Fig. 1 Students with model in the artificial sky at HFT Hamburg

Solar Decathlon goes European

Stuttgart's project home+ is about to race in the famous global competition held in Madrid in June this year

by Jan Cremers and Sebastian Fiedler

The Solar Decathlon Europe is an international competition for universities from all over the world to design and build a self-sufficient home, grid-connected, using solar energy as the only energy source and equipped with technologies that permit maximum energy efficiency. At the hightest architectural design level.

An interdisciplinary team of architects, interior designers, structural engineers and building physicians at the Hochschule für Technik Stuttgart accepted the challenge and is working on the design of the building since October 2008. The basic idea of our design is to use traditional means of dealing with the climate in hot and arid zones and to combine them with new technologies. Thermal mass, sun shading and evaporative cooling will help to achieve a comfortable indoor climate with passive means. The key element of our passive cooling concept is a new building component that we call "energy tower", which is also an important feature of the interior design. In addition night cooling via sky radiation and evaporation is used to discharge Phase-Change-Material (PCM) embedded in the house's ceilings. Active cooling is supplied by a reversible heat pump powered by photovoltaics.

The Solar Decathlon Europe is a great chance for students and schools of architecture to gain experience, to exchange ideas and to promote the concerns of energy-efficient and sustainable building. This article aims to introduce the competition and to present the design and energy concept of our project 'home+'.

The competition

In the Solar Decathlon Europe, 20 different universities from all over the world compete to design and build a home powered only by solar energy. Then the house of each team will be presented to the public in Madrid this year and the winner will be chosen.

In the years 2003, 2005 and 2007 the Solar Decathlon competition was organised by the US Department of Energy (DOE) and carried out in Washington D.C. After the very respected victories of the TU Darmstadt at Solar Decathlon 2007 and 2009 in the USA, the competition will be carried out now for the first time also in Europe, organized by the Spanish Ministry of Housing in cooperation with the US Department of Energy (DOE).

Objectives of the competition

The main objectives of the competition are:

1. To generate knowledge on the industrialisation and sustainability of the homes, increasing suitable scientific benefits, as well as, the dissemination of the knowledge.

2. To make both students and the general public aware of the environmental and sustainability issues, especially of the responsible use of energy and natural resources, promoting the use of the renewable energies.

3. To maximise the publicity of the event by taking advantage of the competition's characteristics and potential to achieve the maximum media coverage and public information.

OUR DESIGN CONCEPT

The design is based on architectural and energetic considerations. The starting point is a compact and highly insulated volume, with a small surface to volume ratio. The volume is segmented into four modules, which are positioned with interspaces between them. These gaps are used for lighting, ventilation, pre-heating in winter and passive cooling in summer. One of these gaps is higher than the others, containing the "energy tower". Based on traditional principles of climate control, the energy tower is a key element for the energy concept as well as for the outer appearance of the building and the interior space. The modules and the gaps are bound together by the building envelope, which is covered in large areas with photovoltaic elements.

Table I: Contests and Scoring

Architecture	120
Engineering and Construction	80
Solar Systems	80
Electrical Energy Balance	120
Comfort Conditions	120
Appliances	120
Communications and Social Awareness	80
Industrialization and Market Viability	80
Innovation	80
Sustainability	120
	1.000

