ST5 – 56 – MULTI-ENERGY SYSTEMS

Dominante : ENE (Energy) and GSI (Large Interacting Systems)
Langue d'enseignement : French
Campus où le cours est proposé : Paris-Saclay

Engineering problem

The objectives of reducing energy consumption and polluting emissions make it necessary to use energy systems that call on sources with complementary yields and characteristics. This is the case for electricity production systems, where the growth of intermittent renewable production requires more flexibility from conventional production means, and also for the transport sector, where electric and thermal engines complement each other advantageously.

These multi-energy systems require advanced control modes to take advantage of the complementarity of energy sources, and to satisfy the needs of users and the economic, technical and environmental constraints.

Advised prerequisites

It is strongly advised to have taken at least one of the SPI Transfer Sciences or Electrical Energy courses.

Context and issue modules: This part is organized around half-days of training aiming to present the sequence, the integration teaching and to introduce the stakes and associated bottlenecks, in particular under the economic aspects and related to the social and geopolitical environment of the topic.

Specific course (60 HEE) : *Introduction to energy production*

Brief description: the course is structured in two parts:

1. Mechanical energy production

- Internal combustion engines: introduction to internal combustion engines (architecture, thermodynamic cycle, operation and control, pollutant emissions, basic sizing)
- Turbomachinery (wind turbines, hydraulic turbines, gas turbines): introduction to turbomachinery (architecture, operation, control modes, interest)

2. Electrical energy conversion

- Structure of alternating current machines, motor/generator operation
- Electronic converters.
- Principles for speed variation of machines (machine and converter system)

Challenge week n°1: *Regulation and control of energy production and conversion systems*

- Associated partners: EDF, GE Converteam

- Location: Paris-Saclay campus

Brief description: the objectives are :

- To be able to model an industrial physical system for a control purpose

- Understand the impact of the regulation of an installation on the overall operation of the electrical system

- To do functional modeling to determine the control strategy of a system

- Be able to develop a control law that meets the specifications

- Take into account the specificities of the conversion elements to associate them and create a system

Challenge week n°2: *Hybrid powertrain*

- Associated partner: to be confirmed

- Location: Paris-Saclay campus

- Brief description: the objectives are :

- Implement a systemic model of the hybrid powertrain

- Implement numerical processing tools under Matlab/Simulink

- Implement a control approach of the whole hybrid chain from the driver to the wheels

- Introduction to cycle sizing: complexity of the system and contradiction of several objectives to be achieved

Challenge week n°3: *Hybrid aeronautical propulsion*

- **Associated partner:** Safran Tech

- **Location:** Paris-Saclay campus

- **Brief description:** The integration course deals with power management in the context of a small single-engine aircraft with a hybrid battery/fuel cell

energy architecture. The aircraft is propelled by a propeller powered by an electric motor and electricity is either directly drawn from batteries or generated by the combination of H2 and O2 in a fuel cell. The objectives are as follows:

- Realize a part and then assemble the whole systemic model of the energy architecture of the considered hybrid aircraft

- Implement the numerical resolution tools via Simulink and analyze the data collected

- Develop the regulation strategy of the system according to the given constraints

- Critique the model used in relation to the state of the art