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Interview of MEP Bendt Bendtsen on EPBD review

Energy Renovation

Sensor positioning and WiFi

Robust NZEB evaluation

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Editor-in-Chief: Jaap Hogeling
jh@rehva.eu

Associate Editor: Stefano Corgnati, Italy
stefano.corgnati@polito.it

Editorial Assistant: Chiara Girardi,
cg@rehva.eu

General Executive: Süleyman Bulak, Turkey

ADVERTISEMENTS
Ms Chiara Girardi, cg@rehva.eu

SUBSCRIPTIONS and CHANGES OF ADDRESSES
REHVA OFFICE:
Washington Street 40
1050 Brussels, Belgium
Tel: 32-2-5141171, Fax: 32-2-5129062
info@rehva.eu, www.rehva.eu

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Active REHVA involvement at policy level in Europe and beyond

Reviewing this summer issue reveals that apart from the usual technical content a number of articles focus on policy and strategic issues of great importance for the HVAC sector in Europe and globally.

In Europe: the news sections report about the involvement of REHVA and allies in the revision process around the EPBD. This revision which is expected to become final by the end of 2017 is of great significance for the level of implementation of energy saving policies in Europe. REHVA and many other parties also supported by European Parliament amendment proposals asked for:

- Ensuring high indoor environment quality and energy efficiency at the same time.
- Ensuring quality, proper maintenance, and performance through mandatory inspection of heating, ventilation, and air-conditioning systems.
- Promoting the harmonized and ambitious application of EPB standards in Europe.

Also important to mention is the wish for an additional Indoor Air Quality Performance Certificate for new and renovated buildings. This idea, strongly supported by EFI, may be momentarily a bridge too far as we may understand from the answers given by the MEP Mr Bendt Bendtsen. But the tone is set.

REHVA reported about the EUSEW 2017 (European Sustainable Energy Week). One of the reported highlights is the establishment of the EPB Center. The EPB Center is an initiative from REHVA and ISSO supporting the implementation of the EPBD, the developed EPB standards in Europe and beyond. The EPB Center could offer support on questions related to working out the Annex A of various EPB standards where needed. This may become feasible when the proposed EPBD revision Annex I regarding the request to describe the national calculation methodologies according to the EPB set of standards becomes enforced. The great advantage of this requirement for MS's to report how their national procedures relate to the set of EPB standards is that they are obliged to analyse, and by doing so discovering, that some possible shortcomings in their national procedures are counterproductive. By not having this obligation, several MS's may not feel the need to improve their national procedures. They may unintentionally report unrealistic EP declarations and assume that their energy saving policies are on the right track. Many national procedures include hidden assumptions and simplifications that may hamper further innovation as possible new technologies are not properly awarded by the national methods. This secondary effect is weakening the EU position on a global market of energy saving products and technologies. It is a mistake to assume that the very successful Ecodesign Regulation can prevent this. The holistic approach implies that we have to look at the building as a system and not as an accumulation of products. Just using A-label products doesn't guarantee a A-label building!

Given the fact that energy efficiency and indoor environmental quality of buildings is a global issue, globalisation of the HVAC sector is to be addressed as well. The new ASHRAE president, Bjarne Olesen clearly stated, in his presidential address, the importance of going global. In this context, the signing of the renewed MoU between ASHRAE and REHVA and the establishing of a European region is no surprise. As the REHVA president, Stefano Corgnati explains in its address: REHVA is a platform through which bridges among REHVA members can be activated and connections with European institutions and international organizations can be enforced. ■

JAAP HOGELING
Editor-in-Chief

Under this title a news item* has been posted on the new www.EPB.center website. The EPB Center is an initiative from REHVA and ISSO supporting the implementation of the EPBD and the developed EPB standards in Europe and beyond.

Boosting energy efficiency of buildings through ISO's holistic approach

The EPB Center activities are to plan, coordinate and guide the process of promoting implementation, use maintenance and further development of the set of EPB standards and safeguard the coherence of their technical content. Continued coordination is essential as the maintenance and further development of the individual EPB standards is carried out by the various individual Technical Committees of both CEN and ISO.

JAAP HOGELING
Chair CENTC 371 Program Committee on EPBD
Fellow of ASHRAE and REHVA
EPB Center
www.epb.center
Rotterdam, Netherlands
jaap.hogeling@epb.center

Other activities, which can be done if the desired amount of supporting members is met, are, for instance: linking the EPB standards with ECODESIGN, supporting implementation of EPBD in national legal frameworks, codes and building traditions and also implementing all the EPB standards in the EN ISO 52000 series of standards. Deliverables could include example calculations, examples of national annexes supporting the EPB standards' use as part of the regional regulation, supporting software tools, FAQ, data files, etc.

All activities focus on achieving uniformity, flexibility and sustainability as well as cost and risk reductions in the built environment.

The set of EPB standards:

Helping to decarbonize the building sector is the goal of the new holistic approach being developed by the ISO joint working group for the energy performance of buildings (EPB) – an approach which reconciles climate and energy needs. And with the future EN ISO 52000 series of standards under development (in collaboration with CEN), the building industry is expected to be much better positioned to attain energy efficiency improvements with the best available technology and practice. That's because solutions that improve energy efficiency often usher in new ways to enhance operational efficacy and drive innovation.

Buildings literally gobble up energy. In fact, energy expenditures account for around 40% of a building's total operating costs. What kind of challenges and opportunities does this represent?

The building industry is confronted with a range of challenges and opportunities when it comes to reducing energy consumption and increasing the use of renewables.

Several European countries, but also several US-states and other countries around the world, have set ambitious goals to reduce to (nearly) zero the energy in new buildings over the next few years. These countries will eventually focus on net zero energy districts, with an emphasis on refurbishing existing buildings and increasing the share of renewable energy.

Clear and consistent policy targets play an important role in driving innovation in the building sector. International Standards will be needed to harmonize the terms, definitions, assessment procedures and indicators in order to develop new concepts and technologies as well as monitor and evaluate progress.

* Based on an article published by ISO and at the www.epb.center site, where Dick van Dijk and Prof. Essam E. Khalil, Co-Convenors of the ISO joint working group of ISO/TC 163 & ISO/TC 205 "Energy performance using holistic approach" have been asked for their vision of the building industry's role in helping to build a low-carbon future.

From energy using product to energy efficient building systems.

In the past, energy performance requirements were set at component level – minimum thermal insulation levels and minimum efficiencies of products. This, however, leads to sub-optimal solutions and creates a barrier to the necessary technology transitions.

The holistic approach to assessing the overall energy performance of buildings and the built environment, provided by the set of EPB standards (inclusive the EN ISO 52000 series of standards), is a key tool to overcome these barriers.

The use of effective and inexpensive energy efficiency solutions. The role of the EN ISO 52000 series of standards now and in the near future.

The EN ISO 52000 series of standards will enable to assess the *overall* energy performance of a building. This means that any combination of technologies can be used to reach the intended energy performance level, at the lowest cost.

Due to this 'competition' between different technologies, the holistic approach is a key driver for technological innovation and change. Countries using the approach for several years – take, for instance, the Netherlands – have experienced large scale implementation and cost savings on a variety of new technologies. This includes thermal insulation concepts, windows, heating, cooling, lighting, ventilation or domestic hot-water systems, building automation and control, and renewable energy sources.

The potential users of the set of EPB standards.

The energy assessment of buildings is carried out for various purposes, such as:

- Judging compliance with building regulations expressed in terms of limited energy use or a related quantity.
- Increasing transparency in real-estate transactions through an energy performance certification and/or display of the level of energy.
- Monitoring the energy efficiency of the building and its technical building systems.
- Helping to plan retrofit measures through predicting energy savings that would result from various actions.

In general, the holistic approach means that the energy performance is assessed as the total energy used for heating, cooling, lighting, ventilation, domestic hot water, and, in some cases, appliances.

How will the EPB standard series benefit in particular regulators/ public authorities? The EPB standards support flexibility:

One of the main purposes of the EPB standards is to enable their use in laws and regulations to, in some cases, make them compulsory. This has led to the development of a systematic, clear, comprehensive and unambiguous set of energy performance procedures.

What's more, differences in national and regional climate, culture and building tradition, as well as policy and legal frameworks are taken into account. Different options are given for procedures, input data and boundary conditions. For each option, a clear template, that can be used to tailor the energy performance assessment to a specific situation, is provided. An informative ("default") set of choices is also suggested (as worked out in the Annex B in most of these EPB standards).

The EPB standards facilitate a step by step implementation:

The modular structure set out by the EPB standards maximizes the possibilities for a step-by-step implementation at the national or regional levels. Different policy priorities and practical constraints may need to be balanced out on a case-by-case basis. This includes taking into account well-established existing practices and procedures, at least during a transition period. ■

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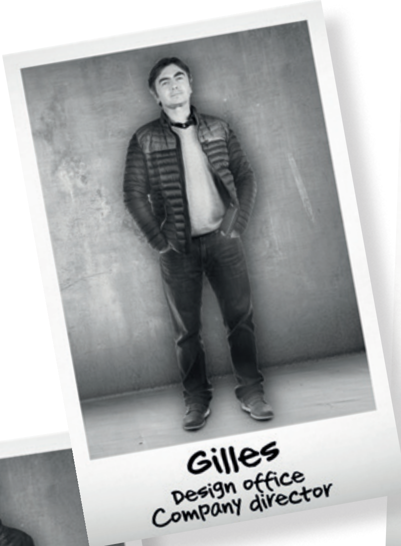

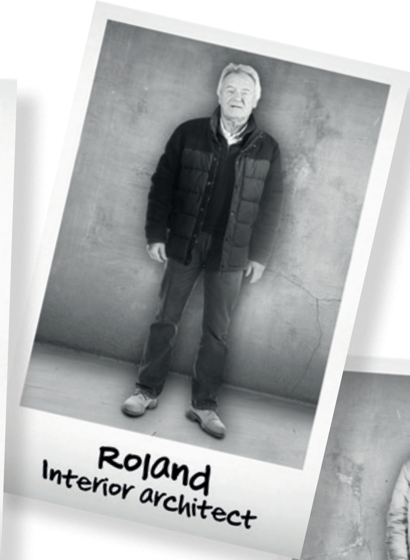

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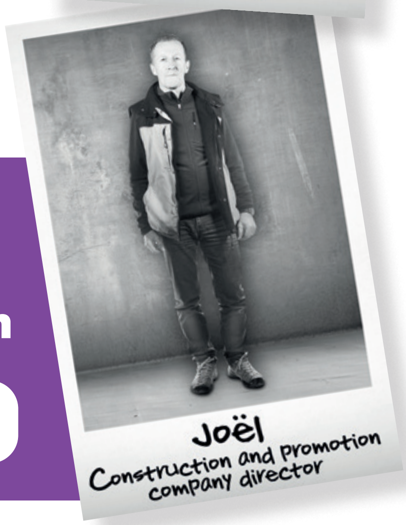

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Contact: Promosalons Belgium - Gaëtan LACHAPELLE
Tel: +32 2 538 69 02
E-mail: glachapelle@promosalons.com

More info at www.interclimaelec.com

Robust net-zero energy buildings

– A methodology for designers to evaluate robustness

RAJESH KOTIREDDY
Building Physics and Services
Department of the Built Environment
Eindhoven University of Technology,
The Netherlands
r.r.kotireddy@tue.nl

PIETER-JAN HOES
Building Physics and Services
Department of the Built Environment
Eindhoven University of Technology,
The Netherlands
P.Hoes@tue.nl

JAN L. M. HENSEN
Building Physics and Services
Department of the Built Environment
Eindhoven University of Technology,
The Netherlands
j.hensen@tue.nl

The European energy performance of the buildings directive (EPBD) recast states that all new buildings should be nearly zero energy from 2020 [1]. Nearly zero energy buildings can be achieved by improving building insulation levels, using energy efficient technologies and integrating renewable energy systems into the built environment. Considering the high economic efforts required for the implementation of these measures in the built environment, it is important to ensure that these measures deliver the desired performance over the building's lifespan. However, many uncertainties arise in the operation of a building such as household size and their corresponding behavior. In addition, external factors, such as climate change and policy changes affect the building's performance over its lifespan. These uncertainties impact the building's performance, resulting in possible performance deviation between the predicted performance in the design phase and the actual performance during operation. To reduce this performance deviation, performance robustness of these buildings considering uncertainties should be assessed in the design phase. Hence, we developed a computational methodology considering these uncertainties to assess the performance robustness of net-zero energy buildings.

Keywords: Robust designs, net-zero energy buildings, robustness assessment, uncertainties, Multi-criteria assessment

The developed methodology is generic and can be used for performance robustness assessment of both new buildings and renovations. This methodology is useful when different stakeholders with multiple performance requirements are involved in a project, and it is also effective in identifying a robust design from a large design space. Due to space constraints, this article demonstrates how a designer can use this methodology to identify robust net-zero energy building designs among only few design alternatives. This demonstration is carried out for the policymaker and the homeowner, who represent different interests in the building industry.

Why robust designs?

In current design practice, building performance is predicted by considering a set of assumptions about the building's operation. Moreover, to predict the performance of the buildings historical weather data is used. Uncertainties in building operation, climate change and policies may influence the building performance, which could cause variations in energy use and operational costs and could also lead to indoor environment quality problems. The potential impact of these uncertainties is very high in low/ net-zero energy buildings [2] resulting in possible performance deviation between predicted and actual performance [3]. Furthermore, multiple net-zero energy building (NZEB) configurations can lead to similar optimal performance under deterministic conditions, but can have different magnitudes of performance deviation under these uncertainties. These uncertainties are rarely considered in the design process of net-zero energy buildings, and hence the decision making process may result in designs that are sensitive to uncertainties [4,5] and might not perform as intended. To reduce this sensitivity, performance robustness taking into account these uncertainties should be assessed during the design phase and should be included in the design decision making.

Who is interested?

Policymakers can use performance robustness to define energy performance requirements in future building regulations to safeguard intended policy targets. They can also define policies considering robustness to support adaptations of current buildings to improve their performance and extend their lifespans. Similarly, performance robustness is a relevant concern for homeowners, since they wish to ensure their preferred building performance over the building's lifespan. Energy performance contractors can benefit from performance robustness assessment by reducing the deviation between predicted and actual performance in operation.

How to evaluate robustness?

The probabilities of occurrence of uncertainties are usually unknown. One way to proceed is to use 'scenarios', which can be understood as formulated alternatives, to integrate uncertainties into the performance robustness assessment [6]. Scenarios are used to present a range of possible alternatives so that the performance robustness of designs can be assessed based on how the different designs perform in each of these alternatives [7]. Following this approach, we developed a computational methodology to assess the performance robustness of net-zero energy buildings [8]. **Figure 1** gives the graphical overview of the performance robustness assessment methodology. This methodology comprises multi-criteria performance assessment and multi-criteria decision making considering multiple performance indicators and their corresponding robustness (see **Figure 2**). In this approach, by prioritizing the decision maker's preferences, the design space, future scenarios and performance indicators are defined. In summary, the performance of the design space is assessed for future scenarios using building performance simulations with multiple performance indicators and their corresponding robustness to identify robust designs.

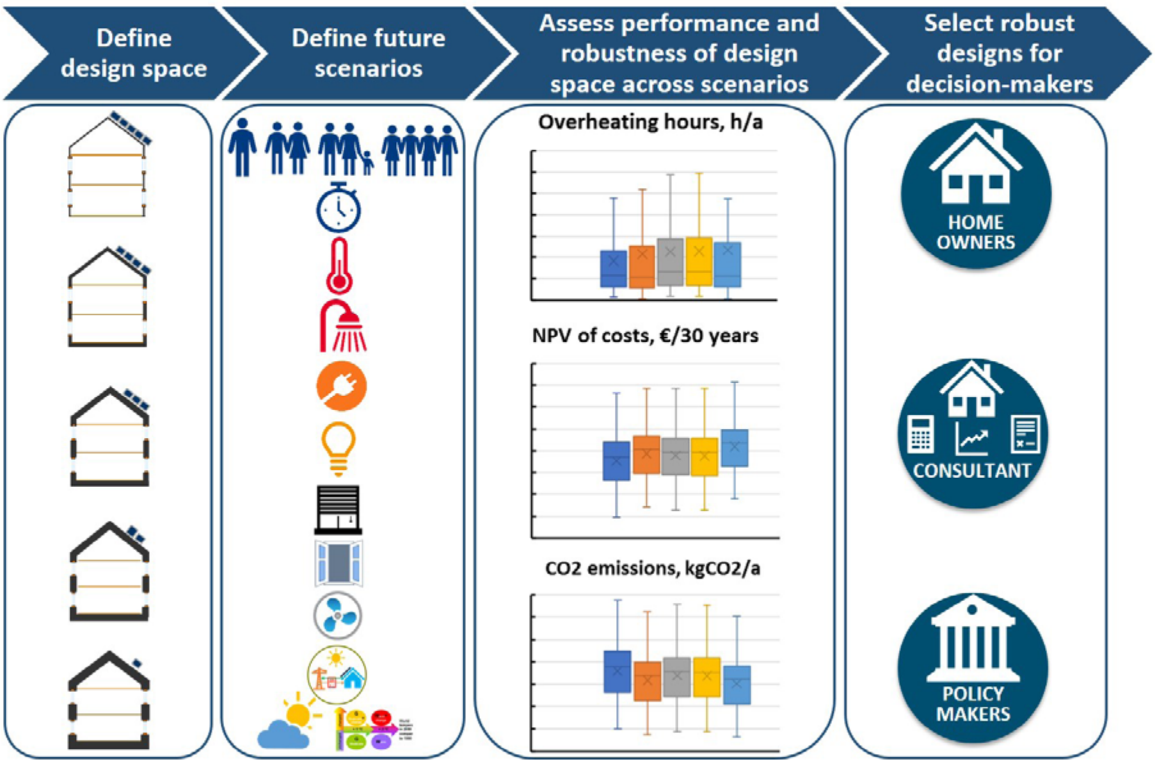

Figure 1. Graphical overview of performance robustness assessment methodology.

The steps of the methodology, as shown in **Figure 2**, are described in detail in the following section.

Step 1: Identify decision maker preferences and define the building design space, future scenarios and performance indicators.

The design space needs to be defined based on the requirements of decision makers and on current and future building regulations such that the preferred design of a decision maker will also meet the criteria of building codes and regulations [9–11]. In practice, it is generally the case that several design configurations lead to similar optimal performance under deterministic conditions, but these configurations have significantly different magnitudes of performance deviation for future scenarios. For instance, all designs shown in **Figure 3**, could be NZEB solutions under deterministic conditions. For example, a NZEB solution can be achieved by combining very high insulation levels (P_1) and a small renewable energy generation and storage system (RES_1). In contrast, another NZEB solution can be realised by combining a relatively lower insulation levels (P_n) and larger renewable energy generation and storage system (RES_n). However, when uncertainties arise, these designs can have different magnitudes of performance deviation in operation compared to predicted performance in the design phase. Hence, the preferred design is based on optimal performance and performance robustness.

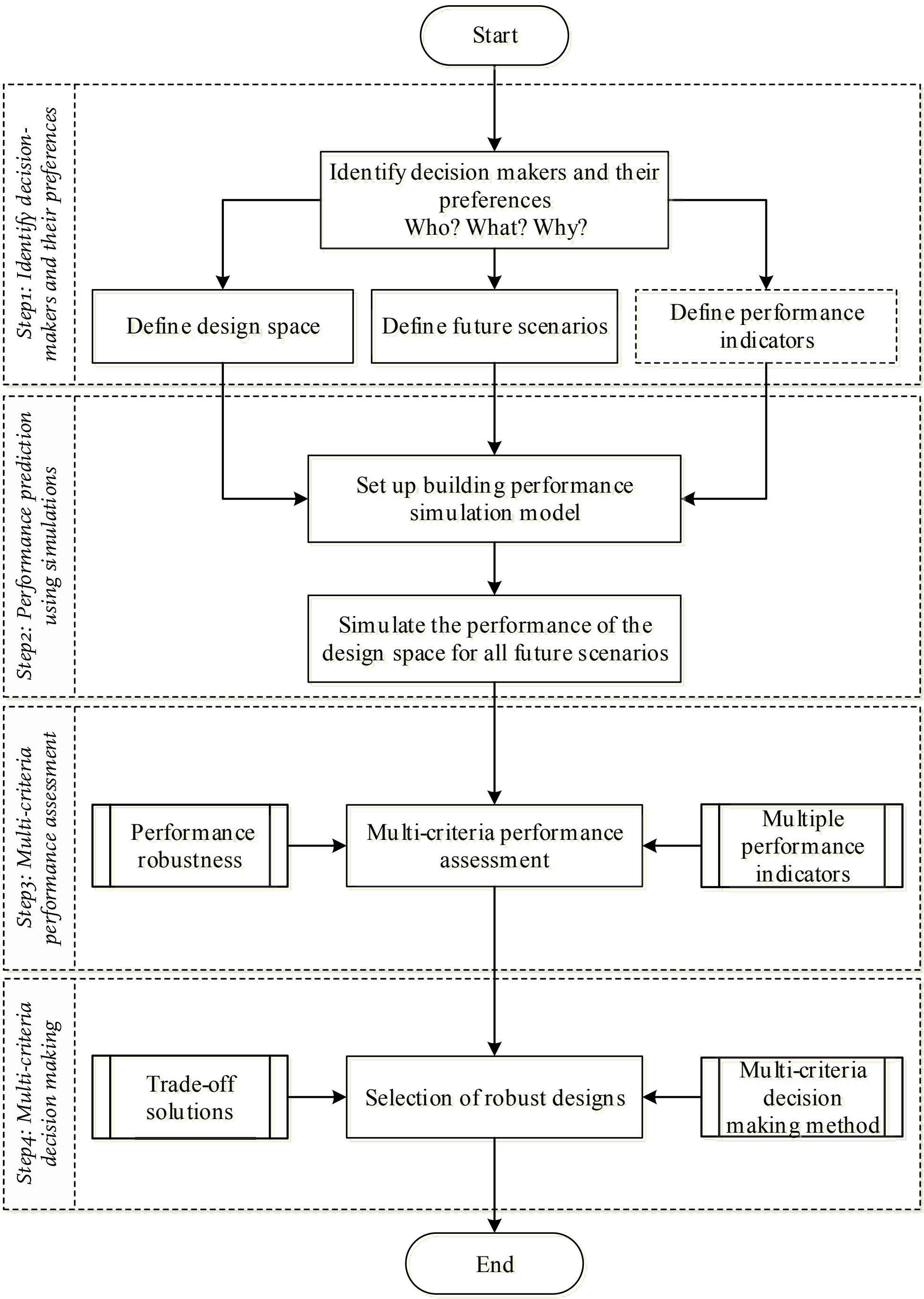

Figure 2. Detailed overview of performance robustness assessment methodology considering multiple performance indicators and their corresponding robustness.

Scenarios need to be defined that consider all uncertain and influential parameters that can cause variations in the building's performance over its lifespan. **Figure 4** provides an overview of scenarios that could be considered. These scenarios include different household sizes that may occupy a building over its lifespan and their corresponding occupant behaviors. In addition, climate scenarios are included and cover a reference climate and future climate change. Policy changes such as feed-in tariff prices for net-metering are also considered. Similarly, performance indicators that are relevant to the decision makers need to be defined.

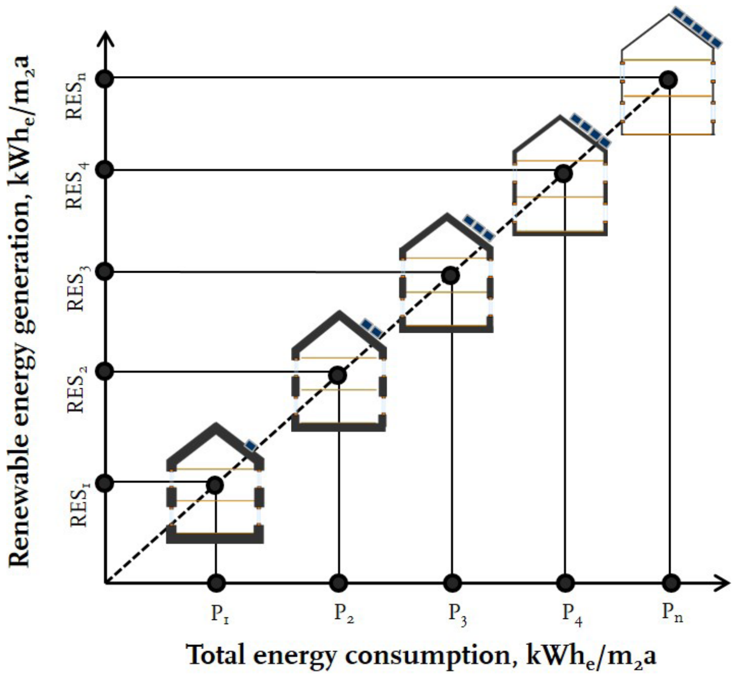

Figure 3. NZEB designs with different insulation packages (energy consumption) and corresponding onsite renewable energy generation and storage systems (energy generation).

For instance, a policymaker prioritizes a building design with low or no CO_2 emissions, but not at the expense of high investment costs. In contrast, a homeowner prioritizes designs with comfortable indoor environment at low cost. Hence, CO_2 emissions and investment costs are the preferred performance indicators for the policymaker, while indoor environment quality and costs such as investment, operating costs etc. are the preferred performance indicators for the homeowner.

Step 2: Set up a building performance simulation model and simulate the performance, based on the defined performance indicators, of the design space for all future scenarios.

Step 3: Carry out a multi-criteria performance assessment considering multiple performance indicators and their corresponding robustness. In the current approach, in order to calculate robustness, we exploit the concept of minimax regret method [12]. In this method, for a given scenario, performance regret is the performance difference between a design and the best performing design in that scenario. Ultimately, maximum performance regret is used as the measure of performance robustness in this approach. In simple terms, the maximum performance regret of a design across all scenarios is the measure of its robustness. This multi-criteria assessment enables different decision makers to choose robust designs from a large design space based on their preferred performance indicators and corresponding robustness.

Step 4: Select robust designs for the decision maker by prioritizing the performance indicators based on his/her preferences. The design that has optimal performance and the lowest maximum performance regret is the most robust [13].

In the next section, using five NZEB designs it is demonstrated how this methodology can be used by designers to aid decision makers in the design phase to identify robust designs.

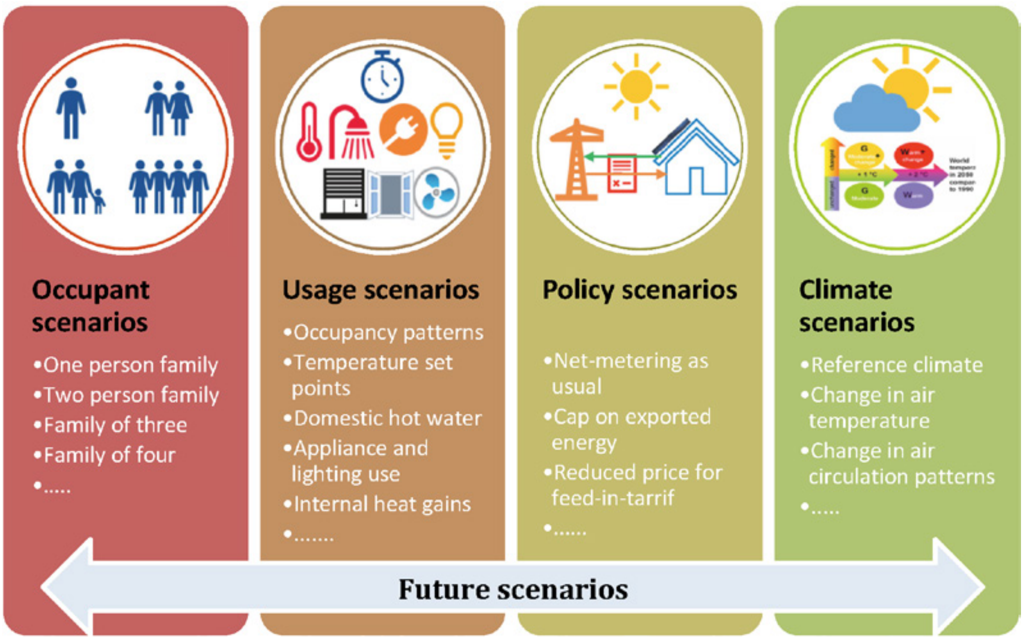

Figure 4. Scenarios formulated based on uncertainties in (future) household size and range of occupant behavior, climate change and policy changes.

Robust NZEB: Demonstration of methodology using a Dutch case study

Description of case study

A semi-detached terraced house, a typical Dutch residence [9], was chosen as the case study building. It is a three-story building with a gross surface area of 124 m² and a treated floor area of 104 m². The building is heated using a floor heating system with an air-water heat pump and is ventilated using a balanced mechanical ventilation system with heat recovery. The heat pump capacity for each design is optimally sized by minimizing underheating hours. To reduce overheating during summer, natural ventilation (free cooling) by opening windows is used instead of mechanical cooling. Windows are shaded by external devices, which are controlled based on indoor temperatures and radiation levels on the window surfaces (see **Table 1**). Domestic hot water (DHW) needs are met by a solar domestic hot water system with an auxiliary heater. It is an all-electric building and the total electricity consumption for heating, ventilation, DHW system, lighting, and appliances of the building is met by an onsite photovoltaic (PV) system. A battery based energy storage system is used to reduce the building's dependency on the grid.

Step 1: Identify homeowner's and policymaker's preferences and define the design space, scenarios and performance indicators

A homeowner prefers a robust design that delivers a comfortable indoor environment with low operational and investment costs. Overheating hours, which are based on adaptive temperature limits proposed by [14], is used for thermal comfort assessment. Total costs, which comprise investment, replacement, operational and maintenance costs, are used to assess the financial implications of design [11]. Since they are the same for all designs, fixed costs such as land, labor etc. are not considered in this study. Operational costs are calculated based on net-energy consumption using the current energy prices in the Netherlands. It is worth noting that the effect of net-metering is also considered in the calculation of operating costs. These costs are calculated for a 30-year period. To calculate net-present value (NPV), these costs are discounted considering inflation rates and real interest rates.

A policymaker prefers a robust design that has low CO_2 emissions with low investment costs to enable the policy of providing subsidies for the implementation of CO_2 reduction measures for end users. CO_2 emissions are calculated based on net electricity consumption. An emission factor of 0,540 $kgCO_2$ per kWh of electricity consumption is used to calculate CO_2 emissions [15].

The NZEB design space is defined, as shown in **Table 2,** by varying envelope properties such as insulation levels, infiltration rates, and window type etc. so that the resulting designs meet a range of applicable standards. Current Dutch building standards are realized in Design-1, Dutch zero energy building standards are realized in Design-2, Design-3 and Design-4 and a passive house standard can be realized in Design-5. Renewable energy and storage (RES) systems such as PV, solar DHW systems and an electric battery based storage system are added to these designs to make them NZEB.

Occupant scenarios are formulated based on Dutch household statistics. These scenarios cover different household sizes ranging from a single person family to a multi-person family of four. For each of the occupant scenarios, usage scenarios are formulated based on energy usage and activity in the building.

