Summary of Workshop in REHVA World Congress Clima 2007
WellBeing Indoors

WS 11 - Low Temperature Heating and High Temperature Cooling Systems for High/Performance Built Environments - Date: 12 June 2007

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Presentations:

Practical introduction to exergy thinking – Dietrich Schmidt, Fraunhofer Institute for Building Physics (Germany), dietrich.schmidt@ibp.fraunhofer.de

Innovative LowEx engineering concepts and their business opportunities – Markku Virtanen, VTT Technical Research Centre of Finland, markku.virtanen@vtt.fi

More efficient integration of renewable energy sources into the built environment – Herena Torio, Fraunhofer Institute for Building Physics (Germany), herena.torio@ibp.fraunhofer.de,

High temperature surface cooling in warm climates – Michele de Carli, University of Padova (Italy), michele.decarli@unipd.it

Comfort issues related to Low Exergy systems – Bjarne Olesen, Technical University of Denmark, bwo@mek.dtu.dk

LowEx in practice, the Minewaterproject – Peter Op´t Veld, Cauberg-Huygen R.I.B.V.(the Netherlands), p.optveld@chri.nl

INTRODUCTION

The main objective of the workshop was to point at directions for a more efficient and rational use of the energy sources in the built environment, which will lead to reductions in the CO_2-emissions caused by the sector. This aim can be achieved through a wider use of low-valued and renewable energy sources in the built environment. The thermodynamic concept of exergy was shown as a tool for optimizing the operation of the systems, and also to point out the required preconditions and best practice examples in the building sector among which the use of low temperature heating and high temperature cooling systems is a must. Issues regarding thermal comfort associated to the use of low temperature heating and high temperature cooling systems can also addressed by using the exergy concept.

DISCUSSIONS AND WS MAIN RESULTS

After a short introduction on the thermodynamic concept of exergy, the main differences between energy and exergy analysis were shown at hand of some examples of different building systems.
A graphical schema of the LowEx approach can be seen on Figure 1: after the reduction of the energy demand in the buildings has been minimized, the use of renewable and low-valued energy sources (e.g. DHC, waste heat) has to be implemented. This approach requires a deeper professional integration of multidisciplinary teams, so that networking and cooperation between real state building expertise professionals and experts from the building services branch is absolutely required.

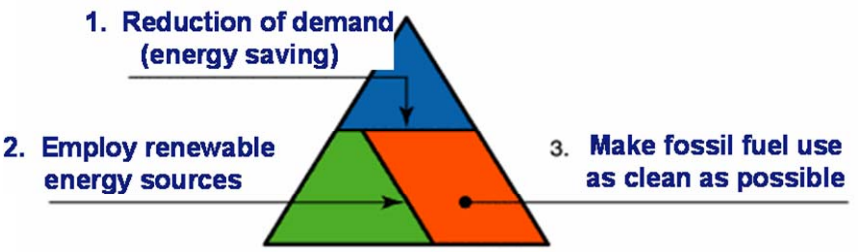

Figure 1. LowEx approach to achieve a more sustainable built environment. Taken from ECBCS Annex 44 – Integrating Environmentally Responsive Elements in Buildings.

According to the exergy approach the highest optimization potential within the building sector lies on one hand on the emission systems installed in the building, and on the other hand on the energy generation (including the primary energy transformation) step.

The exergy losses in the generation step can be minimized by making use of low-valued and renewable energy sources, as it is shown in Figure 2. The lower the slope of the line in each subsystem, the lower the exergy losses are on it and following a more efficient use of the energy can be achieved.

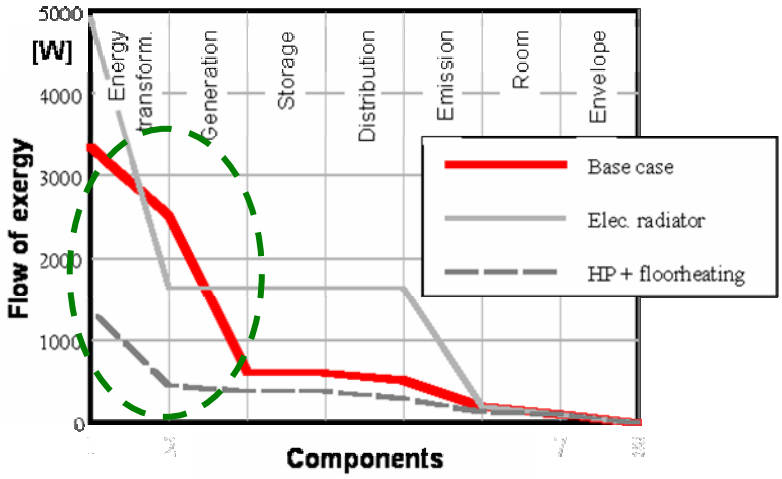

Figure 2: Exergy flows for a building with different building systems.

