YEAR 5 SYLLABUS, SEMESTER 9

The English courses taught at Sup'EnR in semester 9 of year 5 aim to raise awareness among future engineers of the challenges of the energy transition, which is now one of the priorities of the French Ministry of Ecology and Sustainable Development, and one of the main orientations of local planning and development policies. The course is divided into various modules which provide knowledge of the technologies, infrastructures, resources and policies put in place to respond to societal challenges. These modules explore the different paths of this transition, corresponding to different modes of land use, movement and energy production. Some modules are at the interface between the professions of energy specialist, planner, urban planner and economist. Apart from Innovative technological project, Energy softwares, Language (English), students will choose 6 of the 9 modules offered in the Energy Engineering UE and 4 out of 5 in the Humanities UE.

	Codes Apogee	Type	ECTS	Libellé	CM	TD	TP	Stage et autre	Total heures étudiant
Semestre 9	**TIENSN51**	**SE©**	**30**	**SEMESTRE 9 DIPLÔME D'INGENIEUR SUP ENR 5ème ANNEE**	**12**	**243**	**10**		**265**
	TIEN5U11	UE©	20	S9UE1 - Energy Engineering	12	138	10		160
	TIEN5IT1	MAT		Innovative technological project			10		10
	TIEN5ES1	MAT		Software for energy R&D	12	12			24
	TIEN5CH1	INTER		*Choice of 6 subjects out of 9*		126			126
	TIEN5SE1	MAT		Energy storage		21			21
	TIEN5HY1	MAT		District heating network and recovery of industrial waste heat		21			21
	TIEN5ME1	MAT		Materials for energy		21			21
	TIEN5GS1	MAT		Grids and smart grids		21			21
	TIEN5SN1	MAT		Supervision and energy management		21			21
	TIEN5CS1	MAT		Concentrated solar processes		21			21
	TIEN5WE1	MAT		Water and energy : Desalination and pollutant treatment		21			21
	TIEN5BA1	MAT		Bioclimatic architecture and positive energy building		21			21
	TIEN5LT1	MAT		Low-tech		21			21
	TIEN5U21	UE©	10	S9UE2 - Humanities		105			105
	TIEN5IN1	INTER		*Choice of 4 subjects out of 5*		84			84
	TIEN5NC1	MAT		Energy transition and land management of developing country		21			21
	TIEN5EM1	MAT		Transition and corporate social responsibility management		21			21
	TIEN5NT1	MAT		Energy transition and land management		21			21
	TIEN5EK1	MAT		Energy market		21			21
	TIEN5IP1	MAT		Industrial property and patent		21			21
	TIEN5AN1	MAT		English		21			21
Semestre 10	**TIENSN61**	**SE©**	**30**	**SEMESTRE 10 DIPLÔME D'INGENIEUR SUP ENR 5ème ANNEE**					**6**
	TIEN6U11	UE©	30	S10UE1 - Internship					6
	TIEN6ST1	MAT	30	Internship		6		6 mois	6
	TIEN6TO1	MAT	X	*TOEIC*					
	TIEN6DS1	MAT	X	*Durée du stage*					
	TIEN6SE1	MAT	X	*Séjour à l'étranger*					

Energy engineering (20 ECTS)

Innovative technological project :
Hours : 10h (project)

Objective: The end-of-studies project typically consists in designing and developing a complete energy chain, integrating aspects related to innovation. These projects are carried out in partnership with companies or research laboratories.

Contains:
Presentation of the projects
Realization of the projects by the students with the support of the teaching staff
Writing of the reports and preparation of the defence

Assessment methods: group (3/4 students) project report and oral presentation

Prerequisites:
Fundamental principles and processes studied in the courses of the UE sciences of the engineer, to be able to use basic data-processing tools (word processing, spreadsheet, ...)

Number of hours: 10h (project)

Software for energy R&D :
Hours : 24h (12h CM + 12h TD)

Objective: This module is dedicated to the use of an open-source software for solving partial differential equations. Future engineers will simulate energy processes integrating physical mechanisms related to flows and / or heat transfer.