Table 1. Future scenarios considered in this case study.

Scenarios		Units	Low	High
Occupant scenarios (OS)		[-]	1	4
		[-]	Working	Retired
		[°C]	18	22
		[L/day/p]	40	100
		[W/m²]	1	3
Usage scenarios (US)		[W/m²]	1	3
		[W/m²]	200	350
		[ach]	Fully opened (5)	Partly opened (1)
		[ach]	0,9	1,5
Policy scenarios (Net-metering, NM)		[-]	Business as usual	Termination
Climate scenarios (CS)		[-]	NEN5060	W+

These usage scenarios span very careful energy users to energy-wasting users, and cover different types of equipment with low to very high efficiencies. For usage scenarios, occupancy patterns, heating setpoint temperatures, lighting and appliance use, ventilation rates, domestic hot water consumption and shading control are varied (see **Table 1**). Two climate scenarios are considered. One is a typical climate reference year, NEN 5060, which is based on average months of 20 years of historical weather data. Another is a climate change scenario, W+, which represents an extreme case of an increase of temperature of +2°C in 2050 relative to 1990. In the current policy, the energy imported and exported are equally priced if the net annual energy balance is zero. If excess energy is exported, it is priced at 0,07€/kWh. However, since so many buildings have taken advantage of this option to sell excess energy to the grid, the grid is often oversupplied and under great stress in summer months. Therefore, it seems probable that this current net-metering pricing model will be terminated in the future [17] and hence, net-metering scenarios are formulated that represent business as usual and the termination of the current net-metering policy. The combinations of all these scenarios are used for the performance robustness assessment.

Table 2. Details of NZEB designs considered in this case study.

Design parameter	Design-1	Design-2	Design-3	Design-4	Design-5
					
Rc, m²K/W (Floor/walls/roof)	3,5/4,5/6	6/7/7	5/7/8	6/8,5/10	10/10/10
Windows (U), W/m²K	1,43	1,01	1,01	0,81	0,55
Infiltration, dm³/sm²	0,625	0,4	0,4	0,15	0,10
Heating and ventilation systems					
Heating	Floor heating with air-water heat pump				
Ventilation	Balanced mechanical ventilation with heat recovery				
Renewable energy generation and storage (RES) systems					
PV, m²	28,8	24	19,2	14,4	9,6
Solar DHW, m²	5	5	5	2,5	2,5
Battery, kWh	12	10	8	6	4
Additional investment cost, K€	31	32	33	30	32

Step 2: Set up building performance simulation model

In order to predict thermal and energy performance of the designs (**Table 2**), a detailed building and energy systems simulation model was developed in the TRNSYS simulation tool. This model is coupled with Mode Frontier, an optimization tool, to carry out the assessment of the design space for all combinations of considered scenarios (**Table 1**). Performance of the design space is assessed with multiple performance indicators such as overheating hours, NPV of costs, CO_2 emissions and their corresponding robustness.

Step 3: Multi-criteria performance assessment

Homeowner

Figure 5 shows variation of overheating hours and corresponding regrets of five designs across the considered scenarios. Each box plot represents a design and the spread of the boxplot of a design results from the considered scenarios. It can be observed from **Figure 5** that all designs results in similar overheating (length of box) in most of the scenarios, except for extreme scenarios. Therefore, it is difficult to choose a preferred design among these designs based on actual performance. However, by using overheating regret hours it is easy to distinguish between the performance robustness of these designs. For instance, design-1 has the least overheating regret hours among all designs as it has lower overheating hours for most of the scenarios than other designs. Similarly, design-2 and design-3 have comparable variations in overheating hours, but design-2 has lower overheating regret hours as it is more optimal than designs-3 for all scenarios. It is noteworthy that design-1 results in overheating of about 940 hours for extreme scenarios. However, regret of overheating hours of this design is close to zero which indicates that design-1 performs better than the other considered designs even for extreme scenarios. Therefore, design-1 is the most robust NZEB among the selected designs. It can also be observed that the risk of overheating increases with higher insulation levels. The design with a highly insulated and airtight building envelope (design-5) is more prone to overheating risks and is, thus, least robust to overheating.

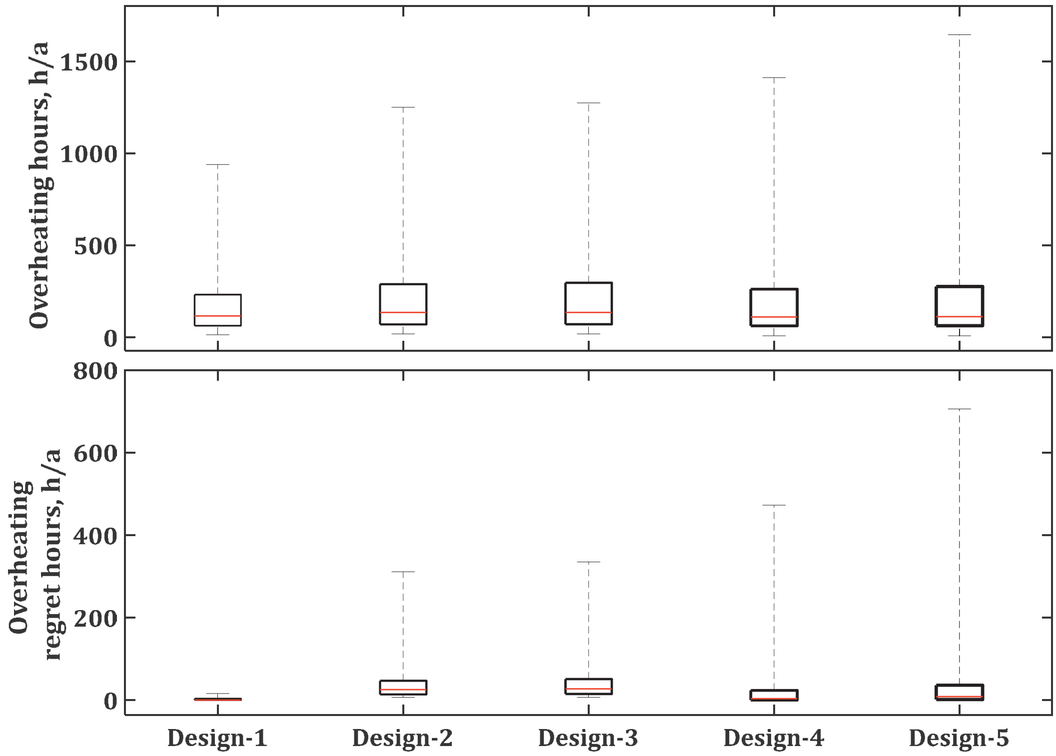

Figure 5. Variation of overheating hours and corresponding regrets of designs for all scenarios for the homeowner.

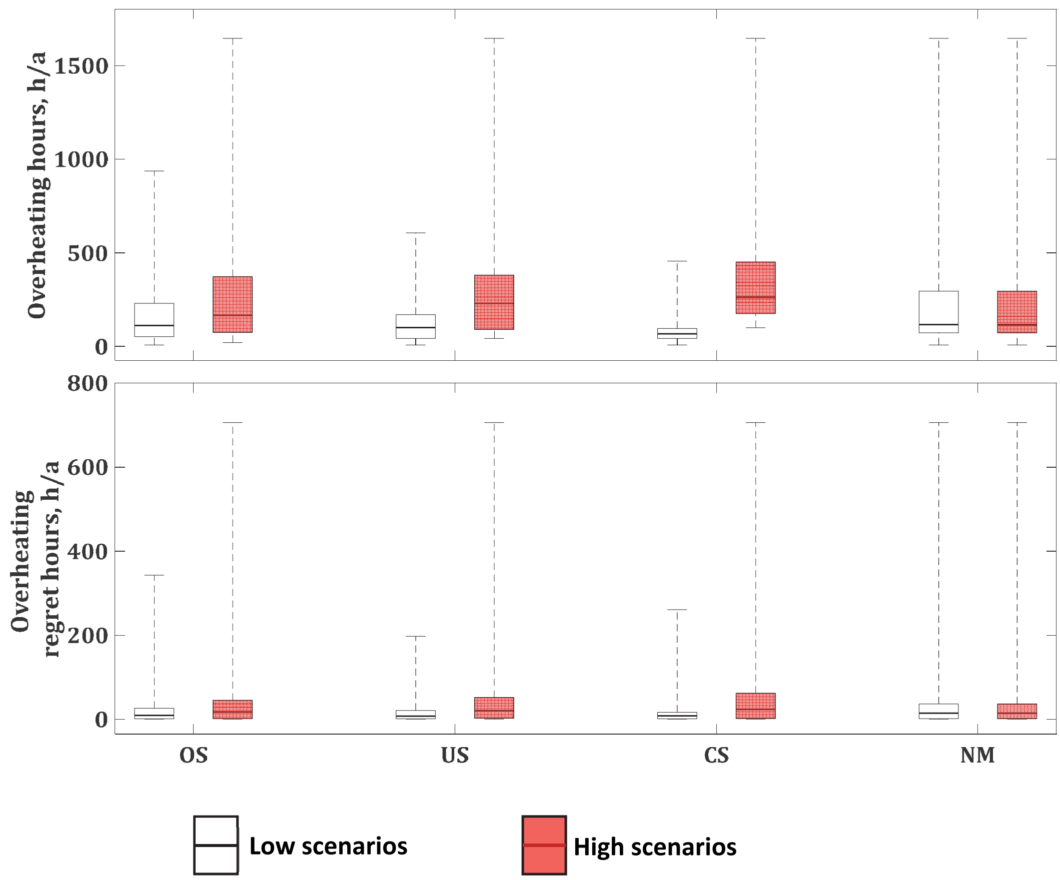

Figure 6. Variation of overheating and corresponding regrets for low and high scenarios. The white box plots represent low scenarios and red box plots represent high scenarios for the homeowner.

The performance of these designs depends on the considered scenarios. For instance, variations in overheating and corresponding regrets increase in all high scenarios, except for the net-metering scenarios, as observed in **Figure 6**. These variations are shown here by pooling all low and high values of each scenario separately. For instance, the spread of the box for the low occupant scenarios includes all scenario combinations that have low occupancy. It can be observed from **Figure 6** that the climate scenarios are the most influential, as the reference climate causes the least overheating and climate change in future causes most overheating. It is inevitable that overheating increases with more number of occupants as observed in the case of the high occupant scenario. This increase in overheating is attributed to rise in heat gains due to the presence and activity of occupants. Usage scenarios also have a considerable influence on overheating. It was found that internal heat gains, window opening, shading and ventilation were particularly influential scenarios. Proper shading control and higher ventilation rates through either ventilation systems or by opening windows can reduce overheating significantly and improve a design's robustness to overheating as observed in the low usage scenarios (see **Figure 6**). It is worth noting that high scenarios of occupants, usage and climate result in the maximum performance regret of overheating. Usage scenarios and climate scenarios are the most influential on a design's robustness to overheating.

Figure 7 shows variation of NPV of costs and corresponding regrets of five NZEB designs across the considered scenarios. It can be observed that design-1 has large variations in costs across all considered scenarios. However, this design has zero regrets of costs for few scenarios, which indicates that design-1 is optimal for these scenarios. Similarly, design-2 and design-3 have comparable variations in costs, but design-3 has less regrets as it is more optimal than design-2 for all scenarios. Therefore, design-3 is more robust than design-2. Design-4 has the lowest maximum regrets of costs and is, thus, the most robust among the five designs. In contrast to overheating, designs with higher insulation levels and small RES systems have low NPV of costs and corresponding regrets. This contrast is attributed to operational costs among other factors. Operational costs are less dependent on the size of RES system, in the case of the termination of net-metering, as the excess energy exported to the grid does not lower operational costs. Therefore, design-1 with the larger RES system results in higher regrets of costs than the other designs. Contrariwise, when net-metering is present, the design with larger RES system (design-1) has lower regrets of costs compared to that of the design with a smaller RES system (design-5), as observed in **Figure 7**. For all scenarios, design-4, which has higher insulation levels than design-1 and a smaller RES system than design-5 has the lowest maximum performance regret of NPV of costs. Therefore, an optimal balance between insulation levels and size of RES system is important to achieve a cost optimal robust NZEB, which is design-4.

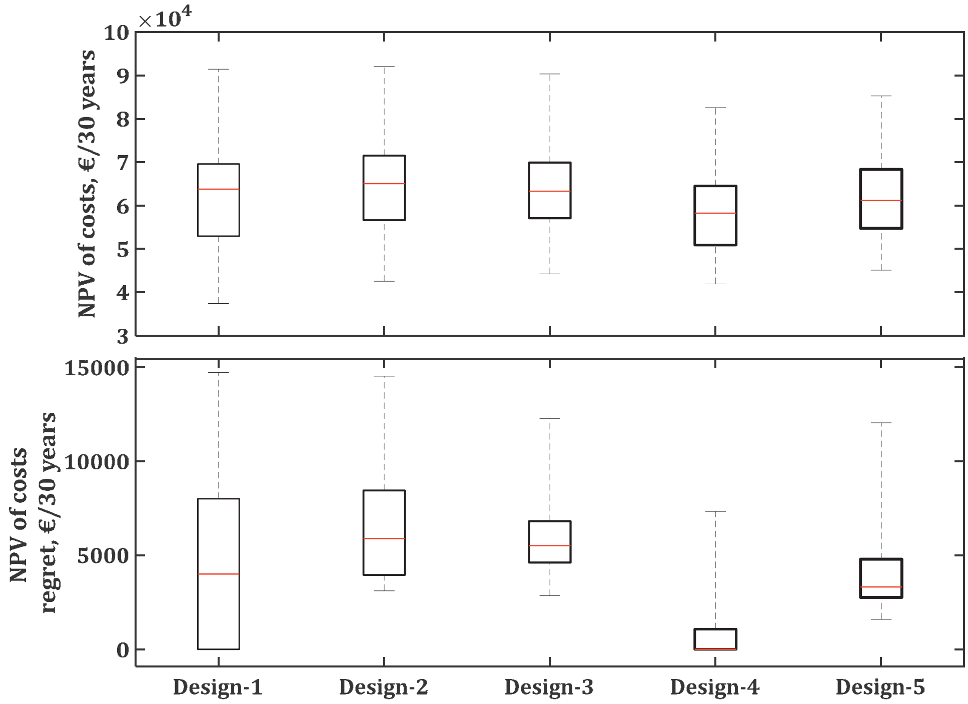

Figure 7. Variation of NPV of costs and corresponding regrets of designs for all scenarios for the homeowner.

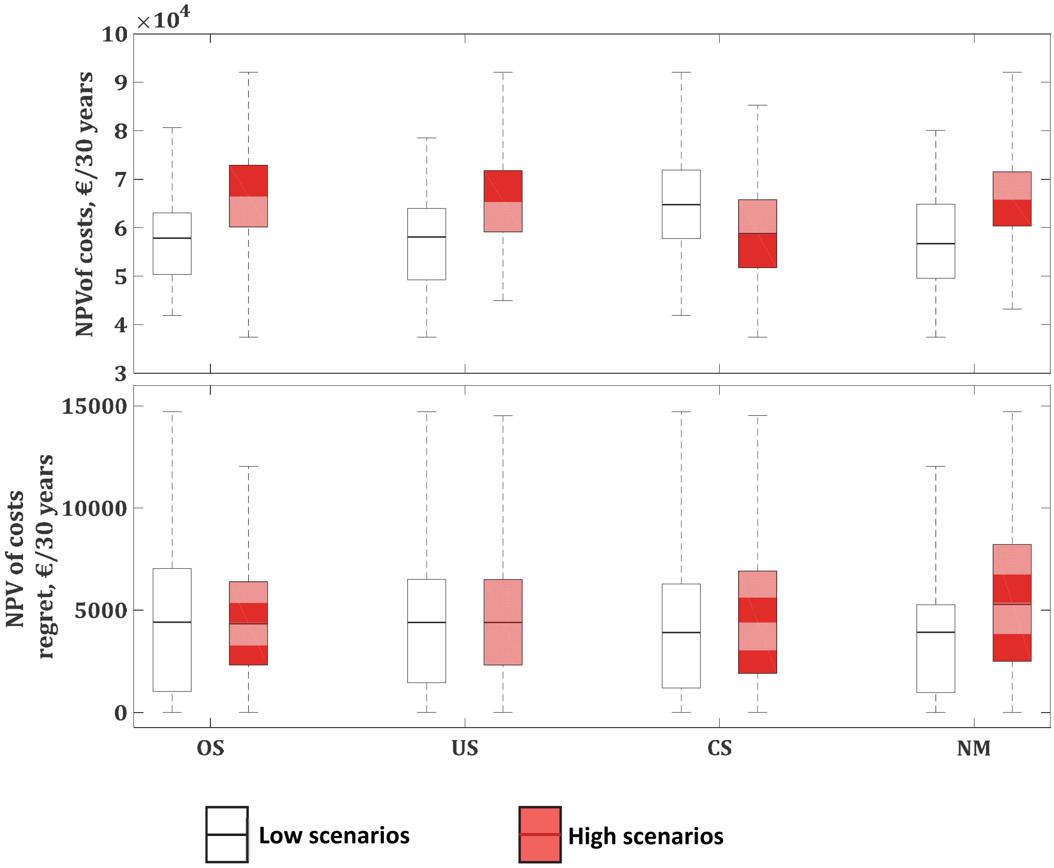

Figure 8. Variation of NPV of costs and corresponding regrets for different low and high scenarios for the homeowner. The white box plots represent low scenarios and red box plots represent high scenarios.

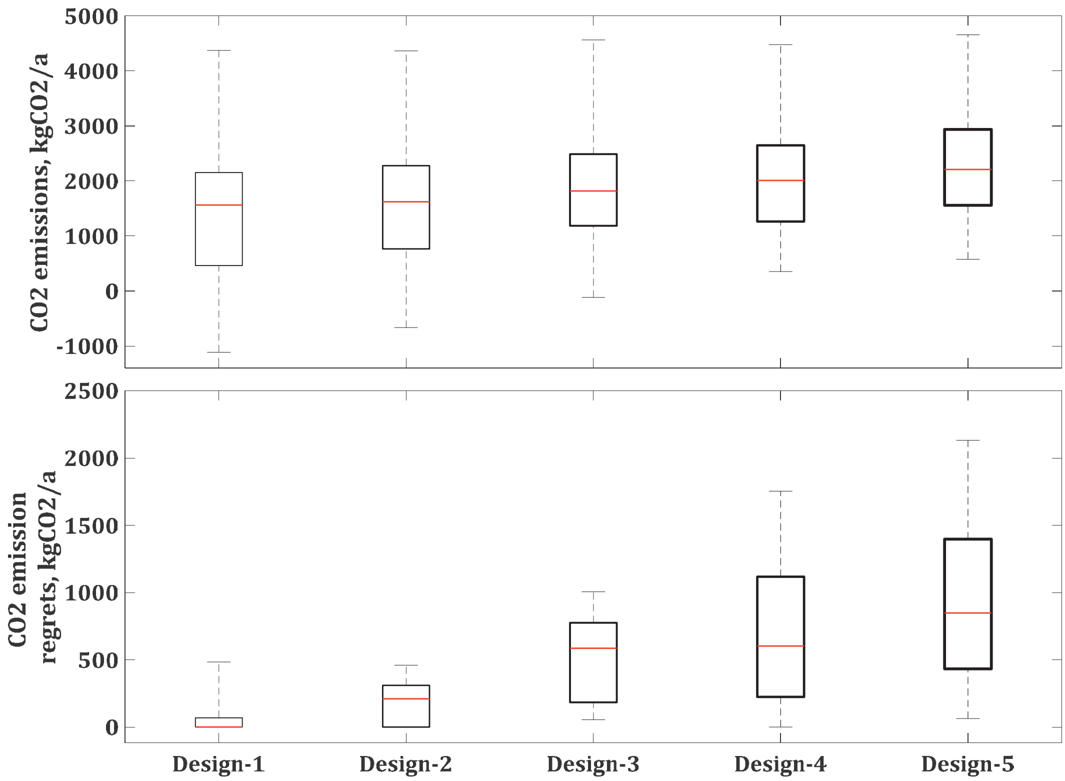

Figure 9. Variation of CO_2 emissions and corresponding regrets of designs for all scenarios for the policymaker.

Net-metering is the most influential scenario on NPV of costs (see **Figure 8**). In the case of net-metering termination, there is a significant increase in the costs and corresponding regrets. It is intriguing that due to climate change the costs are lower in the future compared to the reference climate. This difference is attributed to reduction in heating energy demand for the climate change scenario. It is noteworthy that there is an increase in costs for bigger households, but regrets of NPV of costs are lower, which is probably due to an increase in renewable energy utilization.

Policymaker

It can be observed from **Figure 9** that design-1 has large variations of CO_2 emissions, but has lower variations in CO_2 emissions regrets compared to other designs. This is because design-1 performs better than other designs for most of the scenarios. However, design-2 has the lowest maximum regrets of CO_2 emissions and is, thus, the most robust among the five designs. The designs with low insulation levels and larger RES systems (design-1 and design-2) are found to be more robust than designs with high levels of insulation and smaller RES systems (design-3 - design-5). CO_2 emissions are higher for all high scenarios, except for climate scenarios (see **Figure 10**). This difference for climate scenarios is attributed to a reduction in heating energy demand due to increased temperatures. In contrast, CO_2 emission regrets increase in the climate change scenarios. This increase in CO_2 emission regrets is because of the large performance deviation between the designs in the climate change scenario and the reference climate. It is worth noting that termination of the net-metering policy results in higher CO_2 emissions but in very low CO_2 emission regrets. This reduction in CO_2 emission regrets is attributed to deviation between the performances of the designs from the optimal performance, which is very low in the case of net-metering termination. In contrast, this deviation is higher for the net-metering scenarios. For instance, design-1 is optimal and the performance deviation of other designs from this optimal performance is higher in the case of termination of net-metering. On the other hand, design-2 is optimal for the net-metering scenario and the performance of other designs is not far from this optimal performance, and, thus, these other designs result in lower regrets. It is noteworthy that the designs with larger RES systems are optimal for these scenarios as the renewable energy utilization is higher for these designs.

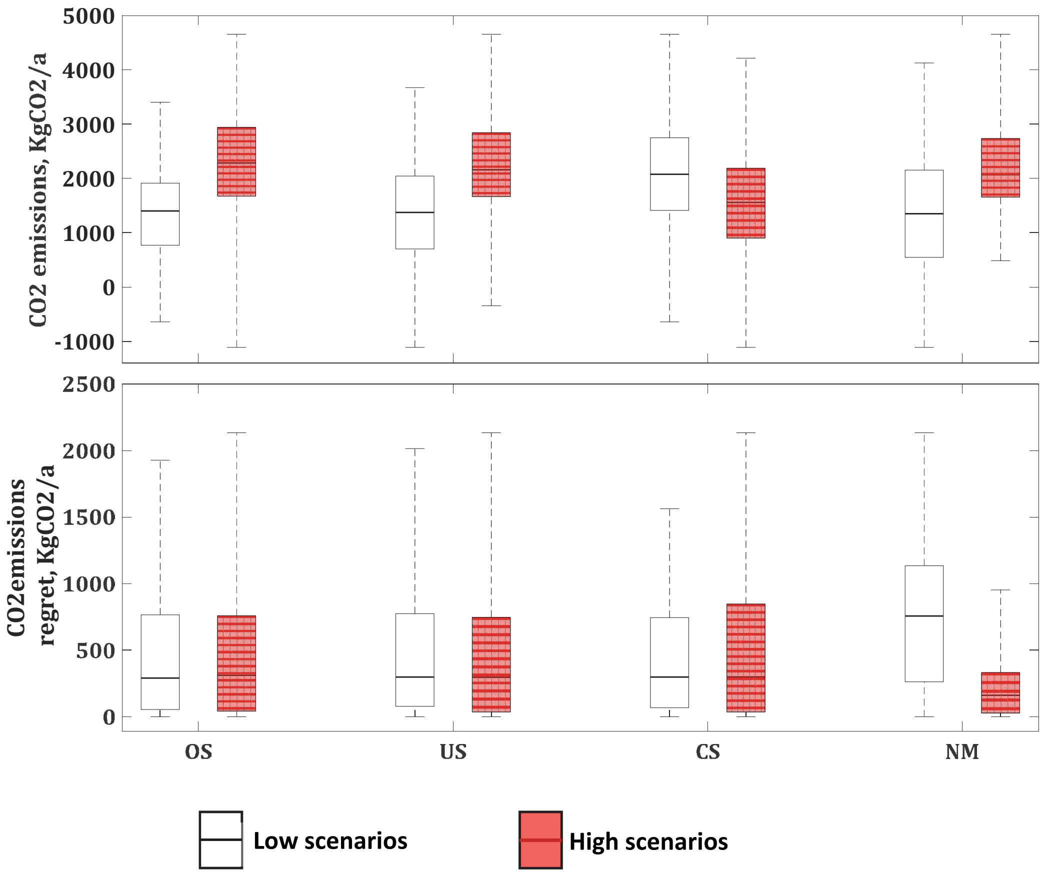

Figure 10. Variation of CO_2 emissions and corresponding regrets for different low and high scenarios for the policymaker. The white box plots represent low scenarios and red box plots represent high scenarios.

Step 4: Multi-criteria decision-making

If a homeowner prioritizes costs and accepts certain overheating hours as a trade-off, then design-4 is the preferred robust NZEB design, as can be seen in **Figure 7.** Furthermore, design-4 has close to zero overheating regret hours for most of the scenarios. However, if a homeowner prefers to reduce overheating, then design-1 is the most preferred robust design as it has close to zero overheating regret hours (see **Figure 5**). That said, design-1 incurs an extra NPV of costs up to 8900€ as a result of the trade-off to reduce overheating regrets of about 456h/a compared to design-4. To reach a compromise, design-3 is the most preferred robust design, as it has lower maximum regret of NPV of costs compared to design-1 and lower maximum regret of overheating compared to design-4. However, the preferred robust design depends on required additional investment cost, but, since the difference in additional investment costs across the designs is a maximum of 3K€ (see **Table 2**), it is too small to have an impact on the design decision making.

Similarly, a policymaker would prefer design-2, as can be observed from **Figure 9,** as it has the lowest maximum CO_2 emissions regret. However, for most of the scenarios, design-1 is more robust compared to design-2. The maximum regret of design-1 is slightly higher than design-2 which is caused by an extreme scenario. If the policymaker is willing to accept this risk, then design-1 is more preferred. To choose a robust design for both homeowner and policymaker, all the preferred performance indicators of both decision makers and their corresponding robustness should be taken into account. The preferred robust design for both homeowner and policymaker is design-1 as it is robust to overheating hours (see **Figure 5**) and CO_2 emissions (see **Figure 9**) and also has zero regrets of costs for few scenarios (see **Figure** 7).

Summary

This methodology, as demonstrated, can be used by designers to aid decision makers in the design phase to select robust NZEB designs that deliver the preferred performance in future operation. Using this methodology, a decision maker can prefer a robust design by prioritizing a particular performance indicator and can trade-off the performance and robustness of other performance indicators. As demonstrated in the case study, it is easier to distinguish between the designs based on robustness than on actual performance. This visualization is instrumental in allowing stakeholders to make informed choices, especially when a design has to be selected from a large design space and multiple performance requirements are considered. This case study shows that buildings with higher insulation levels are prone to overheating and that achieving an optimal balance between insulation levels and size of energy system is essential to achieve a cost optimal robust NZEB for the homeowner. Buildings with low insulation levels and larger RES systems are found to be more robust for the policymaker. ■

References

[1] EPBD, Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast), Off. J. Eur. Union. (2010) 13–35. doi:10.3000/17252555.L_2010.153.eng.

[2] T. Maier, M. Krzaczek, J. Tejchman, Comparison of physical performances of the ventilation systems in low-energy residential houses, Energy Build. 41 (2009) 337–353. doi:10.1016/j.enbuild.2008.10.007.

[3] P. De Wilde, The gap between predicted and measured energy performance of buildings: A framework for investigation, Autom. Constr. 41 (2014) 40–49. doi:10.1016/j.autcon.2014.02.009.

[4] G. Mavrotas, J.R. Figueira, E. Siskos, Robustness analysis methodology for multi-objective combinatorial optimization problems and application to project selection, Omega. 52 (2015) 142–155. doi:10.1016/j.omega.2014.11.005.

[5] C.J. Hopfe, G.L.M. Augenbroe, J.L.M. Hensen, Multi-criteria decision making under uncertainty in building performance assessment, Build. Environ. 69 (2013) 81–90. doi:10.1016/j.buildenv.2013.07.019.

[6] C. Struck, J.L.M. Hensen, Scenario Analysis for the Robustness Assessment of Building Design Alternatives – a Dutch Case Study, (2013) 939–944.

[7] S. Polasky, S.R. Carpenter, C. Folke, B. Keeler, Decision-making under great uncertainty: Environmental management in an era of global change, Trends Ecol. Evol. 26 (2011) 398–404. doi:10.1016/j.tree.2011.04.007.

[8] R. Kotireddy, P. Hoes, J.L.M. Hensen, Optimal balance between energy demand and onsite energy generation for robust net zero energy buildings considering future scenarios, Proc. IBPSA Conf. (2015).

[9] RVO, RVO BENG referentiegebouwen, (2016). doi: http://www.rvo.nl/initiatieven/energiezuiniggebouwd/hoekwoning-m.

[10] RVO, Hernieuwbare Energie in Bijna Energieneutrale Gebouwen (BENG), (2015).

[11] BPIE, Cost Optimality - Discussing methology and challenges within the recast EPBD, (2010) 40.

[12] L. Savage, The Theory of Statistical Decision, J. Am. Stat. Assoc. 46 (1951) 55–67.

[13] R. Kotireddy, P. Hoes, J.L.M. Hensen, Simulation-based comparison of robustness assessment methods to identify robust low energy building designs, in: Proc. IBPSA Conf. Sanfransisco, USA, 2017.

[14] L. Peeters, R. de Dear, J.L.M. Hensen, W. D'haeseleer, Thermal comfort in residential buildings: Comfort values and scales for building energy simulation, Appl. Energy. 86 (2009) 772–780. doi:10.1016/j.apenergy.2008.07.011.

[15] G. Papachristos, Household electricity consumption and CO2 emissions in the Netherlands: A model-based analysis, Energy Build. 86 (2015) 403–414. doi:10.1016/j.enbuild.2014.09.077.

Major energy renovations with the Total Concept method

MARI-LIIS MARIPUU
Ph.D, Project Manager
CIT Energy Management AB
mari-liis.maripuu@cit.chalmers.se

ÅSA WAHLSTRÖM
Adjunct Professor, Sector Manager
CIT Energy Management AB
asa.wahlstrom@cit.chalmers.se

Property owners´ ambitions to carry out major energy retrofitting projects needs to be increased in order to meet the energy efficiency targets in the building sector. The Total Concept method helps building owners to understand the financial benefits and opportunities with energy retrofitting, making it possible to come much further with energy improvements.

