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Detailed information on energy research

In competition for the best energy-plus building

German teams score at Solar Decathlon Europe 2012 with architecture, engineering and marketing opportunities

BINE Information Service

For the competition, 18 interdisciplinary student teams from all over the world developed and built houses that generate at least as much energy – using solar systems – as they consume. They were supported by their universities, researchers and companies. From Germany, students took part from Hochschule Konstanz University of Applied Sciences (HTWG) and RWTH Aachen University, supported with government energy research funds. Whereas the design from Constance has perfected a modular construction system, with the Aachen team the focus is on recycling. After ten disciplines, the two homes achieved 4th and 5th places.

The Team Rhône Alpes from France won first place in Solar Decathlon 2012 using the concept of a “Nanotower”. The developed living unit can be stacked upwards over many storeys, with a communal living space on the top floor. For the competition, the top two stories of a typical nanotower were built by way of example. Just eleven points behind in second place was the Andalucía team, which reinterpreted the idea of the Spanish patio, followed by the Team Rome from Italy.

During the previous two years, all teams taking part developed a sustainable house for two people that can meet its annual energy requirements purely by solar means. In September the prototypes were built on the competition site in Madrid and presented to the public for two weeks. The actual decathlon started at the same time. It was not just the energy efficiency and the architecture that were assessed but also criteria such as the living comfort, sustainability and suitability for everyday use. Because another aim of the competition is to raise public awareness about energy-efficient construction, the students’ communication concepts were also assessed.

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The modular home

All prospective homeowners should be able to individually assemble their own energy-plus homes from modules and be able to adapt them at a later date – that is the idea behind the "Ecolar Home" from HTWG Constance. That won the students the first prize in the "Engineering and Construction" and "Market Viability" categories.

Based on a fixed grid, different buildings can be developed, including multi-storey ones, simply by compiling together columns and beams along with roof and facade elements from a component catalogue. The modular concept is continued in the interior space. A wall unit consisting of room-high elements enables all the furniture, the fittings for the bathroom and kitchen and building services equipment to be concealed behind a uniform front. The separate wall units can be individually compiled and later replaced.

The columns and beams are designed as hollow box sections and achieve a high load-bearing capacity combined with a low material input and weight. Once integrated in the building envelope, the hollow spaces can be easily insulated. The standardised timber components can be precisely prefabricated in series. In order to realise the modular principle in technical terms, special connection pieces were also developed that not only remain stable but are also easy to dismantle.

The Ecolar Home built for the competition consists of six modules – four as interior spaces and two as roof-covered veranda spaces. The facades are only glazed along the veranda spaces. Translucent elements enable additional light to enter the interior. The closed facade consists of special sandwich elements made of an insulated timber frame structure clad with timber absorbers. Lamellar-shaped grooves on the front side of the absorbers mean that the high sun in summer can only heat up the lamellar tips, which makes it difficult for the heat to penetrate into the interior space. In winter the sun is able to penetrate to the rear of the timber elements, thus slowing the transfer of heat from inside to outside. Thin-film PV modules shade the structure and generate electricity.

The roof surface is completely covered with PV modules and the veranda spaces are covered with semi-transparent, multicrystalline solar cells. Mounted beneath the opaque modules are absorber panels containing water-filled pipes that absorb surplus heat under the PV cells during the day and use it to heat the buffer storage tank for the domestic hot water. Conversely in summer nights they can be used for radiation cooling.

Inside, clay panels on the ceiling, which are enriched with phase change materials (PCMs) and contain water-filled pipes, absorb heat from the air and regulate the air humidity in a natural manner. If the building can no longer be air-conditioned using just solar heat and radiation cooling, a heat pump is switched on for this purpose. It uses the solar hybrid roof or a buffer storage tank as its heat source. In order to monitor and fully exploit the building services equipment, the house is extensively equipped with sensors and the various systems are linked via a building automation system.

A subsequent use for the competition building has already been found: it will be used as a research and teaching building on the Constance University campus.

Fig. 1 *The modular structure of the Ecolar Home is less pronounced in the interior space.*
Source: sdeurope

Fig. 2 *Floor plans of the two German competition buildings. Left the Ecolar Home, right the Counter Entropy House.*
Source: HTWG Konstanz/ RWTH Aachen University

Emphasis on recycling

Discarded CDs, used truck tarpaulins and the timber beams from the old Aachen football stadium – the students from RWTH Aachen University were creative in their choice of materials. This is because with their "Counter Entropy Concept" they aimed to design the entire lifecycle of the building in a manner that was as resource saving as possible. This so-called "super-cycling" has been implemented in various versions: discarded products are used for their original purpose, as the basis for something new or in the form of recycling material. An equal emphasis was placed during the planning on the ability to separate all the materials according to type and recycle them once the house has been dismantled.

