Master’s in Energy Storage
Year 1, Aalto University

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<td><strong>One of the following two courses</strong></td>
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<tr>
<td>Introduction to Electric Energy</td>
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<td>Thermodynamics in Energy Technology</td>
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| Elective harmonizing courses (minimum 14 ECTS)    | -    |                 |
| Courses to complement BSc background              | -    | na              |

Introduction to Advanced Energy Solutions

Learning Outcomes:

After this course, the student must:

- Understand holistically energy systems, their components and interaction outside the system boundaries.
- Understand the basics of energy networks and markets.
- Understand the basic components of energy consumption and their influence on energy systems.
- Understand renewable energy integration into energy systems.
- Be able to develop and calculate example cases related to renewable energy and its integration into energy systems.

**Syllabus / Content:**

- Overview of conventional energy systems
- Basics on energy networks and energy consumption
- Introduction to energy markets and economics of energy generation
- Basics of renewable energy forms (e.g. solar, wind, bio, geothermal energy)*
- Integration of renewable energy into energy systems
- Economic aspects of renewable energy forms
- Energy storage in energy systems
- Introduction to developments in selected energy technology materials
- Future of energy systems

A weekly external lecture series, Energy Forum, is arranged alongside with the course. Invited industry speakers present their views on the future of the energy system and on the solutions they see forthcoming. 50 % attendance to the Energy Forum is required to pass the course.

**Evaluation Methods:** Lectures + Course Assignment + Lecture diary + Exam

For students in the Master's Programme in Advanced Energy Solutions: 50 % attendance to the Energy Forum seminar is required to pass the course.

**Link:** [https://mycourses.aalto.fi/course/info.php?id=23858](https://mycourses.aalto.fi/course/info.php?id=23858)

**Renewable Energy Engineering**

**Learning Outcomes:**
After this course, students should be able to:

- Understand what makes the use of renewable energy sources necessary but challenging.
- Understand the capacity requirements for wind and solar power plant technologies.
- Evaluate and analyze principles of wind and solar power plant operation.
- Evaluate and analyze principles of heat pump operation for heating and cooling purposes.
- Evaluate economical feasibility of these processes including levelized cost of energy.
- Understand the challenges and solutions of coupling renewable energy sources into a future energy systems.
- Analyze the available raw materials, land availability and other resources.

Syllabus / Content:

In order to decrease the CO₂ emissions from energy, transport and buildings sectors, and especially emissions coming from the fossil fuel combustion, we need to increase the share of renewable energy sources such as wind and solar power. As an integral part, heat pumps will play an important role in future energy systems as they are used to produce heat with affordable renewable electricity, instead of using combustion heat as energy source.

This course gives a compact theory review on the wind and solar power plants and heat pumps for heating and cooling applications, their operation and design principles. In addition to this, we discuss the capacity requirements and critically evaluate the available sources, including material availability issues, land use and other environmental considerations for wind and solar power. We also discuss the challenges when implementing renewable energy into a traditional energy system.

Evaluation Methods: Personal assignments, projects work.

Electrochemistry

Learning Outcomes:
After the course the student will be able to:
- Understand the thermodynamics in electrolyte solutions;
- Understand the concept of the electrochemical cell;
- Understand the most common electrochemical reactions measurement techniques.

Syllabus / Content:

Thermodynamics of electrolytes, electrochemical cells, electrochemical reactions, most common electrochemical measurement methods

Evaluation Methods: lectures, homework problems, written or oral examination.

Electrochemical Energy Conversion

Learning Outcomes:

After the course the student will be able to:
- Name the most common electrochemical cells used for electrochemical energy conversion and storage;
- Know typical applications for the above-mentioned cells;
- Know how electrochemically active materials function during electrochemical energy conversion and storage reactions;
- Apply electrochemical theories for understanding the behavior of the cells used for electrochemical energy conversion and storage;
- Apply electrochemical analysis methods for investigation of electrochemical energy conversion and storage cells;

Syllabus / Content:

Different type of electrochemical cells used for electrochemical energy conversion and storage applications are presented. These include, for example, batteries, fuel cells and
hydrogen electrolyzer. The students get acquainted with the operation of these cells and effect of the electrochemically active material properties on their performance. Assembly of electrochemical energy cells is practiced and electrochemical analysis methods used to characterize them are introduced.