Keywords: Total Concept, renovation, non-residential buildings, profitability, energy efficiency

In order to reach the 20-20-20 EU-targets it is essential to dramatically lower the energy needs in a large proportion of existing buildings. This, however, has been a great challenge in most of the European countries. The investments required for retrofitting existing buildings are often expected to be carried out by property owners, but how can their ambitions to considerably improve energy performance of their buildings be increased?

It is relatively easy to identify a number of individual measures each of which can reduce energy needs in a building. Although some of these can be carried out at little cost, the measures that significantly reduce energy needs often entail considerable investments. Previous, there has been little support provided to the property owners regarding how to make the best investment decisions. The decisions are often based on profitability of single measures, whereas simple economical methods are often used which does not take into account economic life times of measures nor changes in energy prices. Often only the very profitable measures are considered and carried out, leading to rather modest energy savings.

To change the mindset and motivate property owners to carry out major energy renovation a method, called the Total Concept, has been developed and successfully applied on a number of renovation projects of non-residential buildings in Sweden. The method has during the last three years also been successfully introduced to other Northern European countries. Total Concept aims is to be a market drive for major energy renovation and thereby increase business opportunities in the sector.

Drivers and barriers for major energy renovation

A market analysis carried out in Finland, Denmark and Sweden shows that decreasing energy use in a building is seldom a reason for renovating a building [1]. Based on the interviews with a number of local property owners the most common reasons for retrofitting are change of (large) tenants, the deterioration of existing systems or building's envelope, as well as problems with indoor climate.

Energy is relatively cheap in Nordic countries and, therefore, this is a significant obstacle for starting energy renovation projects. The property owners, especially private ones, are very much profit oriented. Besides low energy prices, another important barrier is the risk of not receiving the whole profit from the energy measures. This is particularly relevant when tenants pay their utility bills. Without a special agreement, benefits of an investment may go directly to a tenant and not to the investor.

Additionally, budgetary limitations as well as a fear of carrying out long-term investments and lack of good economic models are also considered as barriers.

The main barriers for energy retrofitting pointed out during the interviews are illustrated on **Figure 1.**

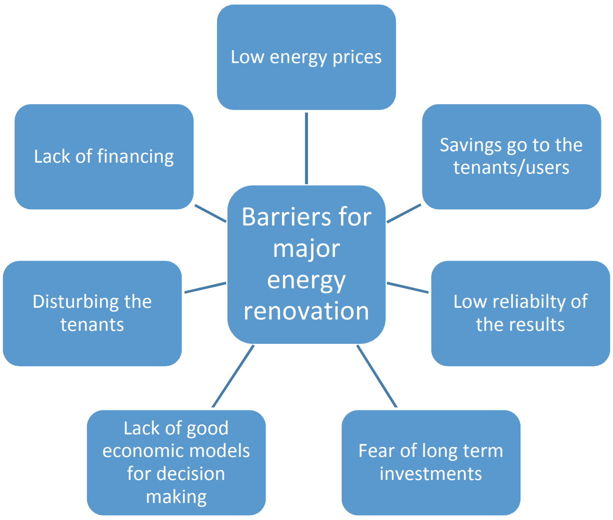

Figure 1. The main barriers for major energy retrofitting in Sweden, Denmark and Finland.

The market study has shown that there is a high demand for energy renovation methods that can provide building owners a comprehensive approach, reliability of the results that energy and financial savings are achieved and that they are based on easy-to-understand economic models. The study couldn´t identify any other method available on the Nordic market that can adapt to this demand. Most companies and services commonly focus on single or few issues or solutions.

Total Concept method in brief

- Total Concept is a method for improving energy performance in existing non-residential buildings.
- The method applies a comprehensive approach to work with energy issues in a building with the aim to achieve maximum savings in a profitable way.
- The method is based on an action plan comprising a package of energy efficiency improvement measures that as *a whole* fulfils the property owner's profitability requirements.
- The work process of the Total Concept is divided into three steps in a systematic approach covering the entire retrofitting process, from pre-study phase to follow-up phase, and ensuring that energy saving targets are actually reached.
- Quality and function of the building must remain the same or be improved.

The profitability assessment in the Total Concept method is based on an internal rate of return method, where an investment is assessed by the actual yields that it creates, expressed as an internal rate of return (IRR). First a comprehensive inventory is carried out in the building to identify all possible energy saving measures, both the single cost-efficient ("low hanging fruits") and the costlier measures. Then, an action package is formed through step-by-step energy and profitability calculations. The criterion for how many measures are included to the action package is that the combined internal rate of return of the whole package must be higher than the real calculation interest rate stipulated by a property owner. How the different measures affect each other when carried out as a package and different economic lifetimes of measures are also taken into account [2].

The profitability calculations are done with the Total Concept tool, the TotalTool, where the outcomes are illustrated in a simple-to-understand way for the decision makers, by using an internal rate of return diagram. The decision maker can see what impact each measure has in the overall profitability and supports the decision to carry out a package of measures instead of single profitable measures.

An example of an action package on an internal rate of return diagram is illustrated in **Figure 2**. In this example five energy efficiency measures were identified during auditing. Every measure leads to certain annual net savings in operating cost (k€/year), requires certain investment cost (k€) and can be represented by a line in the diagram with a certain length and angle. This angle represents the internal rate of return (%) of an investment. The profitability requirement is set as 5% real interest rate.

The formed action package provides a combined internal rate of return of 7% and leads to halving the annual energy costs, which approximately corresponds to a halving of the use of energy. The most profitable

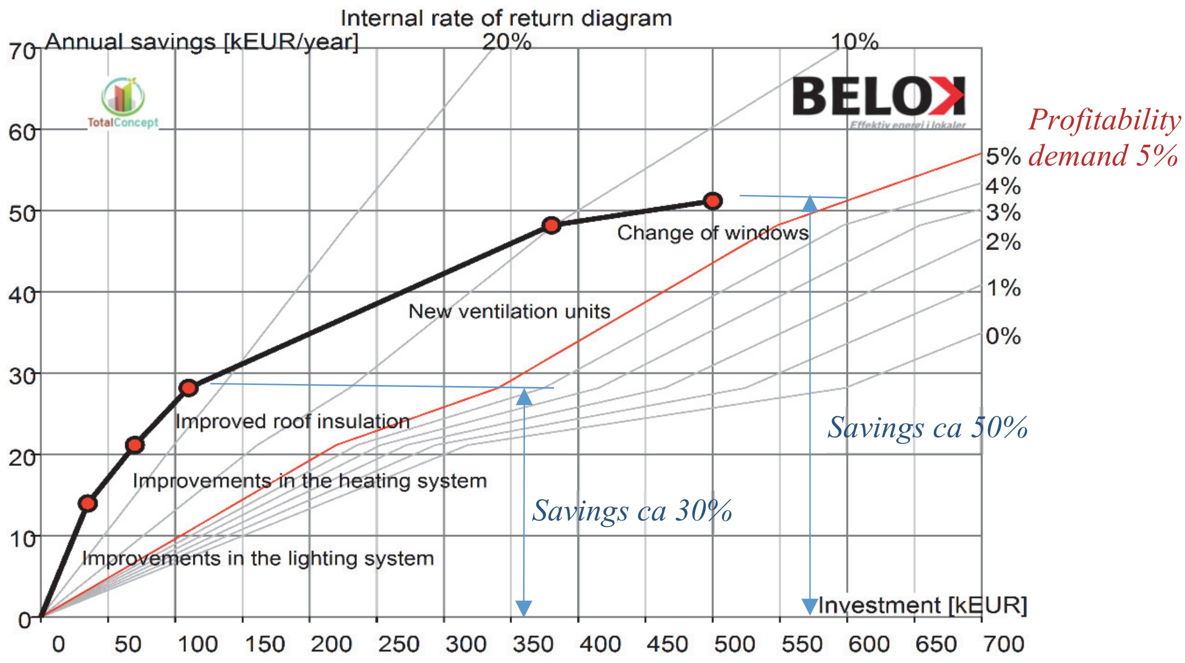

Figure 2. Presentation of a package of measures with five measures in an internal rate of return diagram. The property owners' profitability requirement for the investment is an internal rate of return of 5% (based on real calculation interest rate). The whole package of measures in the example gives an internal rate of return of 7% and leads to halving the annual energy costs.

measures make up for the less profitable measures while the complete action package will fulfil the profitability frame set by the building owner. If only the measures that were profitable on their own were carried out, the first three measures, the savings would have been only 30%. This is the main essence of the Total Concept method that it provides a method to take one step further with energy savings in a profitable way.

Examples of renovation projects and lessons learned

In Sweden, the Total Concept method has been implemented in a number of retrofitting projects in office buildings, schools, hospitals, sports facilities, railway stations and universities [3, 4]. The outcomes show that annual savings over 50% are possible within the profitability frames that property owners have, which is often in between 5% to 8% return on investment. The savings achieved are strongly dependent on the buildings energy performance before the renovation. **Figure 3** presents the expected energy savings in percentage and internal rate of return of the action packages in a number of projects carried out in Sweden. Total investment cost in these projects has been in average about 70 €/m², mean annual savings about 6 €/m²yr and internal rate of return in average about 10%.

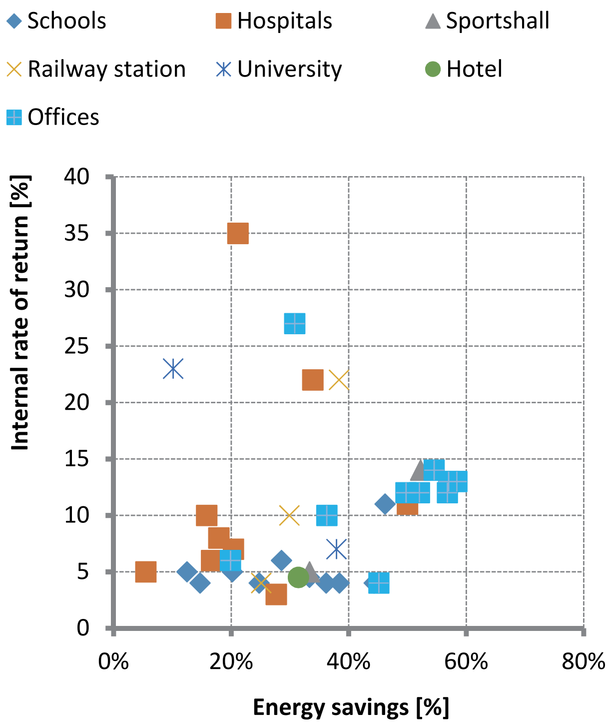

Figure 3. Total energy savings and internal rate of return in Total Concept projects carried out or planned to be carried out in Sweden.

Year built	1989
Renovated	2015–2018
Heated floor area A_{temp}	16 238 m^2
Energy investment cost	1 535 000 €
Total energy savings	ca 55%
Total cost savings	172 000 €/yr.
Energy use before (incl. tenants)	231 kWh/m^2 yr.
Estimated energy use after (incl. tenants)	105 kWh/m^2 yr.
Internal rate of return	11%

Figure 4. Total energy savings and internal rate of return in a major renovation project in an office building in Gothenburg. Improving energy efficiency at the same time based on Total Concept method will lead to total energy savings about 55%.

The Total Concept method can easily be included in the overall retrofitting process of a building, in which the additional investments required for achieving better energy performance is analysed. One example of such a project is an office building in Gothenburg, where a total renovation is carried out in order to adjust the building for new tenants. The proposed package with 15 energy efficiency measures will lead to energy savings about 55% with an internal rate of return on investment of 11%. Renovation works are in progress and will be finished by 2018. The summary of the outcomes action package is presented in **Figure 4**.

Feedback from the Nordic reference projects highlights the following main strengths of the Total Concept method:

- applying a comprehensive approach in energy retrofitting;
- having a good economic tool for decision making;
- making early plans for commissioning and follow-up are important for assuring that expected results are achieved;
- follow-up period is very useful for additional system optimization and for noticing any malfunctions of the systems that can have high impact on the building's energy performance.

Market potential and business opportunities

Retrofitting projects based on the Total Concept method offers business opportunities for a number of key actors in the building sector, such as energy

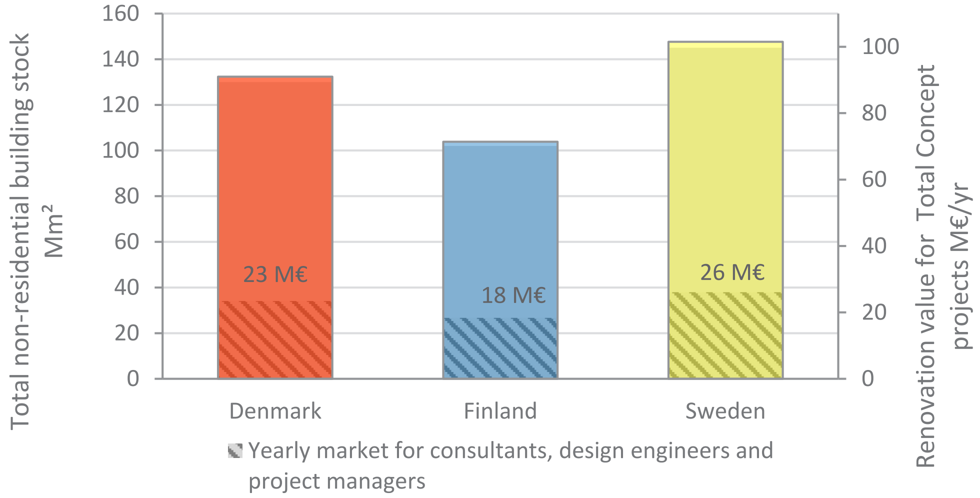

Figure 5. Estimated size of the renovation market for the Total Concept method in Northern Europe.

consultants, design engineers, contractors, energy controllers and project managers.

In Denmark, Finland and Sweden the area of existing non-residential buildings is estimated to be in total about 380 million m². Assuming that about 1 percent of the existing building area would be annually renovated using the Total Concept would mean that the yearly volume of renovation would be about 4 million m². This would correspond to the total investment volume up to 260 M€ per year in the three countries, assuming that the total renovation cost is about 70 €/m² in average [1]. For the key actors involved in the pre-study phase (Step 1), design work and project coordination during construction phase (Step 2) and follow-up in monitoring phase (Step 3) the annual market volume is estimated to be about 70 M€. This is based on the estimation that the consulting, design work and project management share is about 18 €/m² from the total renovation cost. Estimated size of the renovation market for the Total Concept method in the three Nordic countries is illustrated in **Figure 5.**

There is a high demand for energy retrofitting methods on the market that can provide building owners reliable results. Total Concept method includes economic realities which building owners need to consider, while at the same time it aims to increase the ambitions and making it possible to come much further in improving buildings energy efficiency and in improving the overall quality of a building. The Total Concept method has a great potential to become a market leader for large scale energy renovation projects. ■

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References

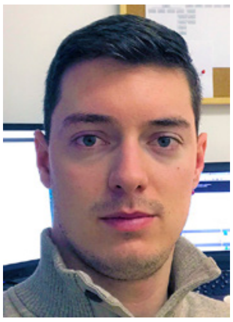
[1] M-L. Maripuu, Å. Wahlström, P. Pasanen, A. Afshari. P. Krawczyk, "Market potential and business opportunities with the Total Concept", report in the Nordic Built project, 2016. www.nordictotalconcept.info.

[2] Total Concept, 2014:1, The Total Concept method -Guidebook tfor Implementation and Quality assurance, Version 1.5: May 2016, www.totalconcept.info.

[3] Å. Wahlström, E. Abel and M-L Maripuu, " Total Concept-for better decision-making about Energy Efficiency Investments in non-Residential Buildings", Accepted for proceeding of ECEEE Summer Study 2015, Toulon, France, paper 6-103-15, page 1239, 1 - 6 June, 2015.

[4] M-L. Maripuu, Å. Wahlström and E. Abel, "Swedish experiences of using Total Concept for refurbishment towards nearly zero-energy buildings", Proceedings of the 7PHN Sustainable cities and buildings; Copenhagen, 20.-21. August 2015.

Energy consumption and Indoor Environmental Quality of a residential building before and after refurbishment



IMRICH SÁNKA
MSc., Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Department of Building Services
imrich.sanka@stuba.sk

VERONIKA FÖLDVÁRY
PhD., Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Department of Building Services

DUŠAN PETRÁŠ
Prof. PhD. Eur. Ing. Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Department of Building Services

The study was performed in one residential building before and after its renovation. Energy auditing and classification of the selected building into energy classes were carried out. This study investigates the impact of energy renovation on the indoor environmental quality of apartment building during heating season. Evaluation of indoor air quality was performed using objective measurements and subjective survey. Concentration of CO_2 was measured in bedrooms, and sampling of total volatile compounds was performed in the living rooms of the selected apartments. Higher concentrations of CO_2 and TVOC were observed in the residential building after its renovation. The concentrations of CO_2, and TVOC in some of the cases exceeded the recommended maximum limits, especially after implementing of energy saving measures on the building. The average air exchange rate was visible higher before renovation of the building. The current study indicates that large-scale of renovations may reduce the quality of the indoor environment in many apartments, especially in the winter season.

Keywords: Carbon dioxide concentration; Energy renovation; Indoor environment quality; Volatile organic commands concentration

Most of the residential buildings in Slovakia that were built in the 20th century do not satisfy the current requirements for energy efficiency presented in the national building code. Nationwide remedial measures have been taken to improve the energy efficiency of these buildings and reduce their energy use (Földváry V., Bekö G., Petráš D. (2014)). However, since the impact of these measures on indoor air quality is rarely considered, they often compromise indoor air quality due to the decreased ventilation and infiltration rate.

The highest development in the housing stock, as a result of economic changes and population growth, has been recognized as taking place during the second half of the 20th century (Jurelionis A., Seduikyte L. (2010)). The majority of housing in Central and Eastern Europe was constructed from panel technology. The degradation of its quality, which has led to its renovation, has become one of the most important measures from an energy-saving point of view.

The aim of the study was to evaluate the impact of basic energy-saving measures on indoor air quality in a typical high-rise residential building built in the 1960s in Slovakia.

Building description and building energy

The residential building investigated (**Figure 1**) is located in Šamorín, Slovakia. It was built in 1964 from lightweight concrete panels. The building was naturally ventilated. Exhaust ventilation was only used in sanitary rooms, such as the bathrooms and toilets. Renovation of the building was carried out in 2015 and included the following measures: insulation of the building envelope using polyethylene (80 mm), insulation of the roof using mineral wool (120 mm) and hydraulic balancing of the heating system. New plastic frame windows had already been installed over the last years in most of the apartments in the building. (Földváry V., Bekö G., Petráš D. (2015)).

Figure 1. The evaluated dwelling before and after refurbishment.

The heat demand was calculated for the non-renovated and renovated condition. The highest energy-saving is provided by the thermal insulation of the external walls. This can be explained with the large heat exchange surface of the walls. On the **Figure 2**, is clearly indicated the heat demand for the structures for square meter and the solar and heat gains for both types of residential building. The figure shows that the heat demand for the insulated part of the building significantly decreased and for the calculated air exchange rate (AER) and gains remained the same.

Table 1. Heat transfer coefficients of the structures.

Structure	Heat transfer coefficient – Non renovated building Ui [W/(m²K)]	Heat transfer coefficient – Renovated building Ui [W/(m²K)]	Area SUM Ai [m²]	Average heat transfer coefficient – Non renovated building Ui [W/(m²K)]	Average heat transfer coefficient – Renovated building Ui [W/(m²K)]	Improvement of the heat transfer coefficient [%]
External wall 1	1,6	**0,37**	1766,85	1,49	**0,35**	76,50
External wall 2	1,59	**0,36**				
External wall 3	0,49	**0,23**				
External wall 4	0,44	**0,23**				
Wall of the machine room	1,69	**0,38**				
Flat roof	0,8	**0,22**	328,77	1,23	**0,23**	81,30
Flat roof of the machine room	1,93	**0,27**				
Ceiling above the basement	0,88	**0,33**	338,77	0,88	**0,34**	61,40
Transparent structures	1,56	**1,3**	569,43	1,56	**1,3**	16,70
			3013,82	1,439	0,544	

The renovated and non-renovated residential building were classified into energy classes by the valid Slovak legislation: Decree of the Ministry of Transport, Construction and Regional Development No:300/2012.

The energy-saving measures mentioned above decreased the energy consumption by 55%. In accordance to our law on energy efficiency of buildings, the original dwelling belonged to the 'E' category (159 kWh/m²a), after refurbishment to the 'B' category (74 kWh/m²a).

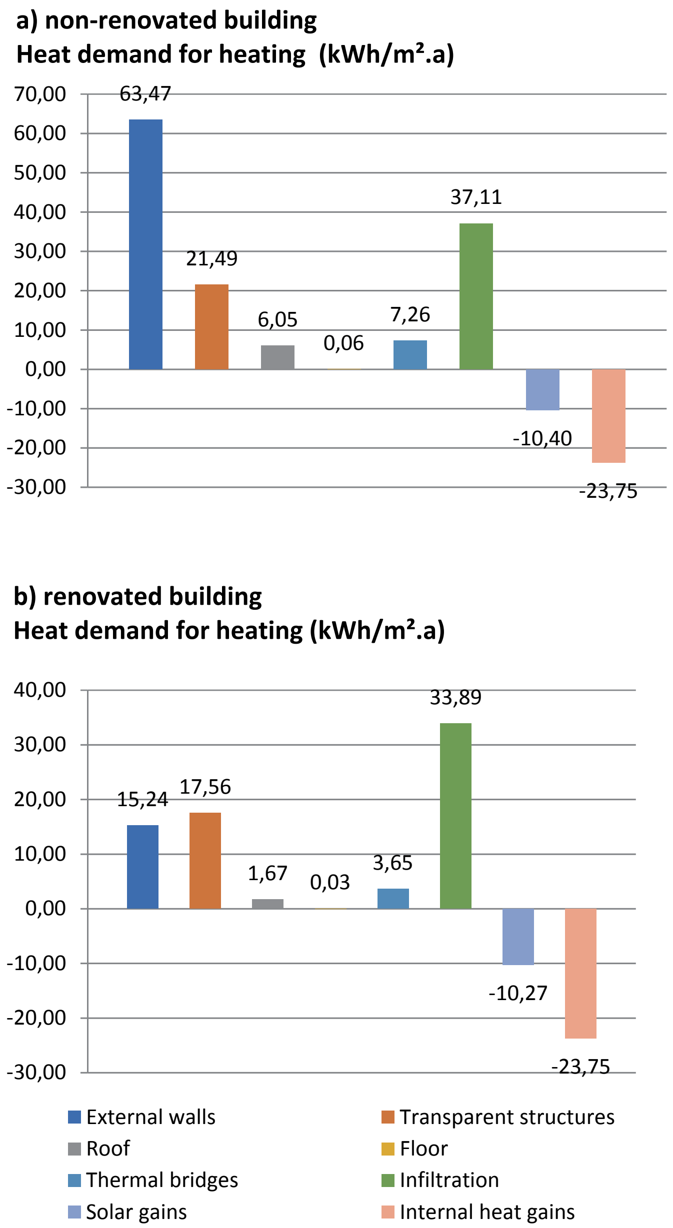


Figure 2. Heat demand of the building.

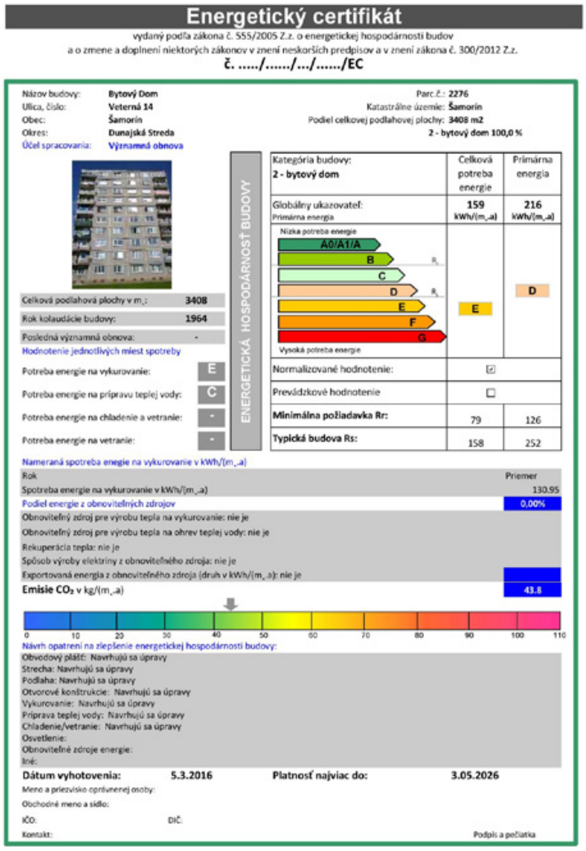


Figure 3. Energy certificate of the non-renovated building.

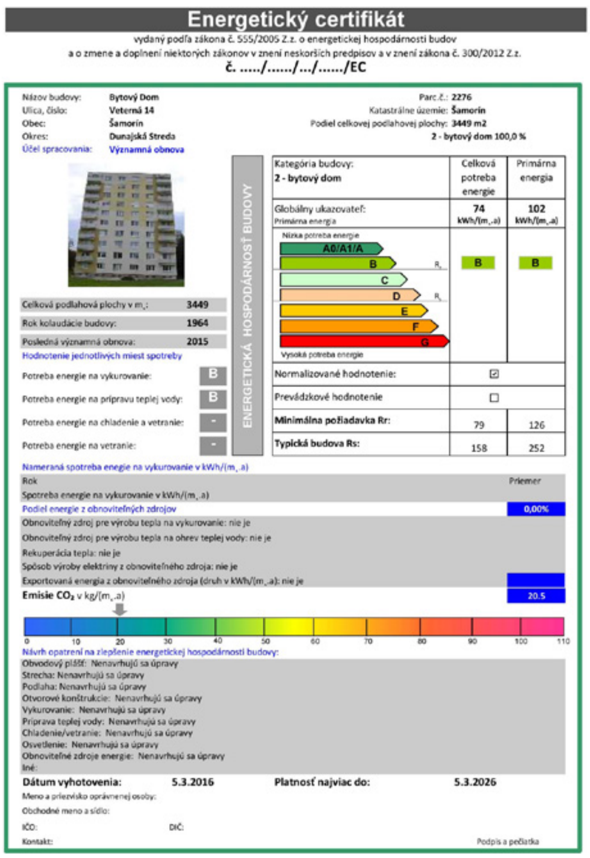


Figure 4. Energy certificate of the renovated building.

Methodology

The first round of the measurements was performed in January 2015 when the building was still in its original condition, and the second round was performed in January 2016 after energy saving-measures had been implemented. Twenty apartments were selected across the residential building; they were equally distributed on the lower, middle and highest storeys of the building. The same apartments were investigated in both winter seasons over a period of eight days (Földváry V. (2016); Bekö G., Földváry V., Langer S., Arrhenius K. (2016)). The temperature, relative humidity, CO_2 concentration, and volatile organic compound concentration (TVOC) were measured in the bedrooms (the TVOC concentration in the living rooms) of the apartments. HOBO U12-012 data loggers and CARBOCAP CO_2 monitors (**Figure 5**) were used for recording the temperature and CO_2 concentration data.

For the TVOC concentration Perkin-Elmer adsorption tubes (**Figure 6**) with 200 mg Tenax TA were used. The measurements were performed according to ISO 16017-2. All the devices were calibrated before the measurement campaign began. The data were recorded at 5-minute intervals for eight days in each apartment. The locations of the instruments were selected with respect to the limitations of the carbon dioxide method (Földváry V., Bekö G., Petráš D. (2015))

Each unit was placed at a sufficient distance from the windows and beds to minimize the effect of the incoming fresh air or the effect of the sleeping occupants. The space between the furniture and the room corners was avoided. The CO_2 concentration was used to calculate the air exchange rate over eight nights in each bedroom. The occupants CO_2 emission rate was determined from their weight and height as set out in questionnaires (Földváry V., Bekö G., Petráš D. (2015); Földváry V. (2016)).

Figure 6. Perkin-Elmer adsorption tube.

The calculation of the air exchange rates was performed using the following mass balance (Persily A. K. (1997)):

$$C_i(t) = (C_o - C_a) \cdot e(-\lambda \cdot t_i) + C_a + (E \cdot 103\,\lambda \cdot VR \cdot (1 - e - \lambda \cdot t_i))$$

$C_i(t)$ = concentration at time t, ppm(V)
C_o = concentration in the beginning (at time t=0), ppm
C_a = outdoor concentration, ppm
λ = air exchange rate, 1/h
E = estimated metabolic CO_2 generation rate per person in the zone, 1/h
VR = volume of the room, m³
t_i = time, h

Figure 5. Hobo data logger and Carbocap CO_2 monitor (Sánka I., Földváry V., Petráš D. (2016); Sánka I., Földváry V., Petráš D. (2017))

A questionnaire survey was used to determine the subjective evaluations of the quality of the indoor environments. The questionnaire survey was carried out along with the objective measurements. Two types of documents were prepared (for the unrenovated and renovated building).

The questionnaire contained 6 main parts:

1. Basic information about the occupants
2. The state of the building
3. The ventilation habits of the occupants
4. Sick building syndrome symptoms
5. Perceived air quality
6. Thermal comfort

Results

The results of thermal comfort, the measured values of CO_2, AER, and the TVOC parameters and the questionnaire survey are as follows:

A. Thermal comfort

The measured values of temperature and relative humidity are presented in the following text.

From the measured data is obvious that day and night average temperature was higher in the renovated building than in the non-renovated (**Figure 7**, **Table 2**).

The relative humidity was very similar in both types of residential building (**Figure 8**, **Table 3**).

Table 2. Indoor air temperature before and after.

1) Before renovation (N=20)

Time period	T [°C]		
	Average	Minimum	Maximum
Day	20,7	20,1	23,6
Night	21,2	18,8	24,2
Whole period	20,9	18,7	23,9

2) After renovation (N=20)

Time period	T [°C]		
	Average	Minimum	Average
Day	22,1	20,1	23,9
Night	22,4	20,8	24,0
Whole period	22,2	20,6	24,0

Table 3. Relative humidity before and after.

1) Before renovation (N=20)

Time period	RH [%]		
	Average	Minimum	Maximum
Day	46,1	34,8	59,1
Night	47,1	34,8	63,0
Whole period	46,2	34,5	60,8

2) After renovation (N=20)

Time period	RH [%]		
	Average	Minimum	Average
Day	47,3	38,3	58,4
Night	48,8	38,9	59,9
Whole period	47,9	38,6	59,1

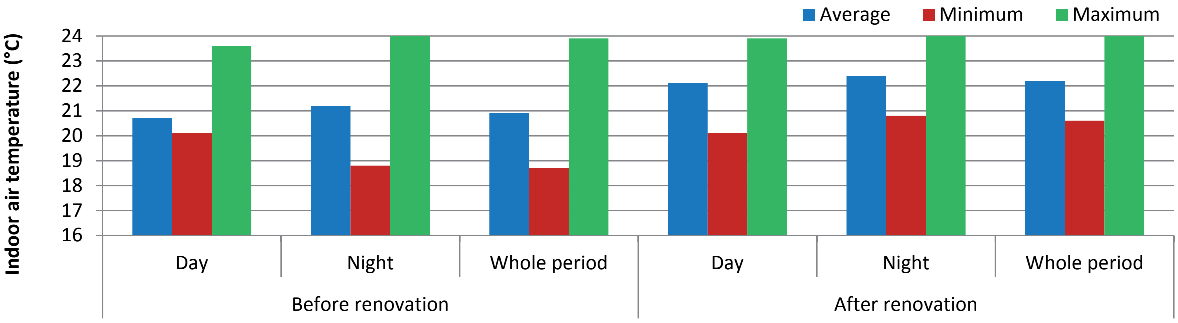


Figure 7. Average temperatures in the apartments before and after complex renovation.

