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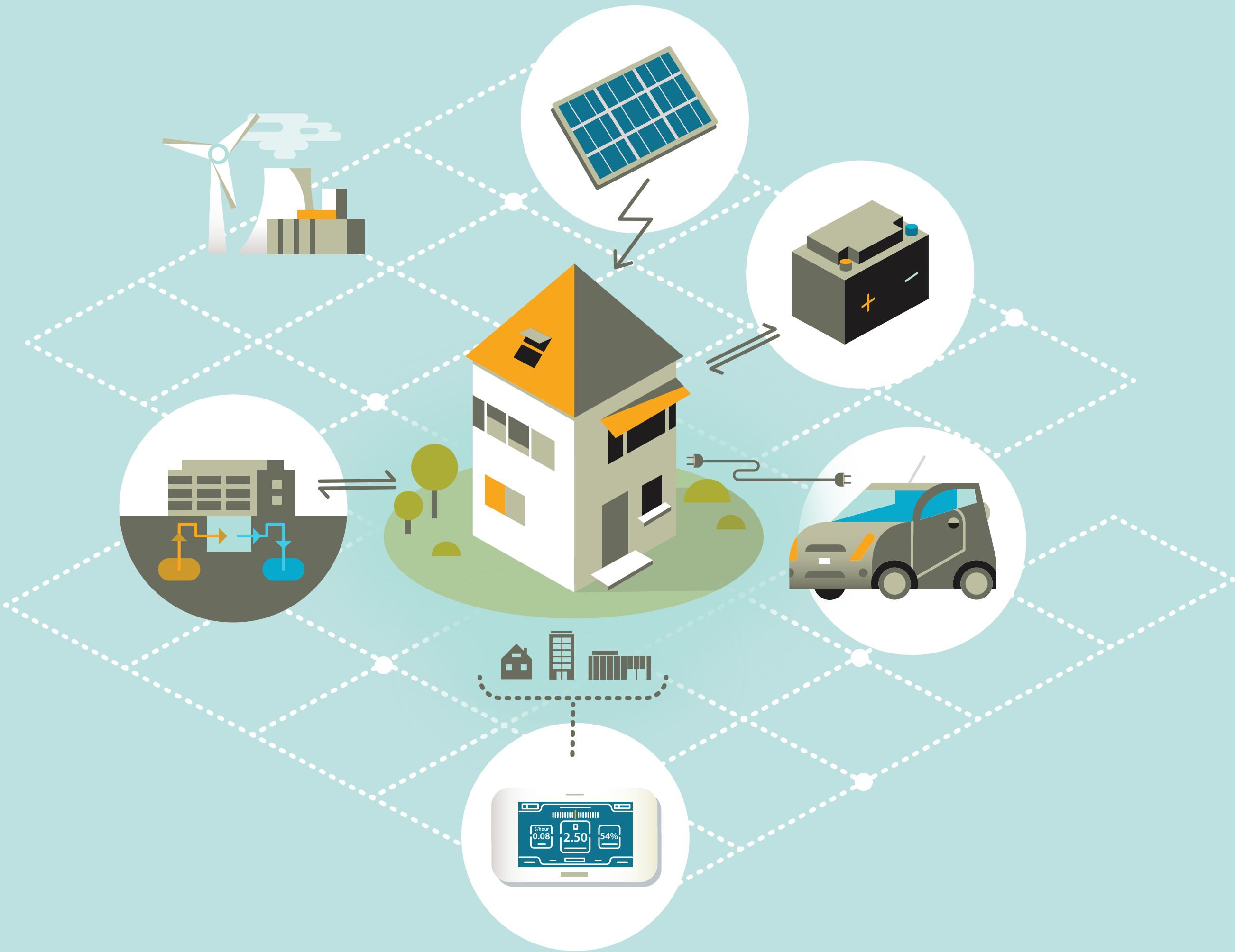
Smart Readiness Indicator a promising concept?



Domestic Hot Water Storage

A Case of Excellence in Indoor Environmental Quality

Cold Climate Conference Report

The REHVA European HVAC Journal

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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

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SUBSCRIPTIONS and CHANGES OF ADDRESSES

REHVA OFFICE:
Washington Street 40
1050 Brussels, Belgium
Tel: +32-2-5141171
info@rehva.eu, www.rehva.eu

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Smart Readiness Indicator (SRI) a challenge for the HVAC professional?

The revised EPBD as approved last May 2018 includes this new SRI concept. The SRI intends to indicate how well the building systems for HVAC and other services are capable to interact with the local energy grid and energy storage capabilities. Storage of electric energy in (car)-batteries and other thermal storage capabilities as integral part of the building energy system. Buildings are to be considered as energy producers and energy users. At the same time our buildings and systems have to guaranty a healthy and comfortable indoor environment. The IEQ performance shall be an integral part of this SRI concept!

EU Commission officials reacted positive on the acceptance of the revised EPBD:

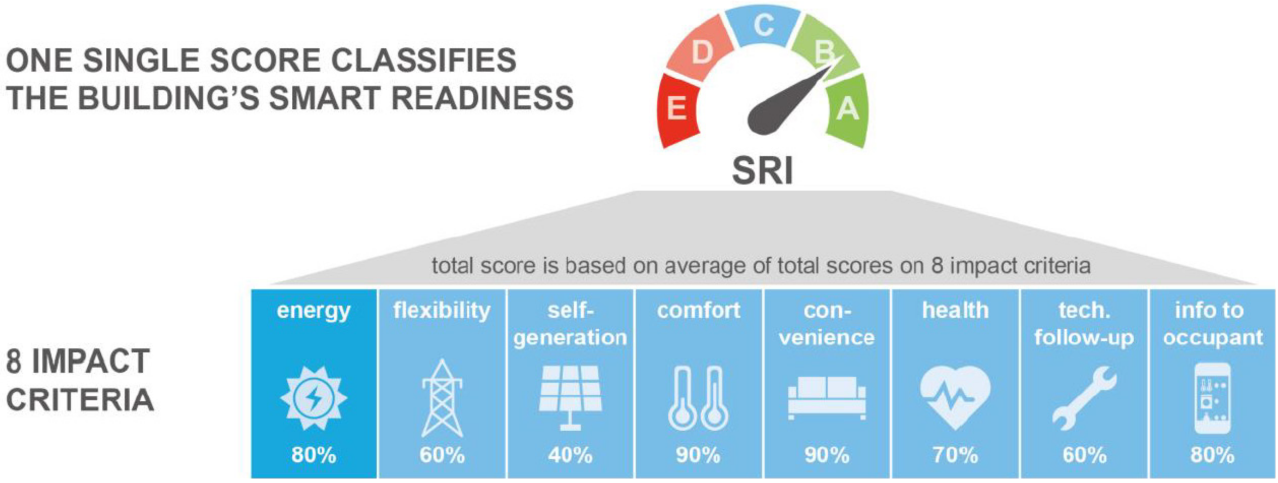
Vice-President responsible for the Energy Union **Maroš Šefčovič** said:

By renovating and making our buildings in Europe smarter, we are attaining several simultaneous objectives: lower energy bills, better health, protection of the environment and reduction of our emissions in the EU, given that over a third of these are produced by buildings. And as technology has blurred the distinction between sectors, we are also establishing a link between buildings and e-mobility infrastructure, and helping stabilize the electricity grid. Another building block of the Energy Union has been laid today, let us continue ahead.

Commissioner for Climate Action and Energy **Miguel Arias Cañete** added:

This is the first final agreement on a proposal of the Clean Energy for All Europeans Package, a signal that we are on the right track and we will deliver on our pledge made at the beginning of the mandate. Our ambitious commitment to clean energy in Europe and the Paris Agreement will be made a reality by laws like the one voted today: the revised EPBD will help create local jobs, save consumers money and improve Europeans' quality of life. It will also help combat energy poverty by reducing the energy bills of older buildings which will be renovated. I now call on the European Parliament and the Council to show leadership and complete the rest of the proposals of the Clean Energy for All Europeans Package.

In the EPBD it is stated that before the end of 2019 the SRI concept should be clear and well defined to become a nominator (or set of nominators?) expected to be included in the Energy Performance Certificate of buildings. Ongoing studies and discussion on what to include in this SRI concept is further addressed in in this REHVA Journal issue. How one single score can address the different criteria is still an open question.



Proposed SRI indicator based on a catalogue of smart ready services, which functionality levels result in scoring on 8 impact criteria (see page 6).

It is urgent that the REHVA professional community actively participates in the definition of the SRI concept. It is expected that the REHVA Technology and Research Committee will actively contribute. ■

JAAP HOGELING
Editor-in-Chief

Smart Readiness Indicator (SRI) for buildings not so smart as expected

JAREK KURNITSKI
Chair of REHVA Technical
and Research Committee
jarek.kurnitski@ttu.ee

JAAP HOGELING
Director EPB Center
Jaap.hogeling@epb.center

Progress of the technical study commissioned and supervised by the European Commission services (DG ENERGY) towards the development of a smart readiness indicator for buildings was reported in stakeholder meeting of 28 May 2018. SRI is a policy initiative by the European Commission, which is part of the amended Energy Performance of Buildings Directive (EPBD) [1]. In more detail, SRI is described in the second progress report from June 12 2018 [2].

Proposed SRI is a catalogue of smart ready services – 52 of such services are to be inspected. This should happen in a site visit, where an assessor inspects which smart ready services are present in a building, and to what functionality level they are implemented. This is assessed based on a simple check-list approach, e.g. "control the power of artificial lighting". Each of the services can be implemented with various degrees of smartness (referred to as 'functionality levels'), e.g. "manual on/off control of lighting", "automatic on/off switching of lighting based on daylight availability", or even "automatic dimming of lighting based on daylight availability". A higher functionality level is assumed to provide more beneficial impacts to the users of the building or the connected grid compared to a lower level. The smarter services with the higher functionality level the higher the score of the SRI.

Smart ready services are grouped into 10 domains; for every service or subservice, the functionality level is assessed with five options, i.e. from level 0 to 4. Assessed functionality levels result in impact scores in 8 impact criteria, which are listed in **Figure 1**. The 10 domains of the services are the following:

1. Heating
2. Domestic hot water
3. Cooling
4. Mechanical ventilation
5. Lighting
6. Dynamic building envelope
7. Energy generation
8. Demand side management
9. Electric vehicle charging
10. Monitoring and control

As a catalogue of smart ready services, SRI does not make an attempt to assess the performance of the building by any calculation or measurement. Therefore, there is no real performance quantification and it is quite evident that in different buildings the same service or technical feature can result in different outcomes. This calls for wider discussion how SRI should be set up. The current approach is very much targeted to existing (old) buildings, where checklist-based assessment is cheap and easy to conduct. However, existing buildings are not the only use case of SRI, as the most focus of EPBD is on design of new buildings and major renovations. In the design phase, quantitative assessment for instance with energy and indoor climate simulation tools, would be natural way for the performance assessment. As the development of SRI is in a half way, it is possible that quantitative, performance-based approach would be considered in next steps.

What are the main challenges of the quantitative approach? According to EPBD SRI should focus on

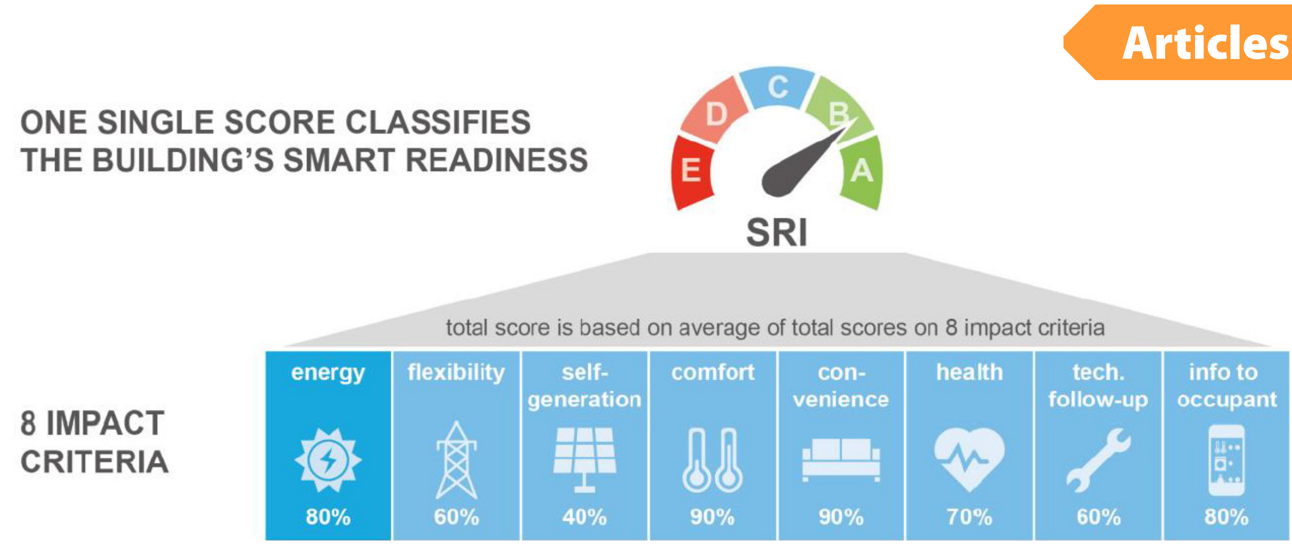


Figure 1. Proposed SRI indicator based on a catalogue of smart ready services, which functionality levels result in scoring on 8 impact criteria [2].

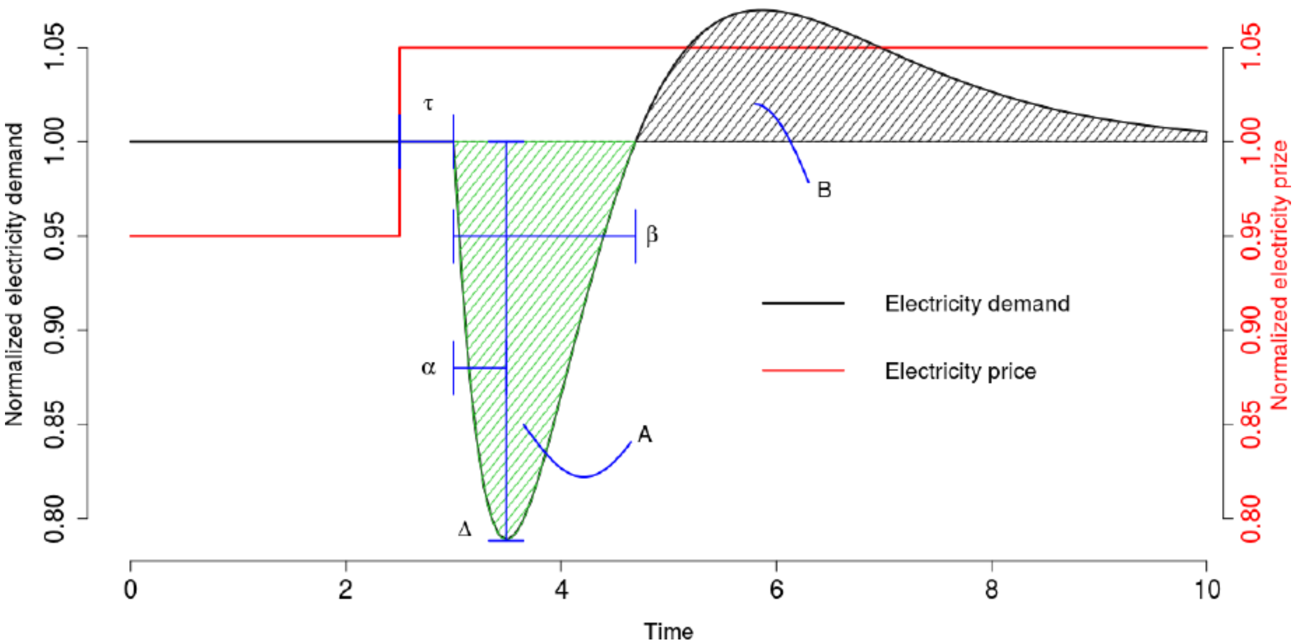


Figure 2. Example of electric power flexibility – response of building's electricity demand to a price signal. τ is the delay time from signal submitted to an action starts, α is the time to max response Δ, β is the duration of the response, *A* is the shifted amount of energy and *B* is the rebound effect for returning the situation back to the balance. [5]

building's adaptation to user and grid needs. EPBD Annex 1A list the key scope of SRI as follows:

(a) Adaption of energy consumption to more renewable sources;
(b) Adaptation in response to user needs;
(c) Flexibility of electricity demand in relation to the grid.

In technical terms it sounds that at least two indicators (or set of indicators) are needed to cover this scope, because it is not meaningful to combine the adaptation to user and to grid needs. (a) and (c) may be combined to flexibility/demand response indicator, because these represent two sides of power generation – surplus and shortage situation. User needs (comfort, air quality, lighting, convenience,…) are not measured in power units and will need completely different set of indicators.

Therefore, the key scope of SRI can be broken down into electric power flexibility and user need indicators. A flexibility indicator basically will indicate how much electric power can be shifted and for how long time – typically from electricity high price situation to low price situation. There are 12 available performance-based indicators [3] listed by IEA EBC Annex 67 Energy Flexible Buildings [4], the concept is explained in **Figure 2**. Therefore, it would be relatively easy to fit some of these existing ones to EPBD purpose and to set up a flexibility indicator that is possible to calculate or measure.

Adaptation to user needs may be described with well-being, convenience as well as relevant information to occupant. These features can be measured with indoor air quality, thermal and visual comfort (acoustic comfort may also be an issue through equipment noise) generally describing occupant satisfaction with the building. For indoor environmental quality a set of indicators based on prEN 16798-1 [6] items and categories are possible to use. An example of measuring user needs related to indoor air quality and thermal comfort is shown in **Figure 3**. Convenience could describe how easy it is to operate the building and its technical systems and perhaps the same for the maintenance, but there are not yet standardized indicators for this domain. Generally, different user needs cannot be summed to one indicator, because for instance good air quality will not compensate bad thermal comfort and vice versa. Therefore, a set of users' needs indicators is needed. Most basic user needs as thermal comfort and indoor air quality can be easily obtained from energy and indoor climate simulation – a method already in use in some Member States for compliance assessment with minimum energy performance requirements.

There is some ongoing discussion to which extent the mandate of EPBD SRI covers the user needs, as the adaptation by smart operation and controls maybe seen on the top of the technical systems basic capacity. However, as every technical system today has built in controls being an essential part of the system and its operation, it is almost impossible to compare the operation with and without controls because without controls situation does not exist in reality. The same applies for self-regulating or passive systems and solutions which also do an adaptation to user needs but

Photo by Joel Filipe on Unsplash

not in actively controlled manner. Thus, the only reasonable way seems to assess the adaptation to user needs as user perceives the wellbeing and convenience in the building, i.e. based on indoor climate and some possible other criteria to cover all aspects included.

To summarize, SRI checklist and scoring proposed by the preparatory study is clearly oriented to be used in existing old buildings to make the assessment easy and cheap. New buildings and major renovations (excluding single family houses) will deserve more credible SRI being based on quantitative calculation, for which purpose energy calculation (hourly) methods could be extended to be used in a fashion some Member States

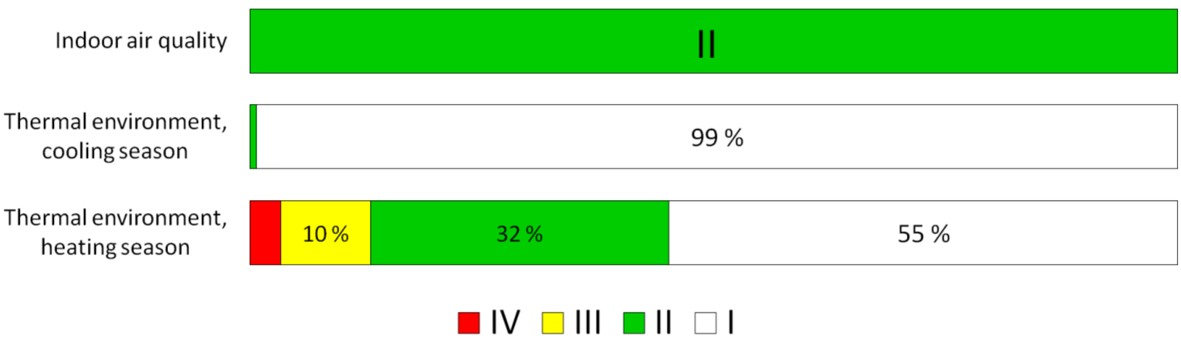


Figure 3. An example of user needs rating based on thermal comfort and air quality Category I, II, III and IV definitions of prEN 16798-1 (replaces EN 15251).

do already energy simulation for compliance assessment and EPC issuing. These simulation calculations allow also to include the add-ons as thermal storages (heat and/or cold) as integral part of the HVAC system. In addition to this electric storage systems could be considered, their dynamic behaviour and proactive role to stabilise the building grid load. While the control based on electricity price signal will direct demand response in the right direction, this is not enough for the stabilising benefits on the local grid level. It would be important to require that the local grid is smart as well. Currently this is not the case, thus, to define an SRI of a building without having a clue if the local grid is smart enough to interact, will reduce its added value.

To continue the development of SRI towards quantitative calculation, already available electric power flexibility indicators proposed by an IEA Annex and a set of criteria for indoor climate describing user needs according to existing European standard, will form a solid basis for next steps. Both should be easily customized for EPBD purposes resulting in the method and allowing to determine real benefits of smart services.

As a next step, the policy making process towards the establishment of the SRI will be undertaken by the European Commission and will formally start when the revised EPBD enters into force. The revised EPBD requires the establishment of two legal acts: a delegated act for the definition and calculation methodology of the SRI and an implementing act for detailing the technical modalities for the effective implementation of the SRI scheme. Both legal acts shall be adopted by 31 December 2019. ■

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[1] Directive (EU) 2018/844 of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency.

[2] Support for setting up a Smart Readiness Indicator for buildings and related impact assessment. Second progress report. 12 June 2018. https://smartreadinessindicator.eu/sites/smartreadinessindicator.eu/files/sri_secondprogressreport_final_0.pdf

[3] Control strategies for building energy systems to unlock demand side flexibility – A review. https://www.researchgate.net/publication/324877113_Control_strategies_for_building_energy_systems_to_unlock_demand_side_flexibility_-_A_review.

[4] IEA EBC Annex 67 Energy Flexible Buildings. http://www.annex67.org

[5] Position Paper of the IEA Energy in Buildings and Communities Program (EBC) Annex67 "Energy Flexible Buildings". http://www.annex67.org/publications/position-paper/

[6] prEN 16798-1 (Will supersede EN 15251:2007). Energy performance of buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics - Module M1-6.

Structuring building monitoring and automation system data




FLORIAN STINNER[1] ALINA KORNAS MARC BARANSKI DIRK MÜLLER

RWTH Aachen University, E.ON Energy Research Center, Institute for Energy Efficient Buildings and Indoor Climate, Aachen, Germany
[1] Corresponding Author: fstinner@eonerc.rwth-aachen.de

This article describes a scheme for naming monitoring data in buildings. This standard supports the automatic analysis of the operation of technical systems.

Standardized monitoring data support automatic analysis of technical systems

Modern non-residential buildings are increasingly equipped with building automation systems. Unfortunately, these buildings rarely reach the promised energy performance indicators and functionality (Waide et al. 2014, Debusscher and Waide 2015, Fütterer et al. 2017). Errors in the programming of complex building automation systems (BAS), but also faulty components must be identified. This requires an analysis of the system. In order to achieve this within a reasonable amount of time, a standardized naming structure of the components is very helpful to quickly find your way around, even in systems that are not planned by yourself.

To achieve this, an intensive analysis is necessary. In practice, time and money for that investigation are limited. In addition, automatic analysis algorithms could accelerate this work. The basis for a reliable working algorithm is a standard for naming the system components. Many data are required for the analysis, which a building automation or an energy monitoring system could supply. Currently, however, the naming of data points is very individual. (Bhattacharya et al. 2016) System integrators or operators have their own idea of a data point naming scheme in order to integrate it into the organizational structure; the scheme of the BAS vendor is implemented, or no explicit scheme is given. After commissioning, this increases the resources (time, money, etc.) required for fault analysis and optimization of the technical systems. Companies that specialize in analyses, optimizations or novel control concepts have to prepare the data with great effort. Only then can the actual desired work begin. This leads to a high basic effort before an action takes place. Standardized monitoring data could break the vendor lock-in, which is a common complaint in building operation practice. This means that specialized and independent companies can focus on analysing building data and provide solutions for the operation of a building system.

Based on four buildings in which the naming scheme is applied, we show how it is used and what possibilities it offers. One of the buildings is currently under construction. For this purpose, we present application fields for the naming scheme.

Actual "Standardization" of monitoring data

For the development of a universal naming scheme, we have investigated different structures from practice (6 examples), norms (3 examples) and schemes (4 examples). The elements of naming are often similar. However, they usually differ in their arrangement, predefined restricted amount of characters and used vocabulary.

The scheme developed by Fraunhofer Institute for Solar Energy Systems ISE (Réhault et al, 2013) proved to be the most applicable, due to its approach of a logical structure and vocabulary, which is why we chose to develop this scheme. We have introduced additional categories and made the entire structure of naming schemes and its vocabulary consistent.

Structure of the naming schemes

The outcome of this development is a "buildings unified data point naming schema for operation management" (BUDO). It has a hierarchical structure, which consists of five categories that form the data point naming scheme: 1) system, 2) subsystem, 3) position/medium, 4) type, 5) I/O function.

An underscore character is used to separate them. A detailed naming is also possible, e. g. to distinguish a temperature sensor (SEN.T) from a volumetric flow meter (SEN.VF). A point is used for subdivision. This supports object orientation in the analysis of attachments. Additional user-specific names are important to ensure that a system integrator or operator can recognize data points. User-specific categories are also decisive for the applicability in an organization. Therefore, we allow a free text before the standardized vocabulary. This can include all additional categories required by the organization (e.g. a building number or focus of information). This text is delimited by two slashes (//) from the developed data point key. We show the structure of BUDO in **Figure 1**. BUDO allows a standardized naming of the components in the building automation systems and at the same time allows an assignment of components in the system, which makes it easier to assign the data points to a component later in the automation schema.

Translation tool

With a translation tool developed by us, the scheme can be easily applied in any construction or retrofit process. We currently implemented the tool in Excel. We planned further integrations (html, python). An application of the tool can be found in **Figure 2**.

The tool is downloadable on the E.ON Energy Research Center's website*.

Due to a simple copy-and-paste of the existing name, our naming scheme can be applied very easily also on existing buildings. A user can select the appropriate vocabulary conveniently via a drop-down menu and receives a new standardized naming at the end. For a

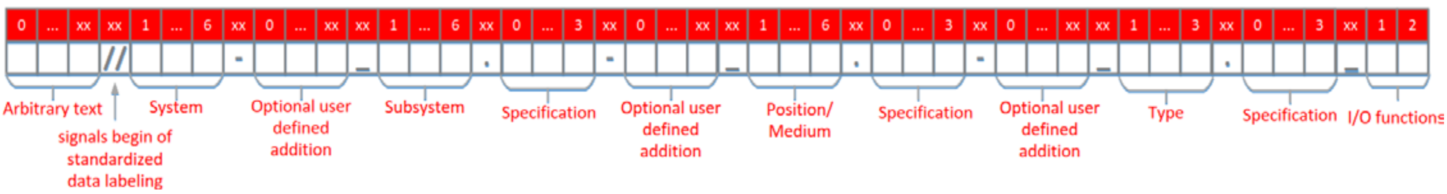

Figure 1. Structure of the unified data point naming structure BUDO.

Alter Datenpunktschlüssel	Gebäud	System	.	Spezifizg.	-	Bezeich	_	Bauteil/S	.	Spezifizg.	-	Bezeich	_
4120.H02_.DEALS01_Heizung Not-Aus	4120	Kessel				H02.1		Schalter		Not Aus			
4120.H02_.AASYY01_Ventil Kessel-1	4120	Kessel				H02.1		Ventil		Verteil		Y01	
4120.H02_.AEMWB01_Temp VL Kessel1	4120	Kessel				H02.1		Sensor		Temperatur		B01	
4120.H02_.DEBMA01_Kessel1 Betrieb	4120	Kessel				H02.1							
4120.H02_.DESMA01_Kesselsteu STO	4120	Kessel				H02.1							
4120.H02_.DASBA01_Kesselsteuerung	4120	Kessel				H02.1							
4120.H02_.DEBMM01_Pumpe K-1 Anf	4120	Kessel				H02.1		Pumpe				M01.K1	
4120.H02_.DEBMM01_Pumpe K-2 Anf	4120	Kessel				H02.1		Pumpe				M01.K2	
4120.H02_.AASYA01_Sollwert Brenner	4120	Kessel				H02.1							
4120.H02_.AEMWB06_Temp RL Kessel1	4120	Kessel				H02.1		Sensor		Temperatur		B06	
4120.H02_.DASBM01_Pumpe Kessel-1	4120	Kessel				H02.1		Pumpe				M01	
4120.H02_.DEBMM01_Pumpe Kessel-1	4120	Kessel				H02.1		Pumpe				M01	
4120.H02_.DESMM01_Pumpe Kessel-1	4120	Kessel				H02.1		Pumpe				M01	
4120.H02_.AEMWB03_Temp hydr Weich	4120	Kessel				H02.1		Sensor		Temperatur		B03	

Figure 2. Example of how to use the translation tool.

