

Energy Concept and Technology in the Rosenheim Solar Decathlon House

Johannes Bayer, Johannes Donaubauer, Johannes Maderspacher, Harald Krause
Rosenheim University of Applied Sciences, Hochschulstrasse 1, DE-83024 Rosenheim,
www.fh-rosenheim.de, harald.krause@fh-rosenheim.de

1 Solar Decathlon Europe 2010 (SDE 2010)

In 2010 the European version of the Solar Decathlon took place in Madrid for the first time. Solar Decathlon Europe is organized by the Secretary of State for Housing and Urban Development at the Spanish Ministry of Public Works with the collaboration of Universidad Politécnica de Madrid and the support of the US Department of Energy. Four editions of the US DOE Solar Decathlon were presented to date, on 2002, 2005, 2007, and 2009. All of them took place in Washington DC. The 2011 edition will start in September [1]. For 2013 the first Solar Decathlon China is announced.

“Solar Decathlon Europe aims to:

- Communicate our need to diminish our energy consumption by changing our habits and using technologies that reduce energy demand without affecting our lifestyle and comfort.
- Prove that the demands of lighting, heating, and refrigeration can be met with technologies in more efficient ways.
- Show how the energy required can be generated using renewable energy sources such as solar radiation.
- Finally, integrate these changes in ways that are affordable in conjunction with solid architecture practices. As European cities are often dense and have a long history, we try to develop ideas that can be transferred to other kinds of buildings as flats or help to refurbish existing ones.” [1]

17 university teams were qualified for the final competition in June 2010 at the Villa Solar near the royal palace in Madrid. The 4 German teams came from Berlin, Wuppertal, Stuttgart and Rosenheim. [2]

During the project duration of some 2 years the student teams had to design their buildings, particularly with regard to the ten contests of the competition. Finally, for ten days the solar houses were presented to different juries and to the public. Some contests were evaluated by a panel of expert judges, e.g. architecture, innovation and sustainability, as well as the communication strategy. Other contests are based on measured values, for example energy production and consumption and comfort conditions.

2 The Rosenheim “Ikaros Bavaria” Team

In the Ikaros team 50 students from different faculties and almost all study courses were working on the project for up to 2 years. As the Solar Decathlon is mainly a student project, student teams were also responsible for the project management with support of the faculty staff and Professors. Fortunately, a lot of our students passed a professional education before their studies e.g. as carpenter. Therefore, the building was not just designed but also manufactured by our students.

3 The Rosenheim House

The Rosenheim house was designed according to passivehouse guidelines for different climates. The most important design criteria were to minimize all kind of energy consumption through passive measures. Depending on the estimated climate the focus had to be put on heating or cooling. In the concept studies the climate of Rosenheim, Madrid and Kuala Lumpur were taken into account. As the final location of the house is planned to be near Rosenheim, the house was accordingly built for that climate. The main goal was to create a plus energy balance building. At all three locations the Rosenheim house produces more energy than is used for heating, cooling and all technical services.

Thermal Envelope and Modules

The Rosenheim house was constructed in a modular structure. Each of the four modules was completely assembled in Rosenheim, including the interior finish and all domestic appliances. Using special fittings, the house can be assembled and disassembled several times.

