1SC4610 – Climate and energy transition

Instructors: Loïc Queval
Department: DÉPARTEMENT SYSTÈMES D'ÉNERGIE ÉLECTRIQUE
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 34,50

Description

This course is divided into 3 parts which prepare each corresponding "enseignement d'intégration ".

Part I
The goal of this course is to present the main physical-chemical principles that determine the climate of the Earth. The first part is dedicated to the account of past climates and of the mechanisms behind climatic changes, in particular orbital variations, greenhouse gases concentration changes linked to perturbations of the carbon cycle, or the evolution of life on Earth. The second part will present the different numerical modeling strategies used in climatology. The equations and approximations used to simulate the atmosphere and oceans, and the couplings between the different components of the climate system.

Part II
Variables/intermittent renewable energy sources are renewable energy sources whose availability varies strongly without any possibility of control. Some have regular variations and predictable as tidal energy, others are more fluctuating as photovoltaics or wind energy. The goal of this course is to present the potential of variable sources of renewable energy. The first part is dedicated to the main features of production of energy from these sources. The second part concerns the integration and management of energy in the transportation and distribution grid. The conversion and storage elements used in this framework will be addressed.

Part III
The energy transition with its efficiency goals associated to rethink the way in which users will have access to electric power. To establish new consumption patterns, it is necessary to analyse behaviours of consumers to organize the new means of production and supply of the network. The course focuses on the description of the operation of main electrical appliances used for domestic and industrial sites to characterize these

charges in order subsequently to identify the presence of these devices by the analysis of consumption data.

Quarter number
ST4

Prerequisites (in terms of CS courses)
SPI course Electric Energy adviced

Syllabus

Session 1 (3h): D. Paillard (courses carried out in collaboration with IPSL (LSCE))
Introduction, paleoclimates
General presentation of the diversity of climates that our planet has known in its history, since the recent era (meteorological measurements) to the early ages of the Earth (geological and geochemical information). Emphasis will be on the main physicochemical principles responsible for climate change : astronomical variations for Quaternary cycles ; episodes Earth-snowball and ice-albedo feedback. The young Sun paradox; evolution of the carbon cycle, geology and evolution of life; etc...

Session 2 (3h): D. Paillard (courses carried out in collaboration with IPSL (LSCE))
Radiative balance, greenhouse, the carbon cycle
The main determinant of the climate on a planet is the balance between incoming solar radiation and outgoing infrared radiation. "The greenhouse effect" stems from the fact that looking generally at the surface temperature while the outgoing infrared radiation is emitted at high altitude. It will look at the role of CO2 on the radiation balance, but also to the carbon cycle: the time constants of the carbon on Earth, the main tanks, the role of global thermostat via the erosion of silicates.

Session 3 (3h): M. Kageyama (courses carried out in collaboration with IPSL (LSCE))
Introduction to the climate modeling
General presentation of the models: the components of the system (atmosphere, ocean, continental surfaces, biogeochemical cycles, calottes ice,...); the various couplings and combinations of components used in modelling of the climate, the hierarchy of models. Description and main principles of the atmospheric circulation, equations of motion, usual approximations. Simulation of climates past, present, future.

Session 4 (3h): M. Kageyama (courses carried out in collaboration with IPSL (LSCE))
The example of the fast simulation of climate events

Description and main principles of ocean circulation. Phenomenology of abrupt events (corner-Oeschger and Heinrich), model Stommel and multiple equilibria. Coupled simulations and disturbances in flow of fresh water.

Session 5 (3h): L. Queval (CS)
Sources and production variables ENRs ½
Wind energy, marine energy

Session 6 (3h): L. Queval (CS)
Sources and production variables ENRs 2/2
Solar PV

Session 7 (3h): E. Odic (CS)
Integration and management of the variable ENRs
Means of storage, principles and implementation

Session 8 (3h): M. Hennebel (CS)
Integration and management of the variable ENRs
Impact of the ENRs, cheap electricity grid

Session 9 (3h): A. Arzandé (CS)
Presentation of electrical quantities in the field of electrical consumption, the general operation principles of electrical devices and power electronics. Study of the waveforms of currents absorbed by electrical devices and methods of recognizing these waveforms by Data Science.

Session 10 (3h): T.D. Le (CS)
Introduction of smart meters for measuring power consumption. Use of power consumption data in Smart Grids. Introduction of load forecasting.

Session 11 (3h): D. Tourin-Lebret (Smart Impulse)
Introduction, challenges and issues of the analysis of the electric consumption in a network. After a reminder of the context of the energy demand, the global warming situation and the supply / demand balance on an energy distribution network, the challenge of automatically identifying unnecessary electrical consumption is tackled with an engineering vision : finding a simple and robust solution to a complex problem that is a priori intractable.

Session 12 (1h30): Written exam (QCM)

Class components (lecture, labs, etc.)
11 lectures + written exam (QCM)

Grading

Written examination of 1h30 (QCM)
The grades are homogenized to reach the target average grade that is set by the school office.

Resources

classroom (100 pers.)

Learning outcomes covered on the course

- Understand the physical basis of Earth's climate and its changes.
- Master the various components for the generation, conversion and gestion of the renewable energy.
- Understand the difficulties related to the integration of renewable energy to the electrical grid.
- Solve simple problems dealing with the alimentation of residential/industrial sites from from renewable energy.
- Evaluate the economic aspects.

Description of the skills acquired at the end of the course

- C1.1 - Study a problem in its entirety, the situation as a whole. Identify, formulate and analyze a problem in scientific, economic and human dimensions.
- C1.2 - Use and develop suitable models, choose the right scale of modelling and assumptions relevant to deal with the problem.
- C4.2 - Know how to identify the value of a solution for a customer, the market. Know how to discern opportunities, opportunities business and enter them.