

are Sweden, Canada, Germany, the United Kingdom and United States.

The workshop included presentations of case studies of energy-efficient supermarkets from the United States, Sweden, Germany and Canada. Modelling and simulation tools used in the energy analysis of supermarket systems have been described and discussed. Special attention has been paid to the topic of heat recovery and improving the utilization of the refrigeration system in supermarkets to meet simultaneous cooling and heating needs.

The workshop offered an excellent opportunity for those involved in supermarket systems research, development and design to keep track of the latest developments and to exchange ideas with other experts in the field.

Current activity in the annex is devoted to collecting experience from modelling of supermarket systems. Each country will report on modelling activities and on available software (whole supermarket computer models), as well as on useful component models specific to supermarkets.

A series of web-based electronic meetings will be hosted during the autumn. The theme will be modelling and simulation of full supermarket energy systems and of component models.

Please visit the Annex web site on address www.energy.kth.se/annex31

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Summary Workshop IEA HPP Annex 32 – Economical heating and cooling systems for low-energy houses

IEA HPP Annex 32 started at the beginning of 2006 with nine participating countries: AT, CA, CH (operating agent), DE, JP, NL, NO, SE and US. Annex 32 is committed to the further development of heat pump systems in low-energy houses (LEH). Obtaining practical experience by field test-

ing of heat pump systems for LEH is further objective. The workshop, that was held in conjunction with the 9th IEA HP Conference in Zurich on May, 19-22 2008, presented interim results of the national projects.

As an introduction, C. Wemhöner of the Institute of Energy of the University of Applied Sciences of Northwestern Switzerland presented features of LEH and the current market state. Most participating countries have a strong growth of both built low energy house and heat pump markets. An exception is the Netherlands, where any house on the market is sold, with the result that there is generally a low thermal quality of building envelopes. However, as outlined by O. Kleefkens of SenterNovem, niche market players are currently specialising in LEH in combination with integrated heat pump and ventilation system solutions. The Netherlands' participation in Annex 32 is a driver of market introduction initiatives, by establishing guidelines and best practice examples in the LEH field.

The first part of the workshop was dedicated to heat pump system developments for LEH. R. Rieberer of the Institute of Thermal Engineering of Graz Technical University described the Austrian development of a heat pump in the 3-5 kW capacity range. A system analysis resulted in a decision for a brine-to-water heat pump with CO₂ refrigerant. A prototype system will be built and lab-tested, and system simulation using the prototype results will yield the seasonal performance factor (SPF) of the overall system design. T. Afjei of the Institute of Energy in Building of the University of Applied Sciences of Northwestern Switzerland presented standard system solutions with heat pumps for space heating and cooling. The first system solution, a ground-source heat pump with free cooling, is currently being field-tested in an ultra-low-energy house. The winter operation shows an overall SPF of about 3.8 for space heating and domestic hot water production. Field monitoring of the space cooling operation and further system configurations will be evaluated in



the ongoing project. M. Voss Lapsa of the Oak Ridge National Laboratory reported on the US development of a highly integrated heat pump providing space heating, domestic hot water, space cooling and ventilation (including humidification and dehumidification). Preliminary annual system evaluation based on prototype laboratory testing results and simulations yielded a reduction in the range of 46 %-67 % of energy consumption of the air-source heat pump, and 52 %-66 % of the ground-source heat pump, compared to a state-of-the-art system for typical sites in the US climate for a net-zero-energy house (NZEH). Initial cost estimates indicate simple payback times of 5-10 years for the air-source heat pump, and 6-14 years for the ground-source heat pump, including the borehole heat exchanger. S. Ruud of SP Technical Research Institute of Sweden pointed out in his presentation that implementation of revised building regulations by 2009 could require higher levels of thermal insulation of buildings and installation of heat pumps, with a resulting specific energy use in new single-family houses with heat pumps being in the range of ultra-low-energy houses. S. Takeda-Kindaichi of the University of Tokyo described common Japanese system solutions of single or multi-split heat pumps for space heating and cooling in reverse operation for the moderate climate zone, where 80 % of the Japanese population lives. However, system simulations revealed that common design proce-





dures lead to oversized heat pumps in LEH applications. The project will determine appropriate design methods. J. Stene of SINTEF Energy Research in Norway described the design of a CO₂ heat pump water heater for use in LEH blocks of flats. System design and simulation show that the unit is both an economical and energy-efficient solution, resulting in energy saving of about 75 % compared to direct electrical water heating and about 25 % compared to common solar domestic hot water heating systems in Norway.