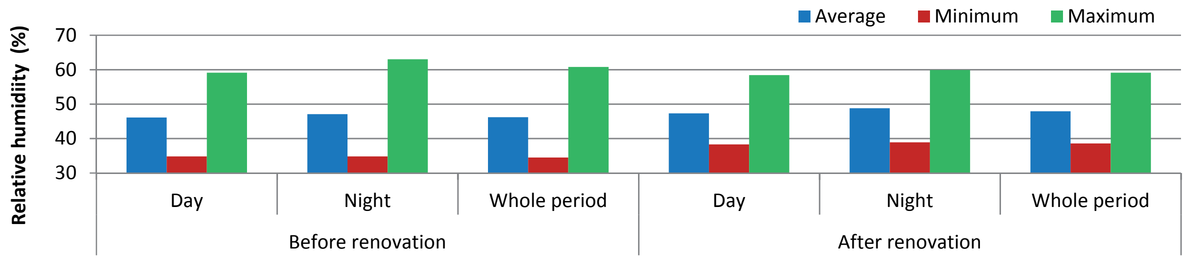


Figure 8. Average relative humidity in the apartments before and after renovation.

Both measured values fulfils the requirement of the Slovak standard STN EN 15 251(T: T>20°C; T<24°C; RH: RH>30%; RH<70%).

B. Carbon-dioxide concentration and Air exchange rate

The CO_2 concentrations before and after the renovation of the building are shown in **Figure 9**. Most of the CO_2 concentration data points were within the acceptable limit (green line) before the renovation (blue line), while significantly higher concentrations were measured after the renovation (red line). **Table 4** and **Figure 10** present the descriptive statistics of the day and night-time CO_2 concentrations before and after the renovation of the residential building. The grand average was 1205 ppm, and the median was 1190 ppm before the renovation.

After implementing the energy-saving measures, the CO_2 concentration visibly increased. The mean was 1570 ppm, and the median was 1510 ppm. **Table 5** shows the percentages of the average day and night-time CO_2 concentrations above four cut-off values in the residential building before and after its renovation. A higher number of the apartments exceeded 1500 ppm and the upper concentrations during both the day and night-time after the renovation than before the renovation.

Table 4. Day- and night-time CO_2 concentrations before and after renovation of the residential building. (Sánka I., Földváry V., Petráš D. (2016); Sánka I., Földváry V., Petráš D. (2017))

1) Before renovation (N=20)

Time period	CO_2 (ppm)			
	avg.	min	max	median
Day	1040	595	1550	1030
Night	1400	740	2665	1300
Whole period	1205	660	2050	1190

2) After renovation (N=20)

Time period	CO_2 (ppm)			
	avg.	min	max	median
Day	1320	790	2210	1265
Night	1925	865	3575	1825
Whole period	1570	870	2770	1510

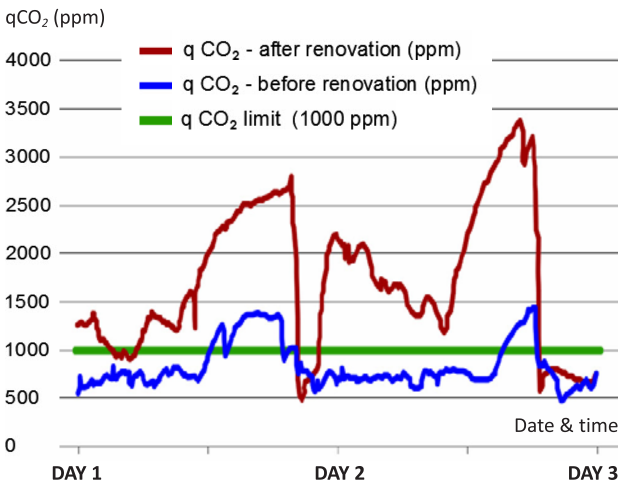


Figure 9. Example of CO_2 concentration in one selected apartment during two days out of the whole measurement period before and after the renovation. (Sánka I., Földváry V., Petráš D. (2016); Sánka I., Földváry V., Petráš D. (2017))

Table 5. The fractions of the apartments where the average CO_2 concentration exceeded 1000, 1500, 2000 and 2500 ppm during the day- and night-time. (Sánka I., Földváry V., Petráš D. (2016); Sánka I., Földváry V., Petráš D. (2017))

1) Before renovation (N=20)

Time period	Cut-off values [%]			
	CO_2>1000 (ppm)	CO_2>1500 (ppm)	CO_2>2000 (ppm)	CO_2>2500 (ppm)
Day	60	10	0	0
Night	75	40	10	5

2) After renovation (N=20)

Time period	Cut-off values [%]			
	CO_2>1000 (ppm)	CO_2>1500 (ppm)	CO_2>2000 (ppm)	CO_2>2500 (ppm)
Day	75	30	10	0
Night	95	70	40	15

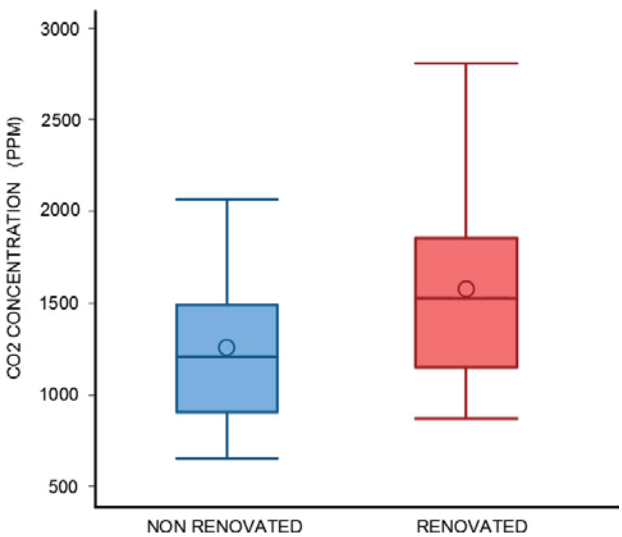


Figure 10. CO_2 concentration before and after renovation as a statistical output (Sánka I., Földváry V., Petráš D. (2016); Sánka I., Földváry V., Petráš D. (2017))

The lower CO_2 concentration before the renovation resulted in higher AERs in the apartments (average 0.61 1/h). After the renovation, the mean air exchange rate (0.44 1/h) dropped below the recommended minimum (0.5 1/h) (**Table 6** and **Figure 11**).

C. Concentration of volatile organic compounds

In both cases (before and after the renovation) the volatile organic compound (TVOC) concentrations were above the maximum limit value (300 µg/m³) Even higher concentrations were measured in the apartments after refurbishment (**Table** 7). In some cases, concentrations of TVOC were measured as very high (>1000 µg/m³), which are illustrated by the green dots on **Figure 12**. **Table 8** contains the percentages of the measured values exceeding the threshold values.

D. Results of the subjective measurements

The results of the questionnaire survey are based on the responses of the occupants of the evaluated residential building. The results below characterize the ventilation habits of the occupants, the perceived air quality, and the acceptability of the indoor air quality.

The residents labelled the acceptability of the indoor air on a scale from −1 to +1. The following figure shows the acceptability of the indoor air quality in the bedrooms and living rooms of the unrenovated and renovated building. The boxplot value of -1 represents poor air quality, and the value 1 represents good air quality.

The changes in the ventilation habits of the inhabitants before and after the renovation are presented in **Table 9**. The first part of the table shows the percentage

Table 6. AER before and after. (Sánka I., Földváry V., Petráš D. (2016); Sánka I., Földváry V., Petráš D. (2017))

AER	avg.	min	max	median
Before renovation (N=20)	0.61	0.32	1.15	0.59
After renovation (N=20)	0.44	0.21	0.76	0.45

Table 7. TVOC concentration before and after.

TVOC concentration, µg/m³	avg.	min	max
Before renovation (N=20)	569	179	1805
After renovation (N=20)	773	185	2362

Table 8. TVOC concentration before and after. (Sánka I., Földváry V., (2017))

Limit values of TVOC concentration	Before renovation (N=20)	After renovation (N=20)
TVOC > 300 µg/m³	80%	85%
TVOC > 500 µg/m³	50%	60%
TVOC > 1000 µg/m³	5%	25%
TVOC > 2000 µg/m³	0%	5%

Table 9. Ventilation habits of the inhabitants.

Ventilation	Before renovation (N=20)		After renovation (N=20)	
	Whole apartment	Bedroom	Living room	Bedroom
Frequency of ventilation [%]				
More than once a day	70	40	60	30
Daily or almost daily	30	60	40	70
The average duration of ventilation [%]				
3.5 min	25	15	15	15
7.5 min	35	20	40	20
20 min	15	30	20	40
30 min	25	35	25	25

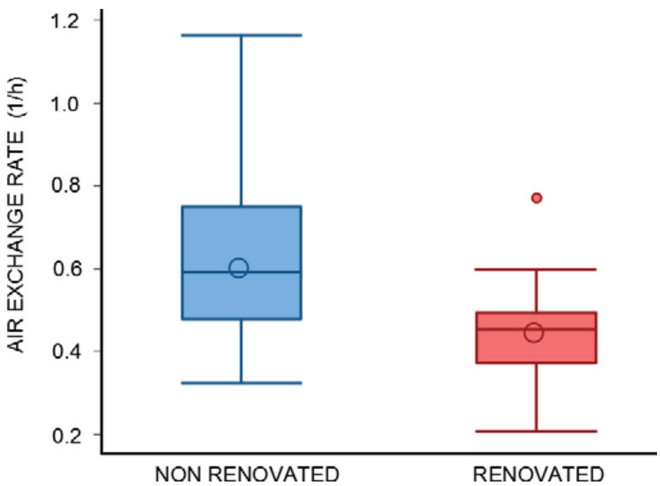


Figure 11. Air exchange rate before and after renovation as a statistical output (Sánka I., Földváry V., Petráš D. (2016); Sánka I., Földváry V., Petráš D. (2017))

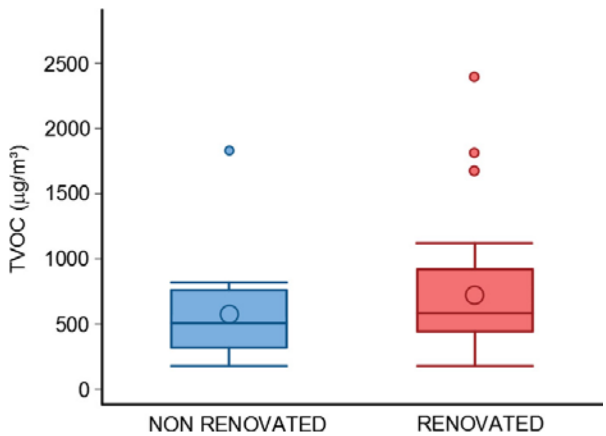


Figure 12. TVOC concentration before and after as a statistical output (Sánka I., Földváry V., (2017))

characterizing the frequency, while the second part contains the duration of the ventilation.

The results indicate that the inhabitants did not change their ventilation habits after the renovation. Most of them ventilated the living room once a day, and the ventilation time was 7.5 min. The occupants ventilated bedrooms daily or almost daily but not every day. After the renovation, the ventilation time slightly increased but not significantly.

The boxplots in **Figure 14** shows the relationship between the duration of the ventilation and the air exchange rate, as well as the relationship between the duration of the ventilation and the acceptability of the indoor air.

The results clearly show a linear relationship between the duration of the ventilation (AER) and the acceptability of the indoor air.

Discussion

Indoor air quality is a dominant contributor to total personal exposure because most people spend a majority of their time indoors (N. Klepeis, W. C. Nelson, W. R. Ott el al. (2001). The findings presented in this measurement campaign support the conclusions of previous studies in Slovakia (Földváry V., Bekö G., Petráš D. (2014)) in which deterioration of indoor air quality follows energy renovations. In this study, the implementation of the energy-saving measures was not combined with measures to improve the indoor environmental quality, which explains the lower AERs and higher CO_2 and TVOC concentrations in the renovated buildings in the winter.

Many international studies have also attributed this phenomenon to the fact that older buildings are leakier and newer ones are more air-tight as a result of improved construction techniques and stricter regulations (Kotol M., Rode C., Clausen G., Nielsen T. R. (2014); Bekö G., Toftum J., Clausen G. (2011)). The limitation of the study is its small sample size. The validation of the results on a larger sample size is warranted. The study is ongoing, and additional results will be available in the near future.

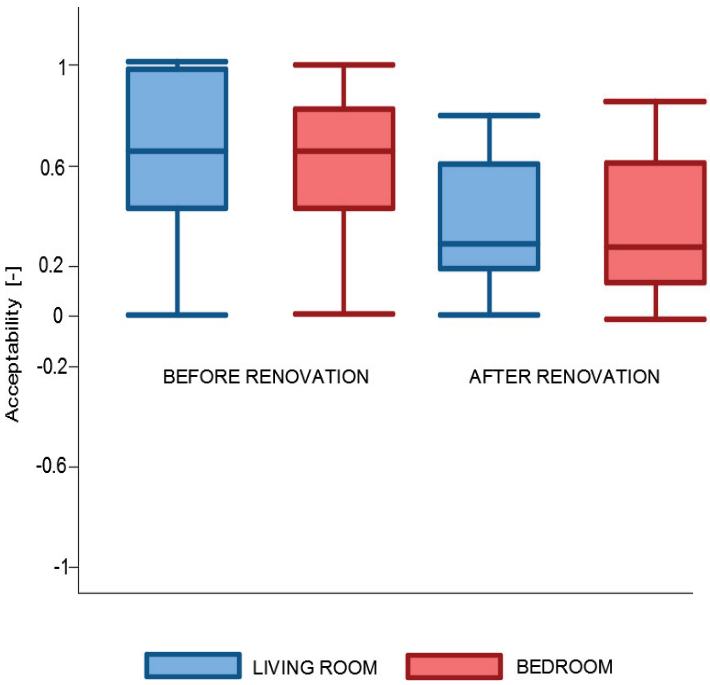


Figure 13. Acceptability of the indoor air as statistical output.

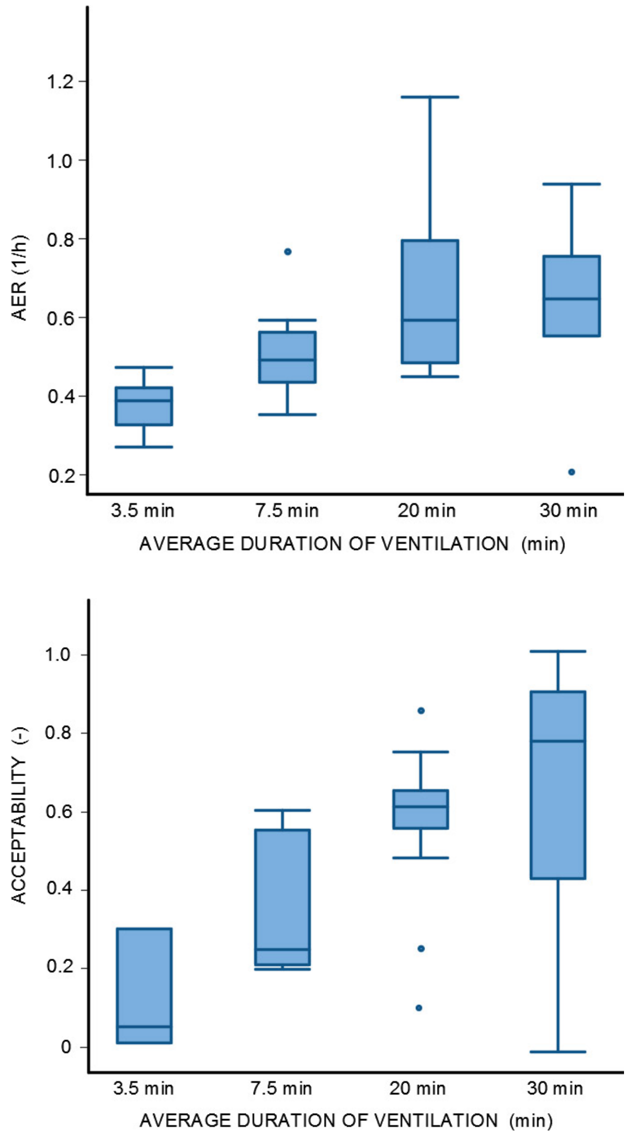


Figure 14. Relation between AER and acceptability.

Conclusion

A key goal of the implementation of an energy renovation strategy is to achieve the improved energy efficiency of buildings. However, the effect of these programs has not been systematically assessed. The effects on indoor air quality and well-being of the occupants is often ignored. There is an urgent need to assess the impact of the currently applied building renovation practices on the residential indoor air quality on a nationwide scale. ■

References

Jurelionis A., Seduikyte L. (2010): Assessment of indoor climate conditions in multifamily buildings in Lithuania before and after renovation. 2nd International conference on Advanced Construction. Kaunas, Lithuania.

Földváry V., Bekö G., Petráš D. (2014): Impact of energy renovation on indoor air quality in multifamily dwellings in Slovakia. Proceedings of Indoor Air 2014, Hong Kong, Paper No. HP0143. Arash Rasooli, Laure Itard, Carlos Infante Ferreira, "Rapid, transient, in-situ determination of wall's thermal transmittance," in Rehva Journal, vol. 5, 2016, pp. 16-20.

Földváry V., Bekö G., Petráš D. (2015): Seasonal variation in indoor environmental quality in non-renovated and renovated multifamily dwellings in Slovakia. Proceedings of Healthy Buildings Europe 2015, Eindhoven, Paper ID 242.

Földváry V. (2016): Assessment of indoor environmental quality in residential buildings before and after renovation. Doctoral thesis. Bratislava, Slovakia.

Bekö G., Földváry V., Langer S., Arrhenius K. (2016): Indoor air quality in a multifamily apartment building before and after energy renovation. Proceedings of the 5th International Conference on Human-Environment System, ICHES 2016 Nagoya, Japan.

Persily A. K. (1997): Evaluating Building IAQ and Ventilation with Indoor Carbon Dioxide. ASHRAE Transactions. 103, Vol. 2.

N. Klepeis, W. C. Nelson, W. R. Ott el al. (2001): The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. Journal of Exposure Analysis and Environmental Epidemiology. 11, pp. 231–252.

Kotol M., Rode C., Clausen G., Nielsen T. R. (2014): Indoor environment in bedrooms in 79 Greenlandic households, Building and Environment, Vol. 81, pp. 29-36.

Bekö G., Toftum J., Clausen G. (2011): Modelling ventilation rates in bedrooms based on building characteristics and occupant behaviour. Building and Environment, Vol 46, pp. 2230-2237.

Sánka I., Földváry V., Petráš D. (2016): Experimentálne meranie CO_2 a intenzity výmeny vzduchu v bytovom dome. (Experimental measurements of CO_2 concentration and air exchange rate in a residential building) TZB-Haustechnik, Vol 25, 5/2016, pp. 46-49.

Sánka I., Földváry V., Petráš D. (2017): Evaluation of Indoor Environment Parameters in a Dwelling Before and After Renovation. Magyar épűletgépészet Vol, 65, pp. 29-33.

Sánka I., Földváry V., (2017): Experimentálne meranie toxických látok vo vnútornom vzduchu pred a po obnove bytového domu. (Experimental measurements of toxic substances in the indoor air before and after renovation) TZB-Haustechnik, Vol 26. 2/2017, pp. 32-35.

Social housing for seniors: best practices on achieving comfortable and energy efficient buildings

PETER BOERENFIJN
Habion & Vastgoed Zorgsector,
De Molen 94, 3995 AX Houten,
e-mail: p.boerenfijn@habion.nl

J. VAN HOOF
Fontys University of Applied Sciences,
Dominee Theodor Fliednerstraat 2,
5631 BN Eindhoven, The Netherlands

Between 2010 and 2015, housing providers in Europe have invested more than €32.8 billion in refurbishment projects in the domain of clean energy transition in 1,843,000 dwellings generating a total of over 500,000 full-time jobs, according estimations by Housing Europe. This paper deals with sustainability and clean energy solutions for social housing for older people in the Netherlands.

Generally, Europeans are living longer than ever in history, and by the year 2020 around 25% of the population will be over 65. The increasing group of older people poses great challenges in terms of creating suitable living environments and sustainable housing facilities (van Hoof & Westerlaken, 2013). In the search for sustainable buildings, building services need to become increasingly energy efficient, or contribute to the concept of energy neutral or energy-producing buildings. It is important to see how such strategies take place in practice and contribute to the innovative capacities in the domain of housing.

In the Netherlands, there are over 7 million dwellings of which 2.4 million are owned by social housing associations that are members of Aedes which amounts to 32 percent of the total housing stock. Aedes is the national Dutch organization promoting the interests of social housing associations. Of these 2.4 million dwellings, over 700,000 units provide a home for people aged 65 years and older. Recent market explorations by ABN AMRO bank (2016) have studied the status of the Dutch healthcare real estate in terms of sustainability performance and the related requirements for change and need for financing. The total surface area of real estate in long-term care is about 22 million m². As this surface area is vast, the bank advises to focus on real estate with an average age between 6 and 15 years old. The premises are adequate in terms of user-friendliness and health but do not yet exploit all potential for energy conservation. The bank, also, estimates that about 5 to 10% reduction in CO_2 emissions is possible by a change of behavior of the occupants, for instance, by tuning the need for lighting and heating. The main solutions for energy savings lie in the installation of LED lighting systems (with sensors to detect the presence of people and availability of daylight), solar panels and heat pumps, which comes at a cost of €185 per m².

This leads to a reduction in CO_2 emissions of over 60%. ABN AMRO further estimates that for the total long-term care sector, €900M suffices to make real estate sustainable. The payback time would be less than 10 years.

According to Aedes, a total of 142,000 dwellings in the Netherlands were retrofitted in terms of energy performance between 2010 and 2015. There is an increasing number of dwellings that are being retrofitted over time, a number that has more than trebled over the last 7 years. This trend is reinforced by a sense of urgency amongst national and local politicians that encouraged the creation of a package of energy efficient measures in combination with yielding positive effects on the purchase power of tenants. This means that energy efficiency in the built environment is a significant domain for business for construction companies and building services engineers.

This paper focuses on the domain of social housing for older people, and presents a number of best practices on energy consumption and sustainability from The Netherlands.

Profile of Habion

The Netherlands has a long tradition and history of social housing, providing housing to people with limited financial resources. Habion is a social housing association specialized in housing for older people in need for care and services. The average age of the residents is 80 years. The association is active in 71 Dutch municipalities.

In 2016, Habion owned 5797 housing units for independent living, 66 residential care facilities and 19 nursing homes. These residential care facilities and nursing homes comprised 4847 units in total. The average rent of a dwelling was €575.42, and the overall rental income totaled €73.1M in 2016.

In 2016, Habion witnessed a number of important events, namely a number of transformation projects in which former aged care facilities were transformed into new living communities for older and younger tenants, which still offer amenities for the provision of healthcare but have a different focus. The quality of housing, community and living together prevail over an institutional model of care. This means that old real estate is re-used and retrofitted also in terms of installing new building services throughout the premises. This is part of the sustainability strategy as included in the association's mission statement. The general tendency in the Dutch care sector is that buildings have an average functional lifespan of 30 to 40 years and, thereafter, disposition or demolition takes place due to an increased frailty of the older residents.

Habion and sustainability

Habion has included sustainability in its extended mission statement on the basis of people, planet and profit. For Habion, this means 'building together', 'a minimal use of resources', and 'flexible buildings'. In collaboration with (future) residents, partners in healthcare, other suppliers and the local community, Habion develops and redevelops its real estate portfolio. The re-use of structures and materials is a foundation stone in these processes. Other key words are energy-neutral buildings, circularity ('Habion no longer demolishes buildings, but reinvents them'), and smart technologies.

The average Energy Index – a Dutch index in use since 2015 for social housing associations which influences the level of the rent - of Habion's portfolio is 1.58. A further improvement of this index is foreseen in the future and it is part of the active mission of the association. In the long run, the Energy Index of the portfolio is expected to come down to less than 1.41. Qualitatively, this roughly corresponds to an improvement from Energy Label C, according to the pre-2015 method[1], to Energy Label B. In order to limit hindrance to its occupants, Habion chooses to improve the energy performance of a building at the moment of new construction or renovation. Overall, the measures taken should not only improve the Energy Index and the sustainability of a dwelling itself, but also contribute to the comfort of the tenants and minimizing the cost of living.

Projects of Habion

In 2016, a number of initiatives in the domain of sustainability were commenced, namely:

- All residents received a letter from a supplier of green energy only (*Woonenergie* company). About 2.5% of the tenants applied for this green energy package.
- In various locations, Habion facilitated the establishment of a building lease to install solar panels on roofs of real estate that is part of Habion's portfolio by other parties.

In the previous years, Habion facilities participated in an energy competition.

[1] This Energy Label consisted of only 9 energetic aspects of a dwelling. The new Energy Index encompasses 150 characteristics of a dwelling and provides a more detailed view of a building's energy efficiency.

Figure 1. Solar panels on the roof of De Benring building.

Solar panels

Habion has decided to continue its participation in the 'Zon op Zorg' initiative. Together with the Dutch sustainability organization Urgenda[2], Habion started the initiative Zon Op Zorg (*~Sun on Top of Care*) in order to install solar panels on as many aged care facilities in the Netherlands as possible. Through the help of the joint crowdfunding website www.zonnepanelendelen.nl [3] (*~sharingsolarpanels.nl*), anyone can be a co-owner of a solar panel that is to be installed on top of an existing or new care building. Habion provides its rooftops for the project but it is not involved in the ownership of the panels or the generation or distribution of the electricity. Together with tenants and www.zonnepanelendelen.nl three crowdfunding actions were started to install solar panels onto Habion's rooftops. The interest in society to participate was substantial: in the first project, it took six weeks to receive sufficient funding, in the second about three weeks, and in the third project just over one week. About 1,300 solar panels were installed at three sites: at De Benring in Voorst in 2015 (**Figure 1**), and at De Molenhof in Zwolle and 't Kampje in Loenen aan de Vecht in 2016. About 20% of the investment is funded through a national scheme for stimulating green energy solutions. The total reduction in CO_2 emissions amounts to 127,000 kg per year. With new projects on the way in 8 Habion facilities, the future reduction will be even larger at an estimated magnitude of 549,000 kg per year. The installation of solar panels meant that an additional electrical infrastructure had to be installed by skilled workers (**Figure 2**).

The return on investment, with a term of 16 years, is predicted to be 3.5% on average per year. This is much higher than the current interest rates for Dutch savings accounts which are around 0%. Residents and non-residents can invest in the crowdfunding actions. Residents and people living in a limited radius of the building are giving priority in buying bonds. Grandparents are called upon to invest in solar panels

In case of De Benring, it took 26 days to raise €160,000 (or sell 6400 bonds) among 119 participants for 512 solar panels (type 512 x CSUN 255 Poly, 255 Wp). The minimum investment was €25 per person, with a single 'solar part' producing about 16 kWh of power per year, or €350 per person for a single solar panel. The output is estimated to be 872.3 kWh/kWp and in the first year the panels produce 114 kWh worth of energy. This equals about 33 household's worth of energy.

In case of De Molenhof, 300 panels (type 300 x REC – REC265PE) were installed, and a total of 136 participants raised €100,000 (or purchased a total of 4000 bonds) for the project. The output is estimated to be 886 kWh/kWp and in the first year the panels produce 70 kWh worth of energy.

In case of 't Kampje, 480 panels (type 480 x REC – REC260PE) were installed and a total of 206 participants raised €150,000 (or purchased a total of 6000 bonds) for the project. The output is estimated to be 904.4 kWh/kWp, and in the first year the panels produce 113 kWh worth of energy.

[2] The Dutch Urgenda Foundation aims for a fast transition towards a sustainable society, with a focus on the transition towards a circular economy using only renewable energy. It works on solutions for this transition, including for example the introduction and realization of 'energy neutral' houses and the acceleration of electric mobility. http://www.urgenda.nl/en/

[3] https://www.zonnepanelendelen.nl/project/debenring/project-update/zon-op-zorg-van-start

Figure 2. Installing solar panels in existing building, requires installers to improve electrical infrastructure.

for their grandchildren, for instance, to save money for future studies and tuition fees. Bonds can even be part of the inheritance when passing away. The tenants of the Habion facilities themselves are benefitting from the Zon op Zorg project as well, through the concept of the Green Wall. This wall displays the amount of energy generated and contains plug sockets that can be used free of charge in order to charge the batteries of mobility scooters. The overall services costs can be lowered as some of the energy generated is used to power the lighting in the shared spaces such as corridors. A small amount of the revenues are used to fund activities of residents, preferably so-called 'green activities' and this amount is kept by the manager of the building.

Energy competition

In the Netherlands, costs for care and costs for housing in aged-care facilities used to be part of a single financial government arrangement. In aged-care facilities, older residents are now more often being obliged to pay for their own expenses for housing and, thus, also for the utilities. In 2012, Habion investigated the quality of its portfolio and this analysis showed that the institutional care facilities showed a large potential for energy savings. Habion has formulated goals for sustainability which are based on the strategic starting-points of controlling costs of housing and being economically profitable. Parallel to setting these goals, Habion engaged in dialogues with societal partners in order to engage in concrete sustainable initiatives that would lead to lower costs for energy. In a time of rising rents and pension rates that remain on an equal level, cutting down on energy may be a way to both be environmentally responsible and save on scarce financial resources. In 2012, the energy costs were about 25% of the total costs of housing, or €150 per month. Being able to save about 10 to 20% per month equals an amount of €30, which can be substantial when one´s pension is low.

Therefore, Habion has participated in the so-called Energiestrijd Zorghuizen[4] *(~Energy Battle Care Homes*), together with the aforementioned organiza-

[4] www.Energiestrijd.nl/zorghuizen

tion Urgenda and Meneer de Leeuw *(~Mister Lion)*[5], in order to create awareness among tenants concerning the costs of energy, as well as change people's behavior doing things together and with enthusiasm. The main goals were the reduction of CO_2 emissions, the control of costs for housing and living and increasing comfort and indoor environmental quality. The Energy Battle is a competition between aged care facilities on energy savings. Every year, residents and staff battle from December 21st to March 21st (start and end of the winter season), by monitoring their energy consumption and by finding out who did best in terms of energy savings. Habion stimulated the participation in the Energy Battle because of the goals it set out in terms of sustainability and affordability also by paying half of the participation fees (€2.000). In the winter of 2014–2015, a total of 38 aged care facilities joined the Energy Battle of which six were Habion locations. In mid-2015, these aged care facilities together managed to cut down €200.000 on the utilities bills, which amounts to a 16% cut in energy consumption without sacrificing comfort and without pre-investments. The winner of the battle managed to save a staggering 55% which amounted to €20.000 for 70 residents, or, on the individual level, €286 per resident. Habion and Urgenda calculated that for the 76 care facilities Habion had in its portfolio, over €1M could be saved. For all 1900 long-term care facilities in The Netherlands, annuals savings could between €20M and €40M.

