INTRODUCTION

This course gives an overview of the use of solar (thermal and photovoltaic), hydroelectric, wind, geothermal, ocean thermal, wave, tidal and geothermal energy, as well as energy from biomass. Issues relevant to energy efficiency and energy storage are discussed.

The potential of using renewable energy technologies as a complement to, and, to the extent possible, replacement for conventional technologies, and the possibility of combining renewable and non-renewable energy technologies in hybrid systems are analysed. Strategies for enhancing the future use of renewable energy resources are presented.

Lectures/presentations are given by both program specialists and experts from relevant fields of industry and research. A visit to a modern renewable energy plant/facility is arranged for the students at the Stockholm Campus.

Objectives

The purpose of this course is to provide an overview of the most important renewable energy resources, and the technologies for harnessing these within the framework of a broad range of simple to state-of the-art advanced energy systems. After completion of the course, students will be able to:

- Describe the fundamentals and main characteristics of renewable energy sources and their differences compared to fossil fuels.
- Explain the technological basis for harnessing renewable energy sources
- Recognize the effects that current energy systems based on fossil fuels have over the environment and the society
- Describe the main components of different renewable energy systems
- Compare different renewable energy technologies and choose the most appropriate based on local conditions
- Perform simple techno-economical assessments of renewable energy systems
- Perform and compare environmental assessments of renewable energy systems and conventional fossil fuel systems
- Design renewable/hybrid energy systems that meet specific energy demands, are economically feasible and have a minimal impact on the environment
- Suggest the best combination of technological solutions to minimize the emission of greenhouse gases and increase the sustainability of the energy system in specific areas/regions
- Discuss how to utilize local energy resources (renewable and non-renewable) to achieve the sustainable energy system
Content

Block 0: Introduction and Overview
1. Course introduction
2. Introduction to Computerised Educational Platform
3. Introduction to Renewable Energy Technology

Block 1: Solar-Derived Renewable Energy
1. Solar Thermal Energy
2. Photovoltaics
3. Wind Energy
4. Biomass
5. Hydropower
6. Wave Energy
7. Ocean Thermal Energy Conversion

Block 2: Non-solar Derived Renewable Energy
1. Tidal energy
2. Geothermal energy

Block 3: Renewable Hydrogen

Teachers and other persons involved

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LITERATURE
- Boyle, Godfrey; 2004
  Renewable Energy: Power for a Sustainable Future, 445 SEK
- WebCompEdu, 200 SEK;
- Handouts in Bilda
- Reference library (located in the reception at KTH – Stockholm and at each of the 10 other SEE campus)
Course Assessment

Approval on Examination (A-E), approval of Home Assignments and Quizzes (A-E).

Examination 4.5 HP
Home assignments and quizzes 1.5 HP

Home Assignments and Quizzes (1.5 course credit)

Quiz
2 times during the course a control quiz will be given to the students. The quizzes will be available online in Bilda for 1 day (from 8:00 until 21:00 Swedish time) with limited time duration and will consist of multiple choice questions divided by topics. The quizzes will be organized as follows:

- The first quiz will include questions about renewable energy, wind energy, solar energy and biofuels. This quiz will be done in the middle of the course (4 or 5 weeks after the course officially started). The quiz will last for 12-15 minutes and each question has only 1 correct answer (besides those questions where it is specifically stated that 2 alternatives must be chosen).
- The second quiz will consist of questions about hydropower, biomass, geothermal energy, renewable hydrogen and energy storage. This quiz will be done at the end of the course (close to the last lecture). The quiz will last for 12-15 minutes and each question has only 1 correct answer (besides those questions where it is specifically stated that 2 alternatives must be chosen).

The exact dates for the quizzes will be announced in advance in the course schedule. The quizzes will deal with the fundamentals and main characteristics of renewable energy sources and their differences compared to fossil fuels as well as the technological basis for harnessing them.

Home Assignments
Four compulsory home assignments are part of the course evaluation. The home assignments will be published in Bilda and must be submitted in Bilda according to the deadline specified for each assignment. These home assignments will deal with the main renewable energies and most important technological, economical and environmental aspects associated with them.

Each home assignment counts for 20 points. Both quizzes also count for 20 points. In total, the quizzes and home assignments gives 100 points. From the total 100 points, 50 points are required to pass.