A central feature of the building is the extensively cantilevered flat roof. The almost 150 square metres of roof provide not only protection from the sun and rain but also plenty of space for utilising solar energy. A curtain running along the edge of the roof provides additional solar shading and privacy. A remarkable aspect is the facade cladding: here the students melted CDs together to form panels and fixed them to truck tarpaulins stretched across frame substructures.

The interior space is defined by five equal-sized cabinet elements. Their rear sides simultaneously form the closed facade areas. Everything is in-

Fig. 3 *With the freestanding furniture, the Aachen students openly display the recycled materials. The facade made of CD panels can be seen behind the external seating area. Source: sdeurope*

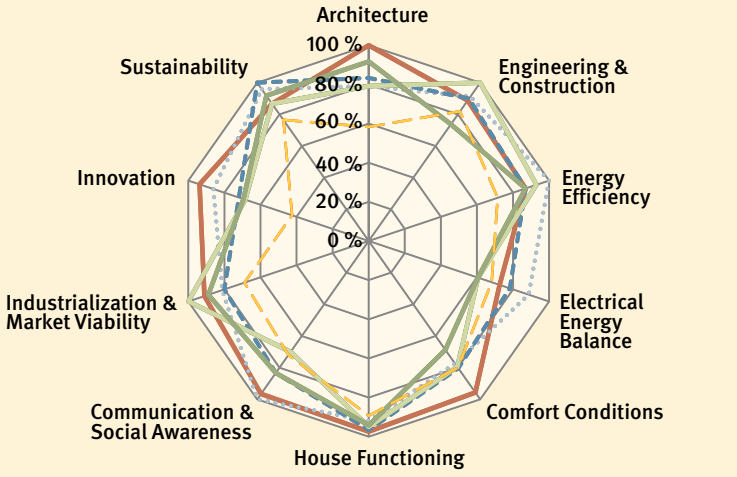

Fig. 4 *Comparison of the top five prize winners across all categories. Source: P. Engelmann*

Three questions to jury member Karsten Voss

In 2010, Prof. Dr.-Ing. Karsten Voss took part in Solar Decathlon Europe with Team Wuppertal. In 2012 he was a member of the Energy Efficiency jury panel.

Can a representative energy balance be determined in the 14 days of competition?

VOSS: In the Energy Efficiency jury panel, we assessed the presented concepts in terms of their overall performance, both at the site of the competition as well as in terms of the planned use afterwards, whereby the teams were able to achieve a maximum of 100 points. The measurement results for the energy performance during the two competition weeks in Madrid enabled another 120 points to be additionally collected. The actual weather impacts on both the indoor climate assessment and the energy performance, and could be an advantage or disadvantage depending on the chosen energy and control concept. There is therefore a certain amount of luck involved.

Do the Solar Decathlon entries really provide an insight into living in the future?

VOSS: I consider the competition entries to be first and foremost experimental buildings, not models. The smallness of the new buildings is mainly due to various feasibility aspects and their improved comparability in a fair competition. However, the innovations developed can have an impact on construction in general – including on existing buildings.

At least one international Solar Decathlon now takes place each year. How will the competition remain interesting?

VOSS: The competition will continue to have a future if it succeeds in strengthening the post-usage phase of the competition entries. In Wuppertal, a two-person household has been living in our house from 2010 for more than a year and it is still undergoing detailed scientific evaluation. It has achieved a neutral energy balance, proven its functionality but also stimulated further research work.

tegrated within these elements: the load-bearing structure and the building services equipment, the furniture, kitchen and the seating alcove for the living room. Even the extensive glass elements in the facades can slide completely back into the block elements. For the interior design of the block elements, the students constructed different-sized boxes made of used timber panels. A uniform front material was used to disguise this colourful collection. The team's design won second prize in the "Architecture" category and first prize for its interior design, which was an "Out-of-Contest" award without points.

The aim was also to achieve a production chain that was as environmentally friendly as possible in regards to the building services equipment: for example, lower-yielding thin-film PV cells were deliberately chosen instead of conventional crystalline cells. The lower yield of the modules is less significant thanks to the large roof area available for solar power purposes. As far as is possible, the house is anyway air-conditioned with renewable solar-thermal methods, whereby electricity is only required for fans and pumps.

