ANNEX I. PROGRAMME DESCRIPTION AT UPC

Objectives

This international master programme **MSc in Energy Engineering** aims to respond to current energy problems from different perspectives: resources, technologies of production, transport and distribution of energy, environmental impact, efficiency, energy saving and rational use of energy.

MSc in Energy Engineering aims to train experts with the knowledge and skills necessary to analyze case studies and manage projects in power generation, and transformation, distribution and utilization of different energy sources.

Competences and Learning outcomes

Overarching competences

CG1: Integrate and apply mathematical, analytical, scientific, instrumental, technological and management knowledge acquired during university education and be an efficient problem solver within the field of power engineering.

CG2: To size, analyze, design and project equipment, facilities, infrastructures and processes of transformation and transport of energy in any of the phases or stages of the energy chain, from energy resources to energy end use, being able to participate in projects planning, writing, direction and management in the field of power engineering.

CG3: Take part in processes of research, development and innovation in the field of energy technology and energy usage in both, productive and services sectors, providing new insights, technological advances and innovative solutions working in national or international multidisciplinary teams.

CG4: Critically analyze regional, national and supranational energy policies, and know how to apply the energy legislation in any of the fields of energy engineering and energy management.

CG5: Owning the leadership skills and the entrepreneurial spirit necessaries to assume the technical and management direction in public or private organizations in the energy sector.

GC6: Conduct technical advice and technical consultancy in the field of power engineering.

CG7: Analyze the economic, social and environmental impact of technical solutions both in the exploitation of primary energy resources, and in processing, transportation and end use of energy.

Transversal competences

The transversal competences describe what a graduate is able to know or do at the end of the learning process, regardless of the degree. The transversal competences established at UPC are: entrepreneurship and innovation, sustainability and social commitment, knowledge of a third language (preferably English), teamwork and effective use of information resources.

See, for a full description:
https://www.upc.edu/ice/innovacio-docent/publicacions_ice/arxius/resum_competencies_postgrau_eng.pdf

Specific ILO for the Renewable Energy Specialization:

At the end of the master's degree, graduates will be able to:

- Show a deep understanding of the role of renewable energy in the context of global and regional energy systems, it's economic, social and environmental connotations, as well as the impact of renewable energy technologies on a local and global context; and to make judgments about opportunities, threats and barriers for renewable energy resources and technologies utilization.
- Show a deep knowledge and understanding on relevant organizations, major international projects, the main sources of information, energy markets, and regulatory frameworks related to the utilization of renewable energy resources.
- Efficiently perform the collection and analysis of renewable energy resource data for the design and evaluation of technology solutions related to the use of renewable energy.
- Carry out feasibility studies, consultancy and engineering projects related to the use of renewable energy in productive and services sectors, working in multidisciplinary and international teams.
- Show a good knowledge on the main topics of research and development in the field of renewable energy, be able to provide ideas for the development of innovative new products and services, as well as be prepared for integrating him/herself in research teams and for starting PhD studies in this field.

Courses descriptions

The descriptions of the courses at UPC include, in the Methodology raw, the number of hours the student should devote to the following training activities:

Classroom activities:

- Lectures and conferences: know, understand and synthesize the knowledge presented by the teacher through lectures.
- Practical sessions: participate in collective decision exercises, as well as in discussions and group dynamics, with the lecturer and other students in the classroom.

- Laboratory: understand the operation of equipment, specifications and documentation; make designs, measurements, verifications, etc.., and present the results orally or by a written report individually or in small groups.
- Presentations: present in the classroom an activity individually or in small groups.
- Tutoring sessions: solving theoretical or practical exercises, individually or in small groups, with the advice of the teacher.

Activities outside the classroom:

- Homework assignments: perform individually or in groups a work or exercise of reduced complexity or scope, applying knowledge and presenting results.
- Project: design, plan and carry out individually or in groups, a project or assignment of wide complexity or scope, by applying and extending knowledge, and writing a report which describes the problem approach and results and conclusions.
- Autonomous study: to study or expand course content individually or in groups, understanding, assimilating, analyzing and synthesizing knowledge.

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	240CF001	**Name**	**Electrical Engineering fundamentals**				
ECTS	**3**	**Year**	1	**Semester**	1	**Character**	Basic Skills
Pre-requisites		none					
Prior skills:		• Elementary operation with complex numbers. • Trigonometry fundamentals • Linear equation systems with complex numbers • Fundamentals of Direct Current (DC)					
Objectives		The main objective of this course is providing insights into single- and three-phase electric circuits and electric machines. In order to achieve this objective, the course mainly focuses on the theory of the proposed themes together with the resolution of practical exercises. The students determine voltages, currents and powers in electric circuits and analyze the main problems related to energy concerns. Electric machines are also introduced, and synchronous and asynchronous machines are studied and their main applications are analyzed.					
Learning outcomes		At the end of the course the student will be able to: • Solve single-phase circuits in DC and AC steady state. • Solve balanced three-phase circuits in AC steady state. • Solve single- and three-phase circuits with transformers. • Determine voltage, current and powers in DC and AC rotating machines working in steady state. • Apply Node Voltage Method for network analysis.					
Course main content		1. Single-phase circuits. 2. Three-phase circuits. 3. Electric network analysis. 4. Electric machines.					
Methodology		The course is developed through theory sessions and exercise sessions. The teacher introduces the fundamental concepts of the course in the theory sessions, which are subsequently worked on with practical exercises related to the main electric circuit topologies and energy concerns.					
Bibliography:		• J. D. Irwin, R. M. Nelms, "Basic engineering circuit analysis", 8th Edition 2004, John Wiley and Sons, ISBN-10: 0471487287, ISBN-13: 978-0471487289. • T. Wildi, "Electrical machines, drives, and power systems", 6th Edition 2005, Prentice Hall, ISBN-10: 0131776916, ISBN-13: 978-0131776913.					
Student assessment		Written exam (midterm exam) 25 % Written exam (final exam) 75 %					
Contact person		Luis Sainz http://directori.upc.edu/directori/dadesPersona.jsp?id=1002268					
Link							

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	240CF002	**Name**	**Electronics Fundamentals**				
ECTS	**3**	**Year**	1	**Semester**	1	**Character**	Basic Skills
Pre-requisites		none					
Objectives		The main objective of this course is to help students to understand the basis of electronic devices, both in the analogue domain and the digital domain. In order to achieve this objective, the course mainly focus in practical works where the students analyze, measure and characterize diodes, BJTs transistors, logic gates and operational amplifiers (op-amps) embedded in practical examples related to power electronics and control of systems dealing with energy concerns.					
Learning outcomes		At the end of the course the student will be able to: • Demonstrate a basic understanding of the electronic devices. • Analyze, measure and characterize diodes, BJTs transistors, logic gates and op-amps.					
Course main content		1. p-n junction. LEDs. 2. BJT and MOS Transistors. 3. Switching and amplifier behaviours. 4. CMOS digital gates. 5. Operational amplifiers.					
Methodology		The course is developed through theoretical learning sessions and practical sessions in electronic and computer labs. In the theoretical sessions, the teacher introduces the fundamental concepts of the course, which is after worked on practical sessions using application examples related to power electronics and/or simple energy circuits. In the theoretical sessions, the teacher introduces the fundamental concepts of the course, which are subsequently worked in practical sessions using examples of applications related to power electronics as well as simple circuits related to renewable energy systems.					
Bibliography:							
Student assessment		Theoretical final exam and continuous evaluation of practical works.					
Contact person		Rosa Rodríguez, http://directori.upc.edu/directori/dadesPersona.jsp?id=1000468					
Link							

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	240CF006	**Name**	**Thermodynamics Fundamentals**				
ECTS	**3**	**Year**	1	**Semester**	1	**Character**	Basic Skills
Pre-requisites		none					
Objectives		The objective of this course is to give students the basis for the understanding of relevant energy production and storage processes related to the use of renewable resources. Fundamental thermodynamics, fluid-mechanics and heat transfer concepts will be reviewed. Elementary processes will be discussed and analyzed using mass and energy balances. Global processes will be discussed and optimized on the basis of energy efficiency and economy criteria.					
Learning outcomes		At the end of the course the student will be able to: • Pursue an analysis of a power generation system with renewable energy using thermodynamics and heat transfer principles.					
Course main content		1. Basic thermodynamics concepts. Energy. Thermodynamic properties. Mass and energy balances. 2. Energy efficiency. Use of thermodynamic cycles in energy production. 3. CASE ANALYSIS: Use of biomass as a non-fossil fuel. 4. Heat transfer mechanisms. Optimization and design criteria for heat exchangers. 5. Pipe flow. Friction losses. Pumps. 6. CASE ANALYSIS: solar water heating systems.					
Methodology		The course is developed through sessions which include both theory and practice. The teacher introduces the fundamental concepts of the course, but the students are encouraged to further develop these concepts in the analysis of elementary processes. Two relevant case studies, integrating the most relevant theory concepts, are analyzed.					
Bibliography:							
Student assessment		Students are evaluated through a final exam.					
Contact person		Xavier Fernández Francos - Laboratori de Termodinamica (ETSEIB H-building, 8th floor)					
Link							

