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QUALICHeCK

Compliance and quality of the works

Crossroads of building quality, EPC compliance, energy policy and technology

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This is the 3rd special issue of the REHVA journal with a particular focus on outcomes of the QUALICHeCK project. You will find information on the outcomes from QUALICHeCK workshops on transmission aspects (Brussels December 2016) and on renewables in multi-energy systems (Lyon January 2017).

QUALICHeCK has produced more than 50 factsheets, of which an overview is found in this journal, as well a summary of one factsheet on the German kfW quality assurance system. There were also 16 QUALICHeCK webinars of which the highlights are presented.

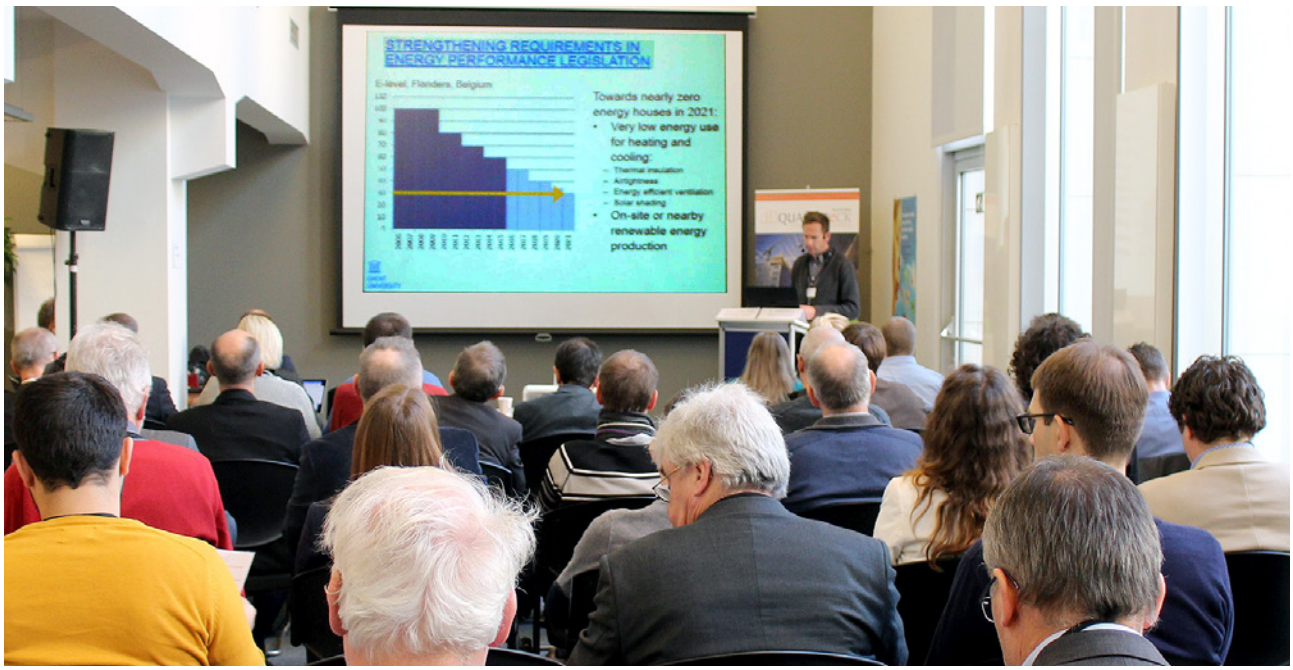
On November 30, the European Commission presented a package of measures to keep the European Union competitive as the clean energy transition is changing global energy markets. As part of this clean energy (or winter) package, there is a proposal for revision of the EPBD.

As one of the proposals for revision, there is the introduction of a 'smartness indicator' (see page 19). It is clear that the rapid developments in smart sensors, IoT, the cloud,… are offering new opportunities in terms of building operation and management, user information and control, as well as a better interaction with the growing share of PV and wind based electricity.

Another interesting development is BIM (Building Information Modelling) which is becoming more and more a mainstream technology. What is its potential impact in relation to the EPC assessment and better quality of the works?

I hope you will enjoy your reading,

Peter Wouters



The QUALICHeCK International Workshop on Transmission Losses

Keywords: thermal transmission, thermal bridges, compliance and quality, super insulation, building envelope

Photo credits: QUALICHeCK / Sympraxis Team

During the international workshop held in Brussels on December 15, 2016, 59 participants from 13 countries exchanged their experience and views on ways to improve the quality of installed insulation systems as well as to secure the compliance of insulation product and system data.

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Of course, these concerns are part of a much broader picture, in particular the European Union's willingness to lead the clean energy transition with the so-called "Clean Energy for All Europeans" legislative proposals. Because of its very significant share in energy use and GHG emissions, the

QUALICHeCK responds to the challenges related to compliance of Energy Performance Certificate (EPC) declarations and the quality of the building works. Find out more at http://qualicheck-platform.eu.

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building sector is largely concerned by these proposals, although a long-term vision for the building sector in 2050 as well as targets for the renovation of the existing building stock, where most of the potential lies, are missing (See Frances Bean's presentation[1]).

Heat losses through the building envelope usually represent a substantial share of the energy losses of a building. Therefore, any gap between the actual and theoretical performance of systems implemented to reduce those losses (e.g., the U-value of an insulation panel) can result in very significant unexpected energy losses (See Arnold Janssens' presentation[2]). In the past 10 years, part of the Belgian approach to reduce this gap has been to build a set of measures to secure consistency between actual and reported performance and to have trustworthy sources to derive product characteristics. More specifically, the 3 Belgian regions developed a website with product characteristics to be used in energy performance assessment for many product families in order to facilitate the work of the expert who has to select input data (See Peter Wouters' presentation[3]). Quality frameworks were developed for existing cavity walls and internal insulation to ensure that the products would be installed according to specifications (See Timo de Mets' presentation[4]).

The issue of thermal bridges was specifically addressed during this workshop because their influence is magnified in (nearly) zero-energy buildings. In fact, there can be more heat losses through thermal bridges than through walls in such buildings if the designer overlooks their influence. A review of calculation methods in 9 EU member states showed that, although thermal bridge impacts were addressed in all countries, compliance and verification processes were often missing. How tabulated or default values correspond to the real values of as built solutions in construction site, is therefore often not known (See Jarek Kurnitski's presentation[5]).

Super insulating materials such as vacuum insulation panels (VIP) or aerogels represent a small market share as of today; however, they show great potential for the renovation market. Many examples in Europe but also in the USA, China, Japan were presented showing how these could be implemented, including in listed buildings with strong aesthetics and architectural constraints, or in expensive districts to save floor area (See Daniel Quenard's presentation[6], and Par Johansson's presentation[7]). Significant progress has been made over the past few years to make these materials less fragile and easier to handle.

Research is on-going to characterise the in-situ performance of super insulation systems and specify the conditions under which they can be installed. A CEN Technical Committee (TC 88) is working on the characterisation of the long-term performance of vacuum insulation panels, in particular as they are subjected to temperature and humidity stress (See Roland Cap's presentation[8]).

Technical approval frameworks are meant to assess risks, to check the fitness for purpose, and to document specifications for workmanship for a given product or system. They go beyond harmonised standards and European Technical Assessments which are limited to product characteristics to be declared in relation to its essential characteristics as defined in the Construction Product Regulation (305/2011). During a round table discussion, panel members shared their thoughts about an increasing need for technical approvals to have common references for issues not covered by harmonisation such as workmanship. Note that there already exist several technical approvals for vacuum insulation panels and aerogels that provide reliable data for their properties and durability as well as specifications for their implementation on site (See Daniel Quenard's presentation[9]).

There are interesting initiatives to guide the market toward achieving high performance insulation. For example, there exists an array of tools to secure the quality of External Thermal Insulation Composite Systems (ETICS) including the EAE's European Application Guideline for ETICS or certification schemes operational in Austria and Germany (See Ralf Pasker's presentation[10]). As for the thermal performance of residential pitched roofs, the European Insulation Manufacturers Association (Eurima) insisted on a system approach and basic understanding of building professionals of the challenges, for instance, when wind "washes" the insulation and therefore degrades its performance. The presenters also insisted on appropriate quality checks and showed positive feedback from their implementation in social housing retrofit in Eeklo, Belgium (See Ross Holleron and Jelle Langmans' presentations [11]).

Finally, the workshop was the occasion to discuss the perspectives given by information technology to ease the documentation and checks in building construction. The construction and commissioning phases account for 10-30% and 15-30% each of the gap between expected and actual energy use in a building. To contain these problems, smart phone applications developed in the Built2Spec project help perform and document quality checks during the construction phase, for instance, with a user friendly interface to archive georeferenced pictures as evidence. User friendly interfaces are operational or under development with innovative solutions to measure building airtightness, acoustic and indoor air quality, and 3D scanning (See Andrea Costa's presentation[12]). The perspective for such tools, in a context where the need for evidence of compliant product and installation is increasing, seems promising.

The workshop was organised by INIVE EEIG on behalf of the QUALICHeCK consortium in cooperation with EURIMA, EAE, VIPA, UEATC and EOTA, and with the support of the Flemish Energy Agency (VEA) and the Walloon Region. ■

Presentations

Presentations of the workshop are available on: http://qualicheck-platform.eu/events/workshops/

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Renewable heating and cooling systems: compliance of product data and quality of installations

National legislations transposing the EPBD require a calculation of the energy performance, using input data to describe the building and its systems. The input data must be compliant, i.e. determined in accordance with the legal rules. The Energy Performance Certificate (EPC) serves as an evidence for meeting energy minimum requirements and as a communication tool for various market actors to inform about the energy performance.

Keywords: EPBD, energy performance, heating, cooling, renewable, product data, quality of installations

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The trend towards Nearly Zero-Energy Buildings (NZEB) implies a better quality of the works, with specific skills of the workforce to reach quality and good performance of the installed systems.

In this context, an international QUALICHeCK workshop took place in Lyon in January 2017, focusing on renewable heating and cooling systems [5]. This article summarises its outputs.

Renewable technologies gain in importance

In November 2016, the European Commission published the "Clean Energy for All Europeans" legislative proposals, covering also energy efficiency and renewable energy use in buildings. The proposals for a revised Energy Performance of Buildings Directive (EPBD) and a revised Renewable Energy Directive (RED) demonstrate the crucial role of renewable energy systems in buildings for achieving the decarbonisation of the European economy, defined as target to be reached by 2050 [1].

The EPBD aims at transforming the building sector towards improved energy efficiency, with Nearly Zero Energy Building (NZEB) requirements by the end of 2020, making that renewable energy systems come to the fore.

QUALICHeCK responds to the challenges related to compliance of Energy Performance Certificate (EPC) declarations and the quality of the building works. Find out more at http://qualicheck-platform.eu.

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The RED aims at promoting the increased use of energy from renewable sources. The building sector has a potential to use renewable energy and to generate it from building integrated systems.

The proposals for revising the directives include provisions for the use of renewable energy systems in buildings, presented in **Table 1**.

Suggested changes show that more emphasis is put on renewable energy systems in buildings as such, and on actual performance of technical building systems including renewable energy systems.

Labelling and certification schemes: potential to generate compliant input data

Labelling and certification schemes assuring quality on product level can support compliance on building level by providing input data for calculating building energy performance. They are often based on European standards [8].

Labels and certifications can be of a voluntary nature or prescribed as part of legislation.

Mandatory labelling

European regulations for setting energy-related requirements and prescribing labelling for energy-related products according to Ecodesign Directive and Energy Labelling Directive are available or under development or revision for the most important components of building systems [9].

Among others, ecodesign criteria specify energy efficiency parameters and minimum requirements which can be used either as input data or as default values for the calculation of Energy Performance Certificates, if the national regulation allows or requires it [10].

Voluntary certification of product data

Certification schemes exist at the European level, such as for example the mark "Eurovent Certified Performance" [11] for heating, ventilation and air conditioning products (with 21 certification programmes and more than 115 000 product references certified), the Heat Pump Keymark and the Solar Keymark for solar thermal systems [12].

If allowed by national regulation, certified product data can be used as input data for the EPC calculation.

Product database

Databases of certified products, and databases in which manufacturers publish product characteristics under the control of a third party, provide easy access to product data useful for EPC calculation (if allowed by national regulation. In some cases, a direct link between these databases and the energy performance of building calculation tools facilitates the choice of the input data, while limiting the risk of errors.

QUALICHeCK has identified and documented several databases, at national or European level [4,13].

How to reach good quality of installed systems?

QUALICHeCK shows that design and installation works need clear specifications on what has to be done, clear procedures on how to decide on non-compliance, and effective control and penalties if non-compliance is detected. Qualification of staff is a key element.

Table 1. Provisions relevant for the use of renewable energy systems in buildings.

Proposal for revised EPBD [2,6,7]	Proposal for revised RED [3]
Definition of technical building systems mentioning the use of renewables, and extended to on-site electricity generation and infrastructure for electro-mobility (Article 2)	Scope extended to self-consumption of renewable electricity (Article 1)
	Minimum levels of renewable energy in new and renovated buildings based on cost-optimal calculations according to EPBD (Article 15)
Requirement that the overall performance of installed, replaced or upgraded systems is assessed, documented and passed on to the building owner (Article 8)	Enabling consumers to self-consume electricity from renewables without undue restrictions (Article 21)

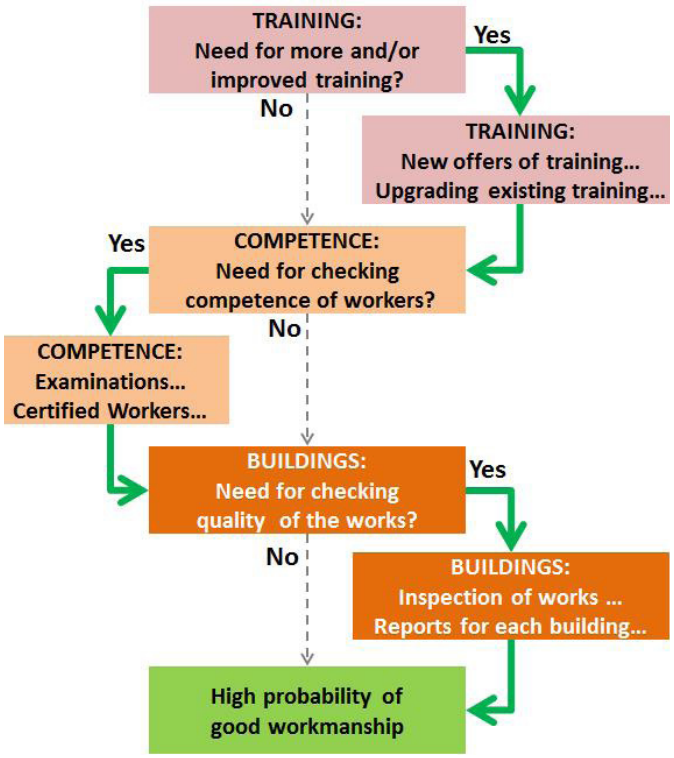

Figure 1. Stepwise approach to analyse the probability of good quality of the works.

Figure 1 shows how training of persons, checking of competence and checks of the quality of the works can be used to have a high probability of good workmanship.

Guidelines, certification of persons or companies and inspection of the works are some of the associated tools [14]. An interesting example of a national initiative to increase the expertise of building professionals is the French programme PACTE [15] in which professional recommendations, technical guides and notebooks for workers (including digital version for smartphones and tablets) are developed to help for design, construction, installation, self-control of quality and commissioning. ■

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[2] European Commission – Proposal for a Directive […] amending Directive 2010/31/EU on the energy performance of buildings, November 2016 COM(2016) 765 final.

[3] European Commission – Proposal for a Directive […] on the promotion of the use of energy from renewable sources (recast), November 2016, COM(2016) 767 final.

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[6] François Durier (CETIAT) – Revision of the EPBD: possible changes and additions.

[7] Michèle Mondot (CETIAT) – Revision of the EPBD: possible impacts on heating and cooling systems.

[8] Dominique Hantz (CETIAT) – The European EPB standards for heating and cooling systems: link with EPC input data.

[9] Geert de Cock (EHI) – How are renewable heating and cooling systems covered by numerous regulations?

[10] Susanne Geissler (ÖGNB) - Input data for building energy performance calculation: which are they? What about their compliance?

[11] Sandrine Marinhas (Eurovent Certita Certification) – Eurovent Certification for heating and air-conditioning products.

[12] Katharina Meyer (DIN CERTCO) - Heat Pump Keymark.

[13] Jean-Paul Ouin (UNICLIMA) – The French product characteristics database for boilers, heat pumps and solar thermal systems.

[14] Hans Erhorn (Fraunhofer IBP) – How to achieve quality of the works? Presentation of QUALICHeCK findings.

[15] Sylvain Mangili (AQC) - Professional rules and guidelines for installers: the French Programmes RAGE and PACTE.

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In the scope of the KfW funding programmes "Energy-Efficient Construction and Refurbishment", loans and subsidies from federal funds are granted, provided that stricter energy requirements than specified in legal regulations are met. To check on the effectiveness of the funding programmes, KfW has developed a comprehensive quality assurance concept.

Keywords: quality of works, QUALICHeCK, construction site, quality assurance, KfW bank

Context

The German KfW Bank is one of the world's leading promotional banks. On behalf of the federal government and the federal states it aims at improving the economic, social and environmental living conditions for people all over the world. Among other issues, its work focuses on funding programmes in the field of energy-efficient construction and refurbishment of residential buildings, to create incentives for energy-efficient new constructions and retrofitted existing buildings. In this context, KfW strives to promote a higher energy standard of the implemented structural measures than stipulated by the legal requirements specified in the German Energy Saving Ordinance

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(EnEV) [1]. This complex matter requires special expertise, meticulous planning and correct implementation. For these reasons, KfW has developed a comprehensive quality assurance concept that comprises several closely integrated elements, which ensure the correct implementation of the funding standards. The key elements of the quality assurance concept include the quality control of the required documents, applications and verifications on the one hand and on-site quality assurance on the other. The required documents, applications and verifications must undergo plausibility checks and randomly selected inspections. For on-site quality assurance, however, it is mandatory to consult an independent expert as early as in the planning stage. The expert will accompany the builder right through to completion of the project.

Quality assurance in four project phases

The quality assurance system consists of closely integrated elements, which become effective during four phases and are designed to ensure the implementation of the KfW funding standards. In detail, these four phases are: project planning, filing the application and commitment, implementation phase and completion of the project as shown in **Figure 1**.

