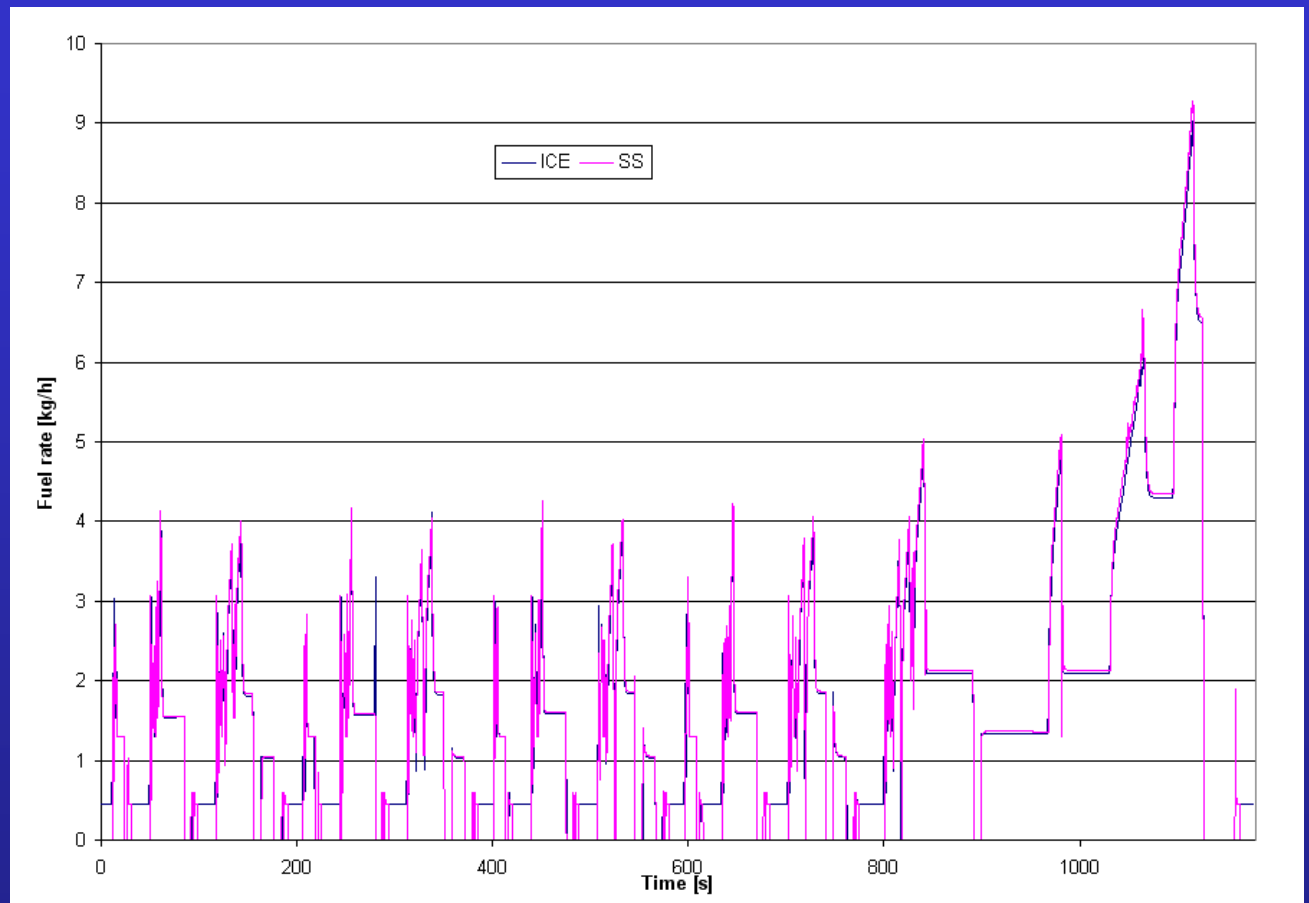
ENGINE RPM



START & STOP STRATEGY

FUEL CONSUMPTION RATE

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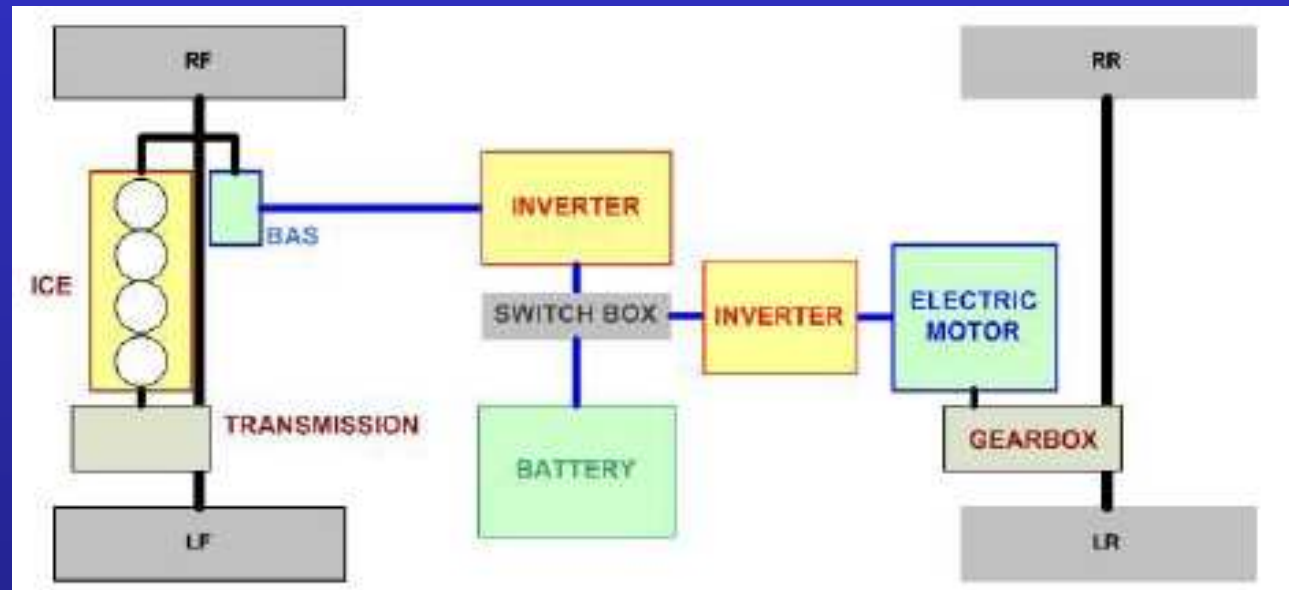