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	240CF009	**Name**	**Hydraulics Fundamentals**				
ECTS	**3**	**Year**	1	**Semester**	1	**Character**	Basic Skills
Pre-requisites		none					
Objectives		The main objective of this course is providing insights into fluid mechanics and hydraulic machines. The behaviour of incompressible fluids in motion, the main characteristics and design criteria of free surface flow and pressure flow in pipes, and the main characteristics of hydraulic machines will be introduced and discussed.					
Learning outcomes		At the end of the course the student will be able to: 1) Identify a hydraulic problem. 2) Analyze and evaluate hydraulic situations to solve them by using appropriate tools On successful completion of this course, students will have developed a range of generic skills spanning: hydraulic analysis, team work, planning and organization, numerical analysis, and data analysis.					
Course main content		• Hydromechanics. • Open channel hydraulics. • Pipe hydraulics. • Hydraulic modelling. • Hydraulic machines.					
Methodology		Lectures, exercises, assignments and a visit to a hydraulic power station.					
Bibliography:							
Student assessment		Final exam and continuous evaluation of practical exercises.					
Contact person		Eduard Egusquiza http://directori.upc.edu/directori/dadesPersona.jsp?id=1000754					
Link							

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820730	**Name**	**Energy Resources**				
ECTS	**5**	**Year**	1	**Semester**	1	**Character**	Mandatory
Pre-requisites		none					
Objectives		The main objective of this course is providing insights into • The need and importance for energy and its relationship to human and sustainable development. • The transformations of energy from its status as a "energy resource" to its use as" energy services ". • The strategic implications for the security of supply of different energy sources Additionally, this course aims to: • Sensitize students to face issues such as energy efficiency, environmental impact security of supply, etc. • Work in students the values of justice, solidarity and equality.					
Learning outcomes		The student must understand, describe and analyze in a clear and complete way the energy conversion chain; beginning from the “energy source” up until its final use as a “energetic service”. Identify, describe and analyze the characteristics of the different energy resources and the final use of the energy, considering its economical, social and environmental dimensions.					
Course main content		Block 1: Introduction. 1. Basic concepts. 2. The energetic problem. The energy economy. 3. Energy storage and transformation. 4. Legal framework. Block 2: The energy sources and its technological applications. Actual and future trends. 5. Oil. 6. Natural gas. 7. Coal.					
Methodology		The course is structured in a series of lectures (participatory conferences) to provide transversal items useful for other courses, and an overview of the energy system from different points of view. At the same time students will do several assignments (lectures and exercises). During the course the students will do, in teams of 3 people, a supervised work on a particular energy issue that will en by writing a technical informative article that they will orally present to the supervisor.					
Bibliography:		V. Smil, Energy at the Crossroads. Global Perspectives and Uncertainties. Massachusetts Institute of Technology, 2003 (and further editions). MIT Press.					
Student assessment		The evaluation is based on grading student’s self-learning activity (40%), the course supervised work (30%), activities made in the classroom (10%) and a final exam (20%). Self-learning activities are divided into exercise (10% - 20%) and others (20% - 30%).					
Contact person		Lluis Batet http://directori.upc.edu/directori/dadesPersona.jsp?id=1002339					
Link							

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820731	**Name**	**The power grid system**				
ECTS	**5**	**Year**	1	**Semester**	1	**Character**	Mandatory

Pre-requisites

- Thermodynamics fundamentals
- Electrical engineering fundamentals

Objectives

- Introduce the different technologies involved in the production of electricity, making particular emphasis on its fundamental characteristics, environmental impact and efficiencies.
- Address the most important aspects related to the transport and distribution of electricity.

Learning outcomes

At the end of the course the student will be able to:

- Demonstrate a good knowledge and understanding of the structure of the electrical system; the role of the electrical system in the context of a global energy system; and the systems and technologies involved in the production of electricity, their fundamental characteristics, their efficiency, and their environmental impact.
- Perform studies on the design, evaluation, selection and implementation of systems for electricity production.
- Demonstrate a good knowledge and understanding of the most significant aspects of the transmission and distribution of electricity.
- Demonstrate awareness to the importance of issues such as energy efficiency; environmental impact, security of energy supply.

Course main content

1. Introduction
   Structure of the electric sector: production and demand.
2. Production
   Scheme and operation principles, efficiencies, equipment and environmental impact of the following technologies: Thermal plants (Steam cycle power plants, gas cycle power plants, combined cycle power plants, solar thermoelectric power plants, nuclear power plants); Hydropower plants; Wind power plants; Others.
3. Transport and distribution of electric power.
   Introduction (difference between transport and distribution. Power losses. Maximum lengths).

Methodology

Lectures, practical sessions, exercises and assignments.

Student workload (hours)

Lectures	30	Tutoring sessions	15
Practical sessions	15	Homework assignments	30
Laboratory	0	Projects	0
Presentations	0	Autonomous Study	35
		TOTAL	125

Bibliography:

Student assessment

Exam 70% Homework assignments 30%

Contact person

Carme Pretel http://directori.upc.edu/directori/dadesPersona.jsp?id=1002326

Link

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820732	**Name**	**Energy and Environment**				
ECTS	**5**	**Year**	1	**Semester**	1	**Character**	Mandatory
Pre-requisites		none					

Objectives

The general objective of the course is to introduce students to the problems associated with energy management and the consequences and effects this has on our environment in terms of pollution with special emphasis on air pollution. The course aims to

- Identify the effects of energy production and to introduce principles and tools, especially those aimed at preventing and minimizing gas emissions.
- Familiarize students with the tools to predict the behaviour of contaminants using basic models of transport and dispersion and to determine the air quality at a specific point.
- Introducing the basic knowledge that allows selecting the most appropriate technology for a treatment according to the type of pollutant, environment, and relevant environmental laws and regulations.

Learning outcomes

At the end of the course the student will be able to:

- Identify the elements of sustainable development and the social, economic and environmental consequences of energy production and utilization.
- Determine the sources of pollution and the effects on the environment caused by power systems and their environmental impact.
- Demonstrate a good knowledge and understanding of the tools for emissions assessment with emphasis on carbon footprint.
- Identify the processes and systems to prevent pollution.
- Demonstrate a good knowledge and understanding of treatment systems to reduce pollution levels.
- Identify and assesses the factors that determine the transport and dispersion of atmospheric pollutants.

Course main content

1. Sustainability, Energy and Environment.
2. Air Pollution.
3. Air Pollution Effects.
4. Emission inventories and carbon footprint.
5. Systems for the treatment and control of particulates and dust.
6. Gas purification systems.
7. Atmospheric dispersion.
8. Radioactive waste management.

Methodology

Lectures, participative sessions, exercices and assignements, including a short project.

Student workload (hours)

Lectures	18	Tutoring sessions	20
Practical sessions	6	Homework assignments	35
Laboratory	6	Projects	0
Presentations	0	Autonomous Study	40
		TOTAL	125

Bibliography

- Sioshansi, F.P. (2011). Energy, Sustainability and the Environment: Technology, Incentives, Behaviour. Ed. Elsevier, Amsterdam.
- Vallero, D.A. (2008). Fundamentals of Air Pollution. Ed. Elsevier, Amsterdam.

	• Hill, M.K. (2004). Understanding Environmental Pollution. Cambridge University Press, The Edinburgh Building, Cambridge cb2 2ru, UK. • Schnelle, K.C., Brown, C.A. (2002). Air pollution control technology handbook. Boca Ratón, Florida: CRC Press.
Student assessment	Written test control of knowledge: 50% Work done individually or in groups during the course: 25% Attendance: 15% Quality and performance of group work: 10%
Contact person	César Valderrama http://directori.upc.edu/directori/dadesPersona.jsp?id=1106028
Link	