The individual elements that are comprised in the quality assurance system are as follows:

- Technical minimum requirements (programme boundary conditions)
- Obligation to consult an independent expert who is registered in the quality-assured list of energy-efficiency experts
- Automatic plausibility check (online) using the so-called "Energy-Efficient Construction and Refurbishment Inspection Tool" (EBS inspection tool)
- Randomly selected inspection 1 (random checks of the calculation documents)
- Funding of energy-related construction supervision conducted by an independent expert
- Randomly selected inspection 2 (random checks of the technical verifications and calculations)
- On-site inspection after completion of the construction work

Results of the on-site inspections

After completion of the construction work, KfW carries out on-site inspections in the scope of a random spot check, during which compliance with the Efficiency House standard and/or the technical minimum requirements is examined. These on-site inspections are coordinated by the German Energy Agency, "Deutsche

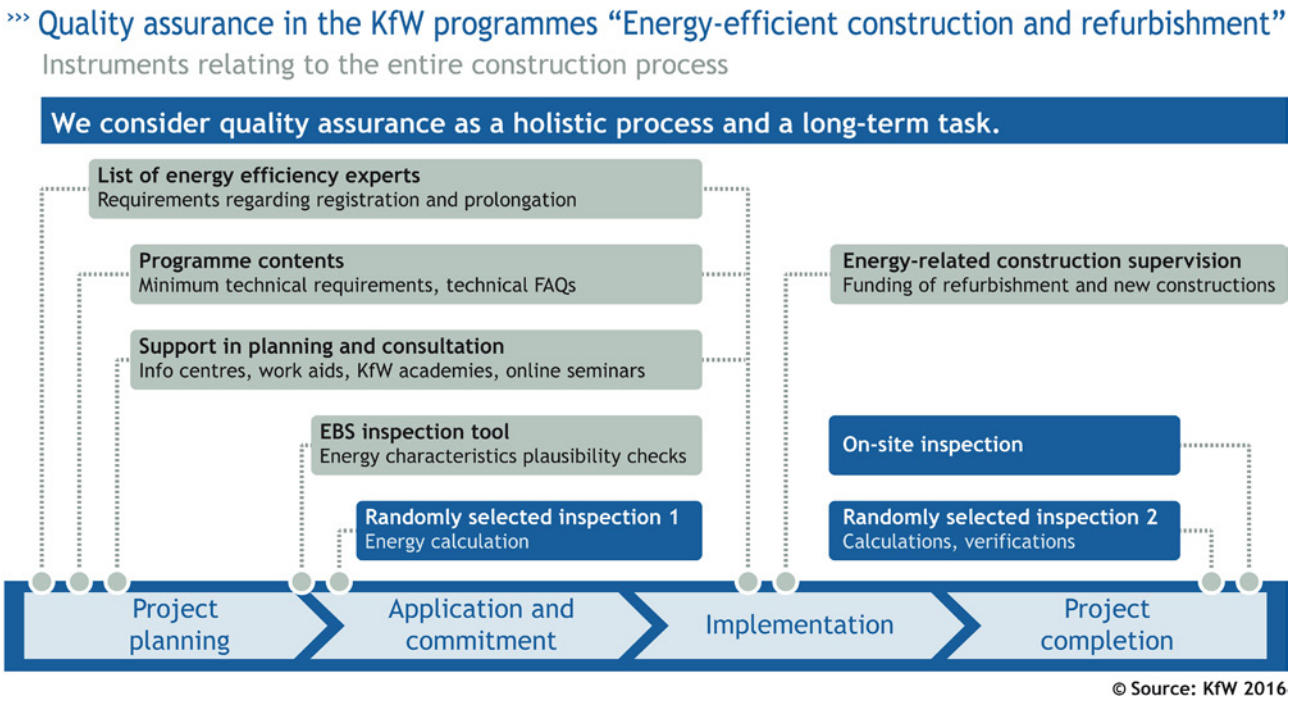

Figure 1. Quality assurance scheme relating to the KfW programmes "Energy-efficient Construction and Refurbishment", describing individual instruments applied during the entire construction process.

Energie-Agentur GmbH (dena)". Coordination is based on cooperation with about 30 specialized inspectors who record all relevant data on site. An assessment procedure was developed especially for the analysis of these inspections to ensure standardisation of the process. By performing these on-site inspections, KfW also aims at increasing the quality awareness of all parties involved. Between 2013 and 2015, more than 1,300 residential buildings were subjected to an on-site inspection. This corresponds roughly to about 430 inspections per year and a sampling rate of about 0.3%. Based on the on-site inspections performed between 2013 and 2015, KfW gained the following insights [2]:

- In the case of both KfW Efficiency Houses and KfW individual measures, the quality of planning and implementation is high
- In the case of KfW Efficiency Houses under refurbishment, the number of cases in which a KfW Efficiency House standard was not achieved and cancellation followed, has declined to 3%
- In the case of new constructed KfW Efficiency Houses, the number of cancellations has increased to 5%
- Risks for non-compliance with programme requirements result from:
  - Calculation errors
  - Modifications in the construction progress that have not been compensated for
  - Absence of compliance verification documents

The results confirm that quality assurance plays an important role in the entire planning and construction process.

Overall evaluation

The comprehensive quality assurance concept developed by KfW for ensuring and checking the effectiveness of its funding programmes "Energy-Efficient Construction and Refurbishment" is very elaborate and well-structured. The individual elements that are comprised in this quality assurance system are interrelated and become effective as early as in the planning stage. The examination covers the entire construction process right through to completion of the project. However, KfW's quality assurance concept implies additional effort and additional expenditure for all parties involved. For instance, communication and the exchange of information and data among all stakeholders are vital for the successful completion of a construction project and must not be neglected. The quality assurance concept is not only useful for KfW - it is also beneficial for the builders to whom it provides additional security for their construction projects. ■

More information

More detailed information on the KfW quality assurance scheme [3] and similar schemes can be found at http://qualicheck-platform.eu/results/fact-sheets/factsheets-by-date

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Can BIM be a disruptive technology for EPC assessment?

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BIM is in may EU countries high on the agenda. This article is focusing on the potential of BIM in relation to the energy performance of building assessment and also in relation to a better quality of the works.

Keywords: EPC, BIM, quality, standardisation, QUALICHeCK

According to Wikipedia*, building information modelling (BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of places. Building information models (BIMs) are files (often but not always in proprietary formats and containing proprietary data) which can be extracted, exchanged or networked to support decision-making regarding a building or other built asset. Current BIM software is used by individuals, businesses and government agencies who plan, design, construct, operate and maintain diverse physical infrastructures, such as water, refuse, electricity, gas, communication utilities, roads, bridges, ports, tunnels, etc.

* https://en.wikipedia.org/wiki/Building_information_modeling

BIM developments in Europe

The future market uptake of BIM is difficult to predict with great accuracy, but it clearly is a development with great potential.

In terms of requirements, an increased number of countries impose the use of BIM for certain types of projects, e.g.:

- Since 2007, obligatory in Norway for public buildings, in Finland for any project above 2 M€ and in the USA for any major project
- Since 2012 mandatory in the Netherlands for any major public project
- Since 2014 mandatory in Hong Kong for any public project
- Since 2016 mandatory in South Korea for any project above 50 M$ and in the UK for public projects

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In a 2016 report 'Shaping the Future of Construction – A breakthrough in mindset and technology' by the World Economic Forum, prepared in collaboration with the Boston Consulting Group, the market view on a whole range of new technologies has been collected. From this survey, it appears that integrated BIM has the highest likelihood AND the highest expected impact on the construction sector in the future compared to thirteen other new technologies (such as advanced building materials, augmented reality, 3D printing of components, big data analytics…).

What can BIM mean for EPC calculations?

At present, the calculation of the EPC of a building is an activity on its own. One has to collect all input data (surfaces, volumes, product and system data, …) and enter them into the software tool. This can be very time consuming. Reducing the effort to collect and enter input data can rely on either simplified calculation procedures (for e.g. dwelling treated as a single zone, default values for various systems, simplified description of thermal bridges) or on calculation software with embedded product characteristics databases.

With BIM, and of course depending on the level of development of the BIM approach, all the input data for EPC calculations are part of the BIM model. Of course, specific tools have to be developed for the EPC calculations, with the ability to use BIM files for input data, and to generate results that are integrated into the BIM. Such BIM approach can very substantially reduce the required efforts for producing an EPC. As such it will be more easy to generate and evaluate variations to optimize the overall performance. In the "as built" stage, it will again be relatively easy to verify if the requirements are met.

What can be the impact on the calculation procedures themselves? An interesting example are **thermal bridges**: with a detailed description of the building envelope through BIM, and given the calculation power or modern computers, it becomes possible to have a 3-dimensional transmission analysis of the building shell, meaning that there is no need any more to have a specific analysis of thermal bridges.

Another example is the **assessment of overheating risks**. At present, most countries use simplified procedures which only give a rough indication of the risk of overheating and/or the related energy consumption for achieving appropriate thermal comfort. With a detailed BIM model, much more refined assessment methods can be used without requiring specific efforts for collecting input data.

Most countries have at present (very) simplified procedures to assess the energy performance of **HVAC systems**. With BIM, a more refined assessment becomes possible as the actual characteristics of the systems are easily available.

BIM and standardisation

In order to accelerate the market uptake of BIM, standardisation of protocols is important. Within CEN, Technical Committee 442 (Building Information Modelling) was created in September 2015. In ISO, Technical Committee 59 (Buildings and civil engineering works) is also dealing with BIM.

With the market uptake of BIM, and assuming that BIM models will be used for EPC calculations, there might be also new tasks for standardisation in relation to EPBD related standards. BIM offers the possibility to have a better physical modelling of energy processes (see examples mentioned ahead for thermal bridges, overheating assessment, HVAC modelling). It is important that the (CEN and ISO) standards reflect such development. A liaison officer between CEN TC 442 and the energy related CEN TC's has been nominated.

BIM and convergence of national EPC calculation procedures

At present, there are still major differences in the national EPC calculation methods. With the new set of CEN standards, one can expect more convergence in the EPC calculation procedures. However, one observes sometimes very big differences in the visions on the need for simplification and this is often a barrier for further convergence.

With BIM, there is the possibility to come with limited or no efforts for the user to a more accurate physical modelling of the energy performances and therefore the possibility of nearly no differences in views between member states. If the thermal bridges are automatically calculated due to the fact that the BIM model has all relevant information, why should countries have different procedures?

BIM and EPC compliance

At present, data collection for calculating the EPC of a building is in most cases an autonomous activity not linked to other design and execution processes. This might fundamentally change if BIM becomes mainstream. All relevant product and system data can then be directly integrated into the BIM objects (brick, thermal insula-

tion, fan, heat pump, …), together with an information about their compliance to the national procedures for determining input data. Moreover, an integrated BIM model will be updated according to design or execution modifications, making that it will effectively represent what is constructed. Therefore, the energy performance calculation can be made for the as-built building.

As a result, it might mean that, once the BIM approach has become mature, there is nearly no need for specific compliance efforts related to the compliance of EPC and its input data.

BIM and quality of the works

Another potential advantage of the market uptake of BIM is the possibility to come to a better quality of the works. This can be illustrated for ventilation systems. If the BIM model of the installation includes all components, it will be easily possible thanks to dedicated software to assess if the required air flow rates can be achieved, if the acoustical performances can be reached.

BIM and smartness indicator

The issue of the smartness indicator proposed by the EC for the amendment of the EPBD is the topic of another article in this journal. With the expected market uptake of BIM, it probably becomes also possible to set up in a cost-effective manner more refined assessment methods for the smartness indicator of a buildings.

Conclusions

It is at present not clear how quickly BIM will become mainstream for new and existing building projects, but there is no doubt that its importance will substantially grow in the coming decade. BIM can offer major opportunities in relation to the energy performance assessment of buildings, including compliance and enforcement. Moreover, it can at the same time contribute to better quality of the construction and of the installed energy systems, as well as to the market uptake of smart building systems. ■

The smartness indicator

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With the growing share of renewable energy by PV and wind, balancing energy supply and energy needs become increasingly important. Smart building management and response becomes therefore crucial.

At the building level itself, smart building design and control technologies can improve indoor climate conditions and at the same time empower building occupants by providing information on energy use and indoor climate conditions. This can also result in a reduction of the energy needs and possible response in times where supply and needs are out of balance.

Finally, smart building technology can also help to operate the building more efficiently, including support regarding maintenance and repair.

Smart Buildings will first of all, as mentioned, give an option for additional savings, because of the use of new technology, but it will also be possible to aim at savings when the pick load is high or when production of renewable energy is low.

Further it will be possible to shift the energy use so that reductions fall when the use of energy is high or to directly shift from high load / or stressed situations to a time when energy supply is high compared to the demand for instance, if there is a strong wind.

Savings by smart elements in buildings are interesting for the users because these often come at relative low costs, while shifting in the load is interesting because they can offset kWh's, which are produced at high costs. With Smart meters, consumers can be awarded for savings at the right time, by higher prices per kWh for these savings.

Smart Buildings can therefore both support the transition towards NZEB buildings and the further uptake of renewable energy in the energy supply.

Therefore, it seems logical to complement the indicator of the energy performance of a building, as reflected by the Energy Performance Certificate (EPC), with an indicator of the smartness of a building.

As part of the proposals released by the European Commission on November 30 2016, the introduction of such a 'smartness indicator' is foreseen.

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With respect to the features of this smartness indicator, the following description is provided:

A smartness indicator will reflect the ability of buildings to

(i) adjust to the needs of the user and empower building occupants providing information on operational energy consumption (complementing the energy performance information provided in the EPCs),
(ii) ensure efficient and comfortable building operation, signal when systems need maintenance or repair, and
(iii) readiness of the building to participate in demand response, charge electric vehicles and host energy storage systems.

Further the proposal gives a rational and some indications for the proposed indicator, as the documents published on November 30 provide the following information:

- "… The EPBD will be amended to empower the Commission to develop a framework calculation of a smartness indicator and enable the implementation of a common framework to assess and certify smart-readiness. …"
- "… During a transaction, this indicator will act as a reward mechanism for buildings with a high level of energy performance-oriented smartness, which can be achieved through ICT-based solutions such as: electronic monitoring systems, remotely controlled equipment/systems, predictive features, self-diagnosis and adaptability… ."

It is clear that such smartness can provide large savings as such solutions constantly enhance and at the same time get cheaper. Especially it can play a large role if it is combined with earmarked "Smart Finance" as indicated in the proposal of November 30. The estimations of the environmental and economic impact are provided (**see Table below**).

The proposal by the European Commission also gives indications about the costs aspects of this smartness indicator:

"This measure implies the assessment of the smartness of buildings.

For the cost valuation, it is assumed that the smartness is systematically included on EPCs. This brings an additional administrative cost to the issuing of EPCs.

The public administration would need to add another item/field to existing EPC databases on the smartness indicator, and conduct the corresponding compliance checking.

However, this is to be integrated within the existing certification systems, so no additional compliance checking costs would be incurred. Business and citizens would need to pay for the additional costs of collecting data to assess the smartness of the building.

Administrative costs for the public sector:

One-off cost of adapting the existing EPC database to include the indicator estimated in 25,000€ per country.

Administrative costs for the private sector:

The additional cost of assessing the smartness of the building is estimated to be 20€ (10% of the average cost of EPCs, i.e. 15€ for residential and 100€ for non-residential).

The number of EPCs issued between 2020 and 2030 was considered to be the same as the total number of EPCs issued between 2005-2015 which was close to 16 million, so on average about 1,6 million per year, of which the vast majority was issued for residential buildings (>95%)"

Measures	Impacts on savings in 2030	Impacts on annual energy expenditures in 2030	Impacts on associated construction activity (annual average for 2020 - 2030)
3B. Framework for the introduction of a smartness indicator	8 – 10 Mtoe	8 – 10 bn€/a	5 – 6 bn €/a

As part of the preparation of such smartness indicator, a call for tender was set up (ENER/C3/2016-554) with as deadline for submission September 1 2016. The work programme foresees also consultation with stakeholders. The indicative list of stakeholders to be consulted gives a good idea of the range of stakeholders involved in Smart Buildings:

Primary stakeholders: manufacturers, suppliers and installers of building/home energy producing and consuming ICT equipment and products and systems integrators. As many as possible of the following associations or group of stakeholders/industries should be involved:

- Manufacturers and suppliers of white goods
- Manufactures, suppliers and installers of HVAC, plumbing, security, electrical systems including electrical recharging infrastructure providers
- Manufacturers and suppliers of lighting equipment
- Manufacturers and suppliers of sensors, controls, automation systems and actuators (e.g. for windows, doors, stores) and monitoring equipment for buildings
- Manufacturers and suppliers of micro renewable home/building solutions (solar panels, solar heaters, wind, etc.)
- Manufacturers and suppliers of multimedia, user-friendly displays or interface applications and home computer equipment
- System integrators

Other relevant industries:

- Construction and ICT industries associations
- Facility Management and Building Control industry association
- ESCO or in general Energy Services Providers association
- Data management and cloud-service industries association
- IoT industry association
- Utilities and operators of the power grid association (e.g. smart meters association)

Standardisation Bodies and Organisations, such as: ETSI M2M group, CENELEC TC59x WG7, Smart Grid/Smart Home Activities, HGI Home Gateway Initiative, buildingSmart International, O.A.SIS Open Building Information Exchange (oBIX) and OSGi

If and how the smart indicator becomes a part of the EPBD amendment depends on the negotiations in the European Parliament and the Minister Council.

On February 14, the EPBD Concerted Action organised an event in Malta entitled "Smart Buildings for a greener Europe: Emerging Policy and Practice", whereby specific attention was given to the smartness indicator, but also practical projects were presented. Recordings of the whole event are available on their website* including presentations and round table discussions:

- The role of smart buildings for energy efficiency – Doris Österreicher, University of Natural Resources and Life Sciences, Vienna
- The emerging practice in Malta for smart buildings – Greta Caruana Smith, Building Regulation Office, Malta
- Smart buildings in the context of the EPBD – Sylvain Robert EC DG Energy
- Voluntary certification for automation and controls – Stephan Kolb, eu.bac
- Demand response in blocks of buildings – the DR BOB project, Vladimir Vukovic, Teesside University
- Innovation in smart buildings under Horizon 2020 – Amandine Lacourt and Philippe Moseley, EASME
- Smart buildings in a decarbonised energy system – Maarten De Groote, BPIE

* http://www.epbd-ca.eu/archives/1363

It is not yet clear what will be the precise specifications of this smartness indicator and the related calculation procedure, nor its impact in daily building practice. It seems however obvious that it should be closely linked to or integrated in the Energy Performance Certification of buildings. But will it be expressed in one or more numbers? In a new scale? Will it be only informative or will it be also used as a basis for new requirements?