Contains:
- Use of an open source EDP resolution software.
- Linux basic commands.
- Initiation to parallel computation.
- Initiation to turbulence modelling.
- Initiation to two-phase flow simulations.
- Initiation to strongly anisothermal flow simulations (quasi-compressible equations).

Assessment methods: project report and presentation

Prerequisites: Fluid dynamics, Heat transfer, Numerical analysis, Programming

Number of hours: 12h lecture, 12h exercise session

Energy storage :
Hours : 21h (TD)

Objective: The aim is to know the stakes in terms of energy management and storage, to acquire the essential notions on energy storage: order of magnitude, rules of pre-sizing, constraints, and limitations..., to know all the storage solutions with their advantages and disadvantages.

Contains:
Generalities on energy storage
Means of energy storage.
The different energy storage modes used in energy processes are described and illustrated by their applications. The material and process aspects are systematically approached in synergy.
- Chemical, electro-chemical storage: biofuels, hydrogen, batteries, accumulators, supercapacitors ...
- Mechanical storage: flywheel, hydroelectric dam, compressed air
- Thermal storage: sensible heat (liquid, solid, vapor), latent heat (gas / liquid, liquid / solid), composite materials with intensified transfer properties.
- Thermo-chemical storage: reactive systems, energy upgrading, production storage.
Comparison between systems (performances, economic, environmental impacts...)
Case studies

Assessment methods: project report and oral presentation

Prerequisites: energy conversion, Heat transfer, mechanics, electricity

Number of hours: 21h exercise session

District heating network and recovery of industrial waste heat :
Hours : 21h (TD)

Objective: This module focuses on defining and studying district heating and energy networks, with an emphasis on their evolution towards hybrid systems that integrate multiple energy sources. It explores the identification and utilization of industrial waste heat, along with various technologies for heat recovery, conversion, storage, and upgrading, all contributing to industrial decarbonization. The concept of eco-industrial parks is introduced as a framework for optimizing energy synergies between industries. The course relies on thermodynamic analysis, technological descriptions, and real-world application examples to support the study of these topics.

Contains:
District heating
Evolution of district energy networks
Hybrid energy networks
Industrial waste heat resources
Waste heat valorisation processes

Assessment methods: group (3/4 students) oral presentation

Prerequisites: Applied thermodynamic (1er et 2nd law, basic thermodynamic cycles)

Number of hours: 21h exercise session

Materials for energy :
Hours : 21h (TD)

Objective: Respond to the various constraints imposed on energy materials.

Contains:
What's next after Silicon PV?
- The limits of Silicon PV: intrinsic performance limitations and production market analysis.
- The alternative of thin film photovoltaics (CIGS, CdTe technologies), advantages and drawbacks.
- New emerging PV technologies: working principle and fabrication approaches of Organic PV, perovskites, and quantum dot solar cells.

Materials for solar thermal (ST) energy
- Low and high temperature ST technologies: basic principles, associated materials, efficiencies.
- Thermo-optical behaviour of materials for ST: definitions, expectations, simulation, characterization.
- Design of ST materials: surface functionalization, optical optimization, aging, and durability issues.

Materials for high temperatures
- Chemical Thermodynamics: phase diagrams, phase changes, CALPHAD modelling
- High temperature materials: properties, selection criteria, potential materials
- Materials for energy: From mines to final product, application to nuclear fuels.

Assessment methods: project report, presentation, written exam

Prerequisites: Knowledge of energy conversion technologies

Number of hours: 21h exercise session

Grids and smart grid :
Hours : 21h (TD)

Objective: the aim is to develop algorithms using Matlab in order to manage flexibilities and ensure the stability of a suburban low-voltage power distribution grid with high penetration of distributed energy resources (solar photovoltaics).

Contains:
Power grid architecture: transmission grid, distribution grid, transformer substations, mesh structure, radial structure, tree structure.
Power transportation and distribution.
Management of power distribution grids: distribution centres, protection, diagnostic and supervision.
Observability of power distribution grids.
Stability of power distribution grids.
From power distribution grids to smart grids.
Distributed generation.
Instrumentation, new information and communication technologies, automatic control, artificial intelligence.
Assessment methods: project report and presentation.

