Summary of REHVA World Congress Clima 2010

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Congress in the numbers

Clima 2010 World Congress was held on 9-12 May 2010, in Antalya, Turkey. Scientific aspect of the congress was a great success. Preparation phase of the congress lasted 3 years. 954 abstracts were received from all over the world by the end of the call for papers phase. Evaluation stage was really difficult to cope with. Each abstract was evaluated by 3 members of the International Scientific Committee. Nearly 100 abstracts were rejected, 550 abstracts were accepted for oral presentation and 300 for poster presentation.

After the results of the first phase were announced, acceptance of full papers started. 636 full papers were received, which included 453 oral presentations and 183 posters. They were also reviewed and the conference program was scheduled accordingly.

Table 1. Distribution of papers by themes and topics

Specific Themes	Number of Technical Sessions	Number of Oral Presentations	Number of Poster Presentations
Sustainable use of energy in buildings			
Energy Performance of Buildings	10	57	18
Sustainable Buildings	5	29	13
Labeling Buildings	3	16	5
Double skin facade	2	12	5
Historical Buildings	2	11	9
Buildings&Architectural design integration			
ICT-Intelligent Buildings	1	6	6
Architectural Design Integration	2	12	-
Building Simulations	4	23	10
Building Services	1	7	-
Lighting	1	6	2
Modern HVAC systems			
HVAC Systems	9	51	29
HVAC System Design	6	37	10
HVAC Equipment	1	6	-
District Heating-Cooling	1	6	-
Renewable Energy Systems	3	15	5
Heat Pumps, GSHP, Geothermal	4	22	8
Theoretical-Experimental approaches	2	13	5
Air Distribution	3	18	5
Maintenance & Operations	1	7	-
Ventilation	2	11	-
Healthy and Productive Indoor Climate			
Natural Ventilation	3	19	7
Personalized Ventilation	1	7	3
Indoor Environment	4	25	9
Health-Productivity	3	15	14
Thermal Comfort	2	15	11
Moisture and Humidity	1	5	-

408 papers were presented orally during the congress and 160 with posters. However, all received full papers including both oral presentations and posters have been included in the conference proceeding on CD. 77 Technical Sessions were held in 8 parallel rooms during the congress. Technical sessions were designed according to congress themes. **Table 1** summarizes the technical sessions, their themes and number of papers presented in each

theme. This table shows that majority of the papers were on sustainable and efficient energy use in buildings and on modern HVAC Systems. In addition 9 invited and 3 keynote lectures were presented during the congress.

25 workshops were held and their definitions and objectives have been summarized in the abstracts book. Following the congress, a workshop report on the results and concusion of the workshops will be published and mailed to each participant. It is also available in the REHVA bookstore at www.rehva.eu

830 participants were registered formally for the conference. Including guests and other accompanying persons, more than 1000 people attended the conference.

Publications

The scientific quality of the conference was quite high. Participants were scientists from all over the world and the concern of relevant scientific journals in the congress was accordingly competent. Three scientific journals are preparing special issues from the conference papers, i.e., ASHRAE HVAC&R Research, International Journal of Ventilation, Energy and Buildings. Special editors of these journals will select the papers to be published and edit them separately for print. This practice will continue in the future Clima conferences to promote participation in conferences.

Sustainable Energy Use

The theme of the congress was “sustainable energy use in buildings” and was discussed extensively during the conference. Sustainable energy use on the one hand is related to the consumption of fossil fuel resources and on the other hand, it is closely concerned with preservation of the environment. In one sense it is involved with energy efficiency, energy conservation, and use of renewable energy sources and in other hand it is entangled with the green building concept and global warming.

