Faculty of Health, Science and Technology
Environmental and Energy Systems

Syllabus

Optimization of Environmental and Energy Systems

Course Code:	EMAD11
Course Title:	Optimization of Environmental and Energy Systems *Energi- och miljöoptimering*
Credits:	15
Degree Level:	Master's level
Progressive Specialisation:	Second cycle, has only first-cycle course/s as entry requirements (A1N)

Major Field of Study:
MEI (Environmental and Energy Systems)

Course Approval
The syllabus was approved by the Faculty of Health, Science and Technology 2015-11-16, and is valid from the Autumn semester 2016 at Karlstad University.

Prerequisites
Degree programme students: Completed courses totalling 120 ECTS cr for the BSc programme in Environmental and Energy Engineering (TGHEM 180 ECTS cr) or completed courses totalling 150 ECTS cr for the MSc in Energy and Environmental Engineering (TACBR-ENMI/INEN 300 ECTS cr), or admission to the MSc programme Environmental Energy and Engineering (TAMEM 120 ECTS cr).

Non-programme students: General admission requirements to undergraduate studies and completed courses totalling 60 ECTS cr, including at least 7.5 ECTS cr in classic thermodynamics, at least 15 ECTS cr in energy engineering and at least 15 ECTS cr in mathematics or equivalent.

Learning Outcomes
Upon completion of the course, students should be able to:
- apply the calculation instrument MATLAB to perform graphic processing of data and to handle data amounts in the form of vectors and matrices,
- identify constants and variables of given energy engineering systems,
- identify and model linear equation systems with constraints and goal functions,
- solve linear equation systems to calculate optimal values (maximal/minimal) for the goal function,
- extend the optimization model by taking the economic and environmental restrictions of existing systems into account,

- calculate entropy generation and exergy loss in an energy system and optimize the system by determine conditions that lead to minimal entropy generation,
-make the assumptions necessary of system demarcation, reference conditions etc required to perform a well founded and consistent exergy analysis,
- calculate exergy content, reversible work, isentropic efficiency, energy loss/irreversibility and energy

efficiency for different parts of an energy system,
- apply the exergy analysis method to energy systems,
- calculate least possible work or least extractable work in a system with ideal solutions in different concentrations,
- calculate adiabatic flame temperature and energy loss in combustion processes,

- determine the pinch temperature and the minimal need of heat and cold in a given industrial process,
- design proposal for heat exchanger networks which can realize the pinch optimal solution and suggest an alternative design in which the requirement of heat recovery is dropped in favour of lower investment cost,
- suggest measures to reduce heating and cooling needs in a existing heat exchanger network,
-identify possibilities and quantify the potential for the integration of energy intensive thermal separation processes (distillation, evaporation, drying) in a process plant.

Content

The course deals with the theory and application of important methods for the optimization of energy and environmentally-friendly technological systems, that is, the systematic search for the best solution given certain circumstances and a certain goal. Example of systems to which the methods can be applied are municipal heating networks, refuse and recycling systems, the process industry, power heating plants, purification plants and national and international energy distribution systems.

The course comprises three modules:

Module 1 (5 ECTS cr): Further review of the calculation instrument MATLAB. Basic instruction of the simplex method, constraints, goal function, state variable and state space. Linear programming of combined energy and environmental optimization of existing systems. Lectures, laboratory sessions and supervision of project assignment in energy and environment system optimization with the instrument MATLAB.

Module 2 (6 ECTS cr): Thermodynamic methods for energy effectivization: entropy generation minimization, exergy analysis. Optimization with thermodynamic goal functions & constraints. Thermodynamic concepts and theory: general definition of exergy; (Dead state)/thermodynamic equilibrium; reference condition; extended system and immediate surrounding; entropy generation in interface; entropy, energy and exergy balance equations for closed and open systems; real work; useful work; surrounding work; exergy as state function; equations for energy loss and exergy change for closed system, open system with stationary flow and heat exergy in the Carnot model. Exergy loss and energy efficiency (Second Law Efficiency) for technological processes; exergy analysis for mixture and separation processes such as desalination and carbon dioxide separation; exergy analysis for combustion processes: air-fuel ratio; theoretical air quantity, air surplus, air deficiency; standard reference condition; adiabatic flame temperature. tLectures. exercises and hand-in assignments.

Module 3 (4 ECTS cr): Basic concepts such as pinch temperature, minimal need of external heating and cooling, composite curves and GCC /Grand Composite Curve) exemplified through current research and literature. Supervision of project assignment on either the design of a new system or suggestions for improvements of an existing system.

Reading List

See separate document.

Examination
Assessment is individual and each module is assessed separately.
Assessment is based on exams, project report and oral presentation.

All module components must be completed satisfactorily for a course Pass grade. The course grade is a final appraisal of grades awarded and their credit load weight.

Grades
One of the grades 5 (Pass with Distinction), 4 (Pass not without Distinction), 3 (Pass), or U (Fail) is awarded in the examination of the course and modules.

Quality Assurance
Follow-up relating to learning conditions and goal-fulfilment takes place both during and upon completion of the course in order to ensure continuous improvement. Course evaluation is partly based on student views and experiences obtained in accordance with current regulations and partly on other data and documentation. Students will be informed of the result of the evaluation and of any measures to be taken.

Course Certificate
A course certificate will be provided upon request.

Additional information
The local regulations for studies at the Bachelor and Master levels at Karlstad University stipulate the obligations and rights of students and staff.

The course contributes to the following learning outcomes required for a MSc in energy and environmental engineering:
- demonstrate the ability to create, analyse and critically evaluate different technical solutions,
- demonstrate the ability to critically and systematically integrate knowledge and demonstrate skills in modeling, simulating, predicting and evaluating processes also with limited information,
- demonstrate the ability to plan and carry out projects,
- demonstrate specialised knowledge in the field of energy and environmental engineering,
- demonstrate knowledge of sustainable application of technology,
- demonstrate the ability to search and assess current research results in energy and environmental engineering, particulraly in the form of articles in international science journals,
- demonstrate specialised insight into the potentials and limitations of energy and evironmental engineering, its role in society, and our responsibiity for how it is used, including social and economic aspects.