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Non-compliant EPCs and building works should not jeopardise EPBD goals

PETER WOUTERS
Coordinator of QUALICHeCK
INIVE, Belgium

Building's Energy Performance Certificates (EPCs) are expected to correctly inform prospective buyers and tenants, to encourage them to invest in energy efficiency in buildings. Progressively, this should lead to a positive relationship between a property's energy rating and its market value. This trend seems to be confirmed by several economic analyses showing, in specific contexts, actual impact in market value of a one-letter improvement of the EPC rating of a building compared to an equivalent building. However, this emerging market transformation should not be jeopardised by discrediting EPC ratings with insufficient quality assurance measures.

There are reasons to be concerned about poor quality EPCs. In fact, the 10 field studies on samples of 25+ buildings in 9 countries, performed within the Intelligent Energy Europe QUALICHeCK project and summarised in this special issue of the REHVA journal, confirm significant non-compliance issues in many countries. In addition, the Concerted Action on the Energy Performance of Buildings Directive reveals that few Member States have a reasonably accurate picture of compliance rates with energy performance requirements based on actual verifications. The 2016 book of the Concerted Action (http://www.epbd-ca.eu/ca-outcomes/2011-2015) contains a lot of interesting information for each member country, as well as with respect to the overall status of implementation.

As for the quality of building works, besides the huge economic impact of non-compliance in this field, non-compliance also puts at risk the directive's goals, as achieving NZEB levels requires upgraded skills and increased attention at design, call for tender, execution and hand-over stages.

So what should we do?

The QUALICHeCK consortium identified 3 fundamental aspects to structure an approach to effective compliance: 1) define clear rules to comply with for issuing EPCs and undertaking building works; 2) define clear rules to handle non-compliance; 3) define concrete actions for handling non-compliance. These 3 aspects are detailed in two draft source books summarised in this special issue of the REHVA journal that include practical examples, as well as hints and pitfalls to avoid, addressing specific questions that may arise when developing compliance frameworks.

Easy access to input data through trustworthy sources is also crucial both for issuing and for checking EPCs. The solar shading or the cool roof products database presented in this issue are interesting initiatives answering this need.

As compliance frameworks are not viable without societal support, we are happy to see a growing interest for quality and compliance issues through our activities (international conferences, technical workshops and webinars, as well as the national roadshows and consultation platforms in the 9 countries represented in the QUALICHeCK consortium). Of course, transforming the market towards effective compliance is very challenging, but it also offers perspectives to significantly improve the quality of buildings not only on paper, but also in reality. ■

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Maximizing building energy efficiency: Ensuring quality of works




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Analysis of additional costs in the European construction sector caused by faults having occurred during the construction process identified nearly 10% of the turnover of the construction sector. Thus, quality of works is not only crucial for achieving EU energy and climate goals but also essential from the economic point of view.

Keywords: quality of works; energy efficiency; proper execution; NZEB; QUALICHeCK

Point of departure: what is the importance of quality of the works?

New buildings as well as the existing building stock must become much more energy efficient to achieve the EU energy and climate goals [1] envisaged for the years 2020, 2030 and beyond. In fact, it will be possible to almost completely cut emissions from residential and office buildings by around 90% in 2050, compared to 1990, if all efforts undertaken are successful. These efforts include quality of the works, meaning that it is not sufficient aiming at an excellent energy performance stated by design descriptions and energy calculations, but also at good quality of the works. Proper execution of building works according to plan and without errors is the precondition to achieve high building energy performance in reality, resulting in actual reductions in energy consumption and emissions. In this regard, experience shows that there are various cases where the quality of the works is an issue of concern, sometimes even causing major difficulties leading to higher expenses.

Status on the ground: what are the actual challenges?

A report [2], written in the context of the IEE project QUALICHeCK, summarises critical situations on the construction site putting the careful execution and thus the high quality of works at risk. This is dealt with in the light of the importance of high quality constructions and their realisation on the building site in connection with the trend towards high performance buildings such as the nearly zero-energy buildings required by the Energy Performance of Buildings Directive (Recast) [3] for 2019 respectively 2021.

QUALICHeCK source book: how to tackle the challenges?

The QUALICHeCK source book [4] is available as draft version and aims to guide and support persons and organizations' interested in determining whether a better enforcement of the quality of the works is needed. If it turns out to be relevant, the source book will help them to identify the possibilities and points for attention for implement a more effective enforcement framework.

In this respect, it is necessary to touch on a definition of terms briefly: What does Quality of the works mean? Work can be defined as a physical or mental effect or activity towards the production or accomplishment of something. In the context of this source book, works are all the activities directed to produce or refurbish a building. What is crucial in the context of this source book is that "quality of the works" for a given activity (e.g. installation of a PV system) has to be clearly defined. As such, one can come to a quite different set of specifications ("stated needs") for the same activity and, in order to minimise the risk of disputes, one should try to minimise the number of implied needs, as different parties might have a completely different view on the implied needs.

Table 1 presents particular findings from the QUALICHeCK project in an overview of reasons for good or poor quality of the works relating to practical procedures.

Table 1. analysis of reasons for good or poor quality of the works.

Aspects which are important for good quality of the works	Reasons for good quality of the works	Reasons for poor quality of the works
Clear description of work specifications	Target groups have clear instructions how to install building and technical elements and what to consider	No consensus between target groups regarding responsibilities
Clear procedures to show evidence of compliance	From the beginning of the process a clear procedure is defined to show the evidence	Unclear what are the criteria and who checks them
Tracing procedures	A comprehensive continuous documentation allows early recognition of faults	All documentation will be checked at the final stage only, which does not allow the craftsmen to react in time
Handling of innovative solutions	Continually trained and experienced craftsmen	Overstrained craftsmen who have not followed the developments on the market
Usability of the specifications in practice	The craftsmen understand clearly, what is expected from them and where possible problems are	Incomplete specifications written in a difficult language style
Giving benefits to systems that have a high probability to perform well	Easy to implement technology in combination with other beneficial effects for the craftsmen	Technologies which need highly experienced craftsmen for the installation and have no beneficial effects for the craftsmen
Rewarding good practice	High motivation of the craftsmen	No sanctioning in case of poor quality of the works
Specific issues for existing buildings	The specific challenges in existing buildings are taken into account	Quality frameworks are not sufficiently specific
Quality management approaches	Advantage of a reduced effort for daily compliance procedures, if the company uses a collective compliance procedure	Too high costs for the compliance procedures leads to failure to comply
Market surveillance and integrating lessons learned	An organisation running a quality framework was involved	Reasons can be of different nature: too low requirements or too high and unnecessary costs
Interrelation with European and national legislations and standards	Possible synergies are investigated and made use of	Limitations are not respected causing refusal of the procedures, thus hindering implementation

Success factors for effective quality frameworks

In order to achieve good quality of the works, societal support is important, meaning that stakeholders understand and accept the need for energy efficiency requirements, the need for compliance and the need to check and enforce compliance.

A three-step approach has been identified in the QUALICHeCK source book how to achieve good compliance:

- There should be clear procedures what requirements must be fulfilled in order to achieve good quality of the works
- There should be clear procedures how to decide on compliance and related actions in case of non-compliance
- There should be effective control and penalties mechanisms to be applied in cases of non-compliance

The detailed description of these 3 steps is documented in the QUALICHeCK source book, as well as the handling of innovation as a key element for progress. The reader will find information how to implement second or third party control and enforcement frameworks without hindering innovation. Emphasis is also put on the fact, that control and enforcement schemes introduce always some extra costs, but as explained in the introductory part of this text, non-existence of control and enforcement schemes might be even more expensive.

Be part of the QUALICHeCK solution: Comments and suggestions are very welcome

During the next months, a review of the source book will be performed by public consultation of stakeholders. Please read the document on the QUALICHeCK project website* and send feedback to the authors. ■

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* http://qualicheck-platform.eu/2016/03/report-source-book-on-guidelines-for-better-enforcement-of-quality-of-the-works-draft/

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Improving compliance of building energy performance certificates

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The European Directive on the Energy Performance of Buildings (EPBD) [1] requires that Member States set up a certification, with an Energy Performance Certificate (EPC). Member States must also establish an independent control system for the EPCs (Art. 18), as well as effective, proportionate and dissuasive sanctions in case of non-compliance (Art. 27). A draft source book [2] has been published from the QUALICHeCK project. It provides suggestions for a more effective compliance of the EPCs with the national or regional legislations. This article summarizes its contents.

Keywords: EPBD, building, certification, energy performance, certificate, EPC data, EPBD compliance

What are compliant EPCs?

The Energy Performance Certificates are produced by collecting data and using them as input in a software that gives an assessment of the energy performance (**Figure 1**).

Input data describe the building, its environment, its systems (including HVAC) and its operation. They must be determined according to the applicable procedures, found in regulations, codes, standards, professional rules, etc. These procedures must be clear and unambiguous in order to allow for control and enforcement with reasonable effort.

The EPC must provide an energy performance value determined as per the rules, so that minimum energy performance requirements are met and the consumer is well informed.

In this context, "**compliant**" means: "in accordance with the procedures of the applicable legislation". This applies to the input data as well to the EPC itself.

QUALICHeCK

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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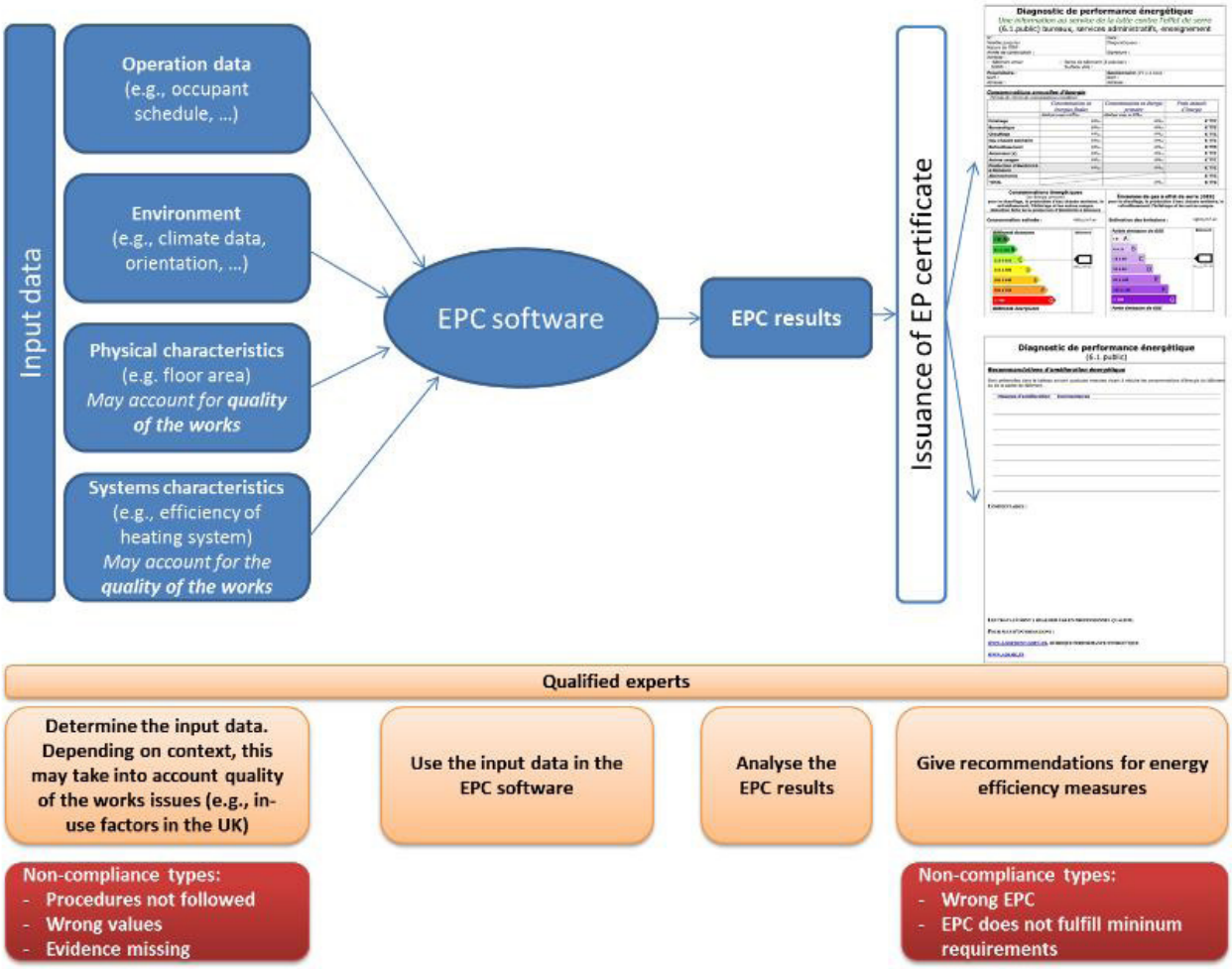

Figure 1. Key steps for the issuance of Energy Performance Certificates (from [3]).

A three-step approach has been identified in order to achieve and enforce compliance (**Figure 2**):

- there should be clear procedures on how to obtain and prove compliant input data (step 1),
- there should be clear legal procedures on how to decide of non-compliance of EPC and/or input data, and what are the related actions (step 2),
- there should be effective control and sanctioning mechanisms in case of non-compliance (step 3).

It is essential that each of these three steps is understood and supported by stakeholders, in order to get the necessary societal support.

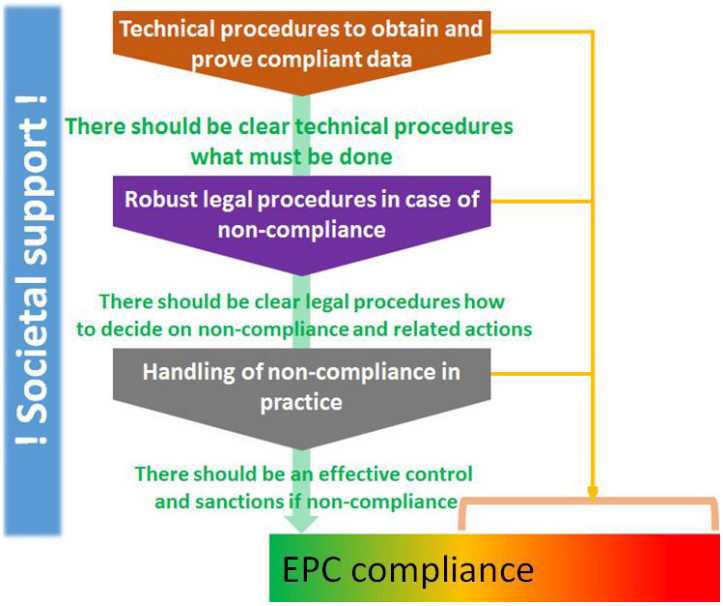

Figure 2. The three-step approach to get compliant EPCs.

Compliance of the EPC input data

The procedures to obtain and prove compliant data should include:

- Clear technical procedures that explain how to determine the data (what is the quantity concerned, its unit, the method to determine it?)
- Clear organizational procedures (for example: mandatory EPC input data form, penalty to the input data value if not determined by a third party, way to use default values if the data is not known,…)
- Clear procedures on how to prove compliance of the input data (third party control, declaration by the one who provides or determine the data, proven competence of persons or companies).

These procedures must be in line with other EU legislations, for example concerning construction products and eco-design of energy related products. They must not restrict imports and exports between Member States.

An easy access to the EPC input data is essential. Tools making use of modern information and communication technologies such as BIM and product databases can play a major role in this respect.

The source book [2] details the issues addressed above. It also includes information and recommendations on topics such as: procedures on how to deal with innovative products, specificities for the input data related to the execution of the works or installation/commissioning of the systems, specificities for existing buildings.

More information about existing approaches to get compliant and accessible EPC input data can be found in [4] and [5].

Procedures on how to decide on non-compliance and related actions

Non-compliance can be (**Figure 1**):

- Non-compliance of the input data (procedures not followed, wrong values, evidence of compliance missing)
- Non-compliance of the EPC (wrong EPC, energy performance not fulfilling the minimum energy performance requirements).

Clear procedures should exist on how to decide of non-compliance and what are the related actions in case of non-compliance. They should cover the following cases:

- No submission of required documents or not done in due time
- EPC not issued according to the procedures or using a wrong value of the energy performance
- EPC not meeting the minimum energy performance requirements
- Non-compliant input data
- EPC indicators not published in real estate advertisements or not made available when selling or renting a property
- EPC not hung out in public buildings and buildings frequently visited by the public.

The legislation must clearly specify the latest moment to submit the EPC and related documents serving as evidence for control to the authorities. Actually, the latest moment should be at least after the completion of the works allowing to take into account changes during building design and construction, but can be also up to 6 months after occupation or based on real consumption requiring at least 1 year of occupancy. Submitting the EPC at building permit stage can be necessary due to existing procedures but will not be sufficient from the energy performance perspective and must be complemented by submitting an updated EPC.

In addition, the moments of the control by the authorities must also be precisely determined, and appropriate resources for effective compliance controls must be available (financial and human resources, database of all issued EPCs, sampling scheme and methodology of control). Appropriate moments for control are prior to building permit approval and prior to issuing the permit of use.

In case of detected non-compliance, an effective enforcement is easier if the legislation itself specifies who can be sanctioned, what are the penalties, and how the sanction is decided.

The source book [2] details these issues. It also includes information and recommendations on topics such as: philosophy on the level and the timeline for the evolution of requirements, clarity in size and proportionality of the penalties, specificities of the execution related performances, specificities for existing buildings, smart procedures.

Handling of non-compliance in practice

Handling of non-compliance in practice must be effective, cost-efficient and affordable.

Experience shows that stakeholders respect clear enforcement procedures resulting in adequately severe sanctions executed in case of non-compliance.

First of all, sanctions should address the room for improvement detected during the compliance-check, not only to ensure compliance but also to assure the quality of EPCs and constructed buildings in general.

Thus, apart from financial sanctions such as penalties and withdrawal of grants, other types of sanctions can be foreseen, such as additional mandatory trainings for EPC experts.

The source book [2] also provides information and recommendations on topics such as: role of political will, support by stakeholders, communication on outcomes of compliance checks, economics of controls and enforcement.

Conclusion

The source book from the QUALICHeCK project about compliance of the Energy Performance Certificates of buildings [2] aims to act as a guidance and support for persons and organizations who want to know if a better enforcement of the EPCs is needed, and what are the ways and points of attention to implement improvements. This source book has been issued as a draft. A final version, including information from other experiences and feedback from stakeholders, will be published in 2017. Contributions are still welcome and are invited to be submitted to the authors. ■

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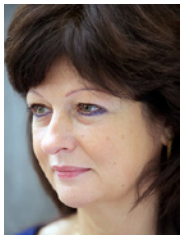
ES-SDA: validated shading data for new build and renovation

Shading has moved from a building component to a smart solar management concept for NZEB or renovated buildings (http://es-so.com/new/314-es-so-position-paper-2015). Although shading is a mature building technology in Europe it is not adequately recognised for its energy saving properties.

Keywords: smart solar management; validated database; compliance EPB; overheating; shading properties; innovative shading; energy savings; indoor climate; NZEB



ANN VAN EYCKEN
Secretary General of ES-SO and Coordinator of the ES-SDA database

DAVE BUSH
Board of Director of ES-SO and Chair ES-SDA. He is CEO of Hallmark Blinds in the London, U.K. and an active member of BBSA-U.K.

Compliance to EPBD: a scattered image of "shading performance" in national calculation methodologies.

The EPBD has become a trigger for the industry to further promote the shading performance properties. Innovative materials such as external fabrics reaching up to 95% heat rejection, interior shading with low e or reflective coatings, maximisation of natural daylight, keeping the colour rendering and with glare control, are all energy benefits.

In the EPBD, the need for shading is mainly related to reduce the risk of overheating; a risk to be considered even more since the EPBD set the NZEB objective for new build by 2020 resulting in adding much more insulation materials to the building and the practice of airtight construction. See studies on overheating in buildings on http://es-so.com/new/319-studies-on-overheating-in-buildings.

However, when it comes to the building regulation compliance in the different countries, shading is often inadequately considered. To mention the performance for heat rejection, shading energy performance properties may only be considered for a defined default g-value, or only for its actual g-value, or equally be considered compliant for both default and actual g-values. The insulation properties are generally only considered in the building regulations for (roller) shutters.

Quality in construction: reliable validated database as a necessary first step

With the involvement in the EU QUALICHeCK project dealing with compliance and quality regarding EPB legislation, ES-SO held a questionnaire among its member countries on the status of actual shading data. The conclusion was that only Belgium considers accredited data verified by an external lab for EPB compliance of actual shading values. In other EU countries, either the manufacturer can present their own data or can have the data measured by an external (accredited) lab. National databases for building products only exist in Belgium and France. Therefore, the decision to develop ES-SDA, the European Solar Shading Database was taken.

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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EU overview showing a wide variety of default values, in some countries considered as conservative negative values (e.g. Belgium), while in other countries very close to the actual market standard (e.g. Austria). Shading can be considered in g-tot or Fc. The g-tot means the solar factor of the glazing and the shading together; the Fc or shading factor is the ratio between the g-tot and the g-value of the glazing only.

Country	Shading in EPB	Methodology
Austria	Prevention of overheating	Fc = 0,15/0,25/0,50 (external/interpane/internal) or EN 13363 g-value
Belgium	Prevention of overheating	Fc = 0,50/0,60/0,90 (ext/interpane/int) or accredited value
Denmark	Yes	Actual g-value; automation/manual
Finland	Yes	
France	Detailed	At least 24 actual values; automation/manual
Germany	Yes, DIN 4108-2, 18599	Actual Fc value
Greece		
Hungary	Prevention of overheating	
Ireland	No	
Italy	Yes, UNI 11300 (13790)	Actual g-value, external
Malta	Yes	
The Netherlands	NEN 7120 (13790)	Fc = 0,30 (external)
Norway	Yes	
Poland	Yes	Default values
Portugal	Yes	
Spain	Yes	Actual g-value
Sweden	No (no EPB calculation)	Dynamic simulation
Switzerland	Yes	
UK	Only non-residential	Default g-value

How to get a reliable validated database for solar shading properties

The designed ES-SDA procedure is compatible with the former existing European Window Information Systems - WIS database for glazing and solar protection devices (WIS has been developed in the beginning of 2000 as part of European Union funded activities).

The same principles are followed, meaning shading and shutter devices values are measured or calculated according to standardised methods. Testing must be done in independent labs with calibrated instruments according to Standards.

The verification of the submitted data follows in accordance with a peer review procedure executed by experts of the profession. Samples of the tested materials are also included in the verification process.

For each product, spectral optical data are given within a determined wavelength starting at least at 200 nm up to 2,500 nm taken at 5 nm intervals. Optical properties are designated on total normal hemispherical transmittance and reflectance surface for direct and diffuse components.

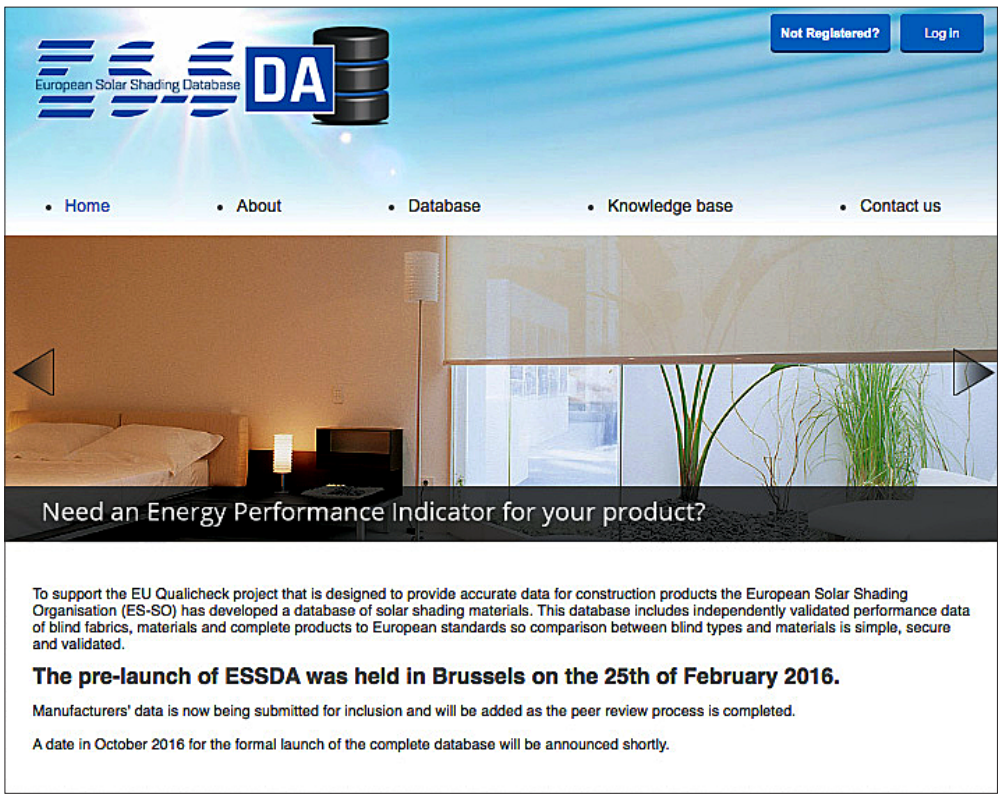
Fabric and material suppliers can submit their data but manufacturers can also submit data related to the finished product. Specific data on emissivity, conductivity, IR transmittance, Delta R that is not derived from the testing can be added.

Integrated values will be calculated by ES-SO as part of the review process in accordance with the procedures defined in EN 13363-1 (soon to become ISO 52022-1). Tests from an external accredited lab (or external accredited labs) are required as a principle. As an exception, manufacturers who test their own products must prove they perform tests according to the same Standards as an accredited independent lab. In addition, 5% of the products are selected by ES-SO for testing by an external accredited test lab in order to compare with the manufacturers' test results.

Where the finished product manufacturer submits an application, a reduced procedure may be followed if they refer to the materials already present on the database.

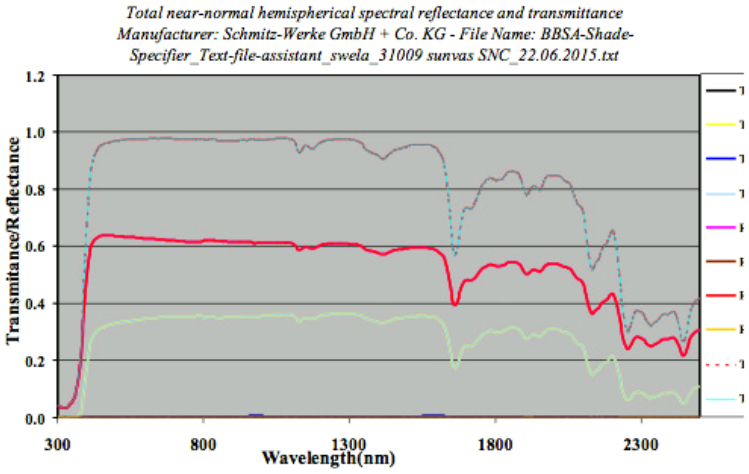
ES-SDA is a comprehensive single source of performance shading data with easy accessible reliable output for many usages

ES-SDA will take performance data of fabrics and materials when combined with reference (typical) glazing and calculate a wide range of outputs such as U-values (heat retention) to Gtot (heat rejection) and Visible Light Transmittance known as Tvis.



A web tool is provided to submit and to peer review the data.
Results will be available on the ES-SDA website: http://es-so-database.com/

ES-SDA will include data on all properties of shading and as it is web based it will be free to access anywhere. The database is searchable by supplier so it's easy to find data. There is an increasing demand from architects for accurate performance data and ES-SDA provides exactly that. Engineers are also using this data in building modelling to get an accurate calculation of the benefits of solar shading, probably for the first time. There is also an international angle. ES-SO has been liaising with the team at Lawrence Berkeley National Laboratory who are working on a similar solution for North America.



An example of spectral curves resulting from the calculation of the web tool..

As updating of the database will be key, ES-SO considers the ES-SDA European solar shading database as one of its essential cornerstones embedded in the objectives of the association. A training tool is being prepared for the industry to participate and to understand the importance of the shading performance values for their industry.

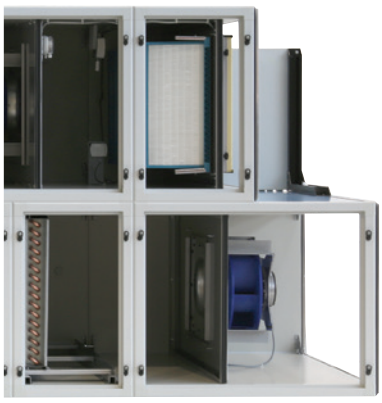
In a recent study commissioned by ES-SO in 2014, it was concluded that shading and shutters used on 75% of the windows in Europe could save 19% up to 22% energy consumption and CO2 emissions in buildings (depending on a split of energy cooling: heating of 30/70 up to 50/50). See the summary report *.

