Boosting Environmental Protection and Energy Efficient Buildings in Mediterranean Region

PROEMED

ERASMUS+ PROJECT : 573677-EPP-1-2016-1-IT-EPPKA2-CBHE-JP

Programme Handbook
Energy Efficient Buildings

MASTER DEGREE PROGRAM

University of Mostaganem – Algeria

Contents

General description

This Master degree is developped in the framework of PROEMED which is the acronym of the project having title «***BOOSTING ENVIRONMENTAL PROTECTION AND ENERGY EFFICIENT BUILDINGS IN MEDITERRANEAN REGION***». The project, having code 573677-EPP-1-2016-1-IT-EPPKA2-CBHE-JP, is promoted by the European Commission Agency EACEA in the scheme of the Erasmus+ CBHE ("Capacity Building in Higher Education") programme.

Study programme

Master in Energy Efficient Buildings

This Master is a professional and applied programme, related to specific employment opportunities

Type of degree & duration

Master degree (120 redits, 2 years).

Institutions

University: University abdelhamid Ibn Badis - Mostaganem

Faculties involved in the project :

- Faculty of Exact Scinces and computer Science
- Faculty of Sciences and Technlogy

Departement :

- Civil Engineering and Architecture

Partners

- **National Partners :**
  - University Abou BakrBelkaid- Tlemcen
  - Institut Mediterraneen de Technologie Oran-
  - Chambre Algerienne de Commerce et d'Industrie (Associated Partner)
- **International Partners**:
  - University of Genoa – Italy
  - University of Sousse – Tunisia
  - University Euromediterraneenne of Fes – Morocco
  - University of Gabes – Tunisia
  - University Cadi Ayyad Marrakech – Morocco

- Agora Institute For Knowledge Management & Development – Spain
- Szkola Glowna Gospodarstwa Wiejskiego Warszawa -Poland
- University of La Rochelle – France
- Tecnologie Innovative Per Il Controllo Ambientale E Lo Sviluppo Sostenibile - Italy
- Horizons pour le Developpement Local Jendouba – Tunisia
- Centre de Développement de la Region de Tensift – Morocco
- Chambre De Commerce Et D Industrie Du Centre– Tunisia (Associated Partner)
- Conféderation Générale des Enterprises du Maroc (Associated Partner)

Context and objectives of the training

Conditions of access

This master is accessible to students with a bachelor's degree in:

- Civil Engineering.
- Mechanical Engineering.
- Thermal Sciences.
- Architecture.

Purposes

The overall purpose of this programme is to prepare graduates with a strong background in energy efficiency and able to conceive, design, implement and operate energy efficient buildings, contributing to the improvement of the life quality and to the energy development sustainability.

Motivation and targeted profiles

Jobs for employment related to energy efficiency will emerge especially after the increase in the price of energy in Algeria and the government's intention to target the subsidy to certain categories of the population. This would require the construction of houses according to standards with good energy efficiency. It will therefore require skills capable of proposing solutions for the improvement of building envelopes that consume a minimum of energy and even produce its own energy. Design offices and energy service companies are at the forefront of recruiting these profiles.

Educational needs of the labour market

In order to identify the educational needs of the labour market, a survey by questionnaire was carried out among organizations involved at different levels in the field of energy efficient buildings.

The Master graduates in Energy Efficient Buildings are requested to have:

Specific skills

- ✓ Strong background in thermodynamics / heat transfer.
- ✓ Skills in material science.
- ✓ Background about energy savings in buildings.
- ✓ Skills in the field of renewable energy.
- ✓ Skills regarding energy auditing of buildings.
- ✓ Skills in the field of thermo-economic analysis.

Soft skills

- ✓ Good with computing.
- ✓ Communication skills.
- ✓ Ability to work in tea.m

Educational objectives

The Main aim of the Master is to prepare graduates with a strong background in energy efficiency and able to conceive, design, implement and operate energy efficient buildings.
In order to enable graduates to achieve this aim, students should develop and obtain a set of competencies such as :

- ✓ ability to apply knowledge and understanding of engineering disciplines underlying Energy Efficient Buildings : Heat transfer, Thermodynamics, Thermal Measurements, Renewable Energy Systems.
- ✓ ability to analyse and solve complex problems, to design complex products (devices, artefacts, etc.), processes and systems, to investigate complex issues, in the Energy Efficient Buildings : HVAC Systems, Heat Pumps and Refrigeration Systems, Renewable Energy Systems, Thermal Design and Optimization.
- ✓ ability to implement and conduct complex activities using and applying practical knowledge, by identifying both societal, health and safety, environmental impact and risks and economic, industrial and managerial implications, taking appropriate decisions, and to meet deliverable, schedule and budget requirements, while fulfilling all legal and regulatory requirements.

