Course Syllabus for
Smart and Sustainable Industry PhD Program
(years 2024-25/2025-26)

Course title	**Real-time Simulation and Hardware-in-the-Loop testing for Smart Energy Systems**
Scientific Discipline Sector	ING-IND/33
Hours of instruction	20 hours
CFU	2 CFU
Semester	Second
Goal	The course aims to give the fundamentals on the concepts of real-time simulation (RTS) and Hardware-in-the-Loop testing for applications in the fields of smart industry and smart energy systems. The students will also participate to laboratory activities where they will learn to use real-time simulation tools, prepare some basic projects and develop Hardware-in-the-Loop tests on cyber-physical systems. The lab activities will focus on applications for electrical power systems, but applications for any other engineering field can be foreseen (power electronics, mechanical, automotive, etc.).
Syllabus	Digital simulation, Real-time Simulations, Co-simulation, Geographical Distributed Co-Simulation. Classification of real-time simulation testing, Software-in-the-Loop (SIL), Hardware-in-the-Loop (HIL), Control Hardware-in-the-Loop (CHIL), Power Hardware-in-the-Loop (PHIL). Coupling methods, accuracy and stability of simulations. Modelling of an electrical power grid for real-time simulation. Coupling with physical devices. Use of communication network and Standard protocols (i.e Modbus TCP/IP). Seminars on the use of HIL/PHIL in the electrical industry. Prior knowledge of the Matlab/Simulink environment is suggested.
Bibliography	Selected papers and books on the field.
Examination method	The participants will prepare a simple RTS project coherent with their field of expertise using the Simulink-based RT-Lab environment.