Fuel consumption savings S&S strategy

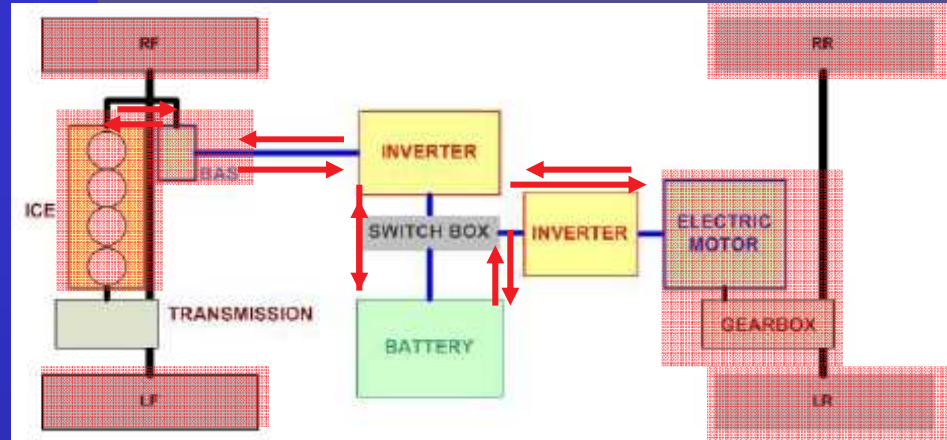
- 2.0 l ICE : 5%
- 1.3 l ICE : 3%

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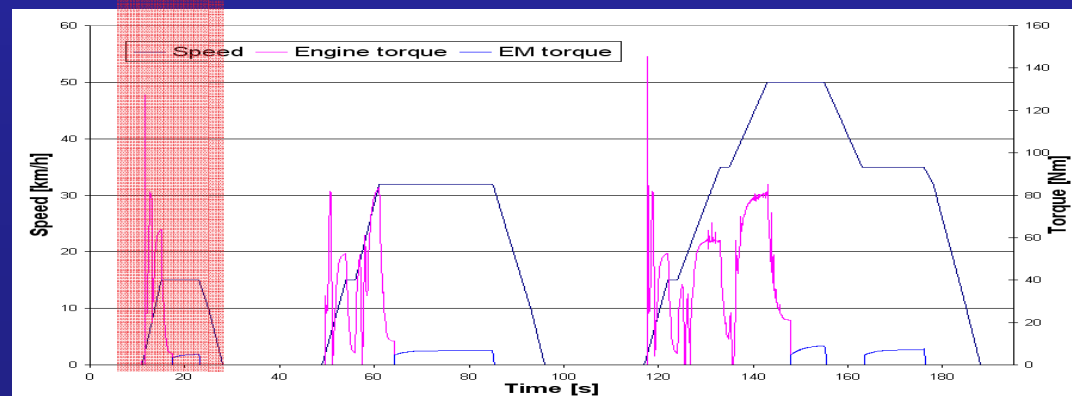