Grades:

Exam (4.5 course credits)
The exam consists of 2 parts. The first part is theoretical (≈ 70% of total points) without help and one calculation part (≈ 30% of total points). On the problem part you will are allowed to have the course handouts but not solved examples or solved assignments. In total the exam gives 100 points. To pass you need at least 50 points.

Grades:
CONTENT OF THE COURSE

Block 0: Introduction and Overview

0.1 Course Introduction and Introduction to Computerised Educational Program (1h)

Teacher: Marianne Salomon

Literature
Software: CompEdu

Teaching Units: 1
Learning Units: 2

0.3 Field Overview (3h)

An overview of the different Renewable Energy Technologies. In this review it is included a description of the renewable source, current status, importance, potential and future trends.

Teacher: Marianne Salomon

Literature
Course Material: available in the course homepage
Book: Boyle 2004, pp 2-15
Software: CompEdu S9B1C1: Introduction to Renewable Energy

Teaching Units: 3
Learning Units: 6

Block 1: Solar-derived Renewable Energy

1.1 Solar Thermal Energy (4 h)

Solar radiation can be converted into useful energy directly, using various technologies. It can be absorbed in solar ‘collectors’ to provide solar space or water heating at relatively low temperatures. Buildings can be designed with ‘passive solar’ features that allow solar energy to contribute to their space heating requirements. Small solar collectors are widely used to supply domestic hot water in several countries. It can be concentrated by parabolic mirrors to provide heat at up to several thousand degrees Celsius, and these high temperatures may then be used either for heating purposes or to generate electricity.

Teacher: Anjane Krothapalli

Literature:
Course Handouts
Book: Boyle 2004, pp 18-64
Software: CompEdu S9B5C1: Introduction to Renewable Energy
S9B5C1: Solar Thermal Energy

Teaching Units: 8
Learning Units: 12
1.2 Photovoltaics (4h)

Solar radiation can also be converted directly into electrical energy using photovoltaic devices (solar ‘cells’). The photovoltaic cell is a device which can harness an energy source that is by far the most abundant of those available on the planet. It is estimated that the total annual solar energy input to the earth is more than 15 000 times as great as the earth’s current yearly use of fossil and nuclear fuels.

Teacher: Anjane Krothapalli

Literature
Course Handouts
Book: Boyle 2004, pp 66-104

Teaching Units: 6
Learning Units: 10

1.3 Wind Energy (10h)

Wind energy offers the potential to generate substantial amounts of electricity without the pollution problems of most conventional forms of electricity generation. Its environmental costs, mainly in the form of visual intrusion, are different from those of conventional electricity generation. Wind energy has been used for thousands of years for milling grain, pumping water, and other mechanical power applications. Today, there are over one million windmills in operation around the world; these are used principally for water pumping. Whilst the wind will continue to be used for this purpose, it is the use of wind energy as a pollution-free means of generating electricity on a potentially significant scale that is attracting most current interest.

Teacher: Thomas Ackermann, Lennart Söder

Literature
Course Handouts
Book: Boyle 2004, pp 244-296
Software: CompEdu S9B2C1: Introduction to Wind Energy

Teaching Units: 10
Learning Units: 16

1.4 Biomass (10h)

Another important category of solar-derived renewable energy sources is biological. Green plants absorb sunlight in photosynthesis, which uses carbon dioxide and water to form sugars which, in turn, form the basis of all the plants’ more complex molecules. So-called ‘biomass’ from plants is one of the major world fuel sources, especially in the ‘Third World’, where provides some 40% of requirements. It is also important in some of the forest-rich parts of the industrial nations (8% in Sweden, 14% in Canada).

Teacher: Reza Fakhrai, Miroslav Petrov

Literature
Course Handouts
Book: Boyle 2004, pp 106-146
1.5 Hydropower (8h)

Hydropower is well established as one of the principal energy-producing technologies around the world, providing some 20% of the world’s electricity. In the developing world this proportion rises to around 40%. The capacity of large hydroelectric schemes can be several times that of a conventional power station. They are highly efficient, reliable and long lasting. They are also very controllable and add an element of storage into the electricity supply system.

Teachers: Thomas Sandberg, Marianne Salomon

Literature
Software: CompEdu S9B3C1: Hydropower
S9B3C2: Small-scale Hydropower
S9B3C3: Dam Design
S2B7C1: Hydraulic Turbines

Teaching Units: 8
Learning Units: 12

1.6 Wave Energy (1h)

Ocean waves are generated by wind passing over stretches of water. A variety of designs for devices for extracting energy from waves have been proposed. Experimental versions of several have been tested, but the technology has not yet reached the commercial stage. Several countries, including the UK, have significant potential for using wave energy.