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820733	**Name**	**Renewable Energy Technology**				
ECTS	**5**	**Year**	1	**Semester**	1	**Character**	Mandatory
Pre-requisites		No specific requisites					
Prior skills		• Fundamentals of applied physics. • Fundamentals of Economics • Economic analysis of projects.					
Objectives		The student should acquire the necessary knowledge and skills needed for the description, selection and sizing of equipments as well as for the feature calculations for preexisting equipments and installations to a basic or pre-project levels. It is intended to give an overview of the technologies and methods to allow the student to perform alternative assessments and studies in conducting engineering projects.					
Learning outcomes		At the end of the course the student will be able to: • Demonstrate a good knowledge and understanding of the role of renewable energy in the production and service sectors, as well as its importance in the energy chain: processing, transportation, distribution and end-use and energy efficient and is able to make judgments about opportunities, threats and barriers to their use. • Demonstrate a good knowledge and understanding of the characteristics and key players in the sector of renewable energies in Spain and Europe as well as its importance in an economic productive context. • Critically analyze the policies to promote renewable energy. • Select the most appropriate systems from the point of view of energy for different types of applications (industrial or service), and analyze the behaviour of system operation and make a diagnosis on your operating system.					
Course main content		1. Introduction. 2. Renewable energy sector. 3. Solar energy. 4. Solar thermal energy. 5. Solar photovoltaic energy. 6. Wind Energy. 7. Marine and hydraulic energy. 8. Geothermal energy. 9. Biomass and wastes. 10. Biogas and biofuels. 11. Hydrogen and fuel cells. 12. Hybrid systems. 13. Research and development.					
Methodology		Lectures, participative sessions, exercices and assignements. Student workload (hours)					

Lectures	30	Tutoring sessions	15
Practical sessions	15	Homework assignments	15
Laboratory	0	Projects	20
Presentations	0	Autonomous Study	30
		TOTAL	125

Bibliography:	• L. L. Freris, D.Infield, “Renewable energy in power systems”. John Wiley and Sons, 2008. • John A. Duffie, William A. Beckman “Solar Engineering of Thermal Processes” 3rd Edition. Wiley, 2006. • Adolf Goetzberger, Volker Uwe Hoffmann, “Photovoltaic Solar Energy Generation”,

	Springer, 2005. • Thomas Ackermann (Editor), "Wind Power in Power Systems". Wiley, 2005. • Simeons, Charles "Hydro-power: the use of water as an alternative source of energy". Pergamon, 1980. • Ronald DiPippo; "Geothermal Power Plants (Second Edition)". Edit. Elsevier. 2008. ISBN-978-0-7506-8620-4. • McGowan, Tom "Biomass and alternate fuel systems: an engineering and economic guide". John Wiley & Sons, 2009. • R.L. Busby "Hydrogen and Fuel Cells. A comprehensive guide". PennWell Corporation, 2005.
Student assessment	Written exam: 60% Assignments: 40%
Contact person	Josep Bordonau http://directori.upc.edu/directori/dadesPersona.jsp?id=1000079
Link	

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820734	**Name**	**Thermal Equipment**				
ECTS	**5**	**Year**	1	**Semester**	2	**Character**	Mandatory
Pre-requisites	Completed at least 10 ECTS in Thermal Engineering, including: • Fundamentals of thermodynamics. • Fundamentals of heat transfer. • Fundamentals of fluid mechanics.						
Prior skills	• Fundamentals of differential and integral calculus • Stoichiometry of chemical reactions.						
Objectives	This course focuses on the engineering of heat and cold equipments as well as on heat exchangers. In this area it is intended that students acquire the knowledge and skills necessary for the description, selection and sizing, as well as for calculating the performance of existing equipment and facilities.						
Learning outcomes	At the end of the course the student will be able to: • Demonstrate a good knowledge and understanding about the role of thermal equipments in the industry and services sectors, as well as their importance in the energy supply chain. • Select the most appropriate thermal equipment from the energy point of view for each application (industry or services). • Predict the behaviour of existing equipment, perform a diagnosis about its performance, and assess measures for improving its energy efficiency. • Design and size -at basic engineering level- thermal equipments used in industry and service sectors. • Be able to propose improvements in thermal equipment, by developing new ideas.						
Course main content	1. Combustion equipment. 2. Heat transfer equipment between two fluids. 3. Refrigeration and AC equipment.						
Methodology	Lectures, participative sessions, exercices and assignements. Student workload (hours)						

Lectures	30	Tutoring sessions	15
Practical sessions	15	Homework assignments	15
Laboratory	0	Projects	20
Presentations	0	Autonomous Study	30
		TOTAL	125

Bibliography	• Márquez, Manuel. Combustión y quemadores. MARCOMBO, 2005. • Schlünder, Ernst U. [et al.] Heat exchanger design handbook. New York [etc.]: Hemisphere, 1983. • Rohsenow, Warren M. (ed.) Handbook of heat transfer. 3th ed. New York [etc.]: McGraw-Hill, cop. 1998. • American Society of Heating, Refrigerating and Air-Conditioning Engineers, ASHRAE handbook. Fundamentals. Atlanta, GA. : ASHRAE, 2005. • ASHRAE handbook. Refrigeration, Atlanta: American Society of Heating, Refrigerating

	and, Air-Conditioning Engineers, cop. 2002.
Student assessment	Written exam: 60% Individual and team curse work. 40%
Contact person	Enrique Velo http://directori.upc.edu/directori/dadesPersona.jsp?id=1002122
Link	

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820735	**Name**	**Electrical Equipment**				
ECTS	**5**	**Year**	1	**Semester**	2	**Character**	Mandatory
Pre-requisites		none					
Prior skills		Calculus, complex numbers, differential equations. Basic physics, basic mechanics.					
Objectives		This course aims students acquire broad knowledge of most common electrical equipment.					
Learning outcomes		At the end of the course the student will be able to: • Demonstrate a good knowledge and understanding on the role of electrical equipment in the production and service sectors, as well as their importance in the energy chain: processing, transportation, distribution and end-use and energy efficient power. • Select the most appropriate electrical equipment from the energy point of view for each application (industry or services). • Predict the behaviour of existing equipment, perform a diagnosis about its performance, and assess measures for improving its energy efficiency. • Design and size -at basic engineering level- electrical equipments used in industry and service sectors. • Be able to propose improvements in electrical equipment, by developing new ideas					
Course main content		1. Introduction and fundamentals 2. Power transformers 3. Electromechanical conversion of energy 4. Static converters 5. Electro-technology					
Methodology		Lectures, participative sessions, exercices and assignements. Student workload (hours)					

Lectures	15	Tutoring sessions	15
Practical sessions	15	Homework assignments	30
Laboratory	0	Projects	20
Presentations	0	Autonomous Study	30
		TOTAL	125

Bibliography		• Ras Oliva, Enrique “Transformadores de potencia, de medida y de protección” 7ª ed. renovada. Barcelona Marcombo, 1988. • Sanjurjo Navarro, Rafael “Máquinas eléctricas” Madrid [etc.] McGraw-Hill, 1990.					
Student assessment		Exam: 70% Assignments: 30%					
Contact person		Samuel Galceran http://directori.upc.edu/directori/dadesPersona.jsp?id=1002930					
Link							

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820736	**Name**	**Economics and energy markets**				
ECTS	**5**	**Year**	1	**Semester**	2	**Character**	Mandatory
Pre-requisites	• Energy Resources • The power grid system						
Prior skills	Basic knowledge on energy systems and their operation, economics and linear programming.						
Objectives	This course aims students understanding and being able to apply the concepts related to energy markets.						
Learning outcomes	At the end of the course the student will be able to: • Demonstrate a good knowledge and understanding on the role of energy management in global and regional contexts, and its economical, social and environmental impacts. • Demonstrate a good knowledge and understanding on the relevant international organizations, the main sources of information, and those regulations related to the management of energy in different sectors. • Carry out activities related to energy management in various sectors, particularly in the energy markets. • Propose transferable results - on issues affecting the implementation of the energy management - through the development of innovative ideas.						
Course main content	1. Structure of energy markets. 2. Optimal operation in energy markets.						
Methodology	Lectures, participative sessions, exercices and assignements. There will be two assignments to perform during the course by students groups. The work will be presented through a written report. Student workload (hours) Lectures 20 | Tutoring sessions 15 Practical sessions 10 | Homework assignments 15 Laboratory 0 | Projects 25 Presentations 0 | Autonomous Study 40 TOTAL 125						
Bibliography	• D. Kirschen and G. Strbac, Fundamentals of power systems economics, West Sussex, England: John Wiley & Sons, Ltd, 2004. • Gómez-Expósito, A., Conejo, A.J. & Cañizares, C., editors, Electric energy systems: Analysis and Operation. CRC Press, Taylor & Francis Group, 2009.						
Student assessment	Exam: 60% Assignments: 40%						
Contact person	Roberto Villafáfila http://directori.upc.edu/directori/dadesPersona.jsp?id=1065131						
Link							