The exergy losses in the emission step can be minimized when low-temperature heating and high-temperature cooling systems are installed in the buildings, as can be seen on Figure 3.

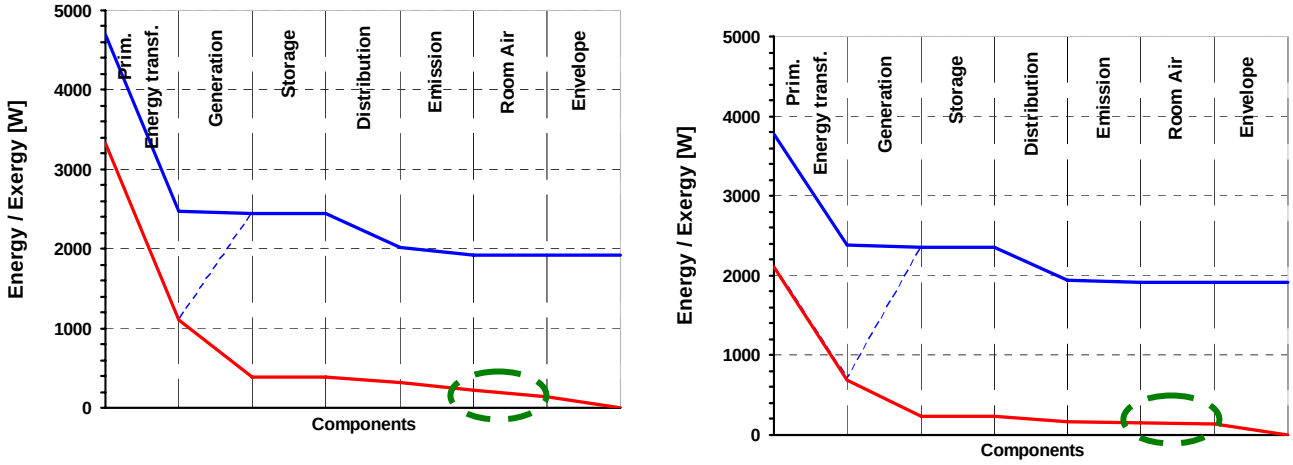

Figure 3: Energy (blue) and exergy (red) flows for a building: a) building with an air-to-water heat pump and radiatiors (55/45°C) as emission system; b) building with an air-to-water heat pump and slab heating (22/28°C) as emission system.

Furthermore, the use of this kind of systems allows also a more efficient integration of renewable energies in the built environment, as was also shown in the workshop. Therefore their implementation is necessary for achieving a more sustainable built environment and their use should be widely taken into account in the building design process.
Following this approach, many innovative systems are being currently developed and implemented into the building sector, e.g. PCM slurries and storages, decentralized AHU with PCM storage or thermally activated surfaces and exterior façades.

The main technical characteristics and performance of some high-temperature cooling systems for warm climatic conditions (as in Italy) were shown. Among them, thermally activated building constructions, so-called TABs, showed very high potential for energy savings and cooling peak power reduction. In addition, the advantage of using this type of systems coupled to a displacement ventilation system instead of using traditional mixing ventilation approaches were also pointed out with regard to the thermal comfort of the occupants and the energy saving potential.
When comfort issues are addressed using the exergy approach, the mean radiant temperature on the room plays a similar role as the mean indoor air temperature. As it can be seen on Figure 4, the minimum exergy consumption rate in human body takes place when mean radiant temperature is higher, being the mean indoor air temperature lower. This indicates that for a better thermal comfort of the occupants in winter conditions may be achieved when the radiant temperature is higher than mean indoor air temperature. A similar analysis can be done for cooling systems under summer conditions. These conclusions led again to remark the high suitability of thermally activated building systems (TABs), which make possible the use of low-temperatures for heating and high-temperatures for cooling.