To conclude, ES-SDA is conceived as a further step for the industry to have included shading and shutters as a reliable solution for energy savings, CO2 reduction and as a healthy indoor solution in renovation and new build. ■

* http://es-so.com/images/downloads/Downloads%20publications/ES-SO___15-498_Extended-Executive-Summary_September-2015.pdf

ADV Next Air

The air treatment evolution



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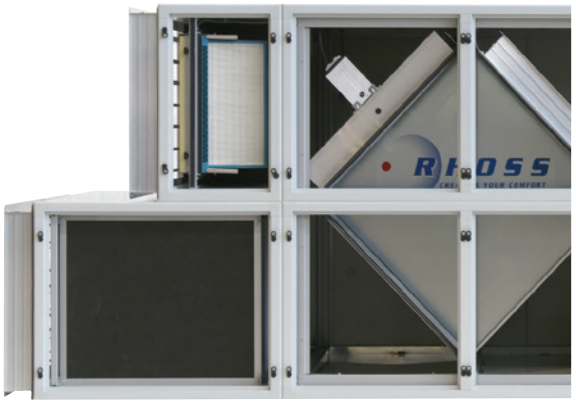

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Cool Roofs in the European context

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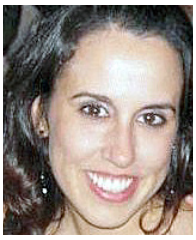

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The status of cool roofs in the European context is presented. Various definitions of cool roofing materials are analysed and presented. The promotion and rating of cool roofs in Europe is pinpointed. The European legislation as well as the challenges for cool roofs' products in the European context is discussed.

Keywords: urban heat island, cool roofs definitions, standards, European policy

Increased urban temperatures have an important impact on the energy consumption of buildings mainly during the summer period. Heat island is the most documented phenomenon of climatic change. Heat island is related to the increase of urban temperatures compared to the suburban areas because of the positive heat balance.

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 [1], [2]. Heat transfer to the internal space by conduction is therefore reduced while the magnitude of the reduction will be determined mainly by the solar radiation intensity, the temperature difference between inside and outside as well as the constructional characteristics of the roof. The extent of cool materials usefulness is dependent on the severity of external conditions and internal heat gains [3].

The effect of cool materials in hot climatic conditions are studied by various researchers [4]–[7]. In most cases a reduction of the cooling load of almost 20-40% is revealed by the application of cool roofs while a consid-

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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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erable indoor comfort improvement is noticed [8]. Moreover, the energy efficiency attributed to cool roofs ranges between 2.5-10 kWh/m2 (with average of 6.25 kWh/m2) of roof. For houses and offices that are not air conditioned, cool-coloured roofing materials offer comfort, typically at very reasonable costs. Assuming an emission rate of 750 gCO2/kWh of electricity savings, the annual CO2 savings ranges from 1.9 to 7.5 kg/m2 of roof area with 4.7 kg/m2 of roof surface as an average [9]. The way cool roofs operate is depicted in **Figure 1.**

The aim of the present work is to outline the efforts performed in the European context for the promotion of the cool roofs.

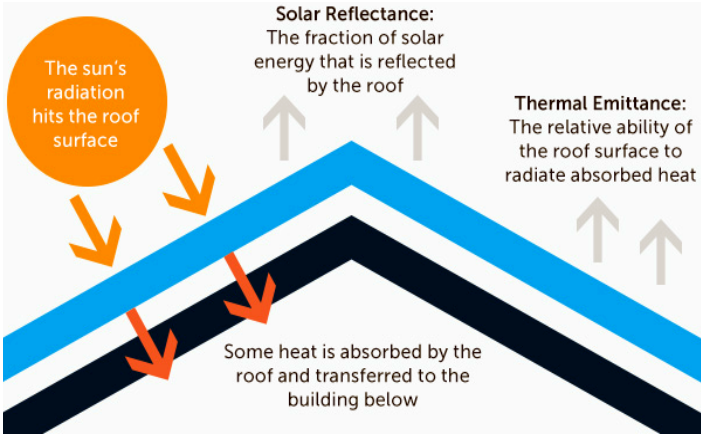

Figure 1. The cool roofs optical properties.

Cool Roof materials definitions worldwide

Cool roofing products are made of highly reflective and emissive materials that can remain substantially (e.g. 30°C) cooler than traditional materials during peak summer weather.

Building owners and roofing contractors have used these types of cool roofing products for more than 20 years to reduce the energy consumption for air conditioning devices.

The main difficulty is that roofing materials are exposed to weather and pollution. Their initial values in the virgin state will vary over time, depending on location, climate and surrounding. Therefore, their ageing characteristics are very important. For that reason, the various organizations such as CRRC (Cool Roof Rating Council) provide or should provide data on the cool roofing products exposition at various climatic conditions and pollution.

The main definitions of cool roofing materials are tabulated in **Table 1.** As we can see different programs have different definitions of a cool roof.

Cool Roofs' products

The various cool roofs' products that exist in the market are described in this section. Two main categories are described [10], [11], i.e. the prefabricated and the on-site application cool roofs.

Table 1. Cool Roofs' definitions worldwide.

		Solar Reflectance	Thermal Emittance	Solar Reflectance Index
ENERGY STAR®	Low slope (1) Initial Aged (2)	0.65 0.50		
Green Globes™	Initial	0.65	0.90	78 (3)
California Title 24	Low slope Aged (2)	0.63	0.75	75 (4)
USGBC LEED, v2009	Low slope, initial			78 (3) (min 75% of roof)
USGBC LEED, v4	Low slope Initial Aged (2)			> 82 > 64
ASHRAE Standard 189.1	Low slope			78 (min. 75% of roof)

(1) A roof surface having a maximum slope of 2 inches rise for 12 inches run.
(2) Three years' exposure.
(3) Roughly equivalent to, for example, 0.65 reflectance and 0.90 thermal emittance, although a number of different combinations of reflectance and emittance can achieve this value.
(4) May not apply in every climate zone.

Concerning the prefabricated type, cool roofs are manufactured in a factory and arrive on site as a prefabricated unit, making it quick and easy to install. The largest use of prefabricated roofs is new-build construction. The 'cool' component of the roof is applied as part of the manufacturing process, often in the form of a cool coating or solar reflecting granules. Some examples include:

Single-ply Membranes: Single-ply roofing is a flexible or semi-flexible roof membrane typically constructed using bitumen, rubber or plastic. They are supplied on rolls of 15 to 40 meters' length and 1–3 m width. The thermoplastic single-ply membranes are PVC or TPO based with built-in reinforcement layer(s) and they are mechanically or adhered fastened.

Coated Metal Roofs: A range of metals is used in the manufacture of coated roofs with the majority being steel-based although aluminium can be used as an alternative. Metal roofs can be sold as panels or tiles and are considered very durable, with service lives of many years (some have guarantees over many decades).

In Cool Roof On-Site products roofing type the cool element such as a coating, a membrane or roofing felt, is applied in the field directly onto the roof structure. The material can be applied in situ to almost any roof substrate ranging from flat bitumen to metal and is used widely in the refurbishment sector for cool roofs. Some examples include:

Applied Roof: Coatings It may be argued that applied coatings should be considered part of the coatings sector. We choose to include it in the cool roof landscape because applied cool coatings are being used to turn existing roofs into 'cool' ones. Cool coatings come in a range of colours and solar reflectance values.

Elastomeric Roof Sub-Segment: Elastomeric roofs can also be called thermoset membrane or rubber roofing and are a flexible membrane system based on compounded rubber materials.

Cool Roofs in the European context

In Europe, the foundation of the European Cool Roofs Council (ECRC) has given an important boost in the cool roofs technology and market. The European Cool Roofs Council is a non-profit European association aiming to develop scientific knowledge and research in relation to "cool roof" technology and to promote the use of cool roof products and materials in Europe, including developing a product rating programme for such products and materials. It is a voluntary organisation that brings value by promoting the benefits of cool roofing products to regulators, policy makers, consumers and other stakeholders.

The ECRC has three strategic objectives:

1. Formulation of cool roof product rating programme in Europe.
2. Inclusion of cool materials in European Standards, Energy Assessment Methods.
3. Promotion of the benefits of cool materials to engineers, stakeholders, etc.

In achieving these objectives, the ECRC has launched the ECRC initial product rating program in 2015, participates in relevant CEN committees for measurement standards development and collaborates with a public affairs and communications company in order to position cool roofs as a sector of importance to relevant EU policies.

The interlaboratory comparison

As stated previously, one of the core objectives of the ECRC is the development of a Product Rating Programme, in which roofing product manufacturers will be able to label various roof products with radiative property values rated under a strict programme administered by the ECRC. The radiative properties that are reported by this product rating program are the solar reflectance and the infrared emittance.

In order to provide the ECRC with information regarding its product rating programme an interlaboratory comparison (ILC) of the measurement methods of reflectance and emittance has been organized and conducted between 12 European laboratories able to perform (one or more) of the above mentioned measurement procedures. The main results of the ILC are summarized below: Regarding the measurement of reflectance using a spectrophotometer equipped with an integrating sphere and the differences in the average SR values determined by using different solar irradiance spectra, it was found that the observed differences are in the range of 0–4%SR and they are more important for spectrally selective materials. These differences contribute to the total uncertainty of the measurement method indicating that the use of single solar spectrum would provide comparable and "fair" results in the framework of a product rating programme. A strong correlation between the SR determined by a spectrophotometric techniques and reflectometers was found indicating that both method can be used for the determination of the solar reflectance. Also ASTM and EN standards for the measurement of thermal emittance using portable emission meters gave comparable results for infrared emittance of flat roof products.

Aiming to assist in the development of a European standard for the measurement of solar reflectance and infrared emittance, the ECRC has identified and participates in a CEN Technical Committee (CENTC254, WG16) working on this subject and has provided this information to facilitate the WG's work. The work within this Committee is still ongoing.

The product rating program

In 2015 the ECRC Product Rating Program was launched. The purpose of the ECRC product rating program is to provide a uniform and credible system for rating and reporting the radiative properties (solar reflectance and thermal emittance) of roofing materials. In the framework of this program, manufacturers and sellers have the opportunity to label roofing products with the measured values of their Initial Radiative Properties. These properties are determined and verified through testing by accredited/approved testing laboratories and a process of random testing of rated products. Laboratories participating in the ECRC product rating program should be ISO17025 accredited (or under accreditation) for the measurement methods adopted by the ECRC and should participate in specific quality assurance procedures. Any roofing product can be tested as long as it is in compliance with the specifications and requirements defined in the ECRC Product Rating Program Manual. Rated products are granted the ECRC label and are published in the ECRC Rated Products Database on the ECRC website. Furthermore, taking into account that in order to assess a cool roof product's long-term performance it is necessary to measure the aged product's radiative values, the ECRC is currently actively working towards adopting a system for the rating of aged products. Aging, caused by weathering and soiling [12], [13] can alter the radiative properties of roofing materials and significant differences in the ageing process have been recorded among product types & different climatic conditions. Products suffer significant loss of SR, especially those with high initial solar reflectance while products with very low initial solar reflectance (SRin<0.2) tend to become more reflective as they age. Ageing significantly affects the performance of cool roofs by increasing the roof surface temperature and by reducing, the cooling load savings by an average 20–30% and therefore aged cool roof product rating is critical. The ECRC aged product rating program will consist of natural weathering for a period of three years in weathering test sites located in European climatic regions that represent the anticipated cool roof market in Europe.

The EU legislation and perspectives

Cool Roof Council aims to raise industry profile at a European Level. Initially ECRC has identified three key objectives that must be achieved for the success in raising the profile of passive cool roof solutions. The most important step here is to enhance the visibility of the ECRC so that it becomes an instantly recognizable organization to relevant policy makers generally.

Moreover, ECRC aims to have that level of organization knowledge in place and a clear understanding of policies currently open for debate, where we can inform the positive attributes of cool roof technologies and how these capabilities can be part of the solution to mitigate climate change.

Finally based upon these two foundation blocks to be able to clearly articulate and position the benefit of the cool roof sector appropriately in difference EU policy areas.

Five initial areas of possible policy interest have been identified with specific insight provided on each individual area, timelines what kind of debate may be possible. Those are:

- Directive on Energy Performances in Buildings: is one of the Eu's main pieces of legislation when it comes to the consumption of energy in buildings and was identified as open for review during 2016.
- Energy Efficiency Directive: which in the future will work towards the establishment of a set of binding measures to help the EU reach its energy efficiency targets for 2020.
- Heating and Cooling Strategy: which is seen as a first step towards and integrated approach to heating and cooling policies under the EU energy legislature.
- Circular Economy Package: The new Circular Economy Package (CEP) was published by the European Commission on 2 December 2015.
- Renewable Energy Directive Developing an overall policy for the production and promotion of energy from renewable sources in the EU.

As this work has developed ECRC recognises the need to have very clear unambiguous articulate messages that clearly explain the objectives and the benefits of cool roofs. The main benefits that should be communicated are included in **Figure 2.**

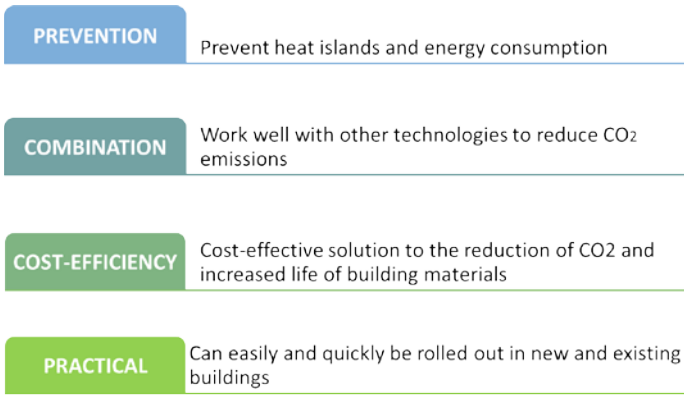

Figure 2. The main benefits of cool roofs.

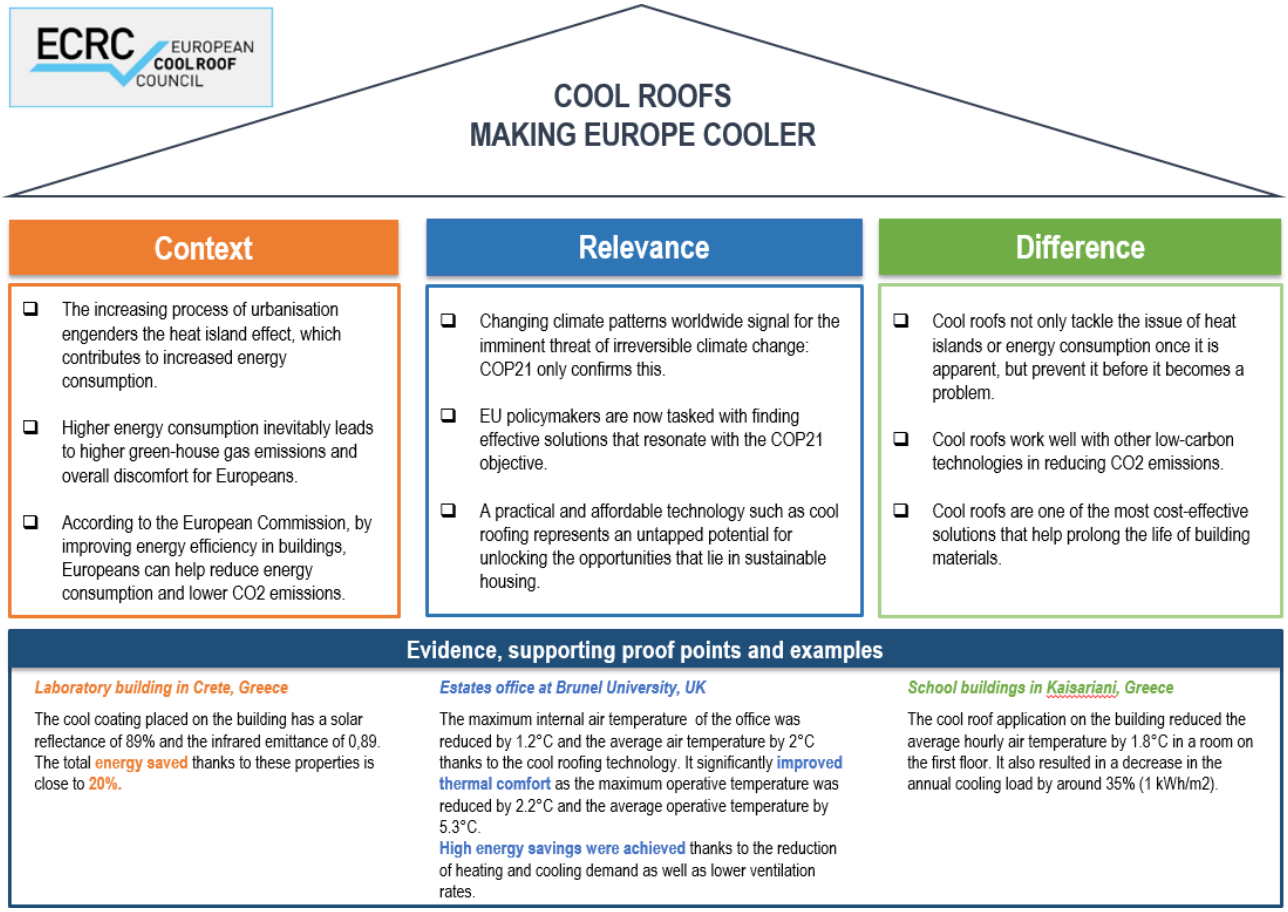

Figure 3. The message house for cool roofs.

The approach being taken to develop this for the ECRC is to create a message house approach. The message house is depicted in **Figure 3**. The context, relevance and difference of cool roofing technology supported by evidence, proofs and examples leads to the main message which is "Cool Roofs can make Europe cooler".

Conclusions and prospects

Cool materials are an environmentally friendly and passive technique that contributes to achieving energy efficiency in buildings by lowering energy demand for cooling and improving the urban microclimate by lowering surface and air temperatures. The various types of cool materials and cool roofs are analysed showing that there is a significant variety that can cover all applications ranging from on-site paints to tiles and membranes. Significant progress is performed in international level to define the characteristics and properties of cool materials both in initial and aged state. In terms of the European policies, cool roofs can play a significant role to at least four objectives, namely the Directive on Energy Performances in Buildings, the Energy Efficiency Directive, the Heating and Cooling Strategy and the Circular Economy Package. A clear understanding and further promotion is needed in order to include cool materials' properties in the EU standards. European Cool Roofs Council has a great challenge towards that direction. ■

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QUALICHeCK Overview of EPC compliance and quality issues on the ground


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EPBD directive 2002 and its recast 2010 have led to significant efforts in EU Member States to improve the energy performance of buildings. The compliance of energy performance assessments and quality of works are increasingly important aspects needing continuous attention and well developed procedures in order to be able to achieve stringent energy and indoor climate targets in practice.

Keywords: compliance assessment, energy performance minimum requirements, overheating, energy performance certificate, quality of works, compliance framework

To understand the status on the ground QUALICHeCK project conducted a review of 31 previous studies dealing with measured performance, reliability of input data, quality of the works and compliance frameworks. Additionally, 10 field studies were conducted in 9 focus countries. These studies covered all main technology areas:

- Transmission characteristics and air tightness
- Ventilation systems
- Summer thermal comfort solutions
- Renewable systems (heat pumps, thermal solar, PV)

Five of the field studies analysed EP compliance and EPC input data quality by site visits, check of design documentation and new energy and EPC calculation to compare actual and reported energy performance. One study was devoted for summer thermal comfort compliance, including temperature measurements in Estonian apartments, check of design documentation and temperature simulations based on actual solutions checked by site visits. Reliability of EPC issued with different calculation methods was studied in Spain. Last three studies worked with transmission characteristics including quality framework for cavity wall insulation and input data on window thermal performance in Belgium and U-values compliance in Cyprus.

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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Most of the studies raise questions related to compliance frameworks. Often compliance frameworks stopped to schematic design/building permit and the final design, construction phase and as-built energy performance was not controlled after the building permit was issued. Only 4 out of 9 countries had compliance frameworks extended to final design and construction and commissioning phases, **Table 1**. This means that the rest 5 countries did not have clearly defined control mechanism and related practices how to take into account changes in final design and production information as well as design changes during construction. No common practice was found from commissioning procedures, which were typically not EPBD driven and were not clearly required, but more related to good practice.

Sweden uses different approach from other countries when issuing EPC. EPC in Sweden is based on measured energy use and EPC is to be issued within 2 years after taken in use. The measured energy use is corrected for the reference year, and should also be corrected for normal use, but as no standard methodology is available this is seldom done.

313 newly built houses were studied in Sweden. Of these 100 houses had been taken in use two years prior to this study and only 44 EPCs were available, which means that only 44% of the buildings complied with the requirements of the EPBD. So far no court cases of home owners lacking EPCs and the authority Boverket have not reported and legal actions to force homeowners seem to be difficult if houses are not sold or rented, when EPC is required and well available.

Swedish study compared calculated and measured energy use in studied buildings. In majority of cases the deviations were reasonable, but in some cases the deviation was much higher than the ±10% band shown in **Figure 1**.

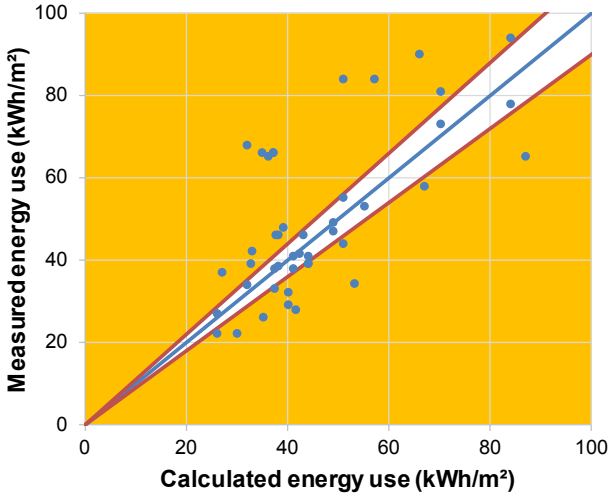

Figure 1. Comparison of measured and calculated energy use in Swedish houses.

Table 1. Overview of time frames for energy assessment requirements for new buildings in 9 countries.

Assessment type[a] →	Calculated (asset)			Measured (operational)
Sub-type[a] →	Design		**As-built**	Actual
Typical time frame →	Building permit		**After completion of the works**	<2 years after completion
Used for EPC →	Yes	No	**Yes**	Yes
Country ↓				
AT	•			
BE			•	
CY	•			
EE	•			
ES		•	•	
FR		•[b]	•	
GR				
RO		•[b]	•	
SE		•[b]		•

[a] Defined in EN/ISO 52000-1:2016 [b] Not based on EPC method

Smaller difference than 10% is considered acceptable according to Sveby guide. 29 houses out of 44 (66%) had a larger difference than 10%. The average difference was 25%, max difference has 113% larger measured energy use than calculated. Since the calculations are performed at an early stage and may not have been updated with the latest drawings and information. It was shown that the difference was larger for houses heated by exhaust air heat pump than for houses heated by ground source heat pump.

Estonian study was focused on summer thermal comfort. In Estonia EPBD Annex I requirement: "1. 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 ..." is addressed by a requirement not allowing to exceed +27°C more than 150 Kh (Kelvin hour) in residential buildings and +25°C more than 100 Kh in non-residential buildings from June 1 till Aug 31, to be simulated with standard building use and test reference year. The principle of the temperature simulation based requirement is shown in **Figure 2**.

This relatively new requirement was not yet well established in practice as in many cases no evidence of compliance was provided in the building permit design documentation and simulations conducted for real apartments showed overheating in 68% of studied apartment buildings, **Figure 3**.

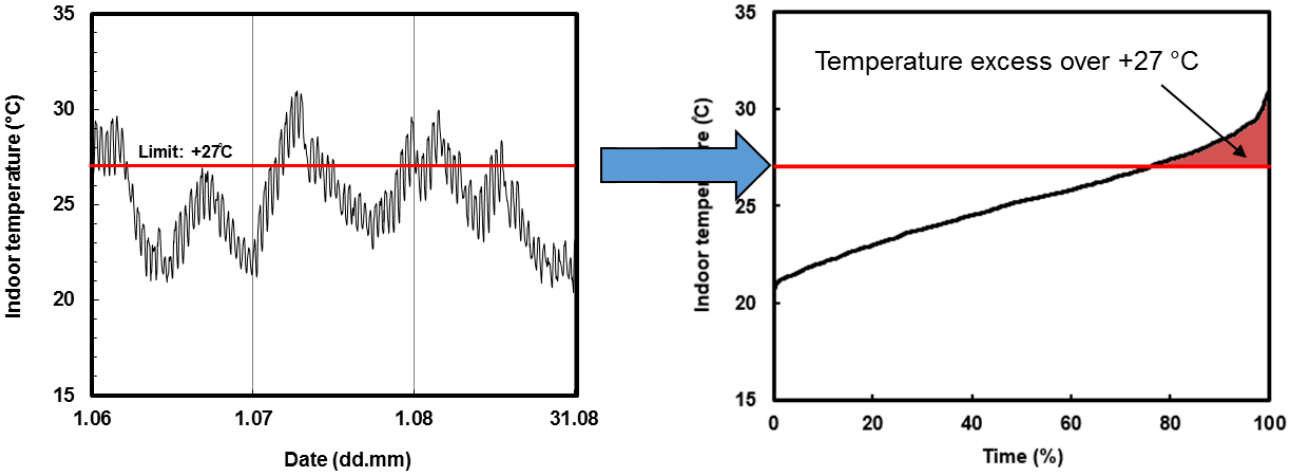

Figure 2. Estonia limits temperature excess over 27 °C to 150 Kh in residential buildings, to be proved by dynamic temperature simulation in critical rooms.

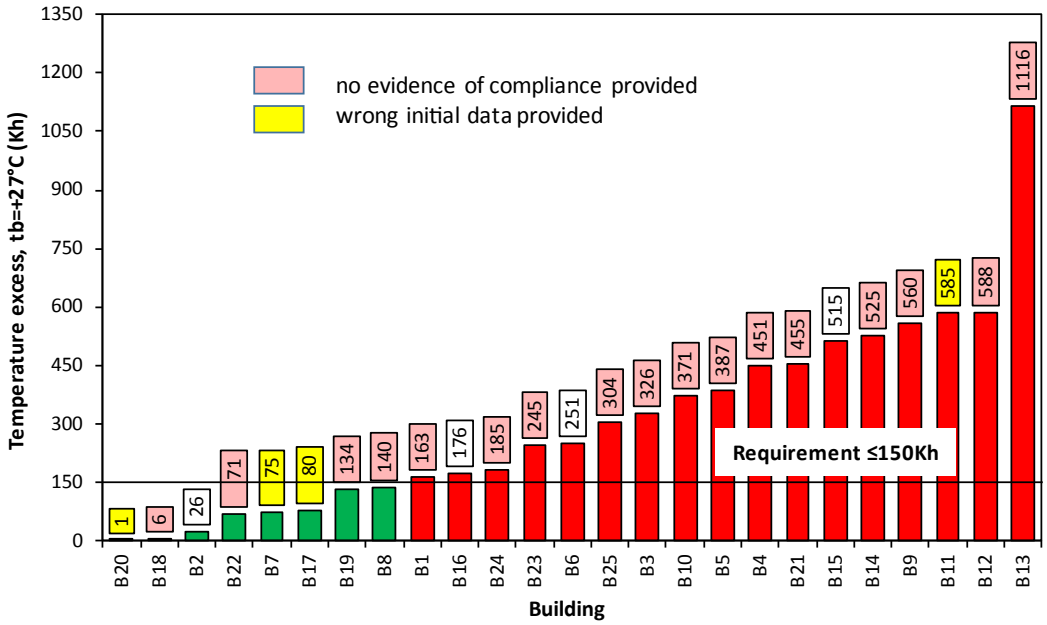

Figure 3. Assessment of overheating index in 25 buildings (based on simulated hourly mean room temperature in degree-hours above 27°C in "worse case" dwellings between 1st of July- 31st of August).