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820737	**Name**	**Energy efficiency and rational use of energy**				
ECTS	**5**	**Year**	1	**Semester**	2	**Character**	Mandatory
Pre-requisites		none					
Objectives		Introducing energy efficiency as a viable option in the energy sector and the technological options involved in energy efficiency, with particular emphasis on the options of storing energy, energy saving in industry, the sector of real estate and housing, and existing mechanisms for its implementation.					
Learning outcomes		At the end of the course the student will be able to: • Demonstrate a good knowledge and understanding on the role of energy eficiency in global and regional contexts, and its economical, social and environmental impacts. • Demonstrate a good knowledge and understanding on the relevant international organizations, the main sources of information, and those regulations related to the energy efficiency in different sectors. • Carry out activities related to energy management in various sectors, particularly in energy efficiency related issues. • Propose transferable results - on issues affecting the energy efficiency- through the development of innovative ideas.					
Course main content		1. Introduction. Basics: Energy efficiency, efficient use of energy, demand management. 2. Assessment and Energy Audit: Energy balance, sample projects, European and local programs for promoting energy efficiency. 3. Energy Storage Techniques: Thermal Energy Storage using underground structures (UTES) phase-change materials, chemical reactions, water tanks, storage of electricity, Case Studies. 4. Energy efficiency in buildings (housing sector): Energy efficiency, solar thermal systems assets and liabilities. 5. Energy efficiency in buildings (commercial and industrial sectors): Application of the methodology of energy audit, Energy Efficiency in Electrical Systems, Energy efficiency in lighting systems, lighting, Examples. 6. Energy efficiency in industry: Demand for electricity and heat to industrial facilities, Cogeneration, parameters of efficiency cogeneration technologies. 7. Energy efficiency in transport: Rail transport and tram; Other modes of transport; 8. Efficient management of energy in different processes: Monitoring, Control.					
Methodology		Lectures, participative sessions, exercices, assignements and visits to energy facilities and companies.					
Bibliography		• World energy outlook 2011; www.iea.org/weo/ • Cibse Guide F.-Energy efficiency in buildings • Asociación para la Investigación y Diagnosis de la Energía. “Manual de Auditorias Energéticas”. Cámara de Madrid. 15 de marzo de 2006. • Generalitat de Catalunya. Institut Català d'Energia. “Gestión de la energía en la industria. Programa d’Assessorament Energètic.” 6 de mayo 2006.					
Student assessment		Exercises: 20 % Final exam: 30 % Lab work: 20 %					

	Monographic work: 30%
Contact person	Jordi Cadafalch http://directori.upc.edu/directori/dadesPersona.jsp?id=1003238
Link	

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	240SEL72	**Name**	**RENE Project**				
ECTS	**5**	**Year**	1	**Semester**	1	**Character**	RENE Specialization
Pre-requisites		none					
Prior skills		Engineering projects					
Objectives		The overall objective of the 2013 RENE Project is a pre-design and in-depth business feasibility discussion for the innovative energy conversion schemes needed in the respective sub-projects. You shall aim for a "product" that can be brought to the market, and you shall prepare your business feasibility discussion such that a business plan can naturally follow as "next step".					
Learning outcomes		After completing the RENE Project, student should be able to: • Apply a system approach in analyzing the chain for energy conversion, from primary energy source to energy services. • To use the result to carry out an environmental and economical discussion at an advanced level. • Develop and explain a need of your product or service. • Use basic models for customer, market and competitor analysis. • Develop a basic business model. • Describe, analyze and develop linkages between technical feasibility and business feasibility. • Through project-based working method, be able to take charge and carry out an innovation process concerning problem solving in complex energy conversion chains. • Effectively communicate a project in writing, as well as orally.					
Course main content		The modern society will need to drastically change its view towards a more sustainable behaviour in a global environment. It is today an accepted fact that the increased CO2 in the atmosphere results in global warming, and that a large part of the drastic increase of CO2 over the last 100 years comes from burning of fossil fuels for various energy services used in the modern society. When striving towards a sustainable energy system, the concept of heat and power generation from renewable energy resources becomes essential. To fully reach the potential of the concept, many innovations are still required. The UPC RENE Project 2013 will be about addressing some specific needs/challenges for change by working on technically sound engineering designs in combine with a thorough business feasibility discussion of the proposed product/service. Project Teams Teams of students, to form a project group (3-4 per group), should be based on students' own interest to address a common challenge. The specific expected outcomes are: • Proof of your developed "literacy" with regards to the field of renewable energy systems:					

	➢ well-investigated concept and background research involving various actors relevant to the task (problem definition – what is needed, engineering approach, critical result analysis, business scenario, etc.) ➢ well-analysed concept ➢ well-written report communicating the developed concept ➢ well performed oral presentation of the concept ➢ well displayed presentation (ppt, poster, etc) of the concept • A well organized and sufficiently detailed background analysis appropriate for each sub-project. • A complete background study of "competing concepts" already available or under development. • A thorough analysis as the basis for proposing a new concept and pre-design • A detailed market analysis including a description of potential customers, an analysis of the market, and a description (based on the background research) of competitors and competing solutions to meet the "need" of your project. • A basic pre-design.
Methodology	During the course students develop an engineering project that is evaluated by the supervisor.
Bibliography	
Student assessment	Students grading is based on the following deliverables and presentations: • Written Report on Project Work Phase I – background, objectives, methodology, principle engineering design and first feasibility results, first business feasibility discussion. 20% ○ 1st Draft ○ Oral presentation and discussion (classroom) ○ WPI Final Report • Final report: 80% ○ Oral Final Presentation ○ Final Report
Contact person	Enrique Velo http://directori.upc.edu/directori/dadesPersona.jsp?id=1002122
Link	

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	240SEL48	**Name**	**Technological Entrepreneurship**				
ECTS	**3**	**Year**	1	**Semester**	1	**Character**	RENE Specialization
Pre-requisites		Students enrolled in other courses related to Project Management, Ideas Maturation & Business Planning. This course works as an accelerator of current activities under work in MSc or MBA.					
Previous skills		Students having innovative ideas.					
Objectives		This course aims to provide students with an experience-based introduction into the process of starting a technology company. It is a real life simulation of the process that founders go through when starting a high-tech company.					
Learning outcomes		At the end of the course the student will be able to: • Develop a creative approach to problem solving. • Use basic product creation/development techniques. • Demonstrate a good knowledge and understanding on fundamentals related to business and entrepreneurship. • Develop presentations, and demonstrate leadership and team-building skills.					
Course main content		From an educational perspective, this course emphasizes problem-based learning, which requires students to be actively engaged in the learning process. Toward that end, participation in class and presentation (oral and written) of ideas are essential to success. As a student in this class (2) Economics: Lecture: RE & Clean Tech Market Review Lecture: Energy into Capitalism (Energy Economics Fundamentals) Lecture: An entrepreneur in a perfect competence world Management: Toolkit: RE & Clean Tech Challenges and Contests Reviews Toolkit: RE & Clean Tech Entrepreneurs Meetings Toolkit: Students Team Work in Process Presentations Toolkit: Un meet Need (demand) and Problem-solving approach Toolkit: Business Planning vs. Validate Learning Toolkit: Pivot vs. Iterate Toolkit: Competition vs. Cooperation Finance: Toolkit: P&L, NPV, CF, Time Value of Money Toolkit: How much money do we need?					
Methodology		Through participation in a series of exercises, students have the opportunity to discover and expand upon their innate creativity. Basic business concepts from an entrepreneurial perspective are touched upon “but this class does not cover all of the issues in sufficient detail to allow the uninitiated to start their own business” (3). Students are faced with the key issues involved in reviewing technologies, evaluating market opportunities, prototyping, designing profitable business models, producing a solid business plan, raising capital (FFF, competitions & challenges), addressing legal issues and patenting and gaining first clients.					

	Students gain the skills testing hypothesis and tools to creatively commercialize high tech research or assembling into profitable businesses. Learn to embrace and understand failure rather than fear it. Students meet some entrepreneurs that are some steps forward.
Bibliography	References: (1) http://e145.stanford.edu/syllabus (2) http://www.sedtapp.psu.edu/leadership/PDF/407syllabus.pdf (3) http://evc.sauder.ubc.ca/techventure/files/BAEN506_507_CourseSyllabusv03.pdf
Student assessment	Note that: *"Every entrepreneur faces endless challenges along the way. These problems never have one right answer, and often they have never been solved before. The only way for an entrepreneur to succeed is to view each challenge as an opportunity for a creative solution. The best entrepreneurs seek out challenges. The bigger the challenge, the bigger the opportunity! In this class we will focus on stirring up your creative juices so that you can tackle the challenges ahead" (1).* Grading Guideline: A) Business Competitions go to 100% straightforward. B) Non-competing ideas: • Personal Portfolio about 15% • Interim presentations 15% • Class Participation, Attendance 30% • Final report 40%
Contact person	Frederic Horta http://directori.upc.edu/directori/dadesPersona.jsp?id=1049352
Link	