* http://www.ebc.eonerc.rwth-aachen.de/cms/E-ON-ERC-EBC/Forschung/OPEN-SOURCE/~qajk/Standardisierte-Bezeichnung-zeitaufgeloe/

building with approx. 400 data points, the renaming into the new scheme required approx. 2 hours without specialized training. This shows that the naming scheme is applicable to existing buildings. We show this below on the examples of a building in construction, an existing building, different organization structures and on the case of a building information model (BIM).

Integration into the Planning Process

BUDO can be composed of entries in the GA function list according to ISO 16484 and can therefore be easily integrated into the planning process. The assignment of the data point key to a specific position in the system makes it easier to find the data point in the automation scheme. The complete data point consists of e.g. a building allocation or focus of information etc., the plant, the description of the data point or object and the I/O functions (see **Figure 3**). For this purpose, the corresponding categories are suitable. The building identifier can be set in the arbitrary text at the beginning. The description of the plant is stored in the system. Several parts of the naming scheme can be integrated into the description. The I/O function is used at the end of the scheme and contains information about which information type one can count on and which signal can be processed by the component. This can already be useful for debugging a system.

Table 1. Example Buildings.

Building No.	Explanation
1	Office Building with mixed utilization
2	Test Hall
3	Canteen
4	Battery Storage System

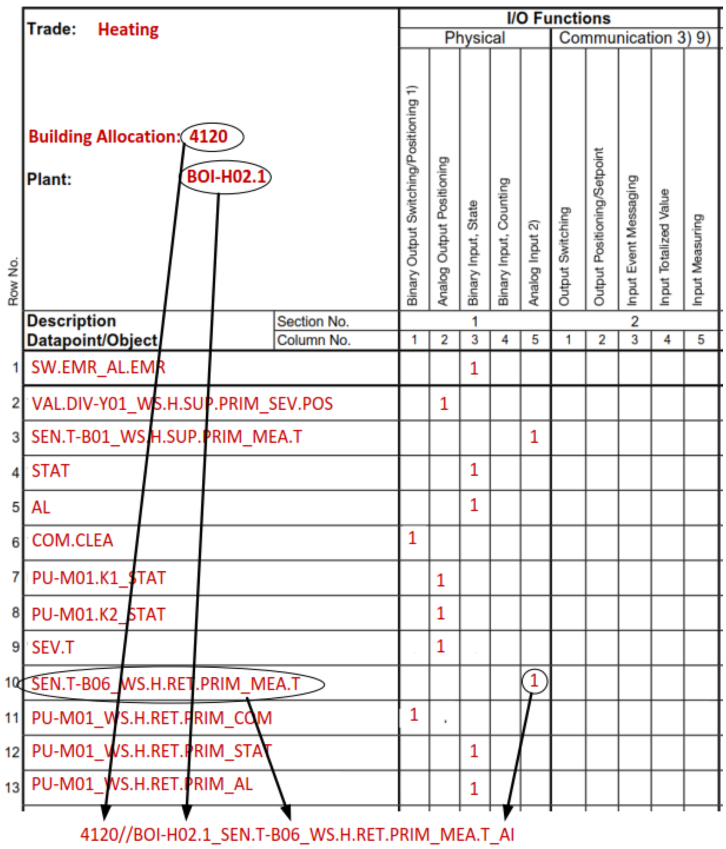

Figure 3. Assembling the data point label from the function list of ISO 16484-3.

Table 2. Data label of BUDO.

System	
BOI	Boiler
CHP	Combined Heat and Power Unit
CCA	Concrete Core Activation
Subsystem	
PU	Pump
SEN	Sensor
SW	Switch
VAL	Valve
Position/ Medium	
HYDS	Hydraulic Separator
STO	Storage
WS	Water System
Type	
AL	Alarm
COM	Command
MEA	Measurement
SEV	Setpoint Value
STAT	Status
I/O Function	
AI	Analog Input
AO	Analog Output
BI	Binary Input
BO	Binary Output
SAO	Shared Analog Output

Specifications	
BOT	Bottom
CLEA	Clearance
CTRL	Control
DIFF	Differential
DIST	Distribution
DIV	Diverting
EMR	Emergency
H	Heat/Hot
LT	Low Temperature
MAIN	Maintenance
MAX	Maximum
MID	Middle
MIN	Minimum
NROT	Number of Rotations
OPR	Operation
POS	Position
PRIM	Primary
RET	Return
SEC	Secondary
SUBS	Substitute
SUP	Supply
T	Temperature
TOP	Top
VF	Volume Flow

Case Study 1: Concrete Core Activation (Test hall, in Construction)

We have integrated the developed key into a building process in a test hall currently under construction. This way, the previous theoretical considerations on the applicability of the key can be examined. The labels of data points in the concrete core activation are located in **Figure 4**. It shows that particularly more complex systems, such as a pump, have significantly more data points than a simple valve. The choice of vocabulary should be consistent. This means that if a component has been named with a certain name once, this name is also used for all subsequent designations.

Case Study 2: Boiler (Office Building with mixed utilization)

Table 2 shows the vocabulary needed to understand the data label in **Figure 5**. It shows a system with two boilers and a hydraulic separator as located in the case study office building. Typical data labels of

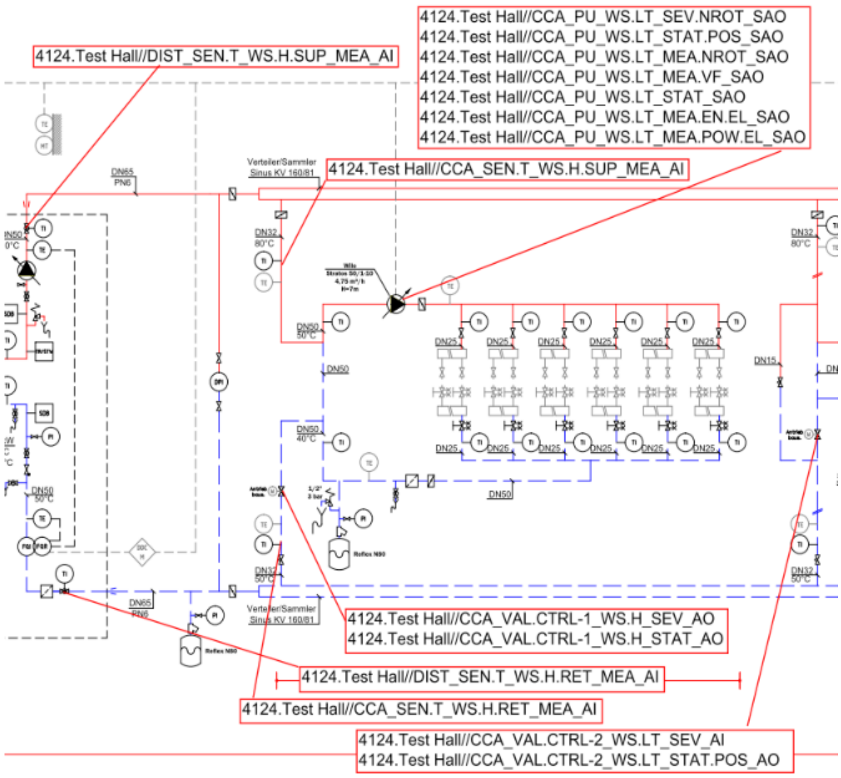

Figure 4. Examples of BUDO in a Concrete Core Activation of a building in construction (test hall) (source: DEERNS B.V.).

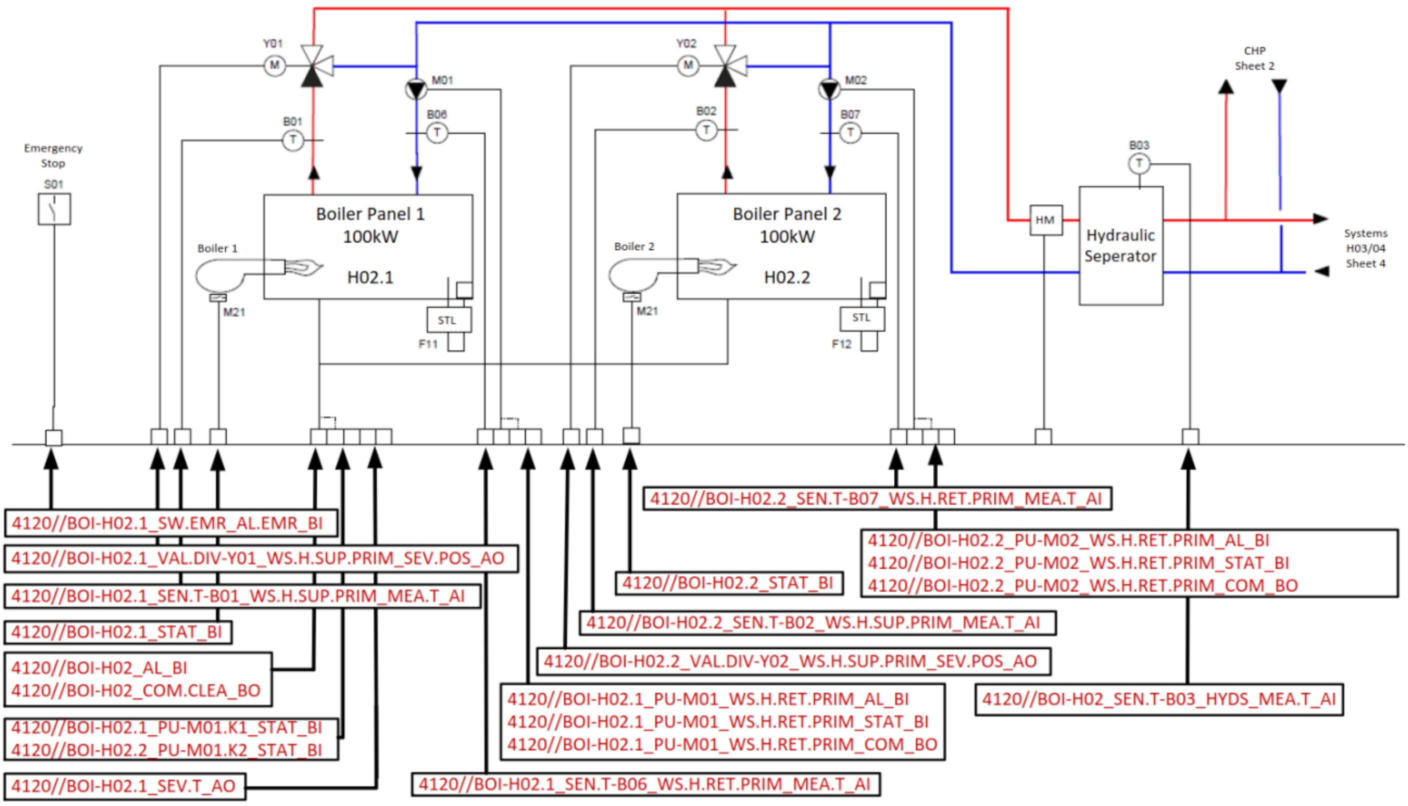

Figure 5. Boiler in case study 2 (office building) (source: Johnson Controls International Plc).

components used in such a system like a thermal energy storage, pump, valve and temperature sensors either to measure the temperature or to watch a maximum or minimum set point of a temperature difference are named according to the BUDO.

Case Study 3: Integration into different organization structures

As we show in **Figure 6**, there are no restrictions in the usage of BUDO at the Cologne Bonn Airport. We integrated the building, trade and room in front of the standardized part of the label. User-specific attributes are also applicable here. The system is integrable in the standardized part. BUDO completely maps the data point designation.

In the case of the city of Frankfurt/Germany (**Figure** 7), we have to depict the street code, house number, building, floor and type of costs. BUDO does not map these parts in a standardized way. Therefore, they must be inserted before the separator (//). For each unstandardized type, we recommend using an underscore as a separator. For the rest, we used the standardized part of BUDO.

Case Study 4: Usage in Building Information Model

The integration of data labels that are named after the developed naming scheme into a building information model (BIM), whose de facto standard is ISO 16739 (IFC4) was successful. We have implemented this in an existing building (see **Figure 8**). Here the description of objects offers the possibility to integrate the new label into BIM. The planning information can be added to BUDO according to the level of development in BIM. For example, if it is not yet clear which boiler type will be implemented, BUDO can initially contain the boiler information (BOI) only and the information of a condensing boiler (BOI. COND) can be supplemented later. If installations are subsequently changed in the planning process, the data point keys can also be adapted automatically by BUDO, thus avoiding errors in the planning process. BUDO therefore supports the workflow and benefits from BIM.

Conclusion

We have developed an easy-to-apply data point naming scheme. It can be easily integrated into existing organizational structures and helps to develop new standardized products for the analysis and optimization of buildings. If everyone would name or rename their building automation system accoring to BUDO, a lot of time spent on finding one's way around in a building automation system could be saved, and it could provide the basis for algorithms for an automatic evaluation of building automation in the future.

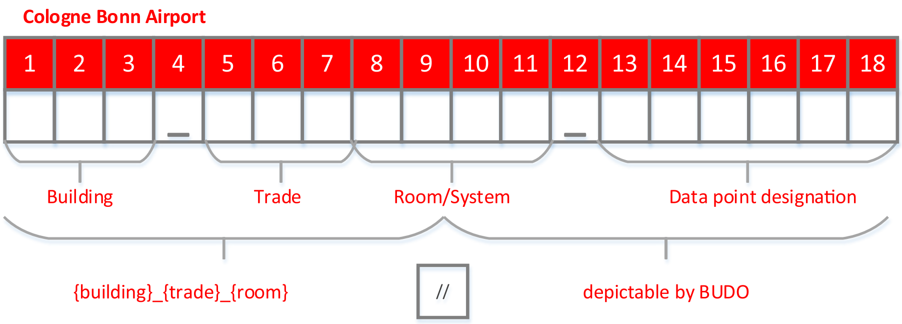

Figure 6. Example of integration into organization structures of the Cologne Bonn Airport/Germany.

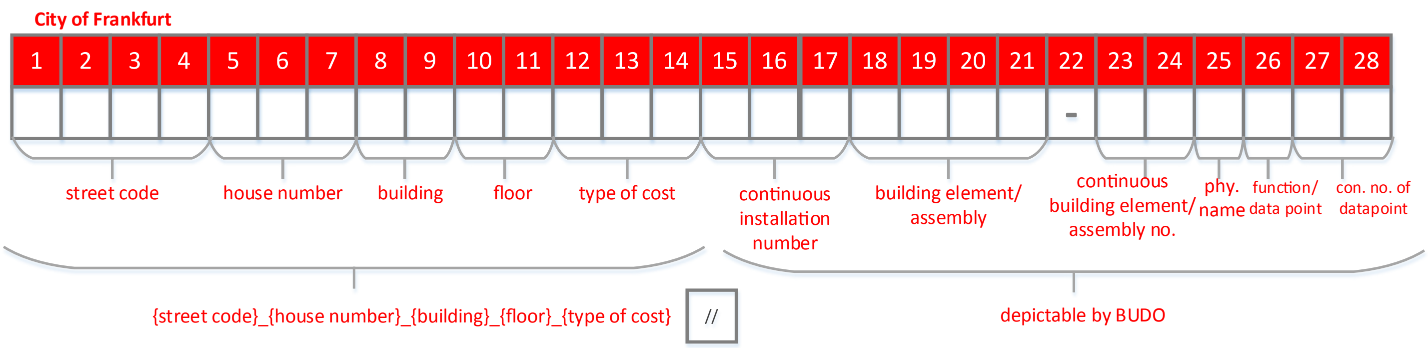

Figure 7. Example of integration into organization structures of City of Frankfurt (Main)/Germany.

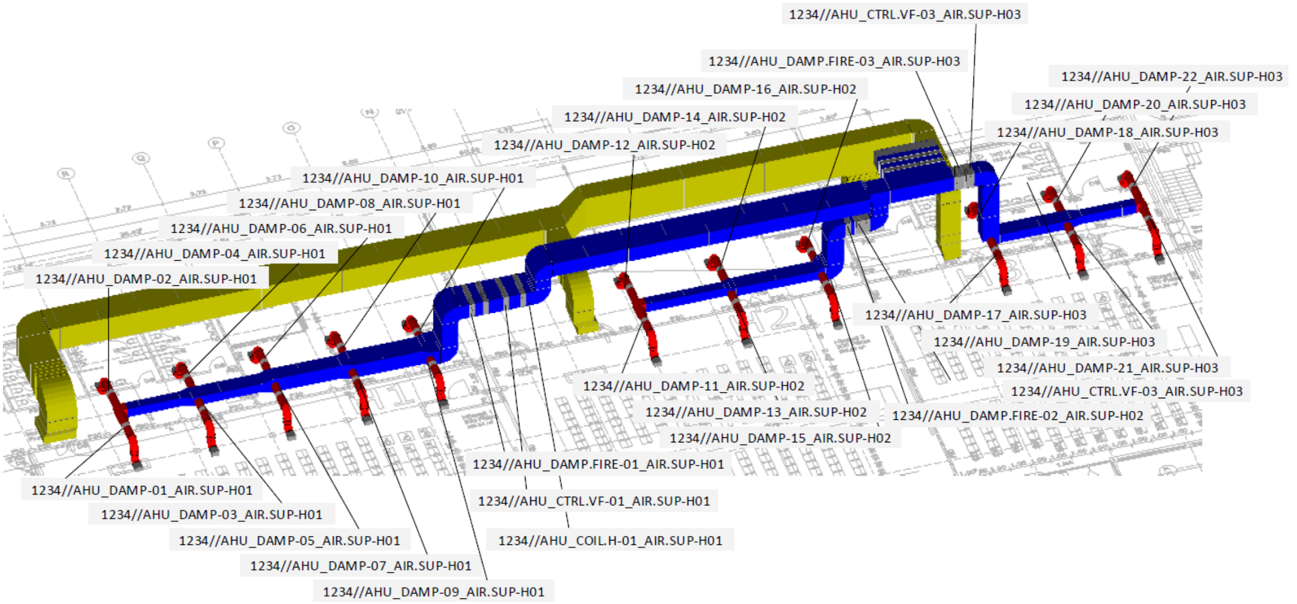

Figure 8. Example of integration of BUDO into IFC4 (Building Information Model).

We showed that the naming scheme can consistently name data points in existing buildings and in buildings under construction. The naming scheme could facilitate the application of innovative analysis and control concepts in the future. ■

Acknowledgements

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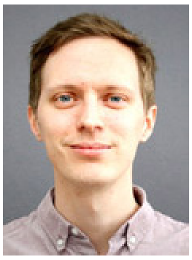
Optimisation of Energy Consumption in Buildings through User-Identification

OSMAN AKYILDIZ
University of Stuttgart,
Institute for Building Energetics,
Stuttgart Germany
osman.akyildiz@ige.uni-stuttgart.de

ANDERS BERG
University of Stuttgart,
Institute for Building Energetics,
Stuttgart Germany
anders.berg@ige.uni-stuttgart.de

TOBIAS HENZLER
University of Stuttgart,
Institute for Building Energetics,
Stuttgart Germany
tobias.henzler@ige.uni-stuttgart.de

KONSTANTINOS STERGIAROPOULOS
University of Stuttgart,
Institute for Building Energetics,
Stuttgart Germany
konstantinos.stergiaropoulos@ige.uni-stuttgart.de

The occupancy of buildings constantly changes. Typically, occupancy profiles from standards or known data are used when determining the energy demands of a building. This often results in a discrepancy between the actual occupancy of rooms and the occupancy used to determine the energy demands of the building. Consequently, the energy usage in buildings can differ significantly from the energy needed to maintain thermal comfort within buildings.

The increased use of mobile electronic devices makes it possible to determine the occupancy in individual zones. This data can improve the energy-analysis of individual zones of the building. With the help of occupancy data, the planning of a building's energy demand, as well as the buildings energy consumption during operation can improve.

In the research project „Building optimisation through user-identification" funded by the German Federal Ministry for Economics and Technology (BMWi, FKZ: 03ET1428A), an application is being developed that determines the occupancy of individual zones. The application will be tested in an office building and the influence of occupancy on energy demand will be determined by building simulation. Additionally, different approaches to building optimisation will be researched – intelligent building control should be able to learn and predict the occupancy profiles in zones. Once the occupancy of the building is learnt, the operation of the building can be adjusted accordingly.

Occupancy of Buildings

The occupancy of zones depends on a variety of factors – within a company, different branches and departments may vary significantly in their building usage. The level of employment (full-time, part-time), the number of days absent from the work-place (holidays, business trips, sick leave) and the type of office (single office, group office, open-plan office) are just some examples of the factors influencing occupancy.

Within office and residential buildings, the distribution and number of hours of daily occupancy, as well as the heat gains from people and devices varies. In **Figure 1**, the cumulative number of occupancy hours (people present multiplied by hours present) is shown. In **Figure 2**, the cumulative heat gains through people and devices are shown for a work day in a single office.

Depending on the chosen standard, the calculated energy demands of the building can vary significantly (**Figure 1** and **Figure 2**). In **Figure 3**, the average level of occupancy of a typical single office on a work day is shown and compared to the norms. The occupancy profile is taken quarter-hourly during a working week (Monday to Friday) and averaged to get the level of occupancy during a week.

User-Identification

The user-identification application is being developed in collaboration with the company Indoo.rs GmbH. The occupancy identification application for the mobile phone, works with Bluetooth. Divers Bluetooth transmitters, also named beacons, are positioned in zones. These beacons are net transmitters. Since there are several beacons in each zone, any chosen reference point has a characteristic Bluetooth signal. It is therefore possible to calculate the position of a mobile phone or user in a room. This is done with the help of a positioning map, generated by an algorithm of the company "indoors". On the positioning map, each reference point corresponds to the characteristic Bluetooth signal of that point. The positioning map is transferred to the application and used to determine the occupancy of the room online.

Data Protection

With the help of the Institute for Business Rights at the University of Kassel, a data-protection plan is being developed, that fulfils data-protection requirements. Currently, the German "Federal Data Protection Act" and other data-protection rules are in place and will be adhered to. As of the 25-05-2016, the European "General Data Protection Regulation" is in place, and is effective as of the 25-05-2018. The aim of the General Data Protection Regulation is to have a consistent data-protection level within the EU. One important legal requirement – the anonymity of the data processed – will be possible with the application for user-identification.

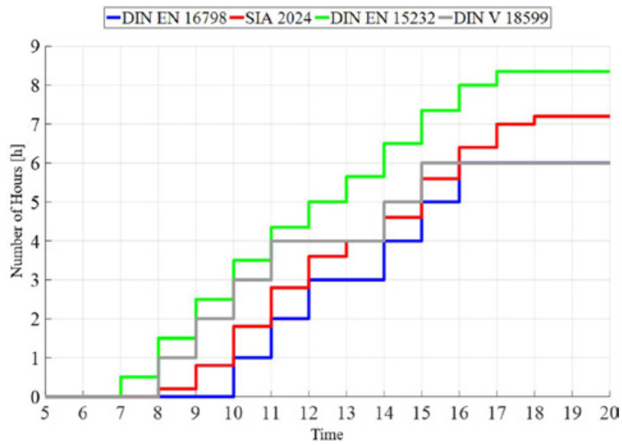


Figure 1. Cumulative Number of Occupancy Hours for a Single Office.

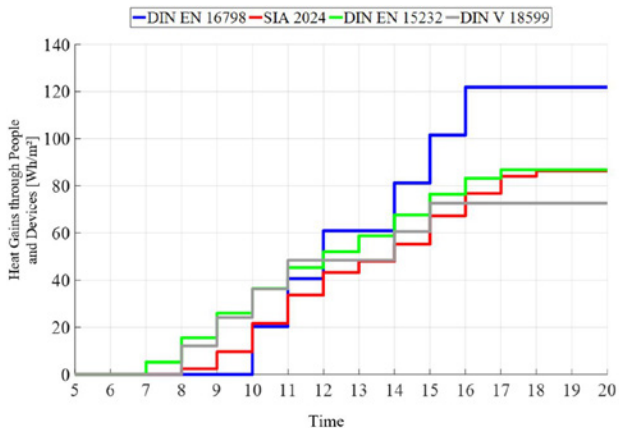


Figure 2. Heat Gains through Devices and People for a Single Office.

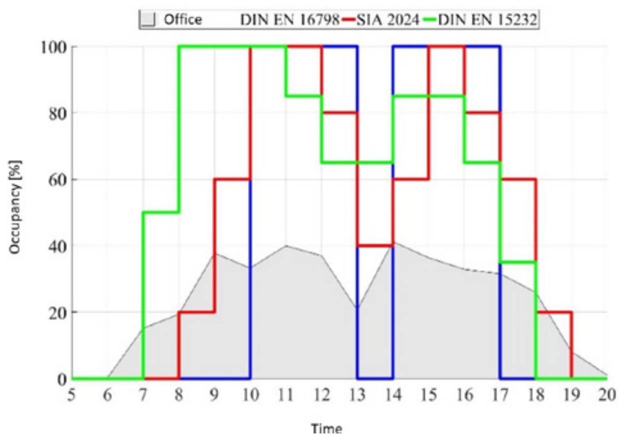


Figure 3. Comparison between a Single Office Occupancy and Occupancy from Standards.

Technical Implementation

The application will be used and tested with mobile devices in office buildings of the Ed. Züblin AG in Stuttgart. The commissioning will start at the beginning of 2018. The recorded occupancy profiles will be compared with the data from existing occupancy detectors and the occupancy profiles from norms. This information will be used to determine the influence of occupancy on energy usage. The recorded occupancy profiles make it possible to better understand the usage of buildings and the user requirements within buildings.

Predictive Systems

Energy-savings can be achieved by adapting the climate control in rooms to suit the occupancy patterns. For example, it is possible to control the climate in meeting rooms when they are in use. Offices should be pre-heated/pre-cooled before the workers are expected to arrive. An array of optimisation possibilities is imaginable. The learning and prediction of occupancy is essential for the implementation of these strategies. The occupancy profiles make it possible to determine the time-frames in which the climate control should be active. The important question of when and how to best pre-condition buildings so that the prescribed room temperatures are met when the building is occupied while minimising energy consumption remains. Given the discussed information, static user-profiles are not the optimal solution. Furthermore, the ambient temperature and solar radiation (the main factors contributing to heat transmission through the building) change daily and throughout any given day. As a result, the buildings and its climate control facilities will have different pre-conditioning times.

To design a robust application which caters for a wide range of scenarios, predictive-control will be used. The main advantage of this approach is that the system can learn continuously during operation. Correlations between input and output data are learned, which allows the system to predict the thermal behaviour of the building. A data set from a simulated building was learnt by such a system. If the control of the room temperature is learnt according to outside temperature and solar radiation, the inside temperature is correctly predicted to an error of max. ± 1K -see **Figure 4**. The building is heated by a heat-pump and an under-floor heating system with their own control systems. It has been demonstrated that such a system is able to deal with multiple links between complex inputs, and accurately learns the thermal behaviour of the building. The influence of occupancy has yet to be learnt by such a system.

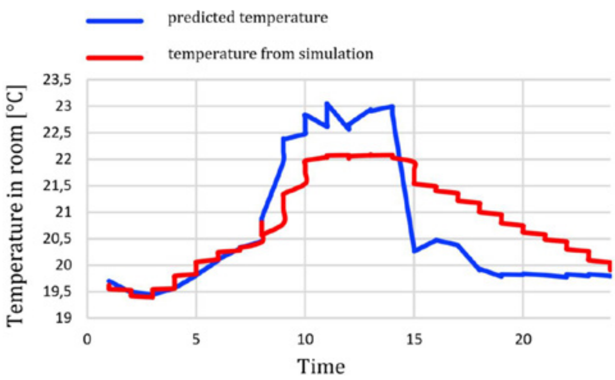


Figure 4. Temperature profile of Room Temperature - Comparison between Simulation and Predictive-Control Model.

Outlook

The field test of the user-identification application starts at the beginning of the 2018. Various configurations of the application will be examined. Parameters such as the time interval for the occupancy checks will be varied to find out how often the occupancy must be recorded to maintain accurate occupancy profiles. One important aspect for the application is to avoid fast battery discharge of the mobile device.

In future, the predictive-control approach should learn the influence of the user on energy usage. The data from the field test should supply a suitable base to this end. The findings of will derive possible application scenarios for user-identification. ■

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Personal control over indoor climate disentangled, Part 2

RUNA HELLWIG
PhD, Professor Building Physics and Indoor Climate at Augsburg University of Applied Sciences in Augsburg, Germany
runa.hellwig@hs-augsburg.de

ATZE BOERSTRA
PhD, managing director BBA Indoor Environmental Consultancy, The Hague, the Netherlands.
ab-bba@binnenmilieu.nl

Many non-residential buildings that were built or retrofitted in the last 20 years use a Building Automation System (BAS). BASs are installed to achieve efficient operated buildings and a reduction of their energy use and operating costs. At the same time BASs allow tight control of the indoor climate in line with requirements as defined in guidelines, standards and building decrees. But this tight control does not necessarily lead to higher occupant satisfaction or lower complaint rates. In Part 1* of this article, published in REHVA Journal in June 2017, we discussed importance of control, effects of control and mechanisms involved (Hellwig & Boerstra, 2017).