Learning outcomes

In order to enable students to achieve the programme educational objectives, the following programme learning outcomes have been established:

- ✓ demonstrate knowledge and understanding of energy efficiency and energy saving innovation technologies at the fundamentals level;
- ✓ demonstrate knowledge and understanding of sustainable energy development, energy audit, environmental protection;
- ✓ demonstrate knowledge and understanding of engineering disciplines underlying Energy Efficient Buildings;
- ✓ carry out numerical simulation, in order to pursue detailed investigations and research of complex technical issues in Energy Efficient Buildings subject area;
- ✓ design and conduct experimental investigations, critically evaluate results and draw conclusions, in Energy Efficient Buildings subject area;
- ✓ implement and conduct complex activities related to Energy Efficient Buildings by identifying societal, health and safety, environmental impact and risks and acting appropriately, and meet deliverable, schedule and budget requirements, while fulfilling all legal and regulatory requirements;
- ✓ manage complex work contexts related to Energy Efficient Buildings, take decisions and formulate judgments demonstrating critical awareness of the ethical and social responsibilities.

Regional and national potential for employability of graduates

The main areas in which graduates can find employment jobs:

- building and equipment companies,
- Governemental institutions,
- technical units of local authorities (municipalities and local gouvernmental organizations),
- design and architecture offices,
- research centers in energy and environment..

Training monitoring indicators

Teaching & Learning Approaches

The teaching approach is teacher guided.

Main teaching and learning methods are: lectures, seminars, laboratory classes, practical work, individual study based on text books and lecture notes but also group work.

Assessment Methods

Several tests for continuous monitoring of students are scheduled during this training :

- written exams,
- oral presentations,
- written essays,
- laboratory reports,
- case studies,
- project work.

Facilities

Laboratories :

Laboratory of Materials

N°	Equipments	Number
1	Permeability mold with accessory	02
2	Concrete mold 7x7x28	08
3	Sand equivalent measurement set	02
4	Volumetric meter Le Chatelier	02
5	Pycnometers with different capacities	08
6	Beakers with different capacities	23
7	Abrahams cones	07
8	Electronic weighing scale 2 Kg	03
9	Electronic weighing scale 5 kg	02
10	Mechanical weighing scale 10 Kg	02
11	molds for concrete16x32	10
12	mortar molds 4x4x16	10
13	Molds for removal4x4x16	05
14	Press for compression and traction tests by bending	01
15	Removal device	02

Laboratory of Thermal Equipment

N°	Equipments	Number

1	Study bench for a gas boiler	1
2	Study bench for a hydraulic piston pump	1
3	Study bench for a flat solar collector	1
4	Solar tube water heater	1
5	Study bench for a double tube heat exchanger	3
6	Bench for the study of a heat exchanger with beam and shell and tube	1
7	Air handling tunnel (heating)	1
8	Fluidized bed study bench	1
9	Test bench for an air conditioning unit	1

Laboratory of Thermodynamics

N°	Equipments	Number
1	Gas law study bench	1
2	Reverse cycle study bench (Heat pump)	1

Laboratory of Fluid Mechanics

N°	Equipments	Number
1	Hydraulic bench for plan flow visualization	1
2	Study of a venturi	1
3	Study of the free jet through an orifice	1
4	Study of pressure losses	1
5	Free fall viscometer	3
6	Bench of compressible flows	1

Laboratory of Simulation and Computing

N°	Equipments	Number
1	Computers	20
2	Server	02
3	Software	(Pack ESRI)

Workspace

A classroom is completely dedicated to this Master. It includes a specialized library containing recent works in the field of energy efficiency. This classroom has also a broadband internet connection

Each student will have a laptop during the entire training period.

Curriculum

The curriculum of the Master in Energy Efficient Buildings is shown below.

For each course unit of the curriculum the following information are shown:

- year and semester of delivery;
- ccredits;
- lecturer (s).

Year/ Semester	Course Unit	Credits	Lecturer(s)	Rank
M1/S1	Heat Transfert	6	BELAS Nadia	Pr.
M1/S1	Applied Thermodynamics	6	BENMEKKI Houari	M.C.A.
M1/S1	Construction Materials	5	BELAS Nadia	Pr.
M1/S1	Transport Phenomena in Porous Media	6	LAREDJ Nadia	Pr.
M1/S1	Hygrothermal Modeling and Simulation in Buildings I	5	MALIKI Mustapha	M.C.A.
M1/S1	Technical English I	2	BENDANI Karim	Pr
M1/S2	Energy in Buildings	6	MISSOUM Hanifi	Pr
M1/S2	Pratical classes in Construction materials	5	BELARIBI Omar	M.C.B.
M1/S2	Hygrothermal Modeling and Simulation in Buildings II	5	MALIKI Mustapha	M.C.A.
M1/S2	HVAC	6	ABSAR Belkacem	Pr.
M1/S2	Norms and Standards	5	MEBROUKI Abdelkader	Pr.
M1/S2	Technical English II	3	BENDANI Karim	Pr.
M2/S3	Energy Efficiency buildings	6	MISSOUM Hanifi	Pr.
M2/S3	High Environmental Quality Buildings	5	MALIKI Mustapha	M.C.A.
M2/S3	Experimental Techniques in Thermal	5	BOUHAMMOU Nasreddine	Pr.
M2/S3	Pratical classes in Thermal in Builidings	5	BELARIBI Omar BELHOUARI Fethi	M.C.B.
M2/S3	Smart Cities	6	MIDOUN Mohamed	M.C.B.
M2/S3	Technical English III	3	BENDANI Karim	Pr.
M2/S4	Final Project	30		