Within the framework of the QUALICHeCK project, a substantial part of the activities has been focused on identifying challenges for obtaining compliant and effective EPC results and possibilities for an effective compliance framework.

With respect to this envisaged smartness indicator (SI), the following recommendations can be formulated:

- It is important that the SI reflects the status after the construction works and not only at the design stage as changes often are implemented between design and execution
- It is essential that there are very clear procedures for coming to input data for determining the SI and what to do, if this information cannot be provided
- The use of databases with compliant data and technologies can be very helpful and can help to keep costs low
- It is also important to have a clear framework for dealing with and supporting innovation. This is in particular a challenge for this domain since innovation in the area of smart control and design will be very considerable in the coming years.
- Change in boundary conditions over time might be an important element to cover in the SI. E.g. how to reflect preparation for changes in the SI; for instance, if a given building, heated by a condensing boiler is designed in such wat that it will be easy to replace the boiler by a heat pump or to add and integrate renewable sources?
- It is important to have a framework, which reflects not only if a building includes smart elements, but also its capacity to respond to or implement further smart controls in the future.
- Finally it is important that the SI includes assessment of the building as a hole, its smart controls and equipment, but also how this interacts with the grid and the surroundings including other buildings in the neighbourhood.

The challenges regarding the robustness of the SI is large, but it depends to a high extent of the use, which will be made of the SI. In case it is only voluntary information, the challenges are more limited. However, if it will become a general requirement and/or a requirement in private contracts, the challenges will be bigger, in particular if the requirements on these SI elements will be severe. ■

ALEXANDER DELIYANNIS

Highlights from QUALICHeCK webinars

Keywords: QUALICHeCK, Status on the Ground, Compliant and Easily Accessible EPC Input Data, Quality of the Works, Compliance and Effective Penalties

The QUALICHeCK project began on 1 March 2014 and was completed on 28 February 2017. The project brought forward major aspects of compliance of Energy Performance Certificates (EPCs) and quality of the works, in support of better energy performance of buildings. Several communication channels, physical and virtual, were utilised to disseminate QUALICHeCK results. One of these were webinars (web seminars) offered free of charge to a broad audience of building professionals. In total, sixteen webinars took place within the course of the QUALICHeCK project. Most of these were produced after the first half of the project implementation period, when there were already substantial results to present.

This article provides an overview of interesting highlights from these sixteen virtual events. The QUALICHeCK webinars have been recorded and are available for viewing on demand on the project website at www.qualicheck-platform.eu and on the QUALICHeCK YouTube channel (link available through the website homepage). Access is provided both to the full webinars and to the individual presentations and Question & Answer sessions. As all QUALICHeCK outputs, the webinars have been developed across four aspects (status on the ground, compliance of Energy Performance Certificates, quality of the works and compliance frameworks) and have focused mainly on four technologies (thermal transmission characteristics, ventilation and airtightness, sustainable summer comfort and renewables in multi-energy systems). The QUALICHeCK website allows users to find webinars either chronologically or through the above classification.

Compliant Energy Performance of buildings Certificates and better quality of the works – ground status, initiatives and perspectives | Webinar #01, 27 April 2015

The Energy Performance of Buildings Directive (EPBD) recast set ambitious goals for the building sector to reduce energy use as well as greenhouse gas emissions. It requires member states to engage in the generalisation of Nearly Zero-Energy Buildings and to set up the necessary actions to support the mandatory availability of Energy Performance Certificates (EPCs), both for new and existing buildings.

This webinar highlighted several issues, on the quality of the EPC input data and on the quality of the works, which can be critical in order to achieve EPBD compliance in practice. It also presented preliminary results of three field studies, in Austria, Cyprus and Estonia, evaluating such issues. The studies showed that there is reasonable cause for concern in respect to the compliance with relevant energy performance regulations.

Building airtightness and initiatives to improve the quality of the works | Webinar #03, 12 January 2016

Building airtightness is a critical factor for Nearly Zero-Energy Buildings and represents a key challenge for the building sector. The objective of this webinar was to give background information on selected initiatives to improve the quality of the works with respect to building airtightness under real world conditions. Such initiatives include the path to quality of works for airtightness decomposed to 10 practical steps under the Etanch'air project, specific market drivers for the development and correct use of new building airtightness products, and the Isov'Air Test for airtightness evaluation.

The webinar was organised in cooperation with TightVent Europe (www.tightvent.eu) and the Air Infiltration and Ventilation Centre (www.aivc.org).

Thermal Bridges – input data, calculation and verification methods | Webinar #04, 15 June 2016

The objective of this webinar was to present good examples of how to deal with thermal bridges in relation to energy calculations and investigation of the real performance, and to provide a platform for discussion. The webinar presented standard approaches to calculations for thermal bridges under the Swedish and Flemish EPBD regulations, as well as common errors

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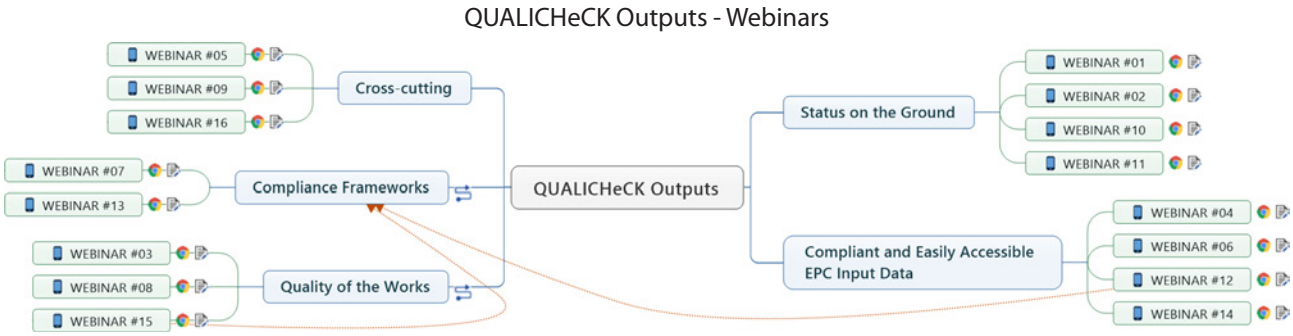

and deviations. In addition, the results from a relevant new field study from Cyprus were presented, identifying the misreporting of U-values and highlighting the practical challenges of correctly documenting thermal transmission characteristics.

Interesting and innovative approaches for improved building envelope performance | Webinar #13, 24 January 2017

The energy challenges for the building stock require ambitious but feasible approaches to secure their performance, including the performance of the building envelope. This webinar provided insights into interesting approaches including voluntary guidelines for high thermal performing roofs, real examples of using vacuum insulation panels for retrofitting, and an approach fully implemented in the UK for acoustic performance based on robust details, with potential relevance for thermal and overall building performance.

Prevention of summer overheating – methods and results | Webinar #11, 2 December 2016

This QUALICHeCK webinar focused on summer thermal comfort by discussing available national requirements, related assessment methods, as well as results from field studies. Overheating prevention is addressed by EPBD Annex I which states that the energy performance of a building shall be determined and shall reflect the cooling energy needs (energy needed to avoid overheating) to maintain the envisaged temperature conditions. This highly important requirement for occupant's comfort and wellbeing has led to variety of practices and regulations in Member States. In principle, overheating is a dynamic problem highly depending on the solar gain, thermal mass, shadings, window airing etc. Some countries address the issue with dynamic simulation based requirements, whereas in other countries more simplified methods are in use. Field studies show that this quite a new issue has not yet been fully established in design and construction practice and more efforts are needed for successful implementation.

Solar Control in the context of quality and compliance | Webinar #05, 23 June 2016

Energy Performance Certificates (EPCs) depend significantly on the behaviour of glazing, which in turn is determined using a well-defined set of data characterising the thermal performance of its transparent elements (glass and frame) and of the shading devices used. The set of data itself, its availability and its quality, as well as the quality of the relevant works are the main concerns from the QUALICHECK point of view. This webinar reviewed some aspects directly related to this topic, including the Spanish building technical code provisions and certification of solar control, the database on shading performance properties ES-SDA prepared under the direction of ES-SO, and the objectives of a training framework for the various type of professionals involved with shading, in order to ensure quality of the works. The webinar was organised in cooperation with ES-SO (www.es-so.com), the European Solar Shading Organisation.

Cool Roofs in the context of quality and compliance | Webinar #09, 28 September 2016

Rejection of solar gains is the aim of passive cooling strategies in any type of building and any climatic region. Cool materials work by reflecting solar radiation and therefore rejecting solar heat gains at the opaque external surfaces of the building.

This QUALICHeCK webinar outlined efforts for the promotion of cool roofs, related to compliance and quality of the works in the European context, including the role and work of the European Cool Roofs Council (ECRC), cool roofs standards and the ECRC product rating programme, as well as practical experiences from relevant markets.

Ventilative Cooling potential and compliance in energy performance regulations | Webinar #02, 17 December 2015 (Belgium, Estonia, Greece) and Webinar #10, 1 December 2016 (Spain and Germany)

Ventilative cooling – i.e., the use of natural or mechanical ventilation strategies to cool indoor spaces – can be very effective in reducing the cooling energy demand in buildings in summer or mid-season conditions. Its importance increases given the rising trends in cooling loads, as well as local climate change and spreading energy poverty. These QUALICHeCK webinars were part of a broader series focusing on ventilative cooling in energy performance, within the context of compliance with building regula-

tions in several countries. In addition, each presentation in the two webinars highlighted an aspect of broader interest, such as the key challenges and limitations of ventilative cooling, the benefits of night ventilation in particular, and the results of new field studies on compliance. The webinar series was organised in collaboration with the venticool platform (www.venticool.eu).

Renewable energy systems for buildings and EPC compliance | Webinar #14, 25 January 2017

On the route to achieve Nearly Zero-Energy Buildings, building services systems increasingly rely on renewable energy sources: solar thermal, heat pumps, geothermal, biomass, photovoltaics. This webinar dealt with the handling of renewable energy systems under the EPC (Energy Performance Certificate) and covered the challenges of providing compliant input data for EPC calculation, and an EPC which can be trusted, as well as the proposed revision of the Energy Performance of Buildings Directive (EPBD), in particular the introduction of a 'smartness indicator' for buildings and the relevance to renewable energy systems.

Product databases and compliance of input data for the Energy Performance Certificates (EPCs) of buildings | Webinar #06, 28 June 2016

Product databases provide validated information about the characteristics of construction products and building systems. They can be used to determine input data for the energy performance rating of buildings on their EPC, provided that the procedures of the national regulation authorise this.

This webinar presented the findings of the QUALICHeCK project on the compliance of EPC input data and the links with product databases, explored the potential of BIM (Building Information Modelling) as a future information source for EPC input data, and discussed possible ways to use product databases in order to improve the compliance of EPCs.

Databases of Energy Performance Certificates (EPCs): structure, content, operation | Webinar #07, 5 July 2016

The EPC database is a precondition for the implementation of an effective control system towards EPC compliance. In addition, data from the EPC database can support decision making, e.g. in shaping policies and financing instruments. Overall, data quality is of utmost importance. In this webinar, an overview of EPC databases across EU members states was presented, with particular focus on the databases and control systems of France and Sweden. In addition, an interesting approach on how to make use of EPC data, with reference to the EU-funded projects EPISCOPE and ENERFUND, was highlighted.

Certification schemes for installers | Webinar #08, 16 September 2016

The trend towards Nearly Zero-Energy Buildings (NZEB) implies the correct execution of classic building works, in line with the NZEB principles of good workmanship, and the use of advanced technologies requiring specific skills of the workforce. Several countries are developing or have already ongoing training and certification schemes for the workforce in place.

This QUALICHeCK webinar presented schemes for training and certifying installers, from Austria, Cyprus and Romania, including their market acceptance, the lessons learnt and the costs involved.

A guide for policy makers to develop better frameworks for EPC compliance and enforcement | Webinar #12, 13 December 2016

Checking and enforcing building compliance with the requirements set by the Energy Performance of Buildings Directive (EPBD) is essential in order to achieve the EU-wide agreed energy efficiency and CO2-reduction targets by 2020 and beyond. This QUALICHeCK webinar presented lessons learnt and best practices throughout Europe on relevant enforcement, compliance checking and control systems. It also presented elements from the QUALICHeCK Source Book on EPC compliance, aimed at supporting policy makers and other stakeholders in developing and implementing effective compliance frameworks.

A guide for policy makers to develop better frameworks for quality of the works | Webinar #15, 23 February 2017

Quality of the works is essential in order to achieve actual energy savings and CO2 reductions in the building sector. This webinar presented elements from the QUALICHeCK Source Book on quality of the works, including examples of technical procedures to obtain and prove good quality of the works, and of compliance frameworks for better quality of the works.

Overview of main QUALICHeCK results and insights | Webinar #16, 28 February 2017

This webinar briefly presented the main results and insights contributed by the QUALICHeCK project, and ways these can be used further to improve the quality and compliance of buildings, towards better energy performance. It covered the found status on the ground, as well as good practices and guidance for EPC (Energy Performance Certificate) compliance and for quality of the works. ■

Overview of QUALICHeCK factsheets

ALEXANDER DELIYANNIS

Keywords: QUALICHeCK, Status on the Ground, Compliant and Easily Accessible EPC Input Data, Quality of the Works, Compliance and Effective Penalties

The QUALICHeCK project works towards improved compliance and quality of the works for better energy performance of buildings. One of the output formats of the project are so-called factsheets: brief documents which comprehensively present a specific situation, framework or practice, relevant to the aspects of quality and compliance examined by QUALICHECK, namely: "Status on the Ground", "Compliant and Easily Accessible EPC Input Data", "Quality of the Works", and "Compliance and Effective Penalties". The aim is to highlight and document interesting approaches, which could be adapted and applied further and elsewhere. To this end, the factsheets analyse approaches that have been implemented, point out the pros and cons of options that may be considered, and give hints and pitfalls to avoid if replicated in other contexts.

This article gives an overview of the 57 factsheets produced within the framework of QUALICHeCK.

All factsheets, in chronological order, are available at http://qualicheck-platform.eu/results/fact-sheets/factsheets-by-date/#

To access only the fact sheets relevant for the topic of your interest, go to http://qualicheck-platform.eu/results/fact-sheets/factsheets-by-topic/ and click on the link inside the relevant cell.

Overview of QUALICHeCK factsheets per topic

Technologies / Aspects	Transmission Characteristics	Ventilation and Airtightness	Sustainable Summer Comfort Technologies	Renewables in Multi-Energy Systems
Status on the Ground	#10, #11, #12, #13, #14, #16, #17, #19, #20, #25, #27, #32, #35, #38	#10, #11, #12, #16, #18, #19, #20, #21, #27, #33, #35, #38	#12, #15, #16, #18, #19, #27, #31, #35, #38	#12, #16, #19, #27, #35, #38
Compliant and Easily Accessible EPC Input Data	#05, #23, #24, #43, #46, #49, #56	#03, #05, #24, #42, #43, #46, #49, #50, #56	#04, #05, #43, #46, #49, #53, #56	#24, #42, #43, #46, #49, #50, #56
Quality of the Works	#02, #08, #09, #22, #28, #29, #30, #44, #47, #51, #52, #57	#01, #08, #09, #22, #28, #30, #44, #51, #52, #57	#22, #28, #51, #52, #57	#22, #28, #51, #52, #57
Compliance Frameworks	#26, #36, #37, #39, #48	#06, #07, #36, #37, #39, #45, #48, #54, #55	#36, #37, #39, #48	#34, #36, #37, #39, #41, #48

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List of QUALICHeCK factsheets

FACT SHEET #01 Building regulations can foster quality management – the French example on building airtightness
FACT SHEET #02 The German contractor's declaration: supporting compliance with minimum energy performance requirements
FACT SHEET #03 French voluntary scheme for harmonised publication of ventilation product data
FACT SHEET #04 European voluntary rating programme of cool roofing products
FACT SHEET #05 Voluntary scheme and database for compliant and easily accessible EPC product input data in Belgium
FACT SHEET #06 Regulatory compliance checks of residential ventilation systems in France
FACT SHEET #07 Building airtightness in France – regulatory context, control procedures, results
FACT SHEET #08 Quality control of Stuttgart's retrofit standard realised by the city's energy consultancy office
FACT SHEET #09 AMA – General material and workmanship specifications
FACT SHEET #10 The Swedish Lågan programme for buildings with low energy use
FACT SHEET #11 The Swedish Sveby scheme – standardise and verify the energy performance of buildings
FACT SHEET #12 QUALICHeCK Study Austria – Assessment of EPC input data based on recalculation and on-site validation
FACT SHEET #13 QUALICHeCK Study Belgium – Assessment of the Belgian quality control framework for installation of thermal insulation in existing cavity walls
FACT SHEET #14 QUALICHECK Study Cyprus – Compliance of Energy Performance Certificates (EPCs): differences between calculated U-values in EPCs versus actual U-values
FACT SHEET #15 QUALICHECK Study Estonia – Summertime overheating prevention requirements and compliance assessment
FACT SHEET #16 QUALICHECK Study France – compliance of regulatory and design studies on energy performance of new buildings
FACT SHEET #17 QUALICHECK Study Greece – Compliance of Energy Performance Certificates (EPCs): comparison of the implemented U-values as reported in the EPC with the design U-values for door/window frames and external insulation
FACT SHEET #18 QUALICHECK Study Greece – Compliance with the reference values of the technical directives: on-site measurements of ventilation, temperature and relative humidity and comparison with the reference values of the national technical guides
FACT SHEET #19 QUALICHECK Study Romania – Assessment of quality and compliance in the certification of energy performance of buildings
FACT SHEET #20 QUALICHECK Study Sweden – Compliance of Energy Performance Certificates (EPCs): differences between measured and calculated energy use in EPCs versus building permits
FACT SHEET #21 Quality framework for reliable fan pressurisation tests
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FACT SHEET #23 Procedures for determining input data for the Energy Performance Certificate (EPC) of existing residential buildings in Belgium
FACT SHEET #24 EPC database and control system for compliant EPC input data in Sweden
FACT SHEET #25 Compliant EPC input data for window thermal performance: Status for new buildings in Flanders, Belgium
FACT SHEET #26 BuildE – A method for quality assurance of energy efficient buildings
FACT SHEET #27 The Austrian building certification system IBO OEKOPASS
FACT SHEET #28 Voluntary Green Building assessment paves the way for better as-built quality
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FACT SHEET #39 Voluntary quality assurance system for retrofitting multi-unit residential buildings based on self-commitment
FACT SHEET #4 Voluntary schemes as a pool of ideas for designing and improving EPC compliance frameworks: the BOILEFF quality assurance scheme
FACT SHEET #41 In view of revised EU-directives: dealing with renewable energy systems in the EPC of energy efficient buildings
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FACT SHEET #44 The quality assurance system of the German reconstruction loan corporation (KfW) in the field of energy-efficient construction and retrofitting (residential buildings)
FACT SHEET #45 The Effinergie approach to ease transitions to new regulatory requirements
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FACT SHEET #56 Certification of experts for the issuance of EPCs in Sweden
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PLATFORM QUALICHeCK
Towards better quality and compliance

Activities of the QUALICHeCK platform

The QUALICHeCK project was running from March 2014 till February 2017, whereby REHVA was a project partner. As the challenges to achieve a better EPC compliance and a better quality of the works are not solved at the end of the project, the setting up of a platform was foreseen from the start of the project.