Keywords: Perceived Control, Occupant Behaviour, Indoor Environment Quality (IEQ), Integrated Design, Energy Efficiency, Smart Buildings, Building Automation System (BAS), Building Management System (BMS)

Introduction

In this follow-up article Part 2 we answered 10 frequently-asked-questions about control, as an addition to the first 10 questions answered already in Part 1. We explained more about the factors influencing personal control of the indoor climate and discussed the design implications. The examples presented mainly focus on control and control effects in office buildings. We conclude Part 2 with suggestions for the future indoor climate guidelines and some general thoughts on further control studies. The answers presented in this article are based upon our own research (as described in e.g. Boerstra, 2016, Hellwig, 2005 and Hellwig, 2015), the work of other researchers and the feedback from participants during workshops at the Clima 2013 conference and the Indoor Air 2016 conference (reported in: Boerstra & Simone, 2013 and Hellwig & Boerstra, 2016).

The 10 questions as answered in Part 1

Q1: What do we mean with personal control?

Q2: Is control over indoor climate really an issue for the modern office worker?

Q3: What are the main problems with control over indoor climate in existing buildings?

Q4: How does control over indoor climate affect comfort and satisfaction in offices?

Q5: Is there an impact of installation type?

Q6: How about the effect of control on Sick Building Symptoms?

Q7: How does control over indoor climate affect productivity?

Q8: How about sick leave effects?

Q9: What do we know about the mechanism involved?

Q10: How about the difference between available, exercised and perceived control?

* https://www.rehva.eu/publications-and-resources/rehva-journal/2017/032017/personal-control-over-indoor-climate-disentangled-part-1.html

Q11: What are the factors influencing the perceived level of control?

How the level of personal control is perceived (perceived control) depends on many factors. First: the access to wall thermostats, operable windows, fans and other controls and effectivity of these controls. Furthermore: a person's actual physiological state, his/her expectations and actual preferences, a person's personality and experiences, his/her beliefs how successfully he/she can cause changes, a person's competences or skills, knowledge of the building and its technical systems as well as success or failure in previous behavioural control actions in the actual or other buildings. Finally, it is important that a person can sense whether the actual control action exercised generally is successful (**Figure 1**, from Hellwig, 2015).

Q12: Is there an impact of building facade on the level of control?

Yes, there is. The building's facades design, insulation, thermal mass and the interrelation with the HVAC and BAS system drive a building's responsiveness under changing external and internal loads. More importantly, the responsiveness of the building towards a control action initiated by an occupant needs to be perceptible for the occupant. Otherwise the occupant may experience that his/her control action generally is not successful (Hellwig, 2015). On the other hand, traditionally heavy to medium thermal mass buildings with a low to moderate window-to-wall ratio equipped with operable windows and thermostats for heating only are often perceived as offering sufficient control (see e.g. Boerstra, 2016). We assume that it is important to occupants that – based on the experiences from the past - they can (unconsciously) foresee a building's thermal behaviour. Predictability of thermal performance would be higher in the above described building type, compared to a highly glazed light-weight building immediately responding to changes in solar loads.

Q13: What are other constraints from the built environment?

One important example is space layout. An open-plan office tends to reduce the availability of the window access for the occupants, affects whether the windows are operable or not and determines the heating or cooling system for such space – most often via mechanical ventilation which normally provides less personal control but zonal control. Furthermore, the office plan layout can also result in constraints for the social environment (see next question). Constraints of the building could also be windows which can be opened only with a small gap of few centimetres or fixed thermostats which cannot be adjusted. In other word: all control opportunities which look as they could be adjusted but in fact they cannot, are likely to be perceived as a constraint.

Q14: What are constraints from the social environment?

A social constraint is, for instance when there is a need to negotiate with others before taking a control action, as in group or open-plan office layouts (Leaman &

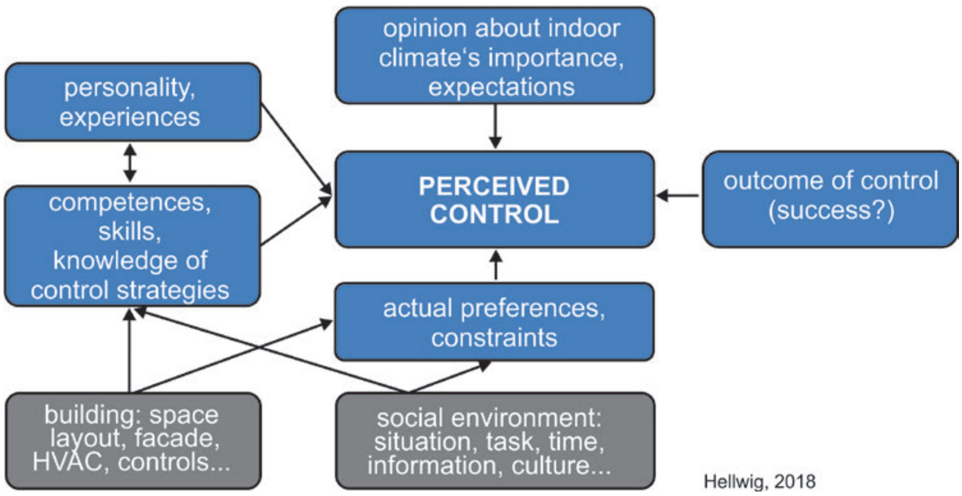

Figure 1. Factors influencing the level of personal control perceived (condensed conceptual model of perceived control from Hellwig, 2015).

Bordass 1999). A social constraint is also when behavioural instructions are implemented by the company or the facility management. Think e.g. of organisation constraints in relation to the use of operable windows or restricted clothing protocols. These kinds of instructions 'from above' will reduce individual freedom to adjust one's local indoor climate and hence limits the perceived level of control.

Q15: Is having more control options always better?

No, not necessarily. There is a finding called the jam paradox or paradox of choice (Iyengar & Lepper, 2000). Jam paradox refers to an experiment about jam buying decisions (choose from a collection of jars with different marmalades, with varying choice options) could also be applied to control in buildings (Hellwig, 2015). The experiment showed that generally speaking people enjoy extensive choice options. But when people have too many choice options this leads to information overload, i.e. too many distinctive features between the options, resulting in a stressful and demotivating situation because it's so hard to evaluate variables when these become too abundant. Subsequently people take fewer choices and if they choose they will be more dissatisfied with the choices taken. Therefore, it is better to offer an appropriate amount of control options. In order words: too little choice options is a problem, but too many choice options is so too.

Q16: How about just putting a dummy thermostat on the wall?

Dummy thermostats are non-connected, fake temperature knobs that promise some level of control over the thermal environment but in fact are non-functional. Although often proposed when HVAC technicians are confronted with indoor climate problems, on the long term the introduction of dummy stats is one of the worst things to realise! Sooner or later, users will find out that their usage of the dummy control device does not have any effect. This can result firstly in a loss of confidence in their own capabilities or in a loss of trust in building systems or the facility manager. Users then may conclude that the building operates by chance or that the facility manager did not treat their complaints seriously. This will make them more critical of the functioning of the building (Hellwig, 2015). In Dutch offices it was found that effective personal control options in offices can decrease the amount of complaints when compared to none or ineffective personal control. If controls are ineffective, like dummy controls, the potential for complaints can be even higher compared to the case with no control at all (Boerstra & Beuker, 2011).

Q17: When designing a new building or retrofitting an existing building, what measures should one take in order to boost personal control?

In both cases it pays off not to just provide in an HVAC system that has the right amount of heating, cooling and ventilation capacity but also to (re)design for adequate indoor climate adjustability. Depending upon the situation one can use low tech or high-tech controls. In case of a retrofitting project, it is advisable to find out what are the most liked (control) features in the old building and keep them in the new building. Think e.g. of existing operable windows. Also, finding out what controls the occupants miss in the old building and add them in the new building can help for higher satisfaction in the new building. In newly designed buildings one can decide to introduce more innovative control solutions like micro-climatisation systems (HVAC integrated in work tables and/or chairs). General strategies for high perceived control over indoor climate are: to reduce the number of persons sharing one office, to ensure the accessibility of control devices for the occupants, and to rely on user-friendly interfaces, and to aim for control over temperature, fresh air supply and lighting (**Figure 2**).

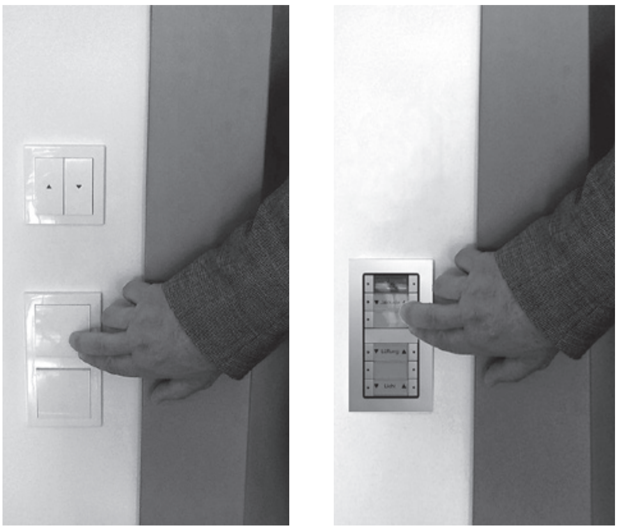

Figure 2. User-friendliness considers common routines of occupants or mounting requirements for new control devices; left: using a light switch when entering a room, right: a traditional mounting height as shown is inappropriate for new control devices (photos/montage: R.T.Hellwig).

Q18: Are there guidelines explaining how a good control device should be designed?

There is an excellent guide by Bordass, Leaman & Bunn (2007) on good design for controls for end-users and their implementation. There is also an international standard ISO 9241 on human-computer-interaction which describes principles of usability: effectiveness in solving a task or problem (successful task completion by users), efficiency in handling the system (task in time), and satisfaction of the user. Very useful additional information about controls and usability can also be found in Karjalainen, 2007.

Q19: What about expectation management in relation to controls and control effectiveness?

When new control-technologies are suggested for implementation, a building system designer has to explain why the new technology provides benefits. The person suggesting the new technology tends to be very enthusiastic about it (otherwise he/she wouldn't propose it). This enthusiastic attitude will raise the user expectation sometimes to the skies! But raised expectations could lead to disappointment later, even if the overall indoor climate has improved objectively. Therefore, it is important that the owner or user has realistic expectations which are consistent with the performance of the system after the building is commissioned. Furthermore, it is important for a building system designer not to discourage the prospective user from taking control actions. For overall satisfaction it is supportive if an occupant feels responsible for the indoor climate at his workplaces to a certain degree. Otherwise, the occupant has to rely too much on a building's autonomic behaviour or changes to be implemented by the facility manager.

Q20: What are suggestions for future work and needs?

Providing the indoor climate exactly according to the standards is probably not enough. As one and the same person might have different needs at different times due to day to day or hour to hour differences in tasks, metabolism, season, actual or previous activity, mood, health status, personal control opportunities are a key element for the future buildings. We see the need for design guides on personal control in indoor environments for planners and we see a need to expand the scope of the standards which so far aim at thermal comfort by incorporating the objective of providing appropriate effective controls. We also see that advanced knowledge on constraints and on effectiveness of control actions is required. Furthermore, we still lack sufficient knowledge on what would be an appropriate and sufficient amount of personal control in different contexts. ■

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Maintenance:
A Matter of Savings, Comfort and Legal Compliance

Performing regular maintenance checks for air conditioning systems is crucial to achieving optimal performance, yet it is not a standard practice in today's market. This article explores why taking a proactive stance on air conditioning maintenance is advantageous to attain higher performance and meet current legal regulations.

Keywords: maintenance, (energy) savings, comfort, legal compliance, monitoring, preventive, inefficiencies, EPBD, F-gas

THOMAS PICQUET
Service Business & Solutions Department, Daikin Europe
picquet.t@daikineurope.com

Regular maintenance service for air conditioners is not a requirement or market standard. In fact, most companies tend to use a more reactive method when servicing their air conditioner. For example, 33% of companies in the U.K. do not maintain their assets (Rexroth Bosch, 2016), which means they only seek maintenance services once an issue occurs.

At first, an end user may assume a reactive maintenance method is a smart choice because they believe if a system runs smoothly, there is no need to pay for regular service checks. However, the buyer will soon realise the price they pay for reactive maintenance services can add up, and over time, they may end up paying more to repair their installation than for a service expert under a regular maintenance contract (Sullivan, Pugh, Melendez & Hunt, 2004).

A study by Plant Engineering (2014) comparing the cost-effectiveness of maintenance methods supports this outlook. According to the study, only 30% of buyers who chose a reactive maintenance method listed their system as “cost-effective overall,” in comparison to 50% who chose a regular maintenance method (Plant Engineering, 2014).

However, cost-effectiveness is not the only benefit of regular maintenance; there are also plenty of other opportunities to consider. In this article, we want to identify these opportunities by looking into the adverse effects of reactive maintenance and how regular maintenance not only improves an air conditioner’s performance but can also help systems meet current regulations.

The drawbacks of reactive maintenance

Before looking at the advantages of regular maintenance, it is essential to understand how reactive maintenance can impact a system and reduce its performance over time. To illustrate this point, let’s take a closer look at the various ways reactive maintenance lowers the energy efficiency of a product.

Refrigerant

Contaminants in refrigerant can build up if an air conditioner is left unchecked. These contaminants range from excess oil to the presence of moisture to non-condensable gas, and when present in specific amounts, these elements can reduce a unit’s energy efficiency and performance (Jones & Harkins, 2005; Klemes, Smith & Kim, 2008; Sine, 2006). On another note, it is also necessary to check the quantity of refrigerant in an air conditioner to achieve on average 29% more energy savings (Knight et al., 2010).

Fouling

Fouling, or the build-up of material in an air conditioner, also significantly impacts an equipment’s energy efficiency. According to the Department of Energy Climate Change & Energy Efficiency (n.d), a build-

up of 0,6 mm of fouling on condenser coils can cause 20% more energy consumption. This spike in energy consumption can also occur if microbes appear in tubes with sticky lime deposits which can reduce heat transfers by 15%, and the potential to decline 10% - 20% more if iron is present (Clark, 2005).

Wrong configuration

If a unit is setup incorrectly, there is a risk the system will not only consume more energy, but also miss energy-saving opportunities. For instance, a condenser fan can attain around 4% more energy savings (Knight et al., 2010), but only if a maintenance operator configures it correctly.

From these drawbacks we can conclude that the more inefficiencies present in an air conditioning system, the more likely it is a product will need to consume more energy to meet customer demands. Furthermore, the cost to fix these issues ad hoc with reactive maintenance will add up over time and become more expensive than investing in a regular maintenance plan. For example, dirty coils causing an increase in condensing temperature from 35 to 40°C can lead to an estimated €250 additional costs (in a 35 kW unit operating 2.000 hours per year) (AIRAH, 2013), but a maintenance operator can clean them for a fraction of that price.

Besides the impact on energy efficiency, reactive maintenance can cause system breakdowns, which are a loss of time and money for end users, but also discomfort.

- For customers, a system breakdown leads to exposure to extreme temperatures and can trigger avoidance behaviour (Bohl, 2012) with negative attraction and affective feelings towards strangers (Lam, 2001). It might cause customer dissatisfaction and impact the purchase intention.
- For employees, poor air quality inside office buildings can decrease productivity up to 9% (Wyon, 2004), while another study concludes creating comfortable temperatures in an office can save up to 2 euros per employee per hour (Witham, 2007).

Based on this research, we can see the costly drawbacks of choosing to service an air conditioner based on a reactive maintenance method. But let us go a step further to see just how a preventive maintenance method is a smart choice for end users.

The benefits of preventive maintenance

Preventive maintenance allows the customer to increase the energy efficiency of their unit and ensure continuous comfort. By establishing a fixed maintenance plan, product deterioration and potential breakdowns are avoidable because a maintenance operator can detect issues immediately and take the right steps to make sure a unit performs at optimal levels. Regular maintenance can also extend the lifetime of a product. For example, a chiller's lifespan can be increased by 50% (Firdaus, Prasetyo & Luciana, 2016). Furthermore, preventive maintenance can save between 12% - 18% on average on costs (Sullivan et al., 2004).

However, the main drawback to regular maintenance is that it does not protect the customer against catastrophic failures, and there is the chance that an operator does not detect all energy inefficiencies. To mitigate this disadvantage, it is worthwhile investing in a maintenance plan that also includes remote monitoring.

Rely on remote monitoring

Monitoring systems are a valuable investment for regular maintenance plans because they can pinpoint additional energy savings and detect abnormal installation behaviour. By tracking and measuring data, a remote monitoring system can take the right steps to prevent system breakdowns and deliver continuous comfort.

A study (i.e. iSERVcmb) supported by Europe Energy Intelligence finds that a combination of "measuring and logging" and inspections is the best way to avoid wasted energy and achieve long-term savings. Such was the case when the study found the McKenzie House of Cardiff University used 28% less energy when it adopted "measuring and logging" as part of its maintenance plan (European Commission, 2014).

It is clear there are many benefits when selecting a regular maintenance plan when it comes to energy performance and savings, but periodic checks for air conditioning systems are also essential to meet current legal regulations.

Legal compliance

In the European Union, preventive maintenance plans must include a mandatory F-gas check (EU NO 517/2014) and an inspection of your air conditioning system (Directive 2010/31/EU).

Since 2015 the F-gas check applies to all HVAC-R equipment containing fluorinated greenhouse gases (if >5 tons of equivalent CO_2). Depending on the F-gas charge, the installation must have a maintenance operator check the equipment a certain number of times a year (see **Table 1**), but the number of visits will be less if the equipment includes a leakage detection system.

In addition to the F-gas check, an air conditioning installation (if > 12 kW) also needs a regular inspection to meet the European Performance of Buildings Directive (EPBD). The number of visits, however, may be less frequent if remote monitoring and control systems are in use. According to the EPBD:

> "Member States shall lay down the necessary measures to establish a regular inspection of the accessible parts of air-conditioning systems of an effective rated output of more than 12 kW. The inspection shall include an assessment of the air-conditioning efficiency and the sizing compared to the cooling requirements of the building"
> (European Parliament & Council of European Union, 2010).

The EPBD allows countries to posit a different measure for inspection, but this option is not popular among member states because the majority already use the current inspection scheme. To ensure each inspection meets the requirements set by the EPBD, a CEN standard was made available (EN 16798-17:2017: Energy performance of buildings. Ventilation for buildings. guidelines for inspection of ventilation and air conditioning systems). It outlines the inspection methodology and requirements.

The current EPBD came into force in 2010. However, it was revised this year. The amendments were published in the Official Journal of the European Union on June 19, 2018 (EPBD 2018/844). The Member States have to incorporate this Directive into their legislative system within 20 months.

This revised EPBD (European Parliament, & Council of European Union, 2018) includes the following changes:

- Extending EPBD's scope to the accessible parts of combined air conditioning and ventilation systems
- Increasing the effective rated output from 12 kW to 70 kW
- Taking into consideration the capabilities of air conditioning or combined air conditioning & ventilation systems during inspection to maximize performance
- Requiring non-residential building owners to equip air conditioning and combined air conditioning & ventilation systems (greater than 290 kW) with automated control systems by 2025
- Exempting non-residential buildings from inspection if they fulfil the measure regarding automated control systems (similar inspection exemption for residential buildings)

Table 1. Frequency of visits depending on the F-gas charge measured in CO_2 tonnes equivalent.

Leak checks frequency	Tonnes of CO_2 equivalent	Refrigerant			
		R410A (kg)	R407C (kg)	R134a (kg)	R32 (kg)
12 months	$5 \leq t\ CO_2e < 50$	2.4 – 24	2.8 – 28	3.5 – 35	7.4 – 74
6 months	$50 \leq t\ CO_2e < 500$	24 – 240	28 – 280	35 – 350	74 – 740
3 months	$t\ CO_2e \geq 500$	≥ 240	≥ 280	≥ 350	≥ 740

Conclusion

Operating under a reactive approach leads to various drawbacks that range from inefficient systems to long-term issues to discomfort for end users. In contrast, end users who choose preventive maintenance can guarantee the optimal condition of their equipment and further enhance their energy savings and comfort by combining it with remote monitoring. On top of these benefits this approach ensures the owners comply with the legal regulations regarding F-gas and EPBD Directive. ■

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The Most Common Mistakes when Designing a Hot Water Storage Tank

The aim of the paper is to highlight the most common mistakes in sizing the domestic hot water (hereinafter only DHW) storage tanks and heat sources for DHW preparation. The article describes two basic ways of design: The method using heat supply and demand curves of the DHW preparation system and the method of priority DHW preparation. Sizing of the DHW storage tank should primarily correspond to the used heat source and expected hot water consumption profile. When using the heat supply and demand curve method, the designer places the greatest importance on the minimum size of the DHW storage tank (i.e., the shape of the supply curve), regardless of the potential changes in the DHW consumption profile (i.e., the demand curve). When using the so-called priority DHW preparation, the basic precondition is often neglected where the required heat output of a common heat source must comply, not only with the DHW preparation system, but also with other connected heat consumption points.

Keywords: calculation methods, hot water, hot water storage tank, heat source

ROMAN VAVŘIČKA
Ing., Ph.D.
CTU in Prague, Faculty of Mechanical Engineering, Department of Environmental Engineering
Roman.Vavricka@fs.cvut.cz

Method of delivery and heat distribution of the DHW preparation system

The DHW heating curve Q_2 depends on the hot water consumption V_{DHW} over time τ. The heat supply curve for DHW Q_1 is dependent on the heat supply from the heat source in the same time interval. Important prerequisites for compiling the curves above are the following two necessary points:

1. The heat supply curve Q_1 is always above the heat demand curve Q_2,
2. The heat supplied by the hot water heater is equal to the heat removed from the heater $Q_{1p} = Q_{2p}$.

The heat supply curve must always be above the heat demand curve, otherwise there will be a lack of energy to heat the water to the desired temperature, so that the water temperature at the sampling point does not have the required temperature (55°C). The delivery and heat consumption curves are not decreasing with increasing time, as they are in principle cumulative curves that add up to individual times of the energy supplied or withdrawn from the DHW preparation system. The inclination of the tangent to these curves to the timeline represents the value of instantaneous heat output. At zero power, the waveform is horizontal with the x-axis, with the maximum curve slope being the assumed heat output of the maximum P_{2max} (see **Figure 1**).

The volume of the hot water tank is determined from the maximum difference between the heat supply and demand curves as:

$$V_{DHW} = \frac{\Delta Q_{\max}}{\rho \cdot c \cdot (t_2 - t_1)} \cdot 3600 \cdot 1000 \quad [l] \qquad (1)$$

In the case of designing a DHW system with storage (DHW tank), the heat supply curve Q_1 can be constructed in two basic variants. The first case occurs when we assume that the heat supply to the DHW cylinder is constant over a period of time (**Figure 2**). This means that the heat source heats the DHW throughout the heating time (typically 1 day). The second case occurs when we think that we will use the heat in the tank from the previous warm water heating period, and the heat supply will be shorter than the DHW period (**Figure 2**).

For heating with a reservoir, the required heat output of the heat source is determined as:

$$P_{1n} = \left(\frac{\Delta Q_s}{\tau}\right)_{\max} \quad [kW] \qquad (2)$$

where the ratio $(\Delta Q_s/\tau)_{max}$ represents the maximum inclination of the tangent to the time axis.

In the case of permanent heat supply from the hot water heater during the whole period (**Figure 2**), $\Delta Q_s = Q_1$. In the case of intermittent operation in several different time phases of one warming period, the maximum value is considered for the calculation according to (2).

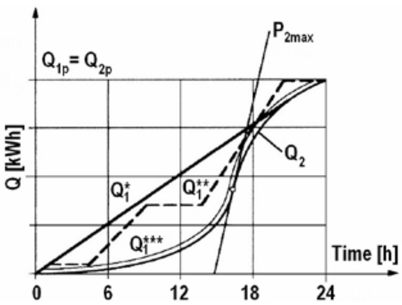

Figure 1. Example of heat supply and demand curves for DHW heating with different time intervals of heat sources: Q_1* – heat sources with continuous operation and storage tank; Q_1** – heat sources with intermittent operation and storage tank; Q_1*** – heat sources with sufficient output that are continuously controlled according to the domestic hot water consumption without a storage tank (flow-through heating).

It follows, from the above procedure, that for a shorter supply of heat from the source to the DHW storage tank, it is necessary to design a larger tank volume, but at the same time require a higher heat output of the heat source than the permanent supply of heat to the tank during the entire hot water collection period (**Figure 3**). Thus, if we have a sufficiently large heat source with continuous heat output regulation, it would be possible to design the DHW heating system without a reservoir, i.e., in a flow-through manner.

The most common mistakes in designing the size of the DHW storage with the heat supply and delivery curve method are the options for constructing the heat supply curve Q_1. The first mistake is, if the designer is trying lean towards the design security side, this then results in a significant increase in the size of the DHW storage tank. The second mistake occurs when the possibility of changing the heat demand curve in the non-standard behaviour of the user is not taken into account, resulting in an insufficient amount of prepared DHW.

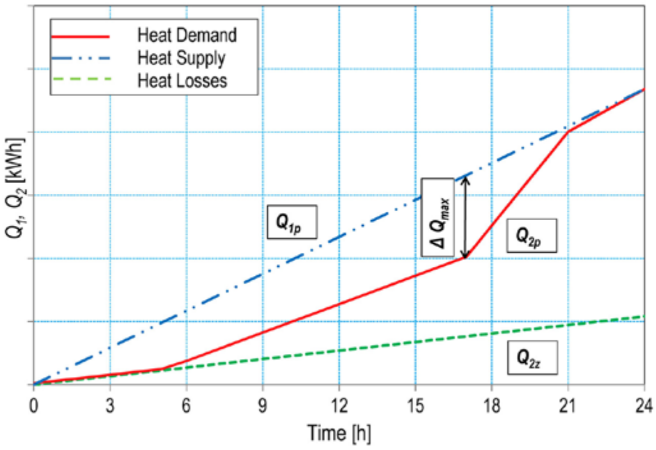

Figure 2. Heat demand and supply curves with uninterrupted heat supply to the DHW storage tank.

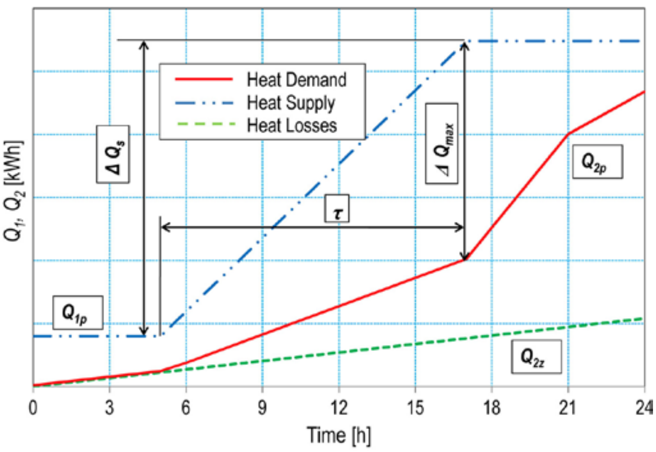

Figure 3. Heat demand and supply curves with heat supply to the DHW storage tank distributed over time.

A typical example of the underestimation of the heat supply curve Q_1 is shown in **Figure 4**. The purpose of such a design is to minimise the size of the DHW storage tank as much as possible by copying the heat demand curve. However, if the DHW production is increased during the DHW preparation period (one day, in this example), this DHW set-up system will not be able to deliver enough DHW. A more appropriate design of the same example is shown in **Figure 5**. The principle of the correct design is not to create the smallest DHW tank (i.e., the minimum difference between the heat supply and demand curve), but to create sufficient storage space for possible non-standard DHW use. Measurements in apartment buildings indicate that at least a 15% increase in the heat demand over a sampling curve is required for the heat supply curve. If a significant morning peak is expected, and if the heat source is also used for other technologies (heating, air conditioning, etc.), it is possible to cover the increase in the DHW consumption in the morning hours by increasing the volume of the tank proportionally enough to allow for a longer period of time that does not require heat to be supplied to the DHW system.

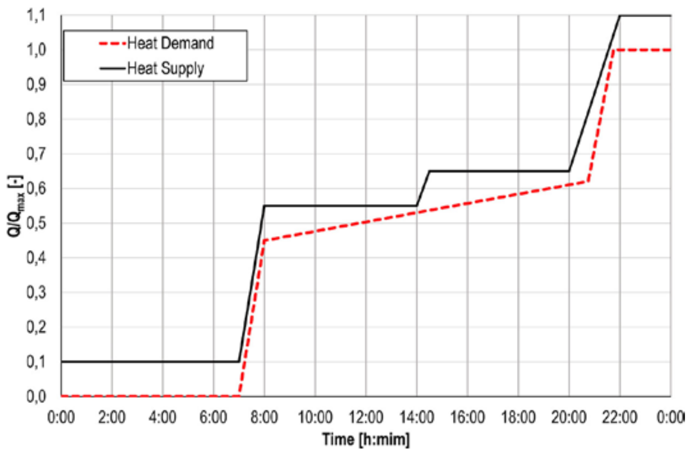

Figure 4. Heat demand and supply curves for an inadequately chosen charging regime of the DHW storage tank.

