KTH Energy Technology

Energy in the built environment, MJ2509, 9 Credits, Fall 2022

The course aims to give the students a unique knowledge of background, theory and tools related to energy use in the built environment to be able to independently use these in a future professional life.

The course intends to provide the students with relevant knowledge of the driving forces for energy in the built the environment. The course first discusses the role of the buildings and the cities, why it is one of the most important aspects to reach a sustainable future with a holistic approach to the built environment. The needs of the building are introduced and what these are influenced by (e.g. thermal comfort, air quality, heating and cooling loads). The effect of how these needs are related to climate impact are covered. Thereafter, sustainable buildings and relevant concepts are introduced and discussed for certification of buildings. The first part also studies the building from the perspective of the city, what are the consequences and the advantages, can one utilise the energy more efficient by means of nearby buildings, can they make use of one another?

The other part of the course focuses on the energy systems in buildings, with special emphasis on understanding of system properties and performance. This part of the course introduces requirements of thermal comfort and indoor air quality, supply of these through the technical systems (different types of distribution systems and production sites). Since the requirements of the building now are known, the expected annual energy and peak effect requirements will be examined (through study of energy transport through the different parts of the building). The student will be aware of the effect of the design of the building (e.g. windows, walls) and how it can change the energy requirements in buildings.

The third part of the course then focuses on production (energy transformation) units that are used to meet the energy requirements. Special focus is on solar energy systems and mechanical heat pump and cooling systems, but other types of production units are also briefly discussed (e.g. boilers, district heating and cooling systems). Furthermore be discussed how the design and the dimensioning of these units can influence the general performance of the building.

The final segment of the course will focus on the distribution systems of the building, i.e. the systems that are used to move the energy that is converted in the production units to the different zones of the building, where the needs are. Fluid and air borne systems are treated in this section. Furthermore, storing of heat is an integrated part of fluid borne systems, which is especially important when renewable energy sources are used in the building. Their function will be introduced. Large-scale supply systems in the form of district heating and cooling will also finally be discussed.

Intended Learning Outcomes (ILOs):

After passing the course, the student should be able to

1. Describe the role of buildings in cities, the needs that buildings have and the technical systems that can be used to meet these needs.

2. Demonstrate proficiency to independently estimate/calculate performance of buildings and their technical systems.
3. Explain function and behavior of components and systems when inspecting real systems.

Course Co-ordinator

Associate Professor Joachim Claesson
Office: Brinellvägen 68, Room L341.

Course Requirements

LADOK ENTRY	COURSE MOMENT	Submission deadline
TEN1 (5 hp)	One written exam	
KON1	Passing grade (E) can be awarded for TEN1 if KON1 and KON2 are passed	2022-10-14
KON2	Passing grade (E) can be awarded for TEN1 if KON1 and KON2 are passed	2022-12-13
INL1 (3 hp = 2 weeks of full time study)	Direction and measure for the future of built environment in your home country	
	Annual and peak requirement of a building	
	Refrigeration system performance predictions	
	Distribution design and performance	
LAB1 (1 hp)	LAB1-1 – Building dynamic evaluation LAB1-3 - Basic Refrigeration System LAB1-4 - Heat and mass transfer in a AHU	

1 hp is equivalent to 27 hours of full-time studies.

*Deadline for submitting reports is according table above. Submitting after these dates are **not allowed**, students failing this date are welcome back next time the course is given (fall semester 2023). For pass of INL1, all four assignment needs to be submitted and passed. If not, the entire INL1 has to be redone the next course round.*

Exam

The exam consists of two parts, TEN1-A and TEN1-B. TEN1-A is basic questions linked to each of the ILOs, and requires a pass grade (E) on all individual questions. TEN1-B is more complex questions for which the student may demonstrate higher level of understanding and skills of the topics within the course. TEN1-B will **not be corrected** unless a grade FX or higher is obtained on TEN1-A.

The exam is scheduled according to KTH central scheduling to be held in January 2023, see official schedule for exact date and time. This may be subject to change; official timing is always according KTH central scheduling. **In order to be allowed to sit in on the exam you need to register for the exam.**

Helping aids: Calculator (not pre-programmed), Any (officially published) book. No solved examples!