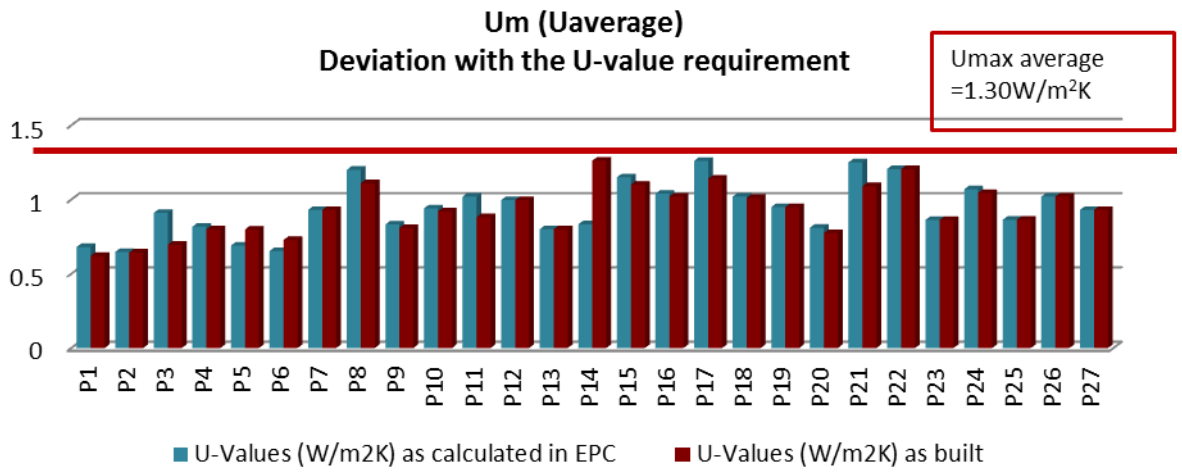

Figure 4. As built U-values comparison to design values in Cyprus.

Estonian study resulted in rule of thumbs how to prevent overheating. In the case of South oriented windows an overhang (by balconies) 0.7 times window height was enough, and for West oriented windows window-to-wall ratio times solar factor no more than 0.2 avoided overheating.

In Cyprus, the compliance with relatively new U-value requirements was studied. Quite modest average U-value requirement of U_{max} = 1.3 was met in all buildings and deviations with design values were reasonable, **Figure 4**.

In Romania EPC-s of 26 residential buildings were recalculated. Compared to existing ones, many deviations were found caused by incorrect calculations, deviations in the assumptions and calculation of input data (net floor area, heated volume, U-values, heat transfer area of building envelope etc.) and by the differences caused by software tools used. As a result, 50 % of the buildings had more than one class higher energy use for space heating and 39 % of the buildings had at least one class higher total energy use, **Figure 5**.

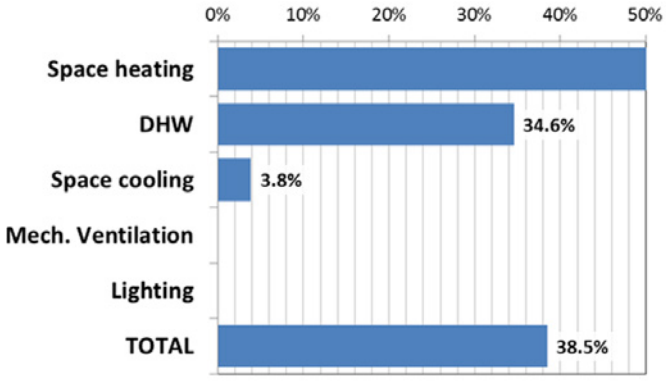

Figure 5. Percentage of EPC-s with more than one class deviation in Romania.

Results reported in this article provide only small insight to QUALICHeCK project results. Outcome of the literature review can be found from the Status on the ground report*. Based on these 31 studies it can be concluded:

- Poor ventilation is seen as a major European problem as ventilation rates and noise typically did not comply with requirements;
- Ductwork air tightness is an issue in Central Europe, but was solved 30 years ago in North Europe;
- Building leakage showed both good and bad examples;
- Studies on transmission characteristics were quite limited and mostly inconclusive;
- Heat pumps, solar thermal and other renewables showed good performance if certified installers type schemes were applied;
- Available data on summer thermal comfort was very limited however the issue was somehow addressed in majority of building codes.

Field studies conducted by QUALICHeCK show:

- In many countries development with 5 years' step can be seen – new requirements and procedures 2007, 2012 etc. have been launched;
- Systemic changes evidently will need time, legislative changes are to be supported with relevant compliance procedures, supervision, commissioning, performance measurements, piloting, model solutions, guidelines, training etc.;
- More ambitious and sophisticated systems (such as Estonian and Swedish examples reported here) more difficult to implement in practice – longer learning curves;
- Compliance frameworks are to be extended in many countries in order to be able to assess as built performance – in about half of studied countries control mechanisms stopped to building permit phase. ■

* http://qualicheck-platform.eu/about/situation-on-the-ground/

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

QUALICHeCK International Workshop on summer comfort technologies in buildings: content and major outcomes

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This article provides a summary of the QUALICHeCK project International Workshop on summer comfort technologies in buildings which focused on voluntary and regulatory frameworks to improve quality and compliance of solar control, cool roofs and ventilative cooling. The Workshop attracted the interest of 90 experts of public and private bodies involved in the field of energy performance of buildings and of the construction sector from 10 countries.

Keywords: summer comfort, compliance of EPC data, quality of works, solar control, ventilative cooling, cool roofs

During the international workshop held in Athens, Greece on 9–10 March 2016, 90 participants from 10 countries exchanged their experience and views on proper consideration of summer comfort technologies in energy assessment procedures, with a specific focus on solar control, ventilative cooling and cool roof products and systems.

The workshop included general presentations on the overall context of energy conservation and thermal comfort in buildings. More specifically, the challenges of thermal comfort for our societies in terms of mortality and well-being, economy, and environment were discussed [1]. Furthermore, climate change combined with critical constraints set by the urban environment both amplify those problems and compromise the extended use of renewable energy sources [2].

Although it is now recognised that solar shading, inertia, and ventilative cooling should be prioritised before considering active systems even in North European regions, this was mostly ignored in European regulations and standards until the mid-2000s as reflected by the poor consideration of summer comfort issues in EN832:2000 [3]. Fortunately, several recent initiatives aim to improve this situation.

[1] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-1.2-Santamouris.pdf
[2] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-2.3-Fintikakis.pdf
[3] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-1.3-Molina.pdf

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The European Solar Shading Organisation (ES-SO) should have, by the end of the year 2016, an on-line access database including all key characteristics – reviewed and determined in accordance with existing standards – that are necessary for dynamic energy modelling. This would a be major step to help designers and consultant engineers easily access input data for energy performance assessment methods, and thereby remove a major barrier to consider the benefits of these technologies at the design stage [4], [5], [6]. ES-SO acknowledged the existence of pre-conditioned or mandatory recognition/certification of persons and companies in France or the UK, as well as technical approvals and labels that support quality and transparency for customers [7].

It was shown that ventilative cooling can be very effective at reducing the overheating risk, both for residential and commercial buildings. Nevertheless, one specificity of ventilative cooling is that this concept cannot not based on certified components, but rather on strategies whose performance very much depend on the strategies implemented, including effective use of building inertia and consistency with solar shading controls [8], [9].

The use of the new EPBD set of standards to fairly account for summer comfort solutions in building energy performance assessment methods was discussed [10]. This new set of standards which was developed to support the implementation of the 2010 Energy Performance of Buildings Directive covers for instance thermal comfort issues and the determination of the airflow rates – which are critical for ventilative cooling assessment. Each standard clearly shows the inputs and outputs of the calculation modules and attempts to ease quality and compliance checks with specific clauses. To cover specifically ventilative cooling, many elements are already there, but some important missing parts – regarding for instance the controls, the long-term comfort criteria, or the effectiveness of heat removal from surfaces – were pointed out [11]. The participants also discussed uncertainties and limitations regarding climate data, time steps, and zoning which may severely influence the performance assessment of summer comfort technologies [6], [8], [11].

Cool roof products reduce solar heat gain on outer building surfaces and thereby have a number of advantages including: reduced buildings cooling energy needs with estimates in the region of 10–40% on air-conditioned buildings; reduced urban heat island effect; improved thermal comfort in non-A/C buildings; improved lifespan of building materials. The European Cool Roof Council (ECRC) was founded in 2011 to promote these products, in particular, with a transparent rating programme, inclusion of cool materials in EU standards and energy assessment methods [12], [13]. Early in 2016, ECRC included in its freely-accessible on-line database the first products rated under its rating programme [14]. Nevertheless, several challenges remain regarding the characterisation of these products in real conditions, i.e., accounting for ageing and soiling effects [15].

This workshop was also the occasion to give an overview of energy saving policies implemented in Greece, in particular the results of the "Energy Efficiency at Household programme", including pre- and post-retrofit energy inspections with over 40,000 completed applications [16]. Also, a field study on 26 Greek buildings showed frequent discrepancies between EPC input data and as-built characteristics [17].

Finally, the QUALICHeCK draft source books on compliance of EPC input data and quality of the works were discussed. These draft books – available on the QUALICHeCK website – unfold 3 fundamental aspects to develop compliance frameworks: clear rules to achieve and show compliance; clear rules to handle non-compliance; elements to consider for effective implementation.

The workshop was organised by INIVE and its member NKUA (the National and Kapodistrian University of Athens) on behalf of the QUALICHeCK consortium, with the support of Sympraxis Team, and with session contributions from ES-SO (the European Solar Shading Organization), venticool (the international platform for ventilative cooling) and ECRC (the European Cool Roofs Council). ■

[4] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-3.1-Beck.pdf
[5] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-3.2-Bush.pdf
[6] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-4.1-Pollet.pdf
[7] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-3.3-Van-Eycken.pdf
[8] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-2.1-Heiselberg.pdf
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[10] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-5.1-Hogeling.pdf
[11] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-4.4-Carrie.pdf
[12] http://qualicheck-platform.eu/wp-content/uploads/2016/04/QUALICHeCK-Athens-6.1-Kolokotsa.pdf
[13] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-6.4-Evans.pdf
[14] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-6.2-Synnefa.pdf
[15] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-6.3-Meier.pdf
[16] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-2.2-Karavassili.pdf
[17] http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Athens-4.3-Karlessi.pdf

Announcement QUALICHeCK Brussels and Lyon workshops

Building envelope thermal transmission | Voluntary and regulatory frameworks to improve quality and compliance - QUALICHeCK International Workshop – 15 December 2016, Brussels, Belgium

This 1-day workshop will focus on various aspects related to EPC compliance and quality of the works. Specific attention will be given to material and system properties, handling of thermal bridges, windows and glazing, insulation of walls and super insulating materials. The precise workshop dates will be announced soon at http://qualicheck-platform.eu/events/workshops/. Interested persons can send an e-mail to peter.wouters@bbri.be.

Renewable heating and cooling systems for buildings - QUALICHeCK International Workshop - 17/18 January 2017, Lyon, France

The objective of this workshop will be to discuss and identify ways to secure the compliance of renewable heating and cooling product data as well as the quality of installed systems, thereby increasing the confidence in declared values on the Energy Performance Certificate (EPC) and achieving the expected energy performance.

The systems covered provide heating, cooling and domestic hot water to residential and commercial buildings from renewable energy sources: solar thermal, heat pumps, geothermal, biomass, photovoltaics.

Three aspects will be more specifically addressed:

- how to provide compliant input data used to issue an Energy Performance Certificate;
- how to improve the quality of the installation works;
- how to enforce compliance, and how to define/apply penalties in case of non-compliance.

The Workshop will be held at CETIAT. The detailed programme is under construction.

Apart from members of the QUALICHeCK consortium, the very first confirmed speakers are representatives of: AQC (Agence Qualité Construction), EHI (Association of the European Heating Industry), RHC Platform (European Technology Platform on Renewable Heating and Cooling), UNICLIMA (Syndicat des Industries Thermiques, Aérauliques et Frigorifiques),...

A visit of CETIAT laboratories will be part of the Workshop: testing of heat pumps and wood heating appliances, systems for practical training of installers and maintenance staff.

More information will be available in the coming months at: http://qualicheck-platform.eu/events/workshops/.

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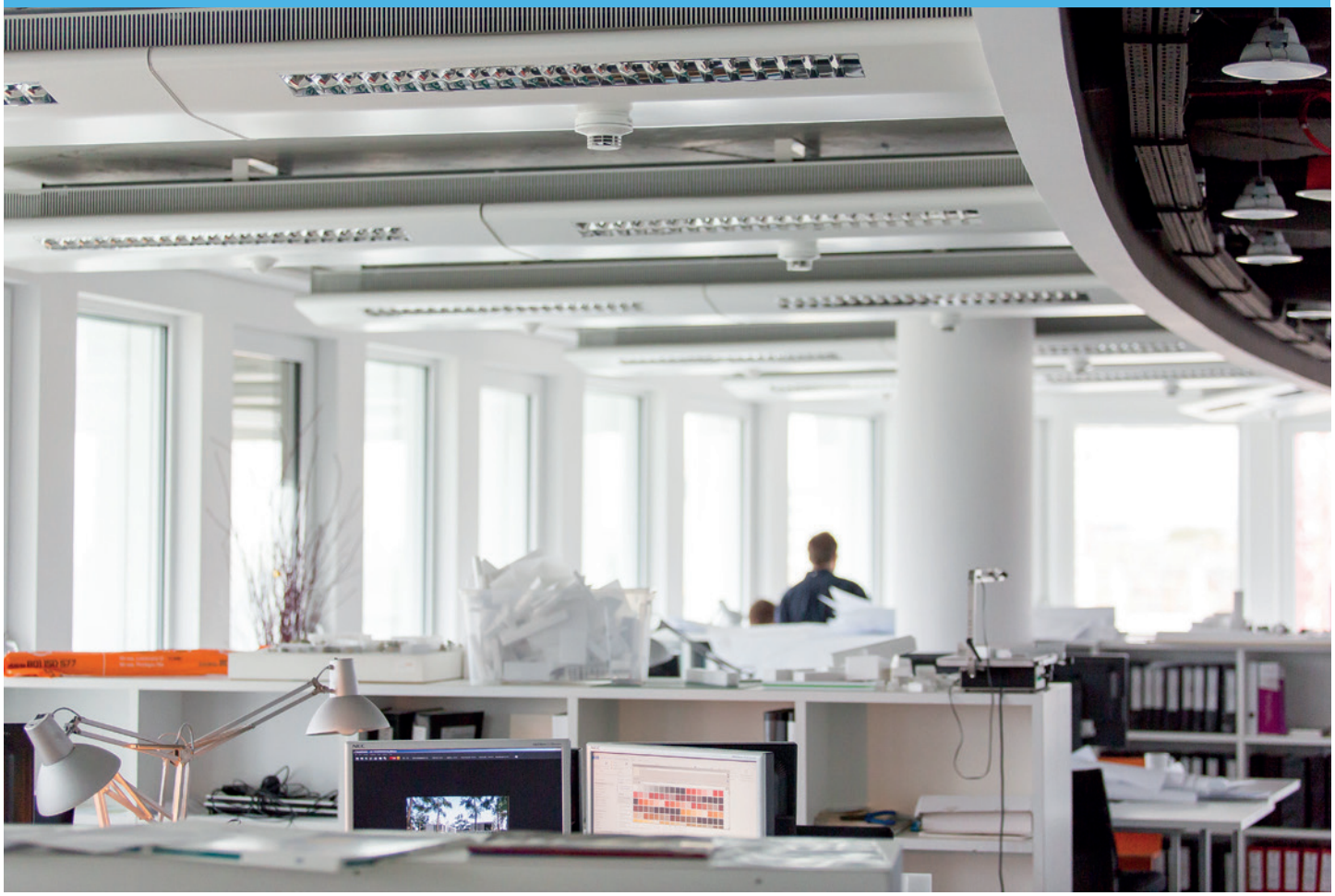
A Class

indoor environment

as defined by
ISO - EN 7730
EN 15251
CR 1752



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A summary of QUALICHeCK factsheets

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.

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

This article summarises the information presented in the factsheets made available by QUALICHeCK until June 2016. Additional factsheets have been published since, focusing mostly on the present "Status on the Ground" in the focus countries examined by the project.

Status on the Ground

Lågan Programme for Buildings with Low Energy Use (FACT SHEET #10): The Lågan programme (financed by the Swedish Energy Agency) reports about low energy buildings in Sweden; in addition, by providing grants for demonstration projects and regional/local cooperation initiatives, Lågan aims to increase the number of low energy buildings. So far the conclusions of the Lågan programme are that there is a slow but increasing market development. The average building cost for low energy buildings is approximately 7% higher than for buildings meeting the general energy performance requirements (BBR 16, 18 and 20).

Sveby Standardise and Verify the Energy Performance in Buildings (FACT SHEET #11): To get a building permit for a new building or for changing an existing building in Sweden, an energy use calculation has to be handed in to the municipality. In general, the calculated energy use for heating, cooling, operation of HVAC systems and domestic hot water should be equal to or lower than a defined maximum value. The calculation and verification of the energy performance in buildings in Sweden are not standardised processes. Sveby ("standardise and verify the energy performance in buildings") is a scheme which aims to clarify and ensure the quality of the entire building process from early stage design requirements to verified results. Sveby is a voluntary national scheme involving major actors in the Swedish building sector aiming for increased compliance with the Energy Performance of Buildings Directive (EPBD).

Compliant and Easily Accessible EPC (Energy Performance Certificate) Input Data

French voluntary scheme for harmonised publication of ventilation product data (FACT SHEET #03): This scheme has been launched in 2012 by Uniclima, the French association of ventilation product manufacturers. It ensures that product characteristics are provided under a harmonised form (same physical quantity, unit and assessment method), and facilitates access to relevant input data for the energy performance calculation of a building. The scheme also contributes to enhancing the compliance of published data.

European voluntary rating programme of cool roofing products (FACT SHEET #04): Cool roofing products are products applied to the roof of a building in order to keep roof surfaces cooler under the sun and thus minimise solar heat gain through the roof,

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especially in the hot season. These products both reflect solar radiation (high solar reflectance) and release absorbed heat (high infrared emittance). In order to provide easy access to relevant and compliant input data for the calculation of a building's energy performance, the European Cool Roofs Council (ECRC), has developed a voluntary product rating programme for such products. Any product may be rated regardless of the reflectance and emittance values, as long as it is tested in accordance with ECRC's programme requirements.

Voluntary scheme and database for compliant and easily accessible EPC product input data in Belgium (FACT SHEET #05): The "EPB product database" is an effective scheme to improve the compliance and easy access to product characteristics used as input data for the EPC calculation. The scheme has been accepted by the market since many years. Compliance of product data is improved by third-party controls, and the recognised product data is published on a specific web page, making it easily accessible. This Belgian scheme was first developed in the context of EPC for new buildings, residential and commercial; nevertheless, the scheme is also used in the context of EPC for existing buildings.

Quality of the Building Works

Building regulations can foster quality management — the French example on building airtightness (FACT SHEET #01): A quality management scheme has been introduced in the French energy regulation to encourage professionals to question their current practice and find effective solutions to improve building airtightness. The scheme allows successful applicants (mostly builders of single-family dwellings) to justify a given airtightness level without systematic third-party testing. Instead, they should set up a quality management (QM) approach for the whole building process, and this approach has to be approved by a national committee. At the end of 2014, 81 such QM approaches have been approved representing a production of about 15.500 buildings per year.

The German contractor's declaration: supporting compliance with minimum energy performance requirements (FACT SHEET #02): This new obligatory scheme introduced in Germany requires contractors to confirm in writing that specific minimum energy performance requirements are met during the realisation of a renovation measure. The requirements cover building envelope components, space heating and hot water generation and distribution systems, and newly installed cooling and ventilation systems. Infringements lead to fines.

Quality control of Stuttgart's retrofit standard realised by the city's energy consultancy office (FACT SHEET #08): The City of Stuttgart's Retrofit Standard comprises various steps to achieve the energy-efficient retrofit of both residential and non-residential buildings. This includes the construction supervision, for which the City's Energy Consultancy Office (EBZ) provides qualified experts. In this process, the interfaces between the different trades/works in particular are checked and documented. Moreover, EBZ-trained craftsmen are introduced who are able to install state-of-the-art energy saving measures, in accordance with the respective manufacturers' instructions. This ensures high quality of implementation and durable buildings.

AMA – General material and workmanship specifications (FACT SHEET #09): AMA is a reference framework describing requirements on materials, work and results related to all types of building projects. It is made available for the following areas: site work, building construction, heating, sanitation and ventilation, cooling technology and electricity. AMA also includes administrative rules and recommendations. The scheme has been used in Sweden for more than sixty years. Between 90 and 95% of all building projects in Sweden refer to AMA in the contract documents.

Compliance and Effective Penalties

Regulatory compliance checks of residential ventilation systems in France (FACT SHEET #06): In the French context, regulatory compliance checks on samples of the yearly production of new buildings have been introduced since the early 1970s, to urge contractors and project owners to build according to the rules set by the building code, and to monitor the application of the regulations. These checks cover the compliance to the ventilation regulation. The analysis of results of checks to residential ventilation systems shows a significant rate of non-compliance, i.e. of the order of 50%.

Building airtightness in France — regulatory context, control procedures, results (FACT SHEET #07): The French energy regulations have included since 2006 a significant reward for good airtightness, combined with a minimum requirement for residential buildings in the 2012 version of the regulation. Airtightness test results show that the average building airtightness performance has improved by nearly 50% in single- and multi-family buildings since 2006 and now stabilises below the minimum requirements. ■

CEN and ISO standards on energy performance of buildings

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Chair of CEN TC 371 Program Committee on EPBD; Chair of JWG of ISO TC 163 & 205 advisory group on coordination of ISO and CEN Work on EPB
Fellow of ASHRAE, Fellow of REHVA

The Recast-EPBD[1] requires an update of the current (2007/2008) set of 52 CEN-EPB standards. This update work started in 2012 and will result in a new set of CEN-EPB standards. Where possible this work is done parallel with ISO. This project is based on EU-Mandate 480. This mandate, accepted by CEN, requires a really out of the box thinking approach of the standard developers. This project is coordinated by CENTC371 the "Program Committee on EPBD" and is considered to be a step forward in progressing towards European Energy Codes for Buildings. This second generation of EPB standards aims on more comprehensive standards, a clear split between informative text in Technical Reports and normative text in Standards, attached excel files to illustrate the calculation procedures etc. The set of EPB standards and technical reports supports the holistic approach needed for the new developed buildings as the nearly Zero Energy Buildings (nZEB) and high performance energy renovation of the existing building stock.

Keywords: EU Energy Performance Buildings Directive; CEN ISO EPB Standards

The modular structure of the set of EPB standards is flexible in order to take into account national and regional choices. This approach has been introduced, via the so-called Annex A and B in all EPB standards. Annex B is an informative Annex and includes all default values, choices and options needed to use the standard. Normative Annex A includes empty tables for these needed values, choices and options, this empty template shall be used by National Standard Bodies (NSB) (or recognized local, regional or national authorities) to declare these values, choices and options to be followed under their jurisdiction if they choose not to follow the defaults in Annex B. This approach allows maximal flexibility and transparency in applying the EPB standards. If published by the NSB's these filled in Annexes conform Annex A are indicated as National Annexes. This flexible approach included in the EPB standards, sometimes criticized, but allowing maximal freedom in innovative design approaches, able to demonstrate the impact of smart energy infrastructures as expected in future smart energy communities.

It is essential to understand that this Annex A/B approach allows a step-by-step introduction of the EPB standards, accepting first the most accepted standard (modules) from the total set and gradually expending to the total set if appropriate.

Formal Voting of all EPB standards is expected to start by 31 October 2016. After the EPB standards are accepted the publication by the NSB's is expected by the beginning of 2017.

Introduction; current status

Analyses regarding the use of the in 2007/2008 published set of CEN-EPB standards and the require-

1 EPBD: DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2002 on the energy performance of buildings.
Recast-EPBD: DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings; (recast).

ments set out in the recast-EPBD showed the clear need to update and improve these standards. The revision will improve the accessibility, transparency, comparability and objectivity of the energy performance assessment in the EU Member States, as mentioned in the EPBD.

This "first generation" CEN-EPB standards were implemented in many EU Member States "in a practical way". Typically: partly copied in "all in one" national standards or national legal documents, mixed with national procedures, boundary conditions and input data.

For a more direct implementation of the EPB standards in the national and regional building regulations, it was necessary to reformulate the content of these standards so that they become unambiguous (the actual harmonized procedures), with a clear and explicit overview of the choices, boundary conditions and input data that can or needs to be defined at national or regional level.

The standards shall be flexible enough to allow for necessary national and regional differentiation to facilitate Member States implementation. Such national or regional choices remain necessary, due to differences in climate, culture & building tradition and building typologies, policy and/or legal frameworks. **Figure 1** gives an impression of the current status. All (52) EN and EN-ISO EPB standards are expected to go out for formal vote by 31 October 2016.

The Principles

The mandate M/480 explicitly requests for identification and prioritisation of items for revision and gaps in the first generation set of EPB standards in consultation with the EU member states (MS).

The EPB standards have been developed by the following CEN/TC's:

- TC 089 Thermal performance of buildings and building components;
- TC 156 Ventilation for buildings;
- TC 169 Light and lighting systems;
- TC 228 Heating systems for buildings;
- TC 247 Building automation, control and building management;
- TC 371 Project Committee on Energy Performance of Buildings.

These TC's are responsible for the technical content of EPB standards to be revised. CEN/TC 371, the overall responsible coordinating committee, also ensuring that the timetable will be met and that the basic principles (CEN/TS 16628:2014) and detailed technical rules (CEN/TS 16629:2014), the modular approach and the foreseen improvements of the current set of EPB standards, are in line with the targets indicated and meeting the expectations of the end users.

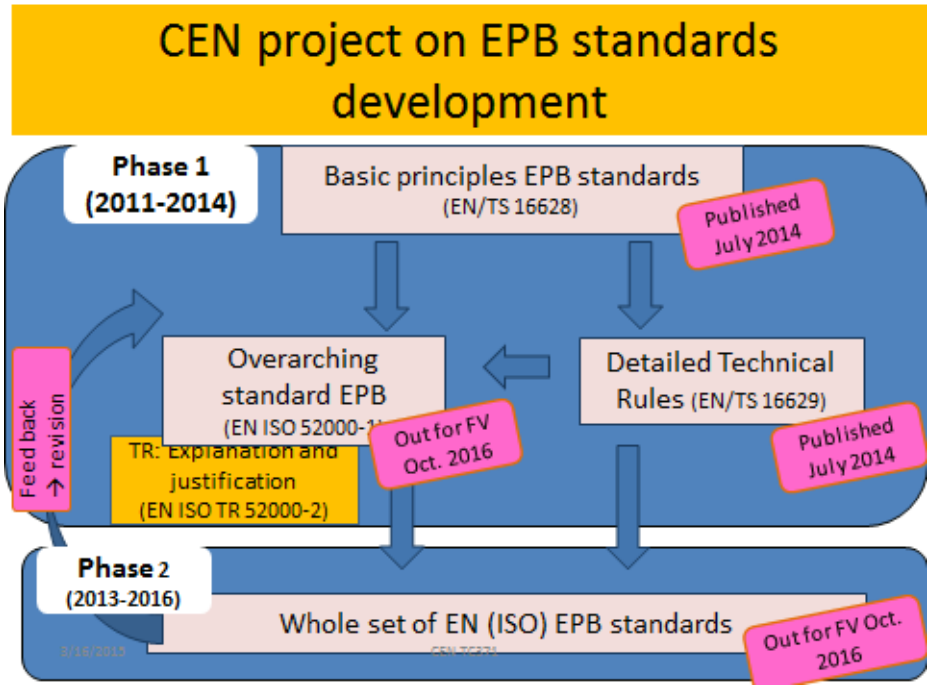


Figure 1. Current status of M/480 work.

The following, general principles are valid for the set of EPB standards:

1. The complexity of the building energy performance calculation requires a good documentation and justification of the procedures. Informative text is required but it will be separated from actual normative procedures to avoid confusion and unpractical heavy documents. Therefore, each EPB standard (or sometimes a close connected set of) shall be accompanied by a Technical Report where all related informative material will be concentrated.[2]

2 Either as a separate TR or if very limited as an informative annex to the standard. It is also possible that a TR will cover more standards.

2. The complexity of the building energy performance calculation requires also a very good coordination and testing of each calculation module. Therefore, each EPB standard shall be accompanied by a spreadsheet where the proposed calculation algorithms and data input/output are tested and proved to be consistent. For these Excel files it is checked that the calculation modules of the total set of EPB standards are functional. On basis of this Excel software it will be possible to assure that the in/output files of the various connected EPB standards are valid and possible to connect to the OAS backbone. These Excel files are publicly accessible via https://isolutions.iso.org/ecom/public/nen/Livelink/open/35102456

The deliverables of CENTC371

CEN/TS Basic Principles

CEN/TS 16628:2014 Energy Performance of Buildings – Basic Principles for the set of EPBD standards. This TS provides a record of the rationale, background information and all choices made in designing the EPB package.

CEN/TS Detailed Technical Rules

CEN/TS 16629:2014 Energy Performance of Buildings – Detailed Technical Rules for the set of EPB-standards. This TS is based on the CEN/TS BP and provides mandatory detailed technical rules to be followed in the preparation of each individual EPB standard.

EN ISO 52000-1 Energy performance of buildings — Overarching EPB assessment – Part 1: General framework and procedures

EN ISO 52000-1 is the overarching backbone of the ISO 52000 series of standards on EPB. It establishes a systematic, comprehensive and modular structure for calculating the integrated energy performance of new and existing buildings in a holistic and systemic way. This includes calculation of the building energy needs, the energy use for heating, cooling, lighting, ventilation and domestic hot-water systems, taking into account the building automation and control, and renewable energy sources/production.