Course units, sequence (year and semester of delivery) and number of credits

Semester I

Teaching Unit	Courses	Lecture	S.W.	P.W.	W.T.H.	Credits	% Credits
F.T.U.	Applied Thermodynamics	2	1	0	4.5	6	60%
	Construction Materials	2	1	0	4.5	6	
	Transport Phenomena in Porous Media	2	1	0	4.5	6	
M.T.U	Heat Transfert	1	1	0	3	4	33%
	Hygrothermal Modeling and Simulation in Buildings I	1	0	2	4.5	6	
D/T.T.U.	Technical English I	1	0	0	1,5	2	7%

F.T.U. : Fondamental Teaching Units

M.T.U : Methodological Teaching Units

D/T.T.U. : Discovery/Tranversal Teaching Unit

S.W. : Supervised Works

P.W. : Practical Works

Semester II

Teaching Unit	Courses	Lecture	S.W.	P.W.	W.T.H.	Credits	% Credits
F.T.U.	Energy in Buildings	2	1	1	6	9	60%
	HVAC	2	1	1	6	9	
M.T.U	Hygrothermal Modeling and Simulation in Buildings I	1	0	1	3	4	27%
	Pratical classes in Construction materials	0	0	2	4.5	4	
D/T.T.U.	Norms and Standards	2	0	0	3	3	13%
	Technical English II	1	0	0	1,5	1	

F.T.U. : Fondamental Teaching Units

M.T.U : Methodological Teaching Units

D/T.T.U. : Discovery/Tranversal Teaching Unit

S.W. : Supervised Works

P.W. : Practical Works

Semester III

Teaching Unit	Courses	Lecture	S.W.	P.W.	W.T.H.	Credits	% Credits
F.T.U.	Energy Efficiency buildings	2	1	1	6	9	60%
	Smart Cities	2	1	1	6	9	
M.T.U	Experimental Techniques in Thermal	1	0	1	3	4	27%
	Pratical classes in Thermal in Builidings	0	0	2	3	4	
D/T.T.U.	High Environmental Quality Buildings	2	0	0	3	3	13%
	Technical English III	1	0	0	1,5	1	

F.T.U. : Fondamental Teaching Units

M.T.U : Methodological Teaching Units

D/T.T.U. : Discovery/Tranversal Teaching Unit

S.W. : Supervised Works

P.W. : Practical Works

Course unit description

Name	**Heat Transfer**
credits	6
Year / Semester	M1/S1
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Demonstrate knowledge and understanding of the fundamentals of the heat transfer discipline 2 – Recognize the different modes of heat transfer 3 – Calculate heat exchange in different unfamiliar configurations and under assigned boundary conditions, by choosing the most suitable numerical or analytical method 4 – Illustrate the fundamentals of the heat transfer discipline and of the fundamental hypothesis of the one-dimensional calculation approach
Contents	Concept of thermal comfort, how to achieve thermal comfort, notion of heat and temperature, definition of heat transfer, thermal transfer by conduction, derivation of heat conduction equation; heat conduction in one dimensional systems; concept of thermal resistance; thermal transfer by forced convection and natural convection, laminar and turbulent flows, fundamental laws of radiation heat transfer, radiative characteristics of a surface, radiation heat transfer among surfaces.
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 35 hours Practical classes, 25 hours
Assessment methods	Written assessment including a mid-term test to assess students' level of understanding and recognising of heat transfers and a final term exam to assess their level of success in solving heat loss problems in each mode heat transfer.
Assessment criteria	In the mid-term test students should demonstrate their ability to identify the heat transfer mode and to calculate heat exchange in a one -dimensional configuration and under assigned boundary conditions. The assessment will regard their capacity to correctly identify the heat transfer mode, to formulate the heat exchange equations and to solve them by using analytical methods. In the final term exam students will be required to solve a problem related to a complex system. The assessment will regard students' capacity to properly frame the problem, to identify the heat transfer mode and, in particular, to identify and correctly apply the best calculation process to the problem under consideration, to correctly interpret technical diagrams for the estimation of relevant parameters, and to obtain correct results. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	Assessment is continuous with written tests during the training period. A final exam is scheduled at the end of the semester. The final grade is calculated according to the following rule : Final_note = 0.4 * Average_Tests + 0.6 * Review A catch-up examination is organized for students who have a final grade of less than 10.
Preparatory course units	N.A.
Educational	• Yves Jannot, 'Transferts thermiques", Ecole des mines de Nancy, 2012

material of reference	• Jean Luc Battaglia, Andrzej Kusiak, Jean Rodolphe Puiggali, « Introduction aux transferts thermiques », Editions Dunod 2010. • Yves Jannot & Christian Moyne, “Transferts thermiques Cours et 55 exercices corrigés”, EDILIVRE

