

CCEM - Innovative Building Technologies for the 2000-Watt-Society (House2000) B4 – Efficient heating and cooling with heat pumping technology Annual report 2008

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1) Scope of activities

The project aims to deliver new integrated solutions for combined operating systems covering heating, cooling and domestic hot water especially adapted to the requirements of low and ultra-low energy houses representing the vision of the 2000-Watt Society. Complete system solutions for MINERGIE® and MINERGIE-P® housing are to be developed using the most advanced active and passive systems combined with the use of heat pumping technology.

Problems to be solved by means of simulations and measurements are:

- Which building type requires which hydraulic design (capability, costs)?
- What is the best control scheme (efficiency, robustness, investment)?
- Which rules and guidelines can be derived?
- How can advanced heating and cooling concepts be disseminated with a real space unit?

During the report period the work was concentrated on the development of simulation models (thermally activated building structures and a model for a vertical borehole heat exchanger), the definition of system layouts for integrated operating systems and the detailed analysis of an exemplary system for heating and cooling with ground coupled heat pumps. Furthermore a pilot plan with ground coupled heat pump for heating, cooling and domestic hot water preparation has been instrumented for measured over one year.

2) Current state of projects compared to the proposal's aims/milestones

The SFOE project "Heating and cooling with ground coupled heat pumps" has been finished in August 2007. The final report and a fact sheet are now available on the website www.energieforschung.ch.

In the SFOE project "SEC: Standard solutions for Efficient Cooling with heat pumping technologies" the evaluation of the defined systems layouts and control concepts by simulation started and an enquiry on the actual practical use of heat pump systems for heating and cooling has been carried out. In close cooperation with our industry partner, a single family residential home with ground coupled heat pump for heating and passive cooling is being equipped with measurement devices. Measurements will start in fall 2008 to be monitored for a period of one year (see [B4-24]).

The project is delayed due to unexpectedly protracted search for a pilot plant and personnel recruitment. Therefore an extension of the SFOE until summer of 2010 is taken into consideration.

In the SFOE project demonstration building Cosyplace a MINERGIE-P® multi family house with 5 flats has been equipped with a ground-coupled heat pump for heating and domestic hot water and passive cooling. The experimental work is in schedule and interim results have been published (see [B4-18] and [B4-23]). An extension of the project enabling measurements for another year is under consideration.

The project IEA Heat Pump Program Annex 32: Economical Heating and Cooling Systems for Low-Energy-Houses started in January 2006. Work is carried out task shared and cost shared with support of member countries and SFOE. In 2008 interim results of the national project contributions have been published (see [B4-16], [B4-17], [B4-19], [B4-20], [B4-21] and [B4-22]). The Annex 32 has been extended by the executive committee until the end of 2009.

3) Main results

The results of the completed SFOE project "Heating and cooling with ground coupled heat pumps" showed that in a residential building a simple built-up system with heat pump and borehole heat exchanger for the heating or domestic hot water generation as well as for the passive cooling using the borehole heat exchanger proved to be the best choice. The use of the heat pump for simultaneous cooling and domestic hot water generation does not pay off compared to the additional investment. A small temperature difference in the heat exchanger between borehole heat exchanger and floor heating circuit is of great importance. It is advisable to use with night ventilation the passive cooling potential of the

outdoor air as well. The dimensioning of the borehole heat exchanger for heating turned out to be sufficient for the passive cooling mode.

In the project “SEC: Standard solutions for Efficient Cooling with heat pumping technologies” integrated system configurations covering heating, cooling and domestic hot water have been defined for various residential heat pump types including heat sources and emission systems. The evaluation of these systems has started. An enquiry on the actual practical use of heat pump systems for heating and cooling showed an increasing demand in cooling options wherein system layouts mainly correspond with the system layouts defined for further evaluation.

The interim results of the field monitored multi-family house CosyPlace showed a good thermal comfort with room air temperatures of 20°C to 25°C in the winter and 22°C to 26°C in the summer period. The generator weekly performance factor for cooling, showing the ratio of generated cooling energy to the consumed electricity in the circulating pump of the borehole heat exchanger is in the range of 8 to 12. The first winter resulted in a seasonal performance factor for heating in the range of 3.7 and 4.3 and 2.5 for domestic hot water operation. However the heat demand was substantially higher as expected. Furthermore comparatively high supply temperatures of the emission system and short running periods of the heat pump resulting in heavy cycling could be observed.

