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## ST7 – 77 – EFFICIENCY OF ON-BOARD ENERGY SYSTEMS

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**Dominante :** ENE (Energy)

**Langue d'enseignement :** French

**Campus où le cours est proposé :** Paris-Saclay

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### **Engineering problem**

The optimization of embedded energy systems is a problem encountered daily in the industrial world.

Whether the objective is to reduce production or usage costs, or to participate in the energy transition by minimizing the carbon footprint, optimization is essential in the energy world.

Volume, cost (optimal design or operating cost), performance or efficiency gains are objectives that can be found in aeronautical, space or automotive systems. The system and multiphysics aspect of the design is now taken into account in order to best meet increasingly demanding specifications.

During this sequence, industrial examples will be discussed: optimization of the efficiency and cost of an electric drive train on a few operating points or on road cycles, optimal management of energy sources in a hybrid system.

### **Advised prerequisites**

It is advised to have taken the course "Electrical Energy".

**Context and issue modules :** These modules include an introductory conference on the theme, a round table involving the partners in the sequence, presentations on the technological and scientific obstacles, and an innovation workshop.

### **Specific course (60 HEE) : *Optimization of embedded energy systems***

**Brief description:** After a description and formulation of the problem and a presentation of the models related to optimization, the techniques of optimization of energy systems, stochastic optimization, parameter estimation, multi-source optimization and multi-criteria optimization will be examined.



### **Project n°1 : *Energy efficiency of electrical machines***

- **Associated partner:** Leroy-Sommer

- **Location:** Paris-Saclay

- **Brief description :** The problem of energy optimization of electrical machines is posed on the one hand by a search for lower costs of use but also by the regulation which imposes increasingly high yields to control the electrical demand.

It is therefore necessary to optimize the efficiency of electrical machines. Of course, this maximization of the efficiency goes against another optimization: that of the manufacturing cost. A multi-criteria optimization between efficiency and cost will therefore be implemented.

### **Project n°2 : *Optimization of the traction chain on road cycle***

- **Associated partner :**

- **Location:** Paris-Saclay campus

- **Brief description :** The increase in the price of fossil fuels as well as environmental constraints are pushing the automotive and mobility sector to turn more and more to electric traction as a replacement or complement to the combustion engine.

The electric motor in the vehicle is not used on a single operating point as it is the case for a static application, but must respond to the solicitations of driving. To model these behaviors, numerous road test cycles are used. The optimization of the powertrain as a system is made complicated and expensive by the large number of operating points generated by these cycles. Reduction techniques will therefore be used to optimize the yields or the masses of the systems.

### **Project n°3 : *Optimal management of a hybrid generator***

- **Associated partner :**

- **Location:** Paris-Saclay campus

- **Brief description:** An energy production generator converts a source into energy. A generator is said to be hybrid when there are several sources



available (in the electric case, it can be a battery and a thermal engine and alternator). The choice of the primary energy source is therefore made at the time of use.

On an operating cycle (power demand curve for example), it is necessary to find the optimal set point leading to the best management of the hybrid generator: to know if the electricity is produced from the battery or from the thermal generator.

An optimization is therefore necessary to reduce the operating costs or to increase the efficiency. Subsequently, an optimization of the system according to this optimal management is possible.

#### **Project n°4:** *Optimization of a naval propulsion chain on cycle*

- **Associate partner:** DCNS

- **Location:** Paris-Saclay campus

- **Brief description:** 90% of world trade is carried out by sea. As a result, maritime transport is one of the main contributors to air pollution: 3% of total greenhouse gas emissions in the world. Naval electric propulsion is one of the candidates to replace conventional thermal propulsion systems.

In an electric ship, gas turbines or diesel generators produce electricity that is then used to power both the electric propulsion motors and auxiliary loads. The electrical system on board can be AC or DC. Such a system must be optimized to minimize its cost and maximize its efficiency. In particular, if the vessel follows a fixed route (such as a ferry), the optimization can take into account the operating cycle.