Name	**Construction materials**
credits	5
Year / Semester	M1/S1
Specific learning outcomes	On successful completion of this module students should be able to: 1- Understand the importance of knowledge of building materials 2- Recognize low environmental impact materials through life cycle analysis 3- Differentiate between eco-materials and materials impacting the environment 4- Enhance natural and industrial waste in energy efficient concretes 5- Demonstrate knowledge about innovation in concrete and insulation techniques 6 - Participate in class discussions with colleagues and teachers
Contents	Importance of knowledge of building materials, concept of life cycle assessment of materials, concept of exposure classes, eco-materials (valorization of natural materials, and activated materials ...), alternative binders (hemp, perlite, natural and artificial pozzolana ...), ecological insulating materials, innovative concretes (self-compacting concrete with perlite, hemp concrete, concrete with pneumatic aggregates, concretes based on dredged sediments ...).
Teaching and learning methods	Face to face, 45 hours
Teaching techniques	Lectures, 45 hours
Assessment methods	Written assessment including a mid-term test to assess students' level of understanding of material characteristics and an end-of-term exam to assess their level of success in answering questions related to eco-materials and concrete innovative
Assessment criteria	Students must demonstrate in the test their ability to know the concepts related to the life cycle analysis of materials and concrete exposure classes During the final exam, students must know how to answer questions related to the choice of insulating material and concrete that contributes the most to energy efficiency.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	Assessment is continuous with written tests during the training period. A final exam is scheduled at the end of the semester. The final grade is calculated according to the following rule : Final_note = 0.4 * Average_Tests + 0.6 * Review A catch-up examination is organized for students who have a final grade of less than 10.
Preparatory course units	N.A.
Educational material of reference	G. Dreux, Jean Festa, « Nouveau guide du béton et de ses constituants » Edition Eyrolles, 1998 Raymond Dupain, Jean-Claude Saint-Arroman, « Granulats, sols, ciments et bétons », Edition Casteilla, 2009. Michael F. Ashby, « Matériaux et environnement: Choix éco-responsable en conception » Dunod, 2011

Name	**Transport phenomena in porous media**
ECTS credits	6
Year / Semester	I /1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Understand the basic principles on which the theories of transfer in the porous media are based. 2 – Recognize the different modes of transfer 3 – Calculate heat and mass exchange under various boundary conditions 4 –Do calculations of the flow of air, humidity and energy in buildings and then apply them to develop adequate strategies of conception of buildings. 5 – Analyze various numerical schema for the discretization of the coupled problems 6 – Participate in class discussions with colleagues and with teachers
Contents	Classification and characterization of porous media; flow in heterogeneous porous media (monophasic, multiphasic, approach local balance); macroscopic modelisation of the hydric transfers in porous media (mass conservation, liquid balance, capillary effects); thermal transfers in the heterogeneous porous media (transfer by conduction, convection); coupling of transfer's phenomena (analyze various numerical schema for the discretization of the coupled problems; numerical resolution of the system of coupled equations.
Teaching and learning methods	Face to face
Teaching techniques	Lectures, 45 hours
Assessment methods	Written final test. A written final test will be devoted to the assessment of the level of achievement of LOs 1 and 6 (ability of students to solve numerical problems related to heat and mass transfer in porous media).
Assessment criteria	In the final term test, the student should demonstrate their ability to identify the different transfer mode in porous media, and will be able to solve a problem related to a complex system. He should know how to represent different geometrical configurations with variable boundary conditions, and will require also the interpretation of technical diagrams for the estimation of relevant parameters. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	- A final examination is programmed at the end of the semester. - A remedial examination is organized for the students having obtained a final note lower than 10.
Preparatory course units	N.A.
Educational material of reference	Yunus A. Cengel "Heat Transfer", MARUEEB Lecture Notes