In terms of sustainable use of energy there are two major threats. First threat is global warming or climate change. As shown in **Fig.1**, CO_2 concentration in the atmosphere was almost constant over the past centuries and is almost doubled during the last century. It is predicted that CO_2 production will increase by 70 % until 2030, relative to today’s rate. Global mean temperature is also increasing accordingly. CO_2 emissions should be reduced considerably to avoid increasing trends of CO_2 and global temperature to intolerable levels. Similar situation is in prospect for fossil fuel resources. World fossil fuel resources can not comply with the present demand. Predictions indicate that fossil fuel consumption should be reduced to 20% of today’s consumption in year 2030. Considering these threats, there are actions all over the world to reduce the CO_2 emission and fossil fuel consumption. The USA target is 30% reduction in the year 2030 and the EU target is 20% reduction (new proposal 30% reduction) in year 2020.

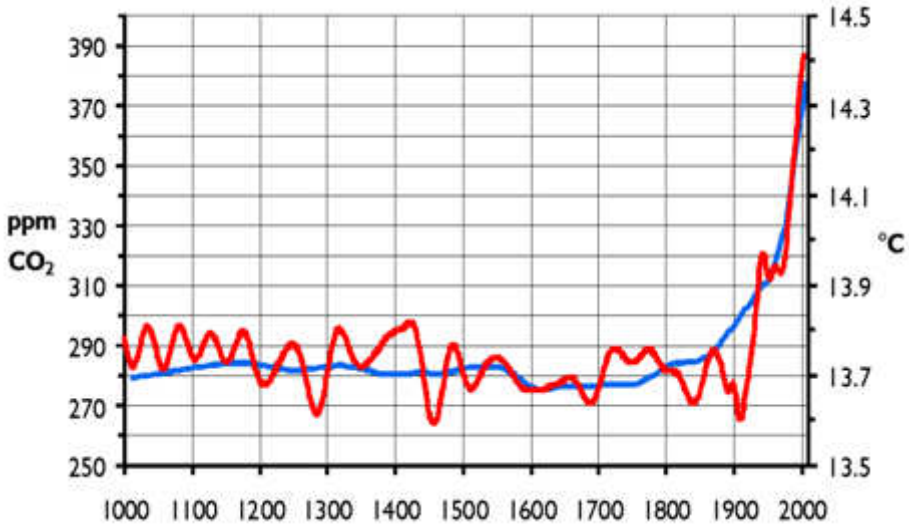

Figure 1: IEA predicts on the basis of 1.8% of growth per year a total emission of 38 billions tons of CO_2 in 2030, 70% more than in 2000, and a significant increase in the global mean temperature. Red line indicates temperature and blue line indicates CO2 concentration.

Sustainable Energy Use in Buildings

Situated at the focal point of the energy issue, building sector comprises the core of the "sustainable energy use action". Building sector is responsible for almost 40 % of the world primary energy use and no wonder there is a great potential to save this energy. Energy saving potentials in the EU in different sectors can be seen in **Fig. 2**. It was concluded that the energy efficiency and environmental impact of buildings is a real and global challenge.

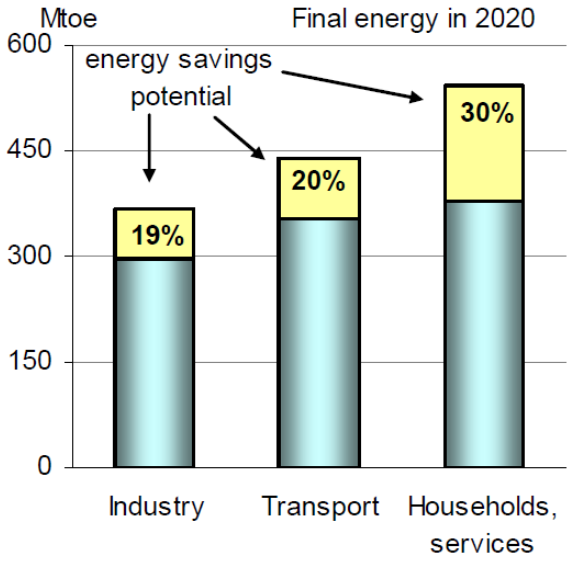

Figure 2: Estimated energy consumption reduction potential in 2020

Issues related to sustainable energy use in buildings are usually considered under two major categories, namely, the building itself and its service systems including HVAC&R systems. In the Clima congress also this usual approach was followed and technical sessions were organized accordingly. However, integrated design is the essential theme in approaching

sustainable building and sustainable future concepts of our age and various professions can't function independently any more. Recent developments (mainly in Europe) show clearly that realistic solutions do exist but a real integrated design effort is necessary. One of the major successes of this congress was the integration of different disciplines. During the congress, both engineers and architects attended same sessions and collaboratively discussed same problems, approaching solutions together. Integrated design was the subject of many presentations.

