



## Applications of Polysun at DTU Denmark

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# Application of Polysun at DTU Denmark

## - Zusammenfassung -

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### **Solar energy courses at DTU**

At the Department of Civil Engineering, Technical University of Denmark, DTU Byg, Polysun is used in two courses: *Solar heating systems* which is a 10 ECTS basic course and *Development of solar energy systems* which is a 5 ECTS advanced course.

In the period from 2008 until today, more than **500** students from all over the world have been taught how to use Polysun in the *solar heating systems* course at DTU.

### **The Solar heating systems course**

The course is given once a year in the spring semester. All students attending the course are taught to use Polysun during the second assignment on large solar heating systems for multifamily houses. The assignments are carried out in groups.

The students are assessed in the course by their performance on the following points:

- Assignment 1, on small solar domestic hot water systems (20%)
- Oral presentation of assignment 1 (10%)
- Oral feedback on assignment 1 to another group (5%)
- Assignment 2, on large solar heating systems and Polysun (20%)
- Individual quiz (45%)

Polysun is introduced to the students during 1 lecture with a duration of 2 hours by Andreas Wolf from Vela Solaris. The introduction takes place in the class room and is based on powerpoint slides and a demonstration of the program which comprises: General features, Loops, Component catalogue, Controller settings and Results.

The students work on the Polysun assignment in a period of 1 month. During this period, around 16 hours of supervision for the assignment is given by 3 experienced

Polysun users. When the assignment period is over, the students hand in a report of the assignment with a clear division of who is responsible for which part of the assignment. This allows for individual grading.

The department has 30 Polysun university licenses. Polysun is available on fixed computers in a databar at DTU. The students can not have Polysun on their own computers. Each group have access to at least 1 Polysun license in the databar. In the years 2008-2009, the Polysun assignment was solved in groups of 2 persons, in the years 2010-2015 in groups of 3 persons and in 2016 in groups of 4 persons.

The number of students following the course since 2008 can be seen in figure 1.

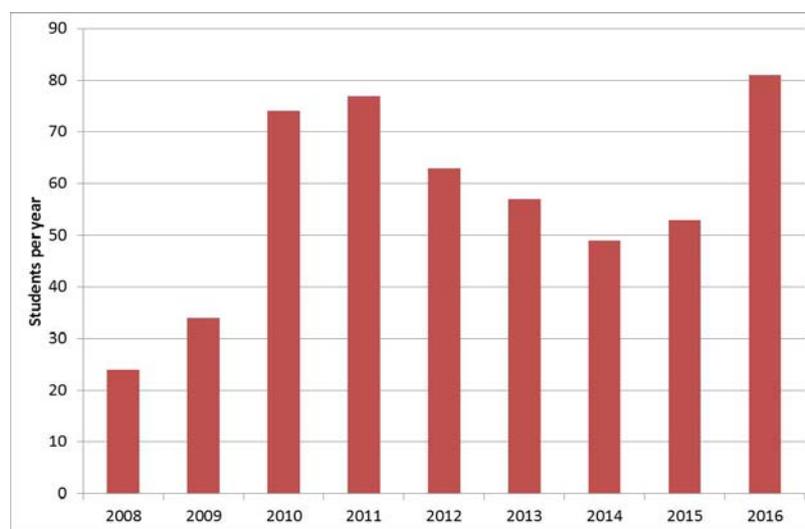


Figure 1. Number of students in the *Solar heating systems* course 2008-2016.

The title of the Polysun assignment is *Planning of a large solar heating system for a multifamily house*. The assignment is solved with the following aids: Danish norm for domestic water installations (DS 439), Danish norm for thermal insulation of installations (DS 452), Lecture slides, Polysun program and manual, Excel sheet for economical evaluation (based on actual costs for a large number of Danish solar heating system installations).

Based on given reference conditions such as: system design and controller types, building size, number of apartments, conventional energy prices etc., the students must determine: Domestic hot water consumption, Domestic hot water supply/circulation pipe heat loss, Space heating consumption, Suitable auxiliary

heated volume and power of auxiliary energy supply system, System size in terms of solar collector area, Tank size, Solar collector type and design of solar collector field, Volume flow rate in solar collector loop, Pump and pipe sizes and lengths, Safety equipment size and location, e.g. expansion vessel, air escape valves etc., Thermal performance and solar fraction, Economy, e.g. system and installation costs, payback time, yearly savings etc.

The students must find the best solar heating system size, seen from an economical point of view. Different heating system sizes must be investigated. The students may create their own component models in Polysun or use predefined component models.

Figure 3 shows the system design from 2016.