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	240SEL44	**Name**	**New Perspectives on Material Science and Technology**				
ECTS	**4**	**Year**	1	**Semester**	2	**Character**	RENE Specialization
Pre-requisites		none					
Prior Skills							
Objectives		The course does not aim to provide specific information necessary for developing new skills or to provide a specific skill. In fact the direct objective is to relate some of the present scientific knowledge to the main ideas that collaborate to the creation of new materials and processes out of them. These are the new perspectives. This is some kind of training with the scientific risk. In order that the students can grasp this approach, they will have to do a few oral presentations of such packages of ideas and knowledge that may lead to a new material or materials, applications and industrial products. In this sense, students' work concentrates on preparing projects and defending them. Within this context, it is interesting to highlight their final assessment, titled **"High Value Opportunities for Materials and Processing Innovation as related to Energy Issues"**, where students (working as 5/6 people team) debate and choose the best materials-related option for investing 10M€ donated by the chairperson of a successful large company to R&D institutions represented by the referred teams. Attempting to narrow the window of technologies to be propelled from research laboratory into application scale, several high priority innovation areas are identified by the Course's mentor: Wave / Wind power; Solar power; Biomass / Biofuels; Hydrogen generation; Hydrogen distribution and storage; Nuclear power; Thermoelectric materials; Natural gas – Gas turbine; Electric car – energy storage devices; and Fuel cells.					
Learning outcomes							
Course main content		Lectures: 1. Revision to some aspects of the structure of matter: Basic elements. Two states of matter: order and disorder. The perfect gas. Crystals. Crystalline solids. Liquids. Non-crystalline solids. Between order and disorder. Composite materials, suspensions and colloidal solutions. 2. Challenges and perspectives: Photonic Materials. Materials for Information Storage. Smart Materials. Materials for Clean Energy. The New Polymers. Surfaces, Interfaces and Nanotechnology. Invited Speakers: This part of the course consists in attending specific talks, given by specialists and experts in the different fields of interest of the course that will present relevant aspects related to the different materials and their characterization. These talks are meant to provide a deeper insight into particular aspects of the challenging areas that are presented in the lectures.					
Methodology		Course is distributed on three well-defined activities: Introduction and brief review of Materials Science and Technology (review lectures by Course's responsible) – 25%; Invited seminars by specialized speakers – 45%; Oral presentations by students – 30%. All the activities will take place in a conventional lecture room. Both the lectures and the invited talks will take place in a conventional way in a lecture room. The presentations are meant to include discussion and the students will be asked to participate in it. The invited lectures will be more formal and it is expected that discussion with every speaker will take					

	place after the presentation. This is a great opportunity for the students to grasp aspects such as development and innovation in the field of Materials Science and Technology. The practical aspect of the course looks for the work in group of the students around the preparation of a subject, the writing of a report and its presentation and defence. In fact what is being looked for is their ability to choose and defend a new technology and its application in industry, including the economical, social and environmental assessment.
Bibliography	
Student assessment	The students will be evaluated by means of a written exam, the report that they will write and the evaluation of their public presentation.
Contact person	Luis Llanes http://directori.upc.edu/directori/dadesPersona.jsp?id=1002332
Link	

Partner University		**Universitat Politècnica de Catalunya · BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	240SEL057	**Name**	**Oral and written communication**				
ECTS	**3**	**Year**	1	**Semester**	2	**Character**	RENE Specialization *
Pre-requisites		none					
Prior Skills		English level: B2					
Objectives		This course aims to familiarize students with the characteristics and peculiarities of technical written communication and to enable them to write documents of different academic and professional genres. Students should learn to communicate in writing in an efficient way.					
Learning outcomes		At the end of the course the student will be able to: • Recognize and distinguish different/ common aspects in technical documents that are addressed to different audiences and written for different purposes (such aspects as tone, style, level of detail and level of technicality in terminology, etc); • Organize, structure and develop information according to the most usual patterns of information organisation in scientific and technical discourse; use connecting expressions that make documents coherent and write documents that are properly punctuated, grammatically correct, and stylistically appropriate; • Write Curriculum Vitae, different formal letters, and reports; • Apply the general guidelines on technical written communication and be able to autonomously continue with their learning by means of several electronic resources.					
Course main content		Part I. Introduction to technical writing 1. What is technical writing? Part II. The Writing process 2. Pre-writing stage 3. Writing stage 4. Post-writing stage PART III. Documents 5. Types of documents					
Methodology		The course focuses on speaking and writing skills and activities are an integral part of the course, including delivering an oral presentation (product –process description), attending meetings, and memo and report writing. Preparation for these activities will require becoming familiar with different degrees of style (formal-informal) and tone, revising some grammatical aspects or practising vocabulary related to meetings (e.g. agreeing-disagreeing), for example. Students will also carry out some teamwork tasks. The course will be based upon a combination of the following three methodologies: • Practical lessons where the teacher starts explaining different aspects and then students do some practice tasks and solve communication problems (Problem-Solving approach). • Individually or in pairs students carry out tasks to practise the aspects covered in every module. • Case Method: reading a case. Students solve communicative problems arising from the case. Different situations will require different types of communication.					
Bibliography							
Student assessment		Individual Work 90% • Work done in the classroom: 5% • Test 1: 15%					

	• Test 2: 15% • Final exam: 55% Working Group: 10% • Project: 10%
Contact person	Marta Aguilar - http://directori.upc.edu/directori/dadesPersona.jsp?id=1000637
Link	

*Mandatory except for students from USA, Canada, UK, Ireland, Australia or New Zealand.

Partner University		**Universitat Politècnica de Catalunya - BarcelonaTech**					
Degree		MSc Renewable Energy					
Code	820739	**Name**	**Wind Power**				
ECTS	**5**	**Year**	2	**Semester**	1	**Character**	Elective
Pre-requisites		Basic Electrical and Mechanical Engineering. Electrical Circuit Analysis					
Objectives		The course aims on providing the knowledge and the tools needed to understand and analyze wind power generation systems. During the course steady state and dynamic analysis of wind turbines and wind power plants are performed.					
Learning outcomes		At the end of the course the student will be able to: • Understand the principles of electrical generation with wind turbines • Determine the steady state conditions of a given wind power generation system • Analyze the dynamic behaviour of wind turbines • Understand how wind turbines can be aggregated in wind power plants • Size and pre-design wind turbines and wind power plants					
Course main content		1. Introduction to wind energy 2. The wind resource PC laboratory. Activity 1 3. Principles and components of wind turbines PC laboratory. Activity 1 4. Fix-speed wind turbines PC laboratory. Activity 2. 5. Variable speed wind turbines PC laboratory. Activity 3 6. Wind power plants PC laboratory. Activity 4.					

Methodology

Theory classes, Simulation practices, Project assignment to be developed at home.

Student workload (hours)

Lectures	14	Tutoring sessions	14
Practical sessions	12	Homework assignments	15
Laboratory	5	Projects	10
Presentations	0	Autonomous Study	55
		TOTAL	125

Activity	Description
1. Power curve and energy extraction	For a given location and known wind resource information, and considering a given wind turbine with a known power curve, the activity will develop an energy extraction analysis also considering the influence of different parameters.
2. Steady-state and dynamic analysis of a fix-speed wind turbine	A given fix-speed wind turbine will be analyzed in steady-state and with dynamic simulations.
3. Steady-state and dynamic analysis of a variable speed wind turbine	A given variable speed wind turbine will be analyzed in steady-state and with dynamic simulations.
4. Wind power plant planning	A simplified planning of an offshore wind power plant will be conducted.

Bibliography	• Wind Turbine Operation in Electric Power Systems: Advanced Modeling, Zbigniew

	Lubosny, Springer Verlag, 2003. • Wind Power in Power Systems, Thomas Ackermann (Editor), Wiley, 2005. • Wind Turbine Control Systems: Principles, Modelling and Gain Scheduling Design, F. Bianchi et al., Springer 2007. • Wind Turbines, E. Hau, Springer 2006. • Wind energy generation: Modelling and Control, O. Anaya-Lara, N. Jenkins, J. Ekanayake, P. Cartwright, M. Hughes, John Wiley and Sons, 2009. • Embedded Generation, N. Jenkins, R. Allan, P. Crossley, D. Kirschen and G. Strbac., The Institution of Electrical Engineers, 2000.
Student assessment	Written exam (final exam) 50% Activity 1: 10% Activity 2: 10% Activity 3: 10% Activity 4: 10% Oral presentation 10%
Contact person	Oriol Gomis http://directori.upc.edu/directori/dadesPersona.jsp?id=1004465
Link	