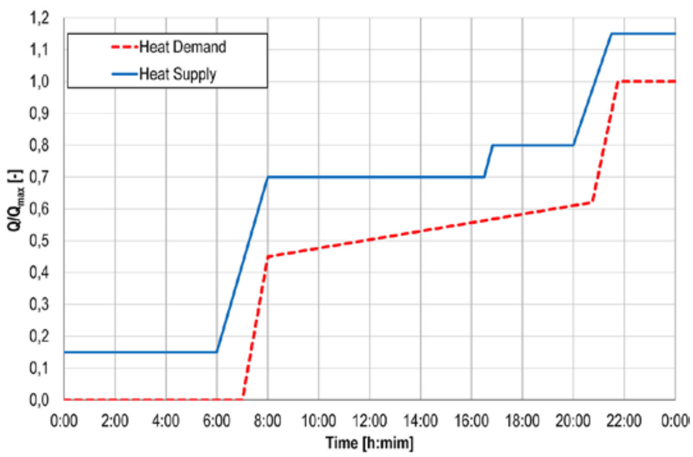

Figure 5. Heat demand and supply curves with the optimised charging of the DHW storage tank

For the examples in **Figures 4** and **5**, it is interesting to compare the size of the calculated DHW storage tank and heat demand of the heat source. The results in **Table 1**, respectively **Table 2** show that a heat source, for both examples, will be required with a power of 30 kW, based on the percent ratio of the heat to the y-axis in the graphs in **Figures 4** and **5**, where 1% = 1 kWh (2). On the other hand, the storage tank is about 250 litres and about 480 litres with respect to the size of the DHW storage tank in the example of **Figure 4** and **Figure 5**, respectively (1).

From the solution shown in **Figure 5** it can be seen that stagnation of the heat demand for the DHW between 8.00 and 16.20 can be expected, which is the possibility of using the heat source for other purposes (technology) than just DHW preparation. However, for the solution of **Figure 5**, it is still necessary to include in the overall energy and cost balance of the proposed system, both

Table 1. Sizing of the DHW storage tank and heat source according to the example in **Figure 4**.

Charging time	Required volume of the DHW storage V_{DHW} [l]	The rated heating power of the DHW P_{1n} [kW]
6:00 to 7:00	It is not critical for the maximum difference	**30.0**
7:00 to 9:00	It is not critical for the maximum difference	7.5
14:00 to 14:30	**248.4**	20.0
20:00 to 22:00	It is not critical for the maximum difference	22.5

Table 2. Sizing of the DHW storage tank and heat source according to the example in **Figure 5**.

Charging time	Required volume of the DHW storage V_{DHW} [l]	The rated heating power of the DHW P_{1n} [kW]
6:00 to 8:00	**477.7**	27.5
16:30 to 16:50	It is not critical for the maximum difference	**30.0**
20:00 to 21:30	It is not critical for the maximum difference	23.3

in the increase in the static heat loss of the DHW tank and the financial costs associated with the acquisition of a larger DHW tank.

Method of previous DHW preparation

The advantage of preferential hot water heating is the possibility of using the maximum heat output of the heat source, which is primarily designed for e.g., the heating system. If the DHW is taken from the storage tank, the water temperature in the t_{DHW} tank will drop. Upon reaching the water switching temperature DHW_{Vmin}, the heat source control preferably provides heat supply to heat the DHW. In the case of the hydraulic connection shown in **Figure 6**, this means that the heating system circulation pump is switched off and the three-way switching valve in the direction of charging the DHW storage tank switches. At the same time, the heat source increases the boiler water temperature (usually a fully rated output to a maximum output temperature, e.g., up to 80°C), and the control switches the DHW tank charging pump. When the water temperature in the tank reaches the set (required) value, the control switches the entire system back into the heating mode. It is, therefore, obvious that the greater the switching difference ($\Delta t_{DHW} = t_{DHW} - t_{DHWspin}$), the longer the time it is to charge the tank. Switching differences are usually selected at 5 K or 10 K depending on the type of DHW storage tank. However, the time required to heat up the DHW tank should not be too long to interfere with the thermal comfort in the heated area during the heat supply interruption to the heating system. e.g., for light buildings with minimal heat accumulation, the time required to heat the water τ_a in the DHW tank should not exceed 10 minutes. For moderate and heavy buildings with masonry storage capacity, the reheat time τ_a should not be longer than 20 minutes.

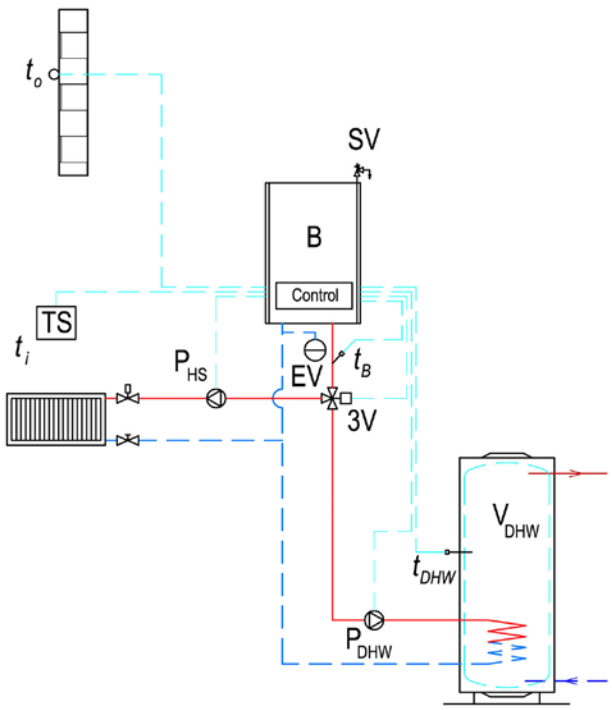

Figure 6. Example of a heat source connection in a system with priority domestic hot water preparation: P_{HS} – circulation pump of the heating system; P_{DHW} – DHW storage tank pump; EV – expansion vessel; B – boiler; TS – remote control with internal temperature sensor; SV – safety valve; 3V – three-way switching valve; V_{DHW} – domestic hot water storage tank; t_o – outdoor temperature; t_i – indoor temperature; t_B – boiler water temperature; t_{DHW} – water temperature in the domestic hot water storage tank.

In order for the above principle to work, it is necessary to meet the basic assumption that the heat output of the boiler Q_k is greater than or equal to the required power for the preparation of the DHW Q_{DHW}. And at this point, the designer sometimes underestimates it. If we realise the different requirements for the function of e.g., a low-potential heat source in a passive house, it is clear that the heating requirements will differ considerably from the requirements for the preparation of the DHW, not only with regard to the required thermal output, but also with regard to the time of use of the source heat. These different requirements make it necessary to adapt the design of the DHW storage tank.

For residential buildings, indirectly heated containers with an integrated exchanger are most commonly used. They work on the principle of natural buoyancy, i.e., the contents of the storage tank are heated from the bottom up. With these systems, it is quite problematic to ensure that the entire volume of the DHW tank is fully heated to the desired temperature. In order to calculate the actual usable content of the container, it is expedient to include the so-called correction factor y (**Table 3**) in the calculation, which is used in German standards (e.g., DIN 4708 [5]).

Table 3. Correction factor of heat consumption from the DHW storage tank [5]

Hot water tank	*y* [-]	
	τ_a < 20 minutes	τ_a < 10 minutes
Vertical storage	0.94	0.89
Horizontal storage (up to 400 l)	0.96	0.91
Horizontal storage (over 400 l)	0.90	0.85

The basic equation for calculating the required warming time τ_a, or the size of the DHW tank volume, is the heat supply balance of a given volume of liquid per unit time at a known temperature difference in the form:

$$Q_k = \frac{V_{DHW} \cdot y \cdot \rho \cdot c \cdot \Delta t_{DHW}}{\tau_a} \Rightarrow$$

$$V_{TV} = \frac{\tau_a \cdot Q_k}{y \cdot \rho \cdot c \cdot \Delta t_{DHW}} \Rightarrow$$

$$\tau_a = \frac{V_{HW} \cdot y \cdot \rho \cdot c \cdot \Delta t_{DHW}}{Q_k} \qquad [W] \qquad (3)$$

The basic example is a family house inhabited by 4 persons, with 5+1 disposition (kitchen = sink, two bathrooms = 3x sinks, 2x showers, 1x bath). You can ignore the amount of DHW sampling for all the sinks. From the point of view of the water supply design values, the maximum hot water flow rate is 0.4 l/s = 24 l/min for the bath and 0.2 l/s = 12 l/min for the shower. From the point of mixing hot and cold water in the outflow battery, when showering and bathing is the most common, with a mixing water temperature of between 38-40°C, the design flow of hot water in these batteries is about 6 l/min. It means that, in a sample family house with simultaneous bathing (running bath) and showering, it is possible to consider the maximum flow of hot water of 12 l/min = 720 l/h. Higher water flow rates are not designed for the water pipe.

The "maximum" water flow rate with the simultaneous use of the shower and bathtub is important in relation to the heat transfer capability in the heat exchanger of the selected DHW storage tank. e.g., a 65-litre specific H65W cylinder has a hot water flow of 438 l/h at temperature t_2 = 45°C at a heat output of 18 kW on the primary side of the heat exchanger (i.e., on the heat source side). In other words, its steady production of hot water at 45°C, at the cold water at the inlet to the tank of 10°C, is 438 l/h. In addition, for example, with another 120-litre hot water tank S 120/5, the manufacturer reports a steady flow of hot water of 834 l/h at 34kW (at t_K = 80°C, t_2 = 45°C, t_1 = 10°C). Thus, if an extreme situation arises when the volume of the DHW storage tank is depleted from previous DHW demands (i.e., $t_{DHW} = t_{DHWspin}$) and, at the same time, the supply of heat for the collection of DHW in the form of bathing and showering is required, it would be necessary to ensure that requesting a heat source with a heat output of about 28 kW (based on the flow rate of a bath and shower in the total of 720 l/h, considering the heat exchanger surface of the exchanger in the S 120/5). This is a short, top-of-the-range sampling of 10 to 15 minutes, but it is clear that in a classical family house, such a heat source is not found today. Therefore, it is more appropriate to take into account the requirements of the sanitary installation and the size of the designed reservoir to adapt these facts to the heat source. In addition, it is clear that with the increasing number of inhabitants (supply points) the calculation flow needs to be corrected and it is appropriate to expect a higher proportion of discontinuity in the hot water consumption.

Also, in this method of preparing the DHW, setting the switching differential of the DHW tank charger remains unavoidable in relation to the position of the sensor in the tank (**Figure 6**). In the case of vertical storage, the temperature sensor that controls the switching process of the DHW storage tank is usually positioned from the middle of the tank up to 2/3 of the tank height. If the sensor is placed too high (i.e., too close to the DHW outlet to the water pipe system), a later reaction and a significant delay in charging the DHW tank may occur, when almost the entire volume of the tank will be depleted, and before the desired DHW temperature is reached again, the DHW temperature drops during the DHW demand. Conversely, in cases where the sensor is located too low (i.e., too close to the heat exchanger surface of the DHW), the heat source can be switched frequently even with the smallest DHW consumption, regardless of the actual desired amount of DHW taken.

Conclusion

Therefore, it can be seen from the examples that although the design methods of the DHW design can appear simple in principle, it is important to understand the link to other professions as well. The connection is mainly related to the profession of heating and sanitary installations in the water supply section. The marginal conditions of the hot water system design can be summarised as follows:

- total DHW demand - per unit of measurement (person, bed, shower, etc.),
- knowledge of the heat collection process - time distribution of the DHW in the object,
- temperature level of heat source for the DHW preparation,
- heat source operation requirements - time intervals of operation of other technologies,
- heat transfer capacity of the DHW tank,
- water flow on drain valves. ■

List of nomenclature

c	specific heat capacity of water [J/(kg·K)]
P_{1n}	rated heating power of the DHW [kW]
P_{2max}	maximum heat output for the DHW [kW]
Q_1	heat supplied by the heater to the DHW [kWh]
Q_{1p}	heat delivered by the heater to the DHW during the period [kWh]
Q_2	heat removed by the heater in the DHW [kWh]
Q_{2p}	heat removed by the heater in the DHW during the period [kWh]
Q_{2z}	heat lost during heating and DHW distribution during the period [kWh]
Q_k	boiler heat output (for a common heat source for the DHW preparation) [W]
Q_{DHW}	heat output required to prepare the DHW [W]
t_1	cold water temperature [°C]
t_2	hot water temperature [°C]
t_k	boiler water temperature [°C]
t_{DHW}	water temperature in DHW tank [°C]
$t_{DHWspin}$	water switching temperature in the DHW tank [°C]
V_{DHW}	DHW storage volume [m^3]
y	correction factor of heat removal from the DHW tank [-]
ΔQ_{max}	maximum possible heat difference between Q_1 and Q_2 [kWh]
ΔQ_s	heat supplied by the heater to the DHW at time τ [kWh]
Δt_{DHW}	switching differential for DHW heating (usually 5 to 10 K) [K]
ρ	density of water at medium storage temperature [kg/m^3]
τ	heat delivery time by the DHW heater [h]
τ_a	DHW retention time at the temperature difference Δt_{DHW} [s]

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The author would like to thank Ing. Stanislav Toman for reviewing this article.

Reviewer's note

The labelling of some of the quantities in the article (e.g., P power, t temperature) respects the closer and more, used Czech habits in Latin characters, as opposed to ČSN 06 0320 (2006), which uses the Greek alphabet (Φ power, Θ temperature).

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Pay the PEX piper say industry experts

JAMES RUSSELL

James Russell is a freelance journalist and Communications specialist in the field of plastic pipe technology. He holds a Masters Degree in Corporate Communication from the Erasmus University in Rotterdam. Past and present clients include National Geographic Channel, TEPPFA, Wavin and Pipelife.
russell_chr@yahoo.com

DAVID WALTON

Dr. Walton has a PhD in Mechanical Engineering from the University of Bristol. He is an independent consultant with forty years of experience in senior management roles within the plastic pipe industry that includes British Gas, Wavin, Borealis and Borouge.

For almost 50 years, PEX pipes have transformed the world of plumbing. A series of technical tests undertaken by the Swedish Research Institute (RISE), has recently endorsed the quality performance of premier PEX pipe brands that are used for delivering drinking water. However, whereas these stringent tests confirmed the high quality of leading brands, a small number of PEX pipe samples achieved very low scores in particular for hygiene testing. Industry expert, Dr. David Walton has called for more clarity in the market. He believes that this can be achieved by a common approach to European standards for mechanical and hygiene performance. Such an approach would eventually help installers and contractors to make a more qualified choice. Meanwhile, his market advice is to deal only with major "tried and trusted" PEX pipe makers.

From January to March 2018, the Swedish Research Institute RISE in Gothenburg and Borås carried out a program to test seven different brands of PEX pipe[1]. These tests focused on brands that are available on the market and specifically used for delivering drinking water to the tap. The emphasis of testing was therefore oriented towards both mechanical characteristics and hygiene performance of the products.

Founded in 1973, RISE is known internationally for industrial research and innovation as well as its testing and certification expertise especially in the field of plastic pipe technology.

Each PEX sample was purchased by RISE on a random basis and on the open market. Five of the seven samples were of the class PEX-A type and the remaining two samples conformed to class PEX-C. It is important to note that there were no PEX-B samples in the final test selection.

There are an estimated 150 different brand types of PEX pipe sold within the EU. According to industry analysts, the manufacturers of the seven tested samples represent approximately 50% of the market for PEX-a and PEX-c drinking water pipes.

Whereas mechanical testing was performed directly by the Swedish Institute, hygiene tests were carried out by the *Hygiene-Institut des Ruhrgebiets* in Gelsenkirchen, Germany. The provenance of each sample was concealed from the German testing personnel and process.

All of the major mechanical tests undertaken by RISE were in accordance with ISO or nationally recognized procedures. However, one particular test with an obvious practical value for installers was used to measure the force needed to bend the pipe during pipe installation (**Figure 1**). This flex for PEX test involved bending a length of pipe into a ring and mounting it upon a tensile testing machine.

1 The original RISE study included 7 brands of PEX pipes and one PE-RT pipe. For the purpose of full comparability, this article only addresses the results obtained from testing the PEX pipes, and the PE-RT sample in the study is not taken into account.

Installers are well aware of the inherent advantages that high flexibility confers. More so within underfloor heating than plumbing situations. PEX pipe is easier to install than rigid pipe and being available in long coils, it can eliminate the need for extra fittings. High flexibility is therefore a desirable characteristic for underfloor heating or building renovation. Lower flexibility means stiffness and less movement – sometimes a desired characteristic for plumbing installations.

Olle Persson who is a RISE scientist and the project leader for the PEX testing program comments: "Some of the tests, for example flexibility and necking at tensile force are not something that are performed at a regular basis by us and probably not by others. However, the elongation at break, pressure testing and degree of cross-linking are well known and standardized."

"One standard and crucial ISO test was to submit samples to internal pressure. RISE applied every PEX pipe product to the same pressure (± 0.7 %) under identical testing conditions. Most PEX pipes physically resisted such stress for at least 400 hours before testing was discontinued."

A total of nine mechanical tests were employed by RISE and their data analysed by the authors of this article. For the purposes of comparison and presentation, a three-star league table for each mechanical test was devised. In this way, high achievers would be recognized in true Olympic fashion and low achievers would be singled out for their poor performance (see **Figure 2a**). An identical assessment approach was adopted for hygiene testing (see **Figure 2b**).

Figure 1. Tensile testing machine used by RISE to measure PEX flexibility.

Product	In top 3	In bottom 3
1	★★★★★★★	
4	★★★★★★★	★★★★
2	★★★★★★★	★★★★
3	★★★★★★	★★★
5	★★★★	★★★★★★
7	★★	★★★★★★★★★
6	★★	★★★★★★★★★

Figure 2a. Performance Summary of pipe samples subjected to mechanical testing. The column "In top 3" illustrates the number of individual tests where the product qualified as one of the three best performers. Equally the column "In bottom 3" refers to the number of tests where the product was among the worst three performers.

Product	In top 3	In bottom 3
4	★★★★	
1	★★★	
3	★★	★★
5	★★	★★
2	★	★
7	★	★★★
6		★★★★

Figure 2b. Performance Summary of pipe samples subjected to hygiene testing. The column "In top 3" illustrates the number of individual tests where the product qualified as one of the three best performers. Equally the column "In bottom 3" refers to the number of tests where the product was among the worst three performers.

Testing the waters

European and national technical standards for hygiene and water quality are particularly stringent when it comes to anything that involves the transportation of water. Two major tests are of particular value when assessing the performance of pipe systems for the purposes of hygiene and water quality. The Ruhr District Institute of Hygiene applied these tests and in strict accordance with the method set by the German institute for standardisation (DIN).

The first test measures the amount of substances containing carbon that end up in the tap water. This provides a clear indicator of the hygienic quality and cleanliness of the plastic pipes in contact with drinking water.

A sophisticated instrument called a total organic carbon (TOC) analyser is used to measure samples of water over an extremely wide range (from 4 µg/L to 25,000 mg/L). Measurements produced by this equipment are precise enough to pass verdict on any drops of water from the ultrapure to the highly contaminated.

But testing the waters also requires tasting the waters. According to Olle Persson from RISE: "the laboratory conditions for evaluating the appeal of drinking water are more scientific than those explored by the age-old methods of wine tasting."

To ensure that all senses were attuned to the delicate task at hand, the Ruhr District Institute of Hygiene in Gelsenkirchen employed a team of three to five water tasters from within the staff of the institute. Their expertise would prove invaluable.

First impressions are important and appearance was their primary concern. Colour, turbidity (clear or cloudy) and any sign of foaming were closely noted. German noses and taste buds were then prepared by exposing them to standard odours and tastes. PEX waters were then rated according to threshold taste and odour numbers (TON).

Their notes as well as the conclusions from across all categories support the basic premise that PEX pipe systems conform to maximum tap water quality and hygiene.

Overall results from hygiene testing were good news for the same PEX pipe makers that topped the mechanical testing league. Their pipes not only stayed within the limits set down by European standards but their waters maintained excellent quality and cleanliness.

However, two of the seven pipes failed to meet the regulatory hygiene requirements. This was particularly evident from the performance of the samples when tested for Total Organic Carbon (TOC). This TOC test is a commonly used parameter for assessing the suitability of plastic pipes for drinking water applications.

These differences are compared in results from TOC testing in **Figure 3**. Two of the samples produced TOC values considerably above the generally applied German hygiene guidelines of 0.5 mg/l. But one sample failed to meet this requirement when tested in two separate temperature conditions.

Given that the remaining products in the test met the required hygiene criteria with a clear margin, it is reasonable to conclude that there are distinct performance differences between brands.

Overview of test results

Albeit a consumer-oriented comparison, the overview was noteworthy. Whereas most of the PEX products performed perfectly, the same two PEX products scored consistently low points when subjected to mechanical and hygiene testing. The entire summary shows clearly that high-performance products tend to perform well in all tested categories, whereas poor performers are consistently at the bottom of the league in most aspects.

"These tests were significant," explains Dr. Walton. "They confirm that PEX pipes are tough, tried and tested when supplied by major European plastic pipe makers. These firms invest a significant proportion (over ten percent) of their turnover in technical research, manufacturing excellence, quality and pipe material testing and development."

"PEX pipes may be buried or hidden out of sight but their lifelong performance is such that they are expected to endure for at least fifty years. However, one of the difficulties with the PEX market is that all the pipe looks the same whereas the quality of the cross-linking can vary considerably from manufacturer to manufacturer especially if the sample is taken from a wide range of suppliers."

"The quality of the processing significantly effects performance and without fairly sophisticated testing it is difficult to check the pipes. Also, the distributors and users tend to be small companies who are not able to carry out the appropriate checks and have to rely on the markings on the pipe. In this environment it is relatively easy for the pipe manufacturer to take short cuts to significantly cut their costs."

Ludo Debever who is General Manager of The European Plastic Pipes and Fittings Association (http://www.teppfa.eu/) agrees: "PEX Hot & Cold water systems are recognized through their European Product Declarations for their sustainability and low environmental impact. My advice to the building services industry is that installers should refer only to TEPPFA Member Companies for assurance in matters of quality and supply."

Given an overview of RISE results on product performance (see **Figures 2a, 2b and 3**), his advice may not be misplaced. TEPPFA member companies collected gold, silver and bronze medals for their mechanical endurance and hygiene performance. The two lowest PEX pipe makers failed to complete their events.

Conclusive advice

PEX pipe systems continue to deliver the practical and economic benefits for which they were created. Nevertheless, the authors of this article believe that they have spotted a potential kink in the PEX pipes

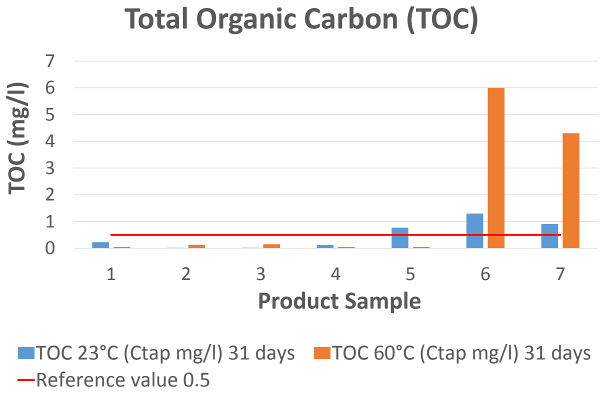


Figure 3. Results from Total Organic Carbon (TOC) testing of product samples. In the absence of common European limit values for TOC, the German KTW Guideline value of 0.5 mg/l is used as a reference for acceptable product performance.

supplied by a very small number of producers. Water authorities expect high standards of the pipes that deliver their precious liquid and the work carried out by RISE suggests that whereas flexibility might be a desirable product characteristic, cutting corners at the manufacturing stage, is certainly not.

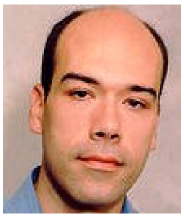
Clearly a common approach at European level is required in terms of standards for mechanical and hygiene performance. But Europe is not known for its fast track harmonization of standards. Meanwhile, according to industry experts, installers should pay only the many "tried and trusted" PEX manufacturers in the market. ■

PEX pipes

From the 1970's onwards, installers have warmed literally and figuratively to PEX pipes as a popular way to transport water in hydronic radiant heating systems. The name PEX derives from cross-linking polyethylene (PE) - a molecular process that improves the performance of the pipe material at higher temperatures.

The economic performance and practical benefits of PEX pipes soon opened the door to wider applications than merely transporting hot water from boiler to radiator. Today, PEX piping also supplies underfloor heating systems and delivers Hot and Cold water. Compared to non-plastic piping whose replacement they are increasingly providing, their global market share for new build is estimated at well over 45 %.

Gemeentehuis Horst aan de Maas: A Case of Excellence in Indoor Environmental Quality


MANUEL GAMEIRO DA SILVA
University of Coimbra, Department of Mechanical Engineering, Portugal
manuel.gameiro@dem.uc.pt

JOÃO DIAS CARRILHO
University of Coimbra, Department of Mechanical Engineering, Portugal
joao.carrilho@dem.uc.pt

LEO VAN CAPPELLEN
Van Cappellen Advies bv, The Netherlands
vca@teleconsult.nl
leo@vancappellen.com

JOHN VAN PUTTEN
Municipality of Horst aan de Maas, The Netherlands
j.vanputten@horstaandemaas.nl

BART SMID
Municipality of Horst aan de Maas, The Netherlands
b.smid@horstaandemaas.nl

An Indoor Environmental Quality monitoring system developed to be installed in a medium size office building is presented. The architecture of the system, comprising two measuring stations and the building management unit is described, being also addressed the two software tools developed to handle, display, process and analyze the data. Finally, the results of a virtual visit to the building data base are presented and discussed, passing through the different windows available in the visualization software tool.

The main functional purpose of a building is to provide its occupants with safe, healthy, and comfortable indoor conditions. The concept of Indoor Environmental Quality (IEQ), usually defined as the set of conditions associated with the thermal environment, the indoor air quality, the acoustic environment and the visual environment, is normally used to assess the extent to which this objective is achieved in a given building.

In order to keep the values of the physical variables characterizing the indoor environment within the comfort intervals, some energy should be supplied to the technical systems that are installed in buildings to compensate the differences between what the building envelope by itself is able to provide and the target indoor conditions. Optimizing this amount of energy all over the buildings stock is a main goal for the European Union (EU) energy policies, concretized, among others, through the Energy Performance of Buildings Directive (EPBD 1992) and its 1st recast (2010), together with the Energy Efficiency Directive.

There is a statement included in EPBD mentioning that indoor climate cannot be compromised when improving energy performance. However, REHVA (2016) calls the attention, in its position paper, to the fact that most Member States of EU implemented the Directive, through its transcription into the national laws, without paying attention to IEQ. And, if the buildings are not providing good indoor environmental conditions to occupants they are not fulfilling the main function for which they were designed. In addition to the damages that may result in terms of occupant health and comfort, which necessarily have an impact on occupational absenteeism, the productivity of workers in intellectual tasks is also clearly affected if good indoor environmental conditions are not provided.

Hence, achieving, at each moment in time, the appropriate balance between the building's energy consumption and the provided IEQ conditions is a delicate problem that requires a continuous effort in the knowledge and quantification of the two involved aspects. Real time monitoring of energy consumption and of the relevant physical variables together with the calculation of the suitable indices used to assess the indoor environment in the different aspects composing IEQ as the most adequate solution. The Smart Readiness Indicator (SRI) concept has been recently launched in the 2nd Recast of EPBD as an optional common European Union scheme to indicate how smart a building is. It is stated that the rating shall be based on the assessment of the building's or building unit's capabilities to adapt its operation to the needs of the occupant, and the grid, and to improve energy efficiency and overall performance, where indoor environmental quality should be included.

In this article, the efforts conducted in the framework of the retrofitting process of Gemeentehuis Horst, the 7.600 m² town hall building of the Municipality of Horst aan de Maas, in The Netherlands, to transform it in a case of excellence in terms of IEQ, are reported. The renewal of a substantial part of the HVAC systems in the building implied the writing of a set of IEQ performance and systems concept specifications and in the process of drafting these, the requirements alone were considered to be inadequate in terms of quality assurance. Thus, has been added to the scope of work a two-year Soft Landings program for objectively assessing and evaluating the real IEQ achievements before a final and formal completion could be established. The work was carried by a partnership where the Dutch consulting company Van Cappellen Advies worked together with a team of researchers from the Mechanical Engineering Department of the University of Coimbra, in Portugal and with the technical staff of the Horst municipality.

Experimental Measuring Chain

The monitoring development project started in 2014 and its main objective was again to install a monitoring system, able to assess the IEQ conditions of the building (**Figure 1**) in the various aspects contributing to the human perception of comfort (thermal, acoustic and

Figure 1. The Gemeentehuis Horst building.

visual environments together with indoor air quality). Besides the measurement of the relevant environmental variables, another feature requested for the system to be installed has been the calculation of the indices commonly used for a more holistic assessment (e.g. the operative temperature, the predicted mean vote (PMV), the predicted percentage of dissatisfied (PPD) and the noise equivalent level (Leq)).

Into the project's performance and concept specifications is incorporated the thermal adaptive model ATG for a Beta type building/climate according to Dutch topical trade publication ISSO-74:2014, Thermal Comfort . In both Fanger's thermal comfort model (ISO 7730:2005), as well as in the adaptive model (EN15251:2007; ASHRAE 55:2013), the Operative Temperature T_o plays a key role, notwithstanding the fact that building management or control systems only operate on the basis of ambient room air temperature and not at local workplace level.