The standard oversees the assessment of overall energy use of a building and the calculation of energy performance in terms of primary energy or other energy-related metrics. It takes into account the specific possibilities and limitations for the different applications, such as building design, new buildings 'as built', and existing buildings in the use phase as well as renovation measures.

To enable the use in laws and regulations, the set of EPB procedures is systematic, transparent, comprehensive and unambiguous. At the same time, clear choices between options and input data allow to take into account differences in national and regional climate, energy infrastructure, culture and building tradition, as well as policy and legal frameworks.

The standard includes the holistic framework of the overall energy performance of a building, covering inter alia:

1. common terms, definitions and symbols to be used in the EPB set; description of the overarching framework and procedures;
2. overarching preparation steps; building and system boundaries;
3. building partitioning; rules for the combination of different partitioning, clear rules for zoning and service areas, Issues like reference floor area, zoning, service areas, the assumed presence of systems;
4. unambiguous set of overall equations on energy used, delivered, produced and/or exported at the building site, nearby and distant;
5. unambiguous set of overall equations and input-output relations, linking the various elements relevant for the assessment of the overall energy performance of buildings which are treated in separate standards;
6. calculation of the energy performance, routing and energy balance;
7. general requirements to standards dealing with partial calculation periods;
8. general rules in setting out alternative calculation routes according to the calculation scope and requirements;
9. methodology for measured energy performance assessment.

The OAS provides a systematic, clear and comprehensive, continuous and modular overall structure on the integrated energy performance of buildings, unlocking all standards related to the energy performance of buildings. The overall framework provided by the OAS will work as the "Backbone" (see **Figure 2**) of the set of EPB standards. This facilitates a step-by-step implementation by the user, taking also into account the nature of each procedure identifying the typical type of user. Facilitating a step-by-step approach is essential for the acceptance for the total set of EPB standards. Not all 52 standards have to be used from day first. This can be done step by step, giving the highest priority to those standards (modules) that are without any debate acceptable. More information is given in a Technical Report accompanying the OAS. The justification for the CEN defaults and options are also provided in this TR (ISO CEN TR 52000-2).

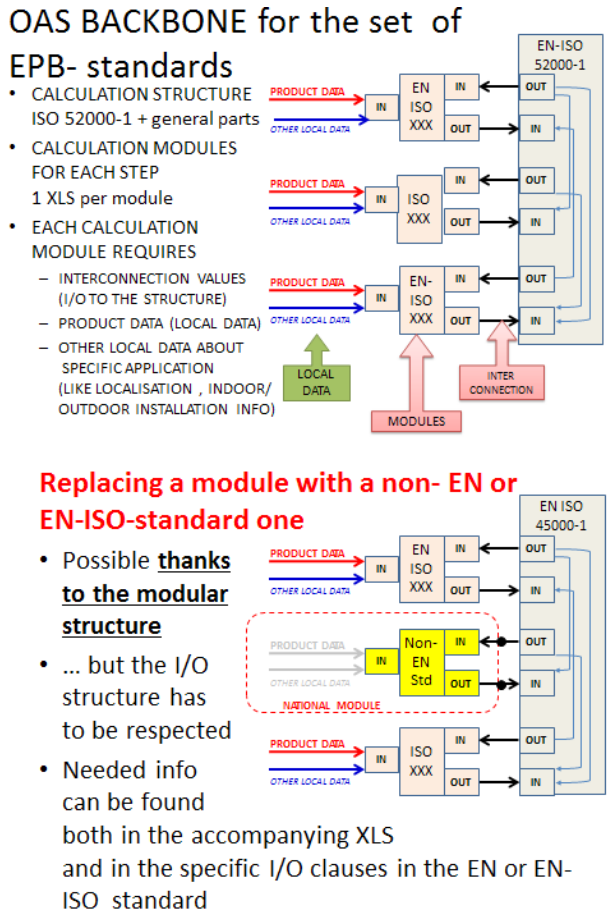


Figure 2. The OAS as backbone for the set of EPB standards illustrating replacement by a national module.

The Annex A/B approach allows maximum flexibility, regarding existing regulation/legislation, traditions or codes, all 35 tables in the informative Annex B include informative default values, informative default choices and references to other EPB standards. When not using these values the used values shall be declared according the empty Annex A template (to be published as a national Annex to the standard). Annex A includes empty tables for these needed values, choices and options, this empty template shall be used by National Standard Bodies (NSB) (or recognized local, regional or national authorities) to declare these values, choices and options to be followed under their jurisdiction if they choose not to follow the defaults in Annex B. This approach allows maximal flexibility and transparency in applying the EPB standards. If published by the NSB's these filled in Annexes conform Annex A are indicated as National Annexes. This flexible approach included in all EPB standards, sometimes criticized, but allowing maximal freedom in innovative design approaches, able to demonstrate the impact of smart energy infrastructures as expected in future smart energy communities.

It is essential to understand that this Annex A/B approach allows a step-by-step introduction of the EPB standards, accepting first the most accepted standard (modules) from the total set and gradually expending to the total set of 52 standards if appropriate.

CEN/ISO TR 52000-2:2016 Energy Performance of buildings — Overarching EPB assessment — Part 2: Explanation and justification of ISO 52000-1

This Technical Report contains information on the justification of the OAS procedures, default values and choices as given in Annex B, this to support the correct understanding, use and national implementation of this standard.

This TR is expected to be published at the same time as the OAS.

Calculation Excel and Module description

The complexity of the building energy performance calculation requires also a very good coordination and testing of each calculation module to ensure coherence and the software-proof of the set of EPB standards. Therefore, each EPB standard is accompanied by a spread sheet in which the proposed calculation algorithms and data input/output are tested and proved coherent. As most of the other EPB standards there is also an excel sheet available to support the EN ISO 52000-1.

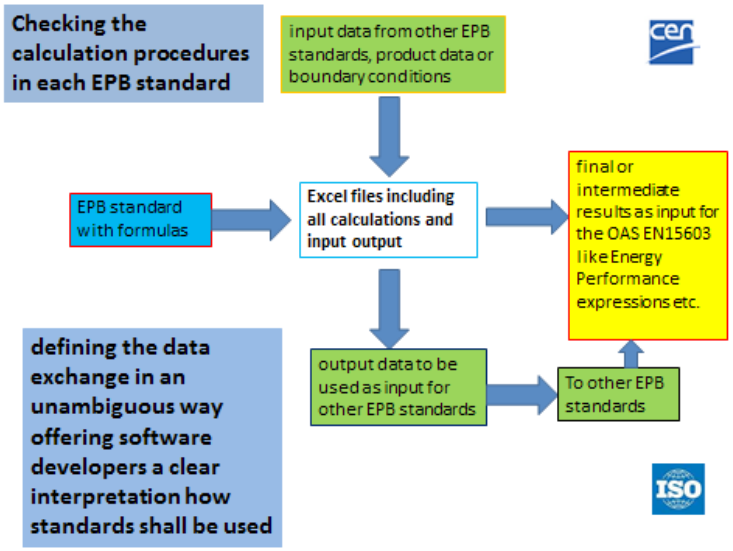


Figure 3 . Software check of the excel sheets of the EPB standards.

How do the EPB standards interact with the relevant product standards?

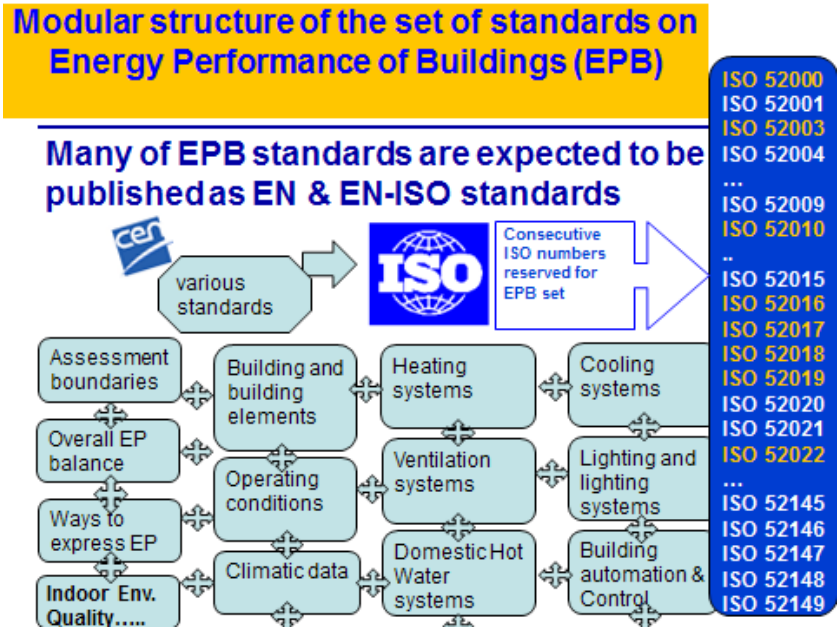
Saving energy in the build environment requires not only that products consuming electricity and fuels are designed to be intrinsically more energy efficient. The interaction of a product with the rest of the system or installation in a building into which it is fitted plays an important role. This appears obvious for a number of product categories such as building equipment for ventilation, heating, cooling, lighting and control & automation.

On one hand we have the Ecodesign Directive requiring via EU regulation minimal energy use of energy using products. On the other hand we have the EPBD where the EU Member States are obliged to require minimal target values for the energy performance of buildings, including partial indicators for the overall thermal performance and the energy performances of the heating, ventilation lighting and cooling systems.

The EPB standards on the systems declare the input data needed to allow a reliable system energy use assessment. The input data are to be specified on basis of the referred product standards (or if not available yet the relevant EU regulation). These data can be retrieved from the Ecodesign product declaration or the underlying publicly accessible data base. It is also the CEN and/or ISO product Technical Committees responsibility to take care that this information is or will become available in the correct format according the EPB standards. Using the EPB system approach, to describe the energy performance of a product as part of a system, is the most efficient way to ensure effective energy performance targets for products, systems and finally the buildings (see also the article "Industry perspective on the holistic approach to buildings" by Drake Erbe, REHVA Journal May 2016).

Co-operation with ISO

There is active process of interaction for the overarching type of standards through the JWG of ISO TC 163 & 205 and for the other EPB standards via the different WG's of ISO TC 163 and ISO TC 205. Experts in the ISO and CEN teams are working on these standards, with the ultimate goal to agree on EN-ISO standards. A challenge given the geographic and other differences in the building sector. For several CEN-EPB standards the cooperation with ISO is still informal. This means that for these standards no parallel voting is expected before 2017. Current parallel voting on EN-ISO EPB standards is expected for the OAS and the building thermal performance related standards as developed by CENTC89 and under ISO/TC 163. These ISO standards are indicated as EN-ISO 520xx-1 and the connected Technical Reports as EN-ISO TR 520xx-2. The central co-ordination of the preparation of a set of international standards on the energy performance of buildings at the ISO level is in the hands of ISO / TC 163/WG 4, the *Joint Working Group of ISO TC 163 and TC 205 on energy performance of buildings using a holistic approach*. The main leading and active experts in CEN and ISO are among the main leading and active members of this ISO Joint Working Group. This co-operation with ISO aims to avoid serious duplication of work, to avoid incompatibilities in (input) product data, procedures and (output) energy performance data. ■



Performance Risk Assessment – Application Example for Large Atria

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Risk assessment has an important issue in design practice for Public Private Partnership projects. However, the use of building simulation tools for risk analysis is not yet common practice. The paper presents a stochastic methodology to efficiently employ building simulation tools in the risk management process. An application example shows its potential.

Keywords: Building simulation, stochastic simulation, uncertainty analysis, risk management, model complexity

A stochastic methodology is presented and applied to efficiently employ building simulation tools in the risk management process. An actual Public Private Partnership (PPP) -project of an atrium in The Netherlands is used for risk treatment decision support. The application showed that a simple assessment approach could already provide guidance either towards potential treatment strategies or more complex assessment approaches. Components of the methodology consist of sensitivity and uncertainty analysis and risk evaluation.

Introduction

Risk can be defined as the product of two contributing factors: the probability of occurrence of a threat and its impact or consequence (de Wilde, 2012) (Munier,2014). Risk assessment of future behaviour of systems enables reduction of unwanted conditions leading, for instance, to less efficient operation of systems or undesired indoor climates.

A new design for a governmental office, in The Hague, has led to the need for assessment of performance risks associated with the indoor climate of the large atria. As the project is developed according to a design, build, finance, maintain and operate (DBFMO) contract, assessment of risks in the design stage of this DBFMO-contract is crucial given the long-term responsibility. Requirements, and related risks, towards the atrium refer to the installation performance and comfort. Large atria are complex environments. Their (risk) assessment nevertheless can be based on methods ranging from simple (e.g. rule of thumbs and traditional physical calculation methods) up to complex (numerical modelling). However, selecting the right method for the problem is not straightforward (Moosavi et al, 2014) (Morbitzer, 2003). In some cases, increasing the level of complexity of the model may decrease the accuracy of the results, due to increasing uncertainties in the input data (Kolsaker, 1995).

The main objective of this research therefore was to support the selection of the appropriate building simulation tool for the risk assessment. The atrium case is used as a means to develop the method.

Methodology

Figure 1 presents the developed performance risk management framework. It originates from the framework as proposed by ISO 31000 (2009a, 2009b). *Risk identification* is the starting point for the analysis. It requires the definition of the Key Performance Indicator (KPI) that reflects the risk, and the variables and its input parameters that affect the KPI. The risk encompasses two factors: *Consequence* and *Probability*. Consequences often can be defined in terms of (extra) costs or penalties. In PPP-projects penalties (money) generally will be the consequence of not fulfilling the requirements agreed on. The probability of a risk generally is harder to quantify, as deterministic models often are not applicable, exact values for the input parameters in time and space are usually unknown. To quantify this uncertainty, and with that the probability (e.g., % chance), reference has to be made to stochastic models.

The stochastic method selected for the uncertainty analysis is the Monte Carlo method. This method gives the probability distribution of possible results by running a simulation model for a number of scenarios and randomly selecting a different set of values from the uncertainty ranges of the input parameters. The number of scenarios depends on the uncertainty ranges, the model and the amount of parameters. To reduce the required computing time in case of large numbers of scenarios and if large simulation models are required Latin hypercube sampling (LHS) can be applied to arrive at a representative probability distribution with less effort (van Goch, 2011) (Hoes, 2007) (de Wit, 2001). Uncertainty analysis gives insight into the influence of the whole parameter set on the risk probability.

Sensitivity analysis can provide additional knowledge on the most influential input parameters. This knowledge can help in focussing on the treatment to reduce the risk most effectively or identify the need to analyse the effect of an input parameter at a more detailed (simulation) level. In this work Monte-Carlo simulation in combination with linear regression analysis is applied. Standardised regression coefficients (SRC) are obtained to quantify the changes of the input parameters relative to the output (Manache and Melching, 2008) (Houben et al, 2010). The input parameter with the largest SRC has the most influence on the output.

Risk *Evaluation* assesses the combined consequences and probability. The outcome is compared to what is regarded *Acceptable*. If the uncertainty in the analysis is too large further analysis is required. Outcomes from the sensitivity analysis then can be used to determine whether the current model applied requires more detailed information or a new assessment should be chosen that allows more variables to be included in the analysis. In both ways complexity of the analysis is increased (*Increase complexity*; **Figure 1**).

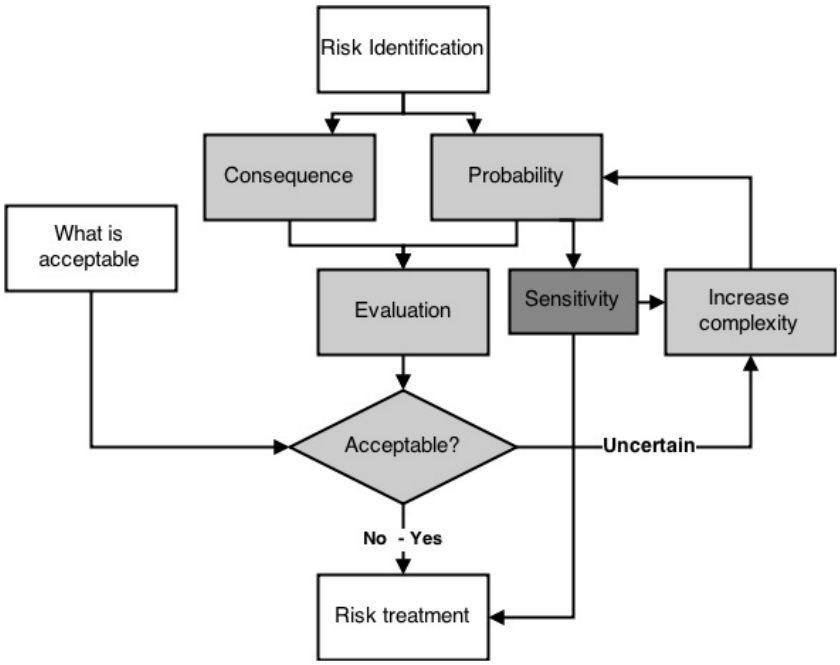


Figure 1. Performance risk management framework.

Figure 2 presents a visualization of a generic example of increasing the complexity of the risk evaluation in the two directions identified.

Application

The presented methodology is applied on the DBFMO-case located in centre of The Hague. The case consists of six atria which have been designed in 1993 as a means to allow office windows to be opened while blocking noise and wind from the immediate surrounding. The atrium is renovated. For part of the atria the indoor thermal requirements decreased (i.e. lower temperatures allowed, till 3°C) while keeping the original atrium façade in place. The office building façade on the other hand was upgraded to have better insulation and air tightness.

For the atrium case, one risk identified was the potential fogging of the atrium windows due to condensation and potential of dripping of water from the ceiling and façade. The risk referred to the visual comfort and the building reputation, with surface temperature and relative humidity level as key variables for assessing the condensation risk. In the original design condensation hours were estimated at approximately 20 hours per year (minimum indoor temperature atrium 12°C; Perquin, and Wapenaar, 1991)

The possible consequences of condensation, comfort and reputation, can be quantified in penalties. Similar penalties are in place for other rooms in the case investigated, e.g., €200 for each hour indoor thermal requirements are not met for more than 12 hours. No values were specified for the investigated condensation risk. Therefore, an assumption was made with an increment in the penalty in case of consecutive condensation hours (5 €/h for 1 hour to 40 €/h for 5 consecutive hours or more).

Figure 3 presents the input parameters and variables that relate to the condensation risk.

The first approach (model M1) for assessing the probability of the risk would assume the simplest model feasible for the case at hand. In this case a steady-state one-dimensional heat transfer model was chosen where only the atrium façade was modelled. The Monte Carlo method is applied where, apart from the weather data for the location and the façade thermal resistance, ranges for the boundary conditions (**Figure 3**) were assumed wide and uniformly distributed. Matlab was used for the calculations. Given the simplicity of the model LHS is not required in this case and convergence of the solution was assessed by increasing the number of scenarios to be calculated.

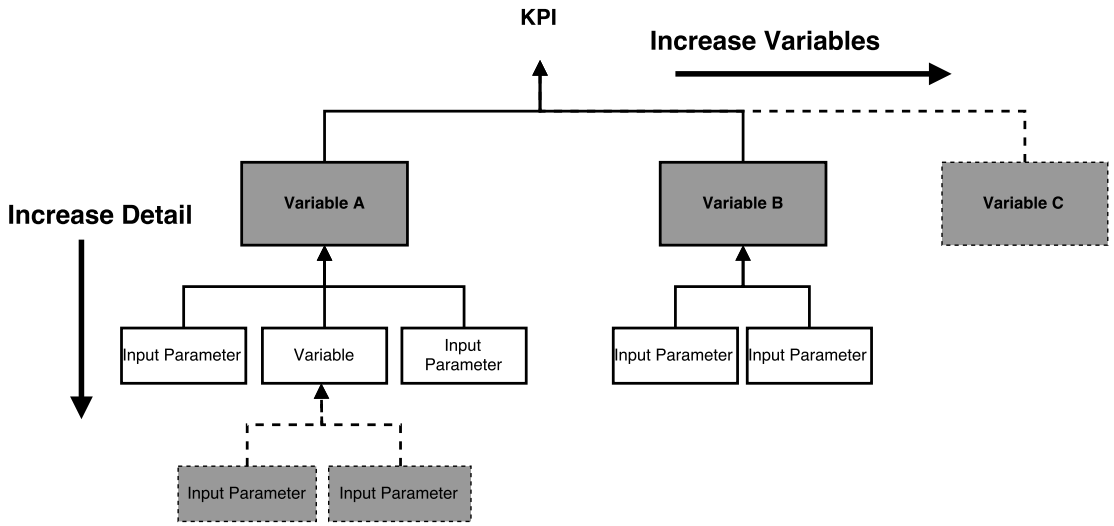


Figure 2. Two ways to increase complexity (generic example).

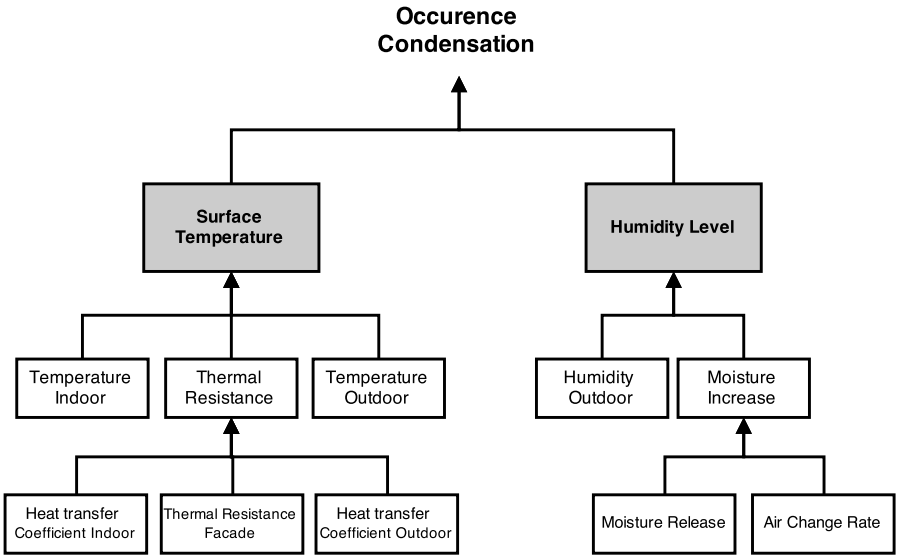
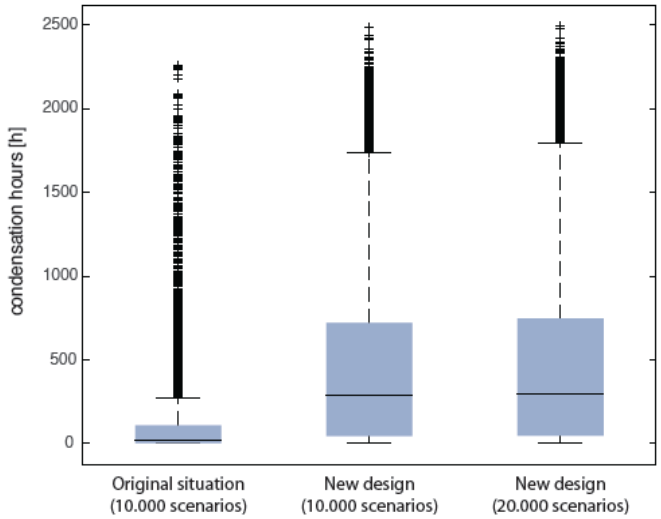


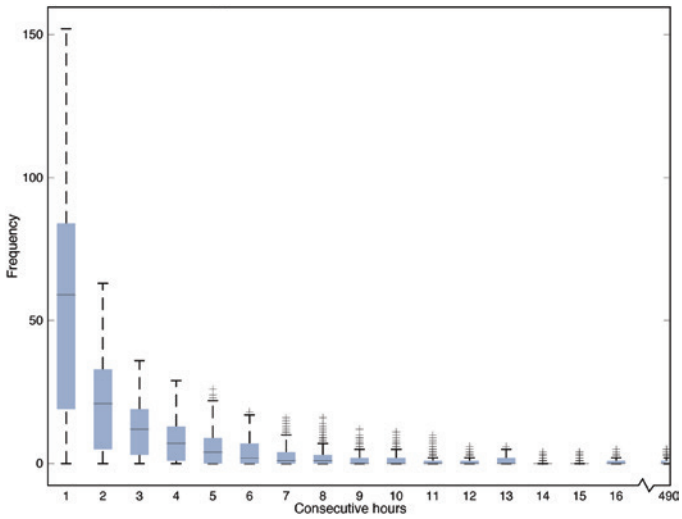
Figure 3. Identification of condensation parameters.

Results of the analysis are shown in **Figure 4a-c**. **Figure 4d** presents examples of the effect of treating individual input parameters (from regression analysis) on the number of condensation hours.

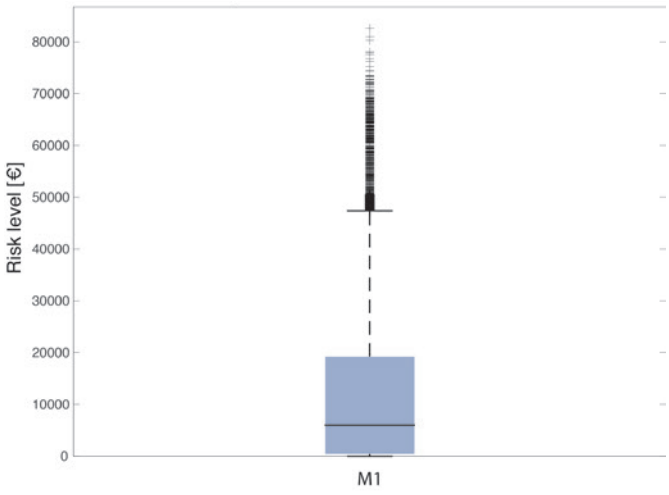
If the condensation risk is unacceptable more complexity in the model can be introduced, either by increasing the level of detail of the input parameters or by introducing additional variables (**Figure 2**). For the practical case the moisture release was most sensitive. Moisture contribution to the atrium is obtained from (humid) airflow from the offices into the atrium. This was assessed by assuming an airflow rate with presumed humidity level from the office into the atrium (model M2). Again ranges and a uniform distribution were assumed for these two parameters. As originally a steady-state approach was assumed an additional variable 'time' was introduced. For these calculations TRNSYS



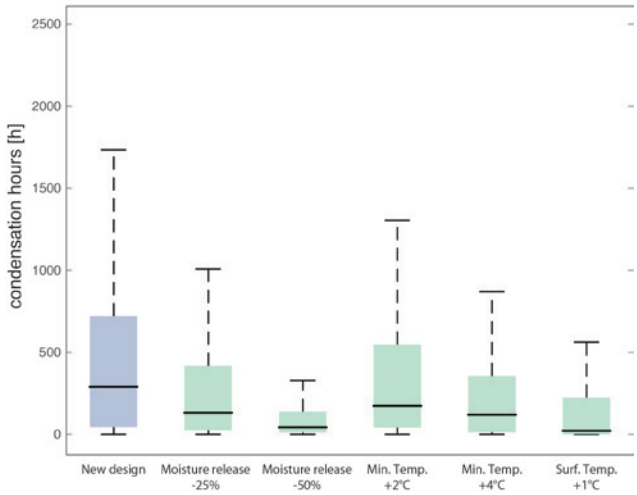
a. Probability of condensation hours per year during office hours. Including validation and verification. Original situation (Med= 19, σ=241), New design 10.000 (Med= 290, σ= 516), New design (Med= 295, σ= 516).



b. Frequency of consecutive hours of condensation per year. The outliers go up to 490 consecutive hours.



c. Risk level condensation simulated with simple Matlab (M1) model. M1 (Med= €5,967, σ= €17,095).



d. Probability of condensation hours per year for different risk treatments. M1(Med= 290, σ= 516), Moisture release reduction 25% (Med= 133, σ=346) and 50% (Med= 44, σ= 177). Minimum Temperature of atria increase by 2°C (Med= 174, σ= 474) and by 4°C (Med= 120, σ=407). Surface temperature increase by 1°C (Med= 22, σ= 329).

Figure 4. Overview of outcomes for model M1 of the application.

was used (model T1). Due to computation time now LHS is introduced in the analysis to reduce the number of scenarios required. With 250 scenarios in this case representative results were obtained. In addition, this model was expanded with the extra parameters as identified for model M2 (Model T2). The latter model also included the heat flow into the atrium, which was not considered for model M2.

Figure 5 compares the outcomes (condensation hours) for the four models.

