Marine Renewable Energies (250585)

General Information

School	ETSECCPB
Departments	Departament d'Enginyeria Civil i Ambiental (DECA)
Credits	6.0 ECTS
Programs	GRAU EN CIÈNCIES I TECNOLOGIES DEL MAR (pla 2018)
Course	2024/25

Main teaching language at each group

- Group 10CA1 Catalan (Q1)

Faculty

Responsible Faculty: Juan Pablo Sierra Pedrico
Faculty: Daniel Alarcón Fernández, Corrado Altomare, Marc Mestres Ridge, Climent Molins Borrell, Juan Pablo Sierra Pedrico

Objectives of Education

This subject will address the most relevant aspects of the use of marine renewable energies and their different alternatives. In particular, specific aspects of 3 renewable energy sources will be shown: offshore wind energy (as well as the dimensioning of floating platforms for wind turbines), wave energy (extracted from the waves by first, second and third generation prototypes) and tidal energy. Its impact on the emerged and submerged coastal zone will also be considered.

1. To be able to carry out a study of the energetic potential of waves, currents, winds, tides, thermal and saline gradients.
2. Know the main marine converters, their sizing and estimation of the basic potential.
3. Conduct technical, environmental and economic feasibility studies and of the parameters that affect each of them in the field of marine renewable energy.

The topics addressed in this matter cover most of the physical, environmental and ecological problems and challenges identified by the scientific community and the social agents that the coastal zone will face in the near future under different development scenarios and climate change.

The main objective of the course is to provide the student with notions about the main renewable marine energy sources, their characteristics and their advantages and disadvantages. Knowledge about the exploitation modalities and the national and international regulatory framework for this type of energy will also be provided. This subject covers aspects with great potential for the future, since energy demands are growing with the population and, every time, there is more pressure to use "clean" energy.
One of the main objectives of the course is to learn to evaluate the energy resource (that is, the amount of energy that could potentially be extracted) of a given area based on its meteorological and hydrodynamic characteristics, and for the different types of energy (wind, waves and tides). The different energy harvesting systems will also be presented and it will be taught how to calculate the real energy production based on the type of converter used, as well as the temporal variability, both of the resource and of the production. In addition, the subject includes training on concepts of hydrodynamics and ocean engineering, which will allow understanding the principles of mechanisms of catchment systems and knowing the characterization of actions, which is highly applicable in the field of design and deployment of devices of sea energy extraction.
The organization of the course has a well-defined hierarchical structure, starting with an introduction to renewable energies, and continuing with an extension of hydrodynamics focused on the properties of floating objects and the typology of the concepts used. It will continue with each of the main marine

renewable energies, wind, wave and tidal, developing the issues related to the evaluation of the resource, the catchment systems and the actions, together with the regulatory aspects.
The orientation of the course aims to be practical, so that, in addition to providing the necessary theoretical knowledge, this will be applied during the course. For this, several practical classes will be held, which must be completed and delivered by the students and which will be used for their evaluation. These practices will be based on real data that will serve to train students in the application of the knowledge acquired in professional life. Additionally, all the topics will include practical examples taken from real cases in which the teachers have been involved (which will allow to give a first-hand knowledge as complete as possible).

Competencies

Especific

To know and apply the lexicon and concepts of the Marine Sciences and Technologies and other related fields.
Establish a good practice in the integration of common numerical, laboratory and field techniques in the analysis of any problem related to the marine environment.
Participate and eventually lead multidisciplinary work teams in the field of Marine Sciences and Technologies to respond to the social challenges related to this field.
Evaluate the bio- and geo-diversity of the marine environment, identifying habitats and ecosystems with multidisciplinary criteria.
Evaluate the dynamics of seas and oceans at different scales, identifying water masses and their properties. (Specific competence of Marine Science and Engineering Mention)
To set, evaluate and propose solutions to the different conflicts of use and exploitation in the marine and coastal environment resources based on scientific and technical criteria.
To set, analyze and optimize the functionality of actions and infrastructures in the marine environment. (Specific competence of the Marine Science and Engineering Mention)
Carry out environmental impact, management and protection studies of the marine environment and adjacent coastal areas, including the corresponding infrastructures and their related impacts.
Carry out operational predictions in the open sea and coastal areas, including the corresponding risk maps. (Specific competence of the Marine Science and Engineering Mention)
Use state-of-the-arte mathematical models in the marine field to analyze impacts and interactions with socio-economic activities supported by this environment. (Specific competence of the Marine Science and Engineering Mention)
Develop a conceptual framework to address the sustainability of the marine environment and the related socio-economic activities at different scales, explaining the effects of climate change.
Write technical reports and disseminate knowledge about the different components of the marine system, considering the applicable legal framework.

Generic

Develop a conceptual framework that links the scientific-technological and management aspects for marine resources, explaining the interactions with marine infrastructures and management plans in coastal areas.
Encompass and teach studies in the different research lines that converge in Marine Sciences and Technologies.
Combining preservation with economic activity within the framework of current legislation promoting the development of a social and environmental awareness.

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	30.0 h	50.00 %
	Medium group	15.0 h	25.00 %
	Laboratory classes	15.0 h	25.00 %
	Guided Activities	0.0 h	0.00 %
Self Study		90.0 h	

Contents

Conceptual framework of the subject

Basic objectives of the subject and approach. Traditional energies. Renewable energies. Marine renewable energies. Units. Conditioners of the marine environment.