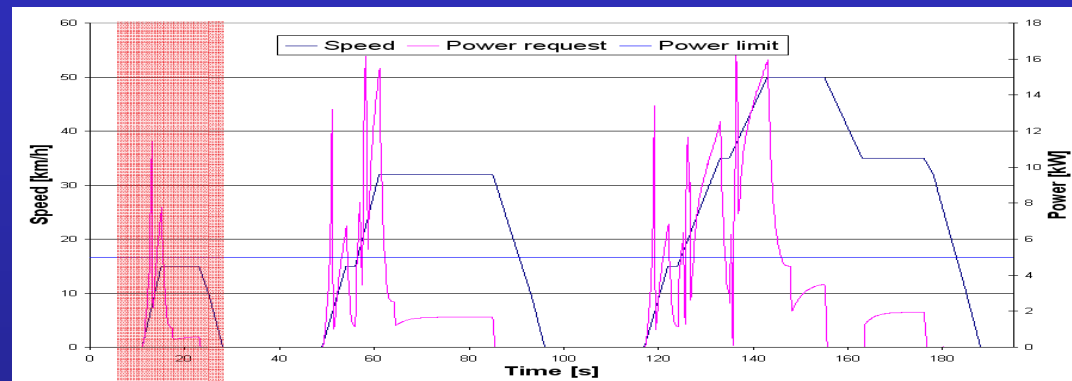
MILD HYBRID STRATEGY



MILD HYBRID STRATEGY



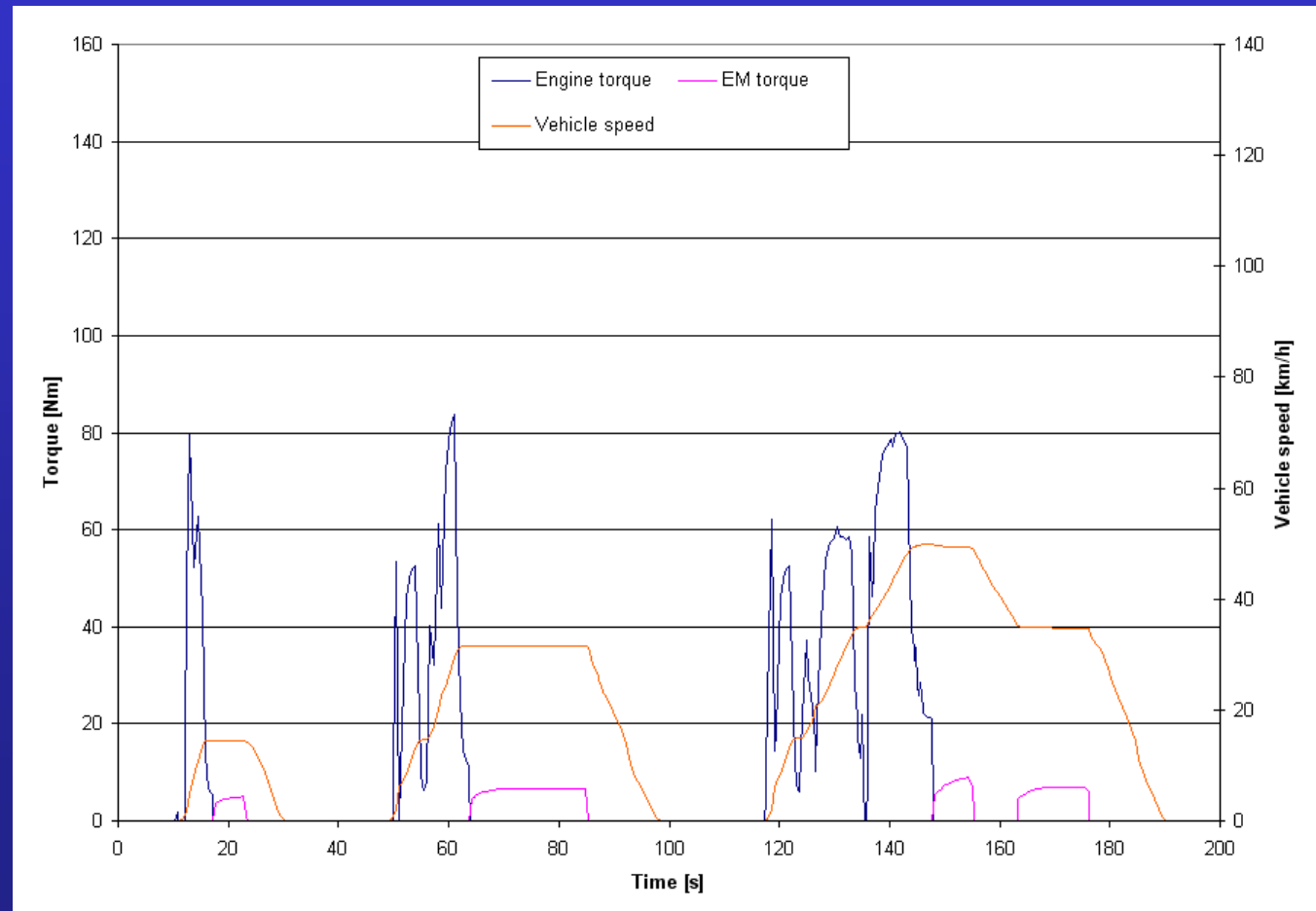
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MILD HYBRID STRATEGY