The initial main technical requirements for the project were:

- Develop a mobile indoor measuring station unit for the evaluation of work place conditions;
- Develop an outdoor sensor station unit, in order to be able to relate the indoor environment to the outdoor environmental conditions;
- Develop a base unit that collects, processes, and computes the relevant descriptors and indices and stores the streaming data in the form of data files per day;
- Develop a presentation/dashboard system that visualizes the measured and calculated real time values at a pre-defined time interval (default value: 5 minutes) and facilitates professional analysis and report making;
- Data communication, either cabled or wireless, should be completely independent from any corporate infrastructure;
- Hardware, sensors in particular, must be commercially available on the market and have a digital output readable through an USB port;
- Software is specially developed into a modular, adaptable concept, which makes future changes easily possible. Widely used software platforms are to be preferred.

The developed system (**Figure 2**) consists of four major hardware parts:

a. Mobile sensor station, named WP from the initials of work place
b. Fixed outdoor sensor station
c. Base station
d. Building manager's station

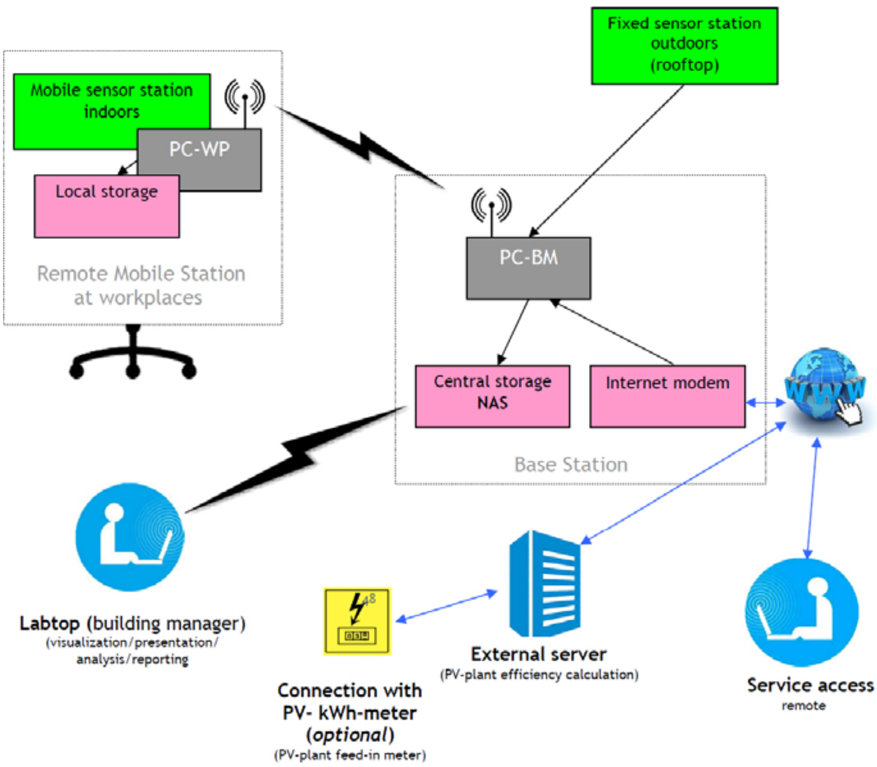


Figure 2. Architecture of the developed monitoring system.

The mobile station can be put freely at each workplace; only the 230 V power has to be plugged in; the power supply when commuting from one work place to the other is assured by an UPS to avoid losses of data. It is equipped with sensors to measure the following variables:

- mean radiant temperature (black globe);
- air velocity/temperature/barometric pressure, at the neck position;
- air velocity/temperature, at the ankle position;
- surface temperature distributions of floor/ceiling/wall-window;
- relative humidity;
- sound pressure level (A weighted);
- Illuminance level;
- Concentrations of CO_2, VOCs, and particle matter PM10, PM2.5 and PM1.0.

Sensors to measure the following variables are mounted in the fixed outdoor station:

- air temperature;
- relative humidity;
- barometric pressure;
- wind velocity/direction;
- solar irradiance;
- concentration of CO_2 and fine particle matter PM10, PM2,5, PM1.0.

The wind and solar sensors are mounted on poles at 5 m+ roof level; the other sensors inside and onto the station's enclosure. Sensors are resistant against common Northern European operational winter and summer conditions (–10°C to 40°C; high humidity levels).

The building manager's station is a laptop on which presentation/dashboard software runs and with which analysis and reports can be made. The laptop has a wireless streaming data communication with the base station.

The sensors produce raw data and processed data generally each 0.1 s, of which a 5 minutes mean is drawn. The raw data are the untreated measuring values and the processed data are the calculated values, or for example in case of the solar irradiance readings, values disposed of obvious outliers, negative values, invalid data points or gross measurement errors, which have a disproportionate effect on statistical completeness or analysis.

Figure 3. The indoor and outdoor measuring stations.

Apart from the direct readings from the sensor channels, other variables and composed indices are calculated to be displayed and recorded, like, for instances:

- Operative room temperature (OT)
- Running Mean Outdoor Temperature (RMOT)
- Wind Chill (WC)
- Thermal Comfort – Perceived Mean Vote (TC-PMV)
- Thermal Comfort – Perceived Percentage Dissatisfied (TC-PPD)
- Vertical Air Temperature Gradient – Percentage Dissatisfied (VATG-PD)
- Room Air Temperature Fluctuation (ATF)
- Indoor Dew Point (IDP)
- Outdoor Dew Point (ODP)
- Draught Rate – Perceived Percentage Dissatisfied (DR-PPD)
- Indoor Absolute Humidity (IAH)

Software Tools

Two software structures were developed, the first one dealing with the data handling, from acquisition till storage, and the second one with the data reduction, processing, analysis and visualization. The first tool is called Volkerak and includes four types of threads are being used for the data handling:

Data acquisition: This type of thread is responsible for reading messages from a sensor at regular intervals and publishing these messages in a dedicated data stream.

Message parsing: This thread subscribes to a single stream created by a data acquisition thread and parses a numerical value from the sensor message to a specified format.

Calculation: This thread can subscribe to multiple numerical data streams (after message parsing), perform calculations and publish the numerical result of these calculations into a new dedicated data stream.

Logging/storage: This type of thread collects data from numerical data streams of interest and stores these data, as it arrives, in a .txt file every 5 minutes.

It is installed both in the Work Place (WP) unit and in the Building Manager (BM) unit. It has been written in C/C++ and is modular in set-up (for future addition or change of sensors for example). An additional utility program takes care of the data streaming (multiple 5 minutes text packages) from the mobile unit to the base station by means of radio modems.

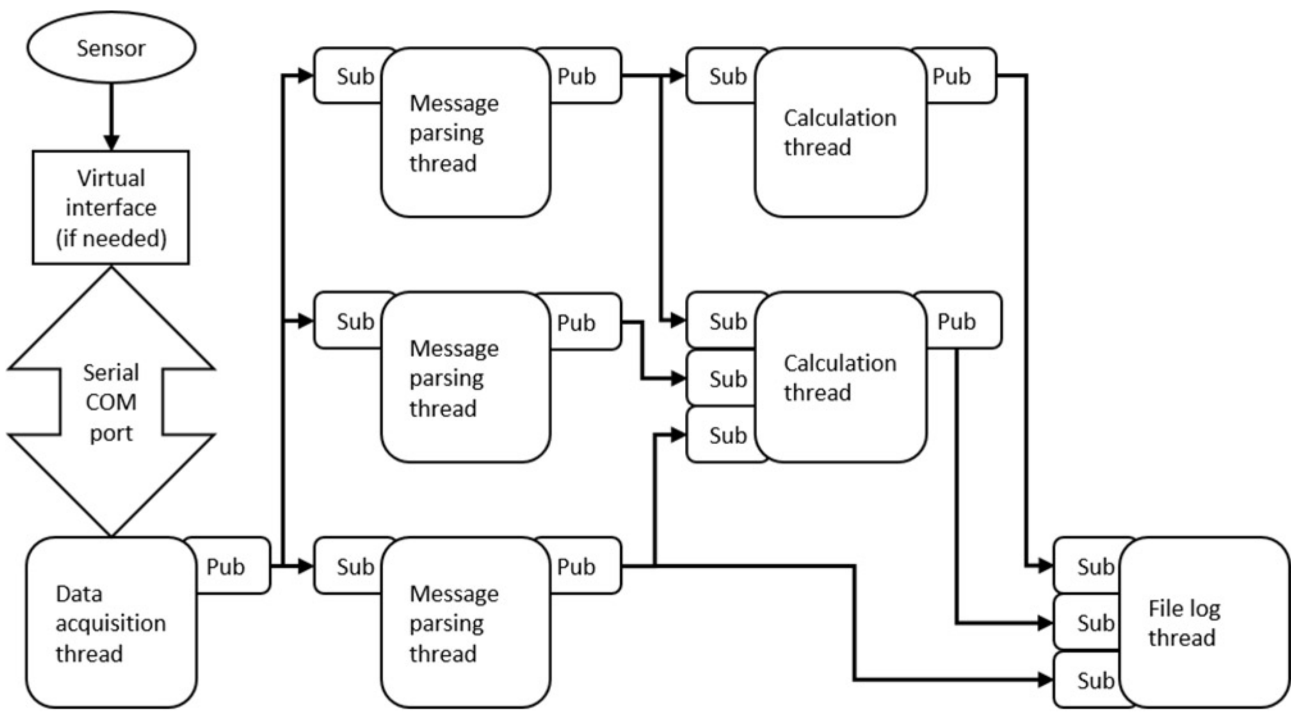


Figure 4. Data handling Volkerak software structure.

The second tool is called Discoverer and it is a multiple windows data presentation and analysis tool written in the programming language Labview. It accesses the Data Container, the folder with the daily data files created by Volkerak. Three different files (indoor probes, outdoor probes and infrared sensors) are saved each day, containing measured values recorded each 5 minute.

The windows of the Discoverer software tool are following described:

01 Dashboard: Window with the last measured values. It is refreshed each 5 minute and displays the time tag and the values of indoor (WP) and outdoor (BM) probes, together with some of the calculated indices (e.g. RMOT, WindChill, PMV, PPD, etc.).

02 Data Streamer: Window where the values of all the indoor and outdoor probes are displayed for the date selected by the user. It is possible to scroll along the time of the day, independently for indoor and outdoor probes.

03 WP Graphs: Window where two different graphs are depicted, based upon the selection of the user among the list of the indoor probes. The user selects the date of the first day and the number of days to be graphed. I tis possible to generate an output file with the data of the two displayed graphs.

04 BM Graphs: It is similar to the previous window, but it deals with outdoor sensors.

05 IR Sensors: Window where the values measured by the infrared temperature measurement probes are displayed. Each probe has an array with 16 measuring points (4 x 4). Besides the arrays with the numerical values of floor, ceiling and façade probes, color maps (interpolated and not interpolated) are also presented. It is possible to scroll along the selected day.

06 Adaptive Model: Window where the Building Adaptive Model graph is displayed, following the model defined in Dutch ISSO 74. The daily indoor operative temperature, during the user defined occupancy period is displayed as a function of the running mean outdoor temperature. The user may select the displayed period, indicating the first day and the total number of days.

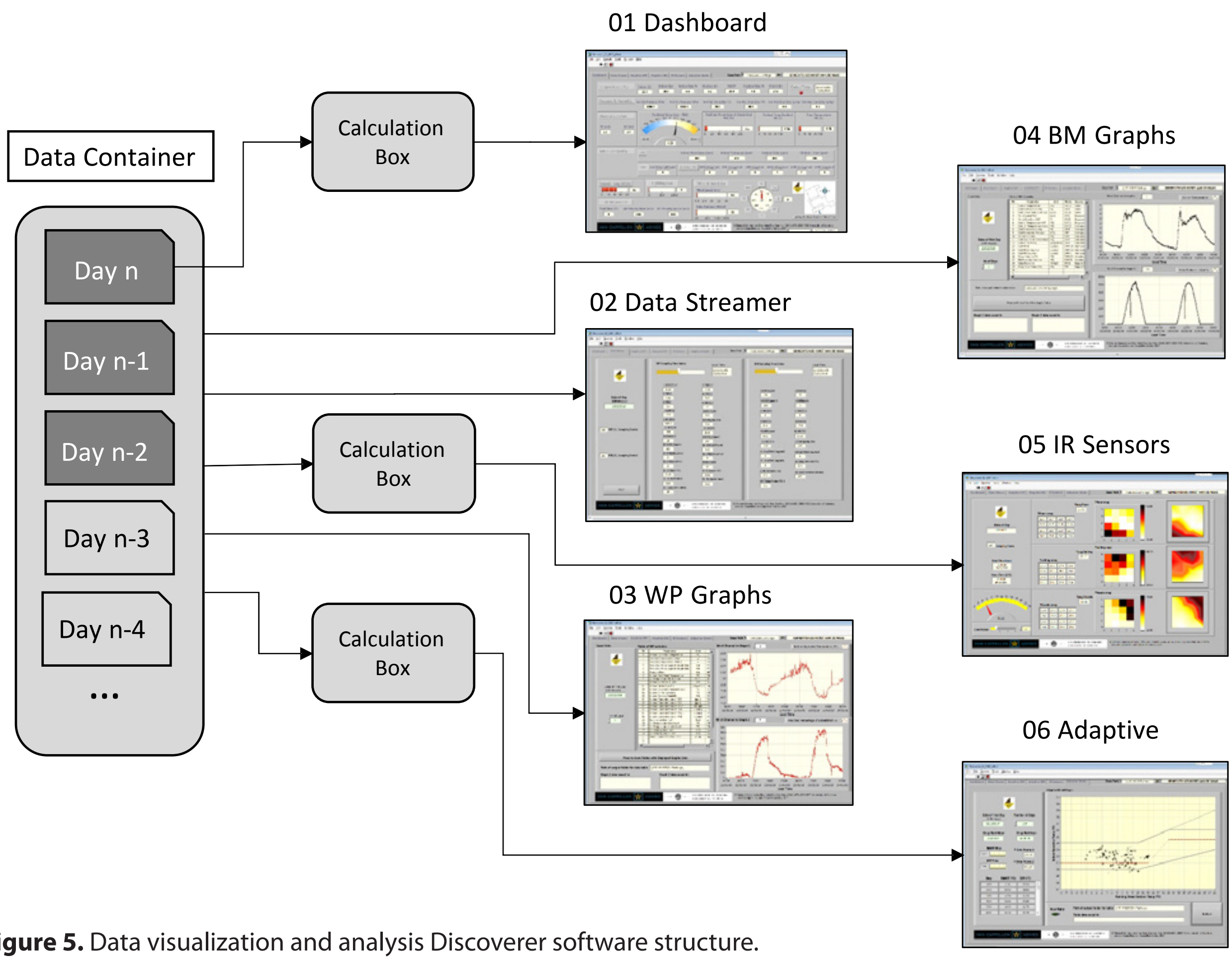


Figure 5. Data visualization and analysis Discoverer software structure.

Results

The results of a consult of the building database, obtained through remote access to the Discoverer software tool installed in the BM computer, are following presented. The access was done in the 11th of March 2018 and the first captured screen refers to the Dashboard window (**Figure 6**).

The graphical interface is divided into 8 different zones, with the first four rows, from top to bottom, being used for Temperatures, Pressures and Humidities, Thermal Comfort and Indoor Quality data, respectively. In the left down corner, three zones are dedicated to Sound, Light and Air Movement values, while the down right corner is used to display outdoor Wind and Sun data. The display is updated each 5 minute i.e. at the same rate used to register the data.

The captured screen of the Graphics WP window, showing the time evolutions of the indoor operative and the thermal comfort index PPD, for the days 22nd and 23rd of February 2018, is presented in the **Figure 7**. The user may select, for graph 1 and graph2, any one of the 25 parameters included in the Table of WP variables. In the showed case, it is patent both the very good thermal environmental conditions of the building (PPD has not exceeded 6%, meaning a class A indoor enclosure) and the excellent resolution of the measuring and evaluation system.

A screen of the Discoverer BM window, captured for the same two days of February 2018, and showing the time evolutions of the outdoor air temperature and the solar radiance is displayed in the **Figure 8**. The outdoor temperature was oscillating between –4°C and 5°C, in an interval that may be considered normal for the season. The two days were sunny with the solar radiance reaching a maximum value of 540 W/m². It is noticeable in the two consecutive days, a perturbation in the solar radiance graph, a little bit before noon due to a shadowing episode of the probe, with a duration of about 20 minutes.

The window named IR Sensors, for the 29th of September 2017, is presented in the **Figure 9**. The floor, ceiling and façade surface temperatures are presented. In each case, values of 16 cells arrays of the three infrared probes are displayed, as well as the respective means, maxima and minima and the color maps in non-interpolated and interpolated versions. The user may scroll along the day, checking the data in 5 minutes' intervals.

A comparison of the building performance in the last Winter season (90 days starting in the 21st of December 2018) and in the last year Summer season (90 days counted from 21st of June 2017), using the Dutch standard ISSO 74 representation for the thermal comfort adaptive model, is presented in **Figure 10**.

The daily indoor operative temperature average, during the user defined occupancy period is displayed as a function of the running mean outdoor temperature, which is a weighted average of previous seven days mean outdoor air temperatures. The weighting factor has a maximum for the day before the one considered in the calculation and decreases as the days become more distant.

The band between the gray lines corresponds to the acceptance zone of the indoor thermal environment (80% satisfaction) and the red line is the optimal condition for ISSO 74 Dutch standard. The first flat section, from left to right, corresponds to the operative temperature set point in the heating season, the second sloped section to the intermediate season conditions and the third section, on the right side, to the cooling season set point.

It is observed that the building was practically always in the zone of comfort, occurring only three days outside this zone, but are points relative to days of weekend in which the building was not occupied. It is also noticeable that the set point chosen for the summer season was 23°C instead of the 24.5°C indicated in the standard.

A possible long-term key performance indicator for the indoor thermal environment is the average of the absolute value of the distance between the actual mean operative temperature of a day and the defined season's operative temperature set point. In the Winter season the value for this descriptor has been 1.11°C, while in the Summer season it was 1.23°C.

The HVAC contractor's control engineer, who's task it is to set and keep the IEQ performances as close to the performance objectives as possible without an unacceptable increase of occupant's complaints and to demonstrate during the Soft Landings period that the contractual obligations are met, is working together with the building manager to skim possible overheating or overcooling and optimize the operation of the systems and instruct the occupants regarding the settings of their room sensor (influence on room level); improvements are made where draught, noise issues etc. arise. ▶

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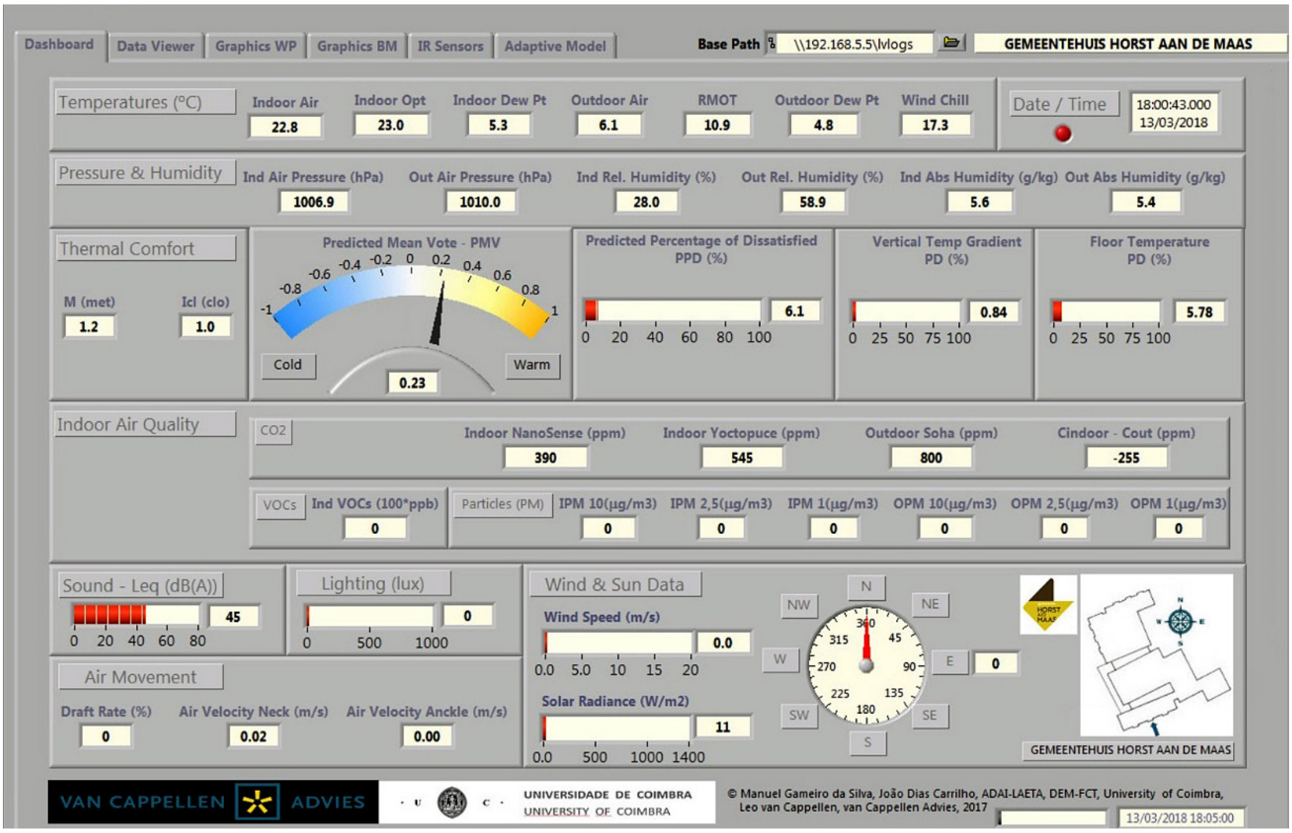


Figure 6. The Dashboard window of the Discoverer software tool.

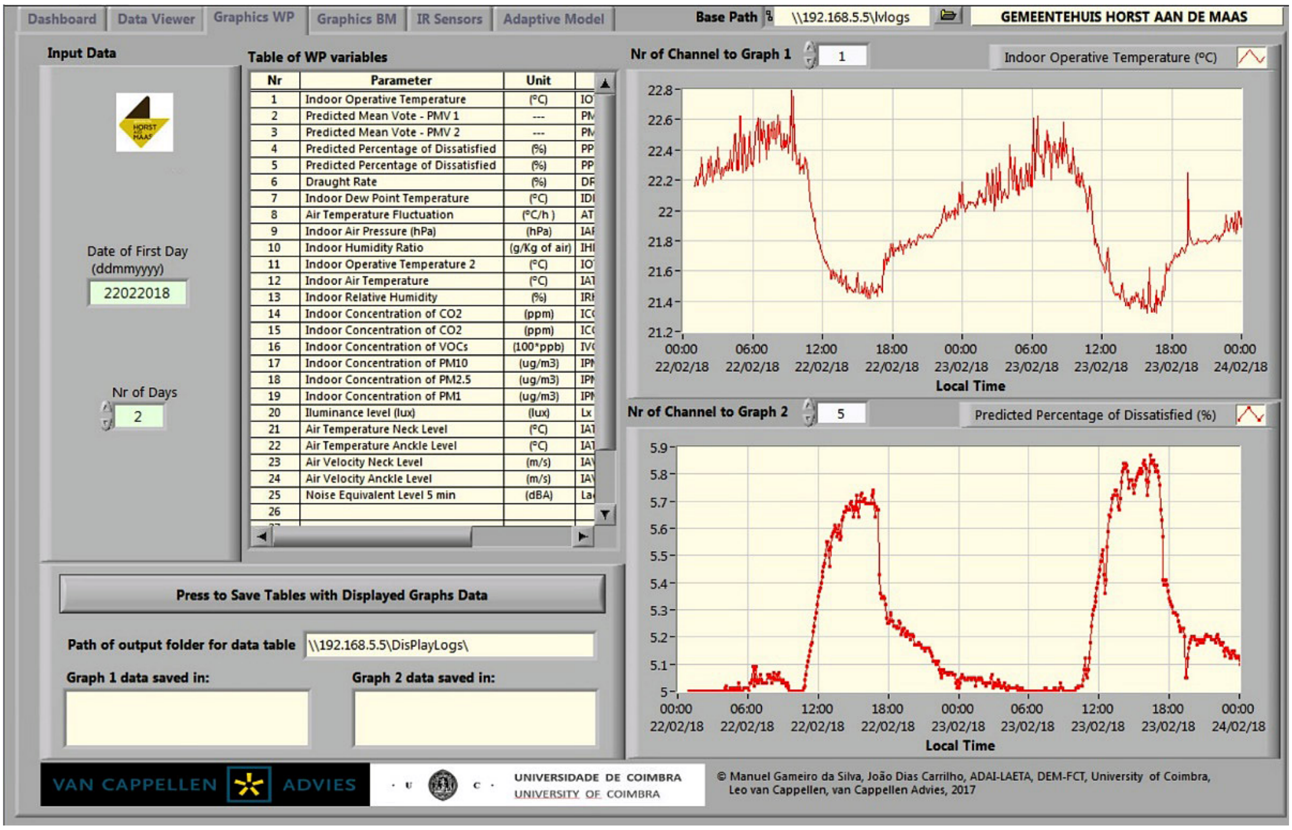


Figure 7. The Graphics WP (indoor work place) window of the Discoverer software tool.

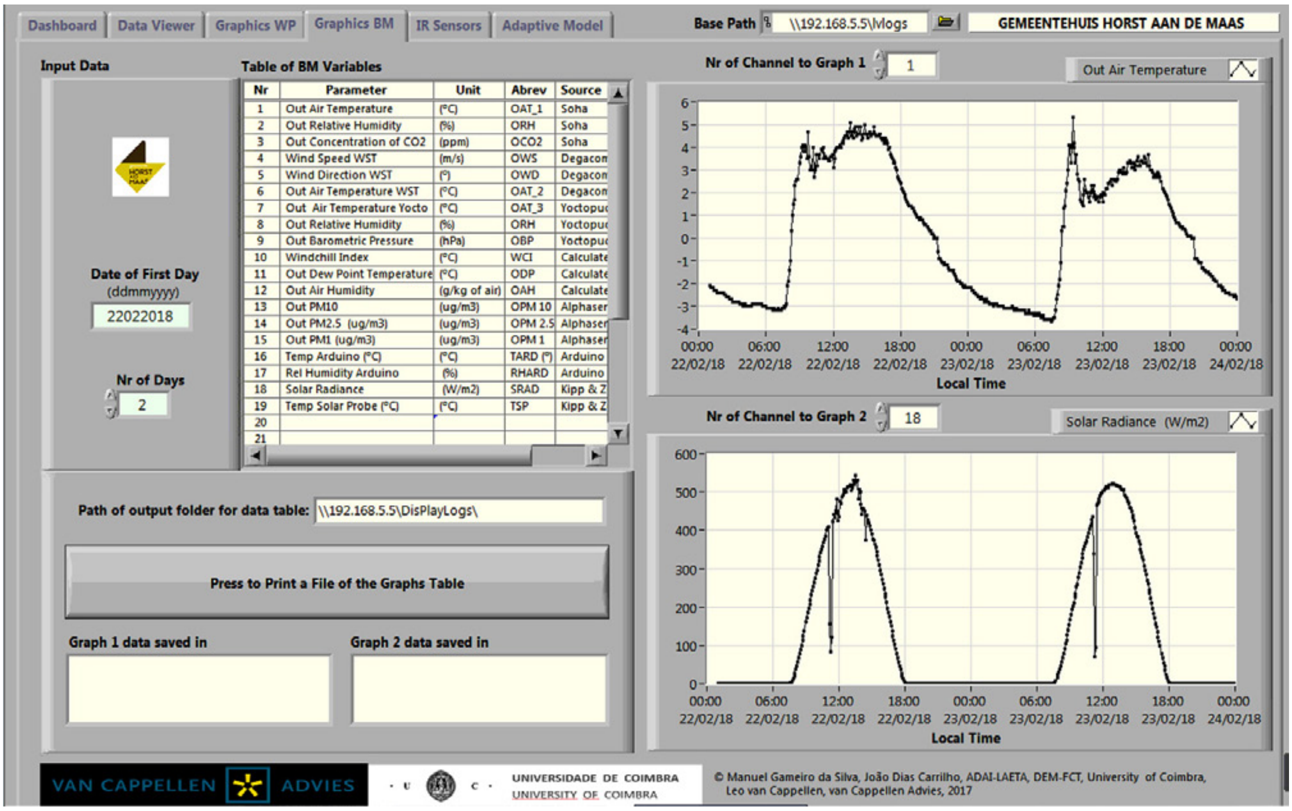


Figure 8. The Graphics BM window of the Discoverer software tool (outdoor station unit).