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Keywords: quality of the works, compliance, EPBD, input data

Therefore, the QUALICHeCK Platform continues its activities beyond the duration of the QUALICHeCK project, with the ambition to become the meeting point for European based organisations, associations and partnerships with a strong interest in quality of energy efficient building design, construction and renovation works, and energy efficiency compliance frameworks. The aim of the QUALICHeCK Platform is to become a real driver for increased engagement and accelerated uptake of better compliance and quality of the works in the various EU Member States.

QUALICHeCK Platform members

eurima – European Insulation Manufacturers Association

venticool – the international platform for ventilative cooling

TightVent Europe – Building and Ductwork Airtightness Platform

European Solar Shading Organization – Energy Savings & Comfort

INIVE

BPIE

At present, the platform has the following members:

- EURIMA, the European Association of Insulation Manufacturers, is a gold member
- TightVent, the European platform on building and ductwork airtightness, is a gold member
- Venticool, the international ventilation cooling platform, is a gold member
- ES-SO, the European Solar shading organisation, is a silver member
- BPIE, Buildings Performance Institute Europe, is an associated member
- REHVA is also an associated member

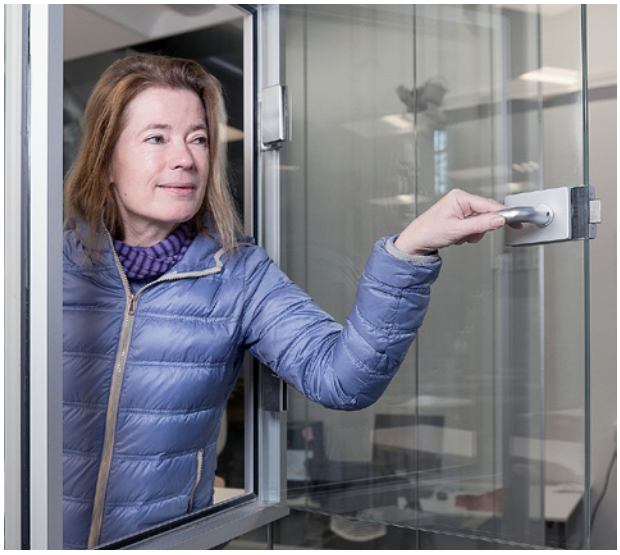
The platform operation is facilitated by INIVE EEIG, the International Network for Information on Ventilation and Energy Performance.

The last steering committee meeting was held on 22 February 2017. The platform is envisaged to set up an international conference in early 2018 around the topic "What can BIM mean in terms of EPBD implementation and quality of the works". ■

QUALICHeCK responds to the challenges related to compliance of Energy Performance Certificate (EPC) declarations and the quality of the building works. Find out more at http://qualicheck-platform.eu.

The QUALICHeCK project is co-funded by the Intelligent Energy Europe Programme of the European Union. The sole responsibility for the content of this article lies with the author(s). It does not necessarily reflect the opinion of the European Union. Neither the EASME nor the European Commission are responsible for any use that may be made of the information contained therein.

SenseLab: a genuine playground for the senses!



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What is Senselab?

The 'SenseLab', a playground for the senses, is a laboratory for testing and experiencing single and combinations of indoor environmental conditions.

Keywords: Semi-lab environment, indoor environmental quality, integrated perception

The SenseLab is built around the four IEQ factors (indoor air, thermal, lighting and acoustical quality) in a room of the Science Centre in Delft (10.75 m (l) × 9.15 m (b) × 4.70 m (h)), The Netherlands, and comprises of (**Figure 1**):

- *The Experience room*, for integrated perception of indoor environmental quality (6.5 × 4.2 m²): constructed of a steel frame, walls of 2 × 8 mm laminated glass (inert material) and two plenums (below and above), through which ventilation, heating/cooling, lighting and acoustics can be provided/changed. It is possible to study the effects, positive and negative, of different combinations of environmental conditions (thermal, sound, lighting and air) in different scenario's (office workers in office buildings, children in schools, people in their homes saving energy, etc.), by changing the architectural design and choice of materials and systems.
- *Four test chambers* (two 2.4 × 3.9 m² on the ground floor and two 2.4 × 2.6 m² at the first level), open to the public, where you can take a sniff of materials, feel heat and cold, see how light influences perception and experience how acoustics can be improved.

Additionally, two air handling units, one for the experience room and one for the test chambers, are located in the basement, right under the SenseLab (**Figure 2a**) and a cooling unit is located outside, near to the SenseLab (**Figure 2b**).

Why built the SenseLab?

In general people do not realize that they spend 80–90% of their time indoors. Also, they do not realize that they can get sick of staying indoors. Moreover, that indoor environmental conditions can affect people's wellbeing is not common knowledge. Senselab is built to make people aware of this. Senselab is a place where people, in particular children and young adults (students) can experience themselves what air quality, light quality, sound quality and thermal quality is.

The four test chambers are especially created for this purpose, each chamber represents one of the factors. The exhibits in these chambers will be flexible. While the air quality chamber currently contains a CLIMPAQ and a set-up for smelling different sources of pollution (**Figure 3a**), the acoustical test chamber contains a sound system with two independently controlled near-field loudspeakers. In the thermal comfort chamber an exhibit is currently running that requires VR equipment (glasses + hardware) and software, a fan (to simulate fresh air when in the virtual environment a window opens) and a construction lamp (to simulate sun radiation when in the virtual environment a solar screen is removed), while in the light chamber a mock-up of the exhibition of Jan Schoonhoven is shown (see **Figure 3b**).

But the lab's role as a research facility is equally important. In the Senselab, in particular in the Experience room, research can be conducted into the perception of all these different parameters together, and their interactions.

In the experience room, three different ventilation principles are present: 1) Natural ventilation through operable windows; 2) Displacement ventilation from floor to ceiling by using a perforated plinth (just above

Figure 1. a+b) Experience room, c) test chambers and d) stairs to first level.

the floor on the long sides of the experience room) and exhaust in the ceiling on the side; and 3) Mixing ventilation from ceiling to floor: air supply in plenum (via 4 ceiling grilles) and exhaust in perforated plinth on the short side of the experience room.

Besides the four air supply grilles, the ceiling of the experience room includes four independently controlled ceiling mounted loudspeakers and a subwoofer above the suspended ceiling, with which it is possible to create different types of sound/noise; and three types of lighting armatures: 4 direct light led, 4 indirect light led and 8 soft light led armatures, which gives the possibility to change the distribution, intensity and diffuseness of light.

In the ceiling and floor of the experience room the panels can be exchanged, while on the inside of the glass walls, panels can be added via a magnetic system.

How was SenseLab created?

First ideas of the SenseLab were ventilated publicly during the inaugural Speech of Prof. dr. Philomena M. Bluyssen, at May 22, 2013. At that time, she defined it as: "a semi-lab environment in which people, students, teachers, researchers, but also the general public, will be able to experience different environmental conditions in order to better understand the indoor environment". Now almost four year later, it is ready to be used.

Figure 2. a) Installations in basement and b) cooling unit outside the SenseLab.

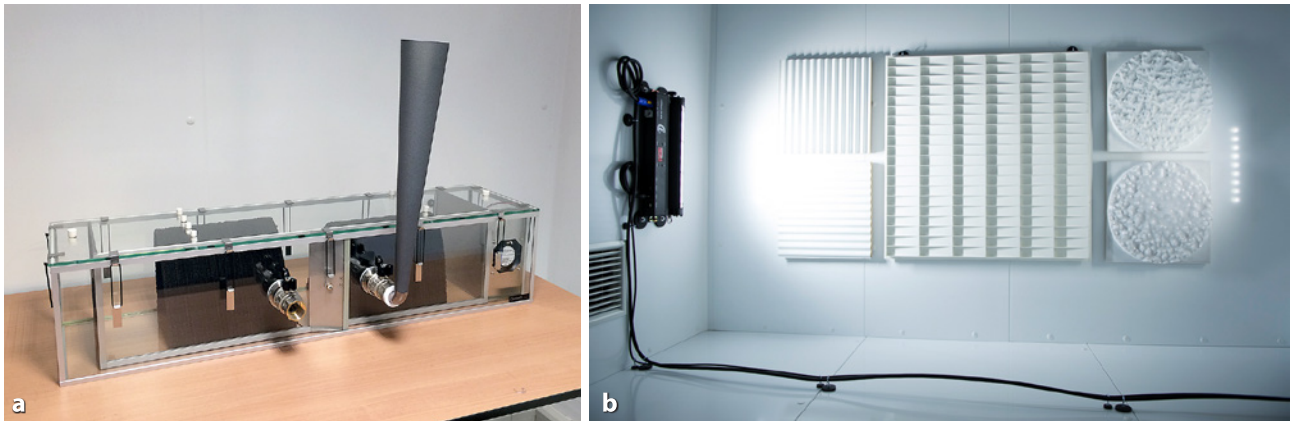

Figure 3. Current exhibits for air and lighting: a) to smell different pollution sources and learn about them b) to perceive how shape, material and space appearance can be influenced by the lighting of it.

Already at the beginning of 2013, a first business plan including a SWOT analysis, was made to convince the dean at that time of the pro's of such a lab. While creating **support** within the organisation was the focus in 2013, 2014 was mainly used to search for the **location** of Senselab. Where can we built such a thing? How much space do we need? After some touring around the campus, Faculty of Architecture didn't have a suitable space, the Science Centre turned out to be 'the place to be'!

In the meantime, it became clear that the first concept of the Senselab would cost a bit more than the fellowship of Bluyssen, or what was left of it. So, next to finding a location, also the acquiring of sponsors became a must. 2015 was the year for the search of **money!** This was not easy. Fortunately, at the end of 2015, the first sponsor agreement with FORBO was a fact, followed by ENGIE, our largest sponsor, and a couple of important commitments. Many followed!

Figure 4. Operable windows and window-in-window construction in the facade.

Figure 5. Class room set-up in Experience room.

At the beginning of 2016, we had support, a location, financing and the basis of design. The construction finally started at May 9, 2016 with drilling of the holes in the floor for the ducts to get through. SenseLab was offically opened by Tim van der Hagen, the President Executive Board of TU Delft, at December 1, 2016.

What is so special about SenseLab?

Besides that the Senselab is one of its kind under the labs around the world, because it focuses on the integral perception of IEQ by using the architectural design, choice of materials and systems, and the occupants as assessment instruments, it is also unique because of its possibility to combine education (knowledge transfer) and research. Especially the location, the Science Centre, makes this a reality.

The Science Centre is a technical and scientific museum which exhibits scientific innovations and research of the TU Delft. The Science Centre receives many visitors among which a lot of school children, but also many students of the Delft University of Technology. It is therefore an excellent location to educate and do tests with both school children and students in classroom and office like environments. The SenseLab makes it possible to involve children, but also young adults in another way than via questionnaires or (physical and mental) performance tests, for example through interactive techniques (e.g. using mock-ups, sketches and focus groups), in order to provide more insight in potential causal relationships at individual level, but also insight in the total picture and interrelationships between different environmental parameters and other aspects (e.g. confounders).

Any last remarks?

After four years of planning, lobbying, preparing and building, the Senselab was created and is now available both for studying integral perception of IEQ under different scenarios in the Experience room, as well as testing and learning in the four test chambers for air, light, thermal and acoustical quality. The design and construction of the Senselab was possible thanks to the fellowship of Prof. P.M. Bluyssen provided by the Delft University of Technology, under the Chair of indoor Environment, as well as the following sponsors: PIT-fonds, Engie, Darellsoffice, ETAP, Unica, Orange Climate, Priva, Cordeel, Viessmann, Forbo, Carrier, Amptec, Saint-Gobain, Ahrend, Trox technik, Gyproc, Interior Glassolutions, Ecophon, The New makers, Li-Tech, Sol4, Seco, Krepla, Garfield Aluminium and Riweltie and Science Centre. ■

Butterfly Conservatory HVAC Design Strategy in Continental Climate

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In this study, it is aimed to expose how the HVAC system has been designed for a Butterfly conservatory in sustainable manner by using climate characteristics and without mechanical cooling. It is also intended to provide guidance for future design attempts considering limited data available in current literature.

Keywords: Butterfly Conservatory HVAC Design, Biomes Design, Butterfly Conservatory, Evaporative Cooling

A butterfly conservatory can be described as environmentally controlled ecosystem for particular species. In this study, it has been aimed to evaluate HVAC design strategy for a tropical butterfly garden located in central Anatolia having continental climate characteristics with sharply contrasting seasons.

In addition to inherent difficulties of butterfly conservatory or biomes design, hot/arid summer and cold winter characteristics of region and tight environmental control parameters make HVAC system design more challenging. HVAC system needs to be flexible to manage different operational control parameters considering significant solar radiation during summer, glass cover, condensation problem etc.

In this study, Konya Tropical Butterfly Garden (KTBG) has been taken as case study to show possible design strategy for a butterfly conservatory in continental climate. KTBG accommodates one of the world's ten largest butterfly aviaries. The project comprises of following sections;

- Butterfly garden, 2 100 m²
- Insect museum, 550 m²
- Multipurpose hall, offices, café and retail units, 800 m²

Design Challenges

The focal point of this project is the Butterfly Garden as it is a habitat for rare species. The main challenges are;

- Creating a microclimate within the Butterfly Garden building to support tropical butterflies
- Glass cover of this area. Butterfly Garden has low-e glass curtain wall carried by circular hollow section steel structure

In the beginning of the design studies we have been given design requirements which demand creating tropical climate within the Butterfly Garden. Local continental climate conditions make the design studies more complicated with the glass façade of Aviary.

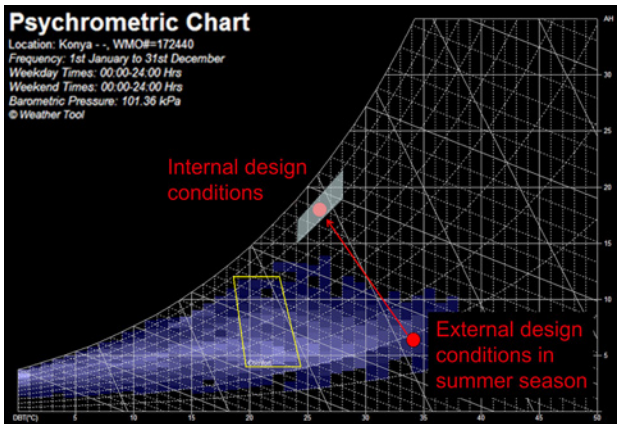
External design conditions; 33,8°C DB (Dry Bulb) and 17,1°C WB (Wet Bulb) in summer (low relative humidity, approximately 19%); –13°C DB in winter.

However, as the butterflies in the KTBG collection would thrive only in a tropical climate, design conditions had to be 26 ± 2°C DB, %85 ± 5 RH throughout the year. By taking the internal design conditions into account, it was necessary to create a high-humidity environment within the butterfly garden where the temperature could be maintained at a consistent level and those requirements are very different from the natural environmental conditions in Konya.

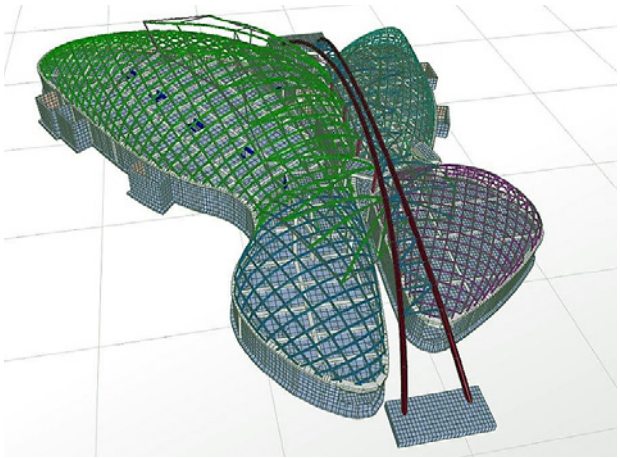
Mechanical Design Solutions

There were two internal design conditions to overcome in energy efficient way;

1. Temperature level
2. Extremely high relative humidity



Psychrometric chart illustrating indoor and summer outdoor conditions against comfort range.



Structural modelling and external view of KTBG.

During design work, some mechanical systems have been reviewed to overcome severe external and internal design conditions which are very different from each other. In addition to achieve the tropical conditions, energy efficiency was the other key issue and finally, it was shown that evaporative humidification/cooling is the most efficient way to create tropical conditions within a continental climate, because it can provide design temperature and humidity levels of 26 ± 2°C DB, %85 ± 5 RH, which means the chillers are free from the cooling loads of the butterfly garden and nursery in summer season. Since the butterfly garden has vast solar loads, due to the abundance of glass, there is a PTFE shading element in the form of butterfly wings, which considerably reduces solar loads located above the building. In winter season, dedicated boiler units provide heating to reach internal design conditions as evaporative humidification process maintains due to the extremely high relative humidity demand.