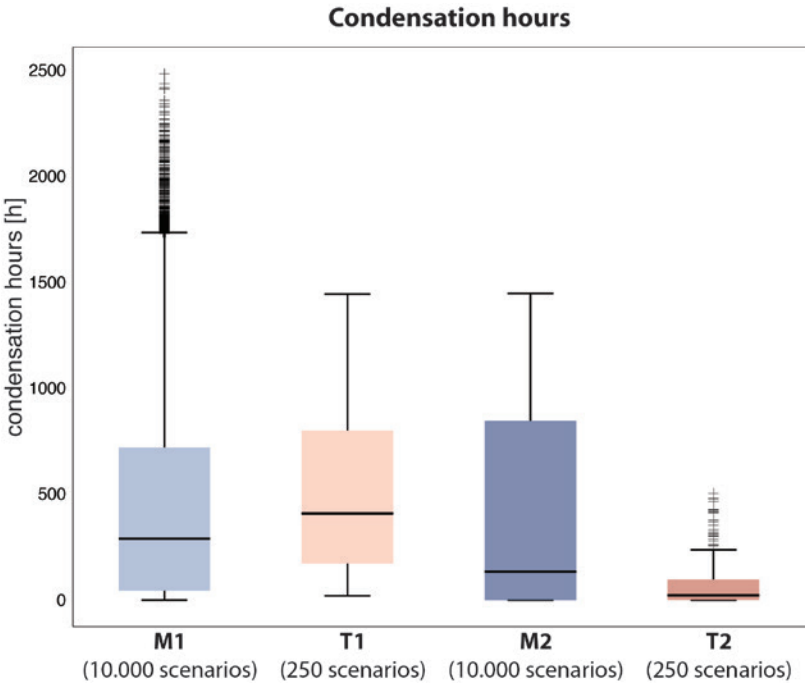


Figure 5. Probability of condensation hours per year for different assessment approaches. (Med= Median, σ= standard deviation) M1 (Med=290, σ= 516), T1 (Med= 409, σ= 386), M2 (Med= 135, σ= 436), T2 (Med=23, σ= 110).

The effect of (thermal) buffering in the transient case is visible in the boxplot outcomes for model T1 compared to the M1 model. The M2 model indicates a reduced but skewed distribution as maximum moisture release is now determined by two input parameters. Finally, the T2 model shows the important aspect of taking the heat transfer from the offices into the model complexity as well. The T2 model simulates an average atrium temperature of 13.2°C compared to 11.9°C for the T1 model. The Matlab models only focus on moisture transfer.

Discussion and conclusion

The application presents an example of the functioning of the model developed. Risk assessment and decision support for treatment selection are useful outcomes in the design process. The application example however did show the importance of providing correct assumptions on the ranges that may be assumed for the input parameters under investigation. Though not easy, this is a critical aspect of the methodology. Nevertheless, the stochastic method and combined sensitivity analysis provide means to visualize this effect and act on it to reduce the risk. In a deterministic method this may be much more difficult to capture. Uncertainty of the result can be reduced effectively by focussing on influential parameters during the selection of the more complex assessment approach. ■

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Improved characterization of water-to-water heat pumps part load performance

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In the present paper it is presented a laboratory experimental work performed to evaluate the efficiency of a water-to-water heat pump of 40.5 kW heating capacity at different water storage and load duty conditions. Results on efficiency degradation are compared with predictions from international standards EN14825, ASHRAE 116-1995 (ARI 210/240) and Italian UNI 10963. Results showed a loss of performance with decreasing load ratio for all water storage volumes tested, with a higher detrimental effect for low inertia conditions. A close analysis of the dynamic behavior of the heat pump revealed significant start-up efficiency losses, proving that this effect may be of consideration for water-to-water systems. This behavior is neglected in current standards for rating water-to-water heat pumps performance at part load, such as EN14825. An improved experimental method for characterizing the performance of water-to-water heat pumps at part load is presented and compared with experimental results and standards.

Key words: heat pump, energy efficiency, part load degrdation

Standards for partial load performance rating of water-to-water heat pumps

Due to the lack of modulation available, fixed-capacity heat pumps present the issue that they will cycle between on and off states in order to match the required load demand. This behavior entails parasitic losses during the stand-by and start-up phases of operation of the equipment, thus reducing their energy performance. Commonly, international rating standards estimate a coefficient of performance (COP or EER) at part load for fixed-capacity units using a correction parameter, called partial load factor (PLF), that is applied on the performance coefficient at steady state conditions to obtain its value at part load as:

$$COP\ (part\ load) = PLF\ x\ COP(steady\ state) \quad (1)$$

The American standard ASHRAE 116-1995 [1] characterizes the part load operation of fixed-capacity heat pumps by determining a cyclic degradation coefficient Cd, which is derived in a dynamic test, as defined in the ARI standard 210/240 [2]. In the ASHRAE 116-1995 and ARI 210/240 standards the partial load factor is calculated as:

$$PLF = 1 - C_d(1 - PLR) \quad (2)$$

where the degradation coefficient Cd can be determined experimentally or take a default value of 0.25.

The European standard EN14825 [3], analogously, calculates the efficiency at partial load from the correction of the performance at steady state as obtained with the standard EN14511 testing method [4]. For air sourced systems the partial load factor correction in EN14825 is identical to (2). For the case of water-to-water heat pumps with fixed capacity the efficiency correction is based on energy losses associated to parasitical electrical

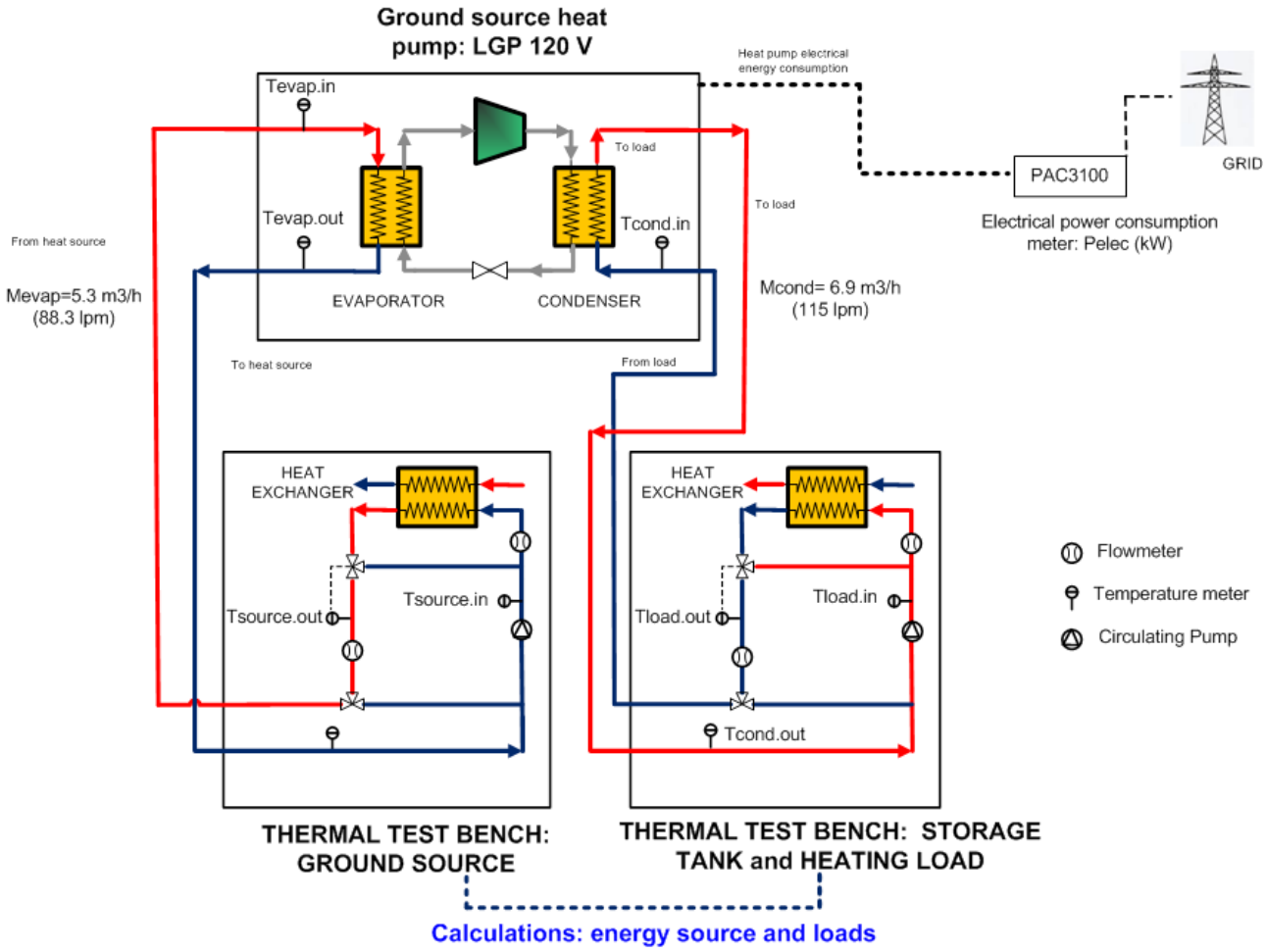

Figure 1. Experimental set-up.

energy consumption at stand-by. The correction for these systems is based on the degradation coefficient Cc and is defined with the following correlation:

$$PLF = \frac{PLR}{C_c PLR + (1 - C_c)} \quad (3)$$

The EN14825 standard allows using the above equation with a default value of Cc=0.9 or with a value determined from the measurement of the electrical power consumption at stand-by.

On the other hand, the Italian standard UNI 10963 [5] proposes an expression for the partial load factor defined as:

$$PLF = \frac{PLR}{Z} = \frac{PLR}{a + b.PLR} \quad (4)$$

The above correlation can be applied with data obtained from a single experiment at part load that allows determining the coefficients a and b in equation (4). This approach has been tested by Betannini et al. [6] with good results for a number of heat pumps.

The general calculation method in standards ASHRAE 116-1995/ARI 210/240 and EN14825 for deriving heat pump annual performance rating consists on applying the so-called bin method, in which a seasonal coefficient of performance (SCOP or SEER) is calculated for a whole year, under a load profile defined at different climatic conditions.

Laboratory semi-virtual testing of a water-to-water heat pump

Laboratory experiments were conducted to assess the behavior of a 40.5 kW heating capacity water-to-water heat pump in a laboratory setting. The heat pump was tested in a semi-virtual environment that allowed its operation while connected to a virtual storage tank and heating load. The virtual system was created with the software TRNSYS. The temperatures and flows of water circulating to and from the heat pump were emulated in the hydraulic test benches of the laboratory in order to operate the heat pump dynamically as in real conditions (**Figure 1**).

The results of partial load factor obtained from experiments at different water storage volumes and partial load ratios (PLR) are shown in **Figure 2A**. The results show degradation in the energy efficiency for decreasing partial load ratio, with a more important effect for low storage size conditions. The stand-by losses for the heat pump under study were found to be negligible for PLR>0.2, the reason being that the stand-by power consumption for this heat pump is 15 W, only a 0.2% of its nominal electrical power. The main source of efficiency degradation is identified after a close analysis of the transient test data (**Figure 2B**). A significant performance loss is found during start-up, resulting from the thermal capacity reaching its maximum value only after 42–60 s from the onset of start-up, while the electrical power consumption reaches its full value in less than 20 s. This behavior, which was consistently observed at any inertia and load duty conditions, provides evidence that significant start-up losses may occur for this water-to-water heat pump. This efficiency loss, however, is neglected in the European standard EN14825 for fixed-capacity water-to-water systems.

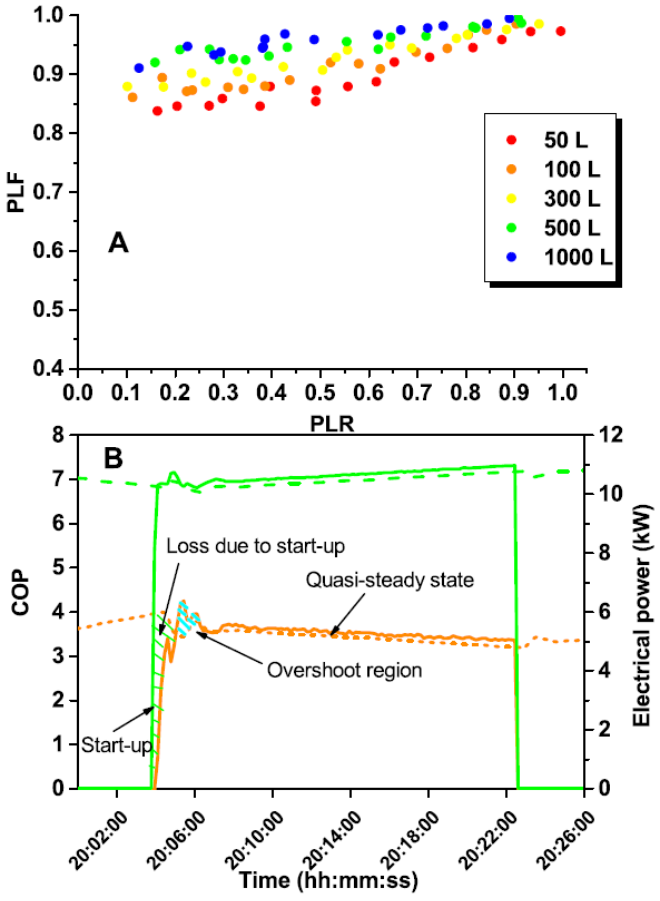

Figure 2. A) Influence of water storage volume on partial load factor B) heat pump start-up (orange: COP, green: electrical power consumption).

Comparison of correlations for partial load factor estimations

Different correlations in the cited standards to estimate the partial load factor were compared with results for the 50 L storage experiment, as shown in **Figure 3**. The predictions from UNI10963 and EN14825 correlations for water-to-water heat pumps substantially deviate from the experiments, while the estimations by the ARI standard (equation (2) is close to the experimental data with Cd=0.22. However, extrapolation of the data to PLR=0 obtained from polynomial fitting analysis (equation fitted to experiments in **Figure 3**) shows that the ARI standard does not account for the drop in the performance for PLR<0.2, produced by stand-by parasitic effects.

New reduced experimentation method for partial load performance estimation

An alternative equation for calculation of the partial load factor is proposed here that is able to account for both stand-by and start-up losses. This equation, which is derived theoretically using the definition of partial load factor by Corberán et al. (2013) [7] is defined as:

$$PLF = \frac{1}{1 + \frac{C_d(1-PLR)}{1-C_d(1-PLR)} + (1-C_c)\frac{1-PLR}{PLR}} \qquad (5)$$

This correlation reduces to equation (2) when stand-by losses are negligible and to expression (3) when start-up losses are negligible. The use of this equation (**Figure 3**) provides a better estimation of the partial load factor when compared with the line fitted to experiments with respect to the other approaches.

Equation (5) can be used to derive the COP value at part load conditions, once the coefficients Cc and Cd are known. A reduced experimentation method is

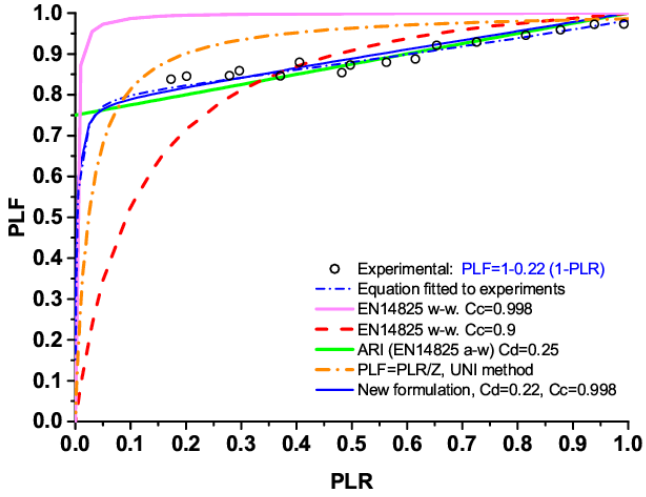

Figure 3. Comparison of experimental data and predictions from parameterizations for 50 L storage inertia conditions.

proposed here to derive these coefficients. The value of Cc can readily be obtained from stand-by measurements as described in EN14825. Then, the value of Cd can be derived from a single experiment at intermediate partial load (eg. PLR≈0.4) by solving equation (5) for Cd, with all the other parameters known.

Figure 4 shows values of partial load factor obtained with this proposed new reduced experimentation method in comparison with the reduced method based on the UNI method and the curve fitted to experiments.

The UNI method achieves good agreement for storage volume of 1 000 L, but it deviates from real degradation as the storage size is reduced. On the other hand, the new method proposed here is able to predict the partial load factor quite closely to the equation fitted to experiments at any inertia conditions.

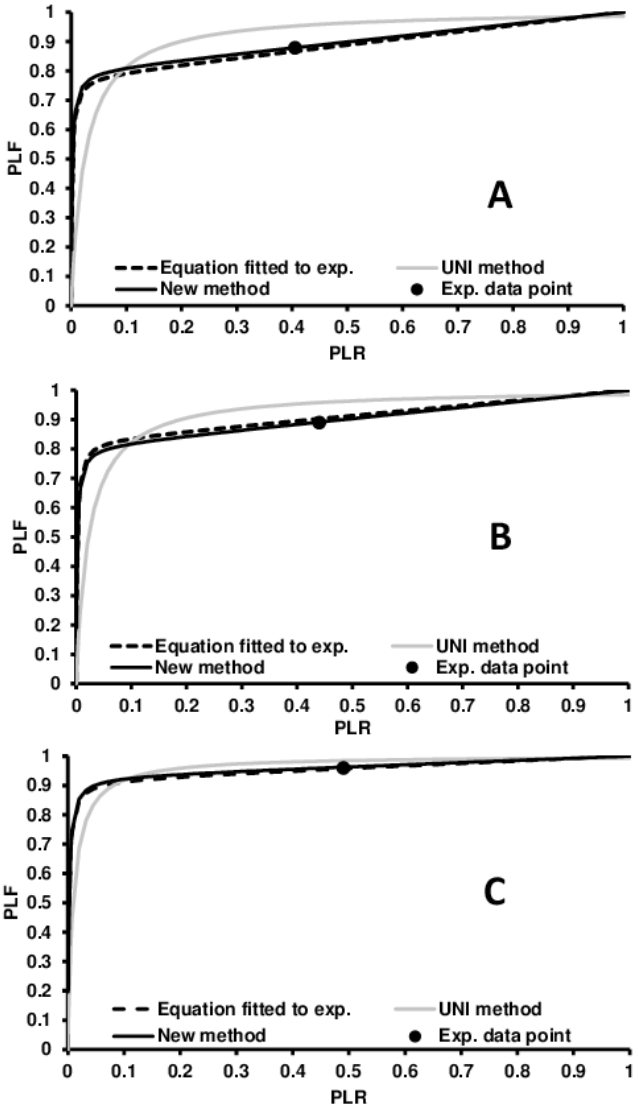

Figure 4. Predictions of partial load factor using the reduced method in UNI standard and the proposed new method for inertia conditions with (A) 50 L, (B) 100 L and (C) 1 000 L.

Improvements in the estimation of yearly COP with standard bin method

In this section the bin calculation method described in the EN14825 standard [3] for estimating the yearly COP is applied to assess the validity of different methodologies determining the heat pump partial load. The bin method is based on the integration of the energy consumed during a year at three different climate conditions with outdoor design temperatures of –22°C (colder), –10°C (average) and 2°C (warmer).

The results of the calculations are presented in **Figure 5**, where the heat pump annual COP (COPnet) is repre-

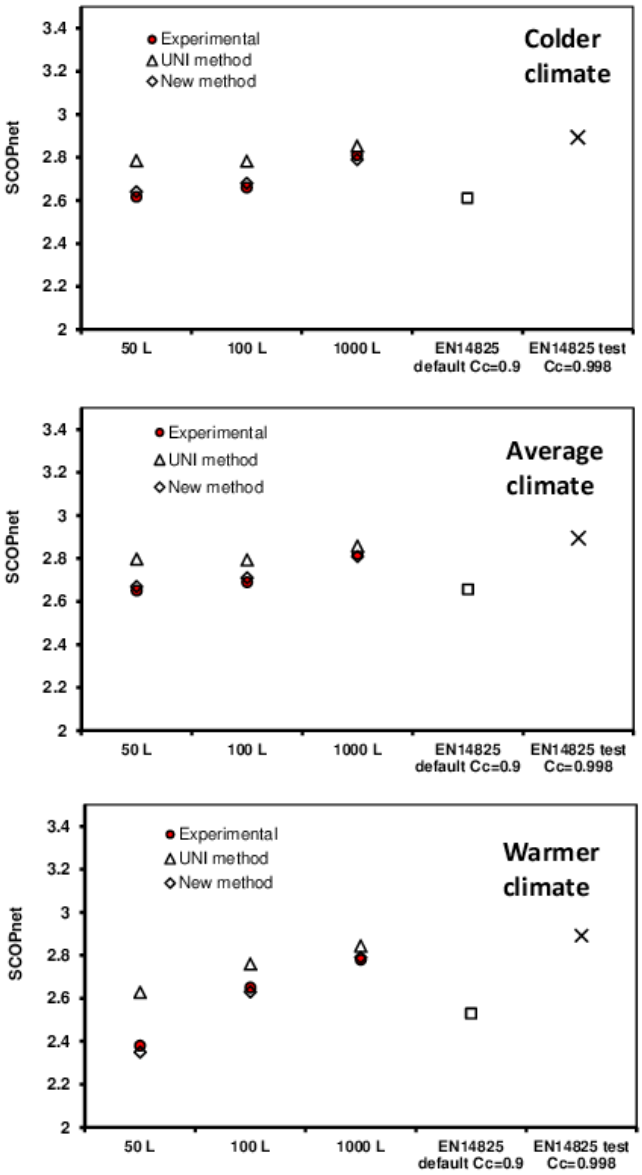

Figure 5. Calculations of SCOPnet with bin method defined in EN14825 standard for different approaches.

sented as obtained from using different methods, namely, 1) the UNI standard reduced experimentation method, 2) the new method proposed in the present study, and 3) the EN14825 standard correlations for water-to-water heat pumps with Cc=0.9 (default value) and Cc=0.998 (as determined from stand-by measurements).

Results in **Figure 5** show that the estimation of the annual COP is sensitive to the storage volume conditions. This implies that the energy performance is dependent not only on the equipment but also on the configuration of a particular system in a building. Hence, similar inertia conditions are required for comparison purposes between equipment. Calculations from using the EN14825 correlations deviate from experiments in as much as 12%, depending on the inertia conditions.

At 1000 L storage conditions the EN14825 standard prediction with Cc=0.998 leads to a small deviation of 3.5%, confirming that this method is reliable for inertia conditions high enough to yield start-up effects negligible. Similarly, the UNI method deviates from real performance as the inertia is reduced, with acceptable predictions for the 1 000 L.

Conclusions

An experimental analysis of the performance at part load of a water-to-water heat pump has shown that these systems may exhibit significant start-up losses and not only stand-by losses as considered in the European standard EN14825. On the other hand, significant sensitivity of equipment performance was found to the water storage configuration. An assessment of existing methods in standards indicated deviations from real part load performance for decreasing inertia conditions. In order to improve this aspect a new reduced experimentation and correlation method is proposed that is able to characterize the real yearly performance of water-to-water heat pumps with inclusion of the inertia conditions and their effects on stand-by and start-up efficiency losses. ■

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"Inert" evaporative cooling using a minimum of water

"Inert cooling" is a new development based on indirect dew point cooling, using evaporating water as a refrigerant and 100% fresh air. The water supply has been developed in accordance with a recent invention, which helps to lower the so-called water surface-tension and minimize the use of water by absorption. It can also utilise evaporating seawater.

Air handling in combination with evaporative cooling using water (R718) as a refrigerant is an answer to the F-gas- and CO2-policy. However, there is a lot of misunderstanding regarding the various types of evaporative cooling, like Direct or Indirect, Adiabatic or Diabatic, and Wet bulb or Dew-point cooling. They all discharge only the sensible heat. In general, evaporative cooling brings down the energy consumption for air conditioning systems by between 70% and 85%, and COP's above 20 are no exception. Besides the need for a very low energy consumption, there is now an increasing demand for the system to operate with low water consumption. Legionella and corrosion must also be points of attention.

Design criteria

- The choice: direct/ indirect.
- Adiabatic (wet bulb cooling) or diabatic (dew-point cooling).
- Evaporating water as refrigerant:
  - (potable) mains water (should be minimized as much as possible);
  - spring water;
  - salt (sea)water.
- Water distribution:
  - gravity without a pump;
  - (re)circulation with a pump;
  - sprinkle (nozzles);
  - absorption.
- Free from Legionella, bacteria and algae:
  - with or without water treatment?
  - descaling
  - demi-water
  - surface tension
- Materials:
  - not be susceptible to corrosion.
  - preferably the use of synthetic materials.

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Adiabatic and Diabatic

Linguistically the word Adiabatic means Non-Diabatic.

During an adiabatic process, the heat itself is taken from the air and not supplied or taken via the cooler surface (in a Mollier diagram this process is drawn with lines of constant enthalpy = h). Theoretically the lowest temperature that can be achieved is the wet bulb temperature, hence the use of the term Wet Bulb Cooling.

During a diabatic process however, there is an exchange of heat between cooler surface and air. In this case the lowest temperature theoretically possible is the dew-point temperature, hence the use of the term Dew-point Cooling. (in **Figure 1** (Mollier diagram) this process is drawn with lines of constant absolute moisture = gr/kg)

Direct cooling systems

Only available as adiabatic (wet bulb) Cooling

Direct adiabatic cooling makes use of a wetted absorbent, an air filter and fan. The air to be cooled is blown through the absorbent, evaporating a part of the water. The energy needed for evaporation is directly withdrawn from the air by cooling it. The discharge temperature depends on the temperature and relative humidity of the air entering the process. These systems mostly use a water circulation pump and means to prevent legionella and bacteria growth.

- These coolers add moisture to the air entering the cooled room, resulting in both a lower room temperature and also an increasing relative humidity (%RH). **Note the contrasting effect**: A lower temperature will be more comfortable, but a higher RH will be experienced as uncomfortable. The latter is especially

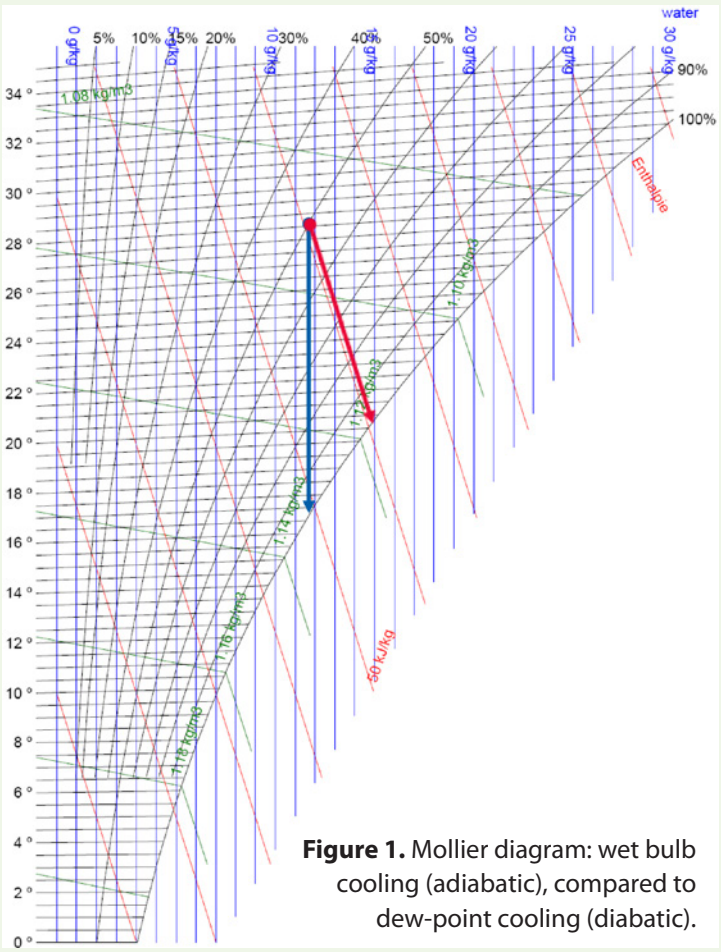


Figure 1. Mollier diagram: wet bulb cooling (adiabatic), compared to dew-point cooling (diabatic).

Example:

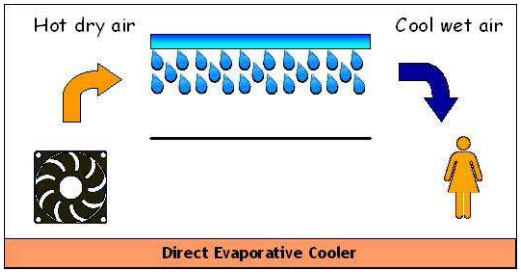
Temperature	28°C
Absolute humidity	11.9 g/kg
RH	50 %
Dew-point (blue)	16.6°C
Wet bulb temperature (red)	19.4°C
Difference	19.4°C – 16.6°C = 2.8°K

this will differ from case to case.

If the temperature of the sucked-in ambient air is higher, this causes a higher wet bulb temperature and so a higher outgoing temperature. This is in contrast with the dew-point temperature, which will not change if the temperature rises. Minimum temperature achievable is a few degrees K (Kelvin) above the wet bulb temperature.

the case when we are dealing with gyms, workshops or other places where physical exertion is taking place, as it is more difficult to perspire in a high RH environment.