ENGINE AND EM TORQUE – ECE CYCLE

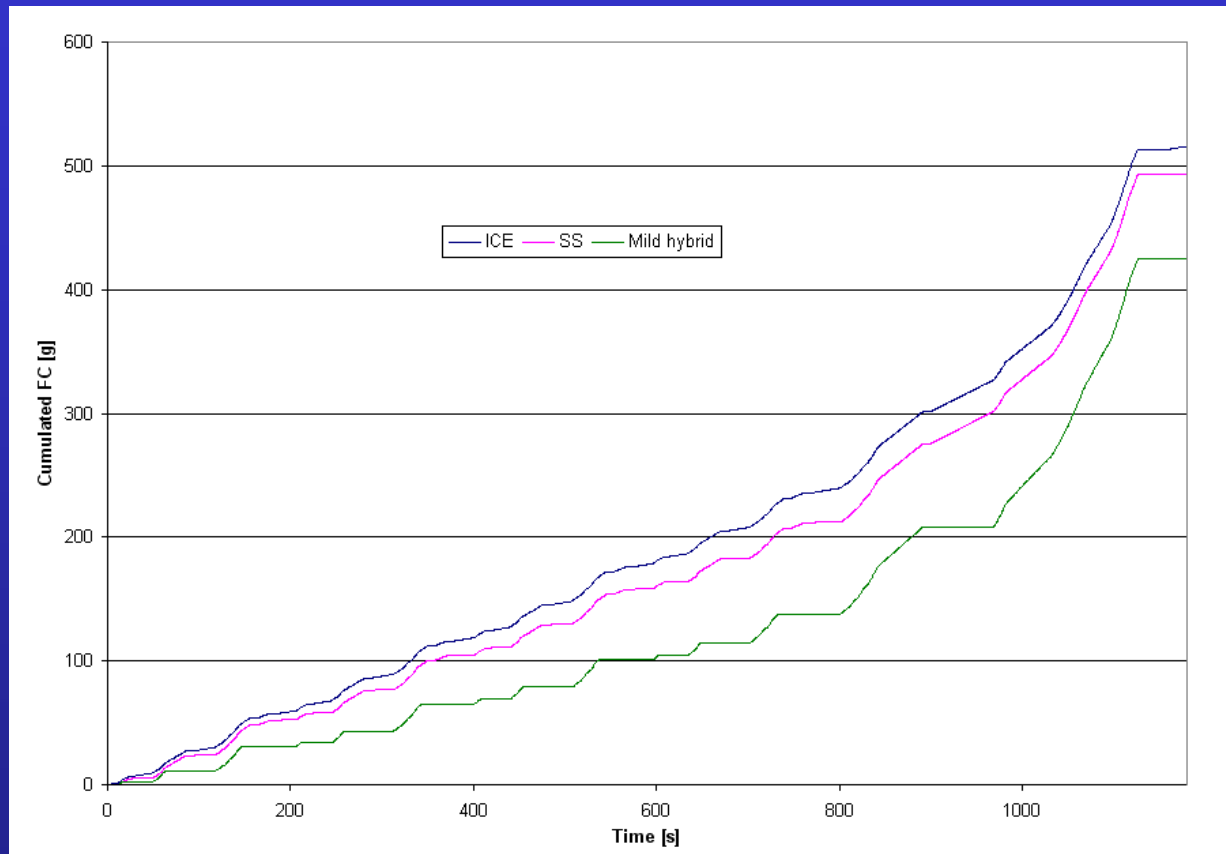
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CUMULATED FUEL CONSUMPTION

