PhD in Energetics

Research Title: (P)HEV Optimal Design

Funded by	CARS@polito of Politecnico di Torino

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Context of the research activity	In recent years, the automotive industry has dedicated a great deal of effort to developing innovative technologies for the realization of green vehicles characterized by low CO2 and pollutant emissions. In particular, powertrain electrification will play a significant role to achieve this purpose. Electrified vehicles include FEVs (Full Electric Vehicles) and (P)HEVs, i.e. (Plug-In)Hybrid Electric Vehicles. ✓ FEVs offer a way to reduce the oil dependency of road transport, diminish urban air pollution and combat climate change (if electricity is produced from low-carbon sources). However, the main road-blocks that negatively affect customer acceptance are: ✓ high costs, mainly related to the batteries. ✓ compromises on performance and range limitations ✓ re-charging time (P)HEVs offer improved fuel economy and lower emissions than conventional vehicles (CVs), as well as the possibility of increasing the driving range and of taking advantage of existing fuel infrastructures with respect to FEVs. However, the exploitation of the full potential of (P)HEVs requires to develop a dedicated energy management system that controls each power-unit. Moreover, the economic convenience of (P)HEVs is strictly dependent on the driving mission specification. In the framework of a joint research project with FPT Industrial, a Matlab toolbox has been developed in order to

	identify the best (P)HEV layout in terms of costs, energy consumption, GHG and/or pollutant emissions of an hybrid powertrain. A dedicated optimization of the initial vehicle design (component sizing and weight) and the contemporary optimization of the operating strategy of ICE, EMS and battery SOC is carried out by the tool. Vehicle performance targets (max velocity, acceleration, grade, payload, …) are added as constraints to the optimization process.

Objectives	OBJ1: submodel for ATS (After Treatment System) thermal management has to be developed and integrated in the toolbox. More specifically, the submodel should be able to correctly predict ATS temperature and thus simulate the activation of ATS thermal management when temperature threshold is not reached as well as the consequent influence on ICE fuel consumption. Heat and Temperature losses between ICE out and ATS must also be predicted. At first, the ATS thermal management submodel will be developed for an SCR-urea layout typical of commercial vehicles. OBJ2: Assessment of the new toolbox release for design of light duty and heavy duty commercial vehicles for user-defined driving cycle. Main outcomes of this phase are: ✓ Optimal design configuration: hybrid concept and size of powertrain components (ICE, EMs, battery, transmission and gear ratios, final drive ratios, …) ✓ OEM/operation cost of the optimal solution ✓ Mission trajectories and control strategy trajectories for optimal and non optimal time histories of torque/speed of ICE and Electric Machines (EMs) along the driving missions ✓ Relations between operating costs, product costs, TCO, CO2 emissions, fuel consumptions etc for the different design variations ✓ critical analysis of how ICE and related accessories should be modified/managed to better suit the new operating conditions in the hybrid architecture OBJ3: Estimate the impact of the vehicle driving mission on the performance of the commercial vehicles, including effects from main environmental conditions that might in fact affect the vehicle performance due to the auxiliary systems (e.g., air conditioning system). The aim of this analysis is to understand the usability of the different vehicle solutions OBJ4: Refine toolbox prediction of engine-out ICE emission levels (NOx, and soot), based on modelling approaches developed in other research projects for real-time applications (such as IMPERIUM IA H2020:

	http://www.imperium-project.eu/) OBJ5: Develop model-based approach for thermal transient simulation of ICEs and integrate them in the toolbox. Assess impact on vehicle design carried out in OBJ2 OBJ6: Refine simulation of the impact of thermal effects on eComponent performance. Assess impact on vehicle design carried out in OBJ2 OBJ7: Upgrade vehicle model simulation: from kinematic (Matlab) to dynamic (Simulink environment). Assess impact on vehicle design carried out in OBJ2

Skills and competencies for the development of the activity	Technical competences about: ICE operation and modeling; HEV architecture and modeling. Good knowledge of programming and simulation tools (Matlab, Simuling) and commercial codes for ICE simulation (such as GT-Power, AVL boost, Ricardo Wave, …). Capability to work in a multidisciploinary research team Good knowledge of English