The second part of the workshop was dedicated to the results of field monitoring of systems. M. Miara of the Fraunhofer Institute of Solar Energy systems presented preliminary results of a German field test in co-operation with seven manufacturers and two utilities, including about 110 state-of-the-art heat pumps installed in LEH. All systems showed an SPF of 3 or more for space heating and domestic hot water production. Ground-source heat pumps showed themselves to be the most efficient systems, as water-source heat pumps have a quite high energy consumption for the auxiliary components, in particular the source pump. The results of the air-source heat pump are based mainly on winter operation. Follow-up work includes the installation of further systems and a more detailed evaluation of single systems.

The Canadian contribution was dedicated to a field test of 2 EQUilibrium NZEH in the frame of a nationwide field test of 13 EQUilibrium house led

by the Canada Mortgage and Housing Corporation. José Candanedo of the Concordia University in Montreal described the field monitoring of two NZEH in co-operation with Hydro-Québec. Both houses incorporate a heat pump and solar components, e.g. heat recovery from ventilation air of ventilated PV-system. J. Stene presented results of field monitoring of an innovative prototype propane heat pump using lake water, which is installed in an ultra-low-energy house in southern Norway. Results of the first winter season show an SPF of 3.3 for space heating and domestic hot water production. However, further potentials for optimisation of the evaporator and expansion valve have been discovered. K. Nagano of Hokkaido University in northern Japan reported the results of field tests of a ground-source heat pump in a low-energy house in the cold climate region. The first field test shows a CO₂ reduction of about 60 %, in comparison with that of a state-of-the-art system. An optimised system is being investigated in a second field test.

C. Wemhöner concluded the workshop. Expected results of the Annex 32 are new HP system concepts for LEH in low capacity range and with natural refrigerants. Field monitoring results will identify field-proven best practice solutions. Design recommendation for standardised system solutions will be derived from both the system simulations and the field trials.

After the workshop, France joined IEA HPP Annex 32, represented by Electricité de France R&D. Work in Annex 32 will continue until the end of 2009. Further information and all workshop presentations for download can be found on the Annex 32 website at <http://www.annex32.net>, under publications.

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9th IEA Heat Pump Conference Report on Workshop Annex 33: Compact Heat Exchangers in Heat Pumping Equipment

A workshop covering the work of Annex:33 - Compact Heat Exchangers in Heat Pumping Equipment - was held during the 9th IEA Heat Pump Conference. Delegates from the participating countries - UK, Sweden, USA and Japan - described the work being undertaken. Austria also attended the workshop, and was welcomed as a new participant in the Annex. Some 25 other delegates from the conference attended the workshop.

Short presentations were given by each participant:

Introduction and background to the Annex. *Dr Peter Kew, Heriot-Watt University, Edinburgh, UK:*

The objective of the annex is to present a compilation of the roles that compact heat exchangers (CHEs) can play in heat pumping equipment, directed at minimising both direct and indirect effects of the equipment on the local & global environment as a result of manufacture, operation and/or disposal of the plant. Dr Kew outlined why compact heat exchangers were attractive from a heat transfer point of view. He then went on to summarise some of the market studies which have recently been carried out in the UK, which assess the potential for heat pumps and compact heat exchangers in UK industry.

Development of non-fluorinated energy-saving refrigeration and air conditioning systems in Japan.

Professor Eiji Hihara, The University of Tokyo, Japan: Prof. Hihara described how the Japanese Ministry of Economy, Trade and Industry is giving considerable support through the New Energy and Industrial Technology Development Organisation (NEDO). The use of compact heat exchangers is likely to play a part in the development of high-efficiency heat pumps using high pressure and/or flammable fluids, for which a low fluid inventory is important from a