Prerequisites:
Scientific programming with Matlab.

Basics in system identification.
Basics in numerical optimization.
Basics in automatic control.

Supervision and energy management :
Hours : 21h (TD)

Objective: Developing a model-based predictive controller to manage electrical power in a smart building equipped with PV panel and batteries.

Contains:
Course outline

- Introduction to Smart Buildings
- Introduction to numerical optimization with Matlab
- Introduction to model-based predictive control

Learning outcomes

- The student will be familiar with different issues in smart buildings.
- The student will be familiar with different optimization methods that can be used in Matlab (linear, nonlinear, local and global).
- The student will be familiar with model-based predictive control methods for supervising electrical power in a residential micro-grid equipped with PV panels and batteries.

Assessment methods: project report and presentation

Number of hours: 21h exercise session

Prerequisites

- Basics of Control Engineering
- Discrete Time Systems
- Simulation of Ordinary Differential Equations
- Scientific Programming with Matlab

Concentrated solar processes :
Hours : 21h (TD)

Objective:

- Develop the student's awareness of the potentialities of concentrated solar resource for energy vectors production
- Develop the student's understanding of concentration optics theory
- Develop the student's understanding of the different solar concentrating systems: linear concentration, point concentration, high concentration systems

Contains:

Solar concentrating systems and receiver

- The solar resource for concentrating systems
- Introduction to concentration optics
- Linear concentration: parabolic trough
- Point concentration: Central receiver systems and solar furnace
- Solar receivers (absorbers) for linear concentrators and point focusing systems

Solar Collectors theory and technologies

- Energy collection and heat transfer in solar collectors
- Design and simulation
- Overview of the solar collector's technologies

Solar power plants

- Introduction to Concentrating Solar Power (CSP): various options, plants in operation, industry
- Tools for CSP design and performance evaluation
- Implementation

Learning outcomes

The student will be familiar with solar collectors' design and technologies and with solar power plants technologies for energy applications.
The student will be familiar with simulation tool and optimization method dedicated to CSP.

Assessment methods: project report, presentation, and written exam

Prerequisites Basic Understanding in Thermal Transfers, Optics, Thermodynamics, Chemistry, Chemical Engineering

Number of hours: 21h exercise session

Water and energy : Desalination and pollutant treatment :
Hours : 21h (TD)

Objective: Introducing the sanitary and environmental issues relative to water treatment, and the main technologies for desalination and water treatment, pointing out the energy issues in water treatment and identifying recent advances in the energetic approaches of water treatment.

Contains:
Marine energies
- Overview of the technologies exploiting the different forms of ocean energy: Marine current, Wave power, Tidal power, Ocean thermal energy, Osmotic power, Marine biomass.

Desalination
Issues on water access in the world, Importance of desalination and technical development. Initiation to the quality of saline waters and objectives of desalination depending on the water uses. Technical and environmental issues in desalination treatment lines. Overview of the different desalination technologies: membrane based and thermal based. Focus on reverse osmosis, with initiation of basic knowledge on the process. A group project on “Energy efficiency, energy recovery and renewable energies for thermal and membrane-based desalination”.

Depollution: issues, associated technologies micropollutants in the environment. Clean processes, real reactors.

Assessment methods: project report and presentation

Prerequisites: none

Number of hours: 21h exercise session

Bioclimatic architecture and positive energy building :
Hours : 21h (TD)

Objective: discover the way of designing buildings based on the local climate

Contains: Basic concepts, parameters, comfort in the building.
Design Principles, Spaces, Envelopes, Resources, Dedicated Techniques, Strategies.
Integration of renewable energy and energy production.
Self-consumption and energy management in housing.

