Energy Supply Systems for Buildings

PCP Buildings as Sustainable Energy Systems

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Introduction

Welcome to the TU Delft course Energy Supply Systems for Buildings: Discover how to convert natural resources into heat, cold and electricity, what the capabilities of renewable systems are and what that means for energy efficiency, resource depletion and carbon emissions. Thank you for joining us! In this syllabus you'll find important information regarding this MOOC.

This MOOC is the second one of the Professional Certificate Program Buildings as Sustainable Energy Systems, in which you learn how to design energy efficient and more sustainable buildings whilst improving their thermal quality and indoor environment. The Program Buildings as Energy Sustainable Energy System consists of four courses: Energy Demand in Buildings (MOOC 1); Energy Supply Systems for Buildings (MOOC 2); Thermal Comfort in Buildings (MOOC 3) in which you will learn how to create a comfortable and healthy indoor environment; and Efficient HVAC Systems (MOOC 4), which is about how to design, control and optimize HVAC systems.

They all four can be followed independently, however, knowledge is built up from MOOC 1 to MOOC 4.

All courses are based on a classic system engineering approach, meaning that you will also learn about the interactions between the different components of the building's energy system. The system we look at is the physical building with its energy systems, occupants and HVAC systems. A classic system engineering approach also means that requirement analysis, modelling, and simulation play an important role. Once you've got a good understanding of the system itself and the interactions between components, you will be able to model it and simulate its working in order to create and analyse alternative design concepts in terms of performances.

In the present course, Energy Supply for Buildings, you will discover the supply side of the energy chain and how to make it sustainable. You will learn to answer questions like: what are the options to create heat, cold and electricity? Why is the efficiency of a heat pump higher than 1? How to make use of waste heat, or the ground to heat or cool a building? How to combine energy conversion systems at building level in order to match buildings' energy demand while keeping costs acceptable, using a minimum of natural resources and producing a minimum of carbon emissions?

Learning Objectives

The main aim is to learn how natural resources can be converted into heat, cold and electricity, what that means for energy efficiency, resource depletion and carbon emissions, what the capabilities of renewable systems are and how to match energy supply with buildings' energy demand.

By the end of this course you will be able to:

1. Explain the different heating, cooling and electricity generation systems and what their working principles are.
2. Estimate primary energy usage, resource depletion and carbon emissions of these generation systems by using systems' efficiencies, energy and carbon contents of resources and building's energy demand.
3. Cope with mismatches between supply and demand when making preliminary studies of cogeneration systems for heat & cold and heat & power.
4. Use the principle of rational use and exergy to choose suitable and sustainable heating, cooling and electricity generation systems at the stage of a preliminary design.
5. Choose and size renewable energy systems adapted to buildings' energy demand, at the stage of a preliminary design.
6. Estimate life cycle costs of the chosen systems.

Course Structure

The course starts with an introduction module in which you can refresh your knowledge relating to the basics of energy use in buildings, like the energy chain, design principles, how to estimate building's energy demand for heat, cold and electricity and the difference between energy amounts and nominal loads.

The first module then introduces all basic principles that will be used further in the course. In the second module you will learn about heat pumps, cooling machines and geothermal energy. The third module is devoted to (renewable) electricity production, rational use of energy and cogeneration. During the last module you will learn about solar systems and how to use your knowledge to design sustainable buildings.

Module one

Efficiency, primary energy, CO2-emissions, and application to electrical heating and combustion boilers

After the first module you will know what the different energy supply systems are. You will be able to understand what efficiency is and how energy and carbon contents of fuels are determined. You will learn how to use this to make estimates of quantities of natural resources needed to match buildings' energy demand, and what the related CO2 emissions and costs are. You will apply your knowledge on electrical heating systems and combustion boilers, and will be able to describe these systems.

Module two

Heat pumps, cooling machines and geothermal energy

In this module you will discover the working principle of heat pumps and chillers and how these systems are able to upgrade low temperature environmental heat to the temperatures needed in buildings. You will learn how to combine them with thermal storage in the ground to obtain highly efficient heating and cooling systems and you will be aware of the possibilities offered by geothermal energy to produce heat and electricity. You will apply your knowledge on the pre-design of an energy flexible building in terms of CO2-emissions, costs and primary energy usage.

Module three

Electricity production, rational use of energy and cogeneration

After this module you will know about the different ways of producing electricity using turbines and generators. This also includes wind and hydropower. You will learn what cogeneration is and how to cope with waste heat; and how the principle of rational use of

energy will help you in selecting systems that are really efficient all over the energy chain. You will apply your knowledge to the pre-design of a building, weighting different cogeneration systems at building and city level.

Module four

Solar energy and energy efficient building concepts

In the final module you will learn about solar heat and power (photovoltaics) conversion systems and how to cope with their intermittency. You will be able to roughly size such a system, also accounting for batteries when needed. Finally you will be able to make informed decisions on how to choose diverse alternatives for the energy supply of a building, leading to energy efficient, low carbon and affordable building concepts.

Learning Activities

In this course, we will use a mix of methods to help you to understand the subject and to integrate and apply your knowledge in practice.

Online video lectures

You will be able to view several video lectures, mostly 5 to 7 videos of 10-15 minutes. In these videos the core of the theory is explained and guided concrete examples are given, that give you an impression of real situations.

Course Reader and additional materials

Of course, the slides supporting all videos are available, as well as the transcripts of the videos. Next to this, a course reader is available as reference. When needed links to other MOOCS or videos are available.

What we expect…

This MOOC is developed to give you the opportunity to learn which (sustainable) energy supply systems you can choose in buildings and what is the combined impact of building design and energy supply systems on carbon emissions, resource depletion, primary energy uses and costs.

It is based on years of practice, research and education and it offers the basics of what every designer, policy maker or energy specialist should know on the thermal behavior of buildings.

So we expect you to be an active participant in this course, not only by doing the exercises but also by sharing your knowledge with us and your peers and by helping others in the discussion forums.

Regarding the deadlines, we expect you to keep on track in order to benefit from learning with the community: learning from others by answering each other's questions and by receiving feedback on your ideas in the discussion threads. By following at the same pace as other participants, the overall learning experience is enriched. When you give feedback on the work of your fellow students please be respectful and give the feedback in a constructive way.

License

Attributions

Course reader:

The course reader is based on the pre-edited version of chapter 5 of the book 'Sustainable Urban Environments: An Ecosystem Approach', 2012, Springer Netherlands, Editors: **van Bueren**, E.M., **van Bohemen**, H., **Itard**, L., **Visscher**, H. . DOI 10.1007/978-94-007-1294-2.

Chapter 5 was written by L.C.M. Itard. The book is available at:

https://www.springer.com/gp/book/9789400712935#aboutAuthors