ES 305 TECHNOLOGY OF RENEWABLE ENERGIES
IES Abroad Freiburg

DESCRIPTION: This course gives a general introduction of renewable energy technologies for non-engineers. The basic conversion technologies applied for turning different renewable energy sources into useful forms of energy are explained. Basic engineering knowledge for (thermal, mechanical, chemical) energy conversion is described where necessary, so that participants can assess the technical challenges and realistic efficiencies of such technologies. The technical problems facing the power grids when integrating fluctuating renewable energy sources are presented and discussed. Also, methods for assessing the environmental impacts of renewable energy deployment are introduced and implications of 100% energy systems are discussed. Where it is suitable, annotations to economic aspects of renewable energy technologies are made.

Through the course, the students should acquire a knowledge base that helps them to better assess the discussion about massive renewable energy deployment by weighing the resulting benefits and challenges and by correctly accounting for given physical and technical limits. The course is taught by engineers who adapt the technical details to a level that is understandable for non-engineers.

CREDITS: 3

CONTACT HOURS: 45

LANGUAGE OF INSTRUCTION: English

PREREQUISITES: None

METHOD OF PRESENTATION:
- Lectures
- Student presentations
- Exchange and discussion
- Application of Moodle

Additional material comes from Moodle. This platform is also the place to share assignments and to follow recent developments in the field. Participation is part of the student’s grade, therefore it is expected that all students contribute during classes.

REQUIRED WORK AND FORM OF ASSESSMENT:
- Written assignment – 30%
- Midterm Evaluation – 10%
- Final Exam – 50%
- Class Participation – 10%

Written assignment
The assignment takes the form of a review and discussion of 2–3 journal articles about one topic of the course (around ten pages); each instructor formulates a number of topics and names the research articles that should be reviewed; the student can choose her/his preferred topic.

Mid-term evaluation
The mid-term assessment is an in-class oral presentation connected to the written assignment mentioned above. The students present their assignments, answer further questions by the lecturer and the fellow students and discuss it in the course. Presentations will be held during the sections that the topic belongs to, respectively.
Final exam
The final assessment is a written exam and tests the students’ overall knowledge and ability to analyze the concepts presented during the course.

Class participation
As the students are expected to come to class having completed required readings and join the seminar discussions, participation in the seminar discussions based upon the compulsory readings and teaching introductions given by the instructors will be evaluated.

LEARNING OUTCOMES:
By the end of the course students will be able to:

- Distinguish the general forms of renewable energy and the technologies for converting the different primary sources into secondary and final energy.
- Estimate the efficiency of conversion of different types of technologies for using renewable energy.
- Calculate annual energy yields of different renewable energy sources.
- Research and analyze basic technological aspects of using renewable energy sources.
- Analyze and discuss the potential of renewable energies to contribute to satisfying the energy demand of a country.
- Compare the environmental impact of different renewable energy technologies and contrast it to fossil and nuclear energy usage.
- Evaluate the consequences of a massive use of renewable energy technologies.
- Understand possible approaches and system designs for 100% renewable energy systems for Germany.
- Critique national, European and foreign energy policy measures for support of renewable energy.
- Investigate the technical problems that fluctuating renewable energy sources pose to the electricity grids.

ATTENDANCE POLICY: IES Abroad courses are designed to take advantage of the unique contribution of the instructor and the lecture/discussion format is regarded as the primary mode of instruction, regular class attendance is mandatory. Every unexcused absence will lower your grade by 5%. Tests/presentations missed during unexcused absences cannot be made up. If you miss a class it is your responsibility to make up on everything that was covered in class. If you can’t attend class because you are sick please go and see a doctor. S/he will issue a doctor’s note. Without that your absence will count as unexcused absence.

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<th>Session</th>
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<td>1</td>
<td>Overview of Renewable Energy Technology and Their Potential</td>
<td>This session gives a presentation of the course content followed by an overview of the different forms of renewable energy and the assessment of their theoretical, technical and economic potential. Concepts for comparing the environmental impact of different energy technologies (both conventional and renewable) are discussed. Policy measures for the support of renewable energy sources are presented and compared.</td>
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Required Readings:
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<th>Photovoltaics</th>
<th>Recommended Readings:</th>
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| 2 | The students will gain understanding of the principle of photovoltaic energy conversion, the elements of industrial solar cells and modules as well as the production technology. Different characterization methods and optimization strategies are discussed. | • Goetzberger, A. and V. Hoffmann. *Photovoltaic solar energy generation*. Berlin, Heidelberg: Springer, 2005.  

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<th>Biomass Energy</th>
<th>Required Readings:</th>
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| 3 | During this session, an overview is given on the different technologies in biomass energy conversion. Detailed presentation and discussion on biogas technology with focus on bio-methane is followed by hydrothermal carbonization. Application to fertilization of exhausted soils with bio-coal is presented. | • Khanal, S. K. (ed). *Bioenergy and biofuel from biowastes and biomass*. Reston: American Society of Civil Engineers, 2010.  

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<th>Solar Thermal Energy Conversion and Applications</th>
<th>Recommended Readings:</th>
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<th>Energy Efficiency in Buildings</th>
<th>Recommended Readings:</th>
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<td>5</td>
<td>Building Automation as a key tool for buildings’ energy efficiency will be introduced. Monitoring of thermal building behavior will be discussed and shown based on R&amp;D demonstration buildings. New technology like predictive building control will be explicated.</td>
<td>• Bollin, Elmar: <em>Automation regenerativer Wärme- und Kälteversorgung von Gebäuden</em>. Wiesbaden: Vieweg+Teubner Verlag, 2009.</td>
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<th>Wind Energy</th>
<th>Required Readings:</th>
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<td>6</td>
<td>The potential of wind energy is discussed. The students learn about statistical analysis of wind as a resource. Wind turbine types are classified and their components are</td>
<td>• Ackermann, Thomas: <em>Wind Power in Power Systems</em>. Chichester, UK: John Wiley &amp; Sons, 2005.</td>
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<tr>
<td>Session</td>
<td>Topic</td>
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<td>7</td>
<td>Hydro Power</td>
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<td>8</td>
<td>Electricity Grids, Intelligent Coordination and Energy Storage</td>
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**Hydro Power**

The potential of hydro power is discussed. The students learn about statistical analysis of the resource, namely about hydrographs. Hydro power plants are classified and their components are explained. Further, it is explained how the annual energy yield can be derived by hydrographs and in combination with the hydro power equation. Finally, selected topics which are important for project developments are discussed, e.g. the assessment of environmental effects.

**Required Readings:**


**Electricity Grids, Intelligent Coordination and Energy Storage**

The last session discusses the technological and organizational challenges posed by the integration of larger scales of fluctuating renewable energy sources into the power grid. The resulting need for grid extensions and congestion management are evaluated, and possible solutions from the area of smart grids are presented. In addition, available technologies for energy storage are introduced and their possible applications in a sustainable energy system are discussed. Finally, economic aspects of the given solutions are considered.

**Required Readings:**


**REQUIRED READINGS:** See readings specified for each session.

**RECOMMENDED READINGS:**


Additional recommendations will be given from each professor during the course.