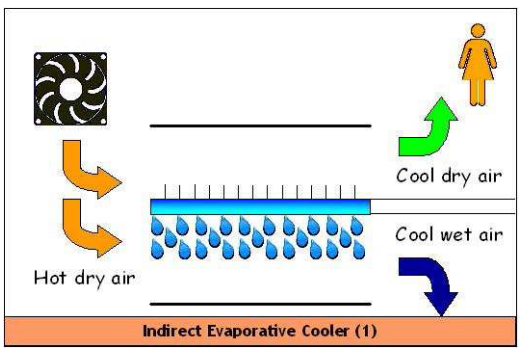
- Direct cooling also might give problems to stored goods and electronics. It is therefore mostly used in dry (desert) climates or in moderate climates only for industrial purposes.
- The minimum discharge temperature of cooled air is a couple of degrees Kelvin above the wet bulb temperature. However, if during the daytime the ambient temperatures rises because of the sun and the absolute humidity (gr/kg) remains the same, the wet bulb temperature will also rise, resulting in a higher outgoing (cooled) air temperature.



Indirect cooling systems

Available as adiabatic (wet bulb) and diabatic (dew-point) cooling

- The vaporized water as a result of the cooling process, will be discharged to the ambient and will not influence the % RH in the room to be cooled.
- Indirect systems are available either as wet bulb cooling or as dew-point cooling each with its own characteristics.



Indirect wet bulb cooling (adiabatic)

- The minimum discharge temperature is a couple of degrees K above the wet bulb temperature. Another outcome, if the ambient temperatures rises during the day, is that the wet bulb temperature will rise, resulting in a higher outgoing (cooled) air temperature.

Indirect dew-point cooling (diabatic)

- The minimum discharge temperature is a couple of degrees Kelvin above the dew-point temperature.
- Comparted with wet bulb cooling, and depending on the temperature and humidity, both the dew-point temperature and cooled air temperature will be between 2 K and 4 K lower.
- If during the daytime the ambient temperature rises, and at the same time the absolute humidity (gr/kg) remains the same, the wet bulb temperature will stay the same and consequently the outgoing (cooled) air temperature will not change. It will, in fact, stay almost the same for the whole day.

Inert cooling

Inert cooling is a new development based on dew-point cooling, an extreme low energy consumption, and suitable to operate in an aggressive polluted ambient with almost any quality of evaporating water. A couple units are now in operation.

This type of dew-point cooling uses only one fan for both the primary air and the process air, resulting in a minimum of moving parts. The outside of the heat exchange plates is covered with a wetted hygroscopic foil.

At the end of the heat exchanger, 33% of the cooled air leaving the cooler becomes process air. This is caused by turning the air 180° and returning it in counter flow along the outside of the heat exchanger plates by using the available extern pressure drop (in ducts and grilles of the building to be cooled) as the driving force. Due to this turning process and a forced air flow (no suction), a centrifugal force is developed and, as a consequence, dirt particles will not be taken into the process air stream. As the dirt particles aren't able to contaminate the cooler surface, there is no pollution and less maintenance costs. Cooling is a natural process existing of a water supply by the combination of falling film, adhesion (foil to plate) and hygroscopic operation of vapor. The amount of heat (kJ) taken from the primary air is equal to the amount of kJ necessary for evaporation of the moisture. The process air discharges the evaporated moisture towards the open air and cannot enter the conditioned room (**Figure 2**).

It is a commonly acknowledged that air can be aggressive in combination with moisture in coastal areas, swimming pools, cattle and poultry, near chemical plants, etc. The use of demineralised water, with $NH4^+$, or salt can also cause corrosion problems. This explains why inert cooling systems are entirely made of synthetic materials.

The use of fresh water can be a problem in certain areas and has to be limited as far as possible, but salt (sea)water is always largely available. The system was successful when tested using sea water for a 6-month period. The use of saltwater is only possible if the whole unit (housing and cooling surface) is made of synthetic material. It is possible to prevent salt crystals by using indirect dew-point cooling with absorption wetting and combined with an overflow of seawater, instead of with nozzles.

Water consumption

In general, the water consumption depends first of all on the amount of air to be cooled, the temperature and humidity of the admitted air. Besides that, also the system as well as the way of wetting has influence.

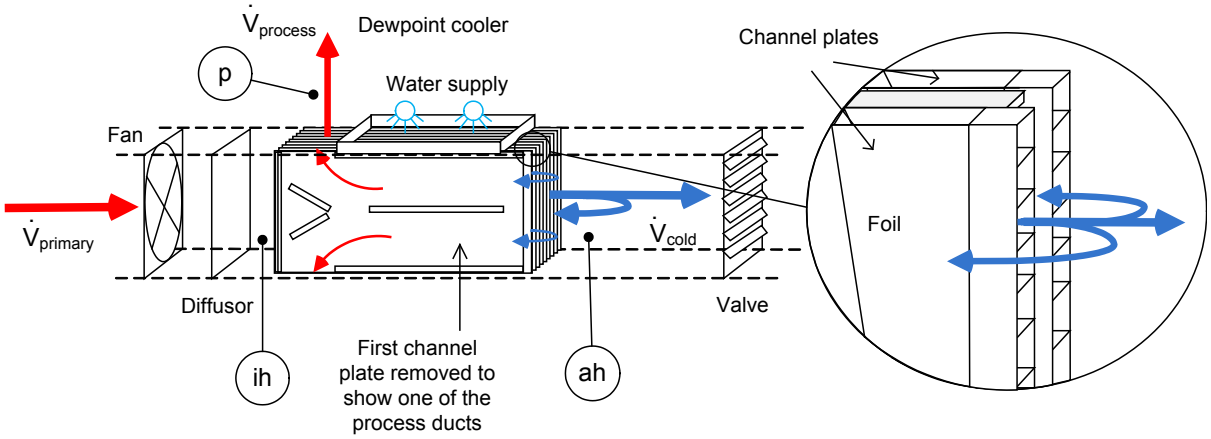


Figure 2. Principle layout of the dew-point cooler.

Based on evaporating, the water supply temperature has practically zero influence on the cooling capacity.

Various methods of water supply

- Constant pump recirculation in combination with a water container
- Without a (re)circulation pump, so using the pressure of mains water supply.
- The use of nozzles for the water distribution. Disadvantage: nozzles can -depending on the water quality- clog, so requires maintenance.
- The water supply can be controlled by periodical opening and closing a solenoid valve in the water supply.

Using Inert cooling:

- A new development water supply is based on absorption, without pump circulation and without the use of nozzles, using the mains water pressure. It takes care of a very constant water flow, with little waste of water and brings down the water surface tension (patent pending).
- Inert cooling is also suitable for evaporating salt (sea) water

Micro-biological aspects of inert cooling

- The cooled air keeps the same absolute humidity during the whole cooling process without any condensation, so stays dry.
- The humidified process air is discharged towards the outside ambient and due to the use of a wetted hygroscopic foil on the process plate surface, as well as a low process air velocity (< 2 m/s), no aerosols will be formed.
- Growth of algae will not occur, because the cooler operates without re-used water circulation, has no water collector and the hygroscopic layers are automatically dried once a day and as soon as the cooling stops. ■

Test

The test data below was recorded last year (2015) in a sports hall, situated close in the seacoast and a blast furnace, so a polluted area, using absorption water supply, so without nozzles.

Primary ambiant air intake:

Air flow ..... 4 500 m^3/h

Dry bulb ..... 22.0 °C

Wet bulb ..... 16.0 °C

% Humidity ..... 54.0 %

Dew point ..... 12.3 °C

Abs. moisture ..... 8.9 gram/kg

Process air:

Air flow ..... 1 485 m^3/h

V = 33 % process air leaving ..... 96% to 98%

Cooled air:

Air flow ..... 3 015 m^3/h

Dew point ..... 12.3 °C

Abs. moisture ..... 8.9 gram/kg

V cold = cooled air leaving at: ..... 14.3 °C

Results:

- According to a simulation program which is based on using water supply by nozzles, the cooled air should be 16.2 °C, however the now reached temperature is 14.3°C.
- 16.2 – 14.3 = 1.9 K lower than according to the simulation program (in this case 33% increase and average 25%). Reason: an optimal and constant water distribution compared with the use of nozzles.
- In this case: 1.7 K below the wet bulb temperature (16 – 14.3) and 2 K above dew-point (14.3 – 12.3).

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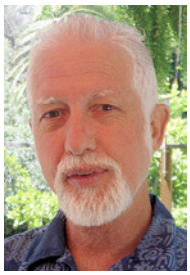
Very high efficiency evaporatively cooled mini-split AC condenser

Research at the Florida Solar Energy Center (FSEC) has developed and refined an evaporative cooled mini-split heat pump. The heavily instrumented mini-split heat was a 1.5-ton Fujitsu model (**Figure 1**) with a 5.62 W/W Seasonal Coefficient of Performance (COP) and a cooling capacity of 2.0 to 6.7 kW. The system has been tested for full summers in the lab and in a field test site.



D. PARKER
Florida Solar Energy Center

We demonstrated an innovative evaporative pre-cooling system that improved energy efficiency of a mini-split air conditioner by 21% seasonally in Florida's humid climate. **Further, the same apparatus was able to improve air conditioner efficiency by almost 50% at a peak condition of 35°C outdoors**. COP at this very hot condition was still 5.1 W/W. Average water consumption of the evaporator cooler was about 22 liters per day – a modest consumption given large improvements in air conditioning energy efficiency. With condensate water plumbed to the evaporative sump, estimated net water needs could be less than 4 L per day in humid climates and need to dump sump water is greatly reduced.

The pre-cooler assembly is inexpensive with few moving parts and could be manufactured as add-on or OEM kits for mini-split air conditioners. Estimated retail cost is €350 or less. The evaporative pre-cooler could improve seasonal cooling efficiency by 30–50% in most European climates (Lecce: 37%, Lisbon: 33%, Athens: 36%, Sevilla: 46% and Madrid: 50%) with dramatic improvements in peak cooling performance- desirable for capacity constrained utilities. Extensive test data is available in the full laboratory report and two units have been under long term evaluation. With no obvious prior art, patents have been filed.

There are two major competing evaporative cooling air conditioner technologies to that developed by FSEC. The two most prominent are *EvaporCool* in the U.S. (www.evaporcool.com) and the *EneCut* in Japan (http://bit.ly/18vtkra). Both systems use nozzles to mist water before the evaporator coil. While nozzles are effective for evaporative pre-cooling, they have several drawbacks as indicated below:

- Mist can be entrained into the air stream reaching the condensing coils, possibly fouling these and making AC manufacturers leery of honoring warranties
- Nozzles are prone to fouling, particularly with hard water supplies
- Variations in city water pressure can affect coverage
- Greater power is required for misting (our system uses a simple 4 W pump) and more sophisticated controls.
- The mist from the nozzles is prone to "drift" from wind which makes this largely impractical for residential AC units where the air flow into the condenser is at a relative low rate. *Misted drift from the nozzles can deface adjacent walls or create other maintenance issues.*

Figure 1. FSEC Evaporative Mini-split cooling system.

Unlike previous evaporative cooling concepts, the configuration is simple and robust. The FSEC concept has much greater potential reliability, no potential to create droplets that might harm the equipment or the home surroundings. We use sacrificial off the shelf and recyclable evaporative media that is replaced every four years. To expend pad life, we measure total dissolved solids continuously and dump sump water (–7 L) when TDS is greater than 1 500 ppm.

The rate of water consumption of the FSEC evaporative cooler is modest and can be effectively supplemented by using condensate water. **Figure 3** shows the condensate release and evaporative cooler water and use rates summarized over a 24-hour period. This shows that, evaporative cooler water use is higher in the daytime hours and lower at night than the condensate release. Evaluating more closely, on average, a condensate collection sump that was 4.2 liters larger in capacity than pump inlet point, would result in best utilization of daily condensate water use for the evaporative cooler.

Offering 30–50% efficiency improvement and modest water use, the evaporative cooling concept is particularly attractive with multi-splits where lower overall efficiency is overcome by large improvements in single condensers. Electric utilities will be interested in the technology since peak summer cooling power is reliably reduced by 50% or more even in humid climate. ■

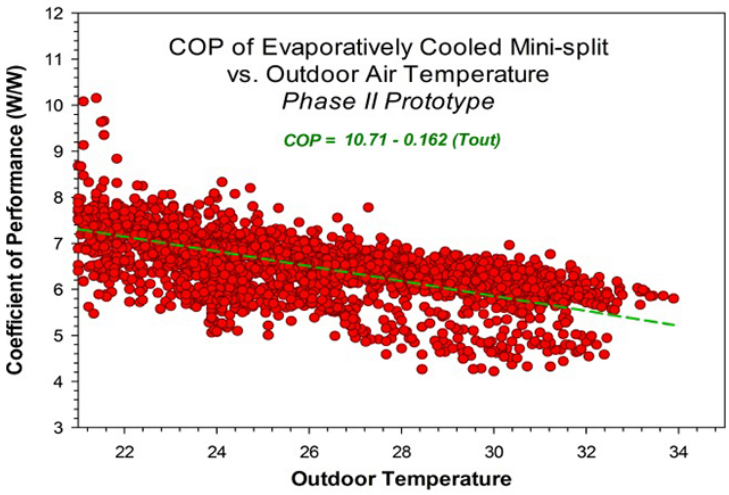


Figure 2. Measured COP vs. outdoor temp.

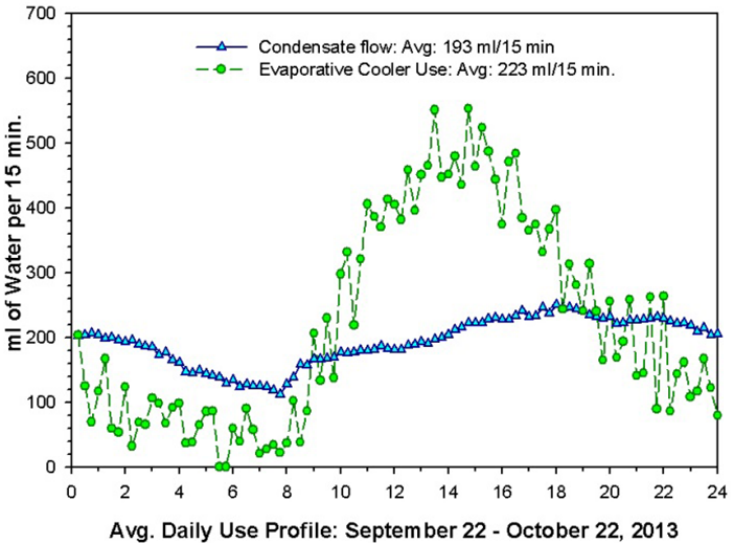


Figure 3. Evap cooler water use v. condensate release.

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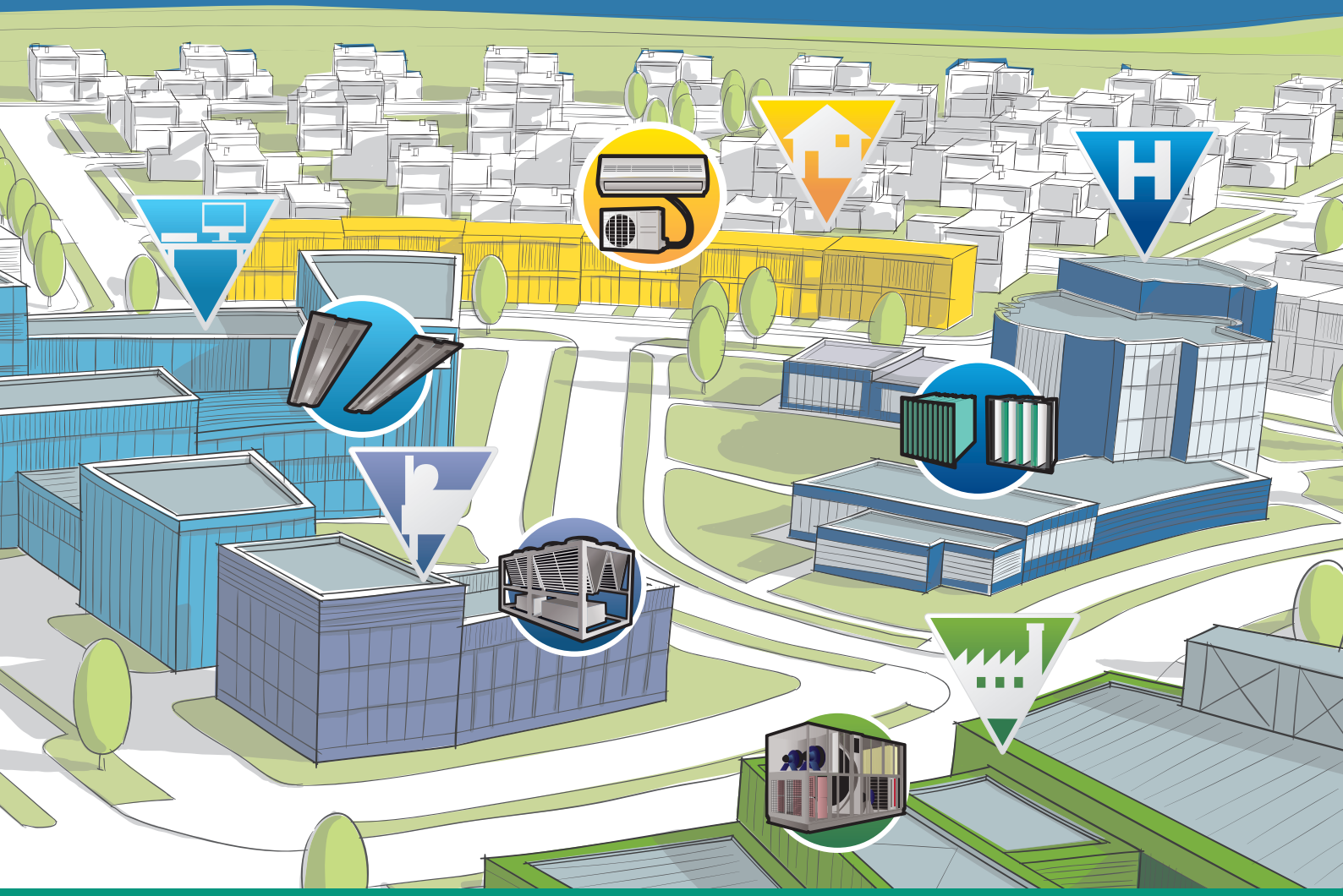

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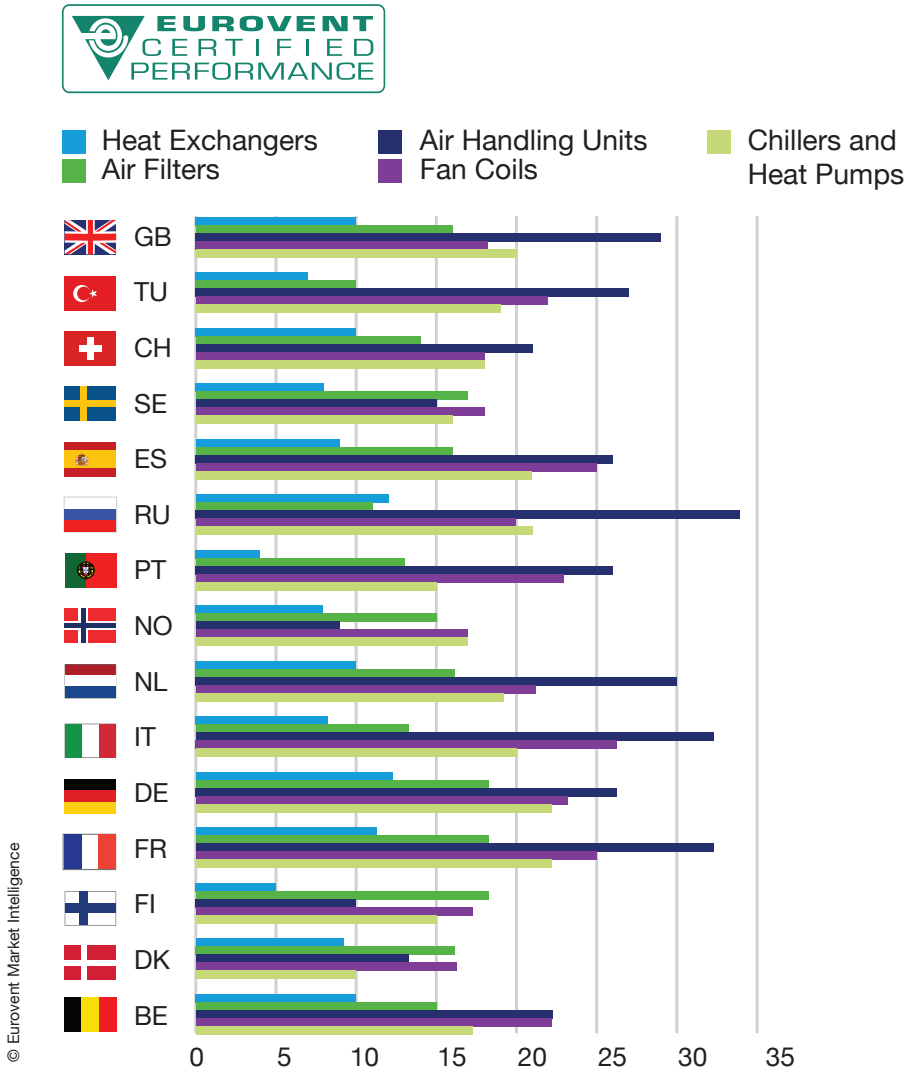

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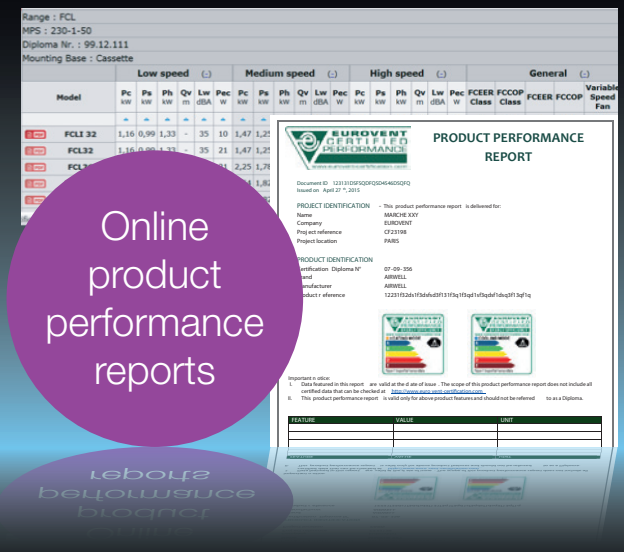

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Indoor Climate	Ventilation & Air Quality	Process Cooling & Food Cold Chain
European Heat Pumps	Air to Air Plate Heat Exchangers *	Cooling Towers
Chilled Beams *	Air to Air Regenerative Heat Exchangers *	Cooling & Heating Coils
Close Control Air Conditioners *	Air Handling Units *	Drift Eliminators
Comfort Air Conditioners *	Air Filters Class M5-F9 *	Liquid Chilling Package & Heat Pumps *
Rooftop (RT) *	Residential Air Handling Units (RAHU)	Heat Exchangers *
Fan Coils Units *		Remote Refrigerated Display Cabinets
Variable Refrigerant Flow (VRF) *		

* All models in the production have to be certified

▼ Indoor Climate

European Heat Pumps

Scope of certification

- Electrically driven heat pumps for space heating (incl. cooling function)
- Electrically driven heat pumps used for heating swimming pool water (outdoors or inside)
- Dual-mode heat pumps, i.e. designed for space heating and domestic hot water production,
- Gas absorption heat pumps (incl. cooling function)
- Engine-driven gas heat pumps (incl. cooling function).

Certification requirements

- Qualification campaign : 1 audit/factory + tests depending on products declared
- Repetition campaign: 2 machines/year + 1 audit/year/factory

Main certified characteristics and tolerances

- Heating and/or Cooling capacities *Ph* and/or *Pc* [kW], Electrical Power inputs *Pe* [kW] and Coefficient of performance *COP*
- Design capacity *Pdesignh*, Seasonal Coefficients of Performance *SCOP, SCOP*$_{net}$ and Seasonal efficiency η_s
- Minimum continuous operation Load Ratio *LRcontmin* [%], *COP* at LRcontmin and Performance correction coefficient at LRcontmin *CcpLRcontmin*
- Temperature stabilisation time *th* [hh:mm], Spare capacity *Pes* [W], Energy efficiency for water heating [COP_{DHW} & WH] or Global performance coefficient for a given tapping cycle COP_{global}, Reference hot water temperature θ'_{WH} and Maximum effective hot water volume V_{MAX} [l]
- Daily consumption for the draw-off cycle in question (Qelec)
- Annual consumption (AEC)
- Sound power levels *Lw* [dB(A)]

ECC Reference documents

- Certification manual
- Operational manual OM-17
- Rating standard RS 9/C/010

Main testing standards

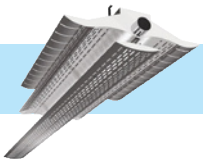
Thermal performance:
- Heat pumps with electrically driven compressors
- Space heating & cooling: EN 14511-1 to 4; Seasonal performance: EN 14825
- Domestic hot water: EN 16147
- Direct exchange ground coupled heat pumps: EN 15879-1
- Gas-fired heat pump : EN 12309-1 to 5

Acoustics:
- Heat pumps and dehumidifiers with electrically driven compressors: EN 12102
- ISO 3741: Reverberant rooms or ISO 9614-1: Sound intensity, measurements by points

▼ Indoor Climate

Chilled Beams

CERTIFY ALL



Scope of certification

This Certification Programme applies to all Active and Passive Chilled Beams. Chilled Beams are presented by ranges but all ranges must be certified. This applies to all product ranges which have either catalogue leaflets with product details including technical data or similar product information in electronic format.

Certification requirements

For the qualification procedure (yearly): 3 units are selected from regular production and tested in the independent Laboratory selected by Eurovent Certification.

For the repetition procedures: the number of units selected is limited to 1 unit/range.

Obtained performances shall be compared with the values presented in the catalogues or electronic selection from manufacturer's website.

Certified characteristics & tolerances

Cooling capacity: 3 conditions are required.

- Active: 80 – 100 – 120% of the nominal air flow rate (for 8°C temperature difference)
- Passive: 6 – 8 – 10°C temperature difference

Tolerance = 12% for the 3 single values; 6% for the average value.
Water pressure drop : tolerance = maximum (2 kPa ; 10%)

ECC Reference documents

- Certification manual
- erational Manual OM-12
- Rating Standard RS 2/C/007

Testing standards

- EN 14518: "Testing and rating of Passive Chilled Beams"
- EN 15116: "Testing and rating of Active Chilled Beams"

Comfort Air Conditioners

CERTIFY ALL

Scope of certification

This certification programme includes:

- AC1: comfort air cooled AC and air to air HP with cooling capacity up to 12 kW, except double duct and single duct units.
- AC2: comfort units with cooling capacity from 12 to 45 kW
- AC3: comfort units with cooling capacity from 45 to 100 kW

This programme applies to factory-made units intended to produce cooled air for comfort air conditioning (AC1, AC2, AC3). It also applies to units intended for both cooling and heating by reversing the cycle. For the AC1 programme units out of Regulation 206/2012 are excluded.

Participating Companies must certify all production models within the scope of the programme they enter. However concerning multi-split air conditioners, only systems with maximum two indoor units are included, same mounting type, capacity ratio 1+/- 0.05.

Certification requirements

For the qualification & yearly repetition procedures: AC1 : 8% of the units declared are selected and tested by an independent laboratory, and 30% of the selected units are tested at part load conditions. AC2 & AC3: 10% of the units declared are selected and tested by an independent laboratory.

Certified characteristics & tolerances

- Capacity (cooling and heating) –5%
- Efficiency (EER and COP) –8%
- Seasonal Efficiency (SEER and SCOP): –0% (the product is downgraded (or rerated) as soon as partload efficiency is out of tolerance
- A-weighted sound power level +0 dB (A)
- Auxiliary power +10%

Minimum continuous operation Load Ratio: LRcontmin [%], COP/EER at LRcontmin and Performance correction coefficient at LRcontmin CcpLRcontmin.

ECC Reference documents

- Certification manual
- Operational Manual OM-1
- Rating Standard RS 6/C/001 - RS 6/C/001A - RS 6/C/006

Testing standards

- EN 14511 • EN 14825 • EN 12102

▼ Indoor Climate

Close Control Air Conditioners

CERTIFY ALL

Scope of certification

This Certification Programme applies to factory-made units intended for Close Control Air Conditioning. This programme includes units with cooling capacities up to 100 kW under the specified test conditions.

Participating companies must certify all production models within the scope of the programme.

Certification requirements

For the qualification & repetition procedures: 10% of the units declared will be selected and tested by an independent laboratory.