The exam will only be available in English. After the results have been reported it will always be a proposed solution available at the student reception at Brinellvägen 68 to look at.

There will be a teacher present during the exam. DO NOT HESITATE to ask if anything is unclear!

Students with special needs who have obtained a recommendation from KTH FUNKA for examination support are entitled to the following:

- Support linked to codes R (i.e. accommodations concerning room, duration, and physical surroundings) is granted without examiner approval required.
- In accordance with KTH regulations, a request for support linked to code P (pedagogical accommodation) is to be submitted by the student to the examiner, who needs to actively approve or reject the request.

Grading Criteria

In order to pass the course, the student is required to obtain:

- Pass grade on LAB1
- Pass grade on INL1
- Pass grade on TEN1.
    - Requires **at least PASS** on each question in TEN1-A.
    - Higher grade requires PASS on ALL questions in TEN1-A
    - OR
        - Pass on KON1 & KON2

Grading of exams questions will follow the structure outlined below:

ILO	Examination	P/E	C	A
1	LAB1	Active Participation	N/A	N/A
1	INL1	Pass grade on assignments	N/A	N/A
1	TEN1	TEN1-A: The student shall apply and practice solutions to basic problems.	TEN1-B: The student shall show ability to propose, compose and formulate solutions to more complex problem statements.	TEN1-B: The student shall show very good ability to propose, compose and formulate solutions to more complex problem statements.
2	LAB1	Active Participation	N/A	N/A
2	ÖVN1	Pass grade on assignments	N/A	N/A
2	TEN1	TEN1-A: The student shall apply and practice solutions to basic problems.	TEN1-B: The student shall show ability to propose, compose and formulate solutions to more complex problem statements.	TEN1-B: The student shall show very good ability to propose, compose and formulate solutions to more complex problem statements.
3	TEN1	TEN1-A: The student shall apply and practice solutions to basic problems.	TEN1-B: The student shall show ability to propose, compose and formulate solutions to more complex problem statements.	TEN1-B: The student shall show very good ability to propose, compose and formulate solutions to more complex problem statements.

The grade on each of the exam questions on TEN1-B will be graded using E, C, and A, corresponding to 1 point, 3 points, and 5 points, respectively. The final grade on the exam will be based on the average of the scores (without any rounding off) of the questions on TEN1-B, adjusted for obtained bonus, see table.

Grade on exam and entire course	General requirement	Required Exam (from TEN1-B) average score, including bonus
A	Pass on LAB1, INL1, TEN1-A	≥ 4
B	Pass on LAB1, INL1, TEN1-A	≥ 3
C	Pass on LAB1, INL1, TEN1-A	≥ 2
D	Pass on LAB1, INL1, TEN1-A	≥ 1
E	Pass on LAB1, INL1, TEN1-A	< 1

The final grade on the course will be the same as on the exam, adjusted for obtained bonus, given the requirement of Pass of **all** ILOs, as indicated above.

The grade Fx, is obtained if Fail is obtained **on only one** of the problems on TEN1-A.

Home assignments

Each student is required to submit results for each of the six assignments through the course CANVAS activity. All of the result of the submitted assignment will be automatically checked within CANVAS, which means immediate feedback if passed or not. **Note that all submitted part results needs to pass in order to pass on each assignment**.

- **INL1-1**: Direction and measure for the future of built environment in your home country
- **INL1-2**: Building Energy Requirement
- **INL1-3** - The Vapour Refrigeration Process
- **INL1-4**: Distribution systems

Each student is required to submit his or her individual result of all the assignments through CANVAS with an individually written report.

*Deadline for submitting reports is according table above. Submitting after these dates are **not allowed**, students failing this date are welcome back next time the course is given (fall semester 2023). For pass of e.g. INL1, all four assignment needs to be submitted and passed. If not, the entire INL1 has to be redone the next course round.*

NOTE: If you receive a **failing/revision grade** on one of the reports **you will need to correct it and submit it again** in order to pass the course, but no later than *31st of January, 2023*. After that date **no resubmissions are allowed**. In order to be allowed for a revision of a report, an honest attempt needs to be submitted in before deadline. Honest attempts **does not** include assignment descriptions or other home assignments, or similar.

