SYLLABUS VT21

MJ2412 Renewable Energy Technology- Advanced Course (6 ECTS)

Course Leader and Examiner: Assist. Prof. Dr. Justin Chiu, Department of Energy Technology

Lecturers: Assist. Prof. Dr. Justin Chiu (Energy Storage), Dr. Rafael Guédez (Solar Energy), MSc. Jose Garcia (Solar Energy), CEO Dr. Thomas Ackermann (Wind Energy), Prof. Dr. Andrew Martin (Bioenergy).

Introduction

The intention of Renewable Energy Technology – Advanced course is to give students a deeper knowledge and understanding on technological aspects of most promising and rapidly developing renewable energy systems. This course goes into details of three main renewable energy systems: Solar Energy systems (photovoltaics and thermal), Bioenergy systems, Wind Energy systems; and covers Energy Storage. This course aims to develop the knowledge and skills of students to analyze the potential of appropriate renewable resources and to deliver renewable energy solutions to meet the societal energy demand.

Students joining this course should have a basic knowledge in Solar, Wind and Bioenergy conversion technologies as well as an understanding on potential resources. The prerequisite for joining this course is the successful completion of the Renewable Energy Technology introductory course (MJ2411) or equivalent.

These three areas of renewable systems have attracted particular interest in recent years where energy supply and climate change are of critical concern. The selection of these three areas of renewable systems and energy storage is a follow-up from the previous course. These three renewable energy resources will not solve major energy issues in the short term, but they will most likely be vital ingredients of future energy mix worldwide.

Bioenergy, particularly the biomass-based fuels have attracted much interest due to their ample supply in some countries and favorable environmental characteristics, if properly managed. Bioenergy systems would be highly important in the holistic renewable energy picture as bioenergy can provide system needs of energy storage cost effectively. Biomass is an indigenous energy source, available in most countries and its multifaceted applications diversify fuel-supply, which in turn leads to a more secure energy supply. Biomass is available either through natural plant growth processes, or as a by-product of human activities, i.e. organic wastes. There is however a growing concern about energy crops competing with food production, so researchers are now focusing on the second generation fuels by considering feedstocks. The effective capture and continued sustainability of this renewable resource requires a new generation of biomass power plants with high fuel energy conversion. The topics covered here are Applied Combustion, Fluidized Beds, and Chemical Equilibrium & Kinetics.

Solar energy on the other hand has so far been more of a niche market development (e.g. microscale distributed generation via photovoltaics, solar hot water heating, etc.) owing to high investment costs, but it has a large potential in the future. Solar thermal systems can help significantly reduce fossil-based heating/cooling needs as the demands can be covered by this renewable source. Solar thermal is also highly promising for kW and MW scale electric power generation via concentrating solar power (CSP) systems; here steam Rankine cycles are commercially available, and more efficient Brayton cycles may soon be on the horizon. This course treats CSP technologies in detail.

The importance of wind turbine as a commercial technology in the current energy systems has already made its justification; its role in the reduction of greenhouse emissions has been identified by governments and energy planners. This subject has acquired a great improvement from the engineering side. A significant change in the economic viability of wind energy has occurred because of technology improvements, while social acceptance is rising among the energy industry and the public due to the steady increase in environmental awareness and to the successful information dissemination of the Kyoto protocol. This course is intended to provide a thorough and highly accessible introduction to the cross-disciplinary field of wind turbine engineering and technology, with focus on topics like small-scale and hybrid systems.

Energy storage is essential in securing a stable electricity grid and thermal network (district heating and cooling) when integrating intermittent renewable energy resources to the energy system. Electricity and thermal energy peak shaving and load shifting are two of the main outcome of the storage systems; a non-exhaustive list of benefits are 1. Energy arbitrage, 2. General capacity deferral, 3. Transmission and distribution deferral, 4. Ancillary services, 5. Reduction of energy curtailment. Here, we will have a closer look at the storage components from an engineering perspective.

Learning Outcomes

At the end of the course, the students should be able to analyze and design energy systems with storage to supply the electricity/heating/cooling requirements using wind energy, bioenergy and/or solar energy resources. The ILOs and corresponding tasks are shown below

ILO	Tasks
1. Compare the effects that renewable energy systems and fossil fuel based energy systems have over the environment and the society.	- In class discussion - Project work
2. Understand in detail the fundamentals and the main characteristics of wind energy, bioenergy and solar energy.	- Lab work - Attend modules in wind, bioenergy and solar
3. Explain the technological basis for harnessing these renewable energy sources.	- In-class exercise solving tutorials - Attend energy storage module - Written examination
4. Design and dimension technological solutions with storage based on wind energy, bioenergy or solar energy that meet specific energy demands, that are suitable for local conditions, that are economically feasible and that have a minimal impact on the environment.	- Project work - Project work peer review and discussion

Grading Criteria

The following grading criteria will be the basis of evaluation on the performed tasks:

ILO	E (minimum pass requirement)	C	A
1. Compare the effects that renewable energy systems and fossil fuel based energy systems have over the environment and the society.	Distinguish the difference between renewable and non-renewable energy sources.	Same as E, and in addition explain the impact of renewable/non-renewable on the environment and the society.	Same as C, and evaluate the pros and cons of both renewable and non-renewable energy sources.
2. Understand in detail the fundamentals and the main characteristics of wind energy, bioenergy and solar energy.	Distinguish the energy sources and their origins.	Same as E, and discern the availability and potential of the sources.	Same as C, and evaluate the pros and cons of each of the energy sources.
3. Explain the technological basis for harnessing these renewable energy sources.	Distinguish the different technical components in these technologies.	Same as E, and in addition discuss the technical features of the different components in each of the technologies.	Same as C, and analyze the pros and cons of different component types in each of the technologies.
4. Design and dimension technological solutions with storage based on wind energy, bioenergy or solar energy that meet specific energy demands, that are suitable for local conditions, that are economically feasible and that have a minimal impact on the environment.	Map the user demand and identify the necessary boundary requirements for each of the technologies.	Same as E, and analyze techno-economic aspect of each of the technologies.	Same as C, and evaluate the design and dimensioning taking into account the environmental and social aspects.