One of the conclusions was that retrofit should be the main target in reducing energy demand and even producing renewable energy. Only 2% per annum new construction in USA, 75-85% of buildings in urban areas that will exist in 2030 have already been built. The other important fact is the uneven distribution of efforts on regulated and unregulated buildings. Our concern is concentrated on only regulated buildings; however, there is plenty of work to be done for unregulated buildings. In the USA unregulated building stock is as high as 48 %.

Within the context of the sustainable building concept, the targets of EU energy policy 20/20/20 and EPBD directive were discussed extensively. Sustainable building design and net zero energy buildings were also among most common subjects. US Department of Energy Net-Zero Commercial Building Initiative Targets are: marketable, net-zero energy commercial buildings in all US climate zones by 2030, sustainable design strategies, on-site renewable power, and purchased renewable credits. ASHRAE Vision 2020 is providing tools by 2020 that enable the building community to produce market-viable NZEBs by 2030. EU targets are: in 2015 a certain percentage of the buildings should be 'nearly zero energy' (shall be defined by the European Commission) in 2018 all new public buildings have to be 'nearly zero energy', in 2020 all new buildings have to be 'nearly zero energy'.

The energy consumption of building depends on the design of building envelope, selected HVAC-systems and the maintenance of them. The quality of windows pays also an important role, when building is designed. Solar shading is another important issue, where architects can greatly affect the quality of building and its energy efficiency. With good solar shading the cooling requirement can be reduced close to internal load level e.g. 40 – 50 W/floor-m2. This also expands the variety of HVAC-systems, which can be used in building. Low temperature heating and high temperature cooling systems (like slab cooling, chilled ceiling and chilled beams) can be used in such buildings. Also full-air systems, like displacement ventilation, become more feasible.

A critical part of the solution is to reduce energy use of both new and existing buildings. Within this scope, double façade, thermally active building systems, passive building design, roof ponds as a passive cooling technology, and using the thermal mass of the building attracted significant attention during the congress. Roof Spraying is an effective method to save energy consumption in buildings.

An ideal approach is designing buildings without mechanical HVAC services, only using natural resources of Sun – Wind – and Gravity.

Energy Efficient HVAC Systems

Energy efficient systems such as dry coolers, indirect and direct evaporative cooling, integration of renewable systems, free cooling systems, solar absorption cooling plants and control strategies were discussed as sustainable HVAC systems. An analytical model was presented for indirect evaporative coolers. Optimizing the operation of multi-chiller systems has been addressed. Building predictive control is very promising. A method to control the optimal set point of condensing temperature and the condenser fan operation was

developed; using Artificial Neural Networks (ANN). Tools are developed to support the operation of buildings. Occupants need to be continuously informed about the impact of their behavior on consumptions. Due to control strategy, savings can be achieved. Savings potentials are highly case dependent. Average numbers are given in **Table 2**.

Table 2. Savings potentials due to different control strategies

IAQ controlled ventilation	13% – 28%
Comfort range widening by ca. 1.5 ℃	6% – 16%
Allowance for night and weekend set-back	0% – 18%
Use of improved non-predictive control	1% – 15%
Theoretical potential of predictive control	16% – 41%

Free cooling by dry coolers in a large shopping mall was presented. Different applications of free cooling were presented by several authors. Absorption cooling with waste heat give primary energy saving and CO_2 emission reduction (55%). Especially Solar Absorption Cooling Plant was presented by different groups. Small lift chiller or low lift cooling systems reach high efficiency values. These systems are used with radiant terminal units. High temperature chilled water using active/passive chilled beam systems were presented. One of the presentation stated that cooling energy was decreased 77% by very high temperature active chilled beam system. Chilled beam systems have the advantages of very low energy consumption and excellent IAQ and comfort conditions. It was stated that these systems are suitable for green building applications.