Name	**Hygrothermal Modeling and Simulation in Buildings I**
ECTS credits	5
Year / Semester	M1/S1
Specific learning outcomes	On successful completion of this module students should be able to: 1- Shell and Interpret the most relevant mathematical models governing hygrothermal transfer. 2- Develop the equations of transient coupled transfer in the multilayered wall of a building. 3- Draw the curves of moisture retention, thermal conductivity and humidity for a material. 4- Write the boundary conditions encompassing surface-transmitted steam, rain infiltration, solar radiation and wind velocity.
Contents	Equation and modeling of moisture storage in a building material; analytical modeling of the moisture retention curve; equation of moisture transfer in a building wall; modeling of heat transfer in the building envelope; simulation of air convection in the envelope of a building; properties of materials for hygrothermal modeling; boundary conditions in hygrothermal modeling; conservation equations for coupled heat and moisture transport; Initial and boundary conditions.
Teaching and learning methods	Lectures and supervised work, 67.5 hours
Teaching techniques	Lectures, 45 hours Supervised work , 22.5 hours
Assessment methods	Mid-term evaluation Final written exam
Assessment criteria	In the final term written exam students will be required to solve a complex problem related to the preliminary hygrothermal design of a building. The assessment will regard students' ability to perform heat transfer and moisture calculations and to formulate adequate hypothesis. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in supervised work classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	Assessment is continuous with written tests during the training period. A final written exam is scheduled at the end of the semester. The final note is calculated according to the following weighting formula: Final_note = 0.4 * Mid Term_Tests + 0.6 * Final term written exam A re-take exam is organized for students who have a final grade of less than 10.
Preparatory course units	N.A.
Educational material of reference	1- Building Physics, From physical principles to international standards. 2- Hygrothermal Numerical Simulation Tools Applied to Building Physics 3- Scientific papers.

SEMESTER II

Name	**Energy in Buildings**
ECTS credits	6
Year / Semester	M1/S2
Specific learning outcomes	On successful completion of this module students should be able to: 1. Know all the energies present in a building 2. Evaluate heat loss through transmission and ventilation. 3. Calculate a thermal balance in a building. 4. Know the different energy production methods useful to the thermal comfort of the occupants of a building.
Contents	Recalls of Building Physics, Occupant Needs, Insulation Materials, Thermal Transmission, Dynamic Thermal Characteristics, Ventilation, Energy Balance, Transmission Losses, Ventilation Losses, Solar Energy Inputs and Internal Gains, Heating Needs , Boilers for fuel, Heat pumps, Solar thermal installations, District heating, Electric heating, Mechanical ventilation systems, Cooling and air-conditioning with low energy consumption.
Teaching and learning methods	Face to face, 45 hours
Teaching techniques	Lectures, 45 hours
Assessment methods	A mid-term written test and a final-term written test are foreseen. The mid-term written test will be devoted to the assessment of the level of achievement of LOs 2 and 3 (students' ability to perform an energy balance to calculate heat losses in a building). The final term written test will be devoted to the assessment of the level of achievement of LOs 2, 4..
Assessment criteria	During the written exam, students will have to evaluate the heat loss of a building taking into account the environmental conditions and energies present in the building. Upon handing over the requested work, students should demonstrate their knowledge and ability to perform heat transfer calculations to evaluate heat loss.
Assessment metrics	Attribution of a final grade varying from 0 to 20
Criteria of attribution of the final grade	Evaluation is continuous with written tests at mid-term during the training period and a final exam is scheduled at the end of the semester. The final grade will be determined according to the following rules: Final grade = 0.4×Mid-term written + 0.6×Final term written test.
Preparatory course units	N. A.
Educational material of reference	Energy Efficiency: Building a Clean, Secure Economy, James L. Sweeney La thermique du bâtiment - 2e éd.: en 37 fiches-outils, Gina Penu BIM et énergétique des bâtiments, Karim Beddiar, Fabien Imbault Notes de Cours

Name	**Pratical classes in Construction materials**
credits	5
Year / Semester	M1/S2
Specific learning outcomes	On successful completion of this module students should be able to: 1- Handle the different test equipment: Mixerr, press 2-Find the physical and mechanical characteristics of the different materials 3- To master the interpretation of the results of the experimental tests 4-Formulate cementitious materials combining strength and lightness, mechanical performances and thermal properties 5- Making insulating panels with hemp, perlite or pozzolana 6- Prepare samples of these materials for thermal tests 7- Participate in class discussions with colleagues and teachers
Contents	Development of mechanically and thermally efficient concretes based on new additions, measurement of the absolute density, measurement of porosity, monitoring of mechanical performances, measurement of capillary absorption, measurement of the activity index of additions.
Teaching and learning methods	Pratical classes
Teaching techniques	PC : 45 heures
Assessment methods	Assessment of the practical work reports
Assessment criteria	Students must demonstrate by writing reports their ability to assimilate experimental tests, handle them correctly and analyze the results obtained
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The final grade corresponds to the average of the notes of all the reports
Preparatory course units	N.A
Educational material of reference	Operative Manuals G. Dreux, Jean Festa, « Nouveau guide du béton et de ses constituants » Edition Eyrolles, 1998 Raymond Dupain, Jean-Claude Saint-Arroman, « Granulats, sols, ciments et bétons »,Edition Casteilla, 2009. Laurence Ducamp «Isolation thermique et acoustique des bâtiments - Réglementation, produits, mise en œuvre » Le moniteur éditions 20/09/2017