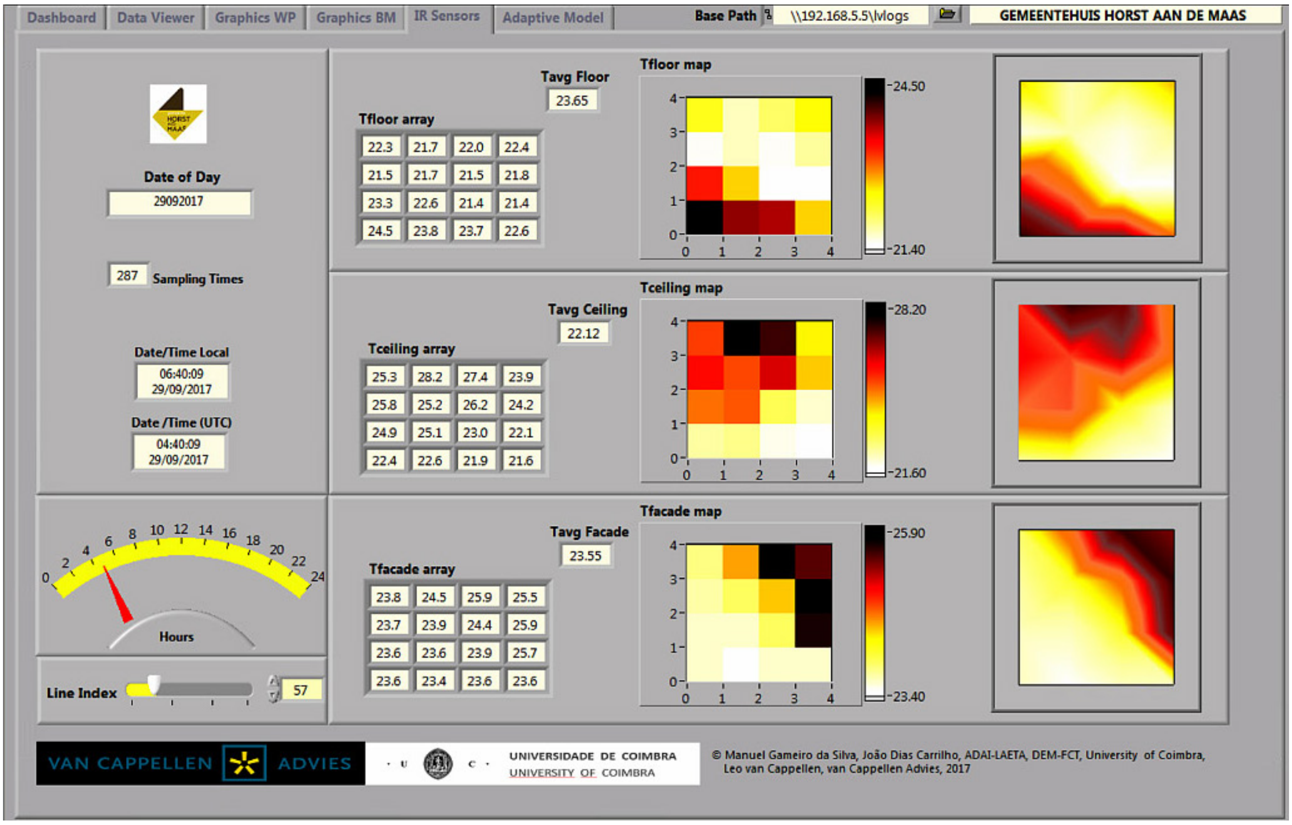
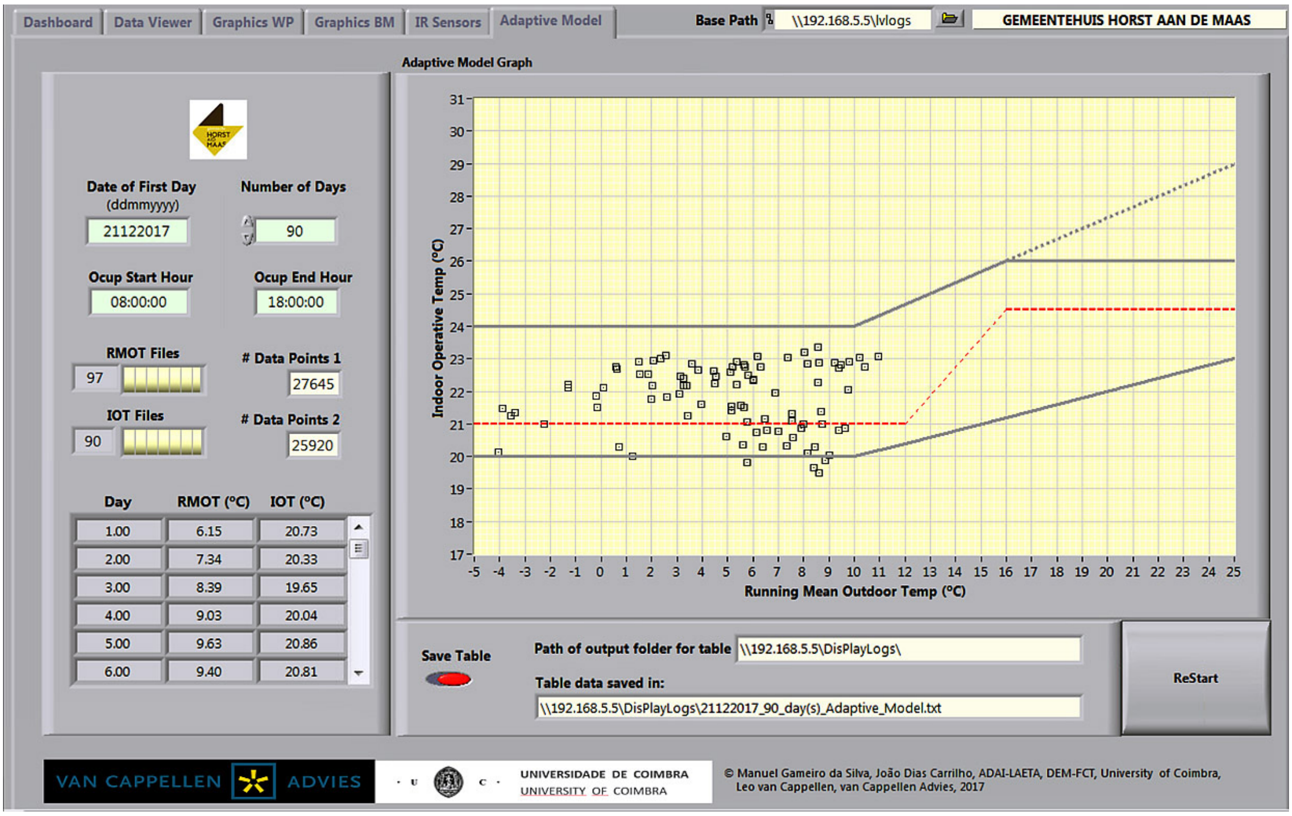


Figure 9. The Infrared Probes window of the Discoverer software tool.



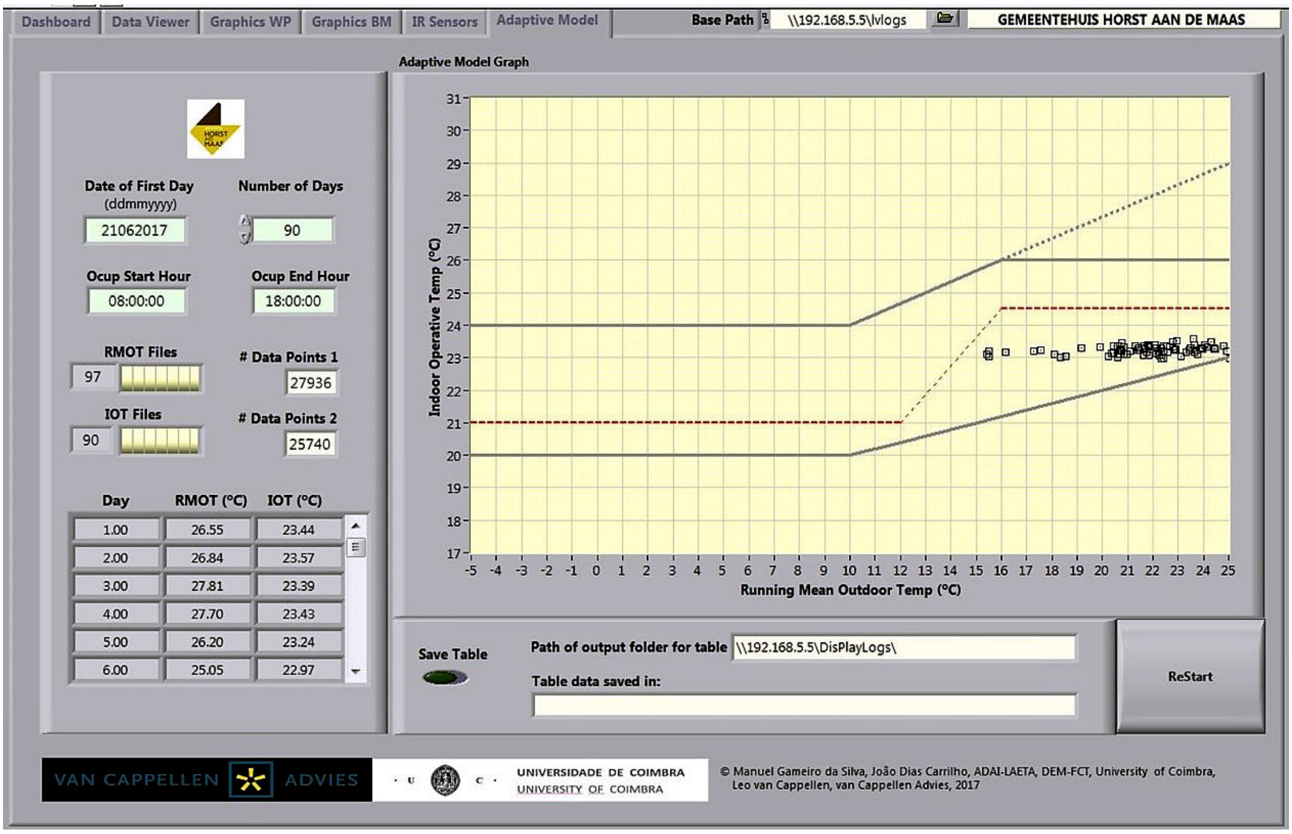


Figure 10. The Adaptive Model window of the Discoverer software tool. Comparison of Winter and Summer seasons.

▶ The control engineer, who had only the BM database available, has been made familiar with the use of the monitoring system and according to his words: "a world of insights has gone open".

A bycatch of the monitoring system's operation is the discovery of hidden energy consumption, due to for instance overventilation, ventilating during off-hours, floor heating and air cooling on in a room at the same time, and not in the least malfunctioning or wrong settings of the control systems.

Conclusions

The concept initially defined for the IEQ monitoring system proved to be adequate and has been successfully implemented. The system allows to follow the building indoor conditions in terms of the various discomfort stressors and a relevant database is being created since more than two years ago.

The monitoring system is recognized by the building management team as an important tool in their effort to provide building well-being conditions to building occupants. New long-term key performance indicators regarding the different indoor ambiance areas (thermal, indoor air quality, noise and lighting) will be explored in the next phase of the project. ■

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Energy and financial evaluation of envelope retrofit measures for an apartment block in Slovakia




JANA BARTOŠOVÁ KMEŤKOVÁ
Department of Building Services, Slovak University of Technology in Bratislava, Slovakia
jana.kmetkova@stuba.sk

DUŠAN PETRÁŠ
Department of Building Services, Slovak University of Technology in Bratislava, Slovakia
dusan.petras@stuba.sk

STEFANO P. CORGNATI
Department of Energy, Politecnico di Torino, Italy
stefano.corgnati@polito.it

CRISTINA BECCHIO
Department of Energy, Politecnico di Torino, Italy
cristina.becchio@polito.it

This study analyses the energy effectiveness and financial viability of some energy retrofit measures for a selected apartment block in Slovakia.

Introduction

As the residential sector in the EU is responsible for about 40% of the total energy consumption and up to 36% of the total carbon dioxide emissions, the residential building stock offers high potential for energy savings [1]. Among the energy efficiency targets, the existing building stock and its energy performance improvements play a crucial role, because energy use in buildings has steadily increased.

While new buildings should be designed as intelligent low or zero-energy buildings, refurbishment of the existing building stock may present even a greater challenge, when in particular financing of the necessary investments to energy saving measures poses the biggest barrier. Improving the energy performance of buildings is a cost-effective way of fighting against climate change and improving energy security [1].

A case study of a selected apartment block located in Slovakia is presented, for which the cost-optimal levels of energy performance are determined in terms of life-cycle costs of the building. Although the housing stock in Slovakia belongs to youngest in Europe, the residential buildings built by mass forms of construction have been in use for several decades and the limitations associated with the excess of the planned lifetime of the building structures and services are becoming apparent. Based on the current building features, the building model was implemented in dynamic simulation software EnergyPlus and retrofit measures were simulated and evaluated by applying the cost-optimal methodology that allows the promotion of sustainable buildings with low energy consumption and cost effectiveness [2].

The case study

The main objective of the study was to design energy effective and financially viable retrofit measures for retrofit apartment blocks in Slovakia.

The chosen apartment block is a typical representative of the old building stock in Slovakia consisting mainly of buildings made from prefabricated ferroconcrete panels. It belongs to the largest group of existing building stock built before year 1983 that account for 46% of total net area of old building stock. [3] It was built in 1978, has 13 above ground floors, no basement and 48 dwelling units.

The apartment block is located in the capital city Bratislava, in the one of the housing estates. Slovakia is located in the northern moderate climatic zone with average heating period comprises 3,500 heating degree-days a year. Outdoor design temperature for Bratislava is −11°C with 202 heating days. Building envelope before retrofit presented a traditional construction system based on prefabricated ferroconcrete panels. The roof is mode of reinforced concrete panel, porous concrete panel and covered with waterproofing. There is just poor insulation in the external wall about 80 mm and about 70 mm in the roof construction. The windows in residential part used to have a single glass with windows frames made of wood. In original condition, about 1/2 of the original windows have been replaced by new windows with plastic frames and double glazing. In the space of stairs and elevator, the windows were made with steel frame and also single glazing.

Building constructions of the apartment building are mostly in original condition, except for the roof construction where a new hydroisolation was made in 2003. The **Table 1** shows thermal properties of the building elements.

Table 1. Thermal properties of the building elements.

Building element	Thermal transmittance (W/(m².K))		
	Before renovation	After renovation	
		Second level (year 2016)	Third level (year 2021)
U_{wall}	1.33	0.22	0.15
U_{roof}	0.86	0.10	0.10
U_{floor}	1.03	1.03	1.03
$U_{window\text{-}replaced}$	1.30 (plastic frame)	1.30	1.30
$U_{window\text{-}original}$	5.20 (steel frame) 2.70 (wooden frame)	1.00	0.60

Figure 1. View of apartment building before renovation and after the renovation.

The source of heat for the apartment block is the heat exchange station, which is in original condition, located in the neighbourhood. Heat is supplied to the building by underground distribution. The system has been hydraulically balanced since 2001. Temperature gradient of 90/70°C. The insulation of the heating distribution pipes does not fulfil the current requirements on thermal insulation. Domestic hot water (DHW) is supplied from accumulation tanks located within the technical room with the exchange station. The distribution efficiency and transformation factor of district heating is 0.84.

The apartment building does not have a mechanical ventilation system and there is no cooling system installed. There are no renovations in technical systems in this part of a research.

Energy simulation assumptions

Energy analysis was carried out for the apartment building through energy simulation by dynamic software, EnergyPlus. Weather statistic data for Bratislava were used as input data, obtained from [4].

The energy model of the building was created in order to assess the energy consumptions for space heating, domestic hot water (DHW) production, lighting and equipment. The model is divided into four different thermal zones (**Figure 2**); the first one is unconditioned. Heating set point temperature is set equal to 20°C. The heating period is from September to May. The use of manually controlled internal blinds is expected in each apartment. Energy consumption of the building is also influenced by internal gains-people, lights, various equipment. As internal gains were used: People-3 persons/apartment, Lighting-10.6 W/m², Electric equipment-3.9 W/m². The number of occupants was based on a questionnaire, the interior lighting was based on the market analysis and the electric consumption was based on the statistical data from SIEA (Slovak Innovation and Energy Agency).

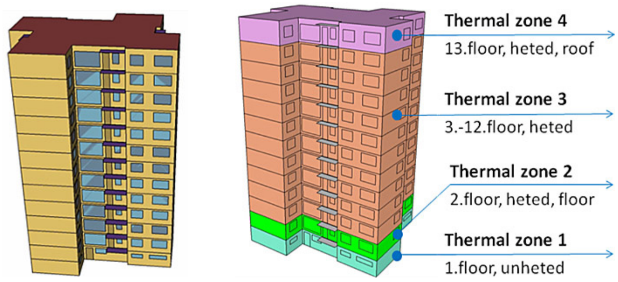

Figure 2. Model of apartment building with thermal zones.

Energy retrofit measures

A series of variants were developed to apply to the building constructions in terms of energy saving and costs. First, some single retrofit measures were defined and then the combination of measures into retrofit packages were developed.

Each measure has different level of thermal insulation of building constructions, based on the requirements on thermal protection as defined in the Slovak standards [5], which is mandatory standard for Slovakian buildings. It divides the time to year 2020 into the three periods: 2012-2015, 2016-2020 and after year 2021 with exact U-values requirements. **Table 2** shows those single measures characteristics and U-values requirements and **Table 2** shows the variants of retrofits with insulations features.

Life cycle costs analysis (LCCA)

Life cycle costing (LCC) is used to evaluate the cost performance of a building throughout its life cycle, including acquisition, development, operation, management, repair, disposal and decommissioning. It allows comparisons of cost among different investment scenarios, designs, and specifications. Standard ISO 15686, part 5 specifies procedures for performing life-cycle cost analyses of buildings and their parts. This assessment typically includes a comparison between options or an estimate of future costs at portfolio, project or component level [6]. Compared to other products, buildings are more difficult to evaluate for the following reasons: they are large in scale, complex in materials and function and temporally dynamic due to limited service life of building components and changing user requirements. [7]

The task of LCCA is to determine the economic effect of different variants of building retrofit and to quantify these effects and express them in financial amounts. Life cycle costs for building and its elements were calculated by summing different types of costs and applied to these the discount rate using a discount factor to express all feature costs to present. Following the Commission delegated regulation (EU) No 244/2012, the formula for calculating global LCC is:

$$LCC = C_O + O + M\&R + C_D - C_{RV}\ (€) \qquad (1)$$

Where: C_O - investments to saving measures, O - operation costs, $M\&R$ - costs of repairs and maintenance, C_D - demolition costs, C_{RV} - residual value at the end of the study life.

The period of 30 years from implementation of the retrofit was considered, which represents the predicted economic lifetime of measures on the building envelope. Costs are relevant when they are different for one

Table 2. Variants of building construction renovation.

Variants of renovation	Additional insulation characteristics		Replacement of windows
	External wall	Roof construction	
W1AR1A	EPS 14 cm; U = 0.22	EPS 30 cm; U = 0.10	–
W1AR1B	EPS 14 cm; U = 0.22	MW 34 cm; U = 0.10	–
W1BR1A	MW 12 cm; U = 0.22	EPS 30 cm; U = 0.10	–
W1BR1B	MW 12 cm; U = 0.22	MW 34 cm; U = 0.10	–
W1AR1AG1	EPS 14 cm; U = 0.22	EPS 30 cm; U = 0.10	double glazing; U =1.0
W1AR1BG1	EPS 14 cm; U = 0.22	MW 34 cm; U = 0.10	double glazing; U =1.0
W1BR1AG1	MW 12 cm; U = 0.22	EPS 30 cm; U = 0.10	double glazing; U =1.0
W1BR1BG1	MW 12 cm; U = 0.22	MW 34 cm; U = 0.10	double glazing; U =1.0
W2AR1A	EPS 20 cm; U = 0.15	EPS 30 cm; U = 0.10	–
W2AR1B	EPS 20 cm; U = 0.15	MW 34 cm; U = 0.10	–
W2BR1A	MW 20 cm; U = 0.15	EPS 30 cm; U = 0.10	–
W2BR1B	MW 20 cm; U = 0.15	MW 34 cm; U = 0.10	–
W2AR1AG2	EPS 20 cm; U = 0.15	EPS 30 cm; U = 0.10	triple glazing; U =0.6
W2AR1BG2	EPS 20 cm; U = 0.15	MW 34 cm; U = 0.10	triple glazing; U =0.6
W2BR1AG2	MW 20 cm; U = 0.15	EPS 30 cm; U = 0.10	triple glazing; U =0.6
W2BR1BG2	MW 20 cm; U = 0.15	MW 34 cm; U = 0.10	triple glazing; U =0.6
W1AR1AG2	EPS 14 cm; U = 0.22	EPS 30 cm; U = 0.10	triple glazing; U =0.6
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W2BR1BG1	MW 20 cm; U = 0.15	MW 34 cm; U = 0.10	double glazing; U =1.0

variant compared with another; in this case, the calculation of LCC includes the following costs:

- *Investments to saving measures* – all investments associated with the retrofit, particularly the costs of material and installation costs, based on prices from company catalogues and bids made by companies.
- *Operation costs* – depends on the heat demand for heating and DHW and on the efficiency of heating and DHW systems (determined by a calculation). The price of heat was based on annual reports of the Office for regulation of network industries, which regulates the price heat in Slovakia.
- *Costs of repairs and maintenance* – include costs of regular repairs of facade, roof, windows; based on the expected time of failure of the construction and expected repair interval.

Results discussion

Building retrofit is proposed with two different levels of thermal protection of building constructions. External walls are insulated with a contact insulation system in variant A made of expanded polystyrene to the height of 22,4 m (8th floor) and of mineral wool from 9th to 13th floor, in variant B made of mineral wool. The roof has the thermal insulation made of expanded polystyrene (variant A) and made of mineral wool (variant B).

Primary energy conversion factor for gas is 1.36 (regulation No 364/2012). The results of energy consumption simulation show that the most of primary energy belongs to space heating. Indeed, space heating consumes about 60% of total energy consumption than it is domestic hot water that consumes about 20% and lighting and electric equipment with 11% and 9% (**Figure 3** - left). Monthly distribution of energy consumption is showed in **Figure 3** - right. The highest energy consumption is in January and December, due to high energy consumption for heating.

The results show that the whole opaque retrofit is more efficient than the single retrofit actions (**Figure 4**). Glazing retrofit is not useful as a single measure, but the combination with wall and roof retrofit, can reduce primary energy consumption by about 32% (Variant W2BR1BG2) to reach 87 kWh/m².a.

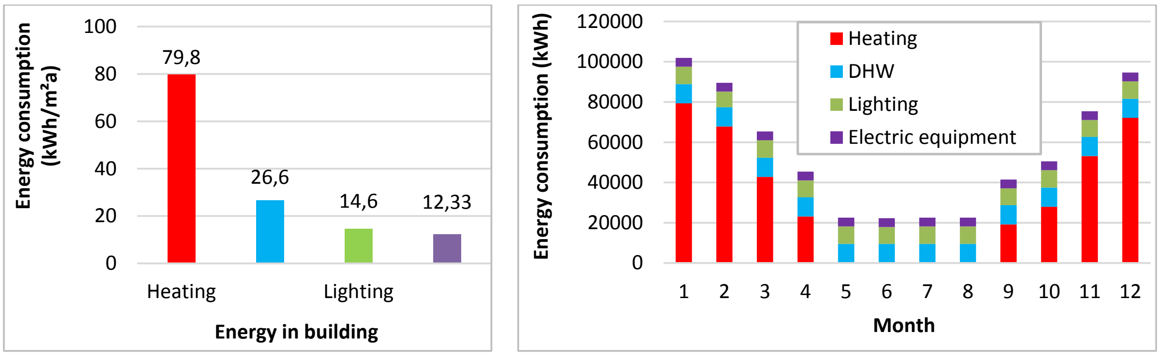

Figure 3. Left -Distribution of energy consumption of apartment building in original, Right - Monthly energy consumption of apartment building in original.

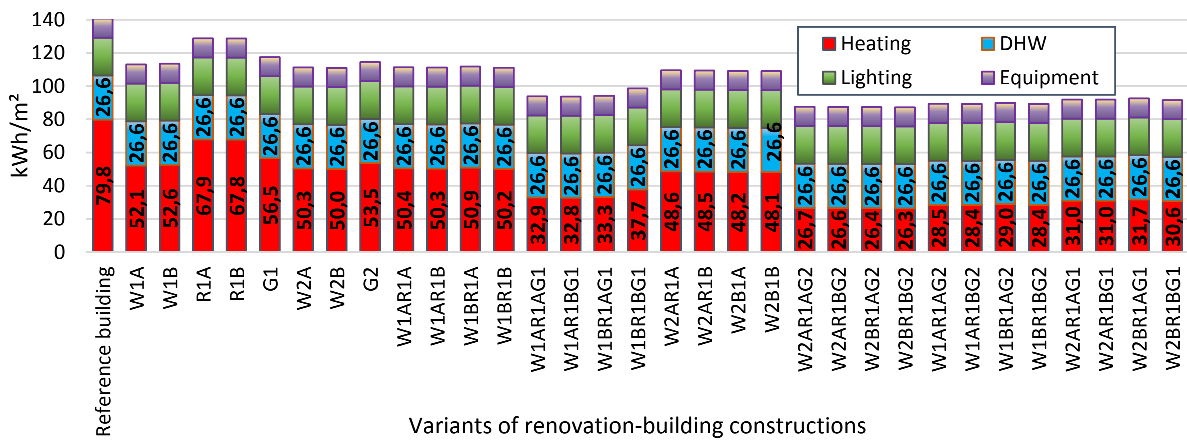

Figure 4. Energy consumption of the Apartment building with retrofit variants.

Different costs for each variant of retrofit are shown in the **Table 3**. The related costs of combined variants of retrofits are calculated. Energy costs are calculated for 30 years period based on the prices from last 10 years and predicted increase. For the calculations the 3% discount rate was applied, which can be considered suitable for the long-term life cycle calculations [8]. This relatively low rate reflects the benefits that investments in energy efficiency brings to users of the building throughout the life cycle.

The building in original has approximately 327 €/m² LCC. Variant W1AR1AG2 with 172 €/m² LCC is the one with the lowest LCC during 30-year period and can provide about 48% LCC reduction during this period. The graph in the **Figure 5** shows the LCC of different variants of retrofit during the 30-year period.

The analysis showed that, if is just energy consumption considered, most profitable variant of retrofit seems to be Variant W2BR1BG2. To obtain more comprehensive results, the operation costs during the defined life-cycle period must be counted with the discount rate using a discount factor to express all feature costs to present. The LCC calculation showed, that the most convenient variant of retrofit during the 30-year period is Variant W1AR1AG2. It is the variant with the opaque retrofit that meet the requirements of second level insulation valid from year 2016; insulation of facade with EPS thickness of 14 cm, insulation of roof with EPS thickness of 30 cm. The original windows are replaced by the windows with high efficient triple glazing and U value = 0.6 W/m²K, that are requirements valid from year 2021. The façade insulation with mineral wool is not a suitable because of the high investment costs. Currently, the materials that meet the most stringent requirements valid after year 2021, are expensive, that cause the variants designed for this requirement have high investment costs. We can predict, that the research of new materials in following years will go forward and the price will be more suitable, so it could change the rank of Variants in feature.

Table 3. Costs of building in original and different variants of renovation during 30 year life cycle.

Variants of renovation	Investment costs (€)	Operation costs (€)	Maintenance costs (€)	Total cost (€)	Cost per area (€/m²)
Original	0	1163386	240568	1403954	327
W1AR1A	163842	733926	88587	986355	230
W1AR1B	175120	733623	88587	997330	233
W1BR1A	192313	741357	88587	1022257	238
W1BR1B	203591	732178	88587	1024356	239
W1AR1AG1	221302	478578	88587	788467	184
W1AR1BG1	232580	478344	88587	799511	186
W1BR1AG1	249773	485711	88587	824071	192
W1BR1BG1	261051	476924	88587	826562	193
W2AR1A	194795	707763	88587	991145	231
W2AR1B	206073	707422	88587	1002082	234
W2BR1A	250266	702487	88587	1041340	243
W2BR1B	261544	702140	88587	1052271	245
W2AR1AG2	267032	389504	88587	745123	174
W2AR1BG2	278310	389270	88587	756167	176
W2BR1AG2	322503	384208	88587	795298	185
W2BR1BG2	333781	383980	88587	806348	188
W1AR1AG2	236079	414901	88587	739567	172
W1AR1BG2	247357	414667	88587	750611	175
W1BR1AG2	264550	421905	88587	775042	181
W1BR1BG2	275828	413266	88587	777681	181
W2AR1AG1	252255	452873	88587	793715	185
W2AR1BG1	263533	452633	88587	804753	188
W2BR1AG1	307726	447549	88587	843862	197
W2BR1BG1	319004	447291	88587	854882	199

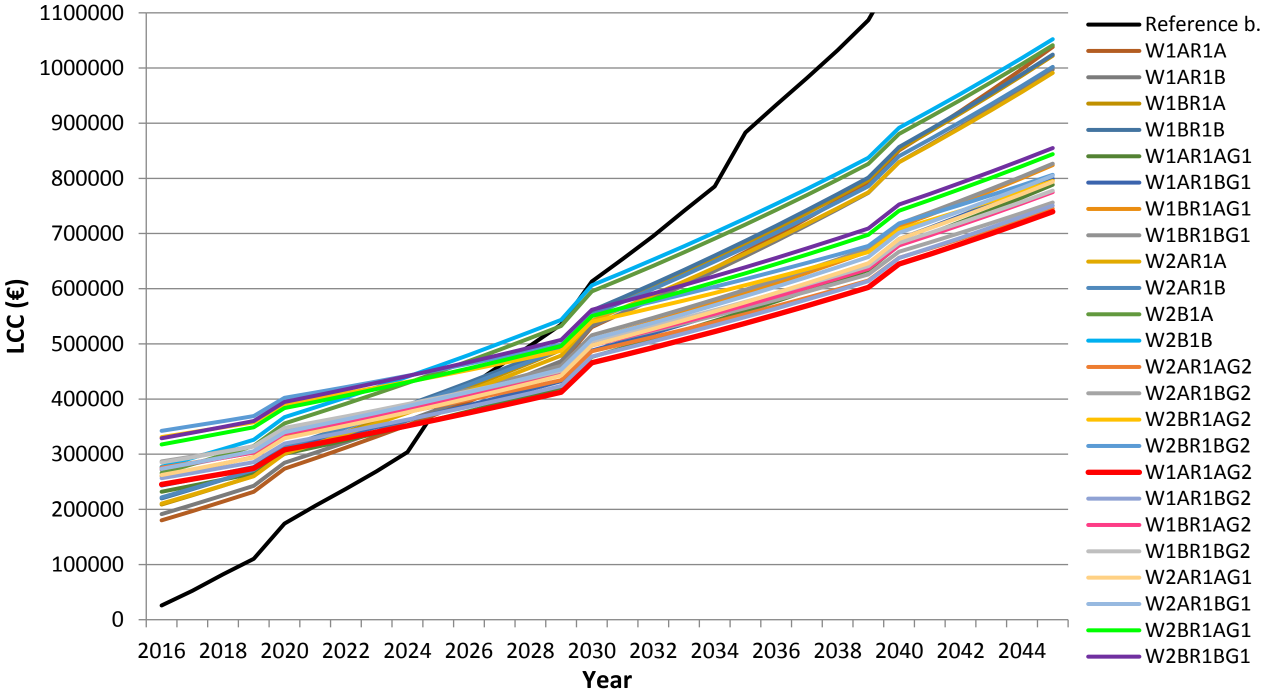

Figure 5. Time-course of total life-cycle costs during the 30 years for the apartment building in original condition and for the different variants of renovation.