Fig. 2 Model Team HFT Stuttgart

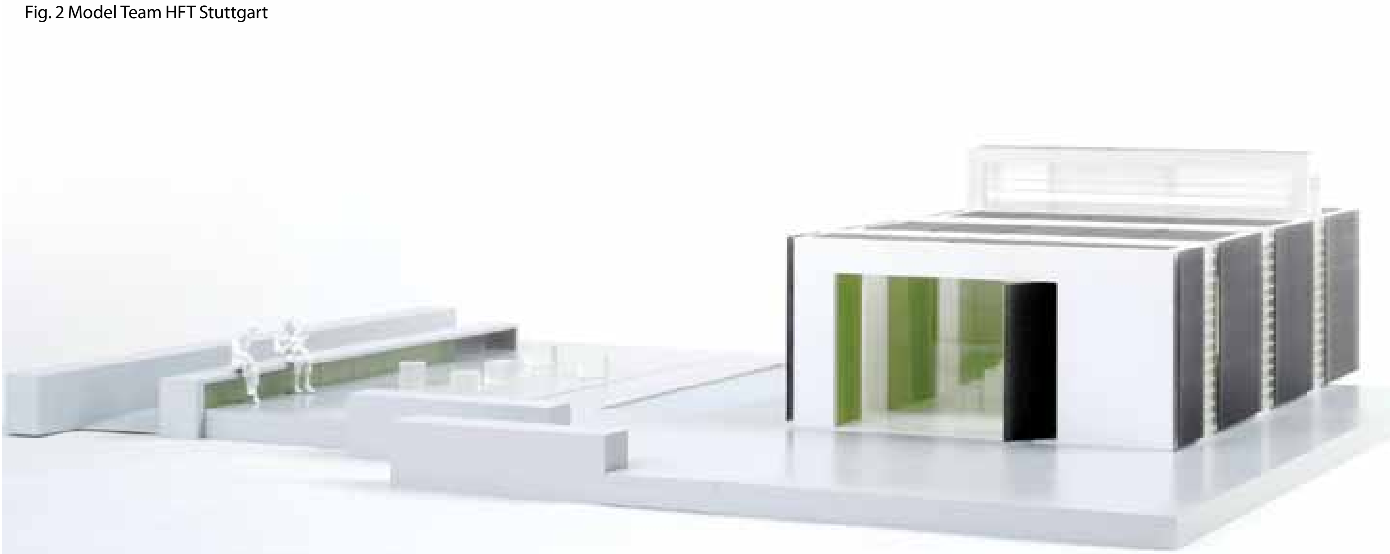


Fig. 3 Computer Rendering of home+

Zoning

The interior shows a clear zoning. In north-south direction the terrace, the living area and the dining area are marked by the gaps, but can be used as one big space also. This is especially important for the two dinners we have to invite our neighbours in the solar village to in June 2010. The more private working and sleeping area is separated by the volume of the energy tower. In east-west direction each area is accompanied by a serving zone (kitchen, entrance and facilities, bath).

Modularity

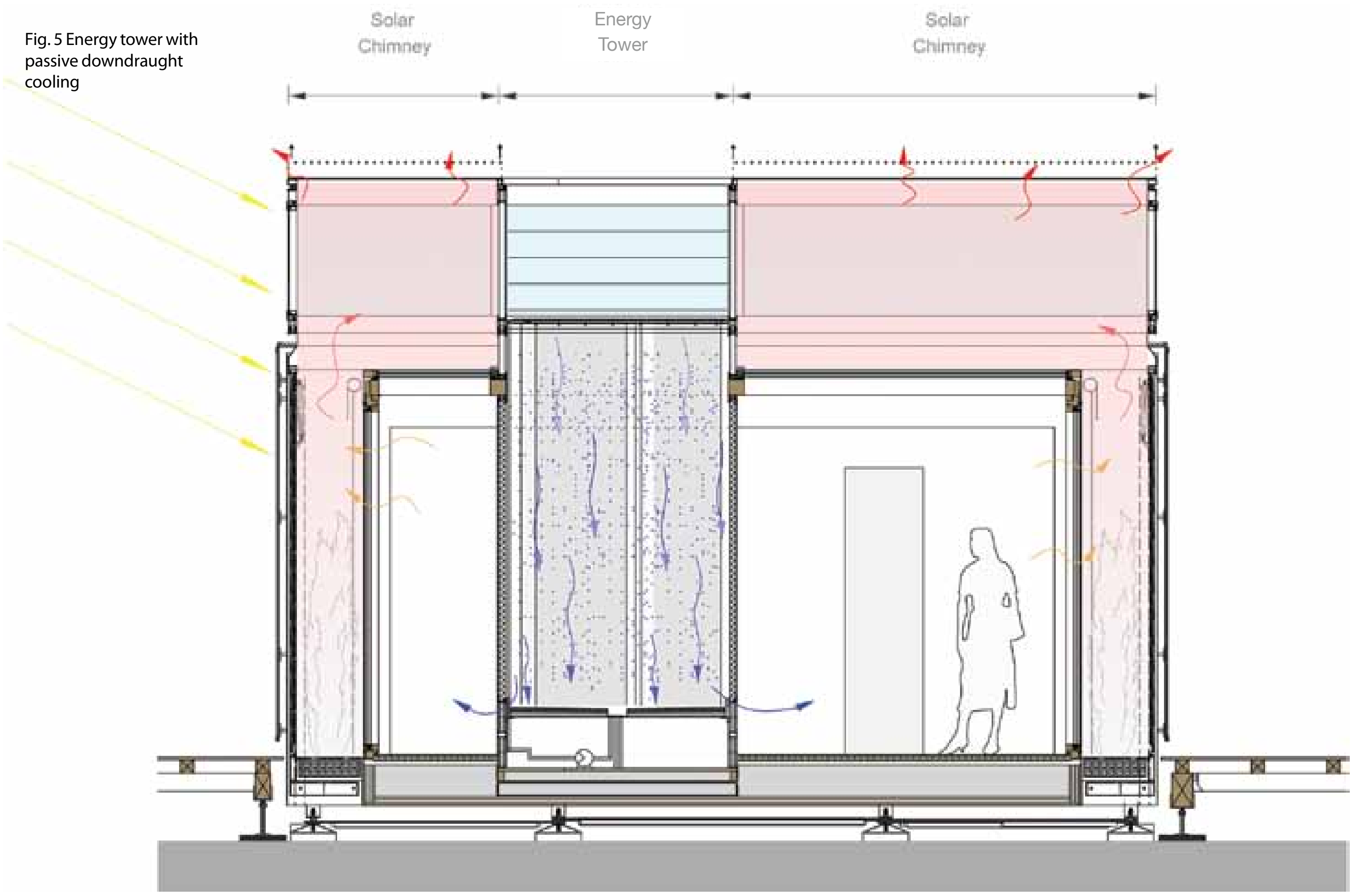
The modular design of the building does not only facilitate the transport to and the assembly in Madrid, but also allows thinking about a modular building system for different requirements. Using the same basic modules it is possible to create living and working space for singles, couples, families or apartment-sharing communities in detached and semi-detached as well as in multi-family houses.