The loading curve and operating conditions show that refrigeration equipment, often over-designed on the grounds of security, cannot run under optimum conditions throughout the entire year. Even if standards provide the best representation of the diverse reality found in the field (EER and ESEER) they do not take operating data into account. There is a huge difference between theoretical EER values and real-life performance of chiller system. Consequently, the installation of a data acquisition system constitutes a *sine qua non* condition used to assess true consumption by refrigeration equipment if the installation's real efficiency is to be assessed.

Multi-source and Multi-use Heat Pump system (MMHP) approaches were presented in order to achieve high efficiency of performance and energy saving. In these systems sources are solar energy, air, and ground; and uses are cooling, heating, refrigeration, and domestic hot water production. The energy consumption of the MMHP system was reduced by approximately 40% compared to the conventional heat pump system.

Building Integrated Renewable Energy, Thermal Storage and Cogeneration via Organic Rankine cycle system were introduced as a new system solution.

For sustainable buildings, renewable energy production on site is essential. Most promising technologies in this perspective are solar energy and photovoltaic. However, cost of renewable electricity production is still very high.

When comfort conditions and levels are considered the absolute value of heat input by heat emitters is not enough satisfying comfort. Distribution of this heat in the room and around the critical person is important. This can be described as "emission efficiency" Emission efficiency can be improved by insulation. So insulation is not important only by reducing heat loss it is also improves emission efficiency and reduces heating energy input to the system.

The primary air volume (fan energy as well as heating and cooling of supply air) is one of the most important HVAC-system design considerations in terms of energy use. Heating of spaces in office type of building is not the first priority when designing energy efficient

buildings. Solar shading, lighting levels and control of lighting and shades are important areas to pay attention, because they reduces the energy consumption of lighting system as well as the energy consumption of cooling system.

Sustainable solutions matches each space with a suitable system e.g. full-air systems to areas where main heat loads are from people (e.g. auditorium) where as in office environment it is more economical to transfer heat using water as media. Target is to design solutions, which can be adjusted according the use of space to meet the different indoor climate conditions over the life cycle of building and use products, which are adaptable to various conditions and designed to create complete solutions.

Simulation Tools

As always has been in previous European Congresses, EPBD directive again was one of the most attractive subjects. Simulation tools especially have been discussed in this congress. Implementation of Energy Performance Building Directive (EPBD) requires that each EU member state has to develop methodology for assessment of energy performance of different types of buildings, including those equipped with advanced systems of control of both thermal comfort and air quality indoors. We still don't have a satisfactory and widely accepted energy performance assessment program. It is difficult to separate the overall efficiency in independent production, distribution, emission and control efficiencies, during the HVAC system simulation attempts, since the each part influence each other strongly. It is concluded that, simulation tools for comfort and energy performance assessments should be developed further. The other important issue is calibration of these tools is a pre-requisite. The future weather data in building simulations is another important issue to be considered. Due to global warming, new building design should be based on predicted future climate.

The aim of the building energy certification is not to calculate the likely energy consumption of the buildings, but to assess its quality on a standard usage base and to allow its comparison with other buildings or with other design solutions, while one of the EPBD objectives is to provide a common procedure for the building energy performance assessment.

Especially, recently developed advanced HVAC systems require special simulation programs. Present simulation tools, used to assess the thermal performance of buildings, are not capable of managing new systems, alternative energy production, and heat recovery. Calculations of room airflows are still a difficult task and it is very expensive in terms of man power and computational time. The thermal comfort and the local air quality are depending on global flow pattern as well as on local flow effects. However, there are concentrated efforts in this area. Precise simulation programs were discussed which are designed to consider both the building and its HVAC systems. Some of them are based on comprehensive methods and are integrated design tools. There are approaches to integrate air flow patterns in the room and dynamic lighting loads to the building energy simulations. A presented research focuses on evaluating thermal energy efficiency in a building including thermal cascading systems such as cogeneration, solar-thermal and PV systems, combined with final energy consumptions for space heating and cooling, dehumidifier and water heater.