Partner University		**Universitat Politècnica de Catalunya - BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820740	**Name**	**Solar Photovoltaics**				
ECTS	**5**	**Year**	2	**Semester**	1	**Character**	Elective
Pre-requisites		none					
Previous skills		Electrical Engineering Fundamentals					
Objectives		This course aims to provide an introduction to the study of electricity generated using photovoltaic technology The different system components (modules or panels, power converters, energy storage, charge controller, loads, etc.) and some aspects of the analysis and design are considered. Some of the two most important applications using solar energy: stand alone and greed connected PV systems are studied.					
Learning outcomes		At the end of the course the student will be able to: • Demonstrate a good knowledge and understanding on the role of solar energy in the context of regional and global energy systems, it's economic, social and environmental impacts, as well as the impact of technology on a local and global context. • Demonstrate a good knowledge and understanding on the basic concepts of solar radiation, the electrical principles and main parameters of PV device. • Demonstrate a good knowledge and understanding on the most important characteristics of the elements within a PV system besides panels: battery, battery charge controller, DC/DC converter, D C/AC converter (inverter) and loads. • Demonstrate a good knowledge and understanding on relevant organizations, the main projects in the international field, the main sources of information and the regulations related to solar photovoltaic technology. • Demonstrate a good knowledge and understanding on some practical applications using solar PV systems: analyze, design (sizing) of a stand-alone PV system and the energy produced by a Grid-Connected Photovoltaic Systems (GCPVS). • Analyze the behavior of a system for energy self-consumption and production with demand-side management and grid metering. • Carry out a project, at basic engineering scale, related to the power supply using solar photovoltaic technology. • Demonstrate a good knowledge and understanding on advanced concepts in photovoltaic conversion and be able to propose-transferable results in implementing solar photovoltaic technology by developing new ideas.					
Course main content		1. Introduction to Solar Photovoltaic Energy 2. Solar Radiation 3. Photovoltaic Systems 4. Analysis, sizing and maintenance of a photovoltaic system					
Methodology		Lectures, participative sessions, exercices, assignements and lab sessions. Student workload (hours)					

Lectures	32	Tutoring sessions	15
Practical sessions	15	Homework assignments	20
Laboratory	0	Projects	30
Presentations	0	Autonomous Study	13
		TOTAL	125

Bibliography	Deutsche Gesellschaft filr sonnenenergie, Planning & Installing Photovoltaic Systems, A guide for installers, architects and engineers: First published by Earthscan in the UK and USA in 2008, First edition published in 2005, reprinted 2006, Copyright © The German Energy Society (Deutsche Gesellshaft fur Sonnenenergie (DGS LV Berlin BRB), 2008.
Student assessment	Written exam 60% Class and lab Work 35% Attendance 5%
Contact person	Rafael Martin Lamaison http://directori.upc.edu/directori/dadesPersona.jsp?id=1002064
Link	

Partner University		**Universitat Politècnica de Catalunya - BarcelonaTech**					
Degree		MSc Renewable Energy					
Code	820743	**Name**	**Photovoltaic Devices**				
ECTS	**5**	**Year**	2	**Semester**	1	**Character**	Elective
Pre-requisites		Solar photovoltaics					
Prior Skills		Basic knowledge on power electronics.					
Objectives		This course aims to provide an introduction to photovoltaic solar cells. Course contents cover from conventional crystalline structures to thin film technologies. Advanced concepts in photovoltaic conversion are also introduced.					
Learning outcomes		At the end of the course the student will be able to: • Demonstrate a good knowledge and understanding on the operation of photovoltaic solar cells, from the most basic aspects of semiconductor device to the final finish. • Demonstrate a good knowledge and understanding on advanced concepts in photovoltaic conversion. • Propose alternative technologies that would result in the manufacture of photovoltaic devices more efficient.					
Course main content		1. Introduction 2. Properties of sunlight 3. PN Junctions and solar cell operation 4. Crystalline solar cells 5. Thin film solar cells 6. Solar cell characterization 7. New Concepts in photovoltaic conversion.					
Methodology		Lectures, participative sessions, exercises, assignments, and presentations. Student workload (hours) Lectures 30 | Tutoring sessions 5 Practical sessions 20 | Homework assignments 35 Laboratory - | Projects - Presentations 5 | Autonomous Study 30 TOTAL 125					
Bibliography		• Green, M.A. Solar cells: operating principles, technology and system applications. Prentice Hall, 1981. ISBN 0138222703. • Markvart, T.; Castañer, L. (eds.). Practical handbook photovoltaics: fundamentals and applications. Oxford: Elsevier, 2003. ISBN 1856173909.					
Student assessment		Exam 50% Work done individually or in groups during the course 40% Attendance and participation in classes and laboratories 5% Quality and performance of the work group 5%					
Contact person		Joaquim Puigdollers http://directori.upc.edu/directori/dadesPersona.jsp?id=1002739					
Link							

Partner University		**Universitat Politècnica de Catalunya - BarcelonaTech**					
Degree		MSc Renewable Energy					
Code	820744	**Name**	**Solar Thermal Energy**				
ECTS	**5**	**Year**	2	**Semester**	1	**Character**	Elective
Pre-requisites		none					
Prior skills		A good knowledge on the fundamental aspects of thermodynamics, fluid mechanics and heat transfer necessary needed for understanding the solar thermal systems.					
Objectives		• Introduce the heat transfer phenomena present in solar thermal systems and equipment. • Study the materials used in solar thermal applications such as selective treatments, accumulating materials for phase change, transparent insulating surfaces, etc.. • Study the different methodologies that allow the design and calculation of solar thermal systems and equipment. • Performing different practical work for testing solar collectors and solar thermal systems to heat-UPC CTTC. • Study different applications of solar energy.					
Learning outcomes		At the end of the course the student will be able to: • Demonstrate a good knowledge and understanding on the role of solar energy in the context of regional and global energy systems, it's economic, social and environmental impacts, as well as the impact of technology on a local and global context. • Demonstrate a good knowledge and understanding on the basic concepts of solar radiation, the principles and main parameters of solar thermal devices. • Demonstrate a good knowledge and understanding on relevant organizations, the main projects in the international field, the main sources of information and the regulations related to solar thermal technology. • Carry out a project, at basic engineering scale, related to energy supply using solar thermal technology. • Demonstrate a good knowledge and understanding on advanced concepts in solar thermal technologies and be able to propose-transferable results in implementing solar thermal technologies by developing new ideas.					
Course main content		1. Introduction. Basics of solar radiation and solar energy availability. Estimation of the available solar radiation. 2. Materials used in the feedback systems. Opaque and transparent surfaces. Selective surfaces and transparent insulation materials. 3. Low, medium and high temperature solar thermal systems (solar collectors). Principles of operation. Study of the mechanisms of heat transfer. Performance of the collecting field. Testing of a solar collector. 4. Thermal energy storage systems for low, medium and high temperature. Thermal stratification and its influence on the performance of an installation. Testing thermal energy storage systems. Modeling of thermal storage systems. 5. Low, medium and high temperature facilities. Solar thermal plants. Applications of solar energy: i) domestic and industrial systems for hot water and heating; ii) solar thermal installations. Dimensioning and simulation of Solar thermal facilities.					
Methodology		Lectures, participative sessions, exercices, assignements and lab sessions.					

<table>
<tr><td></td><td>Student workload (hours)
<table>
<tr><td>Lectures</td><td>15</td><td>Tutoring sessions</td><td>15</td></tr>
<tr><td>Practical sessions</td><td>15</td><td>Homework assignments</td><td>30</td></tr>
<tr><td>Laboratory</td><td>0</td><td>Projects</td><td>20</td></tr>
<tr><td>Presentations</td><td>0</td><td>Autonomous Study</td><td>30</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>125</td></tr>
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<tr><td>Bibliography</td><td>

J.A. Duffie, W.A. Beckman, Solar Engineering of Thermal Processes, John Wiley & Sons; 3rd Edition edition (8 Sep 2006)
Soteris A. Kalogirou. Solar Energy Engineering: Processes and Systems. Academic Press Ed. 2009.
G.N. Tiwari, Solar Energy: technology advances. Nova Science Publishers, Inc. 2006.
W. Vogel and H. Kalb. Large-scale solar thermal power. Wiley-VCH Verlag GmbH& Co. kGaA., 2011.
G.Alefeld, R.Radermacher, Heat Conversion Systems, CRC Press, Boca Raton, 1994.
K.E. Herold, R. Radermacher, S.A. Klein. Absorption Chillers and Heat Pumps, CRC Press, 1996.

</td></tr>
<tr><td>Student assessment</td><td>Exam 50%
Work done individually or in groups during the course 40%
Attendance and participation in classes and laboratories 5%
Quality and performance of the work group 5%</td></tr>
<tr><td>Contact person</td><td>Ivette Rodríguez http://directori.upc.edu/directori/dadesPersona.jsp?id=1004330</td></tr>
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Partner University		**Universitat Politècnica de Catalunya - BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820747	**Name**	**Integration of Renewable Energy Systems to the Grid**				
ECTS	**5**	**Year**	2	**Semester**	1	**Character**	Elective
Pre-requisites		none					
Prior skills		Basic Electric and Mechanical Engineering Electrical Circuit Analysis					
Objectives		The course focuses on providing the knowledge and the tools needed to understand and analyze the interaction between renewable energies and power systems. Specific objectives include covering the following topics: • Analysis of power systems with a high penetration of renewable systems. • Grid integration of renewable systems. • Smart grids • Grid codes • Isolated and connected Microgrids • HVDC Supergrids for offshore wind • The role of energy storage and demand side management					
Learning outcomes		At the end of the course the student will be able to: • Demonstrate a good knowledge and understanding on how power systems interact with renewable energy systems • Analyze power systems with a high penetration of renewables • Demonstrate a good knowledge and understanding on how renewable energies can be efficiently integrated in power systems • Demonstrate a good knowledge and understanding on the smart grid concept and the relevance of renewable energies in it • Analyze and design microgrids • Analyze and design supergrids for offshore wind power					
Course main content		1. Introduction 2. Analysis of power systems with renewable energy 3. Grid support 4. Supergrids 5. Microgrids					
Methodology		Theory classes, Simulation practices, Project assignment to be developed at home.					