Laboratory Lessons

LAB1-1 – Building dynamic evaluation
LAB1-3 - Basic Refrigeration System
LAB1-4 - Heat and mass transfer in a AHU

The laboratory lessons will start at the end of September. A list to sign up for the labs will be available in due time. Instructions may be downloaded from the course CANVAS-activity. The labs are conducted at Brinellvägen 68, Lab hall of Applied Thermodynamics and Refrigeration (room L249).

Please come prepared, Lab assistants **has the right to discharge** unprepared students.

Course Literature

The material used in the course will be for available as "Print-On-Demand" by USAB, instructions will be available through CANVAS. The literature includes:

- **Sustainable Energy Utilization in Built Environment - Part 1 Demand and Distribution**, KTH, Dept. Energy Technology, edited by H. Havtun and J. Claesson latest edition (2022).
- **Sustainable Energy Utilization in Built Environment - Part 2 Supply and Conversion**, KTH, Div. Applied Thermodynamics and Refrigeration, edited by J. Claesson, Latest edition (2022).

It is **strongly recommended** that the
latest editions of the books
are used as exam questions will be constructed assuming information required from the books are available to the students.

Alternative books:
Obviously there are a vast amount of books available that will provide similar topics as given in the above literature. It is recommended to use the above books, as its content is "tailored" for the course. However, some prefer to use other books, here are a list of some alternatives:

- Principles of Heating, Ventilation, and Air Conditioning in Buildings, Mitchell, Braun, ISBN 978-0-470-62457-9.
- Thermal Environmental Engineering, Kuehn, Ramsey, Threlkeld, ISBN 9780139172205.
- Heating and Cooling of Buildings: Principles and Practice of Energy Efficient Design, Reddy, Kreider, Curtiss, Rabl, ISBN-10: 1439899894.

The CANVAS Platform

All hand-outs not included in the course literature will be available on the LMS used by KTH CANVAS. All assignments should be submitted through the CANVAS educational platform, and your progress will be recorded. Please check your status of the assignments and lab attendance in progress section of CANVAS.

Course structure

MEETINGS / EXERCISES
Lectures are presentations of certain topics. The first part of the course will contain a larger share of lectures, while the latter parts of the course will have a large share of exercises, for which pre-recorded lectures will provide the theoretical background.

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LABORATORY SESSIONS

There are three labs each students should attend actively to. These are conducted at three different times for each student.

Each students select a lab-group (**GROUP NUMBER**) which then corresponds to that students specific time slots for the labs. The selection of a lab group is done within the CANVAS - activity of the course, through the GROUP in CANVAS (under PEOPLE).

PRELIMINARY SCHEDULE:

