Reg No: EMAD25/20251

Faculty of Health, Science and Technology
Environmental and Energy Systems

Syllabus

Energy systems: exergy analysis and pinch optimisation

Course Code:	EMAD25
Course Title:	Energy systems: exergy analysis and pinch optimisation *Energisystem: exergianalys och pinchoptimering*
Credits:	10
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 2024-08-29, and is valid from the Spring semester 2025 at Karlstad University.

Prerequisites
Upper secondary level Swedish 3 or Swedish as a second language 3 and English 6

Programme students: 120 ECTS credits completed in the Bachelor programme in Energy and Environmental Engineering or 150 ECTS credits completed in the Master programme in Energy and Environmental Engineering, or admission to the Degree programme in Energy and environmental engineering towards a Master degree

Non-programme students: 60 ECTS credits of completed courses, including 7.5 ECTS credits in classical thermodynamics, 15 ECTS credits in energy engineering, and 15 ECTS credits in mathematics, or equivalent

Learning Outcomes

Upon completion of the course, students should be able to:
- calculate entropy generation and exergy loss in an energy system,
- optimise energy systems by determining conditions that lead to minimal entropy generation,
- make the assumptions about system demarcation, reference conditions, and so on required to perform a well founded exergy analysis and give an account of possible improvements,
- calculate exergy content, reversible work, isentropic efficiency, exergy loss and 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 and mixtures in different concentrations,
- calculate adiabatic flame temperature and exergy loss in combustion processes,
- determine the pinch temperature and the minimal need of heat and cold in a given industrial process,
- design heat exchanger networks according to the principles of pinch analysis and suggest an alternative design in which the requirement of maximal heat recovery is dropped in favour of lower investment cost,
- suggest measures to reduce heating and cooling needs in an existing heat exchanger network, and
- 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 energy- and environment-related optimisation of technological systems, that is, the systematic search for the best solution given certain circumstances and a certain goal. Examples 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 two modules:

Module 1 (5 ECTS cr): Thermodynamic methods for energy effectivisation: entropy generation minimisation
and exergy analysis. The 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, and exergy as state function. Equations for energy content 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 and cycles. Exergy analysis for mixture and separation processes such as desalination and carbon dioxide separation. Exergy analysis for combustion processes.

Module 2 (5 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. Examples which illustrate either the design of a new system or suggestions for improvements of an existing system.

Instruction is in the form of lectures, exercises, and supervision of a project assignment.

Reading List

See separate document.

Examination
Each module is assessed separately. Assessment is individual and based on project reports and oral presentations.

If students have a decision from Karlstad University entitling them to Targeted Study Support due to a documented disability, the examiner has the right to give such students an adapted examination or to examine them in a different manner.

Grades
One of the grades 5 (Pass with Distinction), 4 (Pass with Some Distinction), 3 (Pass), or U (Fail) is awarded in the examination of the course.

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.