Course guide
250585 - ENERENOMAR - Marine Renewable Energies

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.
Degree: BACHELOR'S DEGREE IN MARINE SCIENCE AND TECHNOLOGY (Syllabus 2018). (Optional subject).
Academic year: 2022 ECTS Credits: 6.0 Languages: Catalan

Lecturer
Coordinating lecturer: JUAN PABLO SIERRA PEDRICO
Others: DANIEL ALARCÓN FERNÁNDEZ, CORRADO ALTOMARE, MARC MESTRES RIDGE, CLIMENT MOLINS BORRELL, JUAN PABLO SIERRA PEDRICO

Degree Competences to Which the Subject Contributions

Specific:
13388. To know and apply the lexicon and concepts of the Marine Sciences and Technologies and other related fields.
13390. 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.
13391. 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.
13392. Evaluate the bio- and geo-diversity of the marine environment, identifying habitats and ecosystems with multidisciplinary criteria.
13393. Evaluate the dynamics of seas and oceans at different scales, identifying water masses and their properties. (Specific competence of Marine Science and Engineering Mention)
13395. 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.
13396. To set, analyze and optimize the functionality of actions and infrastructures in the marine environment. (Specific competence of the Marine Science and Engineering Mention)
13397. Carry out environmental impact, management and protection studies of the marine environment and adjacent coastal areas, including the corresponding infrastructures and their related impacts.
13398. 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)
13400. Use state-of-the-art 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)
13403. 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.
13406. Write technical reports and disseminate knowledge about the different components of the marine system, considering the applicable legal framework.

General:
13383. 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.
13386. Encompass and teach studies in the different research lines that converge in Marine Sciences and Technologies.
13387. Combining preservation with economic activity within the framework of current legislation promoting the development of a social and environmental awareness.
TEACHING METHODOLOGY

The course consists of 2.3 hours per week of classroom activity (large size group) and 1.2 hours weekly with half the students (medium size group).

The 2.3 hours in the large size groups are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

The 1.2 hours in the medium size groups is devoted 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.

The rest of weekly hours devoted to laboratory practice.

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.

LEARNING OBJECTIVES OF THE SUBJECT

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. In this line, a work will be chosen that will be carried out throughout the course and that will be delivered at the end, and that will also serve to evaluate. These works will be designed based on existing (real) problems, so in any case they will serve to train the student in the application of knowledge once outside the university. Additionally, all the topics will include practical examples taken from real cases in w
### STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Hours medium group</td>
<td>15.0</td>
<td>10.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>15.0</td>
<td>10.00</td>
</tr>
<tr>
<td>Guided activities</td>
<td>6.0</td>
<td>4.00</td>
</tr>
<tr>
<td>Self study</td>
<td>84.0</td>
<td>56.00</td>
</tr>
<tr>
<td>Hours large group</td>
<td>30.0</td>
<td>20.00</td>
</tr>
</tbody>
</table>

**Total learning time:** 150 h

### CONTENTS

#### Conceptual framework of the subject

**Description:**

**Full-or-part-time:** 4h 48m
Theory classes: 2h
Self study: 2h 48m

#### Concepts of Hydrodynamic and Oceanic Engineering

**Description:**
Exercise of hydrostatic stability
Active and passive position maintenance systems. Definition of mooring system. Types of moorings and materials for moorings.
Moorings anchor systems at the bottom of the sea. Movements of floating structures.
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

**Full-or-part-time:** 31h 12m
Theory classes: 9h
Practical classes: 4h
Self study: 18h 12m
**Offshore wind energy**

**Description:**

- Wind energy. Exercise
- Wind characterization. Practice

**Full-or-part-time:** 40h 48m

- Theory classes: 9h
- Practical classes: 3h
- Laboratory classes: 5h
- Self study: 23h 48m

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**Wave energy**

**Description:**

- Catchment systems. Types of wave energy converters (WECs). Calculation of the production of a WEC. Conversion matrices.
- Capacity factor. Examples of WEC pilot plants.

Exercise on the evaluation of the wave energy resource in a given area and the production of different WECs.

**Full-or-part-time:** 19h 12m

- Theory classes: 5h
- Practical classes: 3h
- Self study: 11h 12m

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**Tidal energy**

**Description:**
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.

**Full-or-part-time:** 19h 12m

- Theory classes: 5h
- Practical classes: 3h
- Self study: 11h 12m
### Other types of considerations

**Description:**
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 physical modeling. Types of physical model tests that can be done to evaluate different types of devices. Examples.
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.

**Full-or-part-time:** 28h 47m
- Theory classes: 2h
- Laboratory classes: 10h
- Self study: 16h 47m

### GRADING SYSTEM
The course will be evaluated through partial exams, in addition to the practical works, which will have a weight of 40% in the final grade.

### BIBLIOGRAPHY

**Basic:**