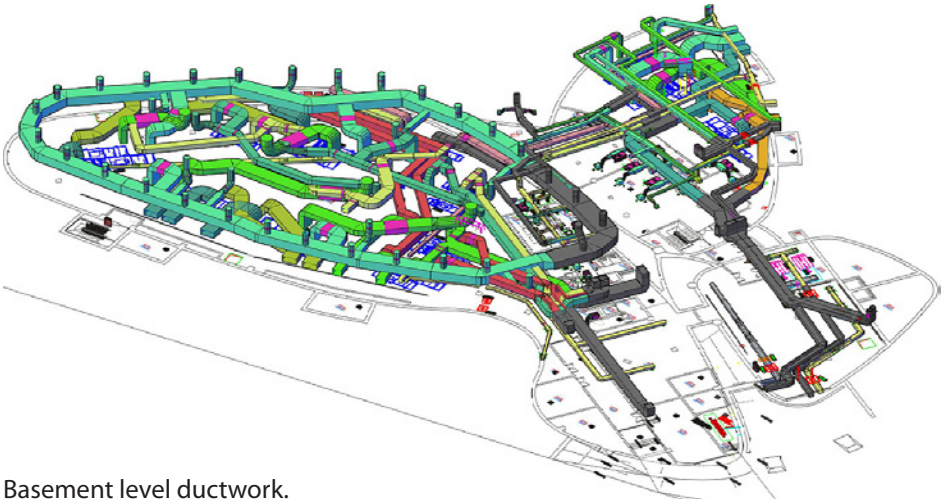
Since the design focuses on the creating a habitat for the tropical butterflies, internal conditions are consistent with these requirements and out of human comfort range.

Ventilation in Butterfly Garden

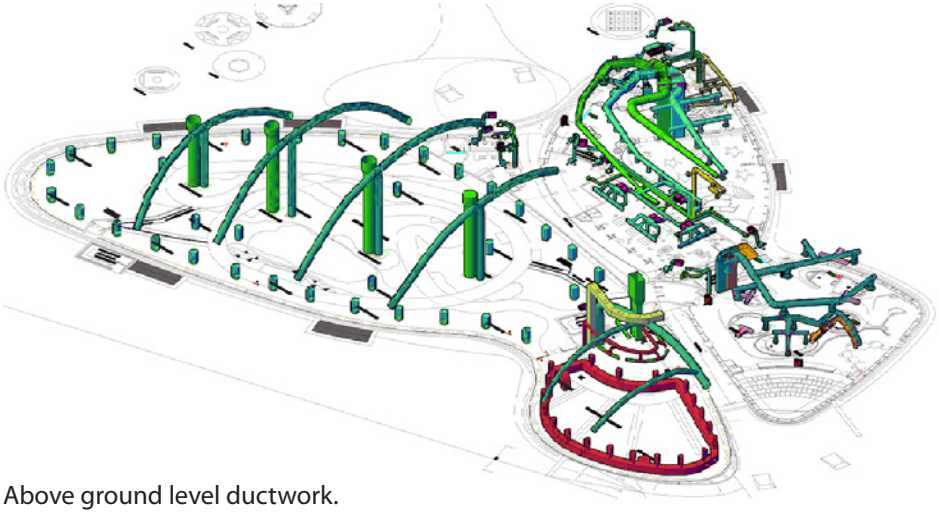
In the beginning of design studies, whole basement level considered and defined as technical areas especially for mechanical systems because of the high-level requirements.

Due to the glass roof, we have tried to find the ways for hiding the ventilation ducts which meet heating and cooling demand in addition to fresh air requirements of indoor area. Conditioned air is provided with displacement air diffusers at the ground level surrounding the butterfly garden and nursery.

In the basement level, a ventilation duct loop has been created. The Butterfly Garden's air handling units, located on the basement floor, are connected to each other with

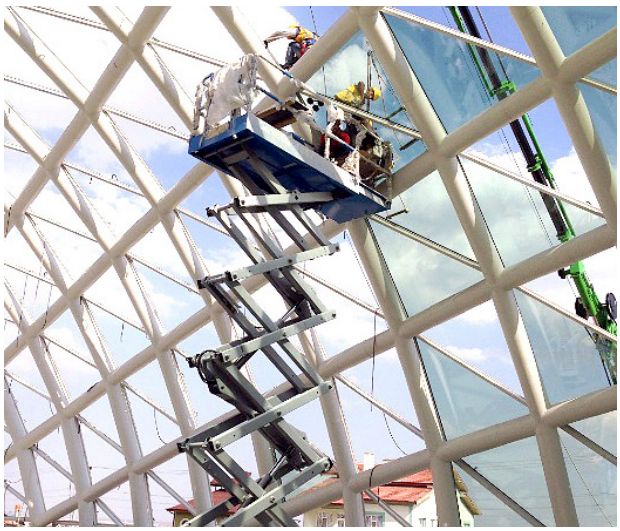


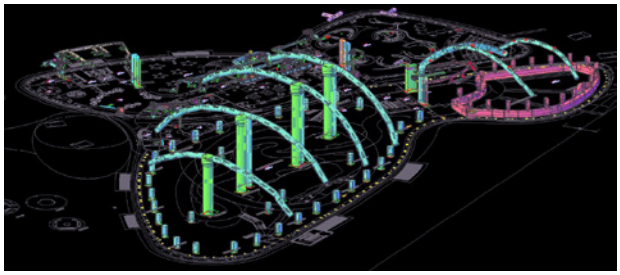
Basement level ductwork.



Above ground level ductwork.

Façade details of KTBG.





Ventilation ducts on the inner side of glass façade and displacement diffusers.

this duct system as a loop in the basement level. Hence the homogeneous air distribution continues even if in the event of air handling unit failure. In this way, high level redundancy and continuity of work have been ensured.

Humidification Process

In order to achieve high level internal relative humidity level by means of evaporative humidifiers, dedicated treatment plant has been accommodated in the basement level. The main plant consists of water treatment units, reverse osmosis system, collection/reserve tank for treated water and all associated equipment.

With regard to the humidification process, there are two humidification steps;

- Air handling unit (AHU) integrated evaporative humidifiers
- Indoor evaporative humidifiers

Treated water, coming from the central treatment plant, is supplied to those humidifier sets accommodated in air handling units and indoor area as outlined above. As a first step, mixed air is humidified by AHU integrated humidifier sets before supplying into the butterfly garden. Indoor sensors detect the internal humidity levels to manage the indoor conditions and allow to operate the indoor humidifiers as a second step of humidification process when the additional humidification is necessary.

Façade

Butterfly garden of which footprint is 2 100 m², has glass cover and this results significant heating/cooling transmission loads including solar load.

Another issue related to the façade is the condensation risk. To overcome this issue, a system which supplies warm air to the inner side of the glass façade was designed to mitigate condensation risk during the cold winter periods.

There is also a net system beneath the glazing which prevents butterflies passing into other spaces or touching the glazing. Exhaust air ducts rise up as columns through the roof, positioned between net and glazing system, so the butterflies are not affected by the exhaust air.

The vitality of UV rays was required for the tropical butterfly species, a UV-permeable lamination film was selected for the laminated glass cover.

Conclusion

In design studies, there were significant constraints to overcome as highlighted above. Although, those conditions made the design more complicated, it was essential to find out inclusive solution in sustainable manner.

Consequences are satisfactory in terms of both perspective; handling the severe climate conditions and sustainable solution. ■

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Analysis of performance metrics for data center efficiency

– should the Power Utilization Effectiveness PUE still be used as the main indicator? (Part 2)

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Previous research posed that PUE (Power Usage Effectiveness) does not always reflect the real energy performance of data centers. This is because PUE does not show performance regarding IT efficiency, water usage, heat recovery, on-site energy generation or carbon impact. Broadening the scope of performance assessment beyond PUE has therefore been proposed by including these subjects. Using a simulation study, this paper shows the potential of finding energy efficiency measures beyond the scope of PUE by using complementary metrics. In this way, a heat reuse potential of 11-15% of the total energy use is found for a 1MW data center in Killarney. It also shows a 4% energy impact reduction for a roof sized PV-system in Sevilla as well as the potential and challenges accompanying the implementation of larger PV-systems. To better evaluate the efficiency of on-site generation the GUE (Grid Usage Effectiveness) metric is introduced. By broadening the scope of data center energy performance assessment, the next step energy efficiency improvement can be taken and the industry can take environmental responsibility by reducing its energy footprint.

Keywords: PUE, Performance metrics, Data Center, Energy Efficiency, Indicators, Simulation, GUE

The data center industry was responsible for between 1.1% and 1.5% of global energy consumption in 2010 (Koomey, 2011) and this value is expected to double by 2020 (Whitney *et al.*, 2014) as the growth of the data center industry is expected to continue following the increasing number of connected devices requiring this infrastructure (Modoff *et al.*, 2014).

Awareness of this trend has led to an effort to improve the sustainability of the data center industry by improving its energy efficiency. Currently, the energy flows within a data center are monitored at different levels to be able to assess both overall and subsystem energy efficiency. Performance metrics are calculated and used as indicators for the efficiency of the systems (Wang *et al.,* 2011).

The main indicator that is being used to assess overall data center energy efficiency is PUE, which shows the ratio between total facility power use and IT equipment power use (Avelar *et al.,* 2012):

$$PUE = \frac{Total\ Facility\ Power}{IT\ Equipment\ Power}; 1 \leq PUE$$

Therefore, the optimal value for PUE is 1.0, the maximum value is infinity. PUE was developed give data collection standards 'to determine the effectiveness of any changes made within a given data center' (*idem,* 2012), but is widely being used to compare energy efficiency between data centers. The scope of PUE however is insufficient to accurately reflect the overall energy performance of a data center as it does not cover, among others, IT equipment efficiency, water usage, energy recovery or on-site renewable energy generation (Van de Voort *et al.*, 2017). This paper aims to show the added benefit of using metrics complementary to PUE in data center performance assessment to further decrease the data center industry energy impact.

Research methodology

To find a solution to the problem described above, the following research question has been formulated:

'How can performance metrics complementary to PUE help to better reflect the real energy performance of a data center?'

High resolution data of the energy flows in a data center is required to evaluate to which extent these additional metrics improve the assessment of the actual energy performance of data centers. Because this information obtained from measurements in data centers is very confidential, a virtual environment has been created. Another benefit is the ability to define different boundary conditions making it possible to simulate various scenarios under controlled conditions. This building energy simulation model is used to analyze in detail the benefit of using complementary metrics beside PUE for data center energy performance assessment. The simulation provides hourly values of the energy flows within the data center for one year. The different energy flows calculated by the simulation can be found in **Table 1**. From this high-resolution data, all required values for the relevant performance metrics can be calculated.

Table 1. Simulation output parameters.

Output	Unit
IT Power	[kWh]
PS Loss	[kWh]
Auxiliry Power	[kWh]
Cooling Power	[kWh]
Total Power	[kWh]
PV Power	[kWh]
Heat Recovery Potential	[kWh]

The analysis of the simulation results is focused on three scenarios which implement different energy efficiency measures. Namely, on-site sustainable energy generation; energy recovery; and geothermal energy harvesting. The calculated values for PUE and other relevant metrics: ERF (Energy Reuse Fraction, Patterson, 2010):, OEM (Onsite Energy Matching, Cao *et al.,* 2013), OEF (Onsite Energy Fraction, Cao *et al.,* 2013) and GUE (Grid Usage Effectiveness, Van de Voort *et al.,* 2017) will be used to assess the benefit of using metrics complementary to PUE.

Simulation setup

For these simulations, an adaptation of the data center simulation model by Van Schie et al. (2015) has been used to represent a 1 MW data center. TRNSYS was used as a modeling tool to create a white-box model which represents this data center. An overview of the model can be found in **Appendix A***.

The model has been used to simulate the effect of the different variables described in **Table 2** on the energy flows in the data center. The locations were chosen to represent three different climate conditions in Europe. Four different HVAC systems have been modelled, representing a wide spectrum of cooling system efficiency. Two different IT workload profiles are used as input to evaluate the influence of IT load on energy flows. Also, two inlet temperature set points have been used as control strategies. Lastly, three differently sized PV-systems are introduced to evaluate the benefit of on-site renewable generation.

The first PV system is sized to the dimensions of the roof area of a typical 1MW data center (2 000 m² PV). This simulation shows to what extent PV systems can reduce the energy impact of a data center within this realistic boundary. There are no issues with energy matching as the OEM value remains 1 all year. For the second scenario, the PV system size is increased to maximize generation while keeping the average OEM close to 1 (11 100 m² PV). This case shows which part of the total energy demand can be met by a PV-system without causing matching issues. The third PV system is sized to generate the same amount of energy yearly as the total energy consumption of the data center (51 750 m² PV). At this point matching issues occur because peaks in generation greatly exceed demand.

Simulation results

Out of the results found by this simulation a selection of three cases has been made for further analysis, these cases are shown in **Table 3**. They have been chosen as they represent three important strategies to reduce the energy impact of data centers. These are on-site generation, energy reuse and the use of geothermal energy.

Results of the PUE values for the chosen simulation cases are given in **Figure 1**. The PUE values are largely dependent on the type of cooling system, this became clear after analysis of the complete simulation results. The figure shows the previously described relationship between PUE and IT load, showing better PUE

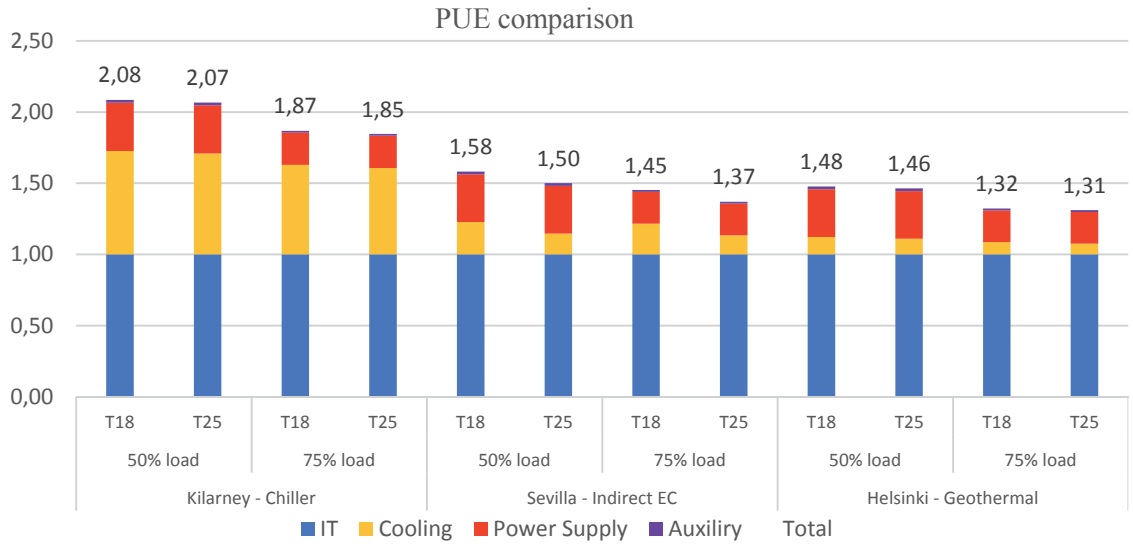

Figure 1. PUE results for the twelve different simulations for the three chosen configurations.

Table 2. Input variables for simulation exercise.

Location	Sevilla	Killarney	Helsinki	
Workload	50%	75%		
Inlet Temperature	18°C	25°C		
HVAC System	Chiller	Chiller/Free Cooling	Indirect Economizer	Seawater Cooling
PV size	Realistic (Roof) 2000 m²	Peak matching 11100 m²	Load Matching 51750 m²	

Table 3. Three cases chosen for detailed analysis.

Location	Sevilla	Killarney	Helsinki
HVAC System	Indirect Economizer	Chiller	Seawater Cooling
Renewable Strategy	PV-panels	Energy Reuse	Geothermal
Workload	50%/75%	50%/75%	50%/75%
Inlet Temperature	18°C/25°C	18°C/25°C	18°C/25°C
Performance Metrics	PUE, OEF, OEM	PUE, ERF	PUE

values for higher IT loads. It also shows the relationship between PUE and IT load, showing better PUE values for higher IT loads. It also shows the relationship between PUE and cooling temperature set point, with a higher cooling set point leading to lower PUE values.

The most interesting results regarding the scope of PUE were found for the Sevilla case where a PV-system has been applied. In the following section this energy efficiency strategy is further analyzed to see whether the metrics put forward provide a better framework for reflecting the real performance of a data center than PUE alone. First the main characteristics of the other two cases are described.

Killarney – Energy reuse

Usable waste energy was defined as exhaust air with temperatures over 30°C. The ERF potential resulting from this is displayed in **Figure 2**. The potential found lies between 11–15% of total energy consumption for the different scenarios.

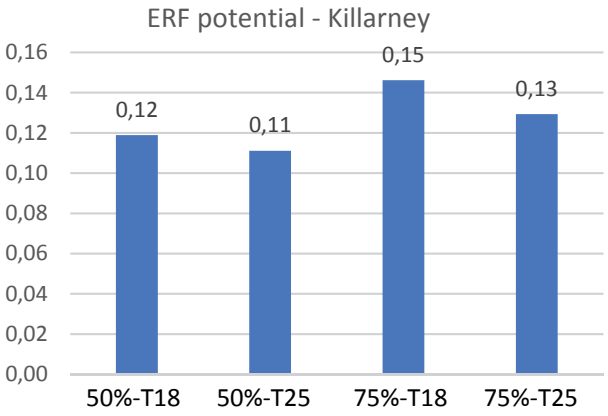

Figure 2. Energy recovery potential for the data center in Killarney.

In cases where this waste energy can only be reused when there is simultaneous demand the actual reuse value can greatly decrease. Losses will also occur during the energy transport. Because of these reasons, it is impossible to translate the ERF potential in an actual value for ERF as the influence of these factors is unknown. To make the best use of the ERF potential the mentioned issues need to be addressed when designers implement energy reuse strategies. An interesting strategy is coupling energy recovery to an aquifer thermal storage system to avoid the necessity for simultaneous demand.

Helsinki – Geothermal

For this case PUE reflects the real energy impact very well. As seen in **Figure 1**, the partial contribution of energy use for cooling to the PUE value has become very small, making this a very efficient design. Because PUE only assesses the use of electric energy, the thermal energy used for cooling the data center in this case does not increase the value for the total facility power, keeping the PUE value low.

Sevilla – PV

As previously stated, PUE doesn't give insight into the positive contribution to the energy impact of on-site renewable energy generation. The OEF and OEM metrics can be used for assessing the amount and efficiency of on-site renewable generation. Results discussed in this section are for the Sevilla case with 75% average workload and 18°C inlet temperature. **Figure 1** shows results from the other simulation setups follow a similar trend for the energy flows making the results discussed in this section also relevant for those cases.