In fact, all participants of the Energy Battle were winners and each one of them managed to save energy and, thus, costs. Some of the successful solutions were the application of a set-back mode for collective heating installation, the reduced use of lighting in shared spaces, separate day and night modes for air handling units and a check of the controls of central heating installations. The most important lessons learnt were that, apart from creating awareness and behavioral change, it was fairly easy to save on energy for heating without sacrificing the perceived thermal comfort. Staff and residents also stated it is 'good fun' to compete with other aged care facilities.

[5] Mister Lion is an Amsterdam-based lab for societal change. Mister Lion organizes local and transnational innovation communities around sustainability issues and has expertise in co-creation and transition management. Mister Lion's work includes interventions in regional development, urban mobility, urban climate mitigation, energy saving, youth employment, international cooperation, refugee shelter, healthcare and civic participation. http://www.meneerdeleeuw.nl/abroad/

Take home messages

Habion shows that real estate, that seems functionally outdated, can still be useful. As the older people in our societies are growing increasingly older, older dwellings are needed from a demographic perspective in order to provide adequate housing. This means providing housing of a scale and size that fits the needs of one's life stage. The crowdfunding actions have demonstrated a substantial willingness in society to invest in green energy partly because of the return on investment. Investors contribute to both financial and societal returns. Many older people participate by buying bonds. This enables them to leave something for their (grand)children: a better world, bonds, and financial revenues. Habion is working hard to achieve an annual reduction in CO_2 emissions of over 1 million kg per year by making its real estate more sustainable. When transforming healthcare real estate, sustainability and energy producing building services technologies should be an integral part of the strategy. Sustainability means business and can be at the basis of collaboration between social housing associations and the building services sector. Chain partnerships can lead to mutual benefits in which real estate for older people and the behaviors of the residents can contribute to the goals set out for a sustainable society. ■

About the Authors:

- Peter Boerenfijn LLM MRE (1963) is CEO of Habion and managing director of Vastgoed Zorgsector in Houten, The Netherlands.
- Joost van Hoof PhD MSc Eur Ing (1980) works with Fontys University of Applied Sciences, Eindhoven, The Netherlands. He is a board member of the Herman Bouma Fund for Gerontechnology Foundation and Vastgoed Zorgsector, and member of the supervisory board of Habion. In 2011, he was awarded the REHVA Young Scientist Award.

References

ABN AMRO (2016) Verduurzamen zorgvastgoed. Yes, you can! ABN AMRO. https://insights.abnamro.nl/2016/11/verduurzamen-zorgvastgoed-van-de-care-sector-is-haalbaar/

van Hoof, J., Westerlaken, A.C. (2013) Indoor environmental criteria for older adults: ageing means business. The REHVA European HVAC Journal 50(3):34-35

Sensor positions – are there good or bad ones?

KANDZIA, C.
Institute of Power Engineering, TU Dresden, 01062 Dresden, Germany

FELSMANN, C.
Institute of Power Engineering, TU Dresden, 01062 Dresden, Germany

GRITZKI, R.
Institute of Power Engineering, TU Dresden, 01062 Dresden, Germany

RÖSLER, M.
Institute of Power Engineering, TU Dresden, 01062 Dresden, Germany

Numerous data of simulation at different climate control concepts in a simplified office room provide information about a useful positioning of a temperature sensor in a room with regard to optimum performance and thermal comfort. The optimum sensor position depends on the installed ventilation system and the temperature-controlled surface.

Keywords: sensor position, energy performance, thermal comfort, coupled simulation, CFD

To operate building energy systems in an efficient way, it is necessary to acquire data of the most important quantities of the building. The more precise these data are, the more accurate the building control can operate.

Latest developments in sensor technology and electronics, together with decreasing prices, offer new opportunities for data acquisition and control of indoor air conditions [EnOcean, 2015]. Unfortunately, there is no uniform indoor air climate in a room which raises the question where the room temperature sensor should be positioned with regard to optimum performance and thermal comfort.

Figure 1 shows the temperature distribution of the wall temperature as well as of the operative temperature. The air temperature shows diff–erences of about 1.5K depending on the position of the working place. This means that the sensor position in a room will have an impact on thermal comfort as well as on energy consumption. Additionally, the type of the sensor as well as the type of the heating/ventilating/air-conditioning systems and the weather conditions are analyzed to make statements about good or bad sensor positions.

In the following numerical simulations should provide information about the influence of the location and type of the sensor, the operation mode of the system (heating/cooling) and the type of ventilation system (mixing, displacement and personal ventilation).

Methodologies and boundary conditions

Various simulations of the room air flow structure in a model room are done under different boundary conditions. The model room (see **Figure 2**) is 8 m long, 3.92 m wide and 2.84 m high.

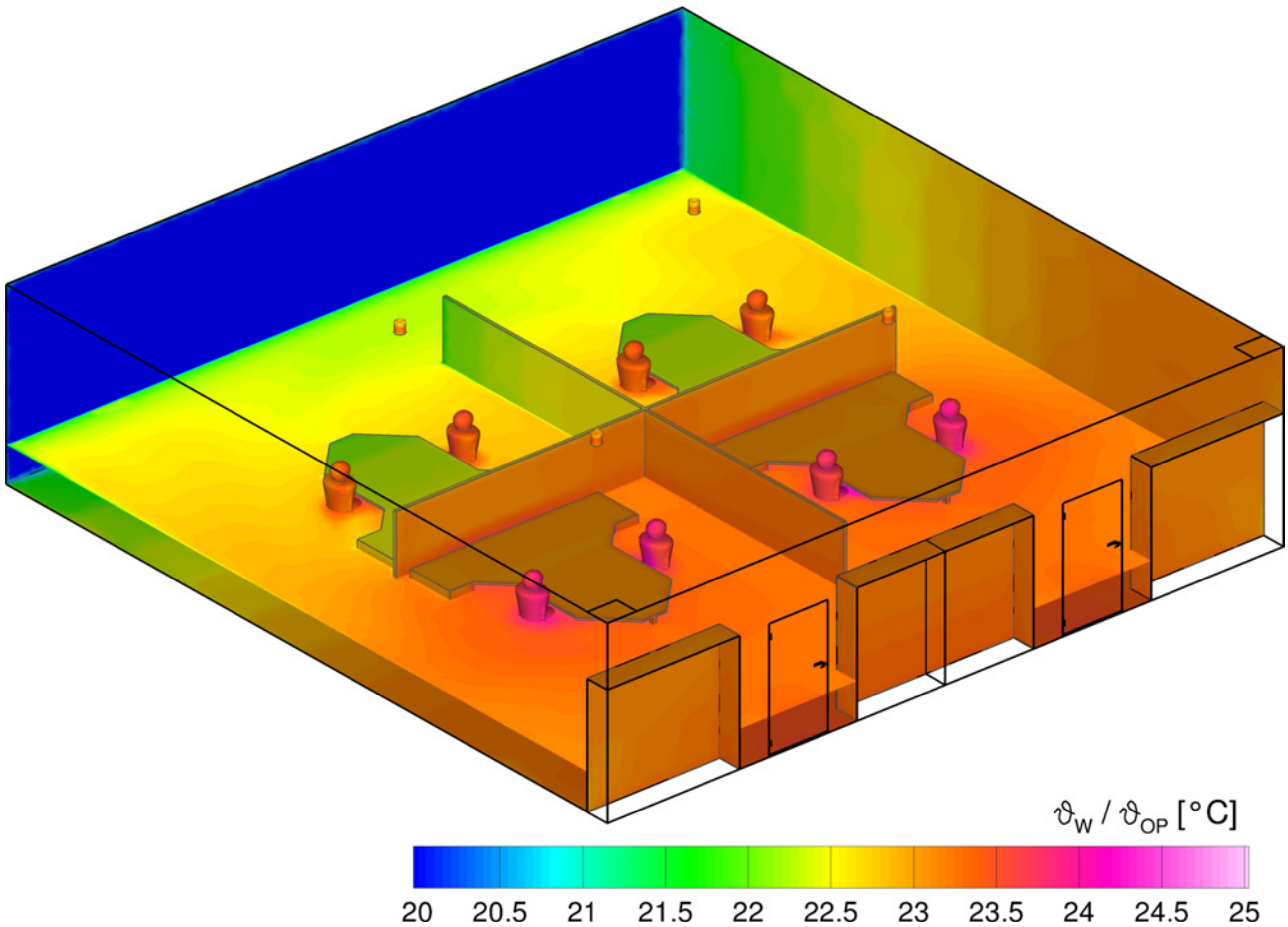


Figure 1. Temperature distribution in an open plan office.

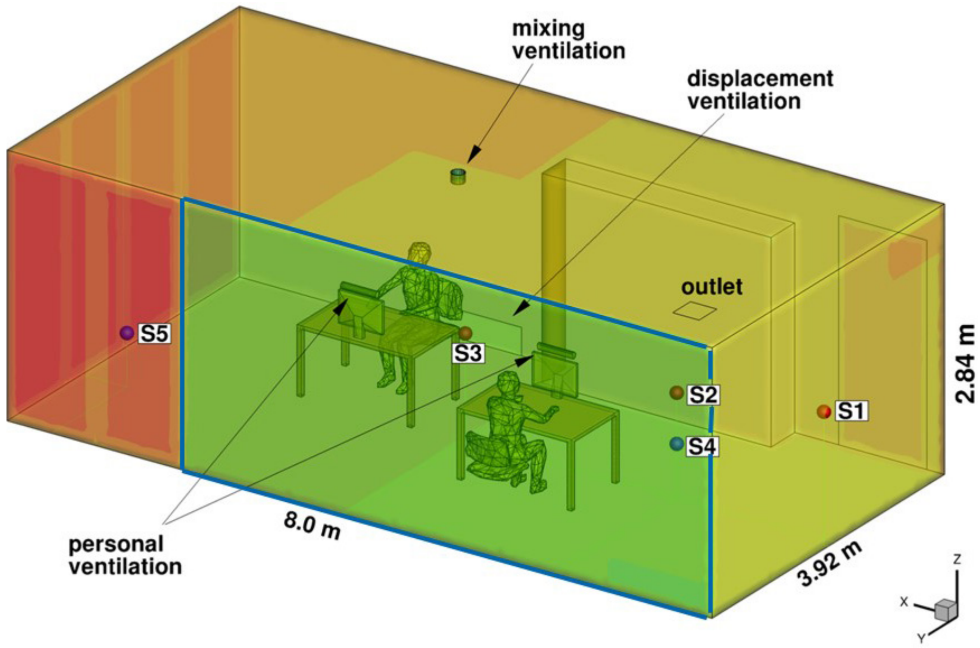


Figure 2. Geometry of the investigated office room with two work places, different sensor positions (in m: S1: x=0.05, y=1.96, z=1.40; S2: x=1.80, y=1.84, z=1.10; S3: x=4.20, y=1.84, z=1.10; S4: x=1.80, y=1.84, z=0.60; S5: x=7.49, y=2.65, z=0.60) and three different types of ventilation systems.

The model room represents a typical situation in an office with two office workers with an occupancy time between 8 am and 6 pm. The wall structures are similar to typical office buildings with the exception of special windows which are used to guarantee the optical access from outside. There are four window segments on the north side of the model room and two window segments on the east side (see **Figure 2**, red surfaces).

Three different ventilation systems (mixing, displacement and personal ventilation) were analyzed in the model room, which are briefly described in the following. In the case of mixing ventilation, a swirl diffuser in the center of the ceiling is used to supply air into the model room. The diffuser of the displacement ventilation is positioned at the bottom zone at one of the both long sides of the model room. The diffuser is 1.2 m wide and 0.3 m high. In the case of personal ventilation, the diffusers were installed directly above the monitors. All systems are mainly used for the ventilation, not for cooling of the office. As shown in **Figure 2**, the position of the outlet diffuser is in the right corner of the ceiling. This is the case for all ventilation situations.

In addition, **Figure 2** shows the position of the five temperature sensors which are integrated into the model room. All five sensors are used to acquire the air temperature, the operative temperature and the predicted mean vote according to EN ISO 7730 (2005). Sensor S1 is used to control either the operative temperature or the air temperature. Sensor S2, S3 and S4 are used to control the operative temperature.

In order to consider all relevant phenomena and influencing factors, such as climatic conditions, wall and window constructions, sensor positions, air inlet types, positions and numerical simulations were performed as coupled transient calculations of both, a dynamic building, system simulation and a Computational Fluid Dynamics (CFD) simulation [Lube et al. 2008].

Numerical simulations are done for the heating mode as well as for the cooling mode. The ceiling and one of the wall surfaces were taken into account. The wall surface surrounded with a blue frame in **Figure 2**. The cooling capacity is 1.6 kW, the heating capacity ranges up to 1.5 kW.

The weather conditions for the cooling mode represent a period of hot summer days with temperatures up to 33°C. In case of the heating period, the ambient temperature is set to a constant value of –5.0°C. The window is equipped with an intelligent shading system, which avoids 90% of the direct solar radiation.

Two surface areas and three different ventilation systems, which are analyzed for the heating as well as the cooling mode in each case, result in a number of 30 simulations. The simulation model has been validated by measurements in a climate chamber of the same dimensions by the Institute of Air Handling and Refrigeration (ILK) Dresden, Germany [Kandzia et al. 2015].

Results

In all cases and for all sensor positions the criteria of the thermal comfort fulfill the demands of category A, given in EN ISO 7730. Thermal comfort for a room can be selected from three categories. In the case of category A, the predicted mean (PMV) vote should have a value between –0.2 and +0.2.

Figure 3 gives an overview about the best possible option of the difference of daily energy demand between two different sensor positions. The energy demand of the heating and cooling surfaces is summed up for 24 h sections for every simulation run. In the case of the wall as temperature controlled surface, the differences of the daily energy performance depending on the sensor position are much higher in the cooling mode. The difference between the sensor positions reaches more than 20% in the case of displacement ventilation. But contrary to heating mode, the optimum sensor position is always S4. In heating mode, it is not possible to define an optimum sensor position that fits for all three types of ventilation. In case of displacement ventilation, the lower position of sensor S4 is beneficial.

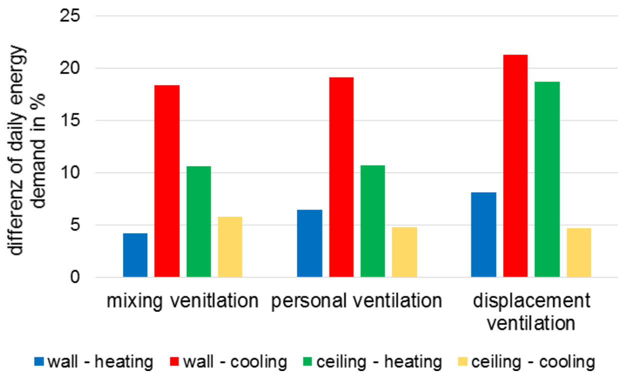


Figure 3. Comparison of possible energy savings depending on the ventilation systems as well as on heating or cooling mode.

Some savings arise in all situations by measuring operative temperature instead of air temperature. In the case of the ceiling as temperature-controlled surface, the possible energy savings are higher in the heating mode.

In no case neither the sensor position S1 nor S5 is the optimum position. Both sensors are located outside of the occupied zone. Hence, they were exposed neither the influence of the temperature controlled surface nor the different ventilation system. They respond much slower to changes in the room and this affects adversely to the energy savings.

Conclusions and outlook

In the specific example examined here, it makes sense to position the sensor as low as possible in the room in the case of the wall as temperature-controlled surface. However, in the case of the ceiling as temperature-controlled surface the sensor should be positioned close to the ceiling. In the cooling mode, it is possible to define sensor S2 as optimum sensor position, but, it is not possible to specify an optimum sensor position in the heating mode. **Table 1** gives an overview about the optimum sensor position depending on the cooling concept.

Sensor S2 as well as sensor S4 are not located in the occupied zone. This means that the permissible temperature at these positions is reached later than in the occupied zone. This effect causes a higher temperature level in the whole room. Consequentially, sensor S4 has the optimum position in the cooling mode by using the wall as temperature-controlled surface. ■

Table 1. Optimum sensor position.

	wall		ceiling	
	heating	cooling	heating	cooling
mixing ventilation	S2	S4	S2	S2
personal ventilation	S2	S4	S3	S2
displacement ventilation	S4	S4	S2	S2

Acknowledgement

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References

EN ISO 7730 (2005) Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria.

EnOcean, (2015) EnOcean Alliance: https://www.enocean.com/en/enocean-wireless-standard/.

Kandzia, C., Gritzki, R., Felsmann, C., Stubbe, D. (2015). Auswirkungen der Sensorpositionen in einem Raum auf den Heiz- und Kühlenergiebedarf und die thermische Behaglichkeit. München / DIV (2015) Gebäudetechnik, Innenraumklima : GI, Volume: 135, Page(s): 368-381.

Lube G, Knopp T, Rapin G, Gritzki R, Rösler M (2008). Stabilized finite element methods to predict ventilation efficiency and thermal comfort in buildings, Int. Journal for Numerical Methods in Fluids, Volume 57, Issue 9, pp. 1269–1290.

Perschk, A (2010). Gebäude- und Anlagensimulation – „Ein Dresdner Modell". GI Gesundheitsingenieur / Haustechnik / Bauphysik / Umwelttechnik, Bd. 131, Nr.4.

Wireless Technology in Demand Controlled Ventilation (DCV) Systems

What are the pros and cons using wireless technology compared to traditional wired solutions in DCV-systems? How does it work?

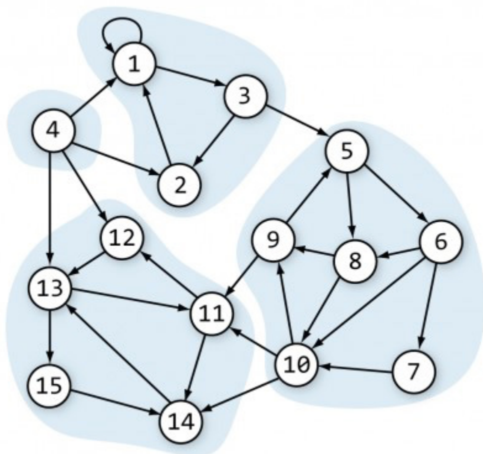
Keywords: Demand Controlled Ventilation, DCV-systems, Wireless Communication, Internet of Things, IoT

JAN RISÉN
System Develop Director
SWEGON
jan.risen@swegon.se

DCV-system, design and function

DCV-systems have been around since the beginning of 2000 and we can now see a growing number of companies offering this type of systems. The basic function of such a system is to optimize the room climate by using a minimum of energy to meet the requirements set. To reach a high performance level a DCV-system controls both room functions and the supporting systems like AHU:s and Chillers. Today's DCV-systems are not only handling ventilation but also heating and cooling of the building, so, the correct naming should be Indoor Climate Systems (ICS).

The communication between the components has been based on traditional wired technology and Modbus is the predominant protocol.



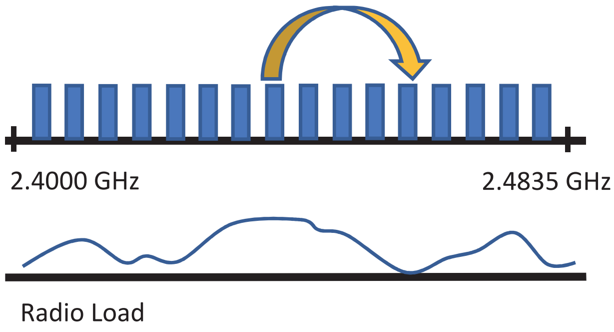
Meshed Radio Network.

Wireless Technology

The only global licence free radio band is the 2,4 GHz and it is, therefore, used by a great number of applications like Mobile Phones, WLAN, Computer Accessories, Microwaves etc. Hence, it can be very crowded in the 2,4 GHz band (2,400–2,4835 GHz). To secure a stabile communication, several techniques can be used and two of the most important ones are Meshing and Frequency Shift.

A mesh network is a network topology in which each node relays data for the network. This means that even if one node is out of service the data will be transferred to all other nodes.

The 2,4 GHz band can be divided into several sub bands and the normal frequency shift strategy is to shift to the next band when the currently used band is crowded. This is not the optimal strategy since the next band not necessarily is less crowded. By using an advanced algorithm, you can utilize less crowded frequencies and, by that, achieving a secure and fast communication. The conclusion is that the winning



Frequency Shift.

Torsplan.

strategy is to shift to the best band (least crowded) and not to the next one.

When talking about wireless technology, the security topic is brought up. A modern wireless system used for DCV-systems must be equipped with encrypted communication to secure a safe function. Advanced Encryption Standard, AES, is a proven solution and often is a 128-bit key used. To crack this encryption with a super computer you need one billion years. An interesting thing to take into consideration is that a wired system is seldom encrypted at all.

Wired vs Wireless Technology

Applying modern wireless technology will generate several advantages compared to traditional wired solutions. The experience from wired systems is that a big part of the problems is related to the installation and commissioning of the network. Finding mistakes in the wiring is, often, quite time consuming.

Another drawback with a wired system is that it limits the flexibility once the installation is completed. All changes in the disposition of the building is generating rework of the wiring and related costs. A typical case is creating additional meeting rooms by merging several small office rooms together. The adaption of a wireless system to this new situation is done by digital reconfiguration of the existing installation, no physical change of the installation is needed.

Torsplan

This is an office building in the centre of Stockholm Sweden, total area 20 000 m². The DCV system is based on 2000 radio nodes linking the VAV dampers and sensors to 20 air handling units. ■

Air distribution in indoor ice skating rinks



DARIA DENISIKHINA
ABOK member
PhD, LEED AP BD+C, Associate Professor of Saint Petersburg State University of Architecture and Civil Engineering, St.-Petersburg, Russia
Deputy Director, MM-Technologies Ltd, St.-Petersburg, Russia
denisikhina@mm-technologies.ru

MIKHAIL SAMOLETOV
ABOK member
Executive Director
MM-Technologies Ltd, St.-Petersburg, Russia
samoletov@mm-technologies.ru

MARIANNA BRODACH
Vice-President ABOK
Professor of Moscow Architectural Institute (State Academy), Moscow, Russia

Designing of indoor ice arenas ventilation and air conditioning systems is considered to be a rather complicated issue due to the necessity to maintain considerably varying air parameters in the zone of ice rink and in spectators' zone. Conventional and simplified engineering techniques normally fail to yield adequate values.

Keywords: Indoor ice rinks, CFD, numerical simulation, air distribution, convective-radiative heat exchange.

Designing ice rinks

Heating, ventilating, and air conditioning (HVAC) are among the most energy consumption systems in civil engineering.

Due to the increased need to control the consumption of energy resources reduce negative impacts on the environment, at present, particular attention has been paid to designing "green buildings". HVAC systems are extremely necessary, not only to reduce electricity consumption, but also to make sure that the designed systems, in practice, are able to provide a comfortable environment for human and/or technological requirements for the project, otherwise, we cannot speak about the efficient use of energy resources. Thus, if we develop energy efficient buildings, it is necessary first to analyse the adequacy and quality of engineering solutions which are incorporated in the design.

Modern sports facilities using artificial ice rinks are the structures with very sophisticated technical and high-power consuming engineering solutions. Designation of refrigeration, ventilation and air conditioning systems consist of maintaining the required temperature level of ice rink as well as air temperature and humidity within the space of ice arena bowl. One of the basic designing problems of the ice arena air distribution and conditioning system is the need to maintain different parameters of air in the zone of ice rink (defined by ice surface requirements) and parameters of air in spectators' area.

Tribunes full of spectators generate free-convective warm air flows which could be strong enough to determine air circulation pattern throughout the entire arena bowl space. This creates a hazard of warm and moist air transition towards ice rink space which is inadmissible (ice melting may cause ice surface warping and fog generation above the rink surface).

The design of ice arena air distribution system should take into account interaction of air flows generated by supply air devices and convective air flows generated by spectators. Taking into consideration a very complex character of air flow generated in arena space, to select zones of influence and behaviour of the above-mentioned flows is becoming rather difficult. Besides, the presence of artificial ice lead to necessity take into account the radial component on a considerable part of surfaces participating in heat exchange process (ice, roofing, walls surfaces).

In such case, the designer may encounter deficit of information and techniques enabling him to find proper technical solutions while simplified engineering techniques are no longer yielding adequate values. As a result, it appears that requirements to ice arena air parameters are generally considered in design calculations but not in actual conditions of facilities operation.

The foregoing features generate a need to make use of computational fluid dynamics (CFD) methods based on numerical solution of differential conservation equations, namely, three-dimensional Navier-Stokes equations.

At the same time, numerical simulation of air distribution in indoor ice rinks is an uncommon task demanding in-depth analysis of mathematic model used.

Setting the mathematic model demands consideration of a number of specific features, like assignment of boundary conditions characterizing heat gains by arena bowl and necessity to consider radiative heat exchange.

Below there is a simulation of air flow behaviour formed in the volume of Sochi "Iceberg Arena" (erected for 2014 Olympic Games) by the designed air distribution systems.

The CFD software STAR-CCM+ based on numerical solution of tri-dimensional differential conservation equations has been selected as a research tool.

Radiative heat exchange in indoor ice rink

Radiative component of heat exchange in roofed buildings with artificial ice is a considerable factor. This is due to intermitting radiation in "ice-roof-walls" system. It is necessary to bear in mind that, not only interior surfaces of arena structures may be the source of radiation, but spectators as well. The latter factor should be taken into account in mathematic model.

Assignment of heat generated from spectators.
Correlation between spectators' sensible heat input radiant and convective components within ambient temperature range from 10°C to 26°C is approximately 50% by 50%. Assuming that sensible heat is transferred from spectators to the premise only with convective constituent is leading to overestimation of velocities in free-convective flow above spectators and, as a result, to improper air circulation in the entire volume of arena.

Separate accounting of short-wave and long-wave components outgoing from lighting fixtures.
To illuminate the ice rinks the ice arenas normally employ illumination devices providing angular concentration of light by means of lamps light redistribution inside small solid angles achieved by the use of illumination fixtures reflectors and lenses. Different types of illumination devices are used: based on incandescent lamps (halogen), gas-discharge lamps (metal-halogen lamps, sodium vapour lamp), light diode lamps.

Figure 1. "Iceberg Arena". Sochi. Russia.

Radiation of illumination fixtures, unlike human's radiation, is taking place within visible (λ=380 – 780 nm) and short-wave constituent of infrared (λ = 0.74 – 2.5 µm) radiation range and not within long-wave infrared range (λ = 50 – 2000 µm).

In the mathematical model, it is required to make separate account for narrow-directional high-frequency radiation of lighting fixture (directed to ice surface) and omnidirectional low-frequency radiation emitted by lighting fixtures heated surfaces (including fixtures casings).

Light output value, specified in product documentation, does not contain data regarding amount of power falling on illuminated surface outside the visible range. However, considerable part of illumination fixture radiation power pertains to high-frequency infrared radiation.

While numerical simulation of flow in ice arena bowls it is required to exactly know total amount of energy falling onto illuminated surface.

Illumination fixture surface will emit (by convection and radiation of infrared range low-frequency part) heat. The higher the air velocity is in the zone of illumination fixture installed in the ice rink, the more heat will be withdrawn by convection towards the upper area of premise volume.

Task definition. Object characteristic

"Iceberg" ice arena capacity is 12.000 spectators.

- In order to maintain design requirements regarding thermal and humidity air parameters in "Iceberg Arena" air supply is foreseen:
- via circumferentially located jet nozzle diffusers located 22 meters above the ice rink;
- via swirl diffusers circumferentially located by arena perimeter at 27.8 meters height (first circle);
- via supply grills located by arena perimeter at 12.2 meters height (second circle);
- via grills made in building structures and located under spectators' seats located by arena perimeter (air supply towards under-tribune space) at heights 0.65 – 3.80 m (third circle);

Air is extracted via grilles circumferentially located 32 m above the ice rink with flow rate L_{total} = 48 000 m³/h and via grilles located by arena perimeter above spectator seat rows at height 25.4 m with L_{total} = 450 000 m³/h.

Location of air distribution devices is shown in **Figure 2**.

Parameters of ice arena supply air are listed in **Table 1**.

Table 1. Supply air parameters.

Description	q_{total} [m³/s]	T [°C]	x [g/kg]
Nozzles directed toward ice rink	42 700	18	4
Diffusers (first circle)	82 200	16	4
Grilles (second circle)	283 300	16	4
Grilles (third circle)	19 200	16	4
Grilles in tribunes (third circle)	65 300	18	4

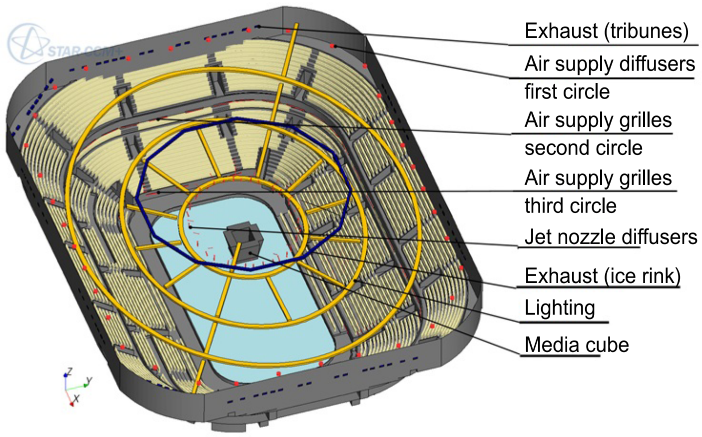


Figure 2. Equipment location.

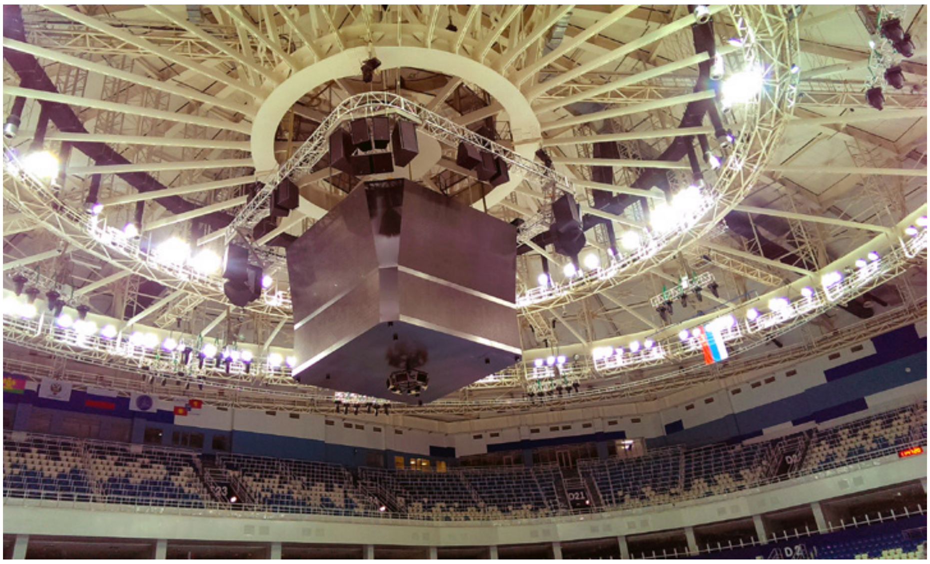


Figure 3. "Iceberg Arena". Sochi. Russia.