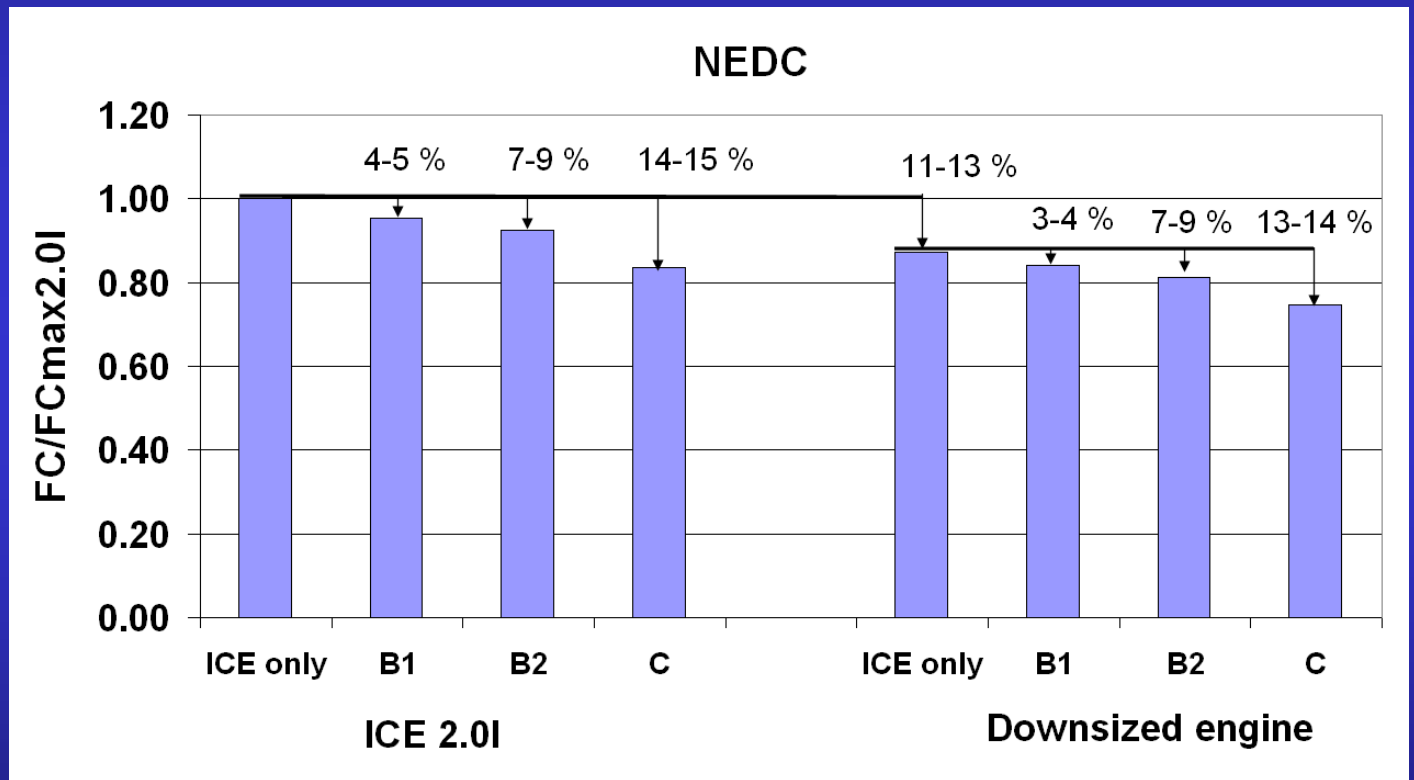


Fuel consumption savings (2.0 l ICE):

