A EUROPEAN M.Sc. COURSE

SOLAR ENERGY: TECHNOLOGY AND *MANAGEMENT*

MODULE SPECIFICATIONS

1. Module Title: Basics II: Overview of Solar Energy Conversion

2. Credits: 8 ECTS credits

3. Keywords

Energy policy; energy sources; primary energy; energy storage. Passive solar energy, Solar collectors & solar heating. Photovoltaics; Solar cells, PV modules, Wind energy. Hydrogen technologies. Solar power plants, (small) hydropower, Thermophotovoltaics, Biomass Simulation, efficiency, sustainability, economics. Principles of economics into energy and R.E.S. applications.

4. Prerequisites: General requirements for the admission to the Master programme.
Co-requisites: Basics I

5. Summary

This module gives an overview on the whole variety of solar energy conversion and its background. Without going too much into details, the following topics are treated: Reasons and ways to a sustainable solar energy supply; energy storage, passive and active thermal use of solar energy: Photovoltaics and Wind energy.
Hydrogen systems, large scale power plants, Biomass, Hydropower and Thermophotovoltaics are optional topics, which are either treated all together in a short, descriptive manner, or selectively in comparable detail to the main topics.
This choice offers a teaching flexibility taking special skills of the teacher or special wishes of the students into account.
Matlab simulation and C++ programming with applications on R.E.S. systems, simulation techniques through the energy balance equation, to order to assess and predict Solar Energy, performance and sizing of R.E.S. systems.

6. Objectives / Skills

On successful completion of this module students should be able to:

1. Describe how a change in energy supply from today's standard (fossil and nuclear) to a solar dominated sustainable energy supply can be performed and which mandatory steps have to be followed,

2. Understand, describe and size storage devices (water tanks, batteries, etc.) for solar thermal and electric systems,
3. Understand principles and basics of passive solar energy use in buildings for heating and daylighting as well as their drawbacks and possible countermeasures in summer (sun and glare protection),
4. Know the most important collector types and collector systems: flat-plate, vacuum tube collectors, thermosyphon systems, small systems for DHW solely and for DHW with heating support, large systems with central storage, application principles, sizing procedures and corresponding "rules of thumb", cost estimations and economy,
5. Describe solar cells, PV modules and generators as well as complete PV systems both stand-alone and grid-connected, application principles, sizing procedures and corresponding "rules of thumb", cost estimations and economy,
6. Explain the drag and lift principle in wind energy conversion, the wind power potential, mechanical and electrical principles of wind energy conversion
7. Prove a general knowledge of biomass, thermophotovoltaics, large scale solar power plants and hydrogen systems, or alternatively.
8. Have a more detailed knowledge of one of these topics and
9. Use principles of economic considerations undertaking cost analysis studies
10. Simulate with advanced programming of regular and understand the principles to size and product performance of R.E.S. systems.

7. Content / Knowledge base

1. Energy supply:
   Energy resources, energy, primary energy, From fossil and nuclear to solar energy supply: sustainable energy supply
2. Energy storage:
   Hot water storage (DHW); large scale heat storage, e.g. for district heating "passive" storage (in buildings); battery storage
3. Passive use of solar energy:
   Building location, windows, transparent insulation, sun and glare protection, natural ventilation, rational use of energy, thermal and visual comfort
4. Thermal (active) use of solar energy for DHW:
   Heating flat plate collectors, vacuum tube collectors, DHW systems, district heating systems, simple sizing procedures
5. Photovoltaics cells:
   modules, stand-alone and grid-connected systems, storage, simple sizing procedures
6. Wind energy conversion;
   drag and lift principle, types of wind energy converters, examples, possible locations, technological problems, controls
7. Hydrogen systems;
   Fuel cells, electrolysers and applications
8. Large-scale power plants; parabolic troughs, solar tower upwind power plants
9. Small-scale hydro power
10. Thermophotovoltaics
11. Biomass

12. Simulation and programming: Simple simulation or worksheet methods for quick determination of solar fractions, efficiencies and R.E.S. systems performance, in particular .

8. Learning Strategies/ Activities	**Hours**	**Comments**
Lectures	40	A large spectrum of bibliography and overview of R.E.S. objectives
Practical/Laboratories	20	Measurements of quantities as in no.7
Tutorials/Seminars	10	
Computer Laboratory	20	
Student management learning	110	
Total hours	**200**	

9. Assessment	**Weight %**	**Comments**	**Outcomes Tested**
Tests	30%	*In class with any ref. Available*	*Ability to analyse, calculate & compare*
Assignments	40%	*A case study assigned to each student*	*Ability to analyse calculate, compare and innovate or apply*
Lab work	30%	*Lab experiments*	*Data analysis comprehension & confidence*

10. References

1. Brosicke, W., *Sonnenenergie,* Verlag Technik Berlin, 2000
2. Duffie, J. and W. Beckman: *Solar Engineering of Thermal Processes,* John Wiley & Sons, New York, 1991
3. Quaschning, V., *Regenerative Energiesysteme,* Carl Hanser Verlag Miinchen Wien, 1999
4. F.Kreith/J.F.K. Kreider, “Principles of Solar Engineering” McGraw Hill Book co 1978
5. J.R. Simonson, “Computing Methods in Solar Heating Design” McMillan Press, London, 1984
6. Sick, F and Erge, T.” Photovoltaics in Buildings” James & James, 1997
7. P.J. Lunde, “Solar Thermal Engineering” John Wiley & Sons, 1980
8. S.Kaplanis: Overview of Renewable Energies (in CD)
9. M.Meliss: Regenerative Energiequellen, Springer Verlag
10. Solar Collector Systems and testing Group, E.C.Publications, J.R.C. ISPRA

11. Resources

Reference books as in no. 10. Case studies and reports. Course material
Journals like: Solar Energy, Renewable Energy, Solar Energy Materials, Solar Physics
Conference Proceedings.

1. Computer pool and simple system sizing tools
2. Laboratory
    a. Solar Thermal: collector efficiency, characteristic curves, stagnation temperature
    b. PV: efficiency, characteristic curve, series and parallel connection
    c. rage: thermal, electric, chemical storage
    d. Daylight measurements: luminance, illumination, glares
3. Several PV-cells
    a. Electrical measurements devices for current, voltage and power
    b. Lamps as light source for PV measurements
4. Lead - acid battery
    a. Charge controller
    b. small collector – pump – storage system
5. Luminance meter
    a. Illuminance meter
    b. Thermometers/thermocouples
6. Small data acquisition
7. PC for data evaluation

Tools (examples): T-SOL, PV-SOL, TRANSYS, other software developed as in no.12.

12. Thesis projects, Case studies, Publications, Reviews and other issues related to the module

1. An investigation of the degreedays concept and subsequent evaluations for the region of Achaia, W. Greece.
   A project led by TEI Patra, Greece
2. A comparative study of the clearness index for the region of Achaia, using various techniques.
   A project led by TEI Patra, Solar Lab
3. Hourly and Daily clearness index for Achaia region, W. Greece, generated by various techniques.
   A project report with a review led by TEI Patra, Solar Lab
4. Measurements of cylindrical concentrating collectors.
   A final year joint project between TEI Patra and Transilvania University of Brasov in Romania
5. Solar Air Heaters. Design Construction applications to Buildings and Agriculture.
   Projects by the Universities of Applied Sciences in Aachen and Berlin and TEI Patra.