Even though the data center industry is characterized by its high-energy density, **Figure 3a** shows on-site renewables can have an impact on its energy footprint. If we look at the roof sized PV system 4% of the total energy demand could be met, even for a high average utilization of 75% IT load. This impact will only increase as PV efficiency increases and therefore this benefit should be considered during performance assessment. When looking at the PV system sized for matching peak loads, the energy impact reduction further increases to 20% of the total energy demand. A larger site would be necessary or extra areas near the data center should be outfitted with PV panels. Nearby building or site owners might allow placement of PV panels for this purpose.

When the PV area is further increased problems will arise with energy matching. This is clear when annual energy generation by the PV system is equal to the annual energy demand of the data center. **Figure 3a** shows that for the simulated workload profile only 41% of the supply is matched by simultaneous demand meaning 59% cannot be used by the data center. Also, the electricity grid must balance this influx of energy, which is causing more and more problems as the adoption of renewable generation increases.

Figure 3b shows the average OEM value is still relatively high, because the value for OEM is 1 when there is no supply, this skews the average figure. Hourly values for OEM should be considered when interpreting results. One-year graphs containing hourly values for OEF and OEM can be found in **Appendix B***. There are ways to improve energy matching for on-site renewable generation. This can be done by matching generation to expected demand, save non-critical workload for periods of high on-site availability or by energy storage. To indicate with a single performance metric the benefit of using on-site renewables and to promote energy matching by showing to which extent the data center operates grid independent, it is proposed to introduce the Grid Usage Effectiveness (GUE) metric.

GUE

The GUE shows the grid dependence of the data center in relation to the IT load, it is defined as:

$$GUE = \frac{(\frac{1}{OEM} - OEF) * Total\ Power}{IT\ Equipment\ Power}$$

$$GUE \geq 0, lower\ is\ better$$

Figure 4 shows how the GUE is dependent of the OEF and OEM metrics. At first, the GUE value improves as the on-site generation and OEF increase, it is optimal when the OEF and OEM are both 1. At this point the data center operates independent of the grid as its demand is exactly matched by on-site generation. When the on-site generation starts to exceed the facility demand the GUE value increases again as the grid is being burdened with the excess electricity.

This accurately reflects to which extent the grid is being used, be it for supply or demand, and will promote energy balancing. GUE combines information concerning on-site (renewable) generation and energy matching with PUE. Though it is adding complexity, it's giving a more complete picture of a data center's energy impact without losing the clarity of the single metric. The average, minimum and maximum PUE

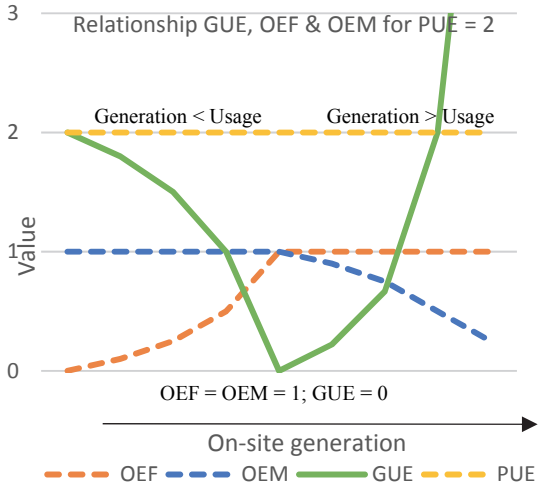

Figure 4. Relationship between GUE, OEF & OEM.

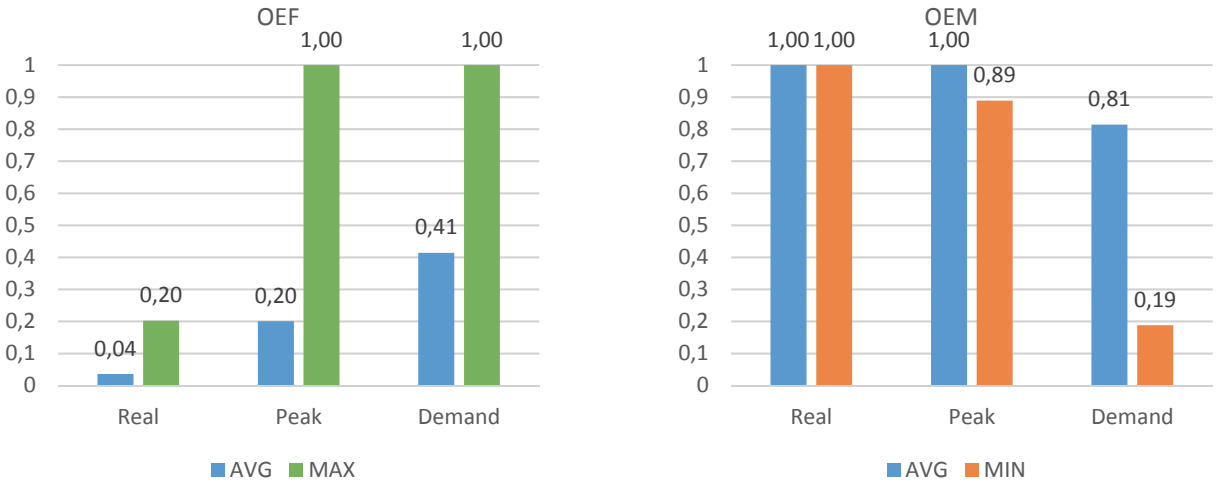

Figure 3. a) OEF values for the three PV-systems. b) OEM values for the three PV-systems.

and GUE values for the case from the previous section is shown in **Figure 5**.

When smart grids are introduced it is conceivable that weighing factors dependent on the momentary grid balance are introduced to the metric. In that case, data centers can help balance the grid by using energy from the grid when supply is abundant and they can supply energy to the grid when demand is high, without penalties to their GUE. This will add a further incentive to implement demand response strategies.

Figure 6 shows a simplified representation of the hourly PUE values and the GUE values for the three PV-system sizes. The full graphs can be found in **appendix C***. The impact of the roof sized PV-system is subtle, whereas the positive impact of the peak size PV-system is very clear. The matching issues related to the demand size PV-system is also clearly illustrated, with the highest peak around noon during summer. This makes it immediately clear where the focus should lie for improvement.

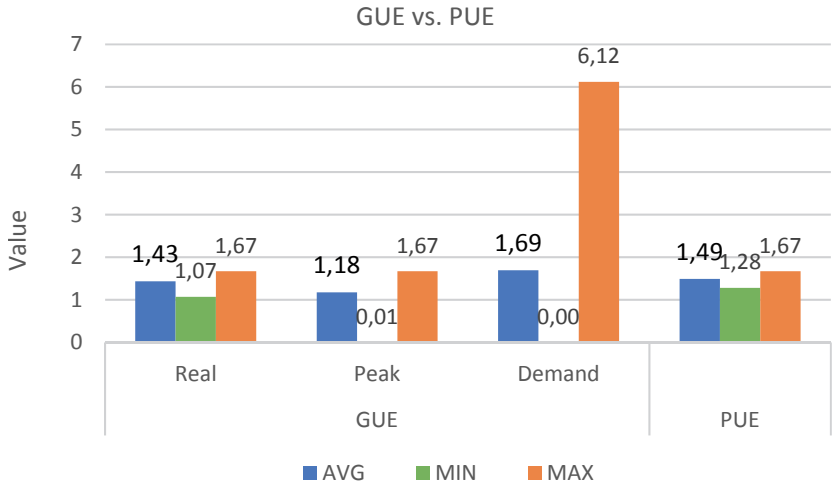

Figure 5. GUE vs. PUE for Sevilla case.

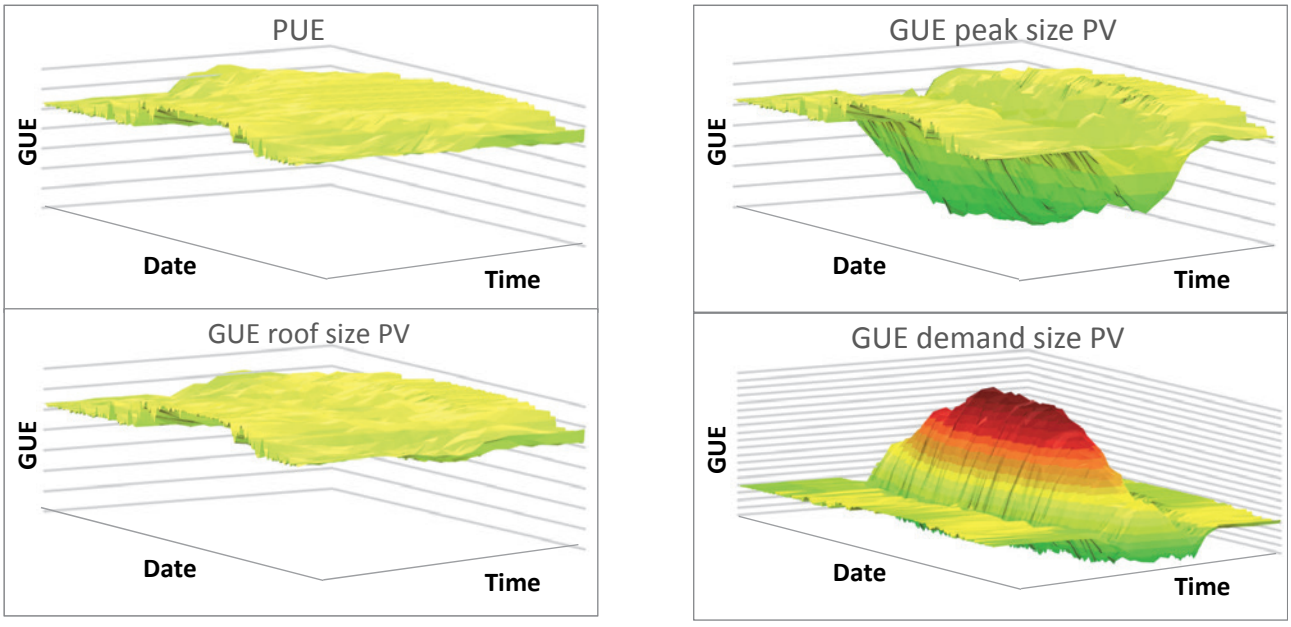

Figure 6. Visualization of the hourly values for the PUE and different GUE values for one year.

Future data center designers will be able to use the GUE metric to design data centers which efficiently use on-site generation to reduce the impact they have on the electricity grid and the environment. As we are preparing for a future solely reliant on renewable energy this will be hugely important. The efficiency of demand management, supply matching and energy storage strategies can be assessed using this metric.

Discussion & conclusion

Though more situations are conceivable where the scope of PUE is too narrow to thoroughly assess the complete energy performance of a data center, the simulation exercise has provided information to answer the research question by reviewing case studies with energy reuse, geothermal energy use and on-site energy generations with PV panels.

'How can complementary performance metrics to PUE help to better reflect the real energy performance of a data center?'

For the simulation case using geothermal energy PUE proved to accurately reflect the cooling systems energy impact. With help of the ERF metric, the simulation scenario for Killarney demonstrated a potential benefit for energy reuse of up to 15% of the total energy consumption. This scenario used a chiller as cooling system and the minimum exhaust air temperature for reusable waste heat was set to 30°C.

Using the OEM and OEF metrics, the simulation case for Sevilla showed a reduction of the total energy impact of 4% for a roof sized PV-system in Sevilla, increasing to 20% for a PV-system sized to maximize generation without causing matching issues. When further increasing the PV size energy matching issues arise that need to be mitigated.

To quickly assess the effectiveness of onsite energy generation, the GUE metric can be used. It shows the positive impact on-site renewable generation can have on the energy footprint and can also help to understand the challenges involved in energy matching. Evaluation of resulting GUE values can help find better strategies to tackle energy matching challenges. Suggested strategies for energy matching can involve demand management, supply matching and energy storage. Further research can provide information on effective use of these strategies to further reduce the energy impact of the data center industry.

In short, it's necessary to broaden the scope of data center performance assessment beyond PUE to meet future challenges the upcoming energy transition will present. The metrics used in this paper, among others, are part of the tools required to meet these challenges. The next step will be to use this expanded framework of energy performance metrics for the creation and evaluation of a new generation of state-of-the-art energy efficient data centers. ■

* Find appendixes A, B and C on the REHVA Website: http://www.rehva.eu/publications-and-resources/rehva-journal.html

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REHVA Delegation visiting Uponor during the guided tours.

REHVA at ISH Frankfurt 2017

From the 15th to the 16th of March, REHVA attended ISH Frankfurt 2017. During this successful edition, REHVA was present at the exhibition with a shared booth with the German Member, VDI.

REHVA organized various sessions in parallel

The launch of the new REHVA Guidebook – GB#22 Introduction to Building Automation, Controls and Technical Building Management, produced in collaboration with eu.bac.

REHVA organized a guided tour to the booths of several REHVA Supporters in order to create a link between the REHVA Supporters and Members, both executives and members of National Associations.

An additional networking occasion closed the first day of REHVA at ISH, as a private reception was organized for REHVA Members and Supporters at the end of the tour, where over 50 people attended.

During the second day, several REHVA Members' executives visited booths both of potential supporters, to discuss eventual future collaboration, and of previous REHVA supporters, to acquire information

REHVA Seminar 'Controlled Residential Ventilation'.

REHVA Reception.

in order to improve REHVA activities for Supporters.

Last but not least, the REHVA Seminar "Controlled Residential Ventilation" had a great success with over 40 attendees.

The 2017 edition of ISH was very positive for REHVA and we would like to thank you Messe Frankfurt for the fruitful collaboration hoping to aim at even better results in 2019. ■

REHVA Booth at ACREX2017. Chiara Girardi, REHVA Publications & Promotion Officer and Jaap Hogeling, REHVA Journal Editor in Chief.

REHVA at ACREX India 2017

23–25 February, 2017, Greater Noida, Delhi, India

The 2017 edition of ACREX India took place in Greater Noida, Delhi from February 23rd to 25th, 2017, this year fair featured more than 500 exhibitors and more than 50,000 attendees from over 25 countries.

As in the previous years, also in 2017, REHVA attended ACREX. This year, REHVA's visibility exponentially improved thanks to the presence of four REHVA representatives for the whole duration of ACREX: Mr. Frank Hovorka (Chair of the Publishing and Marketing Committee), Mr. Jaap Hogeling (Editor in Chief of the REHVA Journal), Mr. Atze Boerstra (Vice-President and Co-Chair of the Supporters' Committee) and Ms. Chiara Girardi (Publications & Promotion Officer).

On site, REHVA had a booth at the exhibition through which over 1500 copies of the REHVA Journal have been distributed to the visitors.

ISHRAE - REHVA Meeting.

The partnership with ISHRAE has strengthened thanks to the presence of the representatives and to the joint organization of the REHVA workshop "*Indoor Environmental Quality*", which has been the REHVA event with the higher number of participants since when it has attended ACREX India.

REHVA would like to thanks ISHRAE and the whole ACREX organization for the successful experience and fair, hoping to continue in this direction for ACREX 2018. ■

◀ ACREX 2017 Opening Ceremony: Frank Hovorka, REHVA Vice President; Tim Wentz, ASHRAE President; Jeff Littleton, ASHRAE Executive Vice President.

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

REHVA position paper on the European Commission proposal of the revised ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE COM(2016)0765

General remarks

REHVA supports and appreciates the principles of EPBD aiming both at the improvement of energy performance in new buildings with cost optimal minimum requirements, as well as at the improvement of energy performance in existing buildings with incentives. REHVA welcomes the binding 30% energy efficiency target of the revised EPBD and is confident that the building sector can and should contribute more to achieving it. While staying on track with highly ambitious nZEB targets for new buildings, **the EPBD must put more focus on the energy refurbishment of the existing building stock,** including the **replacement and upgrade of inefficient technical building systems that waste energy and don't deliver good indoor environment quality.** The revised EPBD shall better tackle this challenge and aim at **strengthening the implementation and its enforcement**.

Ensuring high indoor environment quality and energy efficiency at the same time

Health and comfort of consumers should be ensured and improved in all buildings, especially when implementing deep energy retrofit projects. To achieve this, REHVA advocates for indoor environment quality (IEQ) related requirements in the EPBD. REHVA welcomes that Annex I of the legislative proposal mandates Member states to ensure minimum environment quality levels. However, to provide and maintain good and healthy indoor climate, IEQ aspects should be further strengthened in the directive.

1. The revised EPBD should set a clear mandate for Member States to **define indoor environmental quality requirements that are monitored and reported in a harmonised way** in building regulations across Europe.
2. **IEQ criteria shall be part of the inspection** of heating and cooling systems, and continuously monitored alongside the energy performance of the buildings.
3. REHVA recommends developing an indoor environmental quality indicator to be used beside the primary energy indicator. This **IEQ indicator shall be reported in a transparent way in the energy performance certificates**. EPC-s shall provide information about indoor air quality (ventilation rate) and about the indoor thermal environment (summer and winter). This can be implemented based on the prEN 16798-1 standard (or its equivalent the ISO 17772-1), displaying in the EPC-s a reference to the IEQ categories as defined by the standard.
4. The **definition of technical building system** should be changed to: "Technical equipment and systems for heating, cooling, ventilation, humidification, dehumidification, domestic hot water, lighting, building automation and control and electricity production used to control **indoor environmental parameters** in a building." to cover also solar shading and daylight control, and air cleaning.

Ensuring quality, proper maintenance, and performance through mandatory inspection of heating, ventilation, and air-conditioning systems

The EPBD should address the quality of installed technical systems, including their regular maintenance, and support the replacement of the old equipment where appropriate. The inspection of technical building systems is of key importance in this process, because it can ensure quality, compliance with standards and building codes, as well as high energy performance. Therefore, the **EPBD shall maintain and improve Articles 14-15** on the inspection of heating and air-conditioning systems. Furthermore,

it is advisable to extend the scope **to ventilation and air-conditioning systems**, as these are often combined and ventilation has a significant impact on energy and IEQ. The original articles were poorly implemented as it was not clear how the outcomes were to be used or enforced. REHVA welcomes that the Commission aims at improving the current requirements. However, some important aspects are not clear or missing in the proposed new version, and the requirements on the alternative continuous monitoring and BAC are technically and practically too complex to be implemented and enforced. The issues to improve are detailed below.

1. Setting and measuring clearly defined target values in a transparent way

The primary intention of the EPBD is to cost-effectively improve the energy performance of buildings. This primary intention can be achieved by stating performance requirements, but the technical means of implementation should be let open and technology neutral. Then the market can find cost optimal solutions that is important for encouraging innovation and continuous development.