- S&S strategy: 4%
- Mild hybrid: 15%

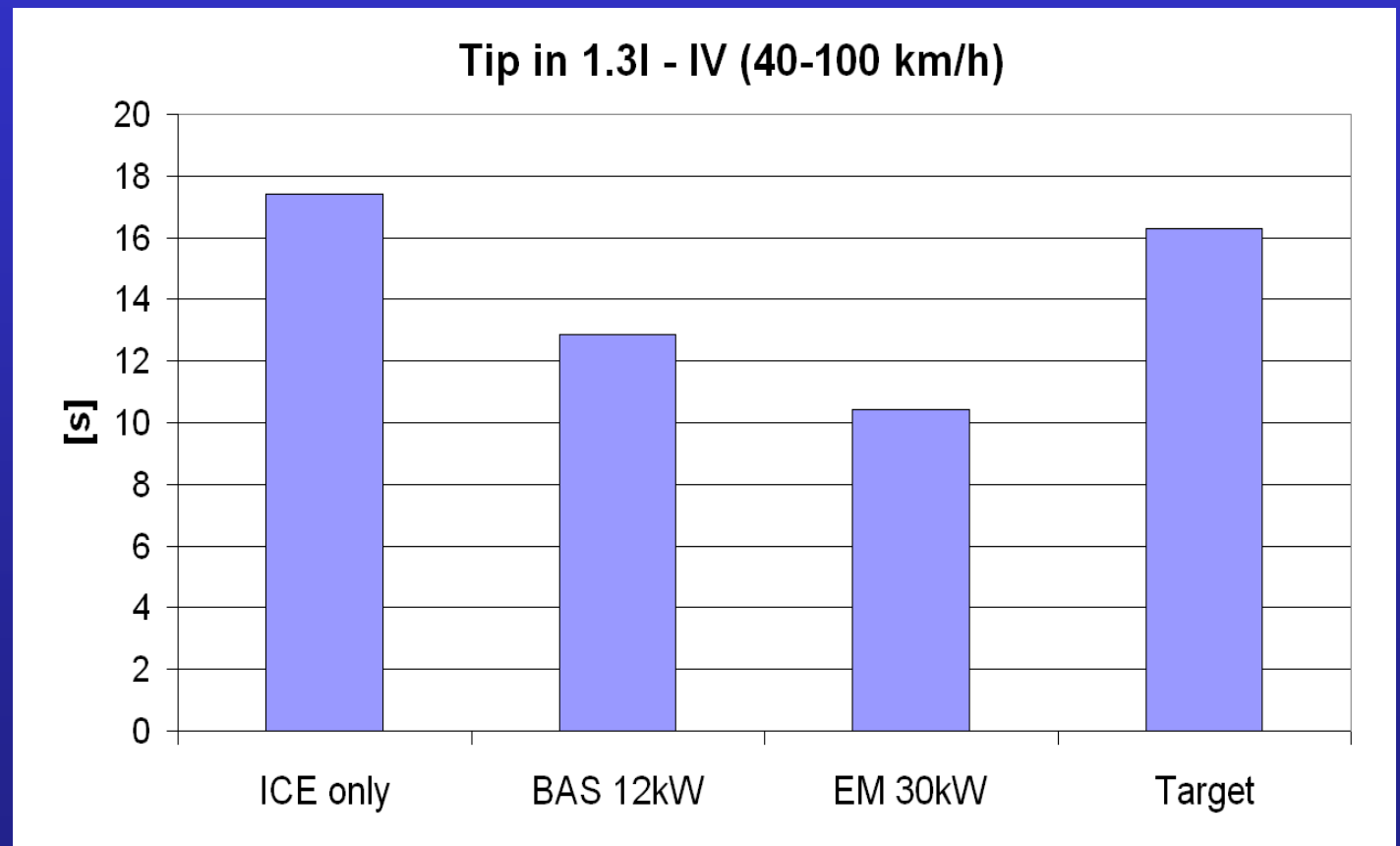
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EFFECT OF ENGINE DOWNSIZING