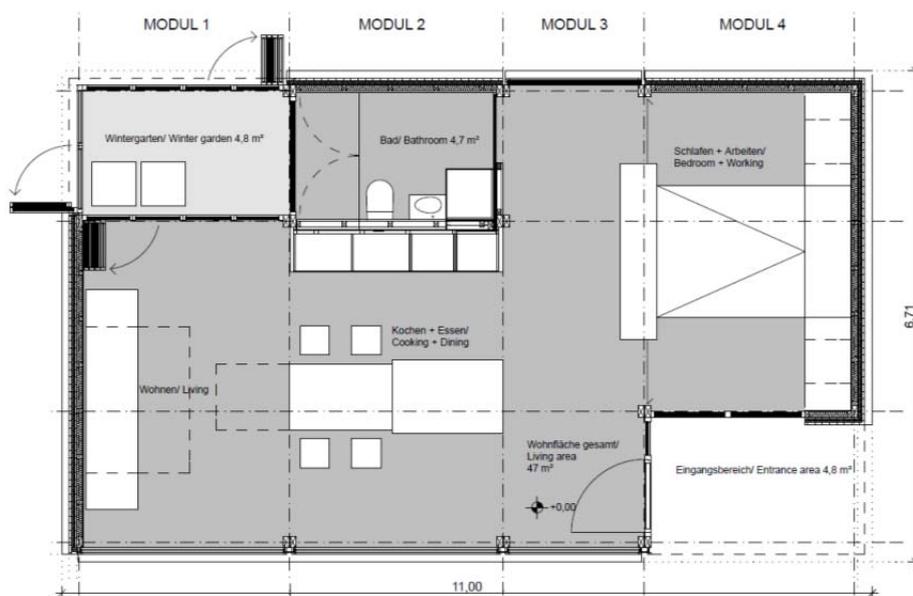


Figure 1 Floor plan and module structure



Figure 2 Picture of the Rosenheim house in Madrid

The building was designed for a two person household. Because of the small dimensions, it was necessary to use relatively slim wall constructions. To reduce the dimensions of a conventional timber frame construction, vacuum insulation panels were used.

	discription	data
Thermal envelope	Area, envelope/volume ratio	255 m ² / 1,54
TFA	Treated floor area incl. winter garden	65 m ²
Window area	Percentage of window area	22 %
External wall	Timber frame construction with VIP	$U = 0,098 \text{ W}/(\text{m}^2\text{K})$
Roof	Timber frame construction with VIP	$U = 0,095 \text{ W}/(\text{m}^2\text{K})$
Windows	Fix frame, triple glazing with sun protection coating, Krypton	$U_g = 0,5 \text{ W}/(\text{m}^2\text{K})$ $g = 0,35$
Entrance door	Certified passivehouse door	$U_d = 0,7 \text{ W}/(\text{m}^2\text{K})$
Sun shading	In-house development: „Zig-Zag-Facade“	$F_c = 0,1 \text{ to } 0,03$

Table 1 General data of the Rosenheim house

Design Tools and Results

The basic energetic design was performed with the PHPP 2007 [3]. These results were also used as first estimations for the heating and cooling loads. Due to the special requirements during the competition in Madrid, e.g. the public visit times, and the very narrow temperature band for the comfort conditions between 23°C und 25°C, dynamical simulations with IDA ICE were necessary [4]. Figure 3 shows the positive energy balance for Madrid. The yearly energy demand for heating and cooling calculated with the PHPP

and IDA ICE were quite similar. The PHPP results therefore seem also to be valid for very small buildings. The cooling load peaks cannot be determined with the PHPP method, because the peak loads were needed to guarantee the comfort conditions, which were measured in an interval of some minutes. Assuming standard living conditions of a two person household, the daily mean values for heating and cooling loads with both methods fit rather well.

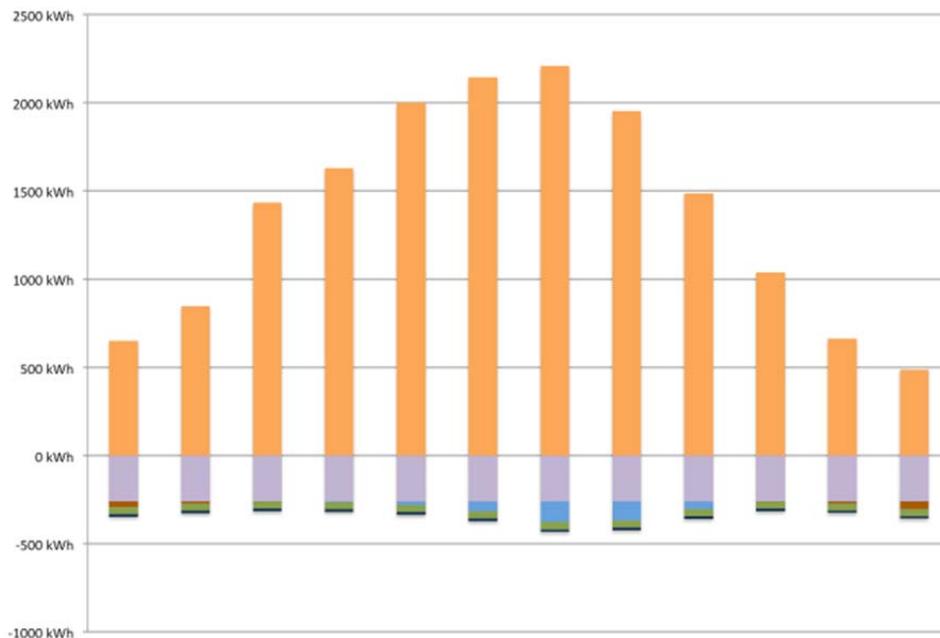


Figure 3 Overall energy consumption (negative scale) and production (positive) for Madrid from Jan to Dec..

