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Energy Procedia 30 (2012) viii – ix
Energy Procedia

SHC 2012
July 09-11, 2012, San Francisco, USA

Editorial to the proceedings of the 1st International Conference on Solar Heating and Cooling for Buildings and Industry (SHC 2012)

Andreas Häberle

The Solar Heating and Cooling Programme was established in 1977, one of the first programmes of the International Energy Agency. The Programme's work is unique in that it is accomplished through the international collaborative effort of experts from Member countries and the European Union.

With SHC 2012 the IEA SHC has started a new series of annual conferences on Solar Heating and Cooling for Buildings and Industry. The conference was organized in San Francisco, co-located with the Intersolar trade fair. SHC 2012 covered papers on technology developments, material research, system design, standardization, reliability, modeling, control, monitoring, demonstration & pilot installations, and best practice examples for the following topics:

Solar thermal collectors
Thermal storage
Innovative components
Solar heating and air-conditioning of buildings
Solar heat for industrial processes
Durability and reliability
District heating
Solar cooling and refrigeration
Building integration
Solar building renovation
Solar architecture
Solar resource assessment
Rating and certification
Market strategies
Policy issues

The conference program consisted of a total of 120 presentations, including 16 keynote lectures and the launch of the IEA roadmap on Solar Heating and Cooling. About 90 scientific posters were continuously displayed throughout the conference.

The proceedings contain 156 manuscripts selected and reviewed by the scientific committee of SHC 2012. We would like to thank all authors for their high quality contributions. Also many thanks to the SHC 2012 committees for their dedicated support throughout the conference organization.

doi:10.1016/S1876-6102(12)01682-7

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Energy Procedia 30 (2012) 305 – 309

Energy Procedia

SHC 2012

Concentrated heat storage for solar heating

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Abstract

The Independent Solar System (ISS) project was initiated in 2008 in order to develop a solar thermal heating system capable of covering the full-year heat and hot water load of a single family house using high temperature thermal storage. A team of European solar thermal experts, research institutions and industrial partners developed the system by combining innovative technologies (high temperature heat transfer fluid, super-insulated storage tanks and a specialized control system) with standard off-the-shelf components. The aim was to create an efficient, affordable and reliable solar thermal heating and hot water system operating at high temperatures for small and medium sized buildings. In 2009, the first prototype system was produced and installed on a pilot building. Over the 2009-2010 heating period actual performance of the prototype system was monitored using web-based applications and then evaluated against system performance simulations. The data shows promising potential for this renewable energy solution for homes in south and central Europe.

Keywords: Advanced thermal storage; solar heating system; solar combi system; buildings

Concentrated heat storage for solar heating

1.1. Introduction

The energy demand in residential buildings amounts to approximately 30% of the overall energy demand in Central Europe, the share of hot water and space heating being about 12% and 75% respectively. In times of an ever-increasing energy demand and the peak of gas and oil extraction to be reached in the near future, energy from renewable energy sources is one way of securing the world economy's energy demand while at the same time contributing to climate protection. Solar combi-systems

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1876-6102 © 2012 The Authors. Published by Elsevier Ltd.
Selection and peer-review under responsibility of the PSE AG
doi:10.1016/j.egypro.2012.11.036

with a market share of more than 50% in the solar sector already in 2008, are gaining in significance. The aim of the Solar Thermal Vision 2030 (ESTTP) has been defined to cover low-temperature heat needs for heating and cooling in the residential sector by solar active housing by 100% and 50% in refurbishments which shall be achieved by improved technological approaches and reduced heating demand in modern buildings.

At present even in the sunniest regions of Europe, solar heating systems for small buildings are not yet capable of supplying the full year energy supply by exploiting solar radiation. Existing solar installations for private homes are typically sized to prevent excessive heat build-up in summer when demand is low, and as a result are incapable of exploiting the much lower winter solar gains for heating or even hot water needs. The ISS project set a goal of developing an innovative high-temperature solar heating system able to generate the thermal load for a single building covering the heat demand year round without curtailing living comfort conditions as a contribution to an effective use of renewable energies.

1.2. ISS system design and development

The purpose of the ISS research project is to validate the design of an autonomous solar heating system at a scale close to industrial applications and compatible with the SME financial capabilities. Standard solar panels are connected to highly-insulated storage tanks containing high-temperature thermodynamic fluid.