Name	**Hygrothermal Modeling and Simulation in Buildings II**
ECTS credits	5
Year / Semester	M1/S2
Specific learning outcomes	This second part dedicated to modeling and simulation will allow students to: 1- Evaluate and compare commercial software for numerical simulation of the hygrothermal behavior of buildings. 2- Use COMSOL-Multiphysics software for the resolution of the numerical models previously developed in S1. 3- Calculate the heat and moisture fluxes passing through the multilayer walls. 4- Calculate the energy consumption of a building. 4- Identify the location of thermal bridges. 5- Identify the most appropriate insulation to use in order to reduce energy losses.
Contents	Implementation of a numerical model in the COMSOL-Multiphysics environment; mathematical writing of partial differential equations governing heat and mass transfer; modeling process under COMSOL-Mutiphysics; implementation in two-dimensional 2D context; implementation in three-dimensional 3D context; Application to a wall of local design.
Teaching and learning methods	Lectures and supervised work, 67.5 hours
Teaching techniques	Lectures, 45 hours Supervised work , 22.5 hours
Assessment methods	Mid-term evaluation Final written exam
Assessment criteria	At the end of the semester, students will be asked to perform a complete energy simulation of a building. The assessment will take into account students' ability to build a model building energy model, use appropriate software, and provide an optimal solution for energy efficiency. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in supervised work classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	Assessment is continuous with written tests during the training period. A final written exam is scheduled at the end of the semester. The final note is calculated according to the following weighting formula: Final_note = 0.4 * Mid Term_Tests + 0.6 * Final term written exam A re-take exam is organized for students who have a final grade of less than 10.
Preparatory course units	N.A.
Educational material of reference	1- COMSOL Mutiphysics Software V 5.3. 2- TRNSYS 18 Software 3- Scientific papers.

Name	**HVAC**
ECTS credits	6
Year / Semester	M1/S2
Specific learning outcomes	On successful completion of this module students should be able to: 1. calculate heating installations 2. calculate air conditioning systems 3. calculate ventilation systems
Contents	Heating technology, Ventilation and air-conditioning technology, Thermal comfort, HVAC in buildings, Heating installations, Ventilation installations, Partial air-conditioning installations, Complete air conditioning systems, Standards and symbols, Regulation and control, Functions of the control technology, Terminology of HVAC technology, The control system, Application areas / examples, Technical management of buildings
Teaching and learning methods	Face to face, 45 hours
Teaching techniques	Lectures : 22,5 hours Practical : 22,5 hours
Assessment methods	A mid-term written test and a final-term written test are foreseen. The mid-term written test will be devoted to the assessment of the level of achievement of LOs 1-3. The final term written test will be devoted to the assessment of the level of achievement of LOs 1-3..
Assessment criteria	During the second semester, students will have to analyze the heat loss a building and calculate a heating or air conditioning system taking into consideration the various means of energy production available on the local market. In the requested work, students should demonstrate their knowledge and understanding of heating, air conditioning and ventilation calculate methods.
Assessment metrics	Attribution of a final grade varying from 0 to 20
Criteria of attribution of the final grade	Evaluation is continuous with written tests at mid-term during the training period and a final exam is scheduled at the end of the semester. The final grade will be determined according to the following rules: Final grade = 0.4×Mid-term written + 0.6×Final term written test.
Preparatory course units	N.A.
Educational material of reference	HVAC: Heating, Ventilation & Air Conditioning Handbook for Design & Implementation, Ali Vedavarz Modern Refrigeration and Air Conditioning (Modern Refridgeration and Air Conditioning), Andrew D. Althouse, Carl H. Turnquist, Alfred Pratique de la climatisation: en 24 fiches-outils, Christian Feldmann, Pratique du chauffage: en 26 fiches-outils, Philippe Menard, Pratique de la ventilation: en 41 fiches-outils, Pierre Bardou