Building Services

The heating and cooling in the Rosenheim house is performed in a combination of active and passive components. A schematic drawing is shown in Figure 4. The system seems to be very complicated in relation to the small energy amount of the building. Indeed, a lot of systems were combined, which are in some cases redundant. As there was the opportunity to use a combination of systems, we decided to learn much about different possibilities for heating and cooling and not to use a prefabricated standard system (even if this had been much simpler and cheaper). The energy source is a 13 kWp photovoltaic system positioned on the nearly flat roof. As all houses were connected to the electrical grid, no batteries were necessary for buffering. The central heating and cooling unit is a heat pump, which is connected to a cold and a hot water tank. The simulations showed, that the waste heat during cooling time is sufficient to provide all domestic hot water needed for showers, washing and the dish washer. Thus, a thermal solar system was not necessary for the competition, although it would be generally helpful.

In addition, a radiation cooling system in combination 2000l non-pressure water tank is used to provide cold water for stationary cooling during day time (see also Figure 5). Both

active and passive systems are connected to a ceiling cooling (heating) system, which covers most of the whole ceiling area. A ventilation system with heat recovery and optional humidity recovery is also connected to the system.

The ceiling cooling system was not able to cover the peak loads after the public visits during the competition. Figure 5 shows a box, which is fitted to the house below the floor, and filled with PCM panels. With this system, a maximum cooling power of 2,5 kW is possible.

PV- system	13 kWp, 40 Module 315 WTH – Sun Power, Wechselrichter – SMA – Sunny Mini Central 4600A, Sunny Boy 3300
Heat pump	EnTitan SW 5,5 kW heating power, COP 5
Warm, cold tank	300 litres
Cooling ceiling	Incotec WEGO, net area 53 m ² , cooling power at $\Delta T=10$ K: 54 W/m ²
ventilation	Zehnder Comfoair 350, ca. 120 m ³ /h
PCM channel	2,6 m x 1,1 m x 0,4 m PCM Dörken: Delta Cool 24 Latent heat: approx. 14kWh Cooling power: at 600m ³ /h, $\Delta T=10^{\circ}\text{C}$: approx. 2,5 kW

Table 2 summarizes the mechanical systems.