Certified characteristics & tolerances

Air-Cooled and Water-Cooled Close Control Air Conditioners

- Total cooling capacity : –8%
- Sensible cooling capacity :–8%
- EER : –8%
- A-weighted sound power level : +0 dB

Chilled-Water Close Controls Air Conditioners

- Total cooling capacity : –8%
- Sensible cooling capacity : –8%
- Effective power input : +8%
- A weighted sound power level : +0 dB
- Water pressure drop :+10%

ECC Reference documents

- Certification manual
- Operational Manual OM-1
- Rating Standard RS 6/C/001
- Rating Standard RS 6/C/004
- Rating Standard RS 6/C/006

Testing standards

- EN 14511
- EN 12102 - EUROVENT 8/1

Rooftop (RT)

CERTIFY ALL

EUROVENT CERTIFIED PERFORMANCE ENERGY EFFICIENCY CHECK ENERGY CLASS ON www.eurovent-certification.com

The Eurovent rooftop certification (RT) program covers air-cooled and watercooled packaged rooftop units below 100 kW in cooling mode, with an option to certify units from 100 kW to 200 kW. The Rooftop program participants represent the five main European rooftop manufacturers.

Eurovent certifies indoor and outdoor sound levels, cooling and heating capacity and efficiency. Certified performances provide transparency and fair comparison between manufacturers. It is also the basis for the reliable study of HVAC system energy performance.

Currently the program evolves towards part load efficiency (SEER, SCOP) and certification of performance simulation tool data. Current work done on EN 14825 aims to address rooftops in the calculation hypothesis. The software certification is a key item to comply with existing and coming certification of building energy calculations in the EU countries.

Mr Philippe Tisserand
Product Manager for rooftop & commercial unitary for Trane EMEIA – Chairman of Eurovent Rooftop program compliance committee

Scope of certification

- This Certification Program applies to air-cooled and water cooled rooftops rated below 100 kW.
- Models with cooling or heating capacity ranging from 100 kW to 200 kW can be certified as an option.
- Models of rooftops using gas burners for heating shall be only certified for cooling.

Certification requirements

- For the qualification and repetition procedures (yearly) between 1 & 3 units are selected and tested by Eurovent Certification, depending on the number of products declared.

Certified characteristics & tolerances

- Capacity (Cooling or Heating): –5%
- EER or COP: -8%
- Condenser water pressure drop: +15%
- A-weighted Sound Power Level: +3 dBA.
- Eurovent Energy Efficiency class (cooling and heating)

ECC Reference documents

- Certification manual
- Operational Manual OM -13
- Rating Standard RS 6/C/007

Testing standards

- EN 14511 for Performance Testing
- EN 12102 for Acoustical Testing

▼ Indoor Climate

Fan Coils Units

CERTIFY ALL

Scope of certification

This Certification Programme applies to Fan Coil Units using hot or chilled water. It concerns both non ducted and ducted fan coils:

- Non ducted units: Fan Coil Units with air flow less than 0.7 m^3/s and a published external static duct pressure at 40 Pa maximum.
- Ducted units: Fan Coil Units up to 1 m^3/s airflow and 300 Pa available pressure.
- District cooling units and 60 Hz units can be certified as an option

Participating companies must certify all production models within the scope of the programme. Selection tools (software) are checked.

Certification requirements

Repetition procedure: the number of units to be tested each year will be proportional to the number of his basic models listed in the Directory, in an amount equal to 17% for Fan Coil Units with a minimum of one test.

Certified characteristics & tolerances

- Capacity* (cooling, sensible, heating): –5%
- Water pressure drop*: +10%
- Fan power input*: +10%
- A-weighted sound power: +1 / +2 dB(A)
- Air flow rate: –10%
- Available static pressure 0 Pa for medium speed and –5 Pa for other speeds
- FCEER & FCCOP
- Eurovent energy efficiency class

(*) **At standard and non standard conditions**

ECC Reference documents

- Certification manual
- Operational Manual OM-1A
- Rating Standard RS 6/C/002
- Rating Standard RS 6/C/002A

Testing standards

- Performance testing: EN 1397:2015
- Acoustic testing: EN 16583:2015

Variable Refrigerant Flow (VRF)

CERTIFY ALL

VRF systems have shown the highest growth amongst cooling systems during the past 10 years and indeed the highest potential for the next 10 years.

Until recently, VRF systems were the only type of direct expansion cooling system that was not covered by a dedicated Certification programme.

The Eurovent Certification scheme was therefore critical.

It was my privilege to Chair the Launching committee from the first meeting to its introduction. Whilst it took 2 years to complete, I believe it was worth the time and effort.

We at Toshiba are pleased as a manufacturer to work with Eurovent Certification Company as they guarantee the consistency of thermal testing and they increase the integrity of the products on the market.

Nick Ball
Toshiba EMEA
Engineer Director

Scope of certification

The certification programme for Variable Refrigerant Flow (VRF) applies to:

- Outdoor units used in Variable Refrigerant Flow systems with the following characteristics:
- Air or water source, reversible, heating-only and cooling-only.

VRF systems with data declared and published as combinations are excluded from the scope.

Heat recovery units are included in the scope but the heat recovery function is not certified.
High ambient systems are included in the scope but tested under standard conditions as specified in RS 6/C/008.

Certification requirements

- Qualification: units selected by Eurovent Certification shall be tested in an independent laboratory selected by Eurovent Certification.
- Repetition procedure: units selected from regular production shall be tested on a yearly basis.

Certified characteristics & tolerances

- Outdoor Capacity (cooling and heating): –8%
- Outdoor Efficiency (EER, COP): –10%
- A-weighted sound power level: 2 dB

ECC Reference documents

- Certification manual
- Operation manual OM-15
- Rating Standard RS 6/C/008

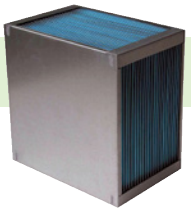
Testing standards

- EN 14511
- EN 12102

▼ Ventilation & Air Quality

Air to Air Plate Heat Exchangers

CERTIFY ALL



Scope of certification

This Certification programme applies to selected ranges of Air to Air Plate Heat Exchangers. Participants shall certify all models in the selected range, including:

- cross flow, counter-flow and parallel flow units
- all sizes
- all materials
- all airflow rates
- all edge lengths
- plate heat exchanger with humidity transfer

Heat Exchangers with accessories such as bypass and dampers shall not be included.

Manufacturers shall declare production places and provenance of products is randomly chosen. The programme does not cover other types of Air to Air Heat Exchangers like Rotary Heat Exchangers or Heat Pipes. Combination of units (twin exchangers) are also included in the scope of the program.

Certification requirements

For each range to be certified, 3 units for qualification and 1 for yearly repetition will be selected by Eurovent Certita Certification and tested in an independent Laboratory.

Certified characteristics & tolerances

- Dimensions: ± 2 mm
- Plate spacing: ± 1% or ± 1 plate
- Temperature efficiency Dry: –3 percentage points
- Temperature efficiency Wet: –5 percentage points
- Humidity efficiency: -5%
- Pressure drop: +10%, minimum 15 Pa

ECC Reference documents

- Certification manual
- Operational Manual OM-8
- Rating Standard RS 8/C/001

Testing standards

- EN 308

Air to Air Regenerative Heat Exchangers

CERTIFY ALL

Scope of certification

This Certification Programme applies to all ranges of Air to Air Regenerative Heat Exchangers (RHE) including sealing systems. Units sold without casing and sealing systems are also included. Participants shall certify all models in the ranges, including:

- all classes: condensation (non hygroscopic, non enthalpy) RHE, hygroscopic enthalpy RHE, hygroscopic sorption RHE
- all RHE geometry (wave height, foil thickness)
- all sizes (rotor diameters and rotor depths and surface areas of Alternating Storage Matrices - ASM)
- all materials
- all airflow rates
- all different types of sealing (if available)

Certification requirements

For the qualification procedures 1 unit per class of rotor will be selected and tested by an independent laboratory. For yearly repetition, 1 unit will be selected.

Certified characteristics & tolerances

- Temperature Efficiency: –3% points
- Humidity Efficiency: –5% points (min. tolerance 0.2 g/kg in absolute humidity of leaving supply air)
- Pressure Drop: +10% (min 10 Pa)
- Outdoor Air Corrrection Factor (OACF): 0.05
- Exhaust Air Transfer Ratio (EATR): +1% point

ECC Reference documents

- Certification manual
- Operational Manual OM-10
- Rating Standard RS 8/C/002

Testing standards

- EN 308
- ARI 1060

Air Handling Units

CERTIFY ALL

Swegon has participated in the program for Air Handling Units from the start. The first priority at that time, and still is, was to find a way for fair competition. This is a long term struggle were we try to cover all aspects from manufacturing to software performance predictions and its agreement with tests. We discuss and take decisions about mandatory performance in software printout, rules for the energy labelling, how to test and what to apply in the, on site, auditor check. Customers should go for Eurovent certified products, to get reliable data, and then they can cut the main cost and take care of the environment by minimising the use of energy.

Committee chair:
Mr Gunnar Berg
Development Engineer, Swegon

Scope of certification

This Certification Programme applies to selected ranges of Air Handling Units.

Participants shall certify all models in the selected product range up to the maximum stated air flow.

A range to be certified shall include at least one size with a rated air volume flow up to 3 m^3/s.

Certification requirements

For the qualification procedure: the selection software will be verified by our internal auditor. A visit on production site will be organized. During that visit, the auditor will select one real unit per range, as well as several model boxes that will cover all mechanical variations.

The selected units will be tested and performances delivered by the selection software will be compared to the performances measured in an independent laboratory.

For the repetition procedures, the auditor will annually check the software conformity against the production data, and tests will be repeated every 3 to 6 years.

Certified characteristics & tolerances

- External Pressure: 4% or 15 Pa
- Absorbed motor power: 3%
- Heat recovery efficiency: 3%-points
- Heat recovery pressure drop (air side): max. of 10% or 15 Pa
- Water coil performances (heating/cooling): 2%
- Water coil pressure drop (water side): max. of 10% or 2 kPa
- Radiated sound power level casing: 3 dB(A)
- Sound power level unit openings:
  - 5 dB @ 125 Hz
  - 3 dB @ 250 – 8 000 Hz
- Casing Air Leakage : same class or higher

ECC Reference documents

- Certification manual
- Operational Manual OM-5
- Rating Standard RS 6/C/005

Testing standards

- EN 1886: "Ventilation for buildings – Air handling units – Mechanical performance"
- EN 13053: "Ventilation for buildings – Air handling units – Rating & performance for units components and sections"

▼ Ventilation & Air Quality

Air Filters Class M5-F9

CERTIFY ALL

Today, people spend most of the time inside of buildings. Hence, indoor air quality is a key factor to human health. Air filters removing fine dust from the air stream are the key component in building heating, ventilation and air conditioning systems to supply air of the required cleanliness and to ensure a high level of indoor air quality. With the air filter certification program, reliable and transparent filter data are ensured to customers. On a yearly base, four different filters are selected out of the product range of each participant for testing at independent laboratories according to EN 779:2012, verifying the initial pressure drop, the filter class and the initial and minimum efficiency, as well as the energy efficiency class to Eurovent document 4/11. Additionally, with the new energy efficiency label, Eurovent provides valuable data to enable users to select the most energy efficient air filters.

Committee chair:
Dr. Thomas Caesar
Head of Filter Engineering Industrial Filtration Europe
Freudenberg Filtration Technologies SE & Co. KG

Scope of certification

- This Certification Programme applies to air filters elements rated and sold as "Medium or Fine Air Filters M5-F9" as defined in EN 779:2012 and with a front frame size of 592 x 592 mm according to standard EN 15805.
- When a company joins the programme, all relevant air filter elements shall be certified.

Certification requirements

- For the qualification procedures: 6 units will be selected and tested by an independent Laboratory selected by Eurovent Certification.
  Then each year 4 units will be selected & tested

Certified characteristics & tolerances

- Filter class: no tolerance.
- Initial pressure drop: +10% + 5 Pa (minimum 15 Pa)
- Initial efficiency for F7 to F9: 10% – point
- Discharge efficiency for F7 to F9: 10% – point
- Annual energy consumption +10% +60 kWh/a

ECC Reference documents

- Certification manual
- Operational Manual OM-11
- Rating Standard RS 4/C/001

Testing standards:

- EN 779:2012
- Eurovent 4/21

Residential Air Handling Units (RAHU)

CERTIFY ALL

Scope of certification

This programme applies to balanced residential AHUs (supply and exhaust) with heat recovery systems such as:

- Air-to-air **plate** heat exchangers
- Air-to-air **rotary** heat exchangers
- **Heat-pumps** with a nominal airflow below 1 000 m³/h.

Certification requirement

- Qualification test campaign: 1 test per heat recovery type.
- Repetition test campaign: 1 test every 2 years for each heat recovery type.
- Units are sampled directly from selling points.

Certified performances

- Leakage class
- Aeraulic performances:
- Airflow/pressure curves
- Maximum airflow [m³/h]
- Electrical consumption [W]
- Specific Power Input SPI [W/(m³/h)]
- Temperature efficiency / COP
- Performances at cold climate conditions
- SEC (Specific Energy Consumption) in [kWh/(m².an)]
- A-weighted global sound power levels [dB(A)]

Tolerances

- Leakage class 0
- Airflow +/-10%
- Temperature efficiency –3%-point
- Temperature efficiency at cold climate –6%-point
- COP / EER –8%
- A-weighted global sound power levels +2dB(A)
- Electrical consumption +7%
- Specific Power Input SPI +7%

ECC Reference documents

- Certification manual
- Operation manual OM-16
- Rating standard RS 15/C/001

Testing standards:

- European standard EN 13141-7:2010

Cooling Towers

The importance of air conditioning and industrial cooling is constantly increasing in modern architecture and industrial process cooling. The human perception of comfort and the new challenges to reduce the electrical power consumption and CO_2 footprint have designers striving for optimal system performances with the highest possible efficiencies. Reliable thermal performances are crucial to ensure these best efficiencies which are typical for cooling circuits driven by evaporative cooling equipment. On a yearly basis, one random picked cooling tower of each Eurovent-CTI certified product line will be full scale thermal tested by applying the CTI standard 201.

Eurovent Certita Certification guarantees the consistency of thermal testing and manufacturing of European and non-European companies that subscribe to the program.

Committee chair:
Mr Rob Vandenboer
Product Manager, Quality Manager
Evapco Europe, BVBA

The first ECC / CTI collaborative certification program for Cooling Towers

The Eurovent Certification Company (ECC, Brussels, Belgium) is pleased to announce the Certification programme for cooling tower thermal performance developed in cooperation with the Cooling Technology Institute Est.1950 (CTI, Houston, Texas, USA). The scope of the program includes standardized model lines for open circuit cooling towers, typically factory assembled. Standardized model lines are composed of individual models that are required to have published thermal rating capacities at corresponding input fan power levels.

Thermal performance certification via this program offers a tower buyer assurance that the capacity published for the product has been confirmed by the initial and on-going performance testing per the requirements of the program using CTI STD-201. It also offers for regulators of energy consumption related to cooling towers, that the capacity of the towers has been validated. Minimum energy efficiency standards such as ASHRAE 90.1, which requires cooling tower energy efficiency validation by the CTI certification process, are used by governments and by green building certification programs such as LEED™.

Scope of certification

This Certification Programme for Cooling Towers applies to product ranges (or product lines) of Open-Circuit series and Closed Circuit Cooling Towers that:

- Are manufactured by a company whose headquarter or main facility are located in Europe, Middle-East, Africa or India. After getting the Eurovent Certification, the CTI certificate could be requested.
- Have already achieved and hold current certification by the Cooling Technology Institute (CTI) according to CTI STD-201.

Certification requirements

For the qualification & yearly repetition procedures our internal auditor visits the production place and reviews the conformity of Data of Records. One unit per range is selected and tested by an independent test agency.

Certified characteristics & tolerances

- Certified characteristic shall be per CTI STD-201
- Entering wet bulb temperature: 10°C to 32.2°C (50°F to 90°F)
- Cooling range > 2.2°C (4°F)
- Cooling approach > 2.8°C (5°F)
- Process fluid temperature < 51.7°C (125°F)
- Barometric pressure: –91.4 to 105.0 kPa (27” to 31” Hg)

ECC Reference documents

- Certification manual
- Operational Manual OM-4-2015
- Rating Standard RS 9/C/001-2014

Testing standards

- CTI STD-201 RS
- ECC OM-4-2015

▼ Process Cooling & Food Cold Chain

Cooling & Heating Coils

Heating Cooling Coils (HCCs) which enable the conditioning of different zones and flexibility in application in buildings are generally employed in compact and central station AHU. To meet the required extra capacity in various processes, they are also used as heating or cooling devices.

With the application of these coils to high energy efficient heat recovery systems, the entire system becomes more compact as well as it avoids occupation of large spaces. Besides, they can be applied to Variable Air Volume (VAV) systems used for conditioning of hospitals, shopping centers and convention facilities.

The Certification programme for the HCCs has increased integrity and accuracy of the industrial performance ratings which provides clear benefits for end users who can be confident that the product will operate in accordance with design specifications. Also, by means of this certification programme users can collect reference data on the fundamental characteristics of the HCCs, such as capacity, pressure drop, mass flow complying with the standard of EN 1216.

Committee chair:
Engin Söylemez
R&D Test Engineer, Friterm A.Ş

Scope of certification

The rating standard applies to ranges of forced circulation air cooling and air heating coils as defined in ENV1216.

Certification requirements

- Qualification and repetition procedures: units declared will be selected and tested by an independent laboratory.
- The number of units will depend on the variety of coil material configurations and their applications for the applied range.
- The selection software will be verified in comparison with the test results.

Certified characteristics & tolerances

- Capacity: –15%
- Air side pressure drop: +20%
- Liquid side pressure drop: +20%

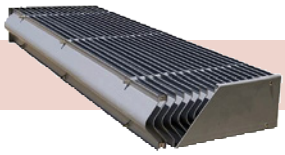
ECC Reference documents

- OM-9
- RS 7/C/005

Testing standards

- ENV 1216

Drift Eliminators



Scope of certification

The Certification Programme for Drift Eliminators applies to Drift Eliminators used for evaporative water-cooling equipment.

Certified characteristics & tolerances

The following characteristics shall be certified by tests:

- For counter-flow and cross-flow film fill, the average drift losses of the two tests at 3.5 m/s are less than 0.007% of circulating water flow rate.
- For cross-flow splash fill, the average drift losses of the two tests at 3 m/s are less than 0.007% of circulating water flow rate.

No tolerance will be applied on the average drift losses.

ECC Reference documents

- Certification manual
- Operational Manual OM-14
- Rating Standard RS 9/C/003

Testing standards

- CTI ATC-140

▼ Process Cooling & Food Cold Chain

Liquid Chilling Package & Heat Pumps

CERTIFY ALL

Certification is a strong way to supply safe information in the right language

Offering guaranteed performances to customers has always been a fundamental benefit thanks to the accredited independency of this certification program. Today the need for certified performances is emphasized by several directives and it is essential for customers to:

- demonstrate the high performance efficiency of their buildings,
- compare safety performances of the products selected with the requirements of the regulations implementing ERP Ecodesign & labelling directives,
- be sure of the return of their investment or energy savings,
- have the ability to compare fairly between chillers, heat pumps or other type of heaters.

In addition to being certified, performances must be seasonal, in line with the new regulations, and assessed according to the new harmonized standards as soon as they apply.

This program is also a great opportunity for fruitful exchanges between independent laboratories, certification body and manufacturers. It also facilitates the understanding and application of new regulations or standards in a regulatory context in perpetual evolution.

A certification is a guarantee of fair competition (for customers/manufacturers). It also helps increase the number of applications using RES, and represents a commitment in the reduction of consumption and emissions.

Didier Perales
Manager of Technical Relations & Concept Projects
CIAT Group France

ECC Reference documents

- Certification manual
- Operational Manual OM-3
- Rating Standard RS 6/C003 - RS 6/C/003A

According to New Regulations for Space heaters Eco Labelling No 811/2013 - ErP No 813/2013.

Seasonal efficiency for heating (η_s) for Chillers & Heatpumps with a design capacity below 70kW is certified since 26 September 2015. (For units above 70kW it is optional).

Scope of certification

- This programme applies to standard chillers and hydronic heat pumps used for heating, air conditioning and refrigeration.
- They may operate with any type of compressor (hermetic, semi-hermetic and open) but only electrically driven chillers are included.
- Only refrigerants authorised in EU are considered. Chillers may be air cooled, liquid cooled or evaporative cooled.
- Heating-only hydronic heat pumps, 60 Hz units and Higher capacities (between 600 kW and 1500 kW) units can be certified as an option.

Certification requirements

Qualification and repetition: a certain number of units will be selected by Eurovent Certification and tested every year, based on the number of ranges and products declared.

Certified characteristics & tolerances

- Cooling & heating capacity and EER & COP at full load: < –5%
- Performance SCOP & Seasonal Efficiency for Heating η_s: automatically rerated when Part Load efficiency criteria fails
- Seasonal Efficiency ESEERfor cooling: automatically rerated when Part Load efficiency criteria fails
- A-weighted sound power level: > +3 dB(A) (> +2 dB(A) for units with Pdesignh below 70kW)
- Water pressure drop: +15%

Testing standards

- Performance testing: EN 14511
- Seasonal Performance testing: EN 14825
- Sound testing: EN 12102

▼ Process Cooling & Food Cold Chain

Heat Exchangers

CERTIFY ALL

EUROVENT CERTIFIED PERFORMANCE ENERGY EFFICIENCY CHECK ENERGY CLASS ON www.eurovent-certification.com

The purpose of the Eurovent "Certify-All" certification programme for heat exchangers is to encourage honest competition and to assure customers that equipment is correctly rated.

The programme covers 3 product groups:
- Unit Air Coolers
- Air Cooled Condensers
- Dry Coolers

The "Certify-All" principle ensures that, for heat exchangers, all models in the three product categories are submitted for certification, not just some models chosen by the manufacturer.

A product energy class scheme has been incorporated into the certification programme, based on 7 classes from "A++" to "E" in order to provide a guide to the best choice of product: this enables the user to minimize life-cycle costs, including running costs which account for a much superior sum than the initial investment cost.

Committee chair:
Stefano Filippini
Technicalmanager - LUVE

Air coolers for refrigeration

Dry coolers

Air cooled condensers

Scope of certification

The Eurovent Certification Programme for Heat Exchangers applies to products using axial flow fans. The following products are excluded from the Eurovent Certification Programme for Heat Exchangers:

- Products units using centrifugal type fans.
- Units working at 60 Hz

In particular, the following products are also excluded from the Eurovent Certification programme for Dx Air Coolers and Air Cooled Condensers:
- Products using R717 refrigerant (ammonia), CO_2, and refrigerants with high glide like R407C or without correction factors
- Product ranges of Dx Air Coolers where maximum standard SC2 is below 1.5 kW.
- Product ranges of Air Cooled Condensers where maximum standard capacity under DT1 15K is below 2.0 kW

Certification requirements

- Qualification: units selected by Eurovent Certification shall be tested in an Independent Laboratory selected by Eurovent Certification.
- Repetition procedure: units selected from regular production shall be tested on a yearly basis.

Certified characteristics & tolerances

- Standard capacity –8%
- Fan power input +10%
- Air volume flow ±10%
- External surface area ±4%
- Energy ratio R
- Energy class

For Dry Coolers:
- Liquid side pressure drop +20%

For Air Cooled Condensers and Dry Coolers:
- A-weighted sound pressure level: +2 dB(A)
- A-weighted sound power level: +2 dB(A)

ECC Reference documents

- Certification manual
- Operational Manual OM-2
- Rating Standard RS 7/C/005

Testing standards

- Thermal Performance EN 328
- Thermal Performance EN 327
- Thermal Performance EN1048
- Acoustics EN 13487

Remote Refrigerated Display Cabinets

CERTIFY ALL

Remote refrigerated display cabinets (RRDC) are the appliances for selling and displaying chilled and/or frozen foodstuff to be maintained within prescribed temperature limits.

Typically, food and beverage retailers are the direct customers of the refrigeration industry while the supermarket's customers are the end users of food and beverage retailers.

Food and beverage retailers ask for food safety and also for appliances with high-energy efficiency, supermarket's customers ask for food safety. Refrigeration industry has to face the hard challenge of satisfying both needs.

How is it possible to assure that the refrigeration appliances perform accurately and consistently to the reference standards? How is it possible to assure that what is rated by the manufacturer is properly rated?

There is only one way: It is necessary to join a globally recognized and industry respected certification program.

Eurovent Certita Certification program for RRDC is the only certification program in Europe that can assure that performance claims have been independently measured and verified. The factory audits and the product's performances tested in an independent and third-party laboratory make the difference!

Since 2011, Eurovent Certita Certification has also launched a voluntary energy label certification scheme, anticipating what only nowadays EC DG Energy is doing in the framework of Ecodesign and Energy Label Regulations. What better way to rate RRDC's energy consumption and to promote their energy efficiency?

What would you trust more: a self-declaration by the Manufacturer or what an independent, globally recognized and forerunner certification program is able to assure? Which one is better?

Maurizio Dell'Eva
Project manager
EPTA S.p.A. – MILANO (ITALY)

Scope of certification

- 100 basic model groups divided in 5 categories of remote units : semi-verticals and verticals (with doors); multi-deckers; islands; service counters; combi freezers.
- At least two references per basic model group representing 80% of sales shall be declared.
- One Bill of Material for each declared reference.

Certification requirements

- Qualification: sampling and test of one unit & Audit of one factory.
- Repetition test of one unit per brand every 6 months & Annual audit of each factory.

Certified characteristics & tolerances

- Warmest and coldest product temp. ±0.5°C
- Refrigeration duty (kW) 10%
- Evaporating temperature –1°C
- Direct elec. Energy Consumption (DEC) +5%
- Refrigeration elec. Energy Cons (REC) +10%
- M-Package Tclass : ±0.5°C
- Total Display Area (TDA) –3%

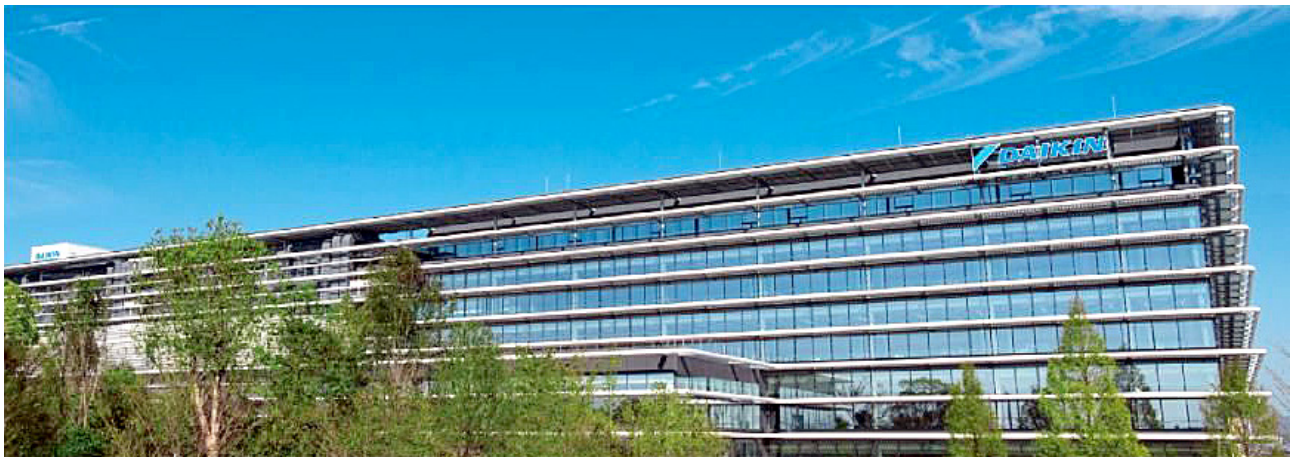
ECC Reference documents

- Certification manual
- Operational Manual OM-7
- Rating Standard RS 14/C/001

Testing standards

- EN ISO 29953 and amendments

Daikin's new zero energy research centre invests in tomorrow's technologies



Market leading HVAC-R manufacturer, Daikin has opened a state of the art new Technology and Innovation Center (TIC) in Osaka, Japan. From this year, the substantial new facility, spanning approximately 58,000 m^2, is the core base for technology development of the globally expanding Daikin Group.

With over 90 years' experience in the design and manufacture of HVAC-R technologies, Daikin is globally renowned for its pioneering approach to air conditioning, heating systems and refrigeration product development; and has grown to become an award winning market leader in HVAC-R technologies.

TIC is equipped with some breathtaking state-of-the-art laboratory facilities. Spanning over six floors, the building houses a ten-meter electromagnetic semi-anechoic chamber, a low temperature/high humidity laboratory, an artificial climate laboratory, a sleep and metabolic laboratory. All with the goal to keep Daikin in the number 1 position of delivering maximum comfort, efficiency and reliability to it's customers.