Name	**Norms and Standards**
ECTS credits	6
Year / Semester	M1/S2
Specific learning outcomes	On successful completion of this module students should be able to: 1. Identify the ISO norms. 2. Algerian and international agencies interested by building energy efficiency. 3. Know European standards for building energy performances 4. Know the principles of building energy. 5. Estimate the importance of the energy decreases. 6. Select the correct devices to be used in respecting norms and standards. 7. Identify fundamental principles of the heat loss. 8. Summarise relevant information regarding to the respect of energic efficiency standards. 9. Formulate a recommendation for norms respecting
Contents	Standards and norms of thermal comforts - analytical Approach - adaptive Approach - ISO 50001: a standard for the energy efficiency - The European standard IN 15232 entitled " energy Performance of buildings ". - The new NF norms IN 162476-1 and NF IN 162476-2 - The fundamental of the thermal regulations applied to buildings - Reminder of the statutory and normative context of renovation energy - Role and limit of the new Diagnosis of Energy Performance (DPE) - The thermal comfort, the passive and active energy efficiency
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 60 hours
Assessment methods	Final written test. Final test will concern the understanding of the various taught norms. Their applications. The statutory context. No respect of the norms and consequences.
Assessment criteria	In the written final test, the students must be capable of recognizing fields of application of every norm and its limit of application. They must also be capable to make difference between universal and local standards (european norms and algerian Norms). They also have to know consequences of the non application of norms on the building energy efficiency. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 20 (maximum). The minimum threshold to pass is 10. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term written test: 100%
Preparatory course units	N.A.
Educational material of	1. Gagge, A. Pharo. 1981. "Chapter 5 Rational Temperature Indices of Thermal Comfort." In Bioengineering, Thermal Physiology and Comfort, Vol. 10 of Studies in

reference	Environmental Science edited by K. Cena and J.A. Clark. 79 – 98. Elsevier. http: //www.sciencedirect.com/science/article/pii/S0166111608710823. 24 . 2. Nicol, J.F., and M.A. Humphreys. 2002. “Adaptive thermal comfort and sustainable thermal standards for buildings.” Energy and Buildings 34 (6) : 563 – 572. Special Issue on Thermal Comfort Standards. http://www.sciencedirect.com/science/article/pii/S0378778802000063. 25 3. EN15251. 2007. Indoor environmental input parameters for design and assessment of Energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.. Tech. rep.. Brussels. 27 4. Standard ASHRAE55. 2004. 2004 :thermal environmental conditions for human occupancy. Tech. rep.. Atlanta, Georgia, USA : American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE),. 27, 91 5. ISO, 8995. 2002. -1 :2002 (CIE S 008/E :2001) : Eclairage des lieux de travail - Partie 1 : IntÃcrieur. Tech. rep. 34 6. ASHRAE. 2009a. “2009 ASHRAE Handbook Fundamentals, Chapter 13 : Indoor environmental modeling.” ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers), Atlanta. 65, 71. 7. Algerian norms, from APRUE.

SEMESTER III

Name	**Energy Efficiency buildings**
ECTS credits	6
Year / Semester	M2/S3
Specific learning outcomes	On successful completion of this module students should be able to: 1. Understanding the big energy losses in buildings 2. Identify some corrective actions 3. Improve energy efficiency.
Contents	Concept of the economic optimization of an energy installation, Technico-economic optimization applied to the building, Measures concerning energy consumption, Thermography, Measurement of thermal insulation, Measurement of airflows, Measurement of the permeability to air of the building envelope, Energy efficiency of the building envelope, Energy efficiency of the ventilation, Energy efficiency of the heating system, Energy efficiency of domestic hot water, Technical management of the building or control system.
Teaching and learning methods	Face to face, 22,5 hours,
Teaching techniques	Lectures : 22,5 hours
Assessment methods	Final term written exam and a mid-term personal work to present (Poster or Oral). A final written exam is foreseen. The final term written exam will be devoted to the evaluation of the achievement level of Specific Learning Objectives 1-3. Personal work to be presented (Poster or Oral) will be devoted to the evaluation of the level of achievement of the Specific Objectives of Learning 2-3.
Assessment criteria	During the last semester, students will have to analyze energy consumption in relation to the energy efficiency of a building taking into consideration economic and environmental aspects. In the requested work, students should demonstrate their knowledge and understanding of the energy efficiency applied to a building. In addition, their ability to clearly illustrate their knowledge and understanding.
Assessment metrics	Attribution of a final grade varying from 0 to 20
Criteria of attribution of the final grade	Evaluation is continuous with a personal work to be submitted during the training period. A final exam is scheduled at the end of the semester. The final grade will be determined according to the following rules: Final grade = 0.4×Mid-term written + 0.6×Final term written test.
Preparatory course units	N.A.
Educational material of reference	- Energy Efficient Buildings: Architecture, Engineering, and Environment, Dean Hawkes, Wayne Forster - Energy Efficiency: Building a Clean, Secure Economy, James L. Sweeney - Bâtiment intelligent et efficacité énergétique: Optimisation, nouvelles technologies et BIM, Karim Beddiar, Jean Lemale - Démarche d'efficacité énergétique, Lionel Munch - Démarche d'efficacité énergétique en 20 fiches-outils, Lionel Münch - La gestion technique du bâtiment, Christophe Lavergne, - Notes de cours