For the simulation purpose, we built-up a finite volume computation mesh consists of 14 million cells. Specific attention was paid to mesh resolution in zone of flows delivered via nozzles and diffusers and to computation mesh quality near ice and roofing surfaces.

Simulation results

Simulation results show that originally designed delivery of 18°C air towards ice rink creates excessive air motion in the zone of ice surface disturbing the "cold bedding" which should be provided above ice surface (Figure 4a) and, thus, preventing formation of

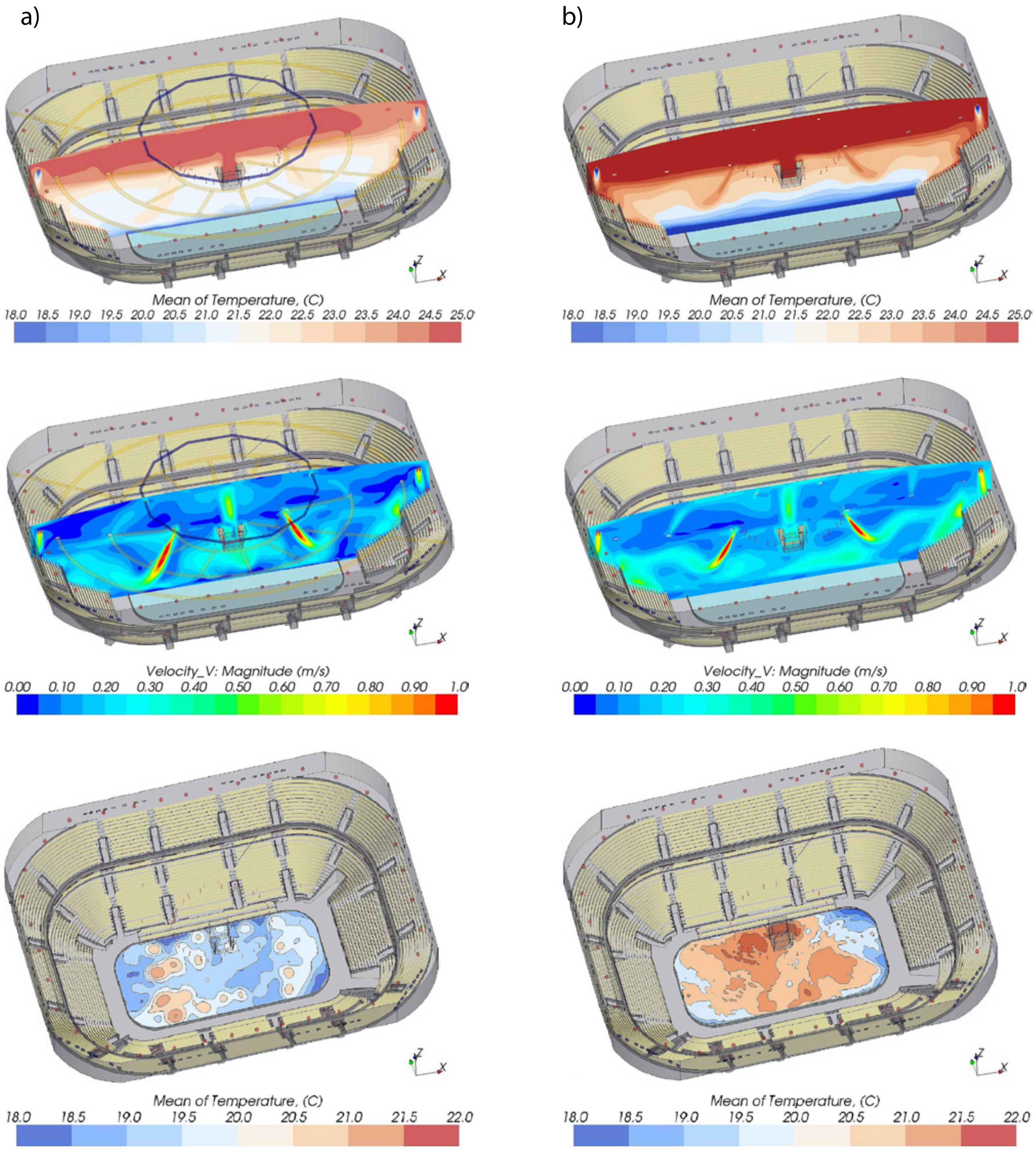


Figure 4. Temperature and velocity field: a) Original design, b) Improved design.

design-required air parameters above the ice surface. In flow distribution areas at 1 meter above the ice surface it is possible to view areas with excessive (up to 21°C) temperatures (**Figure 4a**).

Error in the design solution under consideration took place due to omission of the fact that ice arenas have considerable non-isothermally of air throughout the premise height. Thus, air temperature near ice surface is normally within 12°C – 15°C (depending on the sport event) and it may reach 24°C – 26°C as measured in the top part of the premise. In view of the above, we can conclude that 18°C air delivered via air jet nozzles can be treated as "cold" (being accelerated relatively to isothermal flow), while approaching the ice surface it may be treated as "warm" (it begins to come up). That complicated behaviour of inflow is not correctly described by equipment selection program which takes into account nozzles output temperature and air temperature in the proximity to ice surface. In such case long-range capability of supply air is considered to be much lower than it is in reality. The latter reason caused, as verified by numerical simulation results, ingress of warm air (drawn-up by supply air) to ice rink zone and, as a result, considerable increase of air temperature in the said area.

To improve the design solution, it was proposed to increase supply air nozzles temperature from 18°C to 23°C.

Calculations results show that in the latter case flows delivered by the nozzles are not reaching the ice rink surface and the "cold bedding" is no longer disturbed (**Figure 4b**). Temperature 1 meter above the ice surface is falling from 20°C to 15°C (**Figure 4b**).

Improvement of design decision enabled the operators to avoid (during further exploitation of arena) ice melting, ice surface warping and fog generation above the ice surface.

Physical experiment

Physical experiment was performed in "Iceberg Arena" bowl without spectators and players, with ventilation and air conditioning systems operating and illumination system operating. Measurements were performed for a series of points located in different levels throughout arena height. Correlation of results of physical and numerical experiment performed for identical boundary conditions is shown in **Figure 6.**

As seen from above figures, data variation in physical and numerical experiments in temperature fields amounts to less than 5% and less than 10% in moisture content fields. Accuracy of ventilation and air conditioning system flow rates adjustment is normally around 10%, therefore, there is no need to obtain more accurate calculations since accuracy of boundary conditions assignment is approximately 10%. Therefore, accuracy of mathematic model is sufficient for analysis of ice arenas air distribution designs.

Conclusion

Radiative component of heat exchange in indoor ice rink is considerable and it should be taken into account in the mathematic model.

Figure 5. "Iceberg Arena". Sochi. Russia. Physical experiment.

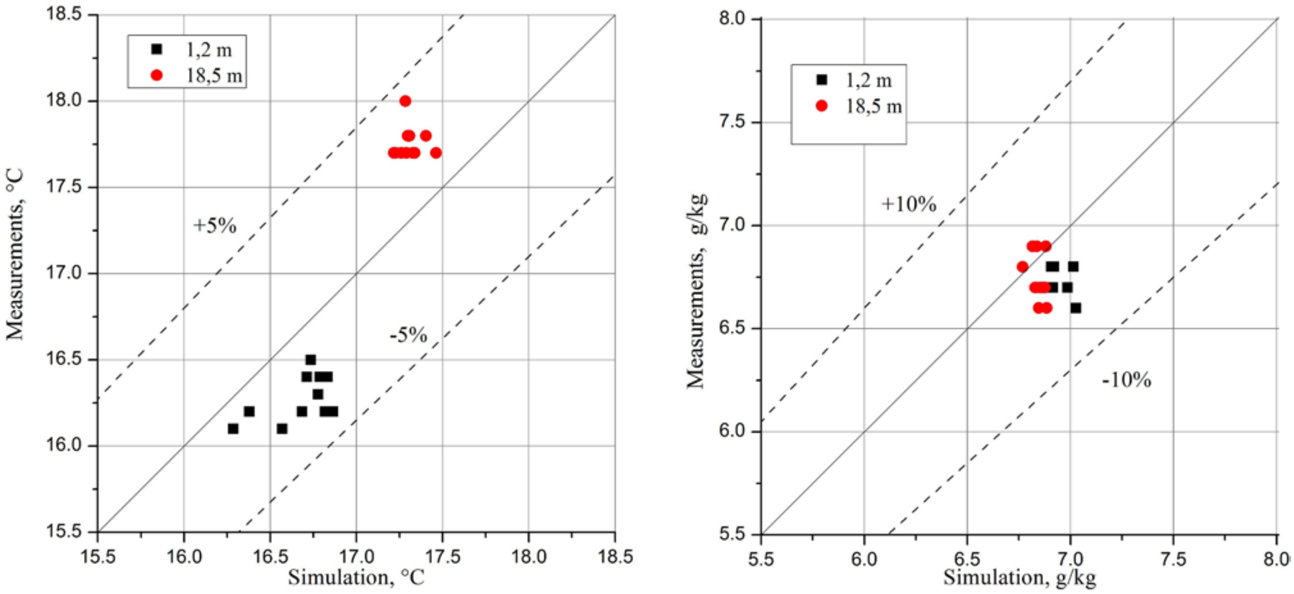


Figure 6. Correlation of numerical simulation and physical experiment results.

Assignment of sensible heat inputs outgoing from spectators only via convective component may lead (due to considerable increased values of free-convective flow velocities) to improper air circulation in the entire volume of ice arena bowl.

Heat flows from heated surfaces of illumination fixtures should be modelled with account to separation into radiative and convective components.

Applying of numerical simulation methods to analyse air distribution in Sochi "Iceberg Arena" enabled the researchers to reveal defects of original design and, therefore, prevented the implementation in the design of an ineffective solution.

Correlation of results of numerical simulation (performed with no spectators inside arena) with physical experiments results gave 4% – 7% calculation mismatch. ■

References

ASHRAE Handbook. Refrigeration. Chapter 44. Ice Rinks (2014) ASHRAE, 314 p.

Nielsen, P.V., Allard, F., Awbi, H.B., Davidson, L. and Schälin. A. Computational fluid dynamics in ventilation design (2007) REHVA Guide Book 10. RHEVA, 104 p.

Bellache, O.; Galanis, N.; Ouzzane, M.; Sunyé, R.; Giguère, D. Two-Dimensional Transient Model of Airflow and Heat Transfer in Ice Rinks (2006) ASHRAE Transactions, vol. 112 (2), pp. 706-716.

Bellache, O., Ouzzane, M., Galanis, N. Numerical prediction of ventilation patterns and thermal processes in ice rinks (2005) Building and Environment, vol. 40, pp. 417-426.

Lestinen, S., Koskela, H., Nyyssölä, H., Sundman, T. L., Laine, T., Siikonen, T. CFD-Simulation and Measurement of Indoor Environment in a Multipurpose Arena (2012) Proc. 10th International Conference on Industrial Ventilation, Paris, France.

Yang, C., Demokritou, P., Chen, Q., Spengler, J. Experimental Validation of a Computational Fluid Dynamics Model for IAQ applications in Ice Rink Arenas (2001) Indoor Air, vol. 11 (2), pp. 120-126.

Stobiecka, A., Lipska, B., Koper, P. Comparison of air distribution systems in ice rink arena ventilation (2013) Science - Future of Lithuania, vol. 5(4), pp. 429-434.

Demokritou, P., Chen, Q., Yang, C., and Spengler, J. The impact of ventilation on air quality in indoor ice rink arenas (2000) Proc. of Healthy Buildings, vol. 2, pp. 407-412, Espoo, Finland.

Yang, C., Demokritou, P., Chen, Q., Spengler, J.D., Parsons, A. Ventilation and air quality in indoor ice skating arenas (2000) ASHRAE Transactions, vol. 106(2), pp. 338-346.

A new technology for airflow and temperature measurement without pressure loss in ventilation systems

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Evaluation of evaporative cooling of walls in hot climates

BURHAN YORUK
Istanbul Technical University,
Istanbul, Turkey
byoruk@itu.edu.tr

AHMET ARISOY
Istanbul Technical University,
Istanbul, Turkey

When a cooling based climate is considered, evaporative cooling of outer walls during summer can be a very valuable tool for reducing cooling energy from outer skin of the buildings. Simulation results show that applying an evaporative layer on the inner surfaces of the outer walls is more successful than the thermal insulation in Mediterranean climate.

Keywords: Energy efficient buildings, Evaporative cooling of walls, Mediterranean Climate

When a cooling based climate is considered, evaporative cooling of outer walls during summer can be a very valuable tool for reducing cooling energy from outer skin of the buildings. There are some solutions in the literature based on this principle. However, applying such an evaporative layer on the inner surfaces of the outer walls is a novel approach. At this stage only the idea has been evaluated.

A case study, in which the target is reducing cooling energy (heat gains) from outer walls for energy conservation has been conducted. Cooling inner surfaces of the outer walls reduces heat gain from the outer walls and more importantly increases the thermal comfort indoors in summer conditions by decreasing the wall temperatures.

Simulation results show that this system is more successful comparing to the thermal insulation in Mediterranean climate. Depending on the design parameters the peak heat gain through the outer walls can be compensated by the system without any additional insulation layer. Even in some favourable conditions an additional cooling effect can be achieved besides avoiding heat gains from outer walls.

Introduction

The definition of energy efficiency measures and packages are strictly related to the climate, considering both temperature and humidity. Therefore, for hot and dry regions, specific solutions are certainly required. In particular, Mediterranean climate is characterized by a dominant cooling demand and varying outdoor conditions along the day.

Behaviour of outer walls plays an important role on heat gains and heat losses of the building. Thermal insulation of walls is known as an important measure to reduce static heat loss of buildings for cold and mild climates. However, increasing thermal insulation thickness plays a reverse effect on heat gains due to dynamically changing outdoor conditions for hot climates [1]. Instead of increasing thermal insulation thickness, evaporative cooling of outer walls can be used reducing cooling energy from outer skin of a building in such climates.

An evaporative layer to be applied on the inner surfaces of outer walls has been designed to reduce the cooling energy of buildings in Mediterranean region in this study. This can be considered as a new approach.

This work presents a case study. A building in Mediterranean region has been considered as an air conditioning system that keeps indoor temperatures at the required level. The target is reducing cooling energy (heat gains) from outer walls for energy conservation. The proposed heat absorbing layer basically consists of two plates with a gap between them and it is applied on the inner side of the outer walls. Indoor air passes through this gap from bottom to top, across all the length of the wall. Back plate is actually a moist pad and evaporation of water from this pad creates a cooled wall surface. Cooling inner surfaces of the outer walls reduces heat gain from the outer walls and, more importantly, increases the thermal comfort indoors in summer conditions.

A dynamic computer model has been developed to simulate the system. This model can consider the effects of thermal mass of the wall too.

It is shown that this system is successful in Mediterranean climate. Depending on the design parameters, the heat gain through the outer walls can be compensated by the system without any additional insulation layer. Even in some favourable conditions an additional cooling can be achieved. This layer is also effective during the winter conditions. In winter season, the layer is used in dry state and it reduces the heat loses.

Methodology

A standard building in Izmir-Turkey is considered as the reference case in this study. Izmir is selected as the representative of the Mediterranean climate. The building is a two storey residential house with 512 m² total floor area. Total outer wall area is 314 m² and only 211 m² of this wall can be covered by the proposed layer. Density of 5 cm thick concrete external walls is 1,600 kg/m³. Thermal mass is an important parameter effecting on thermal performance of the building skin and this value has been parametrically studied in this paper. 5 cm thick thermal insulation is necessary, in this case, to remain within the limits of the standard. All other external and internal heat gains/losses have not been taken into consideration in this study.

It is assumed that there is an ideal HVAC system which controls indoor temperatures ideally. Cooling set point temperature is 24°C for summer period. Heating set point temperature is 21°C during the winter period. Total ventilation air rate is 1,013 m³/h which corresponds to 0.66 air change per hour.

Evaporative cooling layer modules

This approach is based on a modular evaporative layer to be applied on the inner surface of the outer walls. This layer is to be attached to the wall surfaces tightly by screws and it should be leak-proof. The drawing of a module is seen in (**Figure 1**). These modules can be connected to each other and all the outer wall inner surfaces can be covered with these elements. Frame of the module is steel and the panels of the module can be either plastic or sheet steel. There is a porous pad attached to the back-side panel of the module, there is a gap for air flow between this pad and the front side panel of the module. The pad is made of synthetic fibers and it is wetted by the water dripping nozzles at the top. Gap dimensions and air flow rate have been defined by the help of the developed computer program. Room air is introduced to the gap from bottom of the module and this air picks up the evaporated water from wetted pad. Collected moist air at the top of the gap is exhausted to the outdoor by the help of a fan. This air circulation system can also be part of the mechanical ventilation system of the building. In this system, no moist air is introduced in indoors.

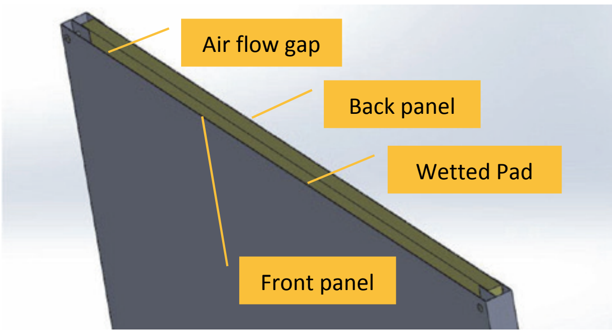


Figure 1. Drawing of the designed evaporative module.

Performance of the modules for the sample building

Two different cases have been studied as wetted pad in summer and dry pad in winter to evaluate the year-round performance of the proposed layer. Hourly temperature and humidity variations and the resultant heat gain/loss values have been solved for these cases. Using the model results, optimized dimensions, air flow rates and water feeding rates have been determined. Effects of wall thermal inertia have been investigated, performance of the proposed system have been evaluated.

The optimized air flow gap/clearance is 0.01 m and optimized air flow velocity is 0.8 m/s. Indoor air temperature (and the air temperature at the entrance of the layer) is 24°C and the humidity ratio of air is 0.0093 kg/kg for summer season. This humidity ratio corresponds to 50% relative humidity. Indoor air temperature (and the air temperature at the entrance of the layer) is 21°C and the humidity ratio of air is 0.0078 kg/kg for winter season. Hourly changing outdoor temperature and solar radiations on the outer surfaces of the wall in each direction have been considered as boundary conditions. Hourly weather data of the typical year has been taken from International Weather for Energy Calculations Database [2].

Evaporative layer performance: case a) wet layer in summer

In Case A, the pad is kept wet by supplying water from top. With the help of evaporation, inside wall surface temperatures can be kept below the room temperature. In these conditions, besides preventing heat gain from outer walls, an additional cooling effect is seen. A heat loss occurs from indoor air. Low inner surface temperatures also help improving comfort conditions due to radiative heat transfer between cooled wall and the human body. Mean leaving air temperature at the middle of the wall for the first week of July in a typical year is 25.3°C which is very close to the room air. Meanwhile, specific humidity increases from 9.3 g/kg to 17.6 g/kg in exhaust air. Leaving air specific humidity corresponds to approximately 70% relative humidity value. This humid and cool air can be used in a conventional heat recovery unit to reduce the temperature of incoming hot ventilation air.

Heat gains through cooling months are given in **Table 1**. Negative values indicate heat loss (additional cooling) and positive values indicate heat gain. Besides preventing heat gains from outer walls, additional cooling created by the evaporative layer along five cooling months, is 16,294 kWh. However, without applying this evaporative layer, total heat gain from same bare walls was 43,925 kWh. Thermal insulation can reduce the heat gain to a certain extent in summer months, but additional cooling effect cannot be created by only a thermal insulation. It seems adding such a layer inside the walls, causes much better performance than the thermal insulation for hot and dry regions and in dynamically changing outdoor conditions.

Evaporative layer performance: case b) dry layer in winter (no evaporation)

Heat loss should be reduced from the outer walls in winter. November, December, January and February are four winter months. The common solution for this is applying thick thermal insulation to the outer walls. Without any thermal insulation, mean inner surface temperature of bare wall is 16°C in a typical January week.

In (Case B) the pad is kept dry but the air flow continues. It is assumed that indoor temperature is kept constant at 21°C by the heating system in winter. Inside wall surface temperatures can be increased by the flowing warm room air in the layer gap. These elevated inner surface temperatures reduce the heat loss and also help improving comfort conditions. The mean temperature of air is 19.1°C in the gap and the mean temperature difference between the room and the layer is about 2°C. In winter conditions, this proposed dry layer can be considered as a heat recovery unit. Air flow rate is also the same as in the summer case and correspond to the ventilation air rate (total 1,013 m³/h). There could be a conventional heat recovery unit in the system, in this case, this layer and heat recovery unit work in parallel.

Heat loss through winter months are given in **Table 2**. Total heating energy for 4 winter months is 15,779 kWh. Without applying this dry evaporative layer, total heat loss from same bare walls is 25,413 kWh. This reduction is big enough to consider.

Thermal insulation is the most effective solution in winter. However, without any thermal insulation EvapWall decreases heat losses almost half compared to the bare wall.

Table 1. Monthly heat gains of the building only from the outer walls [kWh].

	EvapWall	Bare Wall	With Isolation
May	−4587	4516	983
Jun	−2838	9885	2189
Jul	−2512	11637	2593
Agu	−2827	10452	2325
Sep	−3530	7435	1663

Table 2. Monthly heat losses of the building only from the outer walls [kWh].

	DRY	BareWall	Isolation
Jan	−4572	−7352	−1652
Feb	−4011	−6465	−1443
Nov	−2494	−4020	−854
Dec	−4701	−7576	−1672

Annual performance of the proposed layer

Considering both summer and winter performances of the proposed layer, annual energy need for the building and the outer wall have been calculated. This performance value has been compared with the bare wall and the 5 cm thick insulation covered wall. Evaporative layer will work wet during the five summer months and will work dry during the 4 winter months. Building energy simulation has been carried out by using Energy-Plus software for bare wall and the insulated wall. Temperature set points are again 21 for four winter months and 24°C for the rest of the year with air conditioning system that operates 24 hours. Results are given in **Table 3**. Negative sign for EvapWall indicates additional cooling effect. All other figures are considered as load and there is no sign of differentiation for heat gain or loss in the table. March, April and October can be considered as intermediate season. Both cooling and heating are required during these months. However, outer walls in each case more or less perform as a cooling element and reduce total mechanical cooling load in these months.

According to these results, applying evaporative layer is the best solution for İzmir. The 5 cm thick thermal insulation reduces annual building energy requirement from **134,391 kWh** to **72,810 kWh**. Saving of energy is about **61,581 kWh** annually. However, in case of proposed evaporative layer, annual energy saving is higher comparing the thermal insulation. The proposed layer reduces annual building energy requirement from **134,391 kWh** to **61,380 kWh** and saving of energy is about **73,012 kWh** annually. It seems that this proposed system is advantageous for hot and dry climates.

Effects of wall thermal mass

Thermal mass of the wall highly influences the performance of the outer wall. When outdoor whether conditions change daily and heat loss and gain occurs in the same day, thermal mass of the wall becomes important. Increasing thermal mass improves the thermal performance in dynamic climate conditions. This is especially effective during intermediate seasons. Wall thickness has been doubled in this case study and all the calculations were repeated for the EvapWall case. Calculated heat loss values are given in **Table 4**. Because these values are always heat loss, the sign is negative. This monthly negative value should be as low as possible in winter and as much as possible in summer. In case of thick wall, heat loss decreases in winter and cooling effect increases in summer. This means increasing thermal mass acts positively in a year-round performance of the wall.

Conclusions

Evaporative layer to be applied inside surfaces of outer walls in Mediterranean climate is a novel approach.

Table 3. Total monthly heat (energy) lost/gain only from outer walls [kWh].

	Insulated wall		Bare wall		EvapWall	
Month	Heat loss/gain by the wall (kWh)	Total energy requirement of the system (heating or cooling) (kWh)	Heat loss/gain by the wall (kWh)	Total energy requirement of the system (heating or cooling) (kWh)	Heat loss/gain by the wall (kWh)	Total energy requirement of the system (heating or cooling) (kWh)
January	1652	6800	7352	12500	4572	9720
February	1443	6735	6465	11757	4011	9303
March	1430	4196	6178	8944	3804	6570
April	660	2700	3038	5078	1849	3889
May	983	4919	4516	8452	–4587	0
June	2189	8011	9885	15707	–2838	2984
July	2593	8025	11637	17069	–2512	2920
August	2325	10452	10452	18579	–2827	5300
September	1663	5493	7435	11265	–3530	300
October	127	3226	618	3717	373	3472
November	854	5803	4020	8969	2494	7443
December	1672	6450	7576	12354	4701	9479
Annual		72810		134391		61380

This novel element has been designed and its performance has been investigated in this study.

Simulation results indicate that this layer prevents heat gain from outer walls and provides additional cooling during summer period in İzmir conditions.

This layer can also be used in winter conditions as dry.

The other benefit of this layer is improving thermal comfort conditions of the indoor environment.

It has been shown that evaporative layer is the best solution for İzmir. In case of proposed evaporative layer, annual energy saving is higher comparing to the thermal insulation. The proposed layer reduces annual building energy requirement from **134,391 kWh** to **61,380 kWh** and the saving of energy is about **73,012 kWh** annually. ■

Table 4. Comparison of thermal mass on wall thermal performance. Monthly heat loss of outer walls [kWh.]

	EvapWall Heavyweight heat loss	EvapWall Lightweight heat loss
Jan	–4572	–5779
Feb	–4011	–5050
Mar	–8040	–8253
Apr	–6795	–6614
May	–4587	–3496
Jun	–2838	–1258
Jul	–2512	–734
Agu	–2827	–1145
Sep	–3530	–2194
Oct	–6194	–5699
Nov	–2494	–3153,
Dec	–4701	–5941,

References

[1] Stazi, F., Bonfigli, C., Tomassoni, E., Di Perna, C., & Munafò, P., 2015. The effect of high thermal insulation on high thermal mass: Is the dynamic behavior of traditional envelopes in Mediterranean climates still possible? Energy and Buildings, 88, 367-383.

[2] ASHRAE, 2001. International Weather for Energy Calculations (IWEC Weather Files) User Manual and CD-ROM. Atlanta USA.

BY **TIZIANA BUSO,** REHVA PROJECT OFFICER

REHVA at EUSEW 2017

SUSTAINABLE ENERGY WEEK
19-25 JUNE 2017
An initiative of the European Commission

In June, the 12th edition of European Sustainable Energy Week (EUSEW 2017) took place in Brussels and all across Europe. While Energy Days were organized during the whole month in various Member States, from 19 to 25 June Brussels was the set for the EUSEW 2017 Policy Conference, the EU Sustainable Energy Awards, the Networking Village and several side events. REHVA played its part by attending the Policy Conference and by setting up activities in the Networking Village.

The conference dedicated its over 60 sessions to the several facets of the *Clean Energy for All European* package. To get an overview of the most relevant trends and strategies for the HVAC sector, REHVA attended sessions dealing with the role of building energy efficiency, investors, professionals and consumers towards the clean energy transition.

The networking area, instead, hosted exhibitions and presentations, enabling EUSEW participants to exchange knowledge and ideas. There, on 21 June, REHVA and the EPB Center displayed side by side their activities with two booths: one dedicated to the skills, tools and technologies required to go beyond NZEBs, the other to standardized methods to assess the energy performance of buildings.

EUSEW Policy Conference – making the energy transition real

The Policy Conference started on 20 June with a high-level opening ceremony chaired by the Director General for Energy Dominique Ristori. Climate Action and Energy Commissioner Miguel Arias Cañete started his opening speech stating that clean energy technologies and investments in the sector are growing quicker than the EU can collect statistics to measure it. He

confirmed the EU's commitment to the COP21 Paris agreement and called for making the energy efficiency of the European building stock as a key policy to deliver the Paris agreement. The Chair of the European Parliament Industry, Research and Energy Committee Jerzy Buzek well depicted the objectives of the 12th edition of EUSEW by highlighting the urge to make the energy transition real and to use the Clean Energy package for it.

Speakers pointed out the need to define binding targets as a way to provide predictable investment scenarios and highlighted the EU financing efforts to drive these investments towards Energy Efficiency, Renewables and Citizens' empowerment initiatives. As the Member of the European Parliament (MEP) Claude Turmes mentioned, the goal is to "make Europe the Silicon Valley of the energy transition".

In the following sessions and until 22 June, various topics were tackled during the Conference. Among them, REHVA took part to sessions dealing with financial initiatives for energy efficiency in buildings, the role of SMEs in the energy transition, perspectives for energy technologies and professional skills, the market for energy efficiency services and the engagement of building users and owners. Despite the very divers contents and speakers, a *fil rouge* links most of these interventions: even if financial resources and technological expertise are available in Europe to reach the carbon neutrality, a change in mindset in all the involved actors is still missing. Some Member States still do not assign explicit priority to Energy Efficiency in their national plans; investors do not understand the full range of benefits of Energy Efficiency projects; building professionals are often not updated about the latest technologies and requirements; owners and occupants are not aware about the energy performances in buildings they live and how to improve them. The good news is that several EU initiatives to address these gaps were also showcased during the presentations. For instance, in the conference session organized by eu.esco, the MEP rapporteur of review of EPBD for the Committee on Industry, Research and Energy (ITRE) Bendt Bendtsen listed to the audience his key points within the ongoing revision of the EPBD: to require Member States to clearly state priority for Energy Efficiency in national regulations, to provide a stable framework to investors for Energy Efficiency projects, to set up incentives to boost private investments.

The EUSEW Conference programme and most of the presentations of all the session are available on the EUSEW website: www.eusew.eu.

REHVA's highlights on EUSEW sessions

REHVA attended Policy Conference sessions with special relevance to REHVA priorities and ongoing activities.

The session on "Addressing skills shortage in the transformation of the energy system" aimed at fostering discussion, exchange of experiences and lessons learnt, as well as plans for the future in the field of energy education among all attendants. There, Vincent Berrutto, Head of the Energy Unit at the European Commission's Executive Agency for Small and Medium-sized Enterprises (EASME), presented the BUILD UP Skills initiative and the related H2020 projects. Among them PROF/TRAC, a REHVA project of strategic relevance involving 12 REHVA Member Associations in a European training and qualification scheme. In the same session, the Young Entrepreneur Program promoted by the energy company Iberdrola, the FP7 project UNI-SET (UNIversities in the SET-Plan) and the MicroMasters proposed by INNOEnergy were showcased.