Based on these findings various measures have been proposed to be implemented enabling an improved operation in the coming heating period. It is planned to extend monitoring for another year.

The collaboration within the IEA HPP Annex 32 is an excellent possibility to exchange results from research activities on heat pumping technologies from different countries worldwide. In 2008 the website for information dissemination of the Annex 32 project, the participating countries and interim results incl. publications has been launched at the URL <http://www.annex32.net>. In May 2008, a workshop at the 9th IEA HPP Annex 32 has been organized to present the interim results. After the workshop France joined Annex 32, represented by EdF R&D. Due to ongoing field monitoring projects in Annex 32 in the year 2009, the Annex 32 has been extended until the end of 2009.

An example of space unit design developed by students of Zurich University of Art is shown in the following sketch:



location	heating (kWh/m2a)	cooling (kWh/m2a)
Zurich	12.0	0
Davos	5.0	0
Lugano	2.1	0.1

Outline sketch of the space unit “satellite” (left) and heating and cooling requirement for 3 locations (right).

Energy engineering students of FHNW developed an energy concept for a self-sustaining space unit in close collaboration with EMPA (see [B4-25]). The design of the space unit envelope has been developed with students of Zurich University of the Arts. The heating and cooling requirement of the room module was estimated by means of the simulation program HELIOS for three locations with representative Swiss weather data. Possible systems for an energetically self-sustaining room module have been analyzed. Limited space and need for energy storage have been shown as the main challenge. Besides recommendation for an appropriate building technology, the potential in development of self sufficiency have been investigated.

4) Publications/Patents

- [B4-1] Th. Afjei, R. Dott, A. Huber
Heizen und Kühlen mit erdgekoppelten Wärmepumpen
Schlussbericht BFE Forschungsprogramm REN, Muttenz, Aug. 2007
- [B4-2] Th. Afjei, R. Dott, A. Huber
Heizen und Kühlen mit erdgekoppelten Wärmepumpen
Merkblatt BFE Forschungsprogramm REN, Muttenz, August 2007
- [B4-3] Th. Afjei, R. Dott, C. Wemhöner
Hydraulics, Performance and Comfort of ground-coupled heating-cooling systems
IBPSA Building Simulation 2007, Beijing, China, 3. Sept. 2007