1.3. System components

High-efficiency vacuum-tube solar collectors are used to deliver heat to the storage tanks via an innovative heat transfer fluid, also being used as storage medium in the storage tanks. The heat transfer fluid, a mono propylene glycol, is capable of withstanding operating temperatures higher than 160°C. Two types of storage tanks were used: domestic hot water tanks operating at temperatures between 15° and 90°C and high temperature storage tanks with a capacity of 300 liters designed to store heat transfer fluid for several months at temperatures between 50° and 150°C. With the exception of the control unit and the high temperature storage tanks, the system utilizes technologies and items already available on the market.

1.4. Simulations

The conceptual design and hydraulic scheme were initially verified by simulation taking into consideration fixed and variable parameters (such as site, area of solar collectors, angle, volume of tanks, flow rates). Simulations were performed for a standard single family house with 5 rooms, an area of 100 m^2 and equipped with a radiant floor heating.

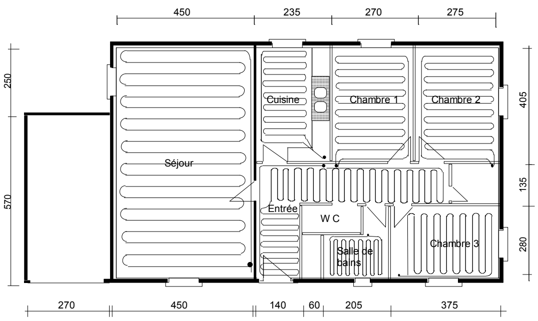

Fig. 1. Floor plan - simulation case study

In order to analyze the requirements and costs of the application of the ISS system in a variety of potential markets, simulations were performed for 5 different locations in South and Central Europe, with building thermal characteristics adapted to national building energy codes.

Table 1 Annual building energy demand

	Space heating demand (kWh/m².y)	DHW demand (kWh/m².y)
Nice	18.2	10.4
Zurich	54.8	12.3
Roma	20.6	10.4
Vienna	39.5	12.3
Constanta	31.6	10.4

Simulations were performed with the dynamic simulation tool TRNSYS and designed to simulate the performance of thermal energy systems by calculating the performance of the ISS components over the period of one year and generating hourly data.

1.5. Results

Considering a solar system operating at high temperatures, the simulation included the assessment of the temperature levels approached during operation. Calculations for the reference case in a Mediterranean climate demonstrated that the liquid at the solar collector outlet reaches a maximum of about 160°C, whereas the temperature does not exceed 120°C when the solar pump is in operation. To prevent overheating of system the solar pump empties the collectors as soon as the storage tank temperature reaches 150°C. The innovative controlling units in combination with the pumps make sure that the unique charging/discharging process is optimized by directing the heat transfer fluid from the solar collector to the storage tank with an upper temperature closest to its own, allowing for tanks at different temperature levels. Discharging was regulated in such a way that a tank with cooler liquid is tapped until its temperature is lower than that required.