**Evaluation Methods:** assignments, laboratory experiments, seminar presentation, written reports.

**Electrical Energy Storage Systems**

**Learning Outcomes:**

After this course, the student must:

- Describe operating principles of key energy storage technologies, including their benefits and fundamental limitations;
- Select relevant technologies for energy storage, including storage and conversion components;
- Design an energy storage interface for a power system or a power train, as a member working cooperatively in a small multidisciplinary team.
- Share the expertise of one field in a heterogeneous team.

The list of courses on this page are examples of possible courses you may be taking in this programme. The universities providing the courses reserve the right to cancel, postpone or reschedule any of their courses.
**Syllabus / Content:**

- Overview of energy storage and conversion technologies;
- Since different energy storage technologies have different features (e.g. capacity, energy density, efficiency, charging cycles), selecting a proper technology for a given application is studied by means of analysis and case examples;
- Developing the system level understanding of energy storage and related grid interfaces;
- Design simple energy storage systems as a member of a multidisciplinary team.

**Evaluation Methods:** Flip the classroom, personal assignments and team projects

**Link:** [https://mycourses.aalto.fi/course/view.php?id=23862](https://mycourses.aalto.fi/course/view.php?id=23862)

**Thermal Energy Storage Systems**

**Learning Outcomes:**

After this course the student must:

- Understand system level approach to thermal energy storage between Power Plants, Industry, Community and Building level;
- Prepare fundamental heat and mass balances of thermal energy storages;
- Connect the need for thermal energy storage created by both RES-Electricity and RES-Heat;
- Compare functioning of different energy storage technologies & materials;
- Able to characterize energy storage by technology, temperature, timescale;
- Apply thermal energy storages for a case study.
Syllabus / Content:

This course introduces system level approach to thermal energy storage (TES), considering the fundamentals of TES and how it can improve the sustainability of energy systems. TES is introduced by assessing the need for its application, including excess heat from industrial and energy sector installations, production and demand mismatch (Especially with RES production) and the role of consumer side incentive such as dynamic electricity and heat tariffs. A common approach is taken to all TES technologies emphasizing the importance of temperature and timescale (seasonal vs. short term). The use of TES at different levels is the assessed as follows:

- Power Plants, Industrial Level, including use of DH network for storage;
- Community level (e.g. ATES, BTES, CTES, PTES);
- Buildings (e.g. Thermal mass, phase change materials, chemical storage, DSM with HP ground heat storage (rock/soil).

Evaluation Methods: case studies, exercises, project.

Energy and Environmental Economics

Learning Outcomes:

The objective is to develop understanding of the basic problems in environmental, resource and energy economics. Tools developed for analyzing market failures and instruments to solving them. Familiarize the student with the main challenges in the energy sector, including those related to the environment.

Syllabus / Content:

Common pool resource use in theory and practice; description and analysis of resource and energy commodity markets; pollution control in theory and practice, with particular emphasis on climate change, energy and environmental policy. Main empirical cases include: investments in nuclear power; emissions trading; pricing and investments in the electricity sector.
**Evaluation Methods:**

Exercises: 3 home exercises passed  
Group work: 3 topics passed  
Case study: scoring 0-5, 40 % of the grading  
Exam: scoring 0-5, 60 % of the grading

**Introductory Entrepreneurship Project**

**Learning Outcomes:**

After this course, the student must:

- Identify the basic entrepreneurial tools and how to apply those in project preparation;
- Be able to have efficient communication in a multidisciplinary team;
- Develop the first entrepreneurial project as a part of a team and pitch for university staff and industrial mentors;
- Personal reflect on student entrepreneurial mindset development.

**Syllabus / Content:**

This course introduces the entrepreneurial concepts and mindset for students in Master's programme in Energy Storage. This course includes all added value activities during the first year. The students form teams where they start to develop their first entrepreneurial project that they will pitch to university staff and industrial mentors. These project ideas might be further developed during the second year InnoEnergy project for business creation.

**Evaluation Methods:** project pitch and written documentation, personal reflection. The list of courses on this page are examples of possible courses you may be taking in this programme. The universities providing the courses reserve the right to cancel, postpone or reschedule any of their courses.