Target Group and Prerequisites

This course is mandatory for students following the Sustainable Power Generation (SPG) Specialization in the SEE Program (TSUEM) and ISEE Program (TIEEM) in Semester 2. This course is track specific for SELECT and RENE Programs.

Completion of MJ2411 Renewable Energy Technology (6 hp) or equivalent prior to the start of this course is a prerequisite.

Activities and Assessment

- Lectures
  - Introduction (2 hr)
  - Solar Thermal (4 hr)
  - Solar Photovoltaic (4 hr)
  - Wind (6 hr)
  - Energy Storage (6 hr)
  - Panelists Seminar on Industrial Experience: Solar + Energy Storage (2 - 3 hr)
  - Biomass (6 hr)
  - Lectures will be offered on line (due to COVID) and will be recorded.

- Tutorials (problem solving in class)
  - Dedicated tutorial for Solar Thermal and Solar Photovoltaic (2 hr)
  - Dedicated tutorial for Wind and Storage (2hr)
  - Biomass and Energy Storage: problem solving will be done together with the lectures, students should be prepared to take notes.

- Lab Assignment (LABA, 1.5 ECTS)
  - Fluidized bed laboratory session, please sign-up for one session among the proposed slots
  - Report including additional calculations, one per group
  - A number of online sessions will be made available for distance based students
  - Graded with pass/fail

- Project (PRO1, 1.5 ECTS) (compulsory project assignment)
  - Group project in Renewable Energy System Establishment
  - Report and oral presentation, one per group
  - Letter grades assigned for each group as follows: A 100-90%; B 89-80%; C 79-70%; D: 69-60%; E 59-50%; Fx 49% and F below

- Exam (TENA, 3.0 ECTS)
  - Due to COVID situation, the exam in 2021VT will be given as a home exam where exam questions will be made available on the exam day. The students will need to send back the answers to the home exam by the deadline.
  - Letter grades assigned as follows: A 100-90%; B 89-80%; C 79-70%; D: 69-60%; E 59-50%; Fx 49% and F below

Final Grade

The final grade is determined by the weighted numerical sum of PRO1 and TENA, using the grading scale indicated above to determine the letter grade:

Letter grades assigned as follows: A 100-90%; B 89-80%; C 79-70%; D: 69- 60%; E 59-50%; Fx 49% and F below

Final grade [%] = (1.5·PRO1 [%] + 3.0·TENA [%]) / 4.5

Note that LABA, PRO1 and TENA must be passed in order for the final grade to be issued. Furthermore the grade issued for PRO1 is final for grades A-E (i.e. it is not possible to improve a grade via re-submission of revised report).

Late Assignments

Reports for LABA and PRO1 must be uploaded to CANVAS by the deadline. Late assignments may be resubmitted during the next occasion this course is given (i.e. the following year).

Lecture Schedule

Please see the separate excel file (course schedule MJ2412)

Lab Schedule

Ten lab meetings have been scheduled during w. 7- w. 9 (Feb 17th – Mar 3rd), as indicated in the official schedule. Sign-up lists will be made available on CANVAS. Each group signs up for one session only.

Lab Responsible: Justin Chiu, Phone Number: 087907414

Oral Presentation (PRO1)

The oral presentations will be held on 2021 March 5th 08:00-12:00 and 2021 March 5th 13:00-17:00. Half of the class will present in the morning and half will present in the afternoon.

Assignment Deadlines and Exam

5 days after own lab session	LABA group report submission
26 Feb	PRO1 group report submission for peer review
5 Mar	PRO1 oral presentation
12 Mar	PRO1 group final revised report submission
16 Mar	TENA Exam
10 Jun	Re-exam

Recommended Reading Materials

Note: Almost all are available on-line through KTH Library

L. Rosendahl (editor), Biomass Combustion Science, Technology and Engineering, Woodhead (2013).

Wiebren de Jong & J. Ruud van Ommen (editors), Biomass as a Sustainable Energy Source for the Future, Wiley (2015).

Soteris Kalogirou, Solar Energy Engineering - Processes and Systems, Elsevier (2009).

Alois Schaffarczyk, Understanding Wind Power Technology, Wiley (2014).

Burheim Odne Stokke, Engineering Energy Storage, Elsevier (2017).

Additional Reference Materials

Note: (Almost all are available on-line through KTH Library)

CompEdu, Computerized Educational Platform in Heat and Power Technology, available at www.energy.kth.se/compedu

Robert Huggins, Energy Storage Fundamentals, Materials and Applications 2nd ed. Springer (2016).

William B. Stine, and Michael Geyer, Power From The Sun (2001). Available at www.powerfromthesun.net

William Shepherd and Li Zhang, Electricity Generation Using Wind Power, World Scientific (2011).

Donald L. Klass, Biomass for Renewable Energy, Fuels, and Chemicals, Elsevier (1998).

Prabir Basu, Circulating Fluidized Bed Boilers: Design, Operation and Maintenance, Springer (2015).

Prabir Basu, Biomass Gasification, Pyrolysis and Torrefaction - Practical Design and Theory, 2nd edition, Elsevier (2013).

Prabir Basu, Combustion and Gasification in Fluidized Beds, CRC Press (2006).

Bruce Miller and David Tillman, Combustion Engineering Issues for Solid Fuel Systems. Elsevier (2008).