The session organized by eu.esco (European association of energy service companies), "Boosting energy-efficiency services markets for building renovation and system efficiency" presented policy recommendations, business models and tools to uncap the full potential of energy-efficiency services market. The specific focus was on how art. 18 of the Energy Efficiency Directive can contribute to the achievement of the national 'long-term renovation strategies' proposed the revised Energy Performance of Buildings Directive (EPBD). In the first part of the session policy makers had the floor, having MEP Bendt Bendtsen, ITRE rapporteur for the EPBD review as key actor in the discussion. The second part of the discussion was dedicated to case studies. Clients and providers of energy efficiency services shared their experiences about successful projects they were involved in. This discussion was also the occasion for the invited speaker from e7, Stefan Amann, to mention the H2020 project QUANTUM of REHVA that develops digital quality management tools to ensure energy and IEQ performance throughout the building life cycle. Finally, the European Code of Conduct for Energy Performance Contracting (EPC) and Quality Criteria for EPC EU-funded projects were presented as potential tools to boost the market of energy-efficiency services.

To focus on building renovation from users' perspective, EuroACE (the European alliance of Companies for Energy Efficiency in Buildings) organized a session titled "Clean buildings for all – helping consumers through the energy renovation maze". Its main goal was to discuss about the need for improvement of the Energy Performance Certificates (EPCs), not addressed in the current revision of the EBPD, and how to make EPCs evolve into Building Renovation Passports. To this extent, the speakers showcased examples of innovative ways to engage users and owners towards the energy renovation of their buildings and the Renovation Pact set up by the Flemish Energy Agency. BPIE speaker Maarten De Groote promoted the recently approved EU project i-Broad (Individual Building Renovation Roadmaps). Louise Sunderland, from Energy Advice Exchange and David Weatherall from the Energy Saving Trust respectively advocated the involvement of consumers and the creation of a reliable database of EPCs as key points to boost of energy renovations in buildings.

The EPB Center, a joint initiative of ISSO and REHVA was the core topic of the session "The role of standardisation towards higher Energy Performance of Buildings" organized by the European Builders Confederation with the aim to promote standards in the construction sector mainly represented by SME-s. Jaap Hogeling presented the EPB Center that will support the implementation of EPB standards, stressing that standards can lead to the harmonisation of performance calculation of different energy saving technologies, and also support good indoor environment quality. Harmonised standards also promote innovation, which is beneficial for innovative SME-s. Vasco Ferreira from DG Energy added that the EU needs more information on the national calculation methodologies to make sure that they are technology neutral and transparent. Today there are 35 different performance calculation methodologies across Europe, often not in line with the EN/ISO standards. Transparency and harmonization of the calculation methodologies will help also to reduce the performance gap that exists today. Adrian Joyce, event moderator and director of EuroACE pointed out that SME-s need guidelines on how the standards work, how they shall be used. A conclusion of the event was that the European Commission should support the capacity building and dissemination of EN standards to promote harmonised application with guidelines, digital tools, training schemes targeting SME-s on one hand, and help and influence national regulators on the other. Vasco Ferreira confirmed that the Commission supports these actions within the Horizon2020 programme, and via the EPBD-Concerted Action.

REHVA and EPB Center at EUSEW17 Networking Village

EASME selected 35 proposals for the Networking Village and REHVA and the EPB Center were among them. REHVA and the EPB Center set up their booths side by side in the Networking Village on 21 June afternoon.

REHVA and EPB Center side by side at the Networking village.

The REHVA booth was dedicated to "Innovative tools, advanced technologies, and new skills for nZEB and beyond". There, REHVA showcased the EU projects it is partner of - PROF/TRAC, QUANTUM and hybrid GEOTABS – which well exemplify strategies to develop and deploy innovative technologies and construction skills. PROF/TRAC (PROFessional multi-disciplinary TRAining and continuing development in skills for NZEB principles) develops a training scheme and has enrolled training providers from across Europe. QUANTUM (Quality management for building performance - improving energy performance by life cycle quality management) elaborates and demonstrates services and tools with high replication potential supporting quality management during the building life. hybrid GEOTABS (Model Predictive Control and Innovative System Integration of GEOTABS in hybrid Low Grade Thermal Energy Systems) optimises the predesign and operation of a hybrid combination of geothermal heat pumps and thermally activated building systems implementing 'Model Predictive Control' (MPC) solutions, to make these systems economically attractive and increasing take up.

Beside EU projects, REHVA promoted its own activities targeted to inform and update building professionals and stakeholders, such Guidebooks and the REHVA Journal.

The engage its visitors, REHVA displayed audio-visual contents and set up a short quiz to raise participants' curiosity about our network, services and activities. ■

INTERVIEWER: **ANITA DERJANECZ,** REHVA MANAGING DIRECTOR

Indoor climate and health is a priority

Interview with Bendt Bendtsen, Member of European Parliament and rapporteur of the EPBD review dossier

Bendt Bendtsen is a Danish politician and Member of the European Parliament (MEP) since 2009. He is a member of the Conservative People's Party, part of the European People's Party Group (EPP Group). He was Deputy Prime Minister and Minister for Economic, Energy and Business Affairs in Denmark from 2001 to 2008. He is a Member of the European Parliament's Committee on Industry, Research and Energy, and rapporteur of the EPBD review dossier.

AD: First, I'd like to congratulate to the excellent and hard work you and your colleagues are doing in the review process of this very complex and technical piece of legislation. We were surprised by the immediate and positive reactions received from your team in the past months, and we appreciate your support and work to achieve a better and ambitious directive, which is of key importance for REHVA members and our professional network. As rapporteur, you published your draft report in April – making it publicly available open for comments from stakeholders and the public. How many contributions have you received and what is the status of the final draft of the ITRE report?

BB: Since I was appointed rapporteur for the revision of EPBD and until I published my draft report in April, my office had more than 170 meetings with stakeholders, including REHVA, providing us with their input.

We also met with the shadow rapporteurs to hear their preliminary priorities, with several governments and with the European Commission to better understand some of the choices that were taken when drafting the proposal. We continued this process with preparatory meetings with stakeholders up until the deadline for amendments in the beginning of June. We met more than 240 stakeholders in total until now – and of course, we received more than 600 amendments from colleagues in the European Parliament by the June deadline for amendments.

Since June, we have been working closely with the shadow rapporteurs of the other political groups to find a common approach and compromises – a work that will continue until we expect to vote on an agreed text in the ITRE committee in October.

AD: You are from Denmark, a leading country in Europe in the field of policies, research and technologies for healthy and energy efficient buildings. We spend 90 % of our life indoors, so maintaining good indoor climate is crucial to improves both the health and productivity of people in buildings. What is your personal experience regarding the indoor climate quality of buildings in Denmark and in Brussels? And what is your opinion about linking health and energy performance of building stronger within the EPBD?

BB: Clearly health and indoor climate has gained much attention in Denmark – a country with high energy prices, relatively low temperatures, high humidity and not much natural light. It has made it natural to focus on how to improve indoor conditions and, therefore, we have many companies specialising in providing energy efficiency solutions as well as products contributing to good indoor environment.

I myself gave it a lot of thought when constructing my own house and paid special attention to ensuring proper ventilation, since highly insulated houses need assistance to ensure proper air-quality.

I think - generally speaking - the condition of the building stock across Europe is very diverse, however there are low-hanging fruits in all countries – also in Denmark – to create a better performing building stock. - Both in terms of energy performance and in terms of the indoor conditions we live and work in.

I am happy that there seems to be broad consensus across the political spectrum, and across the two involved committees, that indoor health and climate is a priority. However, we must ensure that the directive remains technology-neutral and focuses on cost-effective solutions. We should emphasise the aims, rather than on the means to get there – in particular due to the diverse conditions across Europe that I mentioned before.

AD: REHVA has been advocating for the improvement of health, comfort and energy efficiency in buildings and communities for decades. We asked for mandatory indoor climate requirements in the EPBD, and for strengthening the importance of technologies that can ensure this. How do you see the possibility to integrate the changes proposed by REHVA and other stakeholders in the ITRE position? How does the ITRE position address the aspect of indoor climate quality?

BB: I am not keen to stress certain technologies over others. We cannot predict the best solutions in all cases and we cannot predict the technologies of the future, so the market must be allowed to drive the product development, without the political prioritisation of one solution over another.

That being said, indoor health and environment is a clear part of the scope of EPBD and we will continue to work to ensure that Member States deliver the needed results – both to drive holistic renovations of existing buildings and in setting high standards for new buildings.

AD: Can you give us some insights into the currently ongoing political process within the EP to reach a compromise on an ITRE position with the shadow colleagues, as well as your goal to gain strong political support for an ambitious ITRE proposal?

BB: We have of course taken note of the general approach adopted in the Council in the end of June. It is clear from this that Member States do not like to commit to delivering anything substantial when it comes to driving new renovations.

It is therefore up to the Parliament to secure a negotiation position for the upcoming meetings with the Council, which will lead to Member States taking responsibility for delivering a measurable output of their national long-term renovation strategies, which will be a fundamental tool to reach the overall energy efficiency ambitions in a cost-effective manner.

AD: What do you see as the biggest challenge in achieving and delivering the EU energy efficiency targets?

BB: Since we only construct new buildings at a rate of 1,5% annually, we really must get renovations of the existing buildings on track. If we don't, we will continue on a path of importing fossil fuels to Europe at an alarming rate and at a cost of 1 bio EUR daily. Many view the initial cost of energy efficiency renovations as a major obstacle to achieve the savings potential, however I find myself reminding the sceptics daily of three things:

– Energy efficiency doesn't have to lead to lower productions levels – it's about using energy smarter.
– Energy efficiency renovations comes in many shapes and forms – starting at 20 EUR – and doesn't have to entail a major up-front cost for ordinary citizens
– Energy efficiency renovations make up an excellent business case and in the current investment climate, with low interest rates, many private investors such as pension funds and financial institutions are looking for such business cases.

It is up to us as policy-makers to ensure investor certainty and bringing together the energy efficiency projects and the investors. If we succeed with that, I think it will be no problem to cost-efficiently reach our energy efficiency ambitions.

AD: How do you see the role of the EU's clean energy policies and technologies within the global context, especially after the U-turn of the US federal politics under President Trump?

BB: I am particularly concerned for Europe in a geopolitical context. We are wasting energy produced in Europe and buying it expensively from Russia and

the Middle East – making ourselves dependent on unstable sources.

And this dependency is only increasing. I find it ever more important that we become more self-sufficient in terms of energy sources, and to get there we need to realise the ambition on an internal energy market in Europe where using European produced energy comes before imports.

And in light of the global challenges, including Trump's climate kamikaze, I believe that it is ever more important that we in Europe show that energy efficiency pays off – not just for the individual household, but also for making our businesses more competitive on the global market. ■

BY **ANITA DERJANECZ,** REHVA MANAGING DIRECTOR

EPBD REVIEW latest updates – MEPs in favour of strengthening indoor environment quality requirements and health aspects in the revised directive

The first reading by the European Parliament (EP) and the Council of the European Union (Council) concerning the European Commission (EC) proposal of the revised EPBD comes to its end in autumn 2017. The EP ITRE committee is finalising its opinion by October, led by rapporteur Bendt Bendtsen (EPP) who is aiming at a more ambitious legislation than proposed by the EC. The EP ENVI committee contributes with an opinion overseen by rapporteur Anneli Jäätteenmäki (ALDE) focusing on healthy buildings with proper indoor air quality. MEPs submitted several amendment proposals to both drafts showing a consensus in the support of more stringent IEQ and health performance requirements in the directive. The Council approved its proposal end of June serving as basis of negotiations with the EP. The priorities of the two institutions are significantly different.

Eight months after the publication of the Clean energy package containing the legislative proposal of the revised Energy Performance of Buildings Directive (EPBD), the first reading process involving the EP and the Council reached a point where the positions of the two institutions are well visible. In the past months, stakeholders – including REHVA – have been actively advocating for their interests and specific positions and contributed to forming the opinions of the EP and Member States' governments. The final ITRE opinion is scheduled for vote on the 12th of October.

The European Parliament position

The EP draft position on the EPBD review has been assigned to the EP ITRE committee, led by rapporteur Bendt Bendtsen who published the ITRE draft report on 26 April. The ENVI committee was asked to prepare its own opinion for ITRE, led by rapporteur Anneli Jäätteenmäki, the ENVI draft opinion was published the same day. Both committees accepted amendment proposals until the beginning of June. In the past 8 months, the rapporteurs and shadow-rapporteurs had several meetings with stakeholders, including REHVA, and received nearly thousand amendment proposals in total from their fellow-MEPs and from stakeholders.

The **ITRE draft report** supports the key aspects of the EC proposal and brings back some elements, such as the Smart Readiness indicator (SRI) that was part of the leaked version of the EC proposal, disappeared however from the final version. The rapporteur stresses the importance of Member State level actions, such as long-term refurbishment strategies that shall integrate considerations for improvements to health and indoor climate. Some important relevant proposals of the draft report:

- **Health and IEQ aspect** should be part of the long-term renovation strategies. The rapporteur promotes **holistic building renovations** as the best way of ensuring high energy performance and improved indoor comfort.
- Supports **mandatory inspections** and lowers the system size threshold of the EC proposal for the systems that shall be regularly inspected.
- Promotes **BAC technologies** that have a great potential to provide cost-effective and significant energy savings. For large installations, BAC and electronic monitoring may replace on-site inspections, but the draft withdraws the option that BAC can be an alternative to inspection in general.

- Promotes the further **harmonisation of EPC towards building renovation passports**.
- Supports the **Smart Readiness Indicator** (SRI) and reintroduces in the Annex 1 the text on SRI that were initially in the leaked EC legislative proposal.

In the **ENVI draft opinion** the rapporteur stressed and supported two major issues: healthy buildings and the Commission proposal on electro-mobility. Regarding the former point, the draft points out that tens of millions of Europeans suffer from bad indoor air quality, which underlines the importance of improving the health performance of buildings. Key points of the draft opinion regarding healthy buildings:

- Introduces the term **"healthy building"** defined as "being designed to fulfil the needs of its occupants, constructed from durable, repairable, and recyclable non-toxic materials. It uses energy efficiently and might also produce it, has sufficient natural light and is ventilated and heated properly to maintain good indoor air quality and temperature".
- Member States shall ensure that energy performance upgrades also contribute to achieving a healthy indoor environment.
- Energy efficiency improvements should be considered to ensure that all parts and technical systems, including building maintenance, result in a high level of energy efficiency.

REHVA position and contribution to the first reading process

REHVA published its position paper on the EC legislative proposal in March 2017 and shared it with EU policy makers and stakeholders, including the MEPs involved in the EPBD first reading process. The REHVA position is grouped in 3 priorities:

1. Ensuring high indoor environment quality and energy efficiency at the same time
2. Ensuring quality, proper maintenance and performance through mandatory inspection of heating, ventilation and air-conditioning systems
3. Promoting the harmonized and ambitious application of EPB standards in Europe

After ENVI and ITRE have released their draft report and opinion on the EPBD review, REHVA experts also prepared detailed amendment proposals with justification, and sent them to ENVI and ITRE members in charge of the rapport. The **REHVA amendment proposals and comments** are in line with the general REHVA position, but propose textual changes to the relevant paragraphs of the directive. Both documents are available on the REHVA website: www.rehva.eu/eu-regulations/epbd.

Amendment proposals of MEPs – a clear support of indoor environment quality and health performance criteria in the EPBD

Having a look at the submitted amendment proposals proves that MEPs support the inclusion of indoor air / indoor environment quality, health performance criteria and the related requirements to be included in different paragraphs across the directive. It seems that there is a **consensus about the importance and relevance of health and IEQ aspects linked to energy performance**. If we compile all the amendment proposals, they cover almost every points of the REHVA position regarding IEQ: the definition and monitoring of IEQ levels; the inspection and assessment of IEQ performance beside the energy performance of a building; the integration of measures to increase the health and comfort levels of buildings in the renovation strategies; the integration of IEQ criteria in the EPC-s or building passports, as well as in the Smart Readiness Indicator calculation methodology; adding technologies to the definition of technical building systems that maintain and control proper indoor comfort level; requesting minimum energy and health performance criteria linked to renovation project financed by public funding.

An interesting proposal, which appears among both the ENVI and the ITRE amendments, requests the definition of an additional **Indoor Air Quality Performance Certificate**, which is an idea strongly supported by EFI, the European Federation of Allergy and Airways Diseases Patients' Associations. According the proposal, this IAQ performance certificate should be issued for new and renovated buildings and should include minimum air quality requirements, list pollutants and contaminants that are to be tested and measure other criteria that can lead to the increase of certain pollutants or mould, such as temperature and relative humidity. The certificate should also mention whether the technical installation in the building comply with the relevant EN standards.

The council's position

The Council agreed on its position for the EBD review at the Energy Council meeting on 26 June 2017. This Council position allows for the start of negotiations with the European Parliament under the Estonian presidency that started on 1 July 2017. As expected, the Council is less supportive of any new requirements to the existing ones and opts for more flexibility at national level in the application of the directive. Key relevant points of the Council position:

- The Council goes back to the **27% energy efficiency target**, to be reviewed in 2020 having in mind the 30% option.
- **Inspection:** the Council approves the single 70 kWh threshold for the inspection of heating and air conditioning systems, but reintroduces to option of advice as alternative to inspection. BAC systems are considered as cost-effective alternative to inspections in large non-residential and multifamily buildings.
- **Smart readiness indicator** (SRI): the EC should develop a voluntary scheme for the rating of SRI without having any negative impact on existing national EPC schemes and by building on related initiatives at national level.
- Annex 1 – **energy performance calculation**: with reference to the overarching standard, the Council amendment states that this shall not require compliance with the standards. The description of national calculation methods shall remain voluntary in the national annexes.

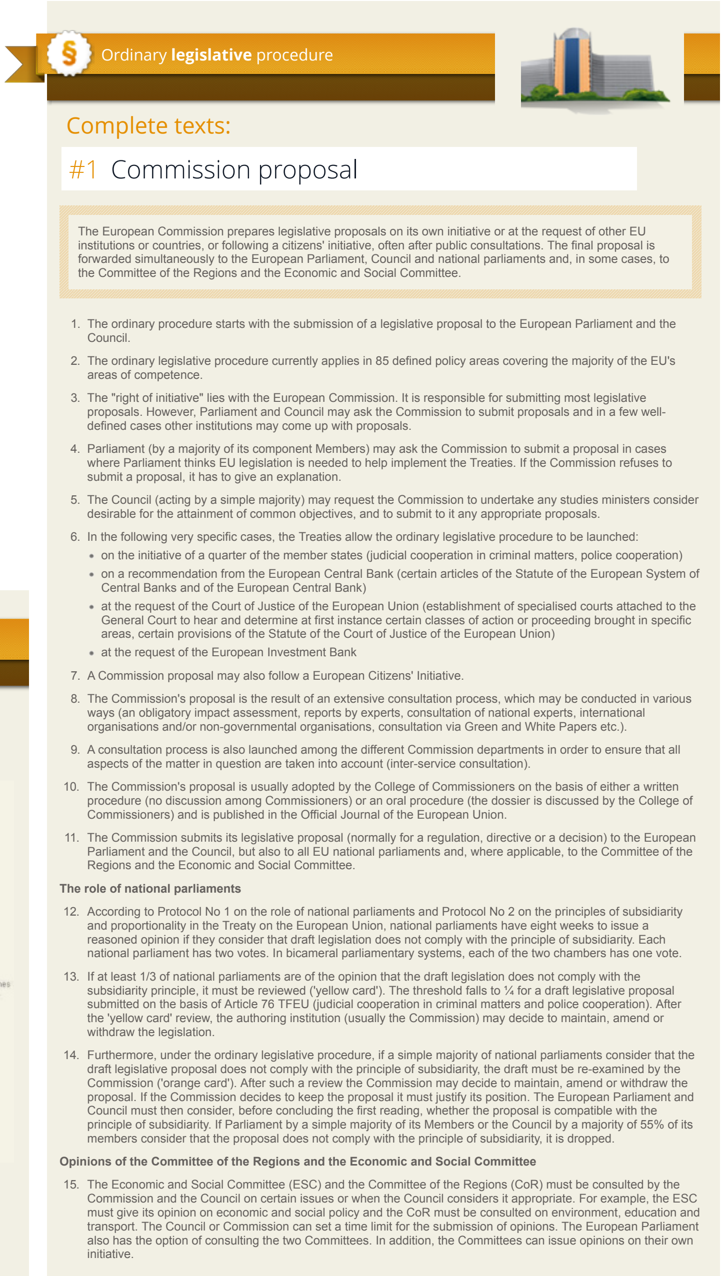
What's next?

ITRE is expected to vote about the final Report on 12th October 2017. Rapporteur Bendt Bendtsen is working with his shadow-rapporteurs to find a consensus and a string political support for the final amendment within the EP.

According to the ordinary legislative procedure of co-decision the EP and the Council have the same weight in the decision making. In the first reading process of the two institutions, the Council examines the EP position and either approves it without change or sends back amendments to the EP for a second reading. In latter case, the EP can approve, reject the

Council opinion, or send back the them its own amendments for a second Council reading.

Beside the EPBD review, the EP and the Council are in the first reading process of the other legislations that were released within the Clean energy for all Europeans package, with 7 separate ITRE committee voting scheduled till November. Agreements on the whole package are unlikely to happen before mid-2018, however, for the EPBD review the overall aim was to reach the final agreement review during the Estonian Presidency in the second half of 2017. ■



Ordinary **legislative** procedure

Complete texts:

#1 Commission proposal

The European Commission prepares legislative proposals on its own initiative or at the request of other EU institutions or countries, or following a citizens' initiative, often after public consultations. The final proposal is forwarded simultaneously to the European Parliament, Council and national parliaments and, in some cases, to the Committee of the Regions and the Economic and Social Committee.

1. The ordinary procedure starts with the submission of a legislative proposal to the European Parliament and the Council.
2. The ordinary legislative procedure currently applies in 85 defined policy areas covering the majority of the EU's areas of competence.
3. The "right of initiative" lies with the European Commission. It is responsible for submitting most legislative proposals. However, Parliament and Council may ask the Commission to submit proposals and in a few well-defined cases other institutions may come up with proposals.
4. Parliament (by a majority of its component Members) may ask the Commission to submit a proposal in cases where Parliament thinks EU legislation is needed to help implement the Treaties. If the Commission refuses to submit a proposal, it has to give an explanation.
5. The Council (acting by a simple majority) may request the Commission to undertake any studies ministers consider desirable for the attainment of common objectives, and to submit to it any appropriate proposals.
6. In the following very specific cases, the Treaties allow the ordinary legislative procedure to be launched:
   - on the initiative of a quarter of the member states (judicial cooperation in criminal matters, police cooperation)
   - on a recommendation from the European Central Bank (certain articles of the Statute of the European System of Central Banks and of the European Central Bank)
   - at the request of the Court of Justice of the European Union (establishment of specialised courts attached to the General Court to hear and determine at first instance certain classes of action or proceeding brought in specific areas, certain provisions of the Statute of the Court of Justice of the European Union)
   - at the request of the European Investment Bank
7. A Commission proposal may also follow a European Citizens' Initiative.
8. The Commission's proposal is the result of an extensive consultation process, which may be conducted in various ways (an obligatory impact assessment, reports by experts, consultation of national experts, international organisations and/or non-governmental organisations, consultation via Green and White Papers etc.).
9. A consultation process is also launched among the different Commission departments in order to ensure that all aspects of the matter in question are taken into account (inter-service consultation).
10. The Commission's proposal is usually adopted by the College of Commissioners on the basis of either a written procedure (no discussion among Commissioners) or an oral procedure (the dossier is discussed by the College of Commissioners) and is published in the Official Journal of the European Union.
11. The Commission submits its legislative proposal (normally for a regulation, directive or a decision) to the European Parliament and the Council, but also to all EU national parliaments and, where applicable, to the Committee of the Regions and the Economic and Social Committee.

The role of national parliaments

12. According to Protocol No 1 on the role of national parliaments and Protocol No 2 on the principles of subsidiarity and proportionality in the Treaty on the European Union, national parliaments have eight weeks to issue a reasoned opinion if they consider that draft legislation does not comply with the principle of subsidiarity. Each national parliament has two votes. In bicameral parliamentary systems, each of the two chambers has one vote.
13. If at least 1/3 of national parliaments are of the opinion that the draft legislation does not comply with the subsidiarity principle, it must be reviewed ('yellow card'). The threshold falls to ¼ for a draft legislative proposal submitted on the basis of Article 76 TFEU (judicial cooperation in criminal matters and police cooperation). After the 'yellow card' review, the authoring institution (usually the Commission) may decide to maintain, amend or withdraw the legislation.
14. Furthermore, under the ordinary legislative procedure, if a simple majority of national parliaments consider that the draft legislative proposal does not comply with the principle of subsidiarity, the draft must be re-examined by the Commission ('orange card'). After such a review the Commission may decide to maintain, amend or withdraw the proposal. If the Commission decides to keep the proposal it must justify its position. The European Parliament and Council must then consider, before concluding the first reading, whether the proposal is compatible with the principle of subsidiarity. If Parliament by a simple majority of its Members or the Council by a majority of 55% of its members consider that the proposal does not comply with the principle of subsidiarity, it is dropped.

Opinions of the Committee of the Regions and the Economic and Social Committee

15. The Economic and Social Committee (ESC) and the Committee of the Regions (CoR) must be consulted by the Commission and the Council on certain issues or when the Council considers it appropriate. For example, the ESC must give its opinion on economic and social policy and the CoR must be consulted on environment, education and transport. The Council or Commission can set a time limit for the submission of opinions. The European Parliament also has the option of consulting the two Committees. In addition, the Committees can issue opinions on their own initiative.

Source: http://www.europarl.europa.eu

More information:

EC Proposal for a Directive of the European Parliament and of the Council amending Directive 2010/31/EU on the energy performance of buildings, COM(2016) 765 final 2016/0381 (COD)

ITRE Draft report on the proposal for a directive of the European Parliament and of the Council amending directive 2010/31/EU on the energy performance of buildings (COM(2016)0765 – C8 0499/2016 – 2016/0381(COD)), and the received amendment proposals

ENVI Draft opinion on the proposal for a directive of the European Parliament and of the Council amending Directive 2010/31/EU on the energy performance of buildings (COM(2016)0765 – C8 0499/2016 – 2016/0381(COD)), and the received amendment proposals

Council Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2010/31/EU on the energy performance of buildings - 10288/17- 2016/0381 (COD)

EC policy package - Clean Energy for All Europeans

Ordinary legislative procedure of the EP and the Council

ISH Shanghai & CIHE 2017

focuses on surface heating systems for East and Central Chinese market with leading brands

Following the success of the record-breaking ISH China & CIHE held in Beijing earlier this year, the sixth edition of ISH Shanghai & CIHE – Shanghai International Trade Fair for Heating, Ventilation, Air-Conditioning & Home Comfort will take place from 5 – 7 September 2017. The fair will be held at Hall W1 of the Shanghai New International Expo Centre (SNIEC) and is jointly organised by Messe Frankfurt (Shanghai) Co Ltd, Beijing B&D Tiger Exhibition Co Ltd and Shanghai Zhanye Exhibition Co Ltd.

With the demand for better living standards on the rise, the desire for more efficient and more comfortable heating is increasing rapidly in East and Central China. As most of the regions' residential buildings are not equipped with built-in heating devices, surface heating systems are becoming a popular heating solution. In view of the market's needs, ISH Shanghai & CIHE, the most influential HVAC trade fair in East and Central China, will focus its offerings on surface heating systems in 2017. The show is not only an established platform for trade and information exchange, but also provides one-stop sourcing solutions to buyers and offers exhibitors unparalleled brand building and business development opportunities.

A comprehensive array of the latest HVAC products and technologies will be featured at the 2017 edition, including wall-hung boilers, heat pumps, radiators, automatic controls, pipes and valves as well as cutting-edge floor heating, solar energy, ventilation and air conditioning solutions. Leading brands confirmed to exhibit include Airpower, Alikes, Haers, Hemansi, Italtherm, Lotte, Menred, Ochsner, Teclic, Unbeatable, Xianfeng and others.

To keep pace with industry trends and market integration, ISH Shanghai & CIHE is held in conjunction with three fairs including Shanghai Intelligent Building Technology, Shanghai Smart Home Technology and Shanghai International Lighting Fair. The four shows will run from halls W1 to W5 and cover 40,000 sqm of exhibition space. More than 600 exhibitors and 52,000 visitors are expected to engage in the business exchange of total solutions for energy-efficient and sustainable building technologies.

European Pavilion and Premium Brand Zone to demonstrate the latest HVAC technologies and products

For the 2017 fair, the European Pavilion has again confirmed its participation in an effort to meet the growing demands for HVAC solutions in East and Central China. More than 20 leading companies including Caleido, Cemsan, Metsan, Plastica Alfa, Solimpeks, Thermotec, Unitherm and WKL will engage in the Pavilion, total booth area of which is over 300 sqm. Furthermore, the Premium Brand Zone will be set up again to host outstanding enterprises like Mufeng, Sanyou(Hengsheng), Suolida(Sikewei), Yixinxing, Zhanghui and more to showcase innovative HVAC technologies and products.

Mr Lu Xiao Hua, founder of Tak Wah International Investment Company Limited, agent of Thermotec Aeroflow, said: "We have joined the European Pavilion at ISH Shanghai & CIHE for three years. Through exhibiting at the show, potential customers are able to learn more about our company and products, while we can obtain latest market intelligence and industry trends. In addition, we found potential target distributors here. The HVAC market in East and Central China is promising and ISH Shanghai & CIHE provides a professional platform to access to it. The show is beneficial to our business and I look forward to the results of this year's participation."

ISH Shanghai & CIHE is headed by the biennial ISH event in Frankfurt, which is the world's leading trade fair for the Bathroom Experience, Building, Energy, Air-Conditioning Technology and Renewable Energies. The mother event will take place from 11 – 15 March 2019. For more information, please visit www.ish.messefrankfurt.com.

As for the next edition of ISH China & CIHE – China International Trade Fair for Heating, Ventilation, Air-Conditioning Sanitation and Home Comfort System, it is scheduled to be held at the New China International Exhibition Center in Beijing, China from 22 – 24 May 2018. For more information, please visit www.ishc-cihe.com or email info@ishc-cihe.com. ■

Stay cool and discover the hottest new technologies at HVAC 2017

Responding to visitor demand, HVAC 2017 will feature even more innovative products and solutions.

The show returns for its third year as part of UK Construction week and will take place at the NEC in Birmingham from 10th – 12th October 2017. Visitors to HVAC 2017 will be spoilt for choice with access to eight other specialist shows all under one roof. Each show will be tailored to meet the needs and requirements of specifiers, engineers, installers, contractors and architects in their chosen areas of expertise and interest.