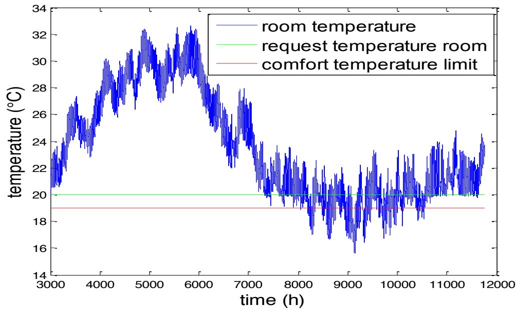

Fig. 2. Indoor air temperature over the year without auxiliary heating – Nice

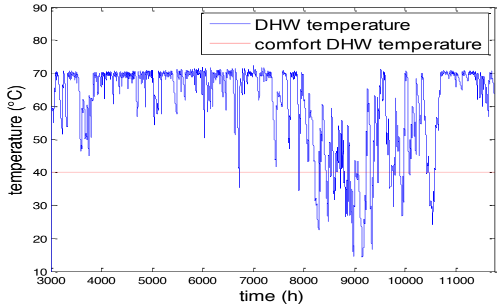

Fig. 3. Upper temperature of DHW over the year without auxiliary heating – Nice

The reference case represented a single family house in a Mediterranean climate (Nice). Initial simulations (solar collectors with an area of 15 m^2 and a storage capacity of 900l in 3 tanks of 300l each connected in series) were carried out without any additional energy source, showing that thermal comfort needs (room temperature permanently over 19°C, DHW upper temperature constantly over 40°C) could be achieved during 90% of the year. Since indoor air temperature dropped below 19°C during 700 hours (8%) of the year and DHW temperature below 40°C during 440 non-consecutive hours (5%), a back-up system would be needed to guarantee the thermal comfort conditions. For this reason, in the later pilot installation, an electric auxiliary heating system was installed in the DHW tank, and a gas boiler integrated into the system to support space heating when solar energy supply is not sufficient.

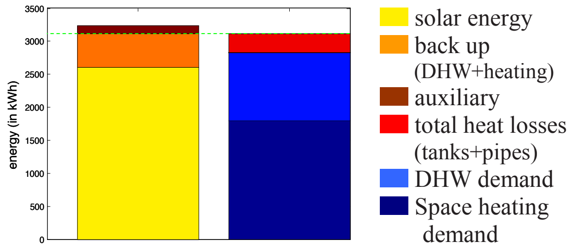

Fig. 4. Annual energy balance – Nice
(15m² sol. coll., 900l tank)

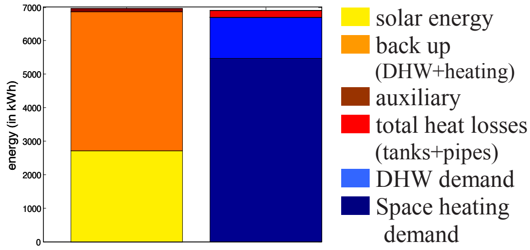

Fig. 5. Annual energy balance – Zurich
(20m² sol. coll., 1200l storage tanks)

Results from simulation runs for a Central European climate (Zurich), reflect space heating demand 3 times higher. Here the energy provided by the ISS solar system covers 75% of the energy needed for thermal comfort conditions. Considering additional energy needed for pumps, the energy saving potential of the ISS system is Fsav,ext=75% for the Mediterranean climate and Fsav,ext=39% for the Central European climate case.

1.6. Prototype development

Simulation results served as basis for the final design and manufacturing of the prototype storage tanks. The tanks use a combination of arc welding and laser welding and are packed in layers of high-efficiency insulation and aluminium sheets. Four prototypes were manufactured in Spain and reliability tests performed between January and August 2009 at a demonstration site in Rians, France.

1.7. Pilot installation and monitoring

In the fall of 2009, the full prototype system was assembled on a country house in Rians, France with an area of 120 m² and a height of 3.25 m^3. Due to the poor thermal performance of the building and its resulting heat requirements, the pilot installation had 4 storage tanks with a volume totaling 1200 liters. The system was fitted with equipment so that the performance could be monitored remotely over a complete heating season. The purpose of this field test was threefold:

- Measure real energy performance of the ISS system on the field
- Validate the numerical simulation tool that has been developed
- Pinpoint critical technology issues that can be observed under a real time experiment

1.8. Conclusions

The production of a cost-effective high performance solar heating system can make an important contribution as Europe strives to meet renewable energy targets. This prototype serves as a model for a compact solution which can help advance the solar thermal market share in Europe.

Temperatures obtained in the ISS system rarely exceeded 120°C. Except for the storage tank and the controller, there is no need to develop specific components since standard technologies are available on the shelf.

Initial simulations have shown that the concept of an autonomous solar heating system applying the ISS system is not yet fully economically reasonable for conventional housing. For the reference case used in this study, it has been shown that without any auxiliary heat source, thermal comfort conditions are not achieved during 10% of the year. Therefore a back-up system would be necessary. Since this auxiliary system would only be required to contribute a small amount of the total building energy demand, this system can be sized as an emergency back-up but still represents additional costs for the system.

Acknowledgements

This project was realized with the friendly support of the Austrian Federal Ministry of Science and Research (BMWF), the European Union and the Vienna Technology Agency (ZIT).

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