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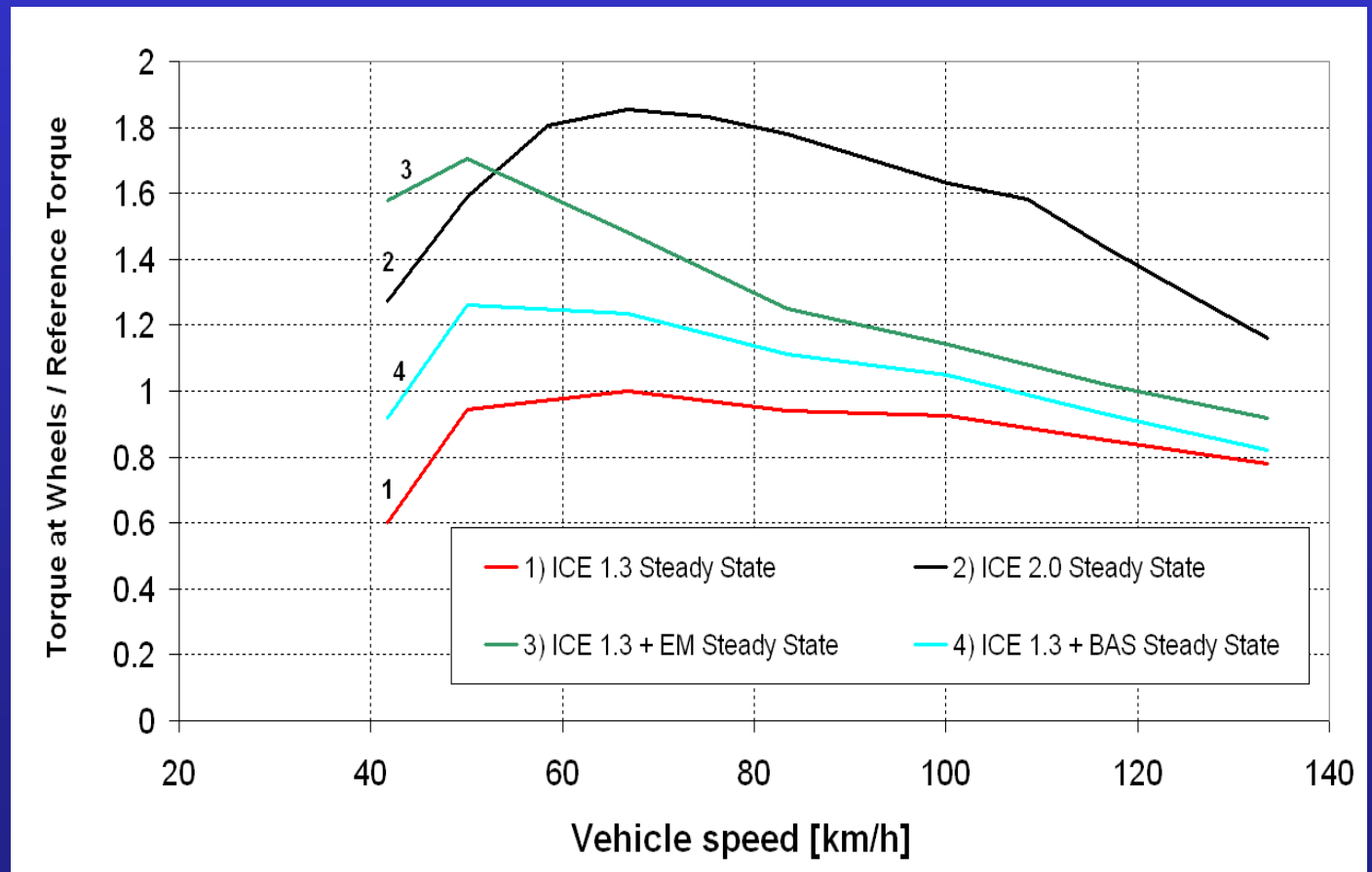
ENGINE DOWNSIZING: PERFORMANCE