The **EPBD shall mandate Member States to set up and enforce a transparent inspection process with clearly defined criteria** ensuring the following points:

- The inspection must be based on a set of generally defined system parameter values (system temperatures, flowrates, schedules, specific fan powers, COPS etc.) for individual components and systems (e.g. boilers, air handling units, CHP, chillers, heating circuits etc.). Data for the testing must be provided by the systems (components, BAC, monitoring systems, etc.) for inspection according to minimum standard data criteria (scope, format) that each system has to provide.
- Energy use and power demands shall be reported at the level of the various technical building systems and occupant controlled non-EPB uses (small power, lighting, and process loads).
- The measured values, design specification and product data shall enable a transparent and explicit evaluation for detecting whether a specified performance is met or not. These tests must be carried out in a technical system independent from the BAC (because the BAC data may be wrong) by an independent third party.
- Based on the results of the above evaluation, the inspection should provide guidance on the potential energy savings possible.

2. Continuous monitoring, energy management, and building automation and control (BAC)

REHVA promotes continuous monitoring and the analysis of operational data to operate buildings in a cost-effective way using automated data input. However, the currently proposed requirements (paragraphs 2, points a-c in articles 14-15) mix the different competences and roles of proper operation and of the inspection process testing it. The **requirements as defined now are technically too complex and difficult to implement and to enforce by the regulatory framework**. Problems of the requirements a-c:

- "*(a) continuously monitoring, analysing and adjusting energy usage;*"
  BAC can support this function from a central place, but not implement the complete process. The adjustment is usually done by a system operator, who is largely responsible for the building performance (e.g. by setting schedules, set points and manual operation) and has therefore to be part of the inspections scope.

- "*(b) benchmarking the building's energy efficiency, detecting losses in efficiency of technical building systems, and informing the person responsible for the facilities or technical building management about opportunities for energy efficiency improvement;*"
  BAC and all the connected services are part of the same system and therefore responsible for the performance of the building. BAC can help in detecting losses, however benchmarking a buildings energy efficiency and identifying improvement opportunities requires understanding of wider context beyond simply the building services. An external service should verify the achieved benchmarked performance, referring to wider world benchmarks and possibilities.

  BAC systems are an important means of improving the energy efficiency of buildings, however, the performance of HVAC and BAC systems are highly sensitive to errors in design, construction, and operation. There are numerous examples of BAC systems not working as intended, as they are complex systems whose interaction with the buildings they serve are often not fully understood by their operators.

  Therefore, equally important as the systems themselves is the quality management for testing the systems performance. Third party testing through well-defined regular inspections or continuous monitoring shall be a mandatory requirement for buildings. This can ensure the closing of the gap between designed and actual energy performance.

- "*(c) allowing communication with connected technical building systems and other appliances inside the building, and being interoperable with technical building systems across different types of proprietary technologies, devices and manufacturers.*"

The requirements on connectivity and interoperability are not linked to the inspection of systems, but go beyond the scope of these articles. It is more appropriate to **move this requirement to article 8. on smart buildings**.

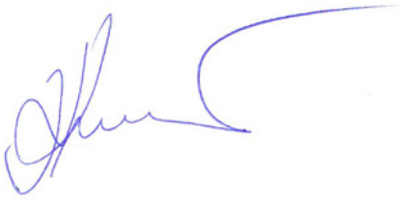
Promoting the harmonized and ambitious application of EPB standards in Europe

REHVA welcomes the approval of the new European standards linked to the EPBD that are of key importance in the compliant implementation of the EPBD. The **EPBD must refer explicitly to the new EPB standards** and promote that national requirements and methodologies are developed in line with European standards. After the approval of all but one EPB standards developed under Mandate 480, **REHVA calls for strengthening the role of EN standards,** and for their **harmonised** and ambitious **application in the European Member States**. This can drive toward a common European market and generally strengthen European competitiveness.

REHVA supports the effort to **harmonize national calculation methodologies to ensure a minimum quality and reliability of the energy performance assessment.** The proposed description of national methods by using the national annexes of the EN standards is in right direction but before the application in all MS it would be wise to test the method with a set of sample MS. If needed, the format of national annexes could then be further developed, as the application of present annexes might be problematic if the national methods are very different. It is also important to compare the results of national methods to the results of the European standards' method. For that purpose, some new activities such as the development of test cases and a common exercise to compare the results of national calculation methodologies could be foreseen to ensure minimum quality and confidence in figures given by MS. ■

Prof. Stefano Corgnati

REHVA President



Prof. Jarek Kurnitski

REHVA Vice-President

Chair - REHVA Technical and Research Committee

About REHVA: The Federation of European HVAC Associations, founded 1963, joins European associations in the field of building engineering services representing more than 100.000 HVAC engineers and building professionals in Europe. REHVA is the leading independent professional HVAC organization in Europe, dedicated to the improvement of health, comfort and energy efficiency in all buildings and communities. It encourages the development and application of both energy efficiency and renewable energy technologies.

JRC review
– evidence based recommendations for IEQ inclusion in EPBD

JRC has completed and published the assessment report of the implementation status of the EPBD by the EU MS in terms of ventilation and indoor air quality criteria and requirements, and whether these are enough to guarantee that existing or future high energy-efficient buildings will be also healthy for their occupants. By this report, JRC and the advisory board there REHVA was represented by Jarek Kurnitski, Olli Seppänen and Anita Derjanecz provided an evidence based contribution to the EPBD review process.

The report concludes that a co-ordinated and coherent implementation of IEQ related requirements in building related policies in EU is still missing as from a regulatory point of view this remains under the competencies and responsibilities of the EU Member States with no binding requirements at EU level. This was seen creating obstacles for the implementation of an integrated performance-based approach for buildings' related energy and IEQ issues in Europe. The report stresses that the progression towards meeting the targets for Nearly Zero Energy Buildings (NZEB) by 2020 should be implemented in an integrated fashion together with appropriate strategies dealing with indoor and outdoor pollution sources, ventilation, thermal comfort, acoustics and lighting.

An important finding is that gaps in the national regulatory framework were observed regarding the indoor environment quality (i.e. indoor air quality, thermal comfort, noise and lighting) and ventilation requirements, in particular for existing buildings where health-based mandatory minimum IEQ requirements can hardly be found in several national/regional building codes.

Regarding the ventilation systems, the main conclusions based on the literature review are:

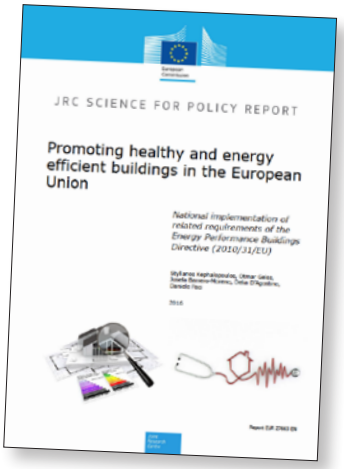
- The reviewed studies show that mechanical ventilation systems in energy-efficient buildings, if properly operated and maintained, lead to an increased removal of pollutants, and thus to an overall improvement of the IAQ and reduction of reported comfort and health related problems.
- In practice, design, installation and operation of mechanical ventilation systems is not an equally preferred solution across the entire building stock of the EU MS due to climatic, cultural and social characteristics and economic possibilities (e.g. different practices observed among Northern and Southern European countries).
- Generally, the report gives no recommendation on ventilation system type however it acknowledges heat recovery and demand controlled ventilation – the main recommendation is to set a health based ventilation rates.

As a main conclusion, the report suggests to prepare a common health-based ventilation guidance in Europe, that will reinforce the definition and setting of ventilation requirements and metrics based on health criteria to be applied after all possible control strategies of indoor and outdoor pollution sources have been exploited. It is found that there is a need to provide guidance at EU level on proper design, construction, installation, maintenance and inspections of ventilation systems. Inspection and compliance checks of ventilation systems are recommended to become part of energy and IAQ auditing under the EPBD

It can be summarized that this JRC report reveals that the statement in the current EPBD "avoid possible negative effects such as inadequate ventilation" has been too soft formulation without expected effect. JRC review developed evidence based recommendation how to include IEQ and ventilation issues in energy regulation which are implemented in proposed changes to the EPBD in EC Energy Efficiency Package 30.11.2016. In this new EPBD proposal being now in the EU Parliament, adequate ventilation and minimum health and comfort levels are clearly mentioned in the EPBD Annex 1:

"*The energy needs for space heating, space cooling, domestic hot water and adequate ventilation shall be calculated in order to ensure minimum health and comfort levels defined by Member States.*" Therefore, it can be expected that in order to implement the proposal all MS should establish minimum ventilation requirements for new buildings and major renovations.

JAREK KURNITSKI
Vice-president REHVA
Chair of Technology and Research committee



Danvak welcomes it's new Secretary General: Claus Andreasson

The Danvak Board of Directors has appointed Mr. Claus Andreasson to Secretary General of Danvak – the Danish Society of Heating, Ventilation and Air Conditioning – with effect from 1st March 2017.

Danvak

Claus Andreasson (57) has more than 20 years' experience from senior management positions and directorships in Denmark and abroad and has through his entire career focused on establishing and executing strategy, improving leadership as well as increasing performance and financial growth.

Claus Andreasson has just returned from Austria where he had the position of Executive Vice President in HOERBIGER Kompressortechnik Holding. Previously he has held positions in Burmeister Wain Energy, Rovsing Dynamics and Ansaldo Vølund. As to education, Mr. Andreasson holds a Master of Science in Mechanical Engineering from the Technical University of Denmark (DTU) and a Bachelor in International Business Administration and Economics from Copenhagen Business School (CBS).

'It is crucial for me that our members will see an increased event activity in the future which means more courses, conferences and workshops. There are two other issues which I find extremely interesting: "our young members" and "the international aspect". The young people are those who will run our country in the future and thus they must be well-prepared technically, so that they can contribute to creating growth in the Danish companies. The task, therefore, is to have the established people in the HVAC industry involve the young people at an early stage. The international aspect is also interesting as Denmark may be a small country, but it is also a unique country. Denmark is a market leader in many segments of the HVAC industry and we are able to implement new technologies relatively fast. Moreover, we are at the forefront of green energy, indoor climate and energy optimization. We must make the world see this and use it to make our industry grow' says Claus Andreasson.

The new Secretary General of Danvak – Claus Andreasson

ZOSIA K. LAV
Communications Manager, Danvak

World Sustainable Energy Days 2017 – REHVA highlights

The 16th World Sustainable Energy Days (WSED) was held from 28 February – 3 March 2017 in Wels/Austria. The 2017's Conference attracted around 700 participants from 59 countries. REHVA was represented at the event as VIP guest exhibitor, while Jaap Hogeling and Jarek Kurnitski were invited as speakers at the different conference sessions.

The 3-days event combined topics such as energy efficiency, biomass and sustainable buildings through 8 specialised conferences:

- European Pellet Conference
- European Energy Efficiency Conference
- Young Researchers Conference: Biomass + Energy Efficiency
- Energy Efficiency Services and Business Conference
- E-Mobility & Smart Buildings Conference
- European Research Conference: Buildings
- European Nearly Zero Energy Buildings Conference
- Energy Efficiency Watch Conference

As well as interactive events to network and exchange experiences like:

- "Energiesparmesse", major tradeshow on renewable energy and energy efficiency
- Technical site visits
- Poster presentation

REHVA had a booth at the event representing PROF/TRAC, an EU Project about developing a European Qualification and Training platform for professionals involved in nZEB design and construction (more information: www.proftrac.eu), distributing REHVA Journals and promoting other EU projects.

Please find below some interesting interventions during WSED 2017.

European Energy Efficiency Conference

The European Energy Efficiency Conference was dedicated to technologies, policies and markets, informed about innovative business and financing models and presented pilot projects and best practice solutions.

The conference started with a Keynote Session on Thursday morning dealing with energy efficiency policies and markets. Paul Hodson from the European Commission gave a presentation on "The new EU energy policy: clean energy for all Europeans". He repeated the 30% target for 2030 and emphasised that slowing down to 27% is no option. But we have to be aware that we already picked a lot of low-hanging fruits. Realise that the step from incandescent light bulb lamps to compact fluorescent lamp (CFL) was a big 80% saving leap but our next step to LED just 10%! Which proves we have to keep up our speed by applying energy saving measures and increasing our share of renewables. To make this work we have to follow on a more holistic approach, which is very much supported by the recently finished CEN EPB standards on Energy Performance of Buildings. These standards are the bridge to the ECOdesign product standards. The ECOdesign program is very successful, an estimated yearly saving of € 490,- on the energy bill for the average EU household due to the increased energy efficiency requirement for energy using products. Member states have to continue in energy saving programs for the existing building stock. For new buildings, cost-effective minimum energy requirements are now in place. The next step is to increase the smartness of building systems including building own energy production, connecting to the local grits where local storage via car batteries and other technologies could contribute to the energy transition needed to make Europe less dependent on energy import.

Tyler Bryant from the International Energy Agency presented the IEA Energy Efficiency Market Report 2016. He is stated that the success of the energy efficiency policies is clear even if corrected for the lower economic grow of the last decade. This is mainly caused by improved energy efficiency.

Harry Verhaar (Philips, the Netherlands) presentation on "Making energy efficiency your business" plead for a higher renovation rate of existing buildings. This should be at least 3%/year which is achievable if the added value of renovated buildings is well communicated. It is not only about energy efficiency and savings but also improved health, comfort and productivity. Technologies like smart digital LEDs could contribute to this. Other business models like leasing the indoor environmental environment with quarantined comfort and IEQ levels could help building owners/users to renovate faster.

Clause Garn (Vice President at Rockwool International) explained that insulating (the enormous existing stock of) buildings is general the low hanging fruit we can still easily harvest. Apart from the energy savings the improvement on comfort, health and wellbeing is an important added value. Rolling out these programs includes training and support of technicians very often employed by SME's. EU training programs are important to help to avoid mistakes.

European Energy Efficiency Watch Conference

The European Energy Efficiency Watch Conference offered an update on EU energy efficiency policies and discussed how they can drive innovation and employment. The conference presented a panorama of successful policies and programmes that support the realisation of energy efficiency potentials in the EU countries such as obligations, energy audits and buildings support programmes.

The two speakers representing REHVA, Jaap Hogeling, REHVA Journal Editor in chief and Jarek Kurnitski, REHVA Vice President, showed their presentations on March 3rd during the **European Energy Efficiency Watch Conference.**

Paul Hodson listed several actions around the EPBD and proposed amendments to consider.

EU Member States are expected to report about the status of the EP-certificates of their building stock. The nZEB requirements and the future smartness indicator are important adds on to consider. The renovation rate of existing buildings needs to increase. In the future, we do not want to have very bad buildings in Europe. The EPBD and Article 7 of the EED plus the ECOdesign goals are the bases for the 30% 2030 objective and the decarbonisation of the emission of the building sector. DG Energy is ready to support the implementation of all these policy measures which needs capacity building in the building sector and support for EU Member State regulators.

Zoé Wilders (EASME) explains the need for upscaling the workforce to meet the 2020 targets. Projects like Build-Up-Skills (22 projects in 21 countries) are needed. The more as 3 million workers in the building sector have to be up scaled with cross craft understanding. Many projects are mentioned among them Prof-Trac with the database for Train-the-trainer programs, Competence guidelines as found in the Build-Up program. The EE14 Construction Skill program under Horizon2020 is still open for 100% supported proposals (closure June 7 2017).

Jarek Kurnitski highlighted the *Indoor environment quality requirements versus energy performance.* He stated that the EP-certificate as required by the EPBD should also include an IEQ indicator which should also be a part of the inspection protocol for existing buildings and the delivery new buildings.

Jaap Hogeling explained that now the set of CEN *Energy Performance of Buildings Standards* passed the final vote they are expected to be published by the European National Standard Bodies in the coming months. Publishing this set of 52 standards as a basis for the European energy performance assessment procedures is an important first step.

This set of EPB standards will be the basis for the Energy Performance Buildings assessment in Europe. It will be more or less obligatory for the EU Member States to use these standards as a basis for their national regulation on Energy Performance of Buildings. More or less because the EPBD is just directing the EU MS's. However, if the MS's regulators seriously respect the outcome of the vote of the CEN community, where professionals, industry and other stakeholders gave their opinion and advice, broad implementation seems a question of time. The proposed amendment of Annex I of the EPBD requires the EU Member States to report their compliance with the EPBD according the Annexes of the EPB standards.

The REHVA (Federation of European Heating, Ventilation and Air Conditioning Associations) member organisations and the many European and national interest groups should combine their forces to convince the national regulators responsible for the regulatory framework to make use of the EPB standards. It is the only way we can develop a strong European market for EPB related technology, systems and products. Making energy efficiency measures for buildings more cost-effective and competitive at the EU and global market.

What will this mean for the future? More harmonisation of the EPB assessment procedures which will have an impact on the harmonisation of the product and system requirements for energy relevant products used for buildings and their HVAC systems. Under the European ECOdesign Directive most relevant energy using products to be applied in buildings are already covered by a product regulation. This regulation requires the products to meet a certain minimum energy performance threshold, which is to be upgraded in the coming years (typically every 5 years). This regulation does not only set the energy performance requirements but also requires the product to have a label (product declaration) where these and other essential requirements have to be reported. Additional the Eco-design regulation refers to CEN or ISO standards describing the measurement and assessment procedures to obtain the required product data. If no standards available the EU-regulation includes, for the time being, this information. The measurement data which are the basis of these product declarations have to be published in a public data base. These public data are again essential input for the assessment procedures described in the EPB standards mentioned before.

This coupling of the two EU directives, the EPBD (Energy Performance Buildings Directive) and the ECOdesign Directive connects product declarations to finally the Building Energy Performance certificates. It accommodates the holistic building and system approach. Energy saving technologies, systems and products can now be awarded at a level playing field. Where transparency, regarding the assumptions and very often needed simplifications of assessment procedures, stimulates innovation. Also, transparency regarding the overall performance parameters (like the levels of Indoor Environmental Quality) and other boundary conditions such as the outdoor climate data and the to be used primary energy factors and assessment procedures to reward sustainable energy use. The overarching EPB standard EN-ISO/52000-1 includes all these essential issues to be considered and refers to the total set of EPB standards where these issues are worked out in full detail.