- [B4-4] C. Wemhöner, Th. Afjei
Standardlösungen für energieeffizientes Heizen und Kühlen mit Wärmepumpen (SEK)
14. UAW Tagung 2007, Burgdorf, 13. Juni 2007
- [B4-5] R. Dott, C. Wemhöner, Th. Afjei
SEK - Standardlösungen zum energieeffizienten Heizen und Kühlen mit Wärmepumpen
Jahresbericht BFE Forschungsprogramm UAW, Muttenz, November 2007
- [B4-6] R. Dott, C. Wemhöner, Th. Afjei
SEC – Standard Solutions for Energy Efficient Heating and Cooling with Heat Pumps
Summary for annual report, BFE Forschungsprogramm UAW, Muttenz, November 2007
- [B4-7] C. Wemhöner
IEA HPP: Berichte aus dem Annex 28 und Annex 32
14. UAW Tagung 2007, Burgdorf, 13. Juni 2007
- [B4-8] C. Wemhöner, Th. Afjei
Operating Agent IEA HPP Annex 32
Jahresbericht BFE Forschungsprogramm UAW, Muttenz, Dezember 2007
- [B4-9] C. Wemhöner
IEA HPP Annex 32 – Status Report for IEA HPP Executive Committee
IEA HPP Annex 32 N 68 rev1, BFE Forschungsprogramm UAW, Muttenz, 2007
- [B4-10] R. Dott, Th. Afjei
Sanfte Kühlung mit Erdwärmesonden im MINERGIE-P Wohngebäude COSY PLACE
Jahresbericht BFE Forschungsprogramm REN, Muttenz, November 2007
- [B4-11] Th. Afjei
Kälte aus Erdsonden
Heizen und Kühlen mit geothermischer Energie, SIA documentation D 0225, Zürich, 20. May 2008
- [B4-12] Th. Afjei, A. Huber
Heizen und Kühlen mit Wärmepumpen - Standardlösungen
Proceedings 12th international passive house conference, p. 281-282, Nuremberg, April 2008
- [B4-13] C. Wemhöner, Th. Afjei, R. Dott
IEA HPP Annex 32: Economical heating and cooling systems for low energy houses
Conference paper 9th IEA Heat Pump Conference, Zurich, May 2008
- [B4-14] Th. Afjei, R. Dott, Wemhoener, C.
Generic System Solutions for heating and cooling of residential dwellings
Conference paper 9th IEA Heat Pump Conference, Zurich, May 2008
- [B4-15] R. Dott, Wemhoener, C., Th. Afjei
Seasonal Performance and test of multi-function heat pump units
Conference paper 9th IEA Heat Pump Conference, Zurich, May 2008
- [B4-16] C. Wemhöner
IEA HPP Annex 32 – Status Report for IEA HPP Executive Committee
IEA HPP Annex 32 N 111, BFE Forschungsprogramm UAW, Muttenz, May 2008
- [B4-17] C. Wemhoener, Th. Afjei, R. Dott
System assessment and field testing
Swiss country report IEA HPP Annex 32 Task 2/3, Muttenz, August 2008
- [B4-18] R. Dott, Th. Afjei
Energieeffizientes Heizen und Kühlen mit Wärmepumpen im MINERGIE-P MFH CosyPlace
Paper 15. Swiss Status Seminar, Zurich, September 2008
- [B4-19] C. Wemhoener, Th. Afjei, R. Dott
IEA HPP Annex 32 - Economical heating and cooling systems for low energy houses
Paper 15. Swiss Status Seminar, Zurich, September 2008
- [B4-20] C. Wemhöner
IEA HPP Annex 32 - Economical heating and cooling systems for low energy houses
Interim Report IEA HPP Annex 32, Muttenz, October 2008

- [B4-21] C. Wemhöner
IEA HPP Annex 32 – Status Report for IEA HPP Executive Committee
IEA HPP Annex 32 N 132, BFE Forschungsprogramm UAW, Muttenz, May 2008
- [B4-22] C. Wemhöner, Th. Afjei
Operating Agent IEA HPP Annex 32
Jahresbericht BFE Forschungsprogramm UAW, Muttenz, November 2008
- [B4-23] R. Dott, Th. Afjei
Sanfte Kühlung mit Erdwärmesonden im MINERGIE-P Wohngebäude COSY PLACE
Jahresbericht BFE Forschungsprogramm REN, Muttenz, November 2008
- [B4-24] R. Dott, Th. Afjei
SEK – Standardlösungen zum energie-effizienten Heizen und Kühlen mit Wärmepumpen
Jahresbericht BFE Forschungsprogramm UAW, Muttenz, November 2008
- [B4-25] M. Lähns Hänggi, C.M. Wegner-Sänger
Demonstrator – Konzept einer „energieautarken“ Raumzelle
Diplomarbeit NDS-E, Muttenz, Juni 2008

5) Activities within the project such as events, talks, workshops

- Events:
- SFOE-Symposium of UAW research program in Burgdorf (June 2007)
 - Presentation at IEA HPP Annex 32 Meetings (Mai & December 2007)
 - Presentation at IEA ECBCS Annex 48 Meeting in Liège (Oktober 2007)
 - IEA HPP Annex 32 Workshop in the frame of the 9th IEA Heat Pump Conference Zurich (May 2008)
 - Presentation Annex 32 at HPP ExCo meetings (May & November 2008)
 - Presentation Annex 32 at IEA ECBCS Annex 48 Meeting in Münster and Lyon (April & October 2008)
- Invited talk:
- IBPSA Building Simulation 2007 Conference in Beijing (September 2007)
 - CCEM-House 2000 BAC Workshop ETHZ, 9. February 2007
 - EMPA Academy heating and cooling with geothermal energy, March 2008
 - 2nd CCEM-House 2000 BAC Workshop ETHZ (April 2008)
 - 12. Internationale Passivhaustagung, Nuremberg (April 2008)
 - 9th IEA Heat pump conference Zurich, May 2008
 - 15th Swiss status seminar ETHZ (September 2008)