# DIN - DEPARTMENT OF INDUSTRIAL ENGINEERING

## PhD Course in Mechanics and Advanced Engineering Sciences (DIMSAI)

**PHD STUDENT POSTER - AY *2016/2017*** **Curriculum number *2*** **Cycle *XXXII***

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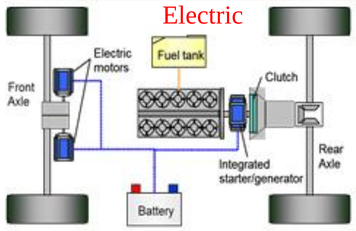
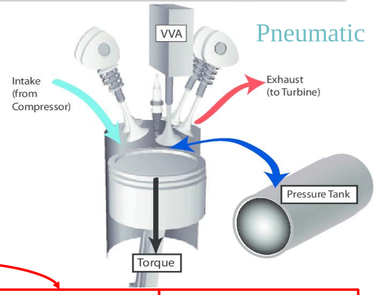
# *MODELLING AND OPTIMIZATION OF ENERGY MANAGEMENT STRATEGIES FOR HYBRID VEHICLES*

## TOPIC OVERVIEW

**HYBRID VEHICLES**

«A hybrid vehicle has two or more energy sources and two or more energy converters»



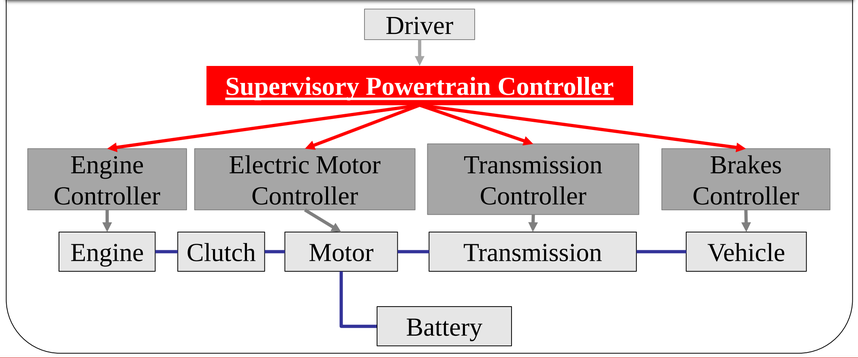




**Hybridization benefits (HEV)**

| STOP/START system | Energy recuperation | Smaller engine sizes | Different driving modes |
|---|---|---|---|

**Higher vehicle global efficiency**

### Control Architecture




## FOCUS

***Energy Management Strategy(EMS)***

Has the task to choose the best use of the energy stored on-board the vehicle

| | On board implementation | Robust | Optimal | Computational burden | Calibration effort |
|---|---|---|---|---|---|
| Heuristic | ● | ● | ● | ● | ● |
| Sub-optimal | ● | ● | ● | ● | ● |
| Optimal | ● | ● | ● | ● | ● |

## PhD STARTING POINT

**Hybrid Control Unit**

Equivalent Consumption Minimization Strategy (Sub-optimal Energy Management Strategy)

Torque request → Search window for the split factor *u* → «u» search window → Local optimal control problem resolution → Optimal split factor → Operating mode selection → Driving mode

System conditions → Search window for the split factor *u*

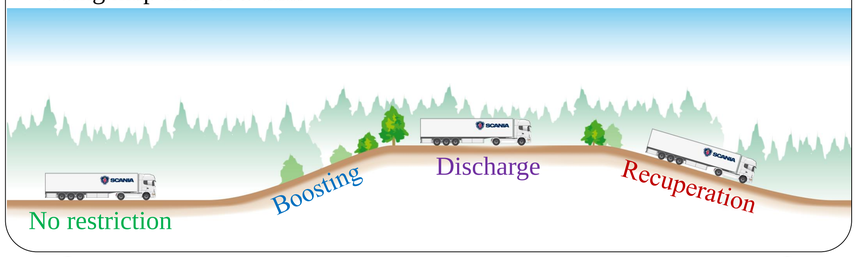
$$u = \frac{Torque_{el}}{Torque_{el} + Torque_{ice}}$$

| | |
|---|---|
| u=1 | Pure electric drive |
| u=0 | Pure thermal drive |
| u<0 | Battery recharge |
| 0<u<1 | Hybrid mode |

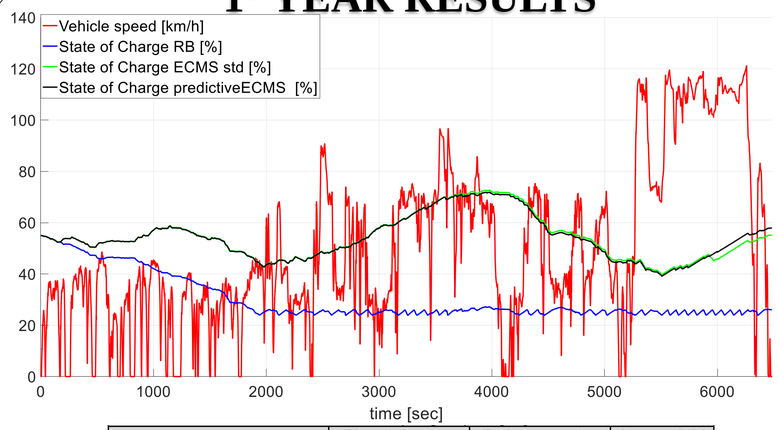
## 1° YEAR IMPROVEMENTS

**PREDICTIVE Battery State Of Charge Levelling**

- Long term e-horizon
- Use expected braking zones for positive levelling
- Use road slope and vehicle speed profile prediction
- Using map and GPS data




## 1° YEAR RESULTS




| *Energy Management Strategy* | Electrical energy [Wh/km] | Fuel consumption [l/100 km] | Corrected FC [l/ 100 km] |
|---|---|---|---|
| *Rule-Based (On-board the vehicle)* | 28.57 | 9.41 | 11.22 |
| *ECMS-Std (Phd Starting Point)* | -6.12 | 10.44 | 10.42 |
| *predictive-ECMS (1st year achievements)* | -9.02 | 10.58 | 10.39 |



IL PRESENTE MATERIALE È RISERVATO AL PERSONALE DELL'UNIVERSITÀ DI BOLOGNA E NON PUÒ ESSERE UTILIZZATO AI TERMINI DI LEGGE DA ALTRE PERSONE O PER FINI NON ISTITUZIONALI