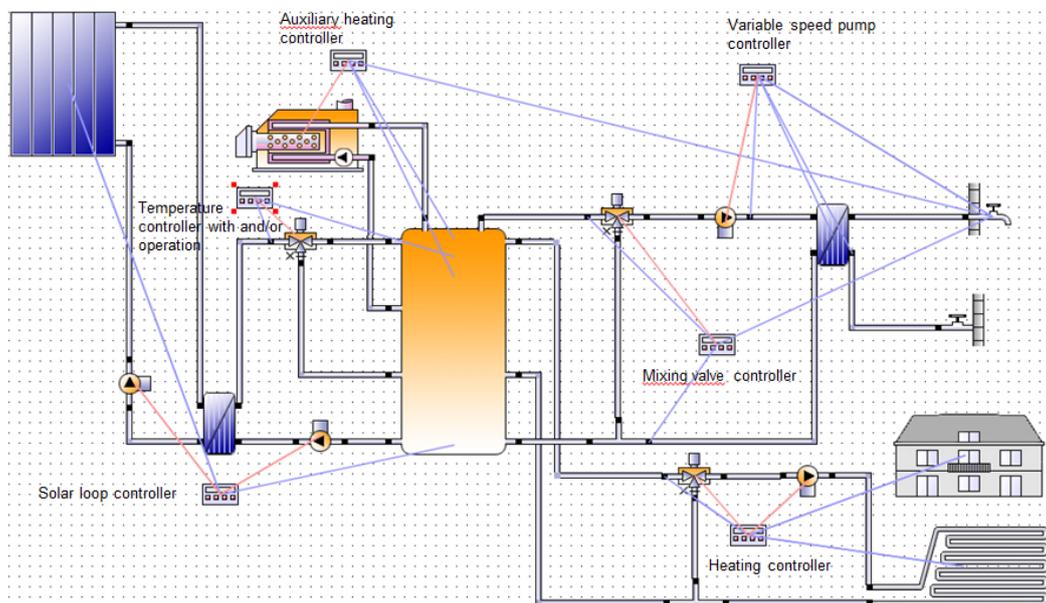


Figure 3. Solar heating system design in the course in 2016.

Further, the students are given a number of tables to fill in with parameters and results for/from the simulations, e.g. %-heights for in-/outlets, layer numbers for sensors etc. Figure 2 shows an example of such a table.

Parameter	40-m <sup>2</sup>	80-m <sup>2</sup>	120-m <sup>2</sup>
<b>Storage tank</b>			
Tank volume [m <sup>3</sup> ]			
Height of tank [m]			
Volume of one layer [m <sup>3</sup> ]			
<b>Auxiliary loop</b>			
Auxiliary heated volume [m <sup>3</sup> ]			
Auxiliary inlet to tank [%]			
Auxiliary outlet from tank [%]			
Layer number for outlet from tank			

Figure 2. Table with parameters used as input for Polysun.

### The *Development of solar energy systems* course

The course is given once a year in the autumn semester. During the second assignment, the students can freely choose the topic, typically related to an ongoing research project. The assignment may be based on Polysun. The assignments are carried out in groups. The students are not taught how to use Polysun in this course. It is expected that the students already know the program from the previous basic course, *Solar heating systems*.

The students are assessed in the course by their performance on the following points:

- Assignment 1, on solar collectors (20%)
- Individual quiz (20%)
- Assignment 2, the students choose the assignment which typically is related to an ongoing research project at DTU (can be based on Polysun) (45%)
- Oral presentation of assignment 2 (10%)
- Oral feedback on assignment 2 to another group (5%)

The number of students following the course since 2008 can be seen in figure 4.

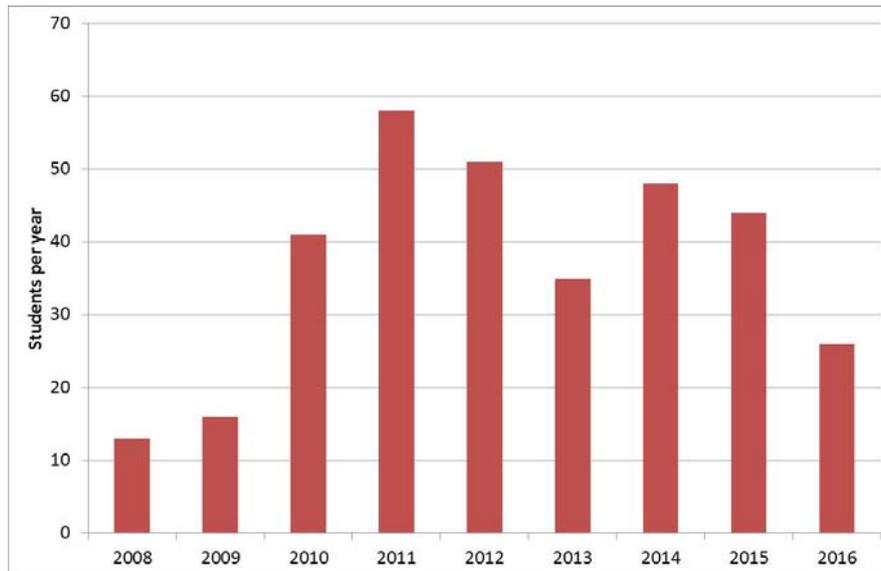


Figure 4. Number of students in the *Development of solar energy systems* course 2008-2016.

### Where do the students come from?

The students come from all over the world, e.g. Denmark, EU, Switzerland, Nordic countries, USA, Canada, Iran, China, Nepal, India, Singapore, Malaysia, Japan, Australia, etc. Most European students come from Greece and Spain but also a large number of students come from outside Europe, especially from China.

Today, the fraction of foreign students at DTU as a whole is around 45 % while the fraction of foreign students following the solar energy courses is around 54 %.

### Learnings from the *Solar heating systems* course

The students find the Polysun assignment very interesting, Polysun very flexible, nice and easy to use and useful for future work.

Many students do not follow all the lectures. Consequently, much help is needed during work on the Polysun assignment.

Generally the course is evaluated very well, but as the group size increases, the satisfaction with the course decreases. The reason may be that different people have different work mentality and too few Polysun licenses. Most likely, the Polysun assignment in its present form is less suitable for groups with many students.