Ventilation

Energy efficient buildings or low energy buildings have brought out the importance of good ventilation and lighting design. Energy use for the purposes of ventilation and lighting has big shares especially in low energy commercial buildings. In accordance, we received a

significant number of papers related to ventilation and lighting. Advances on demand based ventilation, hybrid ventilation design methodology, case studies and design tools were presented. Occupancy-based Distributed Demand-Controlled Ventilation (DDCV) has potential for improving IAQ while reducing energy consumption. A performance-based approach gives the opportunity to satisfactorily address both indoor air quality and energy efficiency.

Natural ventilation main advantage is to save fan electric energy consumption because it doesn't spend any energy for air renovation in the building. In all Europe the ventilation systems are a significant part of the building total energy consumption, for example in EPG the ventilation is responsible for more than 30% of the all building's HVAC system primary energy use.

A worthwhile remark for commercial buildings was that the importance of natural ventilation is not limited to the fan power savings it provides. Of the essence is its high potential in reducing energy usage for cooling (i.e., free cooling capacity). The potential for free cooling is over 95 % for many European countries. On the other hand, increasing the ventilation rate decreases sick leave days and increases relative performance of office workers and students.

A technical session was devoted to Personalized Ventilation (PV), a very effective and energy efficient tool. Results of studies indicate that there is considerable potential for energy savings using PV without sacrificing comfort conditions. Natural Ventilation has always been the first strategy for improving IEQ and reducing environmental impact of buildings. Recent advances in Natural and Hybrid Ventilation strategies and products allow new applications. The development of new systems allows a real strategic approach of sustainable management of Indoor Environments.

Another ventilation related research area is the investigation of air distribution in a room and the effectiveness of ventilation. Both experimental and numerical simulation results were presented during the congress. Under-floor air distribution (UFAD) performance is better than conventional type. In hot climates, findings showed a slight conservation during peak months (July and August) due to less stratification. Better performance of UFAD (analytically) showed potential saving up to 36% in July and 18% in August, a considerable saving found in off peak months more than 50%.

Heat Pumps and Thermal Storage

Future developments in the HVAC sector seem to require system approach. Instead of high efficiency equipment, high efficiency and combined systems are to be developed. Novel systems shall be designed to operate with use of renewable energy sources. One of the promising technologies stressed repeatedly during the congress is thermal storage. Ground is considered to be very convenient heat storage medium. Intelligent use of the available and cheap electricity and energy storage technologies will become a key factor for HVAC systems. Air-, ground- and water- energy are recognised as renewable energy. Heat pumps are a tool to exploit these sources. As shown in **Fig.3**, a heat pump is expected to deliver minimum 115% of primary energy consumed for electricity production. Smaller amount of energy at high temperature/ high quality is used to pump larger amount of heat energy at low temperature/low quality.