MJ2509, Energy in the built environment								
2022-08-29 - 2023-01-16								
Week	**Day**	**Date**	**Time**			**Activity**	**Room**	**Info**
w35	Wednesday	2022-08-31	08:00	-	10:00	Lecture	M1	Built Enviroment and Energy
w35	Thursday	2022-09-01	13:00	-	15:00	Lecture	Q1	Main building systems
w35	Friday	2022-09-02	13:00	-	15:00	Lecture	M1	Sustainable and Green , Buildings.
w36	Tuesday	2022-09-06	15:00	-	17:00	Lecture	M1	Behavioral aspects on energy.
w36	Wednesday	2022-09-07	10:00	-	12:00	Lecture	M1	Holistic Building and District, System perspective.
w36	Friday	2022-09-09	08:00	-	10:00	Lecture	M1	Holistic and District , System perspective.
w37	Wednesday	2022-09-14	08:00	-	10:00	Lecture	M1	Holistic and District , System perspective.
w37	Thursday	2022-09-15	13:00	-	15:00	Lecture	M2	Holistic and District , System perspective.
w37	Friday	2022-09-16	13:00	-	15:00	Lecture	M1	Holistic and District , System perspective.
w38	Tuesday	2022-09-20	15:00	-	17:00	Lecture	M1	Requirements IEQ
w38	Wednesday	2022-09-21	08:00	-	10:00	Lecture	M1	Demand IAQ
w38	Friday	2022-09-23	13:00	-	15:00	Lecture	M1	Demand, Preservation of Food, and Pharmaceuticals.
w39	Tuesday	2022-09-27	15:00	-	17:00	Lecture	M1	Demand, Psychrometrics,, Basics (Thermodynamic).
w39	Wednesday	2022-09-28	08:00	-	10:00	Lecture	M1	Demand, Room process in, psychrometric chart.
w39	Friday	2022-09-30	08:00	-	10:00	Lecture	M1	Demand, Cooling coil behavior, in psychrometric chart.
w40	Monday	2022-10-03			08:00	Submission INL1-1		Deadline for submission of Home Assignment 1
w40	Thursday	2022-10-06	13:00	-	15:00	Lecture	M1	Demand, Heating Peak, and Annual energy need.
w40	Friday	2022-10-07	13:00	-	15:00	Lecture	M1	Demand, Cooling Peak, and Annual Energy need.
w41	Wednesday	2022-10-12	08:00	-	10:00	Lecture	FR4 (Oskar Kleins auditorium)	Supply systems -, Boilers, Furnaces.
w41	Thursday	2022-10-13	13:00	-	15:00	Lecture	M1	Supply systems -, Solar systems.
w41	Friday	2022-10-14	08:00	-	12:00	Partial Exam/Quiz	M23-24, M31-33, M35-36, M38	KS 1
w43	Monday	2022-10-24			08:00	Submission INL1-2		Deadline for submission of Home Assignment 2
w44	Tuesday	2022-11-01	15:00	-	17:00	Lecture	FR4 (Oskar Kleins auditorium)	Supply systems -, Solar systems.
w44	Friday	2022-11-04	08:00	-	10:00	Lecture	M2	Supply systems -, Solar systems.
w45	Monday	2022-11-07	08:00	-	10:00	Lecture	M1	Supply systems -, Solar systems.
w45	Tuesday	2022-11-08	15:00	-	17:00	Lecture	M1	Supply systems -, Solar systems.
w45	Thursday	2022-11-10	14:00	-	16:00	Lecture	M1	Supply systems -, Refrigeration and Heat pumps.
w45	Friday	2022-11-11	08:00	-	10:00	Lecture	M1	Supply systems -, Refrigeration and Heat pumps.
w46	Wednesday	2022-11-16	08:00	-	10:00	Lecture	M1	Supply systems -, Refrigeration and Heat pumps.
w46	Thursday	2022-11-17	13:00	-	15:00	Lecture	M1	Supply systems -, Refrigeration and Heat pumps.
w46	Friday	2022-11-18	08:00	-	10:00	Lecture	M1	Supply systems -, Refrigeration and Heat pumps.
w47	Tuesday	2022-11-22	15:00	-	17:00	Lecture	FR4 (Oskar Kleins auditorium)	Distribution systems -, Hydronic and Air systems.
w47	Wednesday	2022-11-23	08:00	-	10:00	Lecture	M1	Distribution systems -, Hydronic and Air systems.
w47	Friday	2022-11-25	08:00	-	10:00	Lecture	M1	Distribution systems -, Hydronic and Air systems.
w48	Tuesday	2022-11-29	15:00	-	17:00	Lecture	M1	Distribution systems -, Hydronic and Air systems.
w48	Thursday	2022-12-01	13:00	-	15:00	Lecture	M1	Storage systems -, TES short term.
w48	Friday	2022-12-02	08:00	-	10:00	Lecture	M1	Storage systems -, TES short term.
w49	Monday	2022-12-05	10:00	-	12:00	Lecture	M1	Distric Heating and Cooling
w49	Tuesday	2022-12-06	15:00	-	17:00	Lecture	M1	Distric Heating and Cooling
w49	Wednesday	2022-12-07	08:00	-	10:00	Lecture	M1	Course summary
w50	Monday	2022-12-12			08:00	Submission INL1-3		Deadline for submission of Home Assignment 3
w50	Tuesday	2022-12-13	08:00	-	12:00	Partial Exam/Quiz	FB54-55, M2-3, M23, M33, M38	KS 2
w51	Monday	2022-12-19			08:00	Submission INL1-4		Deadline for submission of Home Assignment 4
w3	Monday	2023-01-16	08:00	-	13:00	Written Exam	Q22, Q24, U21, U31, U41, U51	