ENERGY CONCEPT

The basic idea of our design is to use traditional means of dealing with the climate in hot and arid zones and to combine them with new technologies. Thermal mass, sun shading and evaporative cooling will help to achieve a comfortable indoor climate with passive

Fig. 4 Floor Plan (North on top)

Fig. 5 Energy tower with passive downdraught cooling



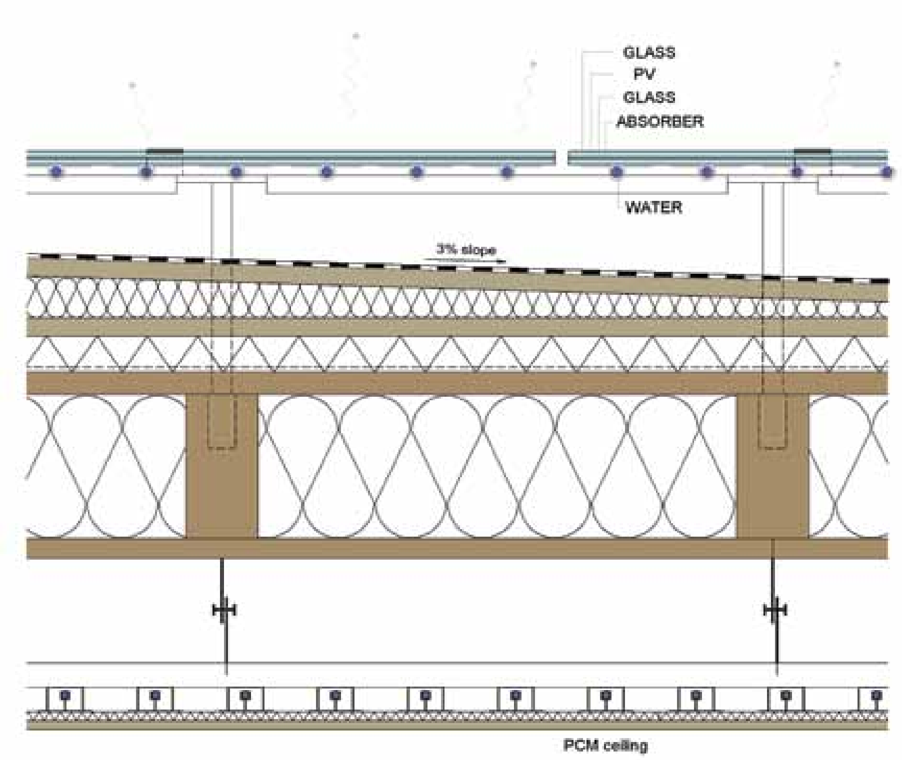
means. The key element of our passive cooling concept is a new building component that we call "energy tower", which is also an important feature of the interior design. In addition night cooling via sky radiation and evaporation is used to discharge Phase-Change-Material (PCM). Active cooling is supplied by a reversible heat pump powered by photovoltaics.

Since the competition occurs in June in a Southern Europe country, the most challenging part is to satisfy the comfort level in cooling mode, which will be the focus of this study.