Student workload (hours)

Lectures	6	Tutoring sessions	15
Practical sessions	20	Homework assignments	20
Laboratory	4	Projects	30
Presentations	0	Autonomous Study	20
		TOTAL	125

Activity	Description
1. Grid support	Simulations on grid support from renewables will be performed.

	2. Supergrids analysis	A given power system of a Supergrid will be analyzed using standard tools for power system power flow analysis. Several offshore wind power plants will be included and analyzed.
	Project	After discussion with the instructor, a project will be assigned and developed by the students with appropriate tutoring.
Bibliography	• Renewable energy in power systems, L. L. Freris, D.Infield, John Wiley and Sons, 2008 • Embedded Generation, N. Jenkins, R. Allan, P. Crossley, D. Kirschen and G. Strbac., The Institution of Electrical Engineers, 2000 • Wind Turbine Operation in Electric Power Systems: Advanced Modeling, Zbigniew Lubosny, Springer Verlag, 2003 • Wind Power in Power Systems, Thomas Ackermann (Editor), Wiley, 2005 • Wind energy generation: Modelling and Control, O. Anaya-Lara, N. Jenkins, J. Ekanayake, P. Cartwright, M. Hughes, John Wiley and Sons, 2009 • Grid Converters for Photovoltaic and Wind Power Systems, R. Teodorescu, M. Liserre, P. Rodriguez, F. Blaabjerg, John Wiley and Sons, 2011	
Student assessment	Written exam 50% Activity 1 15% Activity 2 15% Project 20%	
Contact person	Oriol Gomis-http://directori.upc.edu/directori/dadesPersona.jsp?id=1004465	
Link		

Partner University		**Universitat Politècnica de Catalunya - BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820748	**Name**	**Hydrogen and Fuel Cells**				
ECTS	**5**	**Year**	2	**Semester**	1	**Character**	Elective
Pre-requisites							
Prior Skills		Basic knowledge in chemistry and physics					

Objectives

This course aims to:

- Train students in the development of technical criteria to define an energy system, which involves a fuel cell from chemical data, biological catalysis, materials, heat transfer and flow of matter and energy.
- Provide students the skills to analyze any kind of scientific and technological method of obtaining and handling hydrogen for use in fuel cells and express rules for its implementation, optimization and / or modification.
- Provide students the skills to identify the problems and deficiencies of energy installations and electrical devices and be able to provide engineering solutions.
- Instil in students the cientific spirit to investigate new developments in the field of hydrogen and fuel cell vector.

Learning outcomes

At the end of the course the student will be able to:

- Demonstrate a good knowledge and understanding on the role of hydrogen as an energy vector in the context of global and regional energy system as well as its connotations and impact economic, social and environmental.
- Demonstrate a good knowledge and understanding on the main sources of information, current projects and future challenges related to the processes of obtaining hydrogen and different types of fuel cells.
- Demonstrate a good knowledge and understanding on the applications of hydrogen and fuel cells in stationary environments (buildings), mobile (transportation) and laptops (electronic devices).
- Perform a basic scale engineering project related to energy system for producing hydrogen and / or fuel.

Course main content

1. Hydrogen production technologies
2. Storage and transport of hydrogen
3. Fuel Cells

Methodology

Lectures, participative sessions, exercices, and assignements.

Student workload (hours)

Lectures	15	Tutoring sessions	15
Practical sessions	15	Homework assignments	0
Laboratory	0	Projects	50
Presentations	0	Autonomous Study	30
		TOTAL	125

Bibliography

- J. Llorca “El hidrógeno y nuestro futuro energético”. Ed. UPC, 2010.
- R.L. Busby “Hydrogen and Fuel Cells. A comprehensive guide”. PennWell, 2005.
- CLEFS CEA nº 50/51 “L’hydrogène, les nouvelles technologies de l’énergie”, 2004.
- P. Hoffmann “Tomorrow's Energy: Hydrogen, Fuel Cells, and the Prospects for a Cleaner

	Planet". MIT Press, 2001.
Student assessment	Exam 50% Assignments 50%
Contact person	Jordi Llorca http://directori.upc.edu/directori/dadesPersona.jsp?id=1049344
Link	

Partner University		**Universitat Politècnica de Catalunya - BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820750	**Name**	**Power Electronics applied to distributed Energy Resources**				
ECTS	**5**	**Year**	2	**Semester**	1	**Character**	Elective
Pre-requisites		none					
Prior Skills							
Objectives		This course aims to examine the techniques of power electronics and control systems based on microprocessors. These techniques focus on speed and torque control of electrical machines, as well as in the control of power flow in an electrical grid.					
Learning outcomes		At the end of the course the student will be able to: • Modelling and simulating a static converter. • Designing and using a commercial converter. • Apply a converter to the DER (Distributed Energy Resources). • Apply a converter against the grid (Active Front Ends and FACTS).					
Course main content		1. Fundamentals of static converters 2. Generation of sinusoidal waves (PWM) 3. Intensity loops: constant frequency, quasi constant and variable 4. Applications: solar and wind converters, and active filters					
Methodology		Lectures, participative sessions, exercices, and assignements. Student workload (hours)					

Lectures	20	Tutoring sessions	15
Practical sessions	10	Homework assignments	30
Laboratory	0	Projects	20
Presentations	0	Autonomous Study	30
		TOTAL	125

Bibliography		• Mohan, N., Undeland, T., Robbins, WP., Power Electronics: Converters, Applications and Design. John Wiley & Sons Inc., New York, 1989. ISBN 0471580488 • Philip T. Krein, Elements of Power Electronics. Oxford University Press, Copyright September 1997, ISBN13: 9780195117011 ISBN10: 0195117018					
Student assessment		Exam 50% Assignments 50%					
Contact person		Joan Bergas http://directori.upc.edu/directori/dadesPersona.jsp?id=1002645					
Link							

Partner University		**Universitat Politècnica de Catalunya – BarcelonaTech**					
Degree		MSc Renewable Energy					
Code	820755	**Name**	**Smart Grids**				
ECTS	**5**	**Year**	2	**Semester**	1	**Character**	Elective
Pre-requisites							
Prior Skills	Electrical engineering fundamentals						
Objectives	This courses aims to introduce students to smart grids and to the utilization of tools for calculating basic grids: nodal analysis and load flow.						
Learning outcomes	At the end of the course the student will be able to: • Analyze grids in steady state by using the MNA method (Modified Nodal Analysis). • Analyze grids in steady state by using the load flow method. • Analyze and use the common electro optimization mechanisms: regulation of voltage, active and reactive power flows. • Choose and implement mechanisms for managing grid energy flow.						
Course main content	1. Hardware of transmission & distribution systems 2. Smart Grid Technical Systems						
Methodology	Lectures, participative sessions, exercices, and assignements. Student workload (hours)						

Lectures	20	Tutoring sessions	0
Practical sessions	10	Homework assignments	65
Laboratory	0	Projects	0
Presentations	0	Autonomous Study	30
		TOTAL	125

Bibliography	• Zhang, Xiao-Ping *Flexible AC transmission systems: modelling and control* Springer 2006. • Arthur R. Bergen *Power systems analysis* Prentice-Hall 2000. • Narain G. Hingorani, Laszlo Gyugyi *Understanding facts: concepts and technology of flexible AC transmission systems* IEEE Press 2000.
Student assessment	Exam 50% Assignments 50%
Contact person	Joan Rull http://directori.upc.edu/directori/dadesPersona.jsp?id=1000431
Link	