Concepts of Hydrodynamic and Oceanic Engineering

Archimedes Principle. Hydrostatic stability. Center of Flotation. Metacenter. Dynamic stability curve. Examples of hydrostatic stability.
Exercise of hydrostatic stability
Active and passive position maintenance systems. Definition of mooring system. Types of moorings and materials for moorings. Mooring anchor systems at the bottom of the sea. Movements of floating structures. Fixed and floating. Fixed: mono-pylon, bases by gravity, latticework, tripods. Floating: SPAR, TLP, semi-submersible, barge. Stability triangle: flotation, moorings and ballast. Periods of oscillation of floating structures. Concept of Response Amplitude Operator.
Actions on marine structures: waves, sea currents, vortex detachment, wind action, estimation of hydrodynamic coefficients, radiation, diffraction, viscous forces, marine growth.
Actions on maritime structures. Exercise

Offshore wind energy

Wind energy today in Europe and in the world: penetration. LCOE concept (level cost of energy), evolution of offshore wind.
Physical principles for wind energy extraction. Power coefficient. Betz limit. Use drag or lift. Forces and aerodynamic torsion. Control of the angle of attack of the blades. Power curves, power coefficient as a function of wind speed.
Wind energy. Exercise
Origin of the wind. Variability. Temporal wind distribution. Wind height distribution. Turbulence intensity. Obstacles. Resource maps. Wind measuring instruments.
Wind characterization. Practice
Vertical axis and horizontal axis turbines. Classification of wind turbines according to IEC-61400. Parts of a wind turbine. Evolution of turbine power. Turbine production reports. Evaluation of the resource and production of a turbine. Practice on expected production. Advantages of offshore turbines. Examples of installation of offshore, fixed and floating turbines.

Wave energy

Physical principles for the extraction of wave energy. Wave data sources. Generation of wave data (models). Resource evaluation. Coefficients of variability.
Catchment systems. Types of wave energy converters (WECs). Calculation of the production of a WEC. Conversion matrices. Capacity factor. Examples of WEC pilot plants.
Exercises on the evaluation of the wave energy resource in a given area and on the production of different WECs.

Tidal energy

Physical principles for extracting energy from the tides. Potential energy (tidal range). Kinetic energy (tidal currents). Tide data sources. Generation of tide data (models).
Types of tidal power plants. Calculation of the production of a power plant. Examples of existing plants.
Types of tidal kinetic energy converters (TECs). Calculation of the production of a TEC. Conditioners for production: Betz limit, cut-in speed and rated power. Examples of TEC pilot plants.
Exercise on the energy production of a TEC.

Other types of energies and topics to be considered

Ocean thermal energy: physical principle. State of the ocean thermal energy and examples of pilot plants.
Osmotic energy: physical principle and state of situation.
Introduction to numerical modeling. Types of models that can be used to evaluate marine energy extraction devices. Lagrangian models. Presentation of an SPH type model to carry out studies of wave-device interaction. Practice with the model.

Regulatory framework in Spain and Europe. Criteria for site selection. Protocols for conducting environmental impact studies in the marine environment. Potential impacts of energy extraction on the environment. Situation of the marine renewable energy sector.

Teaching Methodology

The course consists of 4 hours per week of classroom activity, organized in two sessions of 2 hours each.

Part of the time is devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject and shows examples.

The rest of the time is dedicated to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of learning and assessment activities conducted and literature.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

Grading Rules

(*) The evaluation calendar and grading rules will be approved before the start of the course.

The course will be evaluated by means of partial exams, in addition to the practical work, which will have a 50% weight in the final grade. That is to say

Course grade = 0.5 (Average mark for mid-term exams) + 0.5 (Average mark for practical work).

In the re-evaluation only the grade of the re-evaluation exam will be taken into account. The final grade will be the higher of the course grade and the re-evaluation exam grade.

Re-evaluation (RE)
Grading criteria and admission to the re-evaluation (Re):
Students failed at the ordinary assessment who have regularly sat the assessment tests of the failed subject will have the option to sit a re-evaluation test in the period set in the academic calendar. Students who have already passed a subject may not sit the re-evaluation test of a subject, nor may students who are graded as non-submitted or who have not handed in all the exercises/problems (Pr) and assignments and reports (Tr).
The re-evaluation (RE) will consist of a single exam covering the entire course content. The maximum mark for the re-evaluation will be five (5.0) and the final mark for the course will be the maximum mark between the continuous assessment and the re-evaluation exam, i.e. MAX(Ordinary assessment/RE).
The non-attendance of a student summoned to the re-evaluation test, held in the fixed period, may not give rise to the taking of another test at a later date. Extraordinary assessments will be carried out for those students who, due to accredited force majeure, have not been able to take any of the continuous assessment tests. These tests must be authorised by the corresponding Head of Studies, at the request of the teacher responsible for the subject, and will be held within the corresponding teaching period.

Test Rules

If any of the laboratory or continuous assessment activities are not carried out in the scheduled period, it will be considered a zero score. The tests will be carried out individually, with multiple choice questions that can be theoretical or problem type questions. The exams can include short questions to be developed by the students and exercises to be solved.

Office Hours

The students will be attended by appointment

Bibliography

Basic

- Pecher, A.; Kofoed, J.P. Handbook of Ocean Wave Energy. Cham: Springer, 2017. ISBN 9783319398891.
- Chakrabarti, K.S. Handbook of Offshore Engineering. Amsterdam: Elsevier Science, 2005. ISBN 0080443818.
- Multon, B. (ed.). Marine renewable energy handbook (ISTE). London ; Hoboken, NJ: ISTE ; John Wiley & Sons, 2012. ISBN 9781848213326.
- Yang, Z. ; Copping, A. Marine Renewable Energy. Resource Characterization and Physical Effects. Cham: Springer, 2017. ISBN 9783319535364.
- Matha, D., Cruz, J.; Masciola, M.; Bachynski, E.; Atechson, M.; Goupee, A.; Gueydon, S.; Robertson, A. Floating offshore wind energy: The next generation of wind energy. Cham: Springer, 2016. ISBN 9783319293981.