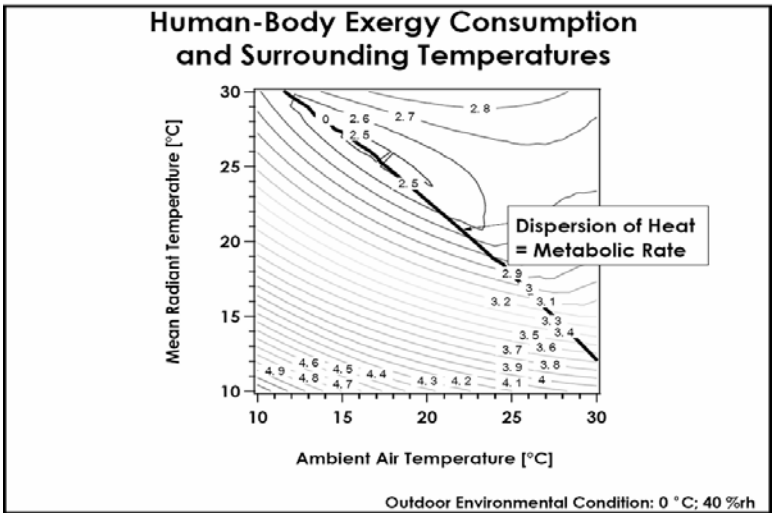

Figure 4: Human-body exergy consumption rate and surrounding temperatures. [1]-Taken from investigations carried out by Masanori Shukuya, Musashi Institute of Technology (Japan).

Finally the Remining-Minewaterproject was presented as a LowEx case study. The first pilot location is in Heerlen, in the Netherlands and the basic principle of the approach lies on balancing the energy flows on the supply and demand sides by making use of low exergy principles for that. In the project, the warm and cold water from abandoned coalmines will be used for heating and cooling purposes. The water, which has temperatures ranging form 17 to 35°C will be either directly used for heating and cooling purposes, or will be used to feed water/water heat pumps to adapt the temperature level at the required output. The project includes residential as well as office buildings, and schools, being therefore an inspiring example of energy efficient planning and management on a community level.

CONCLUSIONS AND FUTURE WORK DIRECTIONS IN THE FIELD

***The main conclusions that can be withdrawn from the workshop are**:*

- *The exergy demand of buildings for heating and cooling is naturally low, and therefore **energy shall be supplied to this sector at low exergy levels** in order to match the exergy of supply and demand (and reduce the exergy losses through the energy chain).*
- *The main optimization potential for the use of energy in the sector can be found in the **generation** and **emission** steps. Consequently, once the building envelope has been carefully designed, building systems allowing a **wider use of renewable energies and low-valued energy sources** have to be introduced. Such systems are low-temperature heating and high-temperature cooling systems.*
- *In particular, **thermally activated building systems** (TABs) are a very suitable option to achieve these aims, as was shown at hand of dynamic simulations of the systems.*
- *First studies show that high-temperature cooling and low-temperature heating systems allow a **better thermal comfort** of the occupants. However, further research has to be carried out for a wider spectrum of conditions.*

***Future work on the field includes**:*

- ***New business models based on a holistic approach**, integrating end-users as well as professionals of the different fields within the building sector are necessary for the implementation and development of these system solutions. Integral live cycle service solutions are requested.*
- *Further research has to be conducted to define **exergy-based sustainability indicators** that can describe the performance of buildings and building systems.*
- *Research is to be carried out using the **exergy analysis on human thermoregulation** and theoretical results obtained have to be verified on a experimental basis with subjects.*
- ***New insights on comfort effects of temperature drift** in buildings will derive from the exergy-based approach and research.*
- *Further **optimization of renewable-based energy systems**, that would enhance the implementation of these systems into the built environment, is necessary. Optimization potential and best uses have to be conducted from the exergy perspective to gain further insight on their actual use of energy flows.*
- *Several **technical questions** of the innovative case/study presented have to be addressed: velocities of the water flow in the distribution network, pressure levels in the grid, appropriate materials for avoiding corrosion, etc…*

REFERENCES

[1] Annex 37 Guidebook (2002): *International Energy Agency – Low Exergy Heating and Cooling of Buildings – Annex 37*, Web Homepage: www.lowex.net

For further information of activities on the field, please check:
www.annex49.com
www.lowex.info
www.lowex.nl