Having these standards available is a first step, implementing them needs dissemination actions at the level of building regulators as well in our professional community. REHVA is involved in supporting this dissemination process in Europe. The EPB-CENTER is an initiative of the leadership of CENTC371 (represented by ISSO) and REHVA, they are the stakeholders in the EPB-CENTER. The CTL of CENTC371, where the current expertise regarding the EPB standards is concentrated will support this process. REHVA member organisations and their members are in a strategic position to implement the assessment procedures nationally and convince their national regulators that using the CEN EPB standards is the most promising way to support reliable building energy performance rating which will stimulate innovation at the same time.

The main benefit of the continued central coordination of the management of the EPB standards is to ensure that the knowledge and experience gained in the previous years is kept. Many institutions and organizations have over the past years, directly and indirectly invested millions of Euro's to develop these EPB standards. Now implementation is needed, the EPB CENTER supports this process. In addition to this a central management of collection and analysis of the feedback from the individual countries and regions who are gaining practical experience with these EPB procedures will be necessary to maintain and further improve the quality (aftercare). Also, to prepare proposals and plans for a coordinated process of further improvement of the consistency, transparency and usability of these EPB standards.

Who are the potential users of the EPB set of standards, and what should they be aware of?

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

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

In general, the holistic approach means that the energy performance is assessed as the total energy used for heating, cooling, lighting, ventilation, domestic hot water, and, in some cases, appliances. It ensures that all technologies are treated equally and balanced.

With the EPB set of standards:

- Policy makers acquire an instrumentation that enables them to take measures in the built environment and to quantify how much these measures would reduce the energy consumed in buildings.
- Building industry, engineers and designers can improve the energy-efficiency of their designs, building products and systems. The set of standards take these current and future products, systems and designs into account. Due to the holistic approach the risk of suboptimum solutions at component level is minimized. This way industry knows in what direction to innovate.
- Building owners and occupants can benchmark against other buildings and predict the energy saving potential of improvements.

The 16th edition of the World Sustainable Energy Days was again a success bringing together international experts, scientists, students, policy makers, public sector intermediaries and industry stakeholders from 59 countries to discuss about sustainability and energy efficiency. More information about the other conference sessions, as well as earlier WSED events can be found on the website www.wsed.at.

CHIARA GIRARDI, REHVA Publications & Promotion Officer

ISH China & CIHE 2017 debuts intelligent household solutions

Keywords: ISH, ISH China, home comfort, boilers, heat pumps, China, coal-to-gas energy reform

ISH China & CIHE – China International Trade Fair for Heating, Ventilation, Air-Conditioning, Sanitation & Home Comfort Systems is Asia's premier HVAC and plumbing event. To be held from 18–20 May 2017, the show is on track to host more than 1,300 exhibitors who will occupy all eight halls of the New China International Exhibition Center that spans over 97,000 sqm. The fair is organised by Messe Frankfurt (Shanghai) Co Ltd and Beijing B&D Tiger Exhibition Co Ltd, and is estimated to attract more than 55,000 professional domestic and overseas visitors.

Boosted by improved living standards and the rapid development of internet technology, future HVAC trends will become more intelligent and integrate further with the Internet of Things. As such, the show's Home Comfort Zone in Hall E4 will be upgraded in 2017 to debut intelligent household products and technologies, featuring HVAC systems, home entertainment systems and intelligent home appliances. Products for water and air purification will also be on display. Leading international and domestic brands confirmed for the upcoming fair include Airspa, Blauberg, BLLC, Enchoy, Gree, GRPXF, Grünbeck, Haier, Kingho, Lunos, Midea, Pentair, Sach, SDFRESH, Senwater, Tendge, Tengya, Zehnder, Ziefir and others.

Coal-to-gas energy reform contributes to rapid market growth for boilers

The introduction of the real estate destocking policies in many provinces and cities throughout China in 2016 has helped to boost the country's real estate industry. With greater demand for property comes greater demand for heating solutions. The market for coal-fired boilers is diminishing as aggressive coal-to-gas energy reform stimulates growth in the wall-hang boilers market. Some areas carrying out local initiatives include:

Beijing

Committed to the switch from coal to clean energy, Beijing has initiated reform in 400 villages throughout the city. Aside from coal-to-electricity and coal-to-gas options, the local government also encourages the use of air-source

heat pumps, solar energy and other new technologies. By the end of 2017, an estimated 200,000 families in four of the city's main districts are estimated to cut their use of coal by a total of 600,000 tons. By 2020, the government aims to replace all existing coal-fired power with clean energy in the non-mountainous rural areas of Beijing.

Hebei Province

- *Xingtai*

In order to promote the use of natural gas in the City of Xingtai, the government has set up a special fund to subsidise the purchase of boilers. Each household is entitled to an allowance of RMB 3,000.

- *Handan*

The City of Handan has also granted a RMB 3,000 subsidy to each of the 130,053 households that make the switch from coal to natural gas. The designated zone encompasses the main urban area and the 309 villages that are located within five kilometres of the city.

Incentives like the ones mentioned above will bring about a boom in boiler sales in the near future. At the expo, Halls E1 and E2 will be dedicated to boilers. Leading brands that are signed up include Alarko, Ariston, Bekaert, Biasi, Devotion, Dynasty, FangKuai, Gassero, Haier, Hansa Heiztechnik, Haydn, Italtherm, Jiton, KD Navien, Kiturami, Lochinvar, Lotte E&M, Radiant, Rinnai, ROC, Sanpaula, Vanward, Vero and others.

Favourable policies stimulate promising industry demand for air-source heat pumps

Energy efficiency and emission reductions are global concerns. As too are coal-to-electricity initiatives in China and the implementation of the Paris Agreement. Supporting policies have made way for increased demand of air-source heat pumps. Given the clean energy that they produce and their low carbon emissions, air-source heat pumps are one of the chosen green home heating and cooling alternatives that comply with national policies.

The market outlook for these systems has never been so promising and Halls W3 and W4 at the show will be dedicated to heat pumps. As of December 2016, over 80% of exhibition space has been reserved by brands including AMA, Aux, Gree, Haier, Micoe, Midea, New Energy, Outes, PHNIX, TCL, Tenesun, TianJia and others.

ISH China & 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 14–18 March 2017. For more information, please visit www.ish.messefrankfurt.com.

Messe Frankfurt also offers a few other ISH events worldwide, including the ISH India powered by IPA in Delhi as well as ISH Shanghai & CIHE, which will be held from 5–7 September 2017 at the Shanghai New International Expo Centre. For more information, please visit www.ishc-cihe.hk.messefrankfurt.com or email info@ishc-cihe.com. ■

Background information on Messe Frankfurt

Messe Frankfurt is one of the world's leading trade fair organisers, generating around €640* million in sales and employing 2,364* people. The Messe Frankfurt Group has a global network of 30 subsidiaries and 55 international Sales Partners, allowing it to serve its customers on location in 175 countries. Messe Frankfurt events take place at approx. 50 locations around the globe. In 2016, a total of 138* trade fairs were held under the Messe Frankfurt umbrella, of which more than half took place outside Germany.

Comprising an area of 592,127 square metres, Messe Frankfurt's exhibition grounds are home to ten exhibition halls. The company also operates two congress centres. The historic Festhalle, one of the most popular venues in Germany, plays host to events of all kinds. Messe Frankfurt is publicly owned, with the City of Frankfurt holding 60 percent and the State of Hesse 40 percent.

For more information, please visit our website at www.messefrankfurt.com.

* Preliminary figures for 2016

AIVC 2017 Workshop on IAQ metrics

Brussels, 14–15 March 2017, a short impression

Peter Wouters (▶) BBRI, Belgium, welcomed on behalf of AIVC, the 65 participants from 14 countries around the globe (Europe, Korea, New Zealand, USA) and presented the first paper on considerations on IAQ metrics from regulatory and compliance point of view – Use of IAQ metrics in practice where the possible applications of IAQ metrics include:

- The characterisation of the indoor air quality as part of a building survey or monitoring, without any consequences in terms of building operation
- The assessment of the indoor climate in order to judge if the IAQ is acceptable (e.g. for working, or to occupy the building).
- Specifications for the design and installation of ventilation systems and other building related aspects.

Bill Bahnfleth, Pennsylvania State University, USA, presented on the promise and problems of performance-based ventilation. He pleaded for monetization of IAQ performance, there is plenty of data showing the health benefits of better ventilation. The Ashrae standards 62 are a good step in the right direction but more should be done to analyse the effect of the interaction of the indoor air pollutants. Research in this field may take another 5–10 years. Or, as brought forward in the discussion should we also pay more attention on reducing the pollution sources, require low emitting building materials, furniture and cleaning agents used in buildings.

Andrew Persily (▶), NIST, USA, warned that CO_2 based ventilation control assumes that pollutants are just coming from persons and person related activities. Most ventilation/IAQ criteria, like standards ASHRAE 62.1 and EN 13779/15251 do not contain CO_2 limits, they only have informative appendices discussing the 1800 mg/m³ (1000 ppm) level. Setting target values and performing the just CO_2 metrics includes that you know what people are doing.

Iain Walker (▶), LBNL, USA, reported about the status and perspectives for the development of IAQ metrics in the USA. Better performance based standards which have to include many prescriptive parts as assumptions and boundary conditions. It should be ideal if we could report the IAQ on one scale like we do for the energy performance. Assuming a scale is 1–100 where 1 is best and 100 is poor we could report the energy performance and IAQ score on a similar scale which makes it more easy to communicate. The score should have the following features: have a single number – like an energy score; supported by a trusted third-party rating system; be based on observations in the home and possibly some diagnostics; include health, odour & moisture issues; and must be simple enough to be reliably performed by home energy rating experts or contractors.

In his paper, Iain pleads for a simple tick box methodology to be able to include this procedure in the standard energy and or building survey procedure.

Gaëlle Guyot (▶), Cerema, France presented a very interesting review of pollutants and sources of concern and performance-based approaches to residential smart ventilation. In this presentation, the standards and regulation of several EU-countries has been compared (Belgium, France, Spain and the Netherlands). It was intriguing to learn the big difference of the number of hours that a certain CO_2 threshold value was accepted in the different regulations. It should be interesting to learn about the justification behind these values.

Caroline Markusson, SP, Sweden presented on demand controlled ventilation in residential buildings, and discussed the current danger in Sweden that energy performance requirements may reduce the ventilation rate. In Sweden DCV is in general not used in residential buildings. It was interesting to learn that the current Swedish regulation doesn't allow DCV for residential.

Based on model studies the first results are reported. CO_2 and humidity in winter and temperature in summer are considered to be control parameters, a big saving potential is expected which will now be analysed based on demonstration of this technology in real houses. This project is expected to contribute to reconsider the Swedish residential ventilation regulation.

To conclude or summarize the 23 papers, is not possible in a few lines but what is the problem we want to solve? We have multiple sources, hazards, we need more information on dose-responds issues. Ventilation rate requirements are sometimes difficult to compare and generally based on bio-effluence and humidity. Confusion about the fact that in most building certification schemes, the IAQ is underappreciated, it counts only on average for 7.5%. Are solutions at our doorstep? Start to remove pollutants by preventing them to enter our buildings! Requirements on pollution level of building products, interior materials and cleaning products, be critical on the use of candles (only ones a year?) and odour products including perfumes (sorry). But finally, we need metrics (and reliable sensors) to assess the IAQ performance. We should explore and report on the monetarisation of better IAQ. If we can communicate the positive impact of good IAQ on the human health and the considerable saving in costs of the national health sector, IAQ should stand at the top of the requirement-list, next to the energy performance of buildings, we must meet.

This short impression doesn't reflect the fast amount of information included in the very interesting 23 papers. And adding to this the very inspiring discussion supported by questionnaires where the audience was challenged to make their choices, which proved to be influenced by the presentations and discussions.

Most of these papers included clear guidance for regulators, standards developers but also HVAC designers and commissioners. The REHVA journal expects to publish the coming months some of those very interesting articles.

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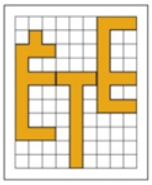

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Send information of your event to Ms Chiara Girardi cg@rehva.eu

Events in 2016 - 2017

Conferences and seminars 2017

April 2–4	REHVA Annual Meeting	London, UK	http://www.cibse.org/rehva-annual-meeting-2017
April 5–6	'Delivering Resilient High Performance Buildings' Engineering and maintaining buildings and systems to provide resilient lifetime performance	Loughborough University, UK	https://goo.gl/ip9v92
April 19–22	Teskon+Sodex	Izmir, Turkey	http://www.teskonsodex.com/
April 19–21	Aquatherm St. Petersburg	Pavilion G, St. Petersburg, Russia	https://goo.gl/ECS8sC
May 10–11	50th International Congress "Beyond NZEB retrofit of existing buildings"	Matera, Italy	https://goo.gl/FbXiZS
May 10–12	1st Buildings India 2017 Exhibition and Conference	New Delhi, India	http://www.smartcitiesindia.com/
May 10–13	Sodex Ankara	Ankara, Turkey	http://www.sodexankara.com/
May 12–13	Climamed 2017 Conference "Historical buildings retrofit in the Mediterranean area"	Matera, Italy	http://www.climamed17.eu/
May 14–17	38th Euroheat & Power Congress	Glasgow, United Kingdom	www.ehpcongress.org
May 30–2 June	Aquatherm Kyiv	Kyiv, Ukraine	http://www.aqua-therm.kiev.ua/en-GB/
August 7–9	Building Simulation 2017	San Francisco, California, USA	www.buildingsimulation2017.org
August 23–25	43rd International Symposium of CIB W062 Water Supply and Drainage for Buildings 2017	Haarlem, The Netherlands	http://www.tvvl.nl/cib-w062-2017
September 5–7	ISH Shanghai & CIHE 2017	Shanghai, China	www.ishs-cihe.hk.messefrankfurt.com
September 13–14	Ventilating healthy low-energy buildings	Nottingham, United Kingdom	http://www.aivc2017conference.org/
September 28–29	7th International Conference on Solar Air-Conditioning - PV Driven/Solar Thermal	Tarragona, Spain	http://www.solaircon.com/
November 10–11	Second ASHRAE Developing Economies Conference	Delhi, India	https://ashraem.confex.com/ashraem/de17/cfp.cgi

Conferences and seminars 2018

March 12–15	Cold Climate HVAC Conference 2018	Kiruna, Sweden	http://www.cchvac2018.se
3–6 June	ROOMVENT & VENTILATION 2018	Espoo, Finland	http://www.roomventilation2018.org/

Exhibitions 2017

May 18–20	ISH China & CIHE 2017	Beijing, China	www.ishc-cihe.hk.messefrankfurt.com
September 5–7	ISH Shanghai & CIHE 2017	Shanghai, China	www.ishs-cihe.hk.messefrankfurt.com
September 19–23	FOR ARCH	Prague, Czech Republic	www.forarch.cz/en/

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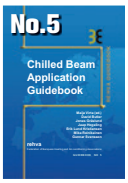
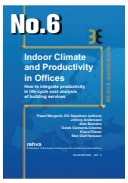
REHVA Guidebooks are written by teams of European experts

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

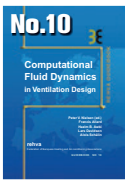


Chilled Beam Cooling. Chilled beam systems are primarily used for cooling and ventilation in spaces, which appreciate good indoor environmental quality and individual space control. Active chilled beams are connected to the ventilation ductwork, high temperature cold water, and when desired, low temperature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

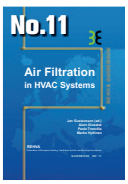


Indoor Climate and Productivity in Offices. This Guidebook shows how to quantify the effects of indoor environment on office work and also how to include these effects in the calculation of building costs. Such calculations have not been performed previously, because very little data has been available.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

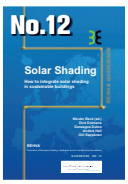
Low Temperature Heating And High Temperature Cooling. This Guidebook describes the systems that use water as heat-carrier and when the heat exchange within the conditioned space is more than 50% radiant. Embedded systems insulated from the main building structure (floor, wall and ceiling) are used in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



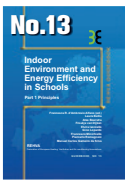
Computational Fluid Dynamics in Ventilation Design. CFD-calculations have been rapidly developed to a powerful tool for the analysis of air pollution distribution in various spaces. However, the user of CFD-calculation should be aware of the basic principles of calculations and specifically the boundary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



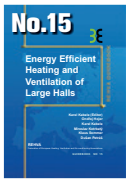
Air Filtration in HVAC Systems. This Guidebook will help the designer and user to understand the background and criteria for air filtration, how to select air filters and avoid problems associated with hygienic and other conditions at operation of air filters. The selection of air filters is based on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



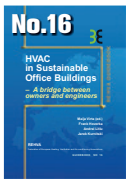
Solar Shading – ***How to integrate solar shading in sustainable buildings.*** Solar Shading Guidebook gives a solid background on the physics of solar radiation and its behaviour in window with solar shading systems. Major focus of the Guidebook is on the effect of solar shading in the use of energy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



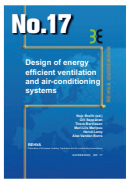
Indoor Environment and Energy Efficiency in Schools – ***Part 1 Principles.*** School buildings represent a significant part of the building stock and also a noteworthy part of the total energy use. Indoor and Energy Efficiency in Schools Guidebook describes the optimal design and operation of schools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



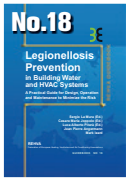
Energy Efficient Heating and Ventilation of Large Halls. This Guidebook is focused on modern methods for design, control and operation of energy efficient heating systems in large spaces and industrial halls. The book deals with thermal comfort, light and dark gas radiant heaters, panel radiant heating,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



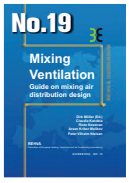
HVAC in Sustainable Office Buildings – ***A bridge between owners and engineers.*** This Guidebook discusses the interaction of sustainability and heating, ventilation and air–conditioning. HVAC technologies used in sustainable buildings are described. This book also provides a list of questions to be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



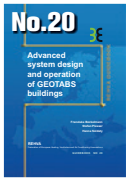
Design of energy efficient ventilation and air-conditioning systems. This Guidebook covers numerous system components of ventilation and air-conditioning systems and shows how they can be improved by applying the latest technology products. Special attention is paid to details, which are often overlooked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



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

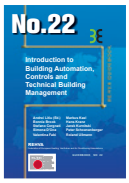


Mixing Ventilation. In this Guidebook most of the known and used in practice methods for achieving mixing air distribution are discussed. Mixing ventilation has been applied to many different spaces providing fresh air and thermal comfort to the occupants. Today, a design engineer can choose from large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



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

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



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

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