Name	**High Environmental Quality Buildings**
ECTS credits	5
Year / Semester	M2/S3
Specific learning outcomes	As real energy efficiency manager, the student must be able to: 1- Guarantee the implementation of energy efficient projects adapted to all current and future challenges of the building sector in Algeria. 2- Address in a multidisciplinary way the energetic, environmental, economic and sociotechnical issues related to buildings. 3- Design civil engineering structures taking into consideration the interactions between materials / structures / implementation processes, for a design of high environmental quality integrating technological innovations and energy efficiency.
Contents	The ecological building; the building and the bioclimate; positive energy building; autonomous building; low energy building (LEB); eco-construction and eco-habitat; passive habitat.
Teaching and learning methods	Face to face, 22.5 hours
Teaching techniques	Lectures, 22.5 hours Supervised work , 22.5 hours
Assessment methods	Final written exam
Assessment criteria	The student evaluation depends on his ability regarding a building's adaptability and sustainability achieved via the choice of construction products and processes (building components and equipment) taking into consideration the flexibility of the internal spaces in the building to adapt to changing use and the future development of the different parts of a building. In addition, this course requires to the student the use of component products which create the conditions for eco-management (energy, water and business waste management) ambient comfort (hygrothermic, acoustic, visual and olfactory).
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	A final written exam is scheduled at the end of the semester. A re-take exam is organized for students who have a final grade of less than 10.
Preparatory course units	N.A.
Educational material of reference	1-Bâtiments HQE et développement durable - Dans la perspective du Grenelle de l'environnement, J. Hetzel

Name	**Experimental techniques in Thermal**
ECTS credits	5
Year / Semester	M1/S3
Specific learning outcomes	The theory is concerned with describing certain aspects of reality, providing the tools for modeling. For this, experiments must be compared with theoretical descriptions and the experiments be as conclusive as possible. The experimental module in thermics aims to introduce students to measurement, the result of which is central from both the fundamental point of view and the point of view applied. In this module, in addition to courses on measurement, a brief introduction on improving energy efficiency in the building sector will be provided. This will allow the realization of simple and illustrative experiments during the sessions of practical work.
Contents	1. Thermogravimetric analysis (TGA) and mass loss measurement 2. DSC thermal analysis 3. Measurement of thermal conductivity 4. Thermal diffusivity 5. Measurement of humidity and temperature 6. Measurement of meteorological conditions 7. Measurement of solar radiation 8. Assessment of energy consumption
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 35 hours Practical classes, 25 hours
Assessment methods	Written a final-term written test is foreseen.
Assessment criteria	In a final-term written test students must demonstrate that they will be able to : • Measure correctly • express the results of an experiment according to current standards • keep a critical eye on scientific production
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The grade goes from 10 (minimum) up to 20 (maximum). The minimum threshold to pass is 20.
Preparatory course units	N.A
Educational material of reference	Richard Franck, Guy Jover, Frank Hovorka "Optimize the energy performance, comfort and value of commercial and industrial buildings ". Eyrolles, 2014.

Name	**Smart Cities (EN)**
3	6
Year / Semester	M2/S3
Specific learning outcomes	At the end of the course the student should be able to : 1. The fundaments of GIS 2. Foundations and principles of smart cities 3. Modelling smart cities using GIS 3D tools. 4. Use Big Data, Big Insights et Data modelling (Hadoop) tools 5. Design of sensor networks (MAS) for energy optimization 6. Use of Energy Management Systems (ex: Smart HVAC) 7. Linking sustainable energy systems with geospatial data 8. Embed CAD to GIS 9. Embed BIM to GIS.
Contents	• Introduction to GIS • GIS and environment • GIS and energy optimization • Foundations and principles of smart cities • Esri City engine for 3D smart cities modelling • Smart cities, smart grid and smart energy • Tools for embedding CAD to GIS • Tools for embedding BIM to GIS
Teaching and learning methods	Courses Pracical works
Teaching techniques	Course : 22.5 hours Practical work : 22.5 hours
Assessment methods	Continuation evaluation of practical work Final Exam
Assessment criteria	During the final test, students will analyze a case study of smart grid project. The assessment will focus on students' ability to identify the key variables, methods and resources needed to model a smart city and prepare a timeline of activities. In practical works, students should demonstrate their knowledge and understanding of the smart city modeling process using GIS and should know how to integrate environmental and energy efficiency indicators.
Assessment metrics	Award of a final grade
Criteria of attribution of the final grade	Continuous assessment with written tests during the training period. A final exam is scheduled at the end of the semester. The final grade is calculated according to the following weighting: Final note = 0.4 * Average Tests + 0.6 * Exam A catch-up examination is organized for students who have a final grade of less than 10.
Preparatory course units	N.A
Educational material of reference	1- *Smart Cities A Spatialised Intelligence*, Antoine Picon, Chichester: Wiley, 2015 2- *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia, Anthony M. Townsend* 3- *Song, H., Srinivasan, R., Sookoor, T., Jeschke, S., & Cities, S. (2017). Foundations, principles and applications. ISBN : 978-1-119-22639-0*