Innovative PV Modules

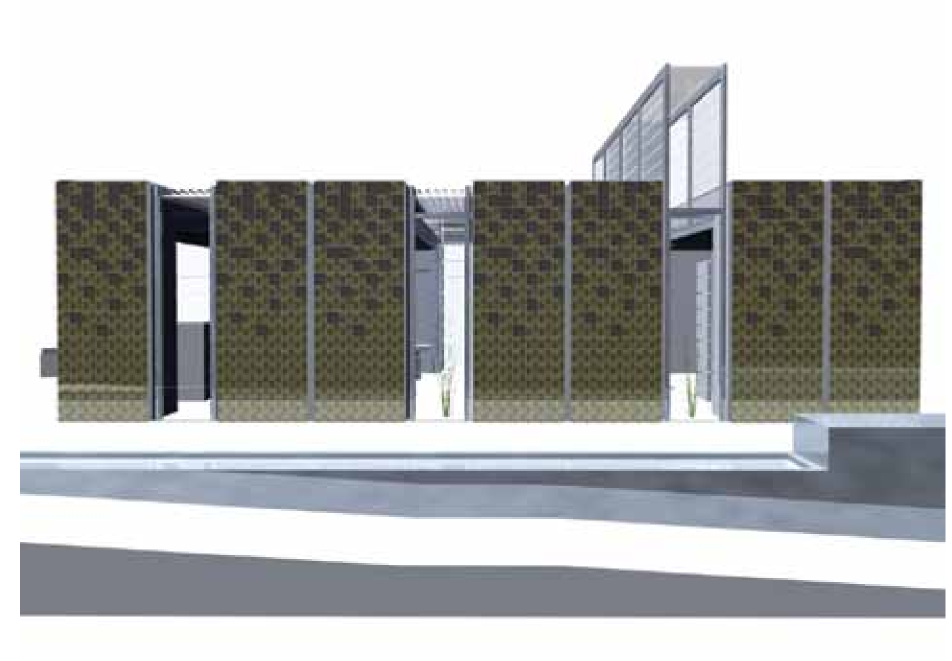
With regard to a unique design we have different façade and roof PV modules. The roof should provide a maximum of electricity output. Roof and façades are visually connected using differently coloured cells in a unique 'pixel design'. The cell colours are gold and bronze on the roof edge and façade while the roof is covered with monocrystalline black cells. The overall installed power will be in the range of 12.5 kWp.

Fig. 6 Night sky radiation cooling system - principle roof section



Window & Facade solutions

Fig. 7 Computer Rendering of PV-Facade



Passive cooling systems

The energy tower supplies passively part of the ventilation and cooling needs by evaporative cooling when the ambient conditions are not extreme (not too hot, not too humid). Free cooling operates in moderate climate conditions and/or at night by letting the air flow through the openings in the gaps.

Low energy night cooling systems

During the day, the PCM ceiling uses the latent heat of the PCM to store the heat and maintain the room temperature around the melting temperature (21-23°C). During the night, the PCM ceiling is actively regenerated using cold water from the night radiative cooling system on the roof. The cold water is stored in a cold storage and used during the day to activate the radiant floor.

The conventional ventilation system (active) is equipped with a heat recovery system between the return air and the supply air for winter and summer. Additionally an indirect evaporative

Fig. 8 Computer Rendering of PV-Facade and Roof

Window & Facade solutions

Fig. 9 Building of the Primary Timber Structure in the Workshop

cooling device enhances the cooling capacity through ventilation in summer.

Back-up cooling system

When the passive or the low energy cooling systems can not cover the demand, the reversible heat pump removes heat from the radiant activated floor to cool down the house. The choice of an electrical solution for the back-up is due mainly to the lack of thermally driven chillers in the range of small power and the lack of space available for the equipments (solar collectors, heat rejection devices,…). Therefore, the façades and the roof will be covered with PV modules in order to provide the electricity needs of the house and inject the rest into the grid. A classic solar thermal system will provide the domestic hot water needs of the building.

Control strategy

Once we know all the components able to meet part of the cooling demand of the house, one needs to define the order of use of these elements in order to meet the required cooling demand. The passive technologies will be used with the highest priority and then the technologies that require low parasitical energy will have the priority. Table 2 shows the priority given for each subsystem in the control strategy.

Table 2
Control strategy of the energy concept

Priority	Subsystems
1	PCM ceiling
2	Energy tower (natural evapor. cooling)
3	Free cooling
4	Night cooling / activated floor
5	Indirect evaporative cooling
6	Reversible heat pump

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