Conclusions

The retrofit requirement was satisfied by using additional thermal insulation for the whole building envelope and by replacing windows. From the energy saving point of view, there is not much need to insulate the basement ceiling. The analysis showed a potential of energy consumption reduction of more than 40% by implementing the energy efficiency measures. In terms of calculations for the period of 30 years, we came to the conclusion that the most convenient combination of retrofit measures is Variant W1AR1AG2. It is the variant with the opaque retrofit made of insulation of facade with EPS thickness of 14 cm, insulation of roof with EPS thickness of 30 cm and the replaced windows with high efficient triple glazing and U value = 0.6 W/m²K. The success of the retrofit project depended mostly on the detailed design of the retrofit solutions and ability to direct the apartment owners to make the right choices. To realize the complex retrofit of apartment buildings, the financial support by retrofit funds or subsidies from the Government are needed. ■

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The 2018 EU Sustainable Energy Week – REHVA highlights

Authors: **Anita Derjanecz**, REHVA Managing Director and **Rebeka Maršnjak**, REHVA EU public affairs and publication assistant

The 13th edition of the EU Sustainable Energy Week (EUSEW 2018) took place in Brussels the 4-8 June attracting more than 2500 participants from all over Europe. EUSEW is a major annual event bringing together policy makers, authorities, industry, NGOs, researchers and other stakeholders from the sustainable energy sector. EUSEW debates energy policy, creates networking opportunities and spreads the word about the latest developments on the sustainable energy market and in research. REHVA attended many sessions related to building performance and the HVAC sector had a joint booth with the EPB Centre. This article is a summary of key sessions relevant for REHVA readers.

The 2018 edition of the **EU Sustainable Energy Week** featured a high-level Policy Conference, the EU Sustainable Energy awards, a Networking Village and many side events with over 60 sessions and more than 2,500 participants. The guiding theme of the high-level EUSEW 2018 Policy Conference[1], organised by DG Energy and the Executive Agency for Small and Medium-sized Enterprises (EASME) was "Lead the clean energy transition".

To learn about the latest policy and research trends relevant for the HVAC sector, REHVA attended sessions focusing on the clean energy transition of buildings, smart finance for energy renovations, energy performance contracting, and energy related products legislation with focus on Eco-design.

Accelerating deep energy renovation of the European building stock

Several sessions were dedicated to the key challenge ahead us: how to increase the renovation rate of the existing buildings in Europe, how to ensure the quality of work and deliver actual performance improvement.

The session "The architects' contribution to the clean energy transition"[2] discussed the role of architects in the decarbonisation of the European buildings stock and the development of new energy systems at city and district level. The workshop featured high profile starchitects, such as David Nelson from Foster + Partners or Reinier De Graaf from the Office for Metropolitan Architecture (OMA) as speakers presenting flagship projects from around the world where with green field construction projects were cities and districts designed as a sustainable ecosystem integrating onsite energy production from waste, battery storage, photovoltaics on rooftops and canopies, district heating and cooling networks. David Nelson pointed out that no currently existing building certification scheme is suitable to asses and ensure the necessary performance levels to achieve the global and European emission and energy performance targets. The speakers also called for strong commitment and active engagement of all sectors to bring forward big innovations for the energy transition with a massive part depending on political decision makers who can create a real sustainable energy union by stopping the support of fossil fuels and promoting the creation of a smart and sustainable energy system.

The session organised by the – this year 20-years old - EuroAce with the title "From here to there – the path to follow leading on national long-term renovation strategies"[3] presented good practices of local policy making, public and private initiatives of planning, implementing, financing and monitoring deep energy renovation projects. To deliver the 2050 efficiency goals in the building sector, national, and sub-national authorities have a huge role in planning and successfully implementing long-term renovation strategies to upgrade buildings. One highlight among the excellent actions presented by the speakers was the industry-led Better Homes initiative of coordinated by market leader Danish companies, Rockwool, Danfoss, Grundfos and Velux, which created a one-stop-shop service to help private home owners to plan and implement energy renovation projects, while providing them with skilled building specialist, who are trained and certified by the platform and are able to handle advanced HVAC technologies and deliver high-quality work.

Product efficiency and the challenge of market surveillance

The session on "Market surveillance[4], ErP and Ecodesign[5]" presented the challenges and efforts towards better market surveillance, highlighted the future of eco-design policy, providing consumers with reliable information. The speakers called for an enforcement or market surveillance at national level and for cooperation and information sharing across borders to ensure transparency and use synergies. At international level, EU projects and EU associations can promote EU level cooperation supporting national market surveillance bodies like AdCos[6] (Administrative Cooperation Groups) as informal groups of market surveillance and ICSMS[7] (The internet-supported information and communication system for the pan-European market surveillance), which provide effective and efficient cooperation (, and join stakeholders in a concerted approach to share and use quality information across borders.

To overcome the challenges at market surveillance, the Commission proposed a new regulation on compliance and enforcement (2017/0353) COD)[8]; joint actions within Horizon 2020 projects and initiatives to improve market surveillance based on supporting business to comply with regulation and eliminate weaknesses in the system with strengthening market surveillance bodies. One of the market surveillance bodies is also "Product Safety Forum of Europe (PROSAFE)"[9], which is working on improvement of market surveillance in Europe, funding, access and sharing data to help to understand which products are complied with new regulations, supporting joint actions to motivate authorities responsible for enforcement of energy labelling and eco-design to work together.

The speakers highlighted local and international good practice initiatives that aim to check and promote whether products are compliant with the eco design requirements. A major challenge is the establishment of new databases to centralise information on products and increase cooperation at both EU and national level.

For instance, Denmark established a list of "name and shame" about non-compliant products. However, very often the problem of fiscal appearance of products arise. The organisation ECOS[10] aims at displaying information and listing new products which require new approaches for market surveillance. One of ECOS' projects INTAS[11] will develop a new package of measures supporting market surveillance.

Smart financing and successful private financing schemes for deep renovation

The workshop "Deep energy renovation"[12] organised by the European Commission showcased innovative lighthouse projects on the planning, financing and successful implementation of deep renovation projects providing evidence-based recommendations to policy makers. The aim was to boost the wide-scale market uptake of deep energy renovation, share the main obstacles encountered and how they were overcome and formulate recommendations to EU policy-makers and the wider audience. These projects also offer an insight into creating synergies by combining different sources of funding, in particular by replicating innovative practices developed under EU-supported projects. Ron van Erck (Energiesprong) delivered a key message to policy makers: to stop giving public funding to deep energy renovation projects without monitoring operational performance improvement. To integrate operational performance monitoring in financial programmes of investment projects is feasible and a must.

The workshop "Smart finance to boost healthy, comfortable and accessible buildings"[13] discussed about the various benefits of investing in energy renovations, including improved comfort, better health, increase of the economic value of the property, increased productivity. However, despite these advantages and the increasing financing opportunities, several barriers prevent building owners and users from starting energy efficiency project. The session presented schemes and projects that have managed to break these barriers and leverage the demand for investments in energy efficiency. Rodolphe Nicole from Buildings2030, a close cooperation partner of REHVA, called policy makers to widen the discourse around the energy efficiency investment in buildings and consider the massive health and productivity related benefits in the equation. This is an aspect, which doesn't get enough attention, although several studies prove the financial benefits related to health and productivity for building users, building owners, and investors, or even for the wider society.

REHVA and EPB Center at the EUSEW18 Networking Village

REHVA and the EPB Center shared a well-visited booth on the 7th of June in the EUSEW Networking Village. The two partners promoting their key knowledge, and capacity building services, and projects including REHVA publications, as well as the expertise on the EPB standards and the support services provided by the EPB Centre. The booth was dedicated to the theme "Developing innovative heating, ventilation and air-conditioning technology". REHVA showcased the EU projects QUANTUM, HybridGEOTABS, and ALDREN with a combination of audio-visual tools and demonstration materials. Booth visitors had a chance to get latest updates on the EPB standards from senior expert Dick Van Dijk. REHVA promoted its Guidebooks, the REHVA Journal and its knowledge dissemination services for building professionals. ■

Links

1. https://sherlock.scribblelive.com/r?u=https://eusew.eu/about-conference&p=9b5211b0-755f-11e8-ab38-53272624708c&c=9593&e=2782707
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9. http://www.prosafe.org/
10. http://ecostandard.org/
11. http://ecostandard.org/projects/intas/
12. https://eusew.eu/deep-energy-renovation
13. https://eusew.eu/smart-finance-boost-healthy-comfortable-and-accessible-buildings

Welcome to the REHVA Brussels Summit 2018

REHVA is delighted to invite you to the second edition of the REHVA Brussels Summit, on 12-13 November 2018, for a two-days event rich of contents. In this year's edition, the Summit will tackle the latest REHVA activities and strategy developments during the Committee Meetings, offer a technical platform for EU projects implementation during workshops sessions, and focus on the latest insights from the HVAC sector for the implementation of the new EPBD standards at the REHVA Conference.

The first day, 12 of November, will be dedicated to REHVA Committees Meetings and to EU Projects CEN-CE and ALDREN workshops. The latest CEN-CE project is developing a European training and qualification scheme based on the new set of EPB standards. The workshop will involve REHVA experts in the critical evaluation of the training material, towards an active involvement in the deployment of such scheme. **ALDREN consortium**, instead, will propose to the Brussels Summit participants a training on the ALDREN procedure based on the European Common Voluntary Certification Scheme for non-residential buildings.

REHVA Conference: "Smart buildings for smart users-implementing the new EPBD"

This year's REHVA Brussels Summit Conference on "*Smart buildings for smart users -implementing the new EPBD*" will be held the second day on 13 of November and will discuss the key technology and policy trends following the publication of the 2nd EPBD recast with the focus on smart buildings, smart energy systems, and the role of digital technologies in building performance monitoring, commissioning and maintenance.

- The morning session provides latest news about the new EPBD officially published in April 2018. The speakers from the European Commission will present the EPBD and the newly introduced smart readiness indicator, as well as the requirements regarding inspection and digital monitoring of HVAC systems in the new EPBD.

Wikimedia Commons

- The IAE Annex 67 will introduce their work on energy flexible buildings, while REHVA TRC experts will present some research initiatives on smart buildings and introduce the new REHVA Task Force on "Smart buildings and user comfort".
- The morning session will feature presentations of two European projects, one of them on Smart users, user interaction and smart devices (Mobistyle project), the other one on digital tools for technical monitoring and quality management of HVAC systems to close the performance gap (QUANTUM project).

After a networking lunch, the session will continue with presentations of further applications and digital tools in the design and operation of HVAC systems.

- First the hybridGEOTABS project will present the model predictive control tool for the design of complex, integrated HVAC system, like hybrid geothermal heat pumps.
- Then the session will continue with presentations from leading manufacturers, such as Siemens, Daikin, and Rhoss, who will present latest market trends regarding the use of BAC for predictive maintenance of HVAC systems, as well as the latest HVAC market trends.
- The full day conference will close with a final question and answer session and closing remarks by the chairing REHVA Board members.

REHVA BRUSSELS SUMMIT
12-13 November 2018

CONFERENCE

Tuesday 13 November 2018, 9.30 –16:30
PENTA Hotel, Chaussee de Charleroi 38, 1060 Brussels, Belgium

"Smart buildings for smart users - implementing the new EPBD"

AGENDA

09:15 *Registration*

09.30 Welcome and opening
__Stefano Paolo Corgnati__, REHVA President

SESSION 1

Chairs: __Stefano Paolo Corgnati__, REHVA President; __Jarek Kurnitski__, REHVA Vice-President

09.40 Smart Readiness Indicator in the new EPBD
__Sylvain Robert__, Policy Officer, Energy Efficiency, European Commission

10:05 IEA Annex 67 - energy flexible buildings
__TBC__, IEA Annex 67

10:30 Smart buildings to maximise user comfort
__Ivo Martinac__, KTH, Chair of the REHVA Smart Buildings Task Force

10:55 Smart users for smart buildings. The Mobistyle project
__Simona D'Oca__, PhD, Huygens Engineering

11:20 *Coffee break*

11:45 Digital monitoring, inspection and the role of BACS in the new EBPD
__Pau Garcia-Audi__, Policy Officer, Energy Efficiency, European Commission (TBC)

12:05 Technical monitoring and quality management of HVAC systems
__Stefan Plesser__, Synavision/TU-Braunschweig, REHVA QUANTUM - Commissioning Task Force

12:30 *Questions and discussion*

13:00 *Networking Lunch*

SESSION 2

Chair: __Atze Boerstra__, REHVA Vice-President

14:30 Model predictive control and its application in hybridGEOTABS systems
__Filip Jorissen__, PhD, KU Leuven

14:55 Predictive maintenance of building systems using BACs
__TBC__, __eu.bac (TBC)__

15:20 Chiller and heat pump. Technology and market trends
__Leonardo Prendin (TBC)__, Rhoss

15:45 Ventilation and climate control. Market and product development trends
__TBC__, __DAIKIN__

16:10 *Questions and discussion*

16:30 Closing remarks

CLIMA 2019 – REHVA 13th HVAC WORLD CONGRESS

Built Environment Facing Climate Change

The 13th REHVA Congress, **CLIMA 2019**, held from 26th till 29th of May in Romania, will address, under the heading ”*Built environment facing climate change*”, four main topics – all related to the built environment, the biggest energy consumer of a given national or regional economy:

- **I.** Modern HVAC&R&S Technology and Indoor Environmental Quality
- **II.** High Energy Performance and Sustainable Buildings
- **III.** Information and Communication Technologies (ICT) for the Intelligent Building Management
- **IV.** Sustainable Urbanization and Energy System Integration

Modern HVAC&R&S Technology and Indoor Environmental Quality

Over 90% of the typical human life is spent indoors. Many of us have adapted to the indoor realm as our “natural” environment IEQ encompasses indoor air quality (IAQ), which focuses on airborne contaminants, as well as other health, safety, and comfort issues such as aesthetics, potable water surveillance, ergonomics, acoustics, lighting, and electromagnetic frequency levels. All these IEQ parameters could not be optimized without advanced HVAC&R&S technologies. The buildings could not be refurbished without advanced HVAC&R&S technologies.

CLIMA 2019 proposed sub-themes are: • Criteria for thermal environment and ventilation • HVAC in residential buildings and schools • Demand controlled, hybrid and passive HVAC systems, Filtration, air cleaning and air distribution • Solar thermal and PV systems • Heat pumps and refrigeration • Natural and mechanical smoke extraction systems • Water and wastewater systems and components etc.

High Energy Performance and Sustainable Buildings

Buildings shall be constructed and renovated with an appreciation of the importance of providing high-quality and sustainable interior environments, with minimum costs for all users.

CLIMA 2019 sub-topics as: Low and zero energy building case studies; Predicted and real energy performance of buildings; Energy performance requirements, compliance assessment and cost optimality; Simulation models and predictive tools for the buildings HVAC, IEQ and energy;

Building components and double skin facades; Occupant behaviour and energy demands in buildings; Future and Emerging Technologies (FET): Nano-, micro- and bio-technologies for buildings components and HVAC systems; Mandatory and voluntary certification and labelling schemes for new and existing buildings; Renovation of historic buildings; could attract an important number of researchers, industrials and young students.

Information and Communication Technologies (ICT) for the Intelligent Building Management

CLIMA 2019 addresses topics like: • New ICT-based solutions for systems and building automation • Energy Efficiency through behavioural adaption based on ICT solutions • Indoor Environment control with advanced BMS solutions • Sensors and methods to control and authenticate indoor environment • Advanced fault detection and diagnostics • Integrated BIM solutions for buildings and systems • Digitalization of buildings equipment etc.

Sustainable Urbanization and Energy System Integration

With justified interest in this area CLIMA 2019 will contribute by offering opportunity to researchers and experts in this field to present their work on subtopics like: • Grid interaction of nZE, green and passive buildings • Architectural design integration • Health, demographic change and wellbeing • Energy management and distributed energy systems (heat and power generation, district heating and cooling) • Innovative heating and cooling solutions using geothermal energy • Large scale and seasonal thermal storage • Smartness indicators • Demonstrating innovative nature-based solutions in cities etc.

The venue of CLIMA 2019 will be its capital Bucharest which is the 6th European town in population terms and the largest city of Romania. It is a beautiful and very alive Romanian cultural, industrial and financial center, offering historical or modern conference venues, very cosy hotels, appealing restaurants, robust infrastructure and a lot of quite unique places like traditional museums, recreational green areas and genuine "shopping arcades".

Some expected figures of CLIMA 2019 congress are the following:

- more than 100 CLIMA 2019 ambassadors and 50 partners promoting this event worldwide;
- more than 1000 attendees (researchers, engineers, architects, students etc.);
- more than 750 papers (with a special care for the selection of those to be published in like Scopus or Web of Science indexed journals).
- more than 20 technical and scientific workshops.

You can find more details on our website www.clima2019.org or ask for more information at our e-desk found on info@clima2019.org.

Seeking for partnership

Here are only few reasons for getting a cooperation agreement with CLIMA 2019 organisers:

- **The congress provides a targeted audience** (event provides you access to an invested, enthusiastic audience of more than 1000 attendees and probably more than 10000 visitors of the exhibitions of posters and products which will have free access).
- **Potential for data capture is immense** if you are present at CLIMA 2019 where your target audience is present; you will create an immense potential for data/lead capture. A creatively designed engagement tactic, possibly integrated with social media, mobile apps, or experiential technologies like RFID and geofencing could mean access to target data and analytics help you shape or promote your publication.
- **You will leverage the media coverage** as CLIMA 2019 will receive the most vast promotion on social media, digital media, press circles and traditional media, reaching the most broader audience since its appearance in 1975.
- **Build credibility and get brand recognition** by choosing CLIMA 2019, which allows you to associate your brand with other reputed brands in the market; you can elevate your brand perception and image enormously, taking advantage of a great way to emerge or acknowledge as a credible business in our target audience's minds; your logo will be seen on the event site and on selected promotionals.
- **Get a chance to know other media providers or future clients** because networking is probably one of the best aspects of our congress; as one of the CLIMA 2019 partners, you'll get to meet decision makers or fellow editors and companies that you can do business with in the future.
- **Give back to the scientific community** getting to establish goodwill and showing the community that you're a reliable promoter that's able and willing to support all things local; think of partnership as a way of giving back to the technical and scientific community and thanking them for their support. ■

Aeroventic – online platform for HVAC suppliers

Aeroventic is an international HVAC platform which helps companies promote their products and services worldwide. A very important operational aspect is the fact that the Aeroventic platforms are available in national languages. This option enables companies to reach precisely specific countries in which they want to sell their products.

Aeroventic offers a way for HVAC manufacturers to connect with industry buyers and do business anywhere, anytime. Suppliers promote their products and services and communicate with the professional audience worldwide.

At the moment Aeroventic is available in the following countries:

Aeroventic is a place where suppliers present the competitive advantage of their products.

Taking advantage of this opportunity, we have chosen three European suppliers who fully use the potential of Aeroventic platforms. See how they promote their brands and devices. The selected suppliers are: VTS, Airidea, Temko & Universal.

VTS - a company operating all over the world presents new air handling units line Ventus Compact

Ventus Compact - why it's worth it?

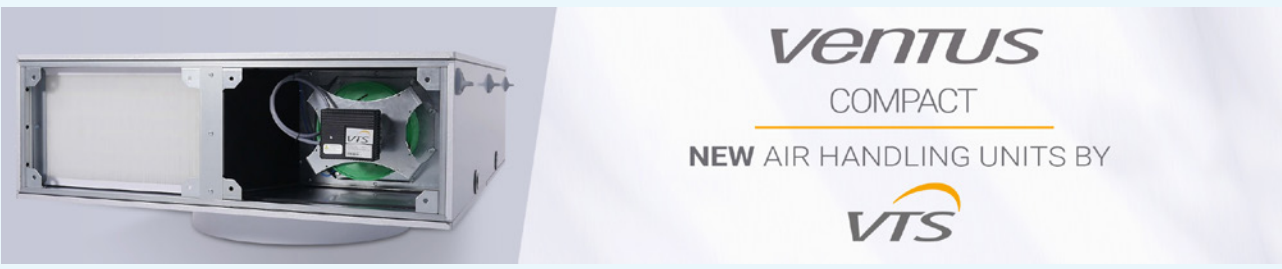
The main distinguishing features of the new line product line are: solid structure with compact dimensions, high efficiency energy recovery system, energy saving and silent EC motors of IE4+ class, long lifetime Mini-Pleat air filters, advanced control systems, and power circuits, which are pre-installed and configured by the manufacturer.

The units are available in two styles:

- compact suspended air-handling units – the scope of type series of suspended air-handling units covers 5 units with the capacity between 250 m³/h and 3 300 m³/h.
- compact standing air-handling units - the scope of type series of standing air-handling units covers 8 standing units with the capacity between 840 m³/h and 16 500 m³/h.

Undoubtedly a unique feature of compact air-handling units is the fact, that at the last stage of their manufacturing all operating parameters of the unit are factory set, making them ready to run just after installation. Both motor operating parameters and their controls are pre-configured and the whole system is tested before the shipment to the customer.

More details available on www.vtsgroup.com



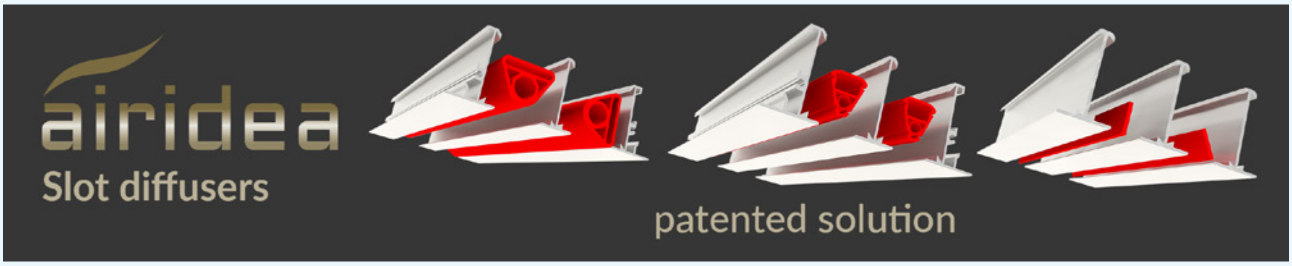
AIRIDEA presents their slot diffusers

Slot diffusers are the most popular solution used in ventilation of commercial buildings (especially in the case of large glazing). The line structure and the possibility of blowing air in various directions cause that architects and ventilation designers are willing to use such solutions. Slot diffusers most often cooperate with fancoil devices in heating and cooling and provide fresh air to the room.

Slot diffusers SZ type are based on the air handle resembling a triangle. This solution provides a perfect air distribution for cooling (horizontally with the Coanda effect) and vertically for heating for each slot individually. The positioning of the triangular steering wheel in the way of the winding up the air stream so that even at very low flows we will achieve horizontal air flow. A single slot can be closed to compensate for the outflow velocity in other slots.

The unique design of the blades, both for heating and cooling, provides the same pressure loss.

The special design of the external profile of the diffuser allows rigid installation of the side of the expansion box and its triple sealing on the profile. The inner part of the diffuser has rounded all edges on the side of the air inflow, thanks to which diffusers work extremely quietly. The air guides have small cuts, which allows the user to manually change the direction of the air stream to the desired direction. The diffusers can also be equipped with micro-actuators that automatically direct the air flow horizontally (cooling) or vertically (heating), automatically or according to the user's preferences. Easy installation based on the use of springs displaced on the sides of the box. Thanks to that it avoids blocking the flow and tearing of the air stream. Slot diffusers are made to individual size with the steering wheel painted in any RAL color.



Temko & Universal – a reliable Romanian supplier of modern ventilation systems

Temko & Universal is a leading manufacturer in Romania, that offers high performance HVAC ventilation systems. SPIRO, round ducts, rectangular ducts as well as ventilation grilles are their key products. The company is particularly proud of its smoke and fire protect line that meets the highest fire safety requirements.

The products manufactured by Temko & Universal are certified by the Ministry of Regional Development and Public Administration.

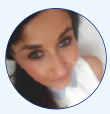
Temko & Universal's main competitive advantage is very short delivery time and that customers are offered the possibility to customize the desired products' size, colour and model.

Dynamic organization, excellent terms of cooperation, modern plant facilities and innovative undertakings guarantee that Temko & Universal is a one of the faster growing companies in this branch.

More details available on: www.temko.ro/en/

If you are interested in joining Aeroventic, or wish to get more information, please contact: office@aeroventic.com

Author: Joanna Kosinska
Project manager
e-mail: office@aeroventic.com
phone: +48 733 259 515



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

Events in 2018-2019

Exhibitions 2018

Sep 3–5	ISH Shangai & CIHE 2018	Shangai, China	https://bit.ly/2EbonUp
Oct 10–12	FinnBuild 2018	Helsinki, Finland	http://finnbuild.messukeskus.com/?lang=en
Oct 16–18	Chillventa	Nuremberg, Germany	https://www.chillventa.de/en
Nov 22–24	REFCOLD India 2018	Gandinagar, Gujarat, India	http://www.refcoldindia.com/home

Exhibitions 2019

Jan 14–16	AHR Expo	Atlanta, USA	www.ahrexpo.com
Feb 28 – Mar 2	ACREX 2019	Mumbai, India	http://www.acrex.in/home/

Conferences and seminars 2018

Sep 11–12	Building Simulation and Optimization 2018	Cambridge, UK	https://www.bso2018.event.cam.ac.uk/
Sep 11–13	ENERGODOM 2018	Cracow, Poland	http://www.energodom.eu/
Sep 18–19	39th AIVC Conference: "Smart ventilation for buildings"	Juan-les-Pins, France	http://aivc2018conference.org/
Sep 25–27	Global District Energy Days	Helsinki, Finland	http://www.2018dedays.org/
Sep 25–28	Eurovent Summit 2018	Sevilla, Spain	http://www.eurovent-summit.eu/
Sep 25	REHVA-ATECYR Seminar "HVAC facilities in Nearly Zero Energy Buildings"	Sevilla, Spain	
Nov 5–7	Retrofit Europe "SBE19 NL" Conference	Eindhoven, The Netherlands	
Nov 12–13	REHVA Brussels Summit 2018	Brussels, Belgium	

Conferences and seminars 2019

Feb 20–22	AiCARR 51st International Conference "The human dimension of building energy performance"	Venice, Italy	
Feb 27 – Mar 1	WSED 2019 - European Energy Efficiency Conference	Wels, Austria	https://bit.ly/2E9WiMS
May 26–29	CLIMA 2019	Bucharest, Romania	http://www.clima2019.org/congress/
Sep 2–4	Building Simulation 2019	Rome, Italy	http://buildingsimulation2019.org/
Sep 5–7	IAQVEC 2019	Bari, Italy	https://www.iaqvec2019.org/
Oct 2–5	ISK-SODEX 2019	Istanbul, Italy	http://www.sodex.com.tr/en

Report on Cold Climate HVAC conference Kiruna

DR. ENG. ATZE BOERSTRA, REHVA VICE-PRESIDENT

From March 12th till 15th the 9th International Cold Climate HVAC Conference was held in Kiruna, Sweden. The central theme was 'Sustainable new and renovated buildings in cold climates'. In this article we describe the ins and outs of this cool (in more than one way) conference.

This year the tri-annual Cold Climate conference was held in Kiruna, located in Swedish Lapland. It was the most Northern Cold Climate conference ever: Kiruna's latitude is: 67° 51'. Which is something that was demonstrated clearly by the outside temperature upon arrival in Kiruna. Your reporter had to adapt himself to an outside temperature of minus 15 degrees Celsius! Luckily later, during the conference daily outside temperatures were less severe: around minus 5 degrees.