Partner University		**Universitat Politècnica de Catalunya - BarcelonaTech**					
Degree		MSc Energy Engineering					
Code	820757	**Name**	**Computational Methods in Energy Technology**				
ECTS	**5**	**Year**	2	**Semester**	1	**Character**	Elective
Pre-requisites							
Prior Skills	A good knowledge on fluid dynamics and heat and mass transfer, as well programming skills.						
Objectives	This course aims students: • Acquiring a basic training in solving numerically the governing equations of fluid dynamics and heat and mass transfer phenomena. • Acquiring a first practical experience in programming, verification and validation of CFD codes & HT (Computational Fluid Dynamics and Heat Transfer). • Become familiar with the use of CFD codes & HT and acquire the ability to judge critically the quality (verification and validation of numerical solutions of mathematical formulations used).						
Learning outcomes	At the end of the course the student will be able to: • Consolidate the basic mathematical formulations of fluid dynamics phenomena and heat and mass transfer. • Demonstrate a good knowledge and understanding on different methods of numerical integration of the Navier-Stokes equations. • Apply RANS, LES and DNS methods to the resolution of turbulent flows. • Apply code verification techniques, and verification and validation techniques for numerical solutions of mathematical formulations.						
Course main content	1. Introduction to numerical methods used in fluid dynamics and heat and mass transfer phenomena. 2. Solving the conduction heat transfer equation in irregular domains. Permanent and transient analysis. 3. Solving convection-diffusion type equations. 4. Techniques for codes verification and numerical solution verification and review of the most appropriate solvers. 5. Solving the Navier-Stokes equation.						
Methodology	Lectures, participative sessions, exercices, and assignements. Student workload (hours)						

Lectures	15	Tutoring sessions	12
Practical sessions	15	Homework assignments	20
Laboratory	3	Projects	30
Presentations	0	Autonomous Study	30
		TOTAL	125

Bibliography	• Incropera, F. P.; DeWitt, D. P. Fundamentos de transferencia de calor. 4ª ed. México: Prentice Hall, 1999 • Eckert, E. R. G.; Drake, R. M. Heat and mass transfer. 2nd ed. New York: McGraw-Hill, 1959. • Patankar, S. V. Numerical heat transfer and fluid flow. New York: McGraw-Hill, 1980. • J.H.Ferziger, M.Peric, Computational Methods for Fluid Dynamics, Springer, 2001 (3r

	ed.). • H.K.Versteeg and W.Malalasekera, An introduction to Computational Fluid Dynamics, Pearson Prentice Hall, 1995 • John D. Anderson, Jr, Computational Fluid Dynamics, McGraw-Hill, Inc, 1995. • Patrick J. Roache, Fundamentals of Computational Fluid Dynamics, Hermosa Publishers, 1998. • Cebeci, T. [et al.]. Computational fluid dynamics for engineers: from panel to Navier-Stokes methods with computer programs. New York: Springer, 2005.
Student assessment	Exam 30% Assignments: 60% Attendance: 5% Quality and performance of the team work 5%
Contact person	Oriol Lehmkuhl Barba http://directori.upc.edu/directori/dadesPersona.jsp?id=1078527
Link	

Partner University		**Universitat Politècnica de Catalunya - BarcelonaTech**					
Degree		MSc Renewable Energy					
Code	820763	**Name**	**Thermal and Thermochemical Energy Storage**				
ECTS	**5**	**Year**	2	**Semester**	1	**Character**	Elective
Pre-requisites		none					
Prior Skills		The general aspects of thermodynamics, fluid mechanics and heat and mass transfer.					
Objectives		The course aims to describe the new energy paradigm of distributed generation, where the thermal/thermochemical energy storage plays an important role in decoupling power generation and energy consumption. The course also aims to give a detailed description of most of the technologies that are used in thermal and thermochemical energy storage such as thermal energy storage tanks for sensitive and/or latent heat, fuel cells and adsorption and absorption refrigeration systems.					
Learning outcomes		At the end of the course the student will be able to: • Demonstrate a good knowledge and understanding on systems and technologies. • Demonstrate a good knowledge and understanding on environmental issues. • Demonstrate a good knowledge and understanding on materials used in thermochemical and thermal energy storage equipment. • Demonstrate a good knowledge and understanding on issues related to the design, evaluation, selection and implementation of chemical and thermal storage systems. • Demonstrate a good knowledge and understanding on fuel cells, types of cells and its technological development. • Demonstrate a good knowledge and understanding on electrochemical energy storage and production and storage of hydrogen as an energy vector.					
Course main content		1. Energetic audits: energy, Exergy and other performance indicators. Use of the accumulation of energy and heat pumps. Distributed energy generation and storage systems: co-generation, thermal cycles and cold and hot networks. 2. Accumulation of thermal energy by sensitive heat. Active and passive systems. Main ways for accumulation. Importance of thermal stratification. Strategies to intensify thermal stratification. Quantification of thermal stratification: methods based on energy and exergy balances. Modelling of the accumulation system. 3. Accumulation of thermal energy by latent heat. Selection of materials of phase change according to the application. Typology of the systems of accumulation by phase change. Modelling of phase change systems. 4. Accumulation systems in solar-thermal plants. Importance of energy accumulation in solar-thermal plants. Typology of main utilized systems. Main storage means: advantages and disadvantages. Integration of the accumulation system in the solar-thermal plant. Cost of the accumulation system 5. Accumulation of thermochemical energy. Operation principles. Reactive couples. Applications: energy storage in buildings, cooling by absorption. Actual developments. Technological aspects. 6. Accumulation of thermochemical energy. Fuel cells: theoretical fundamentals. Operational fuel batteries. Technological development of different types of batteries. 7. Hydrogen as energetic vector. Gathering and storage of hydrogen. Processing of used fuels in the different types batteries. Conventional and non-conventional methods.					
Methodology		Lectures, participative sessions, exercices, and assignements.					

<table>
<tr><td></td><td>Student workload (hours)
<table>
<tr><td>Lectures</td><td>20</td><td>Tutoring sessions</td><td>5</td></tr>
<tr><td>Practical sessions</td><td>20</td><td>Homework assignments</td><td>15</td></tr>
<tr><td>Laboratory</td><td>5</td><td>Projects</td><td>30</td></tr>
<tr><td>Presentations</td><td>0</td><td>Autonomous Study</td><td>30</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>125</td></tr>
</table></td></tr>
<tr><td>Bibliography</td><td>

S. Doty and W.C. Turner, Energy Management Handbook, 7th edition.
D.Y. Goswami and F. Kreith, Energy Conversion, CRC Press, 2007.
Eastop, T. D. and Croft, D. R., Energy Efficiency for Engineers and Technologists, Longman, 1990.
Winter, C. J., Sizmann, R. L.. and Vant-Hull, L. L., Solar Power Plants, Springer-Verlag, 1990.
Thermal Energy Storage Systems and Applications, edited by I. Dincer, and M. A. Rosen, John Wiley & Sons, UK, 2002.
Herold, K. E., Radermacher, R. and Klein, S. A. Absorption chillers and heat pumps, CRC press, 1996.
W. Vielstich. Cèlulas de Combustión. Ediciones Urmo, 1973.
Karl Kordesch and Gunter Simader, Fuel Cells and their applications.

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<tr><td>Student assessment</td><td>Exam 50%
Assignments: 40%
Attendance: 5%
Quality and performance of the team work 5%</td></tr>
<tr><td>Contact person</td><td>Ivette Rodríguez http://directori.upc.edu/directori/dadesPersona.jsp?id=1004330
Yolanda Calventus http://directori.upc.edu/directori/dadesPersona.jsp?id=1002575</td></tr>
<tr><td>Link</td><td></td></tr>
</table>

Master Thesis rules at UPC

Objectives and Scope

The Master Thesis is an individual work where the student must apply and integrate the knowledge and skills acquired throughout the programme. The work should allow a comprehensive assessment of students' professional skills and scientific and technological training, as a prerequisite to achieve the degree MSc in Energy Engineering.

The student under the supervision of a thesis director shall make a written report that reflects the objectives, the methodology, results obtained and conclusions.

Requirements

- The registration is performed at the master secretariat prior to the public defence of the thesis.
- Each thesis shall have a director, who advises and supervises the student.
- To submit the thesis for examination the authorization of the thesis director is required.
- The examination is done by a evaluation committee during a public defence.
- For the defence of the master thesis is necessary that the student has passed all the master courses.
- If the student chooses a specialisation, the master thesis should be related to the area of specialization.

The thesis work must be submitted to the master Secretariat, during the period scheduled at the beginning of each academic year. The student must deliver the following documentation:

- A paper copy of the thesis work in A4 format. This copy should also include the presentation acceptance form signed by the thesis director and the evaluation minutes form (all these forms are available in the Master website).
- A CD / DVD with all the thesis documents in PDF format (in one or several documents). The cover shall include at least the author, director and title.
- The External Director's Report, if applicable.

Examination

The student must present his work during a public defence for a maximum of 40 minutes. Evaluation committee members can make questions and comments to the student. After that, the evaluation committee delivers about the thesis grade. The secretary of the committee completes the examination minutes with the evaluation results. These minutes, which are signed by all committee members and a copy of the thesis work, are delivered to the master secretariat.

Grades are the same than for other UPC courses (0 to 10, where below 5 is not-passed and 10 is an excellent work).

Evaluation committee

The evaluation committees are appointed by the Master Coordinator.

The evaluation committee is composed by three lecturers amongst those of the departments and institutes participating in the master degree, with the possible participation of an external member of the collaborating institutions.