ENGINE DOWNSIZING: PERFORMANCE

STEADY STATE ANALYSIS

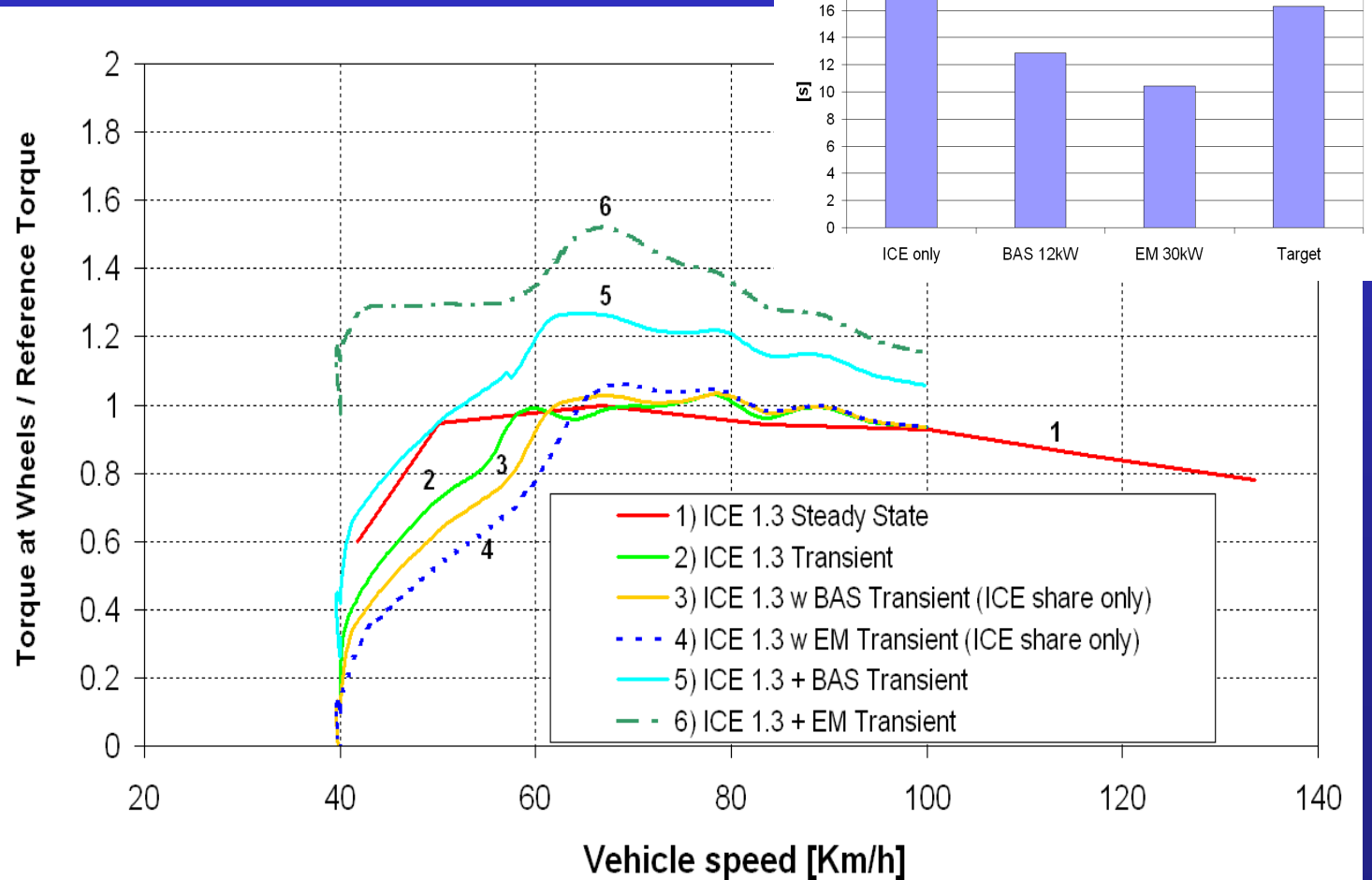
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ENGINE DOWNSIZING: PERFORMANCE

TRANSIENT ANALYSIS (THROUGH GTPOWER COUPLING)

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CONCLUSIONS

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Simulations of different HEV architectures carried out through GT-Drive allowed the evaluation of the fuel consumption and NOx emissions reductions that could be achieved on NEDC.

Simulation results showed to be reliable as far as FC and NOx emissions are concerned, even when using maps obtained under steady state operating conditions. Further investigations will be carried out for more aggressive driving cycles (e.g. US06).

Coupled simulation with GTPower allowed the analysis of the impact on vehicle performance of engine downsizing coupled with electric boosting.



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