Evacuated tube collectors feed a stratified storage tank that supplies the house with hot water and heat in winter. In summer a specially developed cooling ceiling absorbs heat from the interior space. Here PCM dispersion is pumped through the integrated pipes, collected and regenerated at night using radiation cooling. In contrast to passive PCM systems, the dispersion has the advantage that the system is controllable. A sorption air-conditioning system can be used to provide support. This cools using adiabatic evaporative cooling. The solar thermal system provides the necessary energy for regenerating the brine used for the sorptive dehumidification.

The entire building services equipment can be monitored using a special smartphone app. Alternatively, it is even possible to control the most important functions in the house using gestures: a compact LCD projector, which is built into the lamp above the dining table, projects a user interface onto the table top for this purpose. It is used in a similar manner to a touchscreen interface. The gestures made by the user are captured by a 3D camera (Kinect) typically used in game consoles.

In a few months the Counter Entropy House will be rebuilt at the Research Centre Jülich near Aachen and will then be open to visitors.

To be continued

The Solar Decathlon offers the students and faculties taking part a unique opportunity to accompany a concrete project from the initial sketches to the building's inauguration in an interdisciplinary manner. Moreover, in addition to informing experts the competition also manages to raise awareness among the wider public about an important issue: in September more than 220,000 people visited the exhibition site in Madrid in order to see how sustainable living could look like in the future. And there was a wide range of concepts for innovative energy-plus buildings. The fact that the four first prizes were won by four different countries proves that in many places the issues of energy efficiency and sustainability are already firmly anchored in the study curricula.

The Decathlon continues. In 2013 there will be two versions of the Solar Decathlon: the original format, which is held every two years in the USA, and – with a few months separation – the first Solar Decathlon China. In the following year Solar Decathlon Europe is being held in Versailles. The three competition series are being organised independently from one another. The principles and goals are the same but the specific requirements differ in terms of the details.

The German Federal Ministry of Economics and Technology, which has funded all the previous German Solar Decathlon entries, is supporting current efforts to establish a significantly enhanced European competition profile and to place it in the context of a "European Energy Avantgarde". Europe requires answers to urgent issues such as urban density and the modernisation of the existing building stock. These will principally determine the construction tasks of the future. With its idea, the French team that won in 2012 goes already beyond the competition requirements for the Solar Decathlon: with the floors stacked upwards as a high-rise building, the building designed by them can be transferred to an urban context.

With innovative concepts and technologies, such a new, international university competition could make an important and high-profile contribution to achieving the ambitious energy and climate goals in Europe. The focus in this regard should be on future-oriented concepts for specific issues at the respective host sites right across Europe, for example relating to urban densification or building refurbishment. Expert groups are still discussing the possible structure of the competition. In 2016, the first competition in the context of the "European Energy Avantgarde" might be held in Germany.

Project participants

- **Team Ecolar:** HTWG Konstanz, University of Applied Sciences, Prof. Dr.-Ing. Thomas Stark, ecolar@htwg-konstanz.de
- **Counter Entropy Team:** RWTH Aachen University, CAAD Institute, Prof. Peter Russell, solar@solar.arch.rwth-aachen.de

Links and literature (in German)

- www.ecolar.de | www.solar.arch.rwth-aachen.de | www.sdeurope.org (Europe 2010 / 2012) www.energy-avantgarde.eu | www.enob.info | www.solardecathlon.gov (USA 2013) www.sdchina.org (China 2013) | www.solardecathlon2014.fr (Europe 2014)
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- Voss, K.; Musall, E. (Hrsg.): Nullenergiegebäude. Klimaneutrales Wohnen und Arbeiten im internationalen Vergleich. München: Red. DETAIL Verl., 2011. 184 S., 1. Aufl., ISBN 978-3-920034-50-8, 49,90 Euro, Detail Green Books

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Project organisation

Federal Ministry of Economics and Technology (BMWi)
11019 Berlin
Germany

Project Management Organisation Jülich
Research Centre Jülich
Markus Kratz
52425 Jülich
Germany

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Germany

Author
Dorothee Gintars

Cover image
ECOLAR HTWG Konstanz

Contact · Info

Questions regarding this Projektinfo brochure? We will be pleased to help you:

+49 228 92379-44

BINE Information Service
Energy research for practical applications
A service from FIZ Karlsruhe

Kaiserstrasse 185-197
53113 Bonn
Germany
Phone + 49 228 92379-0
Fax + 49 228 92379-29
kontakt@bine.info
www.bine.info

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