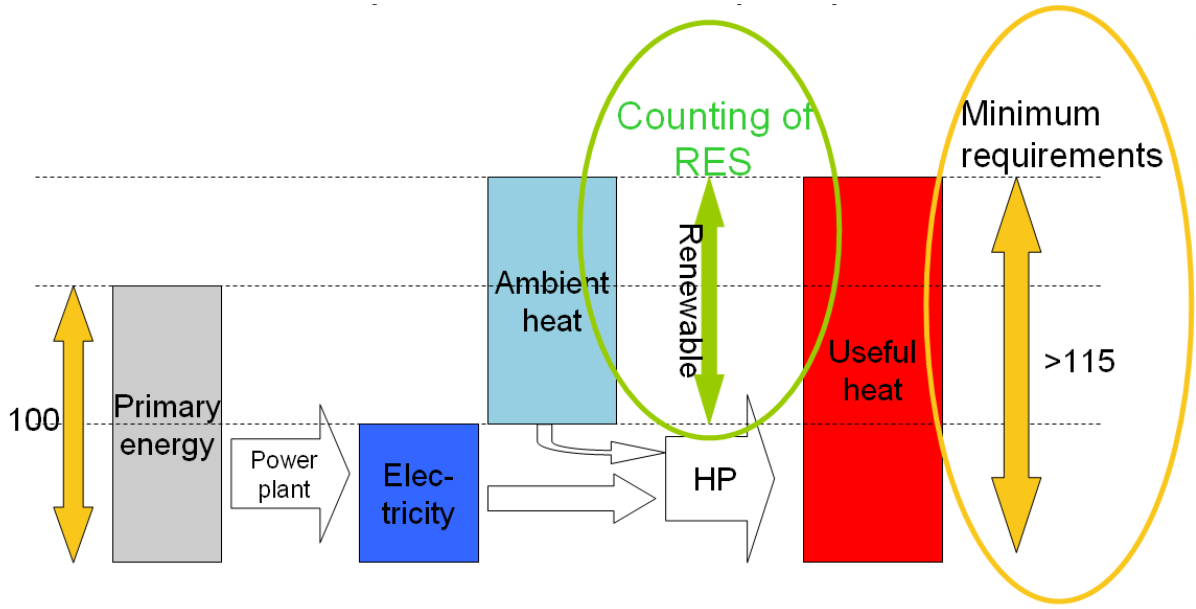

Figure 3: How to count air-, ground- and water energy exploited with heat pumps

In this respect, heat pumps are considered as the most promising renewable technology and were considered extensively in this congress. Especially ground source heat pump use and design essentials and data were presented by numerous authors. Heat pump application cases from all over the world were discussed. An Energy-Optimized Non-Residential Buildings system approach combines ground, heat pump and thermal storage. Reducing temperature-lift has a large non-linear effect on COP of heat pumps. New heat pumps need to be developed. As shown in **Table 3**, optimized system energy supply is the most efficient solution.

Table 3. Energy supply for different solutions of the same case study

Water source HP cooling	Air source HP cooling	Conventional Air conditioning
32 to 100 kWhprim/(m²a)	46 to 147 kWhprim/(m²a)	225 kWhprim/(m²a)

In **Fig 4** heat pump market forecast is given; a seventeen fold increase in heat pump production during the next 10 years is predicted.

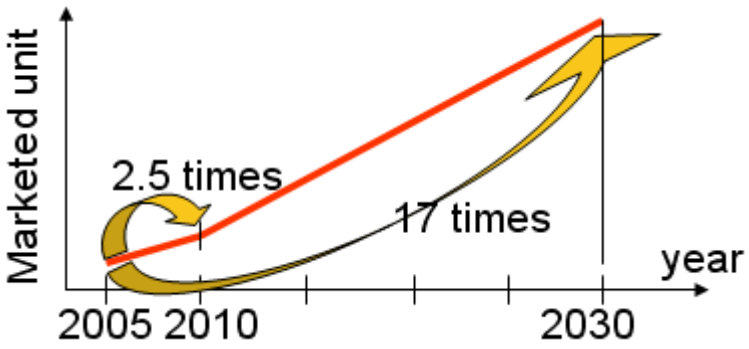

Figure 4: Hydronic heating/cooling “Heat Pump” market forecast

Cost of Sustainable Technologies and Sustainable Communities

Sustainable technologies are usually expensive; especially initial costs are high. However, operational energy costs of sustainable technologies are low. Overall life cycle cost should

be considered evaluating sustainable technologies, as depicted in **Fig.5**. Trends also can be evidenced by this figure. However even optimized sustainable technologies are expensive in initial costs. This fact should be considered by policy-makers in promoting sustainable technologies.