HVAC 2017 will provide a broad range of attractions for its visitors with insightful seminars at the HVAC hub, an exclusive innovation trail as well as invaluable and constructive one to one consultations with exhibitors and entertainment such as the beer and ale festival, casino night and award ceremonies.

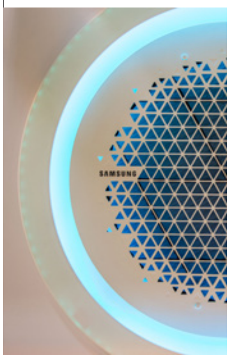
The Carbon Trust will be delivering an educational seminar promoting debate and discussion on key themes such as micro-district ground source heating and its potential in providing a return on investment.

Attendees will be encouraged to undertake a journey of discovery on the exclusive Innovation Trail, uncovering the newly released products and solutions promising to transform the market.

The show is free for trade professionals, where they can come along and gain invaluable expert advice from a wide range of companies and organisations.

Nathan Garnett, Event Director of UK Construction Week reveals: "We're delighted to be back for a third year. For 2017, the show returns on an even grander scale. HVAC 2017 is part of the largest trade show of its kind in the industry and we've introduced many new features which will no doubt prove popular. Join us for lively, educational debates on the subjects that matters to you."

HVAC 2017 is supported by its associate partners - the Institution of Mechanical Engineers (IMECHE) Ground Source Heat Pump Association (GSHP), Federation of Environmental Trade Associations (FETA), Building Engineering Services Association (BESA), British Electrotechnical and Allied Manufacturers Association (BEAMA) and the British Compressed Air Society (BCAS), to name just a few.



UK CONSTRUCTION WEEK | 2017
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It's free to attend HVAC 2017 – Get your ticket here: www.hvaclive.co.uk/register ■

For more information, please contact:
michael@keystonecomms.co.uk

ASHRAE presidential address: 2017 "EXTENDING OUR COMMUNITY"

Bjarne Olesen presenting the ASHRAE presidential address in Long Beach CA USA

Bjarne Olesen, the 2nd European president of ASHRAE , presented his presidential address on Monday June 26th, 2017 at the ASHRAE yearly meeting in Long Beach CA.

Bjarne Olesen overall presidential theme will be "EXTEND" – focusing on three directives:

- EXTEND our global community;
- EXTEND our technological horizons;
- EXTEND our value to Members.

EXTENDING our Global Community

Although ASHRAE's global presence has grown, we as a Society need to be more strategic as a leader, in some cases as a partner and in other cases as both. Why should we be more global? How do members here in the U.S. and around the world benefit from a more global Society? The answers to these questions should serve as the foundation of a new global strategy that addresses challenges facing the global building industry today.

Remember the work of ASHRAE members is not constrained by borders. All major companies have an international presence and reach many countries. Consultants, engineers and architects have worldwide projects. So, ASHRAE needs to have a stronger global presence to better serve our members. As President Tim Wentz said, "We need to be in the room." Now is the time to make the room bigger.

Today we have approximately 57,000 members with 20% located outside of North America, representing more than 130 countries. We have more than 180 chapters and 269 student branches. We have only two regions that are entirely outside North America: Region XIII that encompasses East and Southern Asia and Region at Large (RAL) which encompasses Europe, the Middle East and parts of Asia (India, Pakistan, etc.). Europe is challenged as most of the 1,800 members do not enjoy the benefits of a local Chapter. The roles of national societies in RAL and Region XIII countries often overlap the role of traditional Chapters. In Europe, for example, national HVAC&R societies have about 100,000 members compared to our 1,800 members.

To better serve ASHRAE European members and to improve the influence of ASHRAE members in Europe, the Board has recently decided to carve out a new European region from the RAL. The new European Region will strengthen the grassroots Chapter and Regional infrastructure, a strategy that has proven successful around the globe. It will also provide a dedicated Board representative from Europe. A new Region will also encourage the board to think more globally. With this new region will also come a new chapter in Ireland, which will be vitally important for collaboration throughout the new region.

Collaborating with the individual national HVAC&R Societies throughout Europe is critically important. To help drive those relationships, the Board has approved strategic partnership agreements with CIBSE, AiCARR and REHVA. These agreements will increase the knowledge transfer both ways between North America and Europe.

ASHRAE Associate Society Alliance

As we energize our global presence, we need to build on the relationships established through the ASHRAE Associate Society Alliance (AASA). Although AASA successfully brings more than 60 HVAC&R Societies from around the world together, it has tremendous untapped potential to unite the global built environment. AASA was formed many years ago when we did not have chapters outside North America and today many ASHRAE chapters co-exist with AASA Societies. We need to make AASA stronger. We need to 'upgrade' it to a Global HVAC&R Alliance that unites the global built environment – one that creates a powerful force addressing global issues such as climate change and indoor air quality. One that allows us to speak with a larger, more influential voice on the global stage. I am pleased to announce we are planning to have the first meeting of AASA outside North America specifically to discuss the creation of the Global HVAC&R Alliance. That meeting will be held in Brussels in April 2018

REHVA ambassador Jaap Hogeling had the honour to act as Master of Ceremonies during the traditional presidential lunch. He introduced the Executive committee and various guests, the ASHRAE Board of Directors and Tim Wentz, the ASHRAE president 2016-2017. Tim Wentz thanked the retiring board members installed the new board members and handed his presidential pin to the new elected president Bjarne Olesen. Jaap introduced Bjarne as the second ASHRAE president from Europe which reflects the international character of the ASHRAE membership. Introducing him as a citizen from one of the happiest countries in the world. But, moreover, a world citizen with a focus on the health and well-being of the people, where globalization in our professional fields will support a more sustainable build environment.

parallel to the general assembly of REHVA. Again, this is to emphasize and EXTEND our global presence and our willingness to collaborate.

EXTENDING our Technological Horizons

We also need to EXTEND our Society's scope beyond traditional commercial buildings. We need to extend our standards, research and outreach to broader communities and needs. We need to focus on building performance beyond commercial buildings. We need to EXTEND our technological tools and knowledge to address needs in residential buildings and in developing economies.

Residential

As we spend more than 50% of our time in our homes and as energy use in residential buildings is greater than in commercial buildings, we need to increase our activities to serve the residential marketplace.

The first step was forming a committee under the Technology Council – the "Residential Buildings Committee" – which will be in charge of EXTENDING our presence. Several initiatives are already underway.

An important issue with residential buildings is the significant influence of the user. Occupant behaviour in homes will significantly influence both the indoor environment and energy usage. We need to obtain a much better understanding of occupant behaviour so we can address it in design, control and user feedback in residential buildings.

EXTENDING our Value to Members

It is extremely important that our efforts increase ASHRAE's value to members throughout the world. Innovation must flow in all directions across continental boundaries if the Society is going to achieve its mission of advancing the arts and science of HVAC&R to serve humanity and create a more sustainable world. ■

Building a successful EU HVAC Community through REHVA

When the General Assembly expressed its vote, and elected me as REHVA President, I took the duty to develop and articulate a vision about the mission of REHVA. This was and is fundamental: to track the path from where we are now to where we wish to be in the future. We need this vision: REHVA rapidly grew up during the last decade, changing structure and activities, moving from a Club of Friends as REHVA was in its initial stage, to a recognized European and international organization.

Now, it is time for REHVA to become and to act as an Institution.

The goal of REHVA is to serve its Members and to coordinate actions with its Supporters too. Members are the National Associations: a very heterogeneous mix of different organisms, from big to small, from old to young, managing from very high to very small budgets. If, on one hand, this variety could be difficult to tune within a unique trajectory, this variety itself is a great richness, not known anywhere else in the world. We must be proud of this variety.

In this complex scenario, REHVA has to play as a platform collecting, organizing and disseminating among its Members and in international context the different experiences, skills and activities developed by each single Member. REHVA is a platform through which bridges among Members can be activated and connections with European institutions and international organizations can be enforced.

This bridging activity is strategic in terms of "internal policy": by sharing knowledge and experiences, the big National Associations can help and assist the growing of the new and young ones, and the young Associations can feed the old ones with their enthusiasm and new ideas. REHVA Supporters can help this process too. REHVA must facilitate these connections and networking, to create a strong and powerful European community of the HVAC sector, deeply based on European traditions. To build this strong EU community will ease, both at local and regional level, establishing interaction with international organizations we consider important for our HVAC sector. It is our strategy to act within a global context, taking the mutual advantages through the involvement of our international MoU partners as well.

To enlarge our community, I think it is fundamental wise to consider a revision of the membership policy, as well as the set-up of a specific platform to share products and services among Members, using the REHVA platform as facilitator.

REHVA is, first of all, a cultural organization, improving and sharing ideas based on European principles of mutual cooperation. My duty as REHVA President is to respect the leadership and autonomy of each National Association, but also to encourage and stimulate a continuous and proactive process of sharing the know-how to stimulate the harmonic growing of all the members of the REHVA family.

To score this goal, we have to understand the needs and expectations of each Association and further develop our line of action all together, as a real family. If we will be able to follow this path, I see a successful future for REHVA!

REHVA Hop!

STEFANO CORGNATI
REHVA PRESIDENT

REHVA Annual Meeting 2018

Announced to be held on April 21st and 23rd, 2018, in Brussels, Belgium.

The next REHVA Annual Meeting will be held in Brussels by ATIC, the REHVA Member organizing it.

More information about the exact location and schedule will be upload on the REHVA Website in the next months.

It’s time the HVAC sector acts more global!

The importance of globalisation for our HVAC&R sector cannot be overestimated. Worldwide our systems in buildings use more than one third of our total energy consumption. Most of this energy is still from fossil or other non-renewable sources (considering the non-renewable part of renewable energy producers and sources). The need to apply energy saving technologies. Which implies first of all reducing the energy need of our buildings and second improve the energy efficiency of the HVAV&R systems and integrate where possible renewable energy production at the building (-site). This have to be achieved in a holistic way by optimising all measures taking into account the expected user behaviour and (changing) outdoor climate conditions. This to reduce the impact of the energy use and connected CO_2 emission on our environment. The Paris agreements require us to follow this path, then, in this respect, currently formulated EU policy targets are even on the conservative site. We should do more knowing that despite all our good intentions, the estimated targets are seldom met.

We can improve our existing buildings and new designs by reducing the energy need and HVAC system energy use by making the systems more efficient and integrate sustainable energy sources into our designs. However, this should be done keeping the cost-effectiveness in mind. There two main reasons to emphasise the low-cost approach:

1) Apart from very motivated consumers most of our clients are not to motivated to spent more for a healthy, comfortable and sustainable indoor environment.
2) -The price of energy is not expected to rise substantially in the near future, this assumption is based on the increased energy production by sustainable sources that become that cost-effective, that they compete the conventional sources, which will be even more if the CO_2 pricing mechanism becomes more effective.

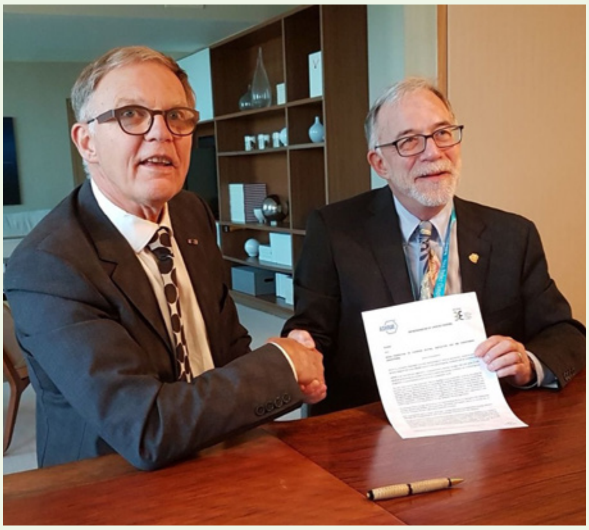
How will globalisation help us to achieve our targets more easily?

If we agree worldwide on the procedures how to asses the energy performance of buildings inclusive the energy using products and HVAC systems. We open the possibility to create a global market for energy saving technologies. A market without the current technology barriers and hopefully with free trade for all related products. If we as technical experts on HVAC&R can agree on the harmonised technical standards for these products and systems, it is up to our politicians to have the insight to create this open market. The current international developments as Brexit, Trump, the G20 results doesn’t seem encouraging, but they should strengthen our efforts to achieve the Paris target!

The realisation of the set of 52 EPB standards under EU Mandate 480, which includes already 17 ISO standards, is a first step. Now they have to be implemented in Europe at first, as we have the EPBD directing our EU Member states to take these implementation steps. Connected to this we have the ECOdesign directive resulting on a regulation regarding energy using products as used as parts of our building systems. These two directives go hand in hand, although some implementation fine tuning is still needed.

Having global network organisations like ISO and CEN, to develop these standards is of great importance. For support of the application of these standards we need the support of professional organisations and their connected educational systems and schemes. The REHVA members’ associations play an essential role in Europe. Their cooperation is part of REHVA, REHVA’s participation in the EPB Center is one of its actions. But we have to move further at global level, the system standards in the EPB set should also become shared EN and ISO standards. This will facilitate the communication about better energy efficient solutions and harmonise our procedures and product declarations. By this creating an innovation supporting global energy saving market.

Given this context it is no surprise that global active organisations like ASHRAE, REHVA, AIVC, etc. supported a few years ago to set-up a global alliance on Indoor Environmental Quality (IEQ) which is expected to be established beginning next year. Last June, the new ASHRAE president, Bjarne Olesen the 2nd ASHRAE president from Europe, raised in his presidential welcome address “Extending Our Community” the question how we could more benefit from a more global cooperation? The answer to this question should serve as the foundation of a new global strategy that addresses challenges facing the global building industry today. REHVA is expected, as voice of its members together with its MoU partners, to be part of this more global approach. All major companies have an interna-



Tim Wentz and Jaap Hogeling signed on June 25th, 2017 on behalf of ASHRAE and REHVA a renewed MoU between ASHRAE and REHVA.

REHVA supports the globalisation of our HVAC&R professional world. Both organisations express the wish to extend the global reach and better support its membership. This was also the background of the formation of a new ASHRAE Region in Europe – Region XIV, which started July 1st, 2017.

This agreement, in line with the ones REHVA signed with its other international partners, will increase the knowledge mutual transfer from the societies and organisation between North America and Europe, will outline how the groups will work together more closely to continue furthering and promoting the advancements of HVAC&R technologies. These include but are not limited to: research; joint conferences and meetings; training and workshop programs; publication distribution and other form of collaboration.

tional presence and reach many countries. Consultants, engineers and architects have worldwide projects. Professional organisations and REHVA committed to serve the European societies needs to have a strong global presence to serve its members and supporters. A possible future HVAC Global Alliance must be seen in line with the urgency contribute to a sustainable build environment where a healthy and comfortable indoor environment is safeguarded. Global professional cooperation will enhance harmonisation of procedures and innovation and give us a voice to be heard solving the challenges we are confronted with.

JAAP HOGELING
Chair REHVA External Relations Committee

Stay Tuned for the REHVA Brussels Summit 2017

REHVA Brussels Summit 2017 will be held on November 13th and 14th, 2017. SAVE THE DATE!

REHVA will organize Committee Meetings on November 13th and a Seminar on November 14th, 2017.

The REHVA Brussels Summit will launch a new sequence of REHVA meetings offering an intense 2-days event with a new concept and a revamped visual design.

Monday, November 13th will be dedicated to meetings with the REHVA Board, Committees and to meetings with MoU partners and sister organisations in the Maison des Associations Internationales (Rue Washington 40, 1050 Bruxelles) followed by a seated dinner in The Hotel (Boulevard de Waterloo 38, 1000 Bruxelles).

Tuesday, November 14th will feature a REHVA Seminar "Delivering healthy and energy efficient buildings with EPBD" giving the floor to European Institutions, stakeholders' representatives, and REHVA Supporters. Our guest speakers will tackle hot topics such as the EPBD review, buildings health performances and the smart readiness indicator. It will be held in The Hotel (Boulevard de Waterloo 38, 1000 Bruxelles).

More information & registration on the REHVA Website.

REHVA World Congress CLIMA2019

May 26th to 29th, 2019, Bucharest, Romania.

The next REHVA World Congress, CLIMA2019 was promoted during the last REHVA Annual Meeting by the new REHVA Board Member Catalin Lungu as vice – president of AIIR, the REHVA Member organizing it. The next CLIMA Congress will be held in the Romanian Parliament Palace in Bucharest between May 26th and May 29th, 2017.

More information http://clima2019.org/

BELIMO

BELIMO CLOUD

Product news

Transparent energy monitoring of multifunctional valves with the Belimo Cloud

The Belimo Energy Valve™, which consists of a 2-way characterised control valve, volumetric flow meter, temperature sensors and an actuator with integrated logic combines many functions in a single installation-friendly unit. This intelligent technology brings new advantages: Quick and certain dimensioning as well as simple commissioning. Energy-saving through automatic, permanent hydronic balancing and correct volume of water despite differential-pressure changes and partial loads. With the integration of the Belimo Energy Valve™ into the Belimo Cloud users create their own account to have full transparency about the energy consumption in the cooling/heating application – anytime and from everywhere and whenever they want.

One optimised complete solution – easier energy control than ever before

The new Belimo Energy Valve™ is an Internet of Things (IoT) device – a smart connected pressure-independent valve that measures and manages coil energy consumption by utilising an embedded flow meter, along with supply and return water temperature sensors. The Belimo Energy Valve™ also has power control and Delta-T manager logics built-in that monitor coil performance and optimise the heat transfer of the coil by maintaining the Delta-T.

The Belimo Energy Valve™ combines several useful functions in one valve unit. Such as the connection to BACnet, MP-Bus and Modbus with the same valve. Besides this multi-bus connection, it is possible to save and reload settings from one valve configuration and load them into another valve allowing for fast and accurate setup. Another highlight is the new designed user interface with an intuitive installation setup to make the valve ready in only a few steps. An exclusive Belimo Energy Valve™ feature is the glycol monitoring. It utilises an embedded temperature sensor and advanced logic algorithms to monitor the percentage of glycol content in the HVAC system.

Belimo Cloud – The future begins now

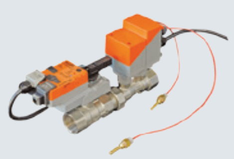
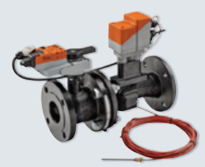
The Belimo Cloud Optimisations make full use of the energy potential. Cloud Analytics offers recommended Delta-T settings by Belimo experts for an efficient operation. Belimo Cloud Support helps to commission and produce the optimum setting for the Belimo Energy Valve™ in all operating phases.

The Belimo Cloud provides straightforward access to all data over the entire life cycle of the Belimo Energy Valve™, thus forming the basis for future operation optimisation. Belimo Cloud Reporting permits a complete overview of the current and previous performance data such as flows, energy consumption, power requirements and Delta-T with the most important performance indicators shown in graphs.

The Belimo Cloud Service regularly provides users with software updates and experienced Belimo technicians help users to solve technical problems and to improve system performance and stability. The access to the Belimo online services makes life easier and gives the security to always have the best settings for the devices.

More information: **www.belimo.eu**

Full range from DN 15 to DN 150 mm

Belimo Energy Valve™		
Nominal diameter DN [mm]	15…50	65…150
$\dot{V}_{nom}$ [l/s]	0.35…4.8	8…45
$\dot{V}_{nom}$ [l/min]	21…288	480…2700
Adjustable maximum flow rate [l/min]	6.3…288	216…2700

Medium temperature: -10 °C…120 °C **System pressure (ps):** 1600 kPa

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations
SUPPORTER

REHVA SUPPORTERS

A REHVA supporter is a company or an organization that shares the same objectives as REHVA. Our REHVA supporters use the latest European technologies to make their products. The REHVA Supporters are also members of reHVAClub. For more information about REHVA Supporters' services, please contact cg@rehva.eu or call +32 2 5141171.

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DencoHappel
Doset Impex
Geneko
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ES-SO European Solar-Shading Organization – Energy Savings & Comfort
Eurovent Certita Certification
evapco for LIFE
FläktWoods A FläktGroup Brand
FRITERM Termik Cihazlar Sanayi ve Ticaret A.Ş.
Granlund Less energy gives more
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Lindab
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REHVA MEMBERS

Network of European HVAC associations

Association Royale de la Technique du chauffage, de la ventilation et de la climatisation—Belgium

Croatian Chamber of Mechanical Engineers—Croatia

Society of Environmental Engineering—Czech Republic

Danish Society of Heating, Ventilating and Air Conditioning Engineers -Denmark

The Estonian Society of Heating and Ventilation Engineers—Estonia

The Finnish Association of HVAC Societies—Finland

Association des Ingénieurs en Climatique, Ventilation et Froid—France

The Association of German Engineers—Germany

Scientific Society for Building—Hungary

Hungarian Coordinating Association of Building Engineering - Hungary

Associazione Italiana Condizionamento dell'aria, Riscaldamento Refrigerazione—Italy

Association of Heat, Gas and Water Technology Engineers of Latvia—Latvia

Lithuanian Thermotechnical Engineer's Society—Lithuanua

Installation Engineers Association from Moldova—Moldova

Dutch Society for Building Services—Netherlands

Norwegian Society of HVAC Engineers, NORVAC—Norway

Polskie Zrzeszenie Inżynierów i Techników Sanitarnych —Poland

Portuguese Association of Engineers—Portugal

Romanian Association for Installations Engineers—Romania

Romanian General Association for Refrigeration—Romania

Romanian Association for Refrigeration and Criogenics Engineers—Romania

Association of Engineers in Heating, Ventilation, Air-conditioning, Heat Supply & Building Thermal Physics—Russia

Serbia HVAC&R Society—Serbia

Slovak Society for Environmental Technology—Slovakia

Slovenian Society for Heating, Refrigerating and Air-conditioning Engineers — Slovenia

Asociación, Técnica Española de Climatización y Refrigeración—Spain

Swedish HVAC Society - Society of Energy and Environmental Technology - Sweden

Société suisse des ingénieurs en technique du bâtiment—Switzerland

Turkish Society of HVAC and Sanitary Engineers—Turkey

Chartered Institution of Building Services Engineers—United Kingdom

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Send information of your event to Ms Chiara Girardi cg@rehva.eu

Events in 2017–2018

Conferences and seminars 2017

September 13–14	Ventilating healthy low-energy buildings	Nottingham, UK	http://www.aivc2017conference.org/
October 24–25	European Heat Pump Summit 2017	Nuremberg, Germany	https://www.hp-summit.de/en
October 31	7th International Conference on Solar Air-Conditioning–PV Driven/Solar Thermal	Abu Dhabi, UAE	http://www.solaircon.com/
November 1–3	XXXIV Conference and Exhibition "Moscow – energy efficient city"	Moscow, Russia	http://events.abok.ru/
November 10–11	Second ASHRAE Developing Economies Conference	Delhi, India	https://ashraem.confex.com/ashraem/de17/cfp.cgi
November 13–14	REHVA Brussels Summit	Brussels, Belgium	http://www.rehva.eu/
December 6–8	The 48th International Congress and Exhibition on Heating, Refrigeration and Air-Conditioning	Belgrade, Serbia	http://kgh-kongres.rs/index.php?lang=sr

Exhibitions 2017

September 5–7	ISH Shanghai & CIHE 2017	Shanghai, China	www.ishs-cihe.hk.messefrankfurt.com
September 19–23	FOR ARCH	Prague, Czech Republic	www.forarch.cz/en/
October 10–12	HVAC 2017	Birmingham, UK	www.hvaclive.co.uk
November 7–10	INTERCLIMA+ELECHB	Paris, France	http://www.interclimaelec.com/

Conferences and seminars 2018

January 22–24	2018 AHR Expo	Chicago, IL, USA	www.ahrexpo.com
February 7–10	ISK–Sodex	Istanbul, Turkey	http://www.sodex.com.tr/en
February 22–24	ACREX 2018	Bengaluru, India	http://www.acrex.in/home
March 12–15	Cold Climate HVAC Conference 2018	Kiruna, Sweden	http://www.cchvac2018.se
June 3–6	ROOMVENT & VENTILATION 2018	Espoo, Finland	http://www.roomventilation2018.org/

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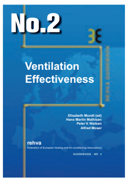
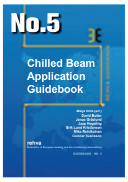
REHVA GUIDEBOOKS

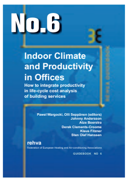
REHVA Guidebooks are written by teams of European experts



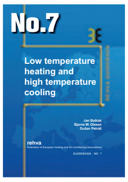
Ventilation Effectiveness. Improving the ventilation effectiveness allows the indoor air quality to be significantly enhanced without the need for higher air changes in the building, thereby avoiding the higher costs and energy consumption associated with increasing the ventilation rates. This Guidebook provides easy-to-understand descriptions of the indices used to measure the performance of a ventilation system and which indices to use in different cases.



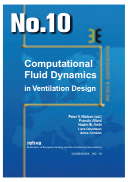
Chilled Beam Cooling. Chilled beam systems are primarily used for cooling and ventilation in spaces, which appreciate good indoor environmental quality and individual space control. Active chilled beams are connected to the ventilation ductwork, high temperature cold water, and when desired, low temperature hot water system. Primary air supply induces room air to be recirculated through the heat exchanger of the chilled beam. In order to cool or heat the room either cold or warm water is cycled through the heat exchanger.



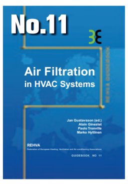
Indoor Climate and Productivity in Offices. This Guidebook shows how to quantify the effects of indoor environment on office work and also how to include these effects in the calculation of building costs. Such calculations have not been performed previously, because very little data has been available. The quantitative relationships presented in this Guidebook can be used to calculate the costs and benefits of running and operating the building.



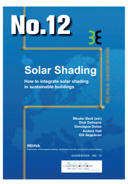
Low Temperature Heating And High Temperature Cooling. This Guidebook describes the systems that use water as heat-carrier and when the heat exchange within the conditioned space is more than 50% radiant. Embedded systems insulated from the main building structure (floor, wall and ceiling) are used in all types of buildings and work with heat carriers at low temperatures for heating and relatively high temperature for cooling.



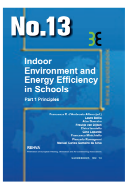
Computational Fluid Dynamics in Ventilation Design. CFD-calculations have been rapidly developed to a powerful tool for the analysis of air pollution distribution in various spaces. However, the user of CFD-calculation should be aware of the basic principles of calculations and specifically the boundary conditions. Computational Fluid Dynamics (CFD) – in Ventilation Design models is written by a working group of highly qualified international experts representing research, consulting and design.



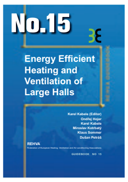
Air Filtration in HVAC Systems. This Guidebook will help the designer and user to understand the background and criteria for air filtration, how to select air filters and avoid problems associated with hygienic and other conditions at operation of air filters. The selection of air filters is based on external conditions such as levels of existing pollutants, indoor air quality and energy efficiency requirements.



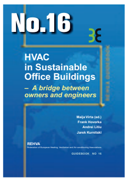
Solar Shading – ***How to integrate solar shading in sustainable buildings.*** Solar Shading Guidebook gives a solid background on the physics of solar radiation and its behaviour in window with solar shading systems. Major focus of the Guidebook is on the effect of solar shading in the use of energy for cooling, heating and lighting. The book gives also practical guidance for selection, installation and operation of solar shading as well as future trends in integration of HVAC-systems with solar control.



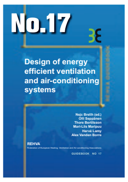
Indoor Environment and Energy Efficiency in Schools – ***Part 1 Principles.*** School buildings represent a significant part of the building stock and also a noteworthy part of the total energy use. Indoor and Energy Efficiency in Schools Guidebook describes the optimal design and operation of schools with respect to low energy cost and performance of the students. It focuses particularly on energy efficient systems for a healthy indoor environment.



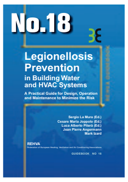
Energy Efficient Heating and Ventilation of Large Halls. This Guidebook is focused on modern methods for design, control and operation of energy efficient heating systems in large spaces and industrial halls. The book deals with thermal comfort, light and dark gas radiant heaters, panel radiant heating, floor heating and industrial air heating systems. Various heating systems are illustrated with case studies. Design principles, methods and modelling tools are presented for various systems.



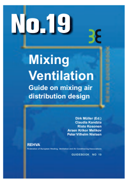
HVAC in Sustainable Office Buildings – ***A bridge between owners and engineers.*** This Guidebook discusses the interaction of sustainability and heating, ventilation and air–conditioning. HVAC technologies used in sustainable buildings are described. This book also provides a list of questions to be asked in various phrases of building's life time. Different case studies of sustainable office buildings are presented.



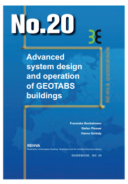
Design of energy efficient ventilation and air-conditioning systems. This Guidebook covers numerous system components of ventilation and air-conditioning systems and shows how they can be improved by applying the latest technology products. Special attention is paid to details, which are often overlooked in the daily design practice, resulting in poor performance of high quality products once they are installed in the building system.



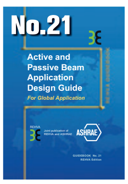
Legionellosis Prevention in Building Water and HVAC Systems. This Guidebook is a practical guide for design, operation and maintenance to minimize the risk of legionellosis in building water and HVAC systems. It is divided into several themes such as: Air conditioning of the air (by water – humidification), Production of hot water for washing (fundamentally but not only hot water for washing) and Evaporative cooling tower.



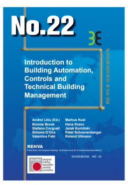
Mixing Ventilation. In this Guidebook most of the known and used in practice methods for achieving mixing air distribution are discussed. Mixing ventilation has been applied to many different spaces providing fresh air and thermal comfort to the occupants. Today, a design engineer can choose from large selection of air diffusers and exhaust openings.



Advanced system design and operation of GEOTABS buildings. This Guidebook provides comprehensive information on GEOTABS systems. It is intended to support building owners, architects and engineers in an early design stage showing how GEOTABS can be integrated into their building concepts. It also gives many helpful advices from experienced engineers that have designed, built and run GEOTABS systems.



Active and Passive Beam Application Design Guide is the result of collaboration by worldwide experts. It provides energy-efficient methods of cooling, heating, and ventilating indoor areas, especially spaces that require individual zone control and where internal moisture loads are moderate. The systems are simple to operate and maintain. This new guide provides up-to-date tools and advice for designing, commissioning, and operating chilled-beam systems to achieve a determined indoor climate and includes examples of active and passive beam calculations and selections.



Introduction to Building Automation, Controls and Technical Building Management. This guidebook aims to provide an overview on the different aspects of building automation, controls and technical building management and steer the direction to further in depth information on specific issues, thus increasing the readers' awareness and knowledge on this essential piece of the construction sector puzzle. It avoids reinventing the wheel and rather focuses on collecting and complementing existing resources on this topic in the attempt of offering a one-stop guide.

REHVA – Rue Washington, 40 – 1050 Brussels – Belgium
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