The Cold Climate HVAC Conference is an international scientific conference on key technologies and processes designed to achieve sustainable and optimal districts / buildings / HVAC systems in arctic environments. Focussing on the realisation of good indoor environmental quality and a minimum use of resources and energy. The conference has a long and impressive history. Previous conferences were organized in Rovaniemi, Finland (1994), Reykjavik, Iceland (1997), Sapporo, Japan (2000), Trondheim, Norway

(2003), Moskva, Russia (2006), Sisimiut, Greenland (2009), Calgary, Canada (2012) and Dalihan, China (2015).

This year's conference was organized by the division of Building Services at Lund University in cooperation with SCANVAC. The core conference team consisted of Dennis Johansson, division of Building Services (conference chair), Hans Bagge, division of Building Physics (conference co-chair) and Åsa Wahlström, division of Building Services (senior conference advisor).

About 150 delegates attended the conference and a total of 95 papers were presented. Attendants came from 19 different countries: Canada, China, Denmark, Estonia, Finland, France, Ireland, Japan, Latvia, Mongolia, Netherlands, Norway, Poland, Russia, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

Below some highlights of the conference are described and further some personal observations of the members of the conference team are presented.

Conference highlights

On Monday afternoon, the conference started with a keynote presentation of Lars Bäckström, Kiruna's Head of Urban Development. Lars presented some general information about life and business life in Kiruna community. He explained how the city is being transformed due to expansion of Kiruna's iron ore mine. This mine is the biggest iron ore mine in the world housing an unexplored iron ore reserve that will last at least another couple of decades. Part of Kiruna is experiencing the ground subsidence problems (and e.g. related sewage system malfunctioning) due to underground mining activities and therefore parts of the city (incl. e.g. the city's main church and the town hall) will be relocated to elsewhere. A huge operation that come with a unique opportunity to make the city and its buildings more energy efficient. The overall ambition is to turn Kiruna into the most sustainable Arctic city in the world.

A second keynote presentation was given by Kristina Mjörnell, Business and Innovation Manager for Sustainable Cities and Communities of RISE (Research Institutes of Sweden (SE)) and adjunct professor in Building Physics at Lund University. Kristina's presentation focussed on transdisciplinary aspects that one has to take into account when renovating buildings in cold climates.

The Tuesday keynote was presented underground in the LKAB iron ore mine. Keynote presenters were Ulf Svennemyr and Håkan Ylvin, both project managers at Sweco's. Ulf and Håkan presented experiences from relocation of heritage buildings due to the expanding iron ore mine in Kiruna.

Using some spectacular photos showing 50+ year old buildings being transported with a huge multiwheel transportation platforms from their old locations above the mine to a new location.

Tuesday afternoon was filled with parallel sessions. One of the session focusing on indoor environment and health, others addressing aspects like renovations of existing buildings and energy performance, building performance simulations, building physics and moisture issues or supply power efficiency.

The Tuesday scientific advisory committee dinner was held at the Jukkasjärvi ice hotel, about 20 minutes' drive from Kiruna. This hotel was also at the main focus during the Wednesday keynote presentation: Arne Bergh, creative director of the ice hotel talked about the backgrounds of the ice-hotel and explained the plans for the construction of ICEHOTEL 365, a new year round ice-hotel.

The rest of the Wednesday morning was again reserved for parallel sessions. The session addressed issues like: district and city energy systems, building and HVAC system operation and cold climate renovation of existing residential buildings. Conference participants had a change on Wednesday to explore the ice-hotel themselves during a conference group excursion. After which the day ended with a conference dinner in Kiruna.

Thursday morning gave the conference attendants the option to join one of several fieldtrips. One of the trips explored the LKAB mine ventilation system. One of the fieldtrip groups went to the new, energy efficient city hall. And the third group went on an architectural tour.

The rest of Thursday was filled with another round of parallel paper sessions. One session focussed e.g. on energy use and power efficiency. Others were about heat pumps and geothermal systems or construction management issues.

The fourth conference day ended with a keynote presentation by William Semple, a Canadian architect from NORDEC Consulting and Design connected to the University of Alberta. William talked about

Environmental and Cultural Sustainability in North America. He explained how he and his colleagues address social issues when (re)designing residences for indigenous communities.

Social program

Kiruna is not just a mining centre, it also attracts tourists from all over the world. Therefore, the conference organizers had made sure to offer a quite impressive social / excursion program.

The first day of the conference, before the opening session, a group visited the Esrange Space Center, a rocket range and research centre located about 40 kilometres East of Kiruna. Furthermore, it is a base for scientific research with high-altitude balloons, investigation of the aurora borealis, sounding rocket launches and satellite tracking. The centre is operated by the Swedish Space Corporation in cooperation with the European Space Agency (ESA).

The second day of the conference all attendants were taken underground into the LKAB iron ore mine. After a bus ride through the mine (total road length within the mine is over 500 km), the conference attendants were given a tour and a group of miners explained the mining process. Few knew beforehand that Kiruna is built upon the biggest iron ore mine in the world. Daily production is about 75.000 tons of ore which is enough to construct 6 Paris Eiffel towers every single day.

The third day of the conference included an excursion to the Ice-hotel Jukkasjärvi (this is the original one). Talking about climatization of buildings in arctic environments. The Ice-hotel is rebuilt each year with a snow and ice from the nearby Torne river. Every year artists are invited to create a different rooms and decorations made by ice, therefore the Ice-hotel is never the same.

The fifth and the last day of the conference the organizers offered a post-conference tour to Abisko National Park with options for e.g. snow mobile riding and Aurora Borealis hunting.

All-in-all enough to make sure that one not just attended a conference but instead could indulge oneself in a true cold climate experience.

Conference backgrounds

The organisation team, that consisted of Dennis Johansson, Hans Bagge and Åsa Wahlström, was interviewed to gain more insight in the conference backgrounds and the specifics of the 2018 Cold Climate conference:

Why a specific conference on cold climate HVAC systems?

'Experience has learned that heating, ventilation and even cooling in extreme cold climates asks for a non-standard solutions. Regular HVAC theory does not always apply in cold environments. Indoor climate and energy aspects often come with a twist when it is minus 20 degrees outside or colder. In Arctic regions one needs to design for oversized, extensive heating systems; draft free ventilation is much more a challenge than in moderate climates and heat recovery is not as easy as normal (heat exchangers can freeze). And how about innovative ways to keep snow out of air handling unit intakes during e.g. snowstorms? These specific arctic issues are why we think that it is very useful to meet once every 3 years with specialists from all over the world to discuss the specifics of cold climate HVAC.'

Is there a difference between the earlier Cold Climate conferences and this one?

'In the past we focussed more on just HVAC technology, often at component level. A lot of papers that are presented at this conference focus on e.g. the relation between or even integration of HVAC system design and adequate building physics. One could say that we have a more holistic view nowadays. One specific aspect that is rather new relates to social aspects, ergonomics and occupant behaviour. Nowadays we can design rather advanced ventilation systems with heat recovery for e.g. dwellings but there is a question how do we make this, so the systems are well understood and easy to use? Robustness of systems also in a social sense nowadays is more of an issue than 10-20 years ago.

How about humidification?

'In extreme cold climate the absolute humidity of the air inside becomes quite low. In Northern Sweden humidity levels of 5% are possible (in empty apartments) to find during cold weather episodes. At this conference we don't have that many papers on air dryness. Maybe because at least here in Northern Europe humidity and humidification traditionally is not so much of an issue. Partly due to Scandinavian studies from the past that showed that dryness complaints can be avoided, even at low relative humidity levels when one keeps the air free of particles, chemical components and other irritants. On the other hand: for example, Canada and the (Northern states of) US, traditionally always has been a lot of discussion about humidification in winter. Not just looking at offices and other commercial buildings, but also looking at dwellings. But here in Northern Europe, especially in dwellings we tend to avoid humification as it can have severe side effects (e.g. moisture and mould problems and internal condensation in constructions). Having said this: sometimes we do use rotary heat exchangers, not just in offices but also in apartment complexes, as these recover some of the humidity from the return air. Therefore, these should be applied with caution as we know from experience that inadequate use of rotary wheels can cause moisture problems too due to condensation in the construction.'

What are trends in heat generation?

'A couple of conference papers touch upon the issue of the heat generation. Indeed, we have an obligation to look at more sustainable ways to generate heat that our buildings stay warm in the future in a 'green' way. Here in Kiruna there is a lot of potential to use waste heat (with a district heating system) from the mine and e.g. heat from waste incineration plants. Also, elsewhere in arctic regions there is still a lot of unused potential when it comes to the use of waste heat. Elsewhere in Sweden we see more and more that heat pumps are being used (esp. ground coupled heat pumps). It is best of course that these heat sources are combined with heat recovery systems as in winter the ventilation losses are substantial. Twin coils systems or plate heat exchangers often work well, sometimes rotary heat exchanges might work as long as these are designed (see text above) in order to avoid moisture problems. In the South of Sweden natural gas is also used for heating of e.g. homes but we probably should start looking for alternatives as heating based on natural gas in the long run is not the most sustainable solution. An interesting trend is furthermore heat / cold storage in the underground using (old) boreholes (Borehole Seasonal Thermal Energy Storage). This is something we are looking into in the Nordic countries too nowadays. Of course, all the above should be combined with the amelioration of building skins. Also, here up North we still have many buildings that are not that well-insulated yet. The strategy always should be to first provide good building physics, extremely well insulated facades, triple glazing, extra air tight sealing around windows etc before one starts to talk about improved heating and ventilation systems.'

Any specific other trends that you see?

'A general trend at this conference is more attention to non-commercial buildings. Traditionally the Cold Climate conferences focussed more on offices, schools, hospitals, etcetera but this round we see a lot of presentations about solutions for both individual dwellings (detached) and apartment complexes. Often with a focus on existing buildings and renovations. And because of that we also see more attention to social aspects, end-user involvement, people-system interactions and occupant behaviour issues. As if nowadays the cold climate researchers are trying to become more tuned in with what 'normal' people want and expect from buildings and building service systems. In the past we might have measured the before and after performance of a renovated apartment complex just in terms of energy use before and after. Nowadays, we also have presentations that look at occupant comfort and perceived quality of the indoor climate before and after the renovation. One other thing we look at nowadays, more than in the past, is the economic impact. If you want to involve end-users (in dwellings, but e.g. also in schools) one really (also) needs to focus on energy expenditures. Especially with projects for low income households it is important to look at energy bill effects, and to come up with innovative cost structures.'

Any other remarks?

'Worldwide we are in the process of realizing an energy transition that is historical. The standards (e.g. those related to the recent EPBD recast) for new buildings are quite strict. For existing buildings however, the requirements – in our eyes - could have more demanding. Everybody is talking about the NZEB buildings but how net zero will our existing building stock really be 10 years from now? More ambitions are needed there, especially when focussing on residential buildings. Ideally also taking health, comfort and financial effects needed to be considered. ■

More information

For more information about the Cold Climate HVAC Conference 2018, see: http://www.cchvac2018.se.
Or send an email to Dennis Johansson, via: dennis.johansson@hvac.lth.se

As far as the next Cold Climate conference is concerned: this will be organized in Tallinn, Estonia from 13th till the 16th of March, 2021. Organisation is shared in between Tallinn University of Technology, from where Jarek Kurnitski will be the president, and EKVÜ, an Estonian Society of Heating and Ventilation Engineers, who will be responsible for programme especially for the practitioners. For more information about the 2021 Cold Climate conference, please send an email to Jarek Kurnitski, jarek.kurnitski@ttu.ee

X IAQVEC 2019

10th Int. Conference on Indoor Air Quality, Ventilation and Energy Conservation in Buildings

5-7 September, 2019
Bari, Italy

Conference theme: **Healthy Nearly Zero Energy Buildings**

www.iaqvec2019.org

Main topics:

- Ventilation and measurement techniques
- IAQ and Indoor Environmental Quality
- HVAC systems
- Smart Technologies for ZEBs
- ZEBs: design and energy modelling

Important Dates:

- June 1, 2018 > Online abstract submission open
- November 1, 2018 > Deadline for abstract submission
- April 1, 2019 > Deadline for full paper submission
- May 15, 2019 > Notification of full paper acceptance
- June 15, 2019 > Deadline for final paper submission

Endorsements:

REHVA Federation of European Heating, Ventilation and Air Conditioning Associations

AIJ ARCHITECTURAL INSTITUTE OF JAPAN

CARR AiCARR Cultura e Tecnica per Energia Uomo e Ambiente

The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan

ati ATI - NAZIONALE

COMITATO ELETTROTECNICO ITALIANO

AICVF ASSOCIATION DES INGÉNIEURS EN CLIMATIQUE, VENTILATION ET FROID

ARCHITECTURAL INSTITUTE OF KOREA 1945

FTI ASSOCIAZIONE DELLA FISICA TECNICA ITALIANA

KIAEBS 한국건축친환경설비학회

The Canadian chapter of the International Building Performance Simulation Association

La Section canadienne de l'International Building Performance Simulation Association

ISH Shanghai & CIHE returns with an elevated sourcing experience for the East and Central China market

ISH Shanghai & CIHE, the sister show of ISH China & CIHE in Beijing, will return to Shanghai New International Expo Centre from 3 – 5 September 2018 as the show cements its position as the most influential HVAC and home comfort exhibition in East and Central China.

As the demand for customised heating solutions, intelligent and comfortable households in East and Central China continues to soar, industry professionals are gearing up for another edition of ISH Shanghai & CIHE – Shanghai International Trade Fair for Heating, Ventilation, Air-Conditioning & Home Comfort System. The show will be concurrently held with Shanghai Intelligent Building Technology, Shanghai Smart Home Technology, Shanghai International Lighting Fair and Parking China to form a one-stop sourcing channel. Together, these five building technology fairs are expected to host over 600 exhibitors across 46,000 sqm of exhibition space and attract 60,000 visitors from around the world.

An increasing number of severe cold winter days during the year has fuelled the heating market in East and Central China. While centralised heating systems are predominant in the north of China, households in East and Central China require a different set of solutions. ISH Shanghai & CIHE enables fairgoers to capture lucrative opportunities generated by recent coal-to-clean energy policies and the growing popularity of fully-furnished deluxe apartments. Those, in fact, require individual household-based heating systems. These changes in the market will be seen through a comprehensive selection of advanced home comfort systems at the fair which also includes fresh air, water and air purification and smart products.

This comprehensive range of products ensures the fair is a focal point for a wide range of buyers. This includes manufacturers, distributors, installation companies, design and decoration companies, property developers, designers and end-users who are all looking to explore the latest products as well as industry trends.

Debut Premium Area elevates sourcing experience

To accommodate the diversified needs of the market in East and Central China, the Premium Area will debut at this year's fair to showcase outstanding technologies and products under the themes of Technology, Quality, Design and Technical Skills. Renowned domestic and overseas brands dedicated to comfortable home products and technologies will offer a variety of sourcing options. The different themes allow visitors to efficiently navigate the various exhibits and discover design patents, quality and design awards, innovative system designs, and advanced skills involved in the manufacturing or installation process.

The European Pavilion will return to the 2018 edition to capitalise on the rapid development of the HVAC market in East and Central China. Renowned HVAC brands from Germany, Italy and the UK will showcase top-of-the-range European heating products and technologies. Last year, 20 top industry players from Europe featured at the pavilion and a strong line-up is expected again this year. Companies that have already confirmed their participation include AeroFlow, Afriso, Bampi, Dephina, KANE, Radius and WKL.

ISH Shanghai & CIHE is headed by the biennial ISH event in Frankfurt, Germany, 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 (Monday to Friday). For more information, please visit www.ish.messefrankfurt.com.

Furthermore, the next edition of ISH India powered by IPA will run from 28 February – 2 March 2019 at Bombay Exhibition Centre, Mumbai. Another ISH event in China, ISH China & CIHE will be held from 6 – 8 May 2019 at the New China International Exhibition Center. For more information about ISH Shanghai & CIHE and ISH China & CIHE, please visit www.ishc-cihe.hk.messefrankfurt.com or email info@ishc-cihe.com. ■

REFCOLD INDIA

22 - 24 NOVEMBER, 2018
Mahatma Mandir Convention Cum Exhibition Centre, Gandhinagar, Gujarat

It gives us pleasure to inform you that ISHRAE (The Indian Society of Heating, Refrigerating and Air Conditioning Engineers) along with NürnbergMesse India (NMIND) is organizing **REFCOLD INDIA 2018** – India's first International Exhibition and Conference on Cold Chain, Industrial Refrigeration and Reefer Transportation from 22-24 November 2018, Mahatma Mandir, Ahmedabad, Gujarat. The Event will cover all the section of the refrigeration and cold chain industry and bring all the stakeholders together under one roof. It will also provide a platform to global investment community to connect with stakeholders in Refrigeration & Cold Chain sector in India.

REFCOLD INDIA has received a tremendous response from the refrigeration industry and support from associations and bodies like All India Cold Storage Federation of India, Government of India, National Centre for Cold Chain Development, Ministry of Agriculture etc. Among international support we have International Institute of Refrigeration (Paris), China Association of Refrigeration, Turkey Association of Refrigeration, ISIB and ISKID. Our conference is supported by UNEP (United Nation Environment Programme).

Advantage India

- 2nd largest arable land in the world
- Largest producer of milk & second largest producer of fruits & vegetables
- Largest livestock population
- Rising consumption expenditure
- Strategic geographic location in terms of exporting processed foods
- Favourable government policies to boost the cold chain industry
- India has about 6,300 cold storage facilities with a capacity of 30 million tonne, which are only able to store about 11 per cent of the country's total perishable produce. Hence, we have huge requirement of cold storage facilities.
- Cold chain market in India is projected to reach USD 234.49 billion by 2020.
- There is a market for around 60,000 Reefer truck requirements of various sizes.

Advantage Gujarat

- India is growing @ 6.17% but Gujarat is growing @ 11%
- Gujarat produces 40% of total Pharma production of Country.
- Fishery Industry Contributes to 1.1% of GDP and Gujarat is 3rd largest producer of Fishery Products.
- Dairy Contributes 22% in Gujarat GDP with Gujarat being 4 largest producers of Dairy products.
- 2 Mega Food parks in Gujarat and few more are being proposed by Govt. of India.
- Pradhan Mantri Kisan Sampada Yojana: 238 projects under integrated cold chain and value addition infrastructure.

Key highlights of the event:

- Delegation from IIR Paris, China and Turkey.
- Entrepreneur's Conclave: Successful case studies and business models will be showcased by the leading industry experts from across the globe.
- Global Poster Competition: Dedicated area for the Global Poster Competition to present the research done on this sector.
- Award nights: Recognizing the stalwarts of the industry.

We are looking forward for your support to make this event a huge success.

For further information and updates, please visit www.refcold-india.com

ACREX India 2019

a member of
BUILD FAIR ALLIANCE
Integrated Building Solutions

28 February - 2 March 2019

BEC, Mumbai

ACREX India 2019, South Asia's Largest Exhibition & Conference on Air Conditioning, Heating, Ventilation and Intelligent Buildings being organized by INDIAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS (ISHRAE) is scheduled from 28 February – 2 March 2019 at Bombay Exhibition Centre, Mumbai. ACREX India will once again witness THE LARGEST NETWORKING PLATFORM for the built environment with the recurrence of Build Fair Alliance. Under the aegis of Build Fair Alliance, the following events will be once again conducted at the same venue coinciding with ACREX:

- ACREX India 2019 covering HVAC, Building Automation Systems & Indoor Air Quality.
- ISH India powered by Indian Plumbing Association – An International trade fair exhibiting plumbing, sanitation, bathroom & kitchen, renewable energy and home automation systems in India
- Fire & Security India Expo (FSIE) 2019 previewing Fire safety & security solutions.

Coming of these three events will ensure maximum number of footfalls from stakeholders of the construction industry and largest ever product display of integrated building solutions. Thus ACREX India 2019 once again promises to be grander with various building services segments coming together at the same platform.

HIGHLIGHTS:

- More than 500 Exhibitors
- More than 50,000 Business Visitors
- 32,000 SqM Gross Area
- Participation of Major Global Players from more than 25 Countries like China, Czech Republic, France, Germany, Korea, Malaysia, Russia, Sweden, Taiwan, Thailand, Turkey, UAE, UK, USA etc.
- Concurrent Activities: Workshops, Seminar, Interactive Panel Discussions, Students Quiz, Curtain Raiser, ACREX Awards of Excellence & ACREX Hall of Fame
- Supporters: Federation of European Heating, Ventilation and Air-Conditioning Associations, Bureau of Energy Efficiency, Indo-German Chamber of Commerce, Indian Green Building Council, Indian Plumbing Association, Contamination Control Society of India, Fire and Security Association of India, Refrigeration and Air conditioning Manufacturers Association, All India Air conditioning & Refrigeration Association etc.

ACREX India 2019 will also host a series of workshops and conferences with leading experts, academicians and technocrats from across the globe. The workshops will focus on interesting topics covering a whole range of industry.

In an attempt to inspire the HVAC&R and building services industry to produce energy efficient products, ACREX India 2019 will award the exhibitors who display latest innovation and energy efficient products at the show. ACREX Awards of Excellence is an initiative to award Products & Services in categories such as Innovation, Green Buildings, Energy Saving, Energy Saving in Refrigeration segment, Green product, Innovation, Innovation in Building Automation, and Product with technology developed in India, Indoor Air Quality.

ACREX Hall of Fame is a new industry benchmark instituted by ISHRAE to recognize the excellence achieved in conserving energy by commercial buildings in the Indian subcontinent. The coveted recognition aims to recognize iconic projects in India which can be global benchmarks in Energy Efficiency and Sustainability and further encourage industry to utilize these experiences in building a sustainable HVAC industry and to also further showcase success stories in the HVAC space in India.

aQuest, is a student quiz competition organized by ISHRAE every year which is concluded with Grand Finale at ACREX India.

For further information and updates, please visit www.acrex.in

AiCARR 51st 2019, WSED 2019 and 16th IBPSA Conference

AiCARR 51st International Conference "The human dimension of building energy performance"

AiCARR organizes in Venice, **from 20 to 22 February 2019**, the 51st International Conference titled "The human dimension of building energy performance", with the patronage of ASHRAE and REHVA.

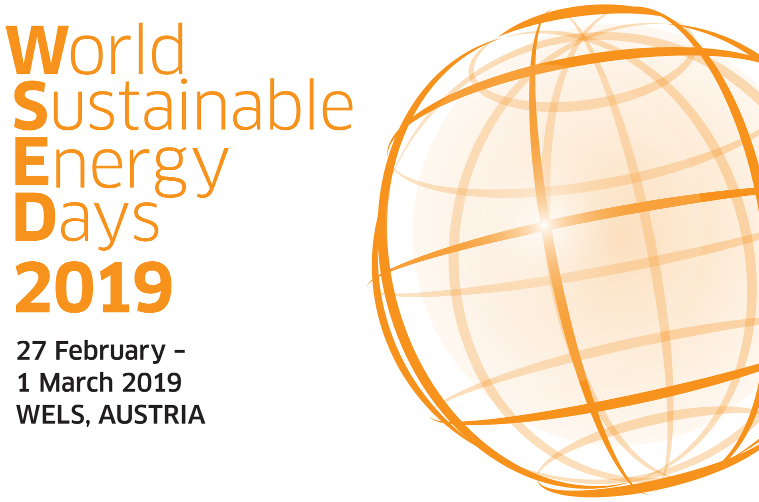
The Conference comes from the observation that the human factor affects significantly the actual energy performance over the building life cycle. Research efforts are therefore needed for fully integrating human dimensions in the building energy performance: data on occupant behavior have to be collected and properly elaborated; drivers and motivations have to be understood; indexes describing users comfort preferences and the impact on health and productivity have to be identified; new modeling approaches and tools need to be developed; design and operating strategies centered on occupants have to be defined.

This paradigm shift, based on occupants more than on advanced systems and technologies to reduce energy costs, activates a virtuous process, where not only occupants can benefit from it but also building owners, building operators and energy managers, enhancing comfort conditions and productivity and making more cost effective and energy efficient the whole process.

The Conference will gather researchers, professionals and practitioners from across the world to present and discuss the latest research on this topic.

European Energy Efficiency Conference 2019

In the context of the annual World Sustainable Energy Days (WSED), the European Energy Efficiency conference 2019 will be held from 27 February – 1 March 2019 in Wels/Austria.



"Energy efficiency first" is at the core of Europe's commitment to a **clean energy transition** that serves the needs of citizens, economic development and the environment. Achieving a **smart, socially fair and sustainable energy system** requires strong policies, competitive businesses and technology innovation. Mastering the **digital transformation** of energy and buildings will be crucial for creating a thriving economy and for the success of the global clean energy transition.

Six conference tracks will cover policies, markets, business models, financing, research & innovation, technologies and best practice solutions. Three interactive events offer opportunities for networking and making business contacts.

CALL FOR PAPERS & SPEAKERS DEADLINE: 10 OCTOBER 2018. Check out the website www.wsed.at/en to get more information on conference events, fees, call for papers/speakers and other.

16th International IBPSA Conference

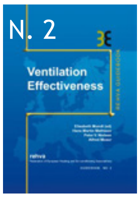
Building Simulation is the premier international event in the field of building performance simulation and will be held in **Rome (Italy)**, on **2-4 September 2019** organized by the IBPSA Italian Chapter. An exceptional opportunity to share information about simulation tools and applications, present and get updates about recent achievements and new developments in the research, illustrate case studies and share best practices, join special programs for students and practitioners, network during session and social programs.

Registration is opening on **October 1st, 2018**. Visit the website www.buildingsimulation2019.org for more information. ■

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

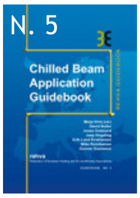
REHVA GUIDEBOOKS

written by teams of European experts



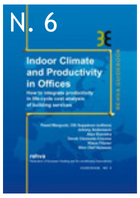
Ventilation Effectiveness

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.



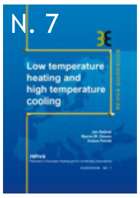
Chilled Beam Application Guidebook

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.



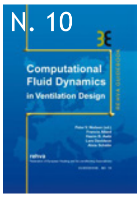
Indoor Climate and Productivity in Offices

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.



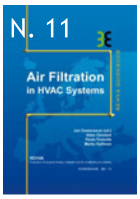
Low temperature heating and high temperature cooling

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.



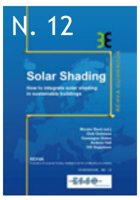
Computational Fluid Dynamics in Ventilation Design

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.



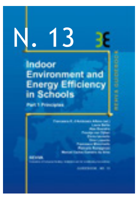
Air Filtration in HVAC systems

Air filtration 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.



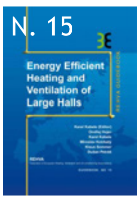
Solar Shading

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.



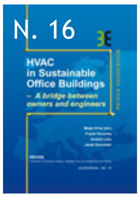
Indoor Environment and Energy Efficiency in Schools

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.



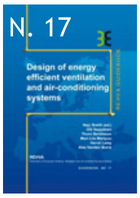
Energy Efficient Heating and Ventilation of Large Halls

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.



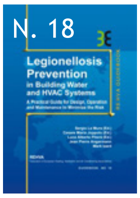
HVAC in Sustainable Office Buildings

This Guidebook talks about 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.



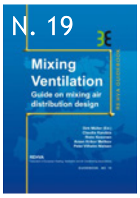
Design of energy efficient ventilation and air-conditioning systems

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.



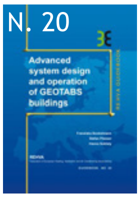
Legionellosis Prevention in Building Water and HVAC Systems

This Guidebook is a practical guide for design, operation and maintenance to minimize the risk of legionella 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.



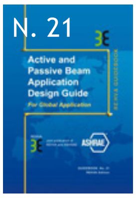
Mixing Ventilation

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.



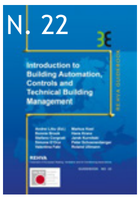
Advanced system design and operation of GEOTABS buildings

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.



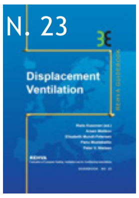
Active and Passive Beam Application Design Guide

This Guidebook 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. This publication 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.



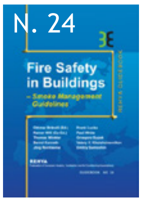
Introduction to Building Automation, Controls and Technical Building Management

This Guidebook provides 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 focuses on collecting and complementing existing resources on this topic in the attempt of offering a one-stop guide.



Displacement Ventilation

The aim of this Guidebook is to give the state-of-the art knowledge of the displacement ventilation technology, and to simplify and improve the practical design procedure. The Guidebook discusses methods of total volume ventilation by mixing ventilation and displacement ventilation and it gives insight of the performance of the displacement ventilation. It also shows practical case studies in some typical applications and the latest research findings to create good local micro-climatic conditions.



Fire safety in buildings. Somke Management Guidelines

This guidebook describes the different principles of smoke prevention and their practical implementation by way of natural and mechanical smoke extraction systems, smoke control by pressurization systems and appropriate partition measures.

REHVA - Rue Washington, 40 - 1050 Brussels - Belgium
Telephone: +32 2 514 11 71 - E-mail: info@rehva.eu - website: www.rehva.eu