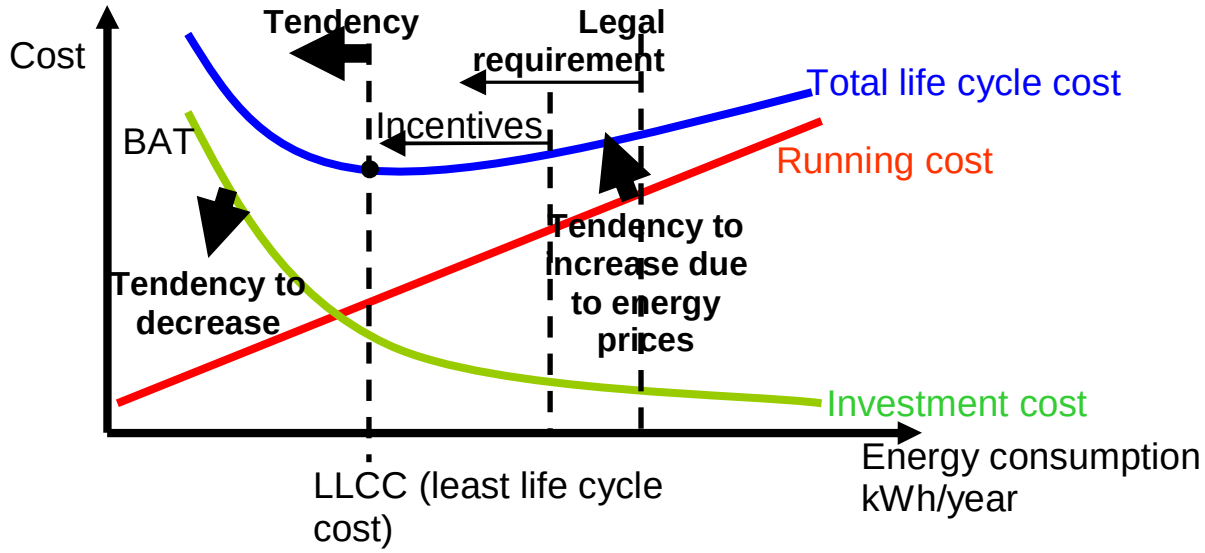

Figure 5: Cost evaluation of sustainable technologies. Reducing energy consumption requires more expensive technologies; however running cost will decrease accordingly. Optimum solution can be achieved as the least life cycle cost. Regualtions and incentives also impose the limiting criteria towards this solution.

Actually individual sustainable building solutions are expensive, but sustainable communities are more efficient. Up to 20 % of energy could be saved using energy optimization of a building shape and orientation. New forms and new systems can be used efficiently, effectively and economically in district, town or city scale. Sustainable districts, towns or cities can integrate all aspects of sustainable society, sustainable energy use and sustainable environment. Energy Efficient Cities have the below opportunities:

- larger efficiency potentials than by limited building scope
- greater chance of overall system optimization
- options for innovative system solutions

There were presentations about the sustainable districts, villages and towns in the congress.

District heating and especially district cooling can be energy efficient and offer sustainable solutions for many cases. It has advantages; however, the system should be carefully studied and designed. A special technical session was designed on district heating and cooling and one invited lecture has covered this issue.

The urban structure modifies the climate and microclimate outdoors, i.e. the air temperature, as well as the potential of solar irradiation and wind flow. Building energy simulation usually uses standard climate data as input, which are assumed to represent the surrounding environment. Also, the physical urban surroundings (obstacles to sun and wind) are often neglected during building energy simulation. Effects of micro-climate within urban areas were discussed and measured values were presented. Maximum difference between urban and rural temperatures can be as high as 14 ℃.

Urban heat island phenomenon can also affect public health, environment, and amount of energy used for heating or cooling in buildings. The airflow and ventilation ability can be very limited in a modern dense city. The heat and pollutant exhaust from buildings and vehicles can be accumulated more easily in a compacted space.

Building density influences energy consumption in traffic, in infrastructure and in buildings and it also influences building integrated energy production. However, same building density does not necessarily mean the same daylight performance. Increasing density does not automatically entail a deterioration of daylight performance. It also depends on the structure of city. Point development can achieve up to 65% higher density with the same daylight conditions as in a linear development. Corner situations are of great importance in terms of floor plan layout, not only with regard to spatial qualities but also to energetic parameters. Point block development should be considered as an adequate structure for new building projects and for re-densification strategies.