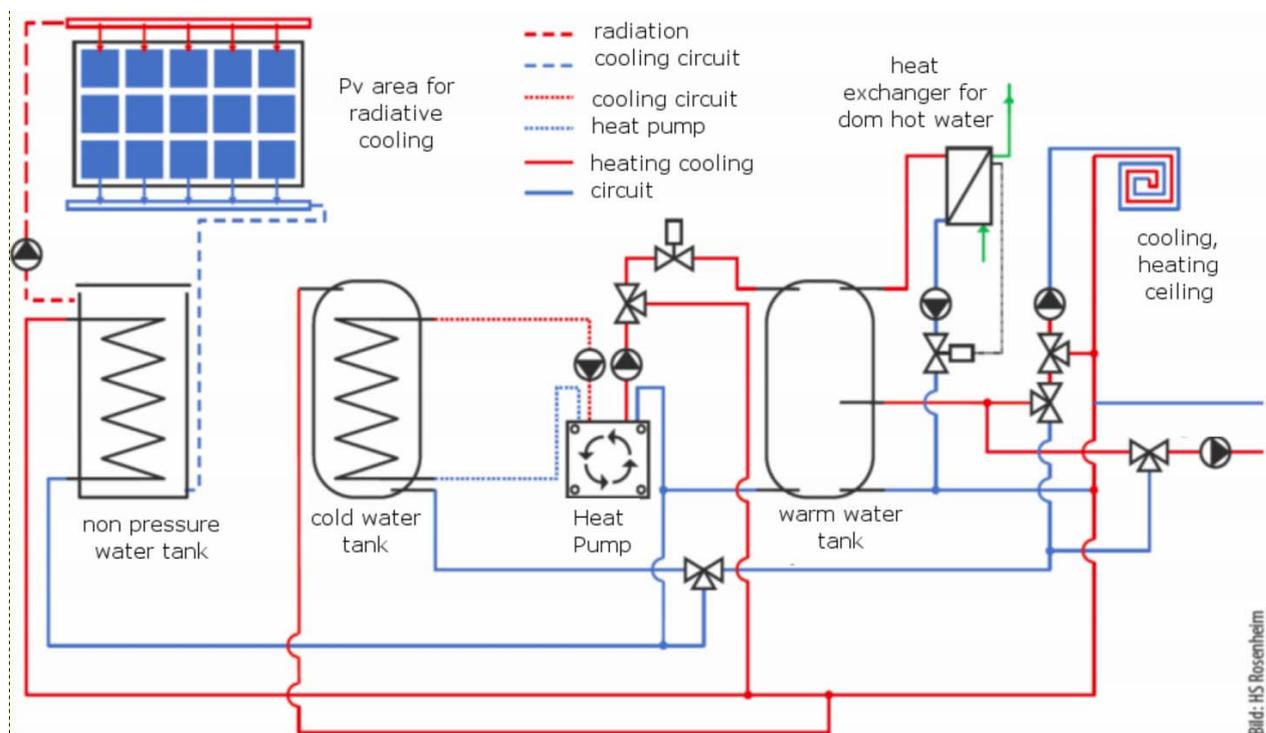


Figure 4 Schematic drawing of the mechanical services for heating, cooling and domestic hot water

PV- system	13 kWp, 40 Module 315 WTH – Sun Power, Wechselrichter – SMA – Sunny Mini Central 4600A, Sunny Boy 3300
------------	--

Table 2 General data of the heating and cooling systems in the Rosenheim house

Heat pump	Emitec SW 5,5 kW heating power, COP 5
Warm, cold tank	300 litres
Cooling ceiling ventilation	Incotec WEGO, net area 53 m ² , cooling power at $\Delta T=10$ K: 54 W/m ²
PCM channel	2,6 m x 1,1 m x 0,4 m PCM Dörken: Delta Cool 24 Latent heat: approx. 14kWh Cooling power: at 600m ³ /h, $\Delta T=10^{\circ}\text{C}$: approx. 2,5 kW



Figure 5 Passive radiation cooling on the roof using the PV panels and the PCM channel.

Results

The Rosenheim house finally won the second price at the SDE 2010. First places were obtained in the following competitions:

- Energy balance
- Comfort conditions
- Appliances
- Lighting

Students of all teams (and Professors too) learned much about the designing, running and monitoring of energy efficient buildings. The Rosenheim house was presented at the Landesgartenschau in Rosenheim (open air exhibition) and the BAU 2011 in Munich to a large audience. Every visitor left the house with the same impression, that passivhouses are beautiful, comfortable and produce almost no costs for energy.

Acknowledgements

The authors want to thank all sponsors and partners. The project was mainly funded by the Bundesministerium für Wirtschaft und Technologie. The radiation cooling concept was supported by ZAE Bayern e.V. in Würzburg. Finally we want to thank the whole Ikaros team and the project leader Markus Wehner and Mathias Wambsganß and all members of the staff at Rosenheim University of Applied Sciences.

For further informations see: <http://solar-decathlon.fh-rosenheim.de/>

¹ according to http://en.sdeurope.org/?page_id=2

- ² Solar Architektur: Die deutschen Beiträge zum Solar Decathlon Europe 2010 von Bergische Universität Wuppertal, Hochschule Rosenheim, Hochschule für Technik Stuttgart und Hochschule für Technik und Wirtschaft Berlin von Ins. F. Int. Architektur, detail Verlag 2011
- ³ PHPP 2007: W. Feist, R. Pfluger, B. Kaufmann, J. Schnieders, O. Kah, Passivhaus Institut, 2010
- ⁴ IDA ICE, Ver. 4, Equa Simulation AB