Assessment methods: project report and presentation

Prerequisites: none

Number of hours: 21h exercise session

Low-tech
Hours : 21h (TD)

Objective: Acquire knowledge of low-tech systems and approaches; Be able to lead a low-tech project from design to completion; Understand the integration of low-tech at different organizational scales

Contains:

- Introduction to the Low-Tech Approach
- Economic Model, Low-Tech Project Management: What economic models are available for low-tech companies (associations, SCICs, businesses, etc.) and how to implement these "alternative entrepreneurship" models?
- Low-Tech at the organizational and territorial levels
- Culture of Cooperation: Tools and fundamentals of cooperation (shared governance, different decision-making methods, etc.)
- Improvement and/or study of a low-tech prototype: experimentation and life cycle assesment
- Collective cooking using low-tech systems

Assessment methods: project report and presentation

Prerequisites: none

Number of hours: 21h exercise session

Humanities (10 ECTS)

Energy transition and land management of developing country :
Hours : 21h (TD)

Objective: Acquire notions of energy transition in developing countries

Contains: After a general presentation of the specific challenges related to developing countries (poverty, demographic growth, rise of the middle class, etc.), the course will highlight the particularities of energy transition in those countries: a huge demand for energy, generally not driven by ecological issues, the need of an affordable energy, etc. Then, students will endorse the role of a leading organisation trying to implement development actions in the country of their choice.

Assessment methods: project report and presentation

Prerequisites: none

Number of hours: 21h exercise session

Transition and corporate social responsibility management
Hours : 21h (TD)

Objective: The course will look at corporate strategies in terms of social responsibility (environmental, economic and social issues) and transitions in the broadest sense. Students will study a specific company to determine the extent to which it is responsible or irresponsible. The social and solidarity economy, as an economic alternative to the dominant model, will also be addressed.

Contains:
The ability to find relevant information, to evaluate it and to use it: information competence.
The ability to take into account the challenges of the company: economic dimension, respect for quality, competitiveness and productivity, commercial requirements, economic intelligence.
The ability to take environmental issues into account, in particular by applying the principles of sustainable development
The ability to take into account the issues of labor relations, ethics, safety and health at work.
The ability to take into account the challenges and needs of society

Assessment methods: project report

Prerequisites: none

Number of hours: 21h exercise session

Energy transition and land management :
Hours : 21h (TD)

Objective: Acquire notions of planning policies for the energy transition

Contains: Integration of the paradigm shift (energy transition) into planning policies and practices.
Identification of actors, operational tools, planning procedures, new professional standards (smart-grid, regional plans for wind development, Territorial Energy Climate Plan ...).

Assessment methods: project report and presentation

Prerequisites: none

Number of hours: 21h exercise session

Energy market :
Hours : 21h (TD)

Objective: The aim of this course is;
- to present the main characteristics of electricity markets around the world;
- to describe the interdependence between energy markets;
- to analyse the economic regulation of transportation and distribution in electricity networks;
- to study rationale and impacts of public support schemes for renewable electricity production;
- to introduce the functioning of demand-side management and the concept of aggregator;
- to describe the main characteristics of energy and pollution regulation (coal, oil, gas...).

These items will be illustrated by examples in different countries.

Contains:
Energy markets and regulation (deregulated electricity markets, adjustment market, other energy market)
Pollution regulation
Modern energy management: Demand-side management and aggregators

Assessment methods: project report and presentation

Number of hours: 21h exercise session

Prerequisites: Modulus S6UE1 on optimisation

Industrial property and patent :
Hours : 21h (TD)

Objective: This teaching unit will bring students knowledges in innovation, intellectual and industrial property, and patents.

The aim of this course is :

- To know elementary principles of intellectual property law
- To be able to think about protection
- To have tools and reflex in practical situations

Contains: trade secret and know-how; general aspects of IP rights; software and databases; trademarks; patents

Assessment methods: project report and presentation

Prerequisites: none

Number of hours: 21h exercise session

English :
Hours : 21h (TD)

Objective: Fluent in English

Contains: All the work is based on actual and recent developments in technology with main focus on renewables. Courses are based on:
- Listening comprehension of actual talks, process descriptions, actual installations.
- Reading comprehension.
- Oral expression.
- Written expression and oral interaction.
- Scientific article analysing.
- Abstract reporting.
- Project debating.
- Grammar

Assessment methods: written exam, speaking, listening comprehensions

Prerequisites: B2

Number of hours: 21h exercise session