Energy Efficiency and Indoor Environmental Quality

A sustainable energy-positive built environment with indoor environmental quality optimized for health, comfort and/or productivity, while considering ecological/ climatic requirements and economics; requires a multiscale and transdisciplinary approach which addresses technological solutions for energy generation, storage, distribution and conservation, and integrates and optimizes these in design, construction and operation of new and existing buildings. Comfort and energy efficiency are the two sine qua nons of proper design. Solutions should satisfy both parameters simultaneously. New evaluation approach is seen in **Fig.6**. Two axes of the evaluation diagram are primary energy demand and % of occupied hours uncomfortable. Building energy and environmental performance- BEEP and cost lines also given in same diagram. Target solutions should be left-bottom quarter of the diagram.

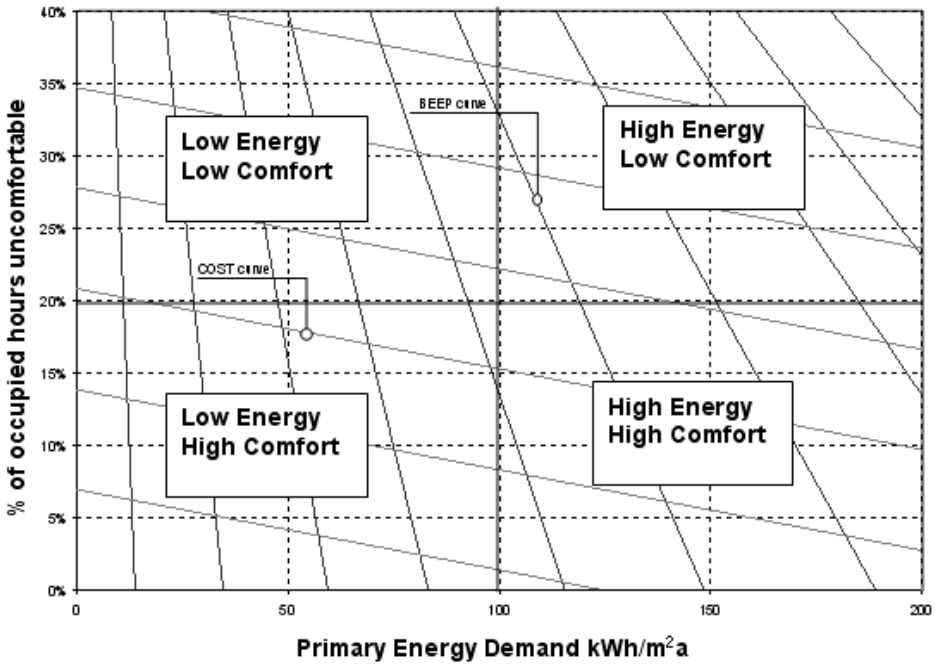

Figure 6: Building energy and environmental performance (BEEP) diyagram.

Implementing realistic occupant behavior in system design and in energy consumption calculations is an important issue. In this respect indoor environment quality was one of the four main sub-themes of the congress. Quality parameters for the indoor environment are thermal comfort, air quality, lighting and acoustics. Control performance is also considered as

a parameter. We received many papers on these subjects. Especially Japan colleagues' contributions were appreciable. Many of the IAQ papers were also in relation with ventilation. User behavior has an important influence on the energy performance and thermal comfort. The influence of the manipulation of the shading device gives the largest variations in the energy demand and thermal comfort results. Positioning the thermostat Influences on both comfort and energy performance.

The use of low-polluting materials should be part of a strategy for good perceived air quality in sustainable buildings. The use of low-polluting materials reduces the ventilation rate required to achieve an acceptable level of perceived air quality and thereby prevents unnecessary use of energy for ventilation.

Last Word

This congress has contributed to HVAC technology and sciences considerably. With this opportunity, I would like to thank all contributors for their companionship in this conference and also for their knowledge they shared with our community.

The papers presented at the Congress are available on Congress CD. This CD can be ordered from REHVA bookstore at www.rehva.eu.