Teacher: Marianne Salomon

Literature
Course handouts
Book: Boyle 2004, pp 298-340
Software: CompEdu S9B7: Lecture Notes on Ocean Energy

Teaching Units: 1
Learning Units: 2

1.7 Ocean Thermal Energy Conversion (1h)

The technology for generating electricity from different ocean temperatures is known as "ocean thermal energy conversion," or OTEC. OTEC makes use of the difference in temperature between the warm surface water of the ocean and the cold water in depths below 2,000 feet to generate electricity. As long as a sufficient temperature difference
(about 4.5 °C) exists between the warm upper layer of water and the cold deep water, net power can be generated.

Teacher: Marianne Salomon

Literature:
Course handouts
Software: CompEdu S9B7: Lecture Notes on Ocean Energy

Teaching Units: 1
Learning Units: 2

Block 2: Non Solar-derived Renewable Energy

2.1 Tidal Energy (1h)

The gravitational forces between the earth and the moon cause them to rotate around one another in a 28-day cycle. Another result of those forces tidal ‘bulge’ in the sea facing the moon, and another tidal ‘bulge’ on the opposite side of the earth, due to centrifugal force generated by the mutual rotation. There are certain sites, where geographical features create natural funnels and resonance effects, which concentrate and amplify the tides. Some sites, have the potential to produce as much electricity as several large conventional power stations.

Teacher: Marianne Salomon

Literature
Course handouts
Book: Boyle 2004, pp 196-241
Software: CompEdu S9B7: Lecture Notes on Ocean Energy

Teaching Units: 1
Learning Units: 2

2.2 Geothermal Energy (4h)

The interior of the earth is very much hotter than its surface, with estimated temperatures of several thousand degrees Celsius. This high temperature was originally caused by the gravitational contraction of the earth when it was formed, but this has since been enhanced by the heat from the decay f the small quantities of radioactive materials contained within the earth’s ore. There are some places where the hot rock is very near or actually on he earth’s surface and heats water in underground aquifers. Such places have provided hot water or steam for centuries.

Teacher: Marianne Salomon

Literature
Course handouts
Book: Boyle 2004, pp 342-382
Software: CompEdu S9B6C1: Introduction to Geothermal Energy
Block 3: Renewable Hydrogen (3h)

Hydrogen and electricity are often considered as complementary energy carriers for the future. Hydrogen has some unique properties, which in conjunction with electricity make it an ideal energy carrier or fuel. Just as electricity hydrogen can be produced from any energy source, including the renewable energy sources. Hydrogen can be produced from electricity and can be converted into electricity at relatively high efficiencies. Some processes for hydrogen production directly from solar energy are also being developed. Hydrogen as an energy currency is environmentally compatible, since its production from electricity (or directly from solar energy), its storage and transportation, and its end use do not produce any pollutants (except some NOX if hydrogen is burned with air) or any other harmful effects on the environment. It also does not produce any greenhouse gases, particularly CO₂.

Teacher: Lars Pettersson

Literature
Course Handouts

Teaching Units: 1
Learning Units: 3
The books given in the reference list are available in this student library. There are around 10 books of each title that are possible to be borrowed by the students.

The personal at the reception is responsible for the key, please contact the present responsible person. **Monday 09.00-10.00 and Friday 14.00-15.00**

**Rules to borrow a book:**

- The key-responsible take name and phone number from the student borrowing a book. He/she also writes down the book title and book number.

- The student who borrowed the book Monday should return it on Friday and for student borrowed the book Friday should return it on Monday. This so that no one sits on a book several weeks and the library is empty. To return a book together with the note, again contact the key-responsible so that he/she notes this on the list.

- It is only allowed for a student to borrow **one title at time**, so one title must be returned before borrowing the next.

- **It is not allowed to copy whole chapters from any book.** According to international copyright laws only isolated pages, figures, etc are allowed to be copied and only for own private use.

- **Please do not to lend the book to another person in the class** without contacting the key-responsible, so that he/she can note this on the loan-list.

- If a book disappears, it should be compensated for by the person signed on the list presently having the book (Each book has a number).

*Note that this is a service from the department in order to cut the expenses for each student individually. We don't earn anything else than more work on this service. We hope therefore that all students will co-operate in order to make this work smoothly and that and all books are returned to the library when the course has finished.*