Small footprint, big impact

TIC encompasses Daikin's advanced low-carbon technologies to achieve a zero energy building (ZEB). With the completion of TIC, Daikin aims for an initial 70% energy reduction and 100% energy savings in the future by updating facilities as a solution model for development and verification of each new energy technology. Specifically, TIC, is a living example of energy-saving technologies in practice; such as individual control of temperature and humidity by multi-split air conditioners, peak shift by thermal storage and heating by exhaust heat recovery. Optimum setting of the overall system by BEMS and Solar panels with tracking mounts also improve power generation efficiency.

Built to pioneer

The new centre's aim is primarily to be a hub of innovation. To achieve this, a variety of design innovations were incorporated in the TIC office and laboratory areas to promote collaborative creation for engineers. Office work areas are arranged at distances that facilitate optimum communication between people. On the third floor is the space linking product development and collaborative creation gained through customer negotiations and information exchanges, and where Daikin's core/advanced technologies are displayed. On the sixth floor, partners' experts have an area to share their wisdom and knowledge and participate in stimulating discussions. "Fellow Rooms" are also provided as office space for university lecturers, opinion leaders and satellite office for ventures.

> By encouraging collaborative innovation both from inside and outside the company, TIC's aim will be to leverage new and advanced technologies and in turn create new value and business opportunities for the group. Our approach to "collaborative creation" on a global level through alliances and collaborations with various companies, universities and research organizations will result in breakthrough applied technologies in industries beyond the HVAC-R environment.

Looking to the future

The company's former development of highly energy efficient heat pumps and units has already led to the application of the inverter and other technologies, to aerospace parts, home medical equipment and product development process software built up through its air conditioning business.

Daikin active partnerships with Kyoto University, Osaka University and Nara Institute of Science and Technology, along with joint research and development with homebuilders, manufacturers of electrical appliances and materials, and architectural firms, have given the group a firm collaborative network to promote further technology developments and pursue a low-carbon society globally. ■

International Building Performance Simulation Association

CALL FOR ABSTRACTS

One-page abstracts are sought for peer-reviewed papers to be presented at Building Simulation 2017 in San Francisco, California, August 7–9, 2017. This is the 15th biennial conference of the International Building Performance Simulation Association (IBPSA).

You are encouraged to submit abstracts of papers on any aspect of building-related performance modeling and associated software techniques.

Abstract Due Date: August 10, 2016

Paper Due Date: November 30, 2016

Abstracts will be judged primarily based on scientific soundness of the applied methods and the degree to which the contribution advances the state of the art. Authors of accepted abstracts may submit 4–10 page manuscripts that will be double-blind reviewed. Papers that are accepted and presented will be published in the citable conference proceedings.

BUILDING SIMULATION 2017
AUGUST 7-9 • SAN FRANCISCO

Submission details and conference information: **www.buildingsimulation2017.org**.

Non-paper oral presentations will be solicited later in 2016 -- that format may be appropriate for case studies or application examples.

The mission of IBPSA is to advance and promote the science of building simulation in order to improve the design, construction, operation, and maintenance of new and existing buildings and urban developments. The U. S. regional affiliate, IBPSA-USA, is the host of Building Simulation 2017.

More information is found at **www.ibpsa.org** and **www.ibpsa.us**

INTERNATIONAL BUILDING PERFORMANCE SIMULATION ASSOCIATION

Conference Platinum Sponsors

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For information on sponsorship opportunities, please see **www.buildingsimulation.org**

REHVA grants auspices to FOR THERM, a HVAC trade fair to be held on 20-24 September 2016 in Prague, Czech Republic

The HVAC sector is on the rise in the Czech Republic as the government continues to financially support installations of new, more ecological heat sources through a system of subsidies and allocation of EU funding resources. This is why both businesses and end clients are willing to invest in new heating and AC systems. And this is why now, half a year before the event takes place, the FOR THERM trade fair witnesses an unprecedented interest of companies seeking to exhibit at the trade fair.

The 2016 FOR THERM, the 7th trade fair for heating, alternative sources of energy and air conditioning, will be held on 20-24 September 2016 in Prague's largest exhibition centre. Co-located with FOR ARCH, the largest and longest-standing Czech construction exhibition, FOR THERM annually presents solutions and presentations of leading companies of the HVAC sector. In 2015, the set of concurrent exhibitions was visited by more than 74,000 visitors and attended by 830 exhibitors from 13 different countries, which makes it the top event of the building industry in the Czech Republic.

Due to its location in Prague, an important hub of Central-European business, FOR THERM is a unique opportunity for both domestic and foreign exhibitors to present their services and products within an international competition. If you want to address the Czech region, FOR THERM is the one place you need to meet new partners, dealers, suppliers and customers.

Besides exhibits and stand presentations, the trade fair furthermore offers a rich accompanying programme, awards for the best solutions presented, lectures, professional seminars, conferences, and much more. The fact that this is a second time in a row that REHVA has granted auspices to FOR THERM proves that FOR THERM can easily compete with the top HVAC exhibitions in Europe. To further strengthen the international scope of the event, a set of organized B2B meetings entitled Matchmaking Business Meetings will be held. The meetings are designed to help international participants to introduce themselves on the Czech market and to find new business partners, suppliers, manufacturers, producers and wholesalers.

Both visitors and potential exhibitors are welcome to visit **www.for-therm.cz** for more information about the event.

ISH Shanghai & CIHE

ISH Shanghai & CIHE plays an important role in introducing individual heating solutions to China's East and Central regions. The show is co-located with three other fairs: Shanghai Smart Home Technology, Shanghai Intelligent Building Technology and Shanghai International Lighting Fair. Collectively known as the "Intelligent Green Building - IGB" exhibition platform Shanghai edition, the shows provide participating exhibitors and visitors a prime opportunity to explore interrelated building technologies at one location. These include heating, ventilation, air conditioning, plumbing, lighting and LEDs, building automation, smart home and solar building. The 2016 edition is expected to welcome 51,000 visitors, more than 700 exhibitors and cover 40,000 m^2 exhibition space.

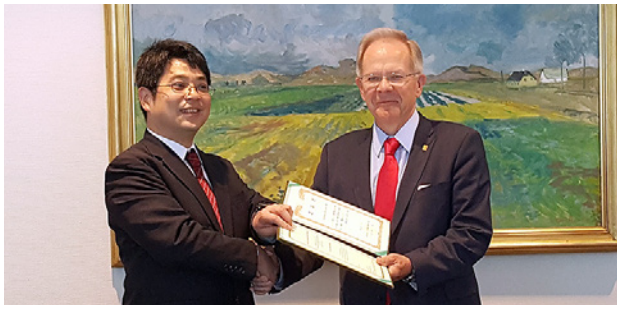
Exhibitors of ISH Shanghai & CIHE will include international and domestic manufacturers of boilers, radiators, floor-heating, air-conditioning and ventilation systems, meters, pumps, valves and renewable energy thermal utilization products. The renowned Shanghai International HVAC Forum is also a show highlight.

For more information please visit **www.ishc-cihe.com** ■

SHASE award to Olli Seppänen

In connection of the REHVA General Assembly in Aalborg SHASE, the Society of Heating, Air-Conditioning and Sanitary Engineers of Japan, awarded prof Olli Seppänen, the former president and secretary general of REHVA with an International Honorary Membership for his long term activities in developing the relations between SHASE and REHVA. The award was presented by professor Ryozo Ooka.

REHVA and SHASE signed a memorandum of understanding in 2014. Three REHVA guidebooks have been translated in Japanese.



Lindab **Munio**

Superior comfort for longer stays

An active chilled beam for efficient heating, cooling and ventilation in hotel rooms

Discover the leading ventilation solution that heats, cools and ventilates hotel rooms. Lindab Munio is designed for easy installation in rooms where suspended ceiling and bulkhead mounting are standard, making Lindab Munio the optimum active chilled beam in hotels. In addition to ensuring fresh air and low noise levels, it efficiently regulates the room temperature using water. Lindab Munio is characterized by the highest quality and unique compactness - with the lowest weight and height on the market. Despite its compact design, Lindab Munio offers superior energy efficiency and all round performance, creating the perfect indoor climate.

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REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

New REHVA President and Board Members

REHVA installed a new president and elected two board members at its Annual Meeting in Aalborg as part of the CLIMA 2016 Congress. Prof. Stefano P. Corgnati was elected as president-elect one year ago during the REHVA Annual Meeting in Riga, Latvia. His term began at this year Annual Meeting and will last till CLIMA 2019 in Romania.

Karel Kabele and Stefano P. Corgnati.

Two new board members for 2016-2019 have been elected during the REHVA General Assembly 2016 in Aalborg:

- Mr. **Atze Boerstra** as Vice-president and Co-chair of the Supporters Committee
- Prof. **Milos Lain** as Vice-president

Three Board Members have been re-elected as well until 2019:

- Mr. **Frank Hovorka** as Treasurer and Chair of the Publishing and Marketing Committee;
- Prof. **Manuel Gameiro da Silva** as Vice-president and Chair of the Education and Training Committee;
- Prof. **Jarek Kurnitski** as Vice-president and Chair of the Technology and Research Committee.

Egils Dzelzitis, Vice-president AND Chair of the Membership Committee, will continue his term until 2017.

The new REHVA President and the new Board Members replied to some questions regarding their new involvement in REHVA.

PROF. STEFANO P. CORGNATI

REHVA President 2016-2019

Q: Prof. Corgnati, how has your background and experience prepared you to be effective as REHVA President?

A: I got involved in REHVA around 2007, through a mandate of AICARR during which I had the pleasure to work with Carmine Casale. I was involved in REHVA Committees and Task Forces, chairing with Manuel Gameiro da Silva the Task Force on "Indoor Climate Assessment".

In 2011 I was elected Vice-President and, in 2014, nominated Treasurer. This experience was fundamental to enter in all the dynamics of the Federation, understanding its relationships and priorities.

In 2015, I was elected by the General Assembly, President-Elect, keeping my position as Treasurer too.

Q: What are the most important issues REHVA should work with in the near future?

A: The main priority is to develop a strategic plan, with medium-long term perspective. This document has to be developed in cooperation with REHVA Member Associations and supporters. We will dedicate the first half of my mandate on this task, so, in this way, the next President, that will be one of the present Board Members, will start the operational implementation of the strategic plan.

This is a crucial moment for REHVA: lots of new opportunities are in front of us, but we need to have a clear and solid organization to consolidate our reputation in Europe and at international level.

Q: What is your vision of REHVA? What do you want to accomplish during your presidency?

A: REHVA is a complex organism.

We have to face different needs and expectations, from big associations to very small ones. This is a big challenge. First of all, I think we should change our mentality: REHVA has to be focused in providing services to its members and supporters. Which services? This fundamental question has to be solved and clarified by a transparent relation with our members and supporters: we have to listen to them, understanding what they expect from REHVA.

MR. ATZE BOERSTRA

Vice-president 2016-2019
Co-chair of the Supporters Committee 2016-2019

Q: Mr. Boerstra, how has your background and experience prepared you to be effective as Vice-president and Co-chair of the Supporters Committee?

A: I have a background in Indoor Climate control and HVAC technology and graduated at the Delft University of Technology. In the past I was board member of TVVL, the Dutch member-association of REHVA. Over 20 years have been involved in environmental design and standardization and my specialty is indoor air quality and thermal comfort. In 1996 I founded BBA Indoor Environmental Consultancy. Today I am still managing director and senior IEQ consultant there. I'm also active member of the International Society of Indoor Air Quality and Climate (ISIAQ).

Q: What are your ideas to enhance REHVA's potential in particular regarding your activity within the Supporters Committee?

A: I'm looking forward to work with Ioan Dobosi who fortunately decided to stay as chair of the committee. I think that there is a lot of potential in terms of corporation at European level with close involvement of members and supporters in REHVA. There are quite a few things that have to be done such as a stronger engagement at European level and the joint exploration of other markets outside Europe as China, India, North America.

Q: What would you like to achieve at the end of your 3 years' mandate?

A: One of the things that I would like to work on is a stronger presence of REHVA in Brussels, and e.g. a strengthened relationship with the European Commission, the European parliament and other European institutions.

PROF. MILOS LAIN

Vice-president 2016-2019

Q: Prof. Lain, how has your background and experience prepared you to be effective as REHVA Vice-president?

A: I've been participating for 20 years in the national Air-conditioning and Ventilation Committee of Czech Society of Environmental Engineering also member of REHVA. Currently, and I am the president of this committee. I have deep experience in organising national and international conferences. As the Czech Technical University professor, I have technical background and experience in teaching HVAC, research and international cooperation in this field.

Q: What are the main changes you would like to make within REHVA?

A: I don't hope to change REHVA, I believe, as a board member, I will participate on the future development of the current REHVA's activities in all fields. Especially, I hope to improve REHVA in fields such as congress organization, education, technology and research.

Q: How do you see REHVA in 3 years' time? Exactly when your mandate will end or you will be re-elected?

A: I see REHVA as strong and stable player on international construction and HVAC sector, fulfilling its mission to develop and disseminate economical, energy efficient and healthy technology for mechanical services of building; to serve its members and the field of building engineering by facilitating knowledge exchange, supporting the development of related EU policies and their national level implementation.

CLIMA2016 Congress on hot HVAC Topics

By ZOSIA K. LAV, Communications Manager at Danvak

The CLIMA2016 Congress was successfully held in Aalborg – Denmark – from 22nd to 25th of May. The congress was attended by 875 people from 49 different countries and included a large exhibition, which added an exciting atmosphere to the event.

In the evening on the 22nd of May, speakers, participants, sponsors, exhibitors and organizers mixed and mingled at the Robbers' Camp in the Forest of Rold where we all had the opportunity to try axe throwing!

CLIMA2016 was attended by 875 people from 49 countries. Speakers, participants, sponsors and exhibitors were busy networking during the breaks.

The congress attracted all stakeholders from the building sector as it focused on energy efficient building and HVAC system performance in practice and dealt with the complete live cycle of buildings and their HVAC systems from design specification to demolition and reuse. The aim of the congress was to provide a forum for academics, professionals, engineers, architects and journalists from the HVAC field to meet and exchange their ideas, results and latest research.

President of CLIMA2016, Professor Per Heiselberg from Aalborg University, giving his welcome speech at the opening ceremony in the House of Music in Aalborg, Denmark.

Taking a broad and cross-disciplinary approach to addressing HVAC issues in contemporary society, conference topics included: Building and HVAC System Design, Efficient HVAC Systems, Sustainable Energy for Buildings and Smart Building Operation & Management. The congress, moreover, offered technical tours, student competitions and a poster competition.

The CLIMA2016 Congress was arranged by Danvak - the Danish Society of Heating, Ventilation and Air Conditioning - in collaboration with Aalborg University and REHVA and it was sponsored by Daikin, Grundfos, Flex Coil, Danfoss, Eurovent Certification, VELUX, Lindab, Camfil, Broad A/C and Airmaster. The congress is held every three years and next CLIMA2019 Conference will be held in Bucharest, Romania from 26th – 29th of May, 2019. ■

The top ten list of participating countries

1 – Denmark: 191
2 – Germany: 69
3 – Japan: 51
4 – Italy: 48
5 – Belgium: 47
6 – Republic of Korea: 35
7 – France: 33
8 – Sweden: 31
9 – People's Republic of China: 29
10 – Turkey and The Netherlands 27

REHVA Supporter – Introduction W+H

WALDHAUSER + HERMANN ENERGIE + HAUSTECHNIK INGENIEURE

Waldhauser+Hermann AG was established in 1973 and is now in its second generation as a family-owned company, managed by Marco Waldhauser and Roman Hermann. The HVAC engineering consultancy also develops energy and sustainability concepts, monitors building systems in operation and consults building owners on operational optimization opportunities. There are currently 55 employees at the main office in Münchenstein, close to the city of Basel in Switzerland. A satellite office is located in eastern Switzerland, in St. Gallen.

Due to the company's strategy for acquiring the majority of its projects, which is based on architectural competitions in partnership with the relevant consultants, the projects are varied and located all over Switzerland. Office buildings, hospitals, universities, museums, residential buildings and laboratories are typical projects for Waldhauser+Hermann.

Waldhauser+Hermann is well known for its confident leadership in aiming for simple and minimized HVAC systems, whilst focusing on a high conceptual integration of the HVAC and energy concepts into the buildings and their facades. Natural ventilation concepts, nzeb-concepts (nearly zero energy buildings) and geothermal energy use are just some of the specialties Waldhauser+Hermann is well known for.

Another important facet of the company is its effort in the field of education. It starts by having its own lecturers at universities and business schools and is followed by offering young people apprenticeships.

Following on from this, we engage in professional development by high-level participation and activity in associations and committees. Waldhauser+Hermann values opportunities to discuss and exchange ideas within the engineering community.

REHVA is therefore a perfect complement for a European knowledge exchange.

REHVA Annual Meeting and Conference 2017

April 7th and 8th, 2017, at Loughborough University, Leicestershire, UK.

The next REHVA Annual Meeting and Conference will be held in the heart of England, in Loughborough. The date (April 7th and 8th, 2017) has still to be confirmed by the CIBSE, the REHVA Member organizing it.

Upfront the REHVA Annual Meeting, the CIBSE will (April 5th and 6th, 2017) host the Technical Symposium "Delivering Resilient High Performance Buildings". This symposium is organized by CIBSE and is co-sponsored by ASHRAE and REHVA.

See **www.cibse.org/**

REHVA World Congress CLIMA2019

May 24th to 29th, 2019, Bucharest, Romania

At the 12th REHVA World Congress, CLIMA2016, held in Aalborg, Denmark, in May 2016, the next REHVA World Congress, CLIMA2019 was announced with the projection of a promotional video (available on REHVA YouTube channel). The next CLIMA Congress will be held in the Romanian Parliament Palace in Bucharest between May 26th and May 29th, 2017.

For more information: **http://clima2019.org/**

The presentations of the workshops are available at
http://www.rehva.eu/events/clima2016/clima-2016-workshops.html

REHVA Workshops at CLIMA2016

CLIMA2016 Congress, was organized by REHVA Danish member DANVAK in Aalborg last May 22nd to 25th, 2016. Theme of the congress was: "building and HVAC system performance". The "CLIMA World Congress" is the official conference of REHVA, organized every 3 years by one of REHVA Member Associations.

As part of the conference, REHVA organized 25 technical Workshops. The objective of these workshops was to provide an opportunity for two-way communication between the speakers and their audiences on technical subjects. The REHVA Workshops were organized by REHVA Supporters such as SWEGON, Grundfos, Eurovent Certita Certification, Belimo, ES-SO and Eurovent Association as well as by REHVA International Cooperation partners as CCHVAC, SHASE, SAREK and AIVC. EU Projects' workshops were also present: PROF/TRAC, QUANTUM, Cheap-GSHPs and QUALICHeCK. The rest of the REHVA Workshops were organized by Task Forces from REHVA's technical and research committee. Those Task Forces will use the workshops outcomes to develop European guidelines and tools in order to improve the energy efficiency and indoor environment of buildings.

The REHVA Workshops offered a platform for all the attendees in which they could share ideas and enlarge their technical knowledge and horizons. These Workshops gave everybody the unique chance to reflect about the advancement of energy efficient HVAC technologies for buildings, including indoor environment, cost optimization as well as consideration of occupant behavior and intelligent management techniques.

In September 2016, a REPORT on all the REHVA Workshops' summaries will be published, the report will include the outcomes of each workshop and will be available as a downloadable-PDF and as printed report to be ordered at the REHVA Guidebooks' e-Shop. Subscribers to the "REHVA Restricted Area" have access to the e-Report version on the REHVA Website-restricted area.

REHVA workshops on EU projects

REHVA organized two successful workshops with the latest international research projects that are funded by the European Commission.

4 new REHVA members joined the PROF / TRAC Training and Qualification Scheme for NZEB

Nearly Zero Energy Buildings require an integrated design approach and multi-disciplinary work. The PROF/TRAC workshop presented the PROF/TRAC Platform for continuous professional development in nZEB design and construction which aims also to improve the collaboration between architects, technical experts and managers. The panelists – including 4 involved REHVA Member Association - presented the outcomes of the mapping of skills gaps and shared first experiences about the pilot courses under development. 4 additional REHVA members from the audience has joined the PROF-TRAC scheme and will attend the Train-the-Trainer course hosted by HKIS in September. The involved training providers will to adapt and develop nZEB related courses within their countries.

More information: **www.proftrac.eu**

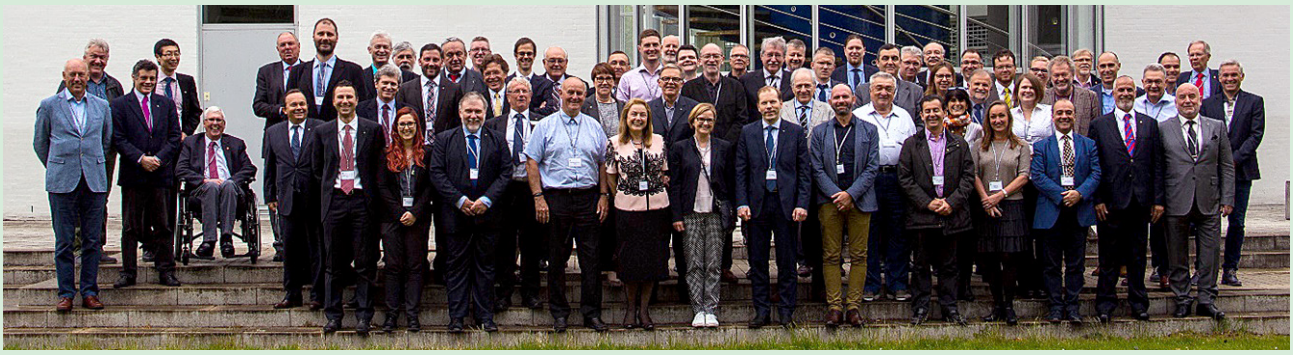
QUANTUM project debuted at CLIMA 2016

The estimated average gap between calculated and actual energy performance of the European building stock is 25% for energy performance and 1,5% for comfort performance (as scored by building occupants). Research has shown that poorly commissioned and operated building management systems are often responsible for this gap, caused by the lack of appropriate Quality Management Systems for building performance. To tackle these challenges QUANTUM develops and demonstrates pragmatic services and tools with high replication potential supporting QM for building performance in the design, construction, commissioning and operation phases. The core mechanism is to "design for testability" by specifying transparent performance targets with cost effective testing methodologies. The project will apply three innovative ICT driven tools to enable effective quality management in all relevant services within the building life cycle. The tools will be demonstrated in a representative set of typical European buildings from 7 countries. QUANTUM organised its first workshop at CLIMA2016. The workshop informed participants about the potential of QM and presented the three innovative ICT tools. The presentations were followed by interesting debate.

More information: **www.quantum-project.eu**

REHVA 2016 General Assembly

The 60th REHVA General Assembly was held on Saturday May 21st, 2016 in Aalborg, Denmark during the REHVA World Congress Clima2016.



About 64 were the participants from 20 countries. After a welcoming address by the host, DANVAK President, **Lars Sonderby Nielsen**, President of Danvak, Professor **Karel Kabele** opened the REHVA General Assembly with the presentation of the 2015 reports.

During the meeting, President Karel Kabele thanked the members of the board having contributed to his presidential term as good collaborators and left the stage to Professor **Stefano Corgnati** as the 16th REHVA President for the period of 3 years, 2016-2019. Both Professor Corgnati and the assembly thanked Professor Kabele for his contribution to REHVA's development.

Besides the election of the new President, also new Board Members were elected and others were reaffirmed. Two new Board Members were elected, **Atze Boerstra** as Vice-president and Co-chair of the Supporters Committee and **Milos Lain** as Vice-president. Three Board Members were re-elected until 2019**, Frank Hovorka** as Treasurer and Chair of the Publishing and Marketing Committee, **Manuel Gameiro da Silva** as Vice-president and Chair of the Educational and Training Committee, **Jarek Kurnitski** as Vice-president and Chair of the Technology and Research Committee. **Egils Dzelzitis**, Vice-president and Chair of the Membership Committee continues his term until 2017.

All REHVA Committees' Chairs presented their reports of activities, outcome and future goals.

Two important announcements on next GA and CLIMA 2019:

- 61st REHVA Annual Meeting and Conference will take place in Loughborough, UK in April 2017;
- CLIMA2019 will be held in Bucharest, Romania from May 26th to May 29th, 2019.

After the General Assembly, a Gala Dinner was organized in the Aalborg Museum of Modern Art, during this event the following persons received REHVA Awards:

- Dr. Ing. **Tiberiu Catalina**, Professional Awards for Young scientist;
- Prof. **Karel Kabele**: REHVA Professional Sciences Award;
- Dr. Ing. **Jiri Hirs**: REHVA Professional Education Award;
- Mr. **Petr Fisher**: REHVA Professional Design Award;
- Prof. **Dusan Petras**: REHVA Gold Medal. ■

Stefano Corgnati and Tiberiu Catalina.

Karel Kabele and Jiri Hirs.

Petr Fisher and Karel Kabele.

Karel Kabele and Dusan Petras.

REHVA 2016 Student Competitions

During CLIMA2016, REHVA organized two different competitions, the REHVA Student Competition and the REHVA World Student Competition.

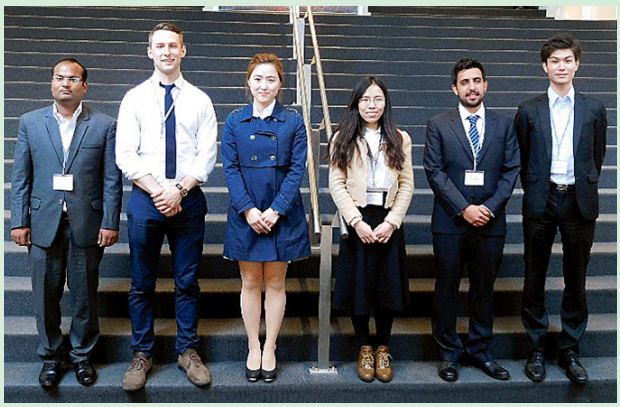
Under the leadership of Manuel Gameiro da Silva, REHVA Vice-President, the REHVA Student competition took place on Monday May 23nd, 2016 in Aalborg, Denmark.

Fifteen candidates representing twelve countries participated in competition. Denmark, Hungary and Romania have been represented by a team of two students. The jury declared as winner: Arash Rasooli from Delft University of Technology for his work on "Computational and Experimental Investigation of Wall's Thermal Transmittance in Existing Buildings". The second student awarded was Tuomo Niemelä from the Aalto University and the third prize was conferred to the Romanian team from the Technical University of Civil Engineering of Bucharest, Andrei Bejan and Traian Munteanu. The winners received a certificate and a financial prize sponsored by Eurovent Certita Certification. The first winner received also the Trophy Cup for his university.

Under the leadership of former President Karel Kabele, the REHVA World Student competition took place on Tuesday May 24th, 2016 in Aalborg, Denmark.

Seven candidates from five countries selected by our international partners (ASHRAE, CCHVAC, ISHRAE, SHASE and SAREK) were part in this competition.

The winner of the REHVA Student Competition, Arash Rasooli, took also part at the world competition representing Europe. After the deliberation, Arash Rasooli was nominated winner of the REHVA World Student Competition on basis the same work he presented in the REHVA Student Competition. The second student awarded was Matthew Tokarik



from the Ryerson University of Toronto, Canada, the third position was an ex-aequo of Tian You from the Tsinghua University in Beijing, People's Republic of China and Robin Jain from Malaviya National Institute of Technology in Jaipur, India. The winners received a financial prize sponsored by Eurovent Certita Certification and REHVA certificates. The first winner received a Trophy, the second for him. ■

ACREX 2017
– Join us at the REHVA Seminar and book your exhibition space

ACREX is the biggest and most dynamic global platform for HVAC&R, Electrical & Plumbing Services, Building Automation and Cold Chain Industry.

REHVA would like to invite you to consider your participation to the REHVA Seminar during ACREX 2017 and to give you the incredible opportunity to book your exhibition space at a discounted price.

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For more information:
ACREX 2017 Brochure (PDF 1MB). http://www.rehva.eu/fileadmin/events/upcoming/ACREX_India_2017_Brochure.pdf

CCHVAC 2016 Conference
– Join us at the REHVA Seminar

REHVA would like to invite the REHVA Supporters to consider a participation to the REHVA Seminar during the CCHVAC 2016 Conference in Hainan, China from November 8th to 12th, 2016. Click here to have more information.

REHVA's offers you visibility in the CCHVAC 2016 Conference proposing you to choose between our services below:

- Active participation in the REHVA Seminar with the presence of one speaker;
- Distribution of 650 Brochure promoting your company during the event and in other REHVA events;
- Display of full size roll up promoting your company;
- Invitation in social events during the congress;
- Social Media Coverage during the whole event;
- Advertisement in the REHVA Journal disseminate during the Event.

Check here the details regarding services and promotional packages, once decided, send the form filled in and signed to Chiara Girardi at cg@rehva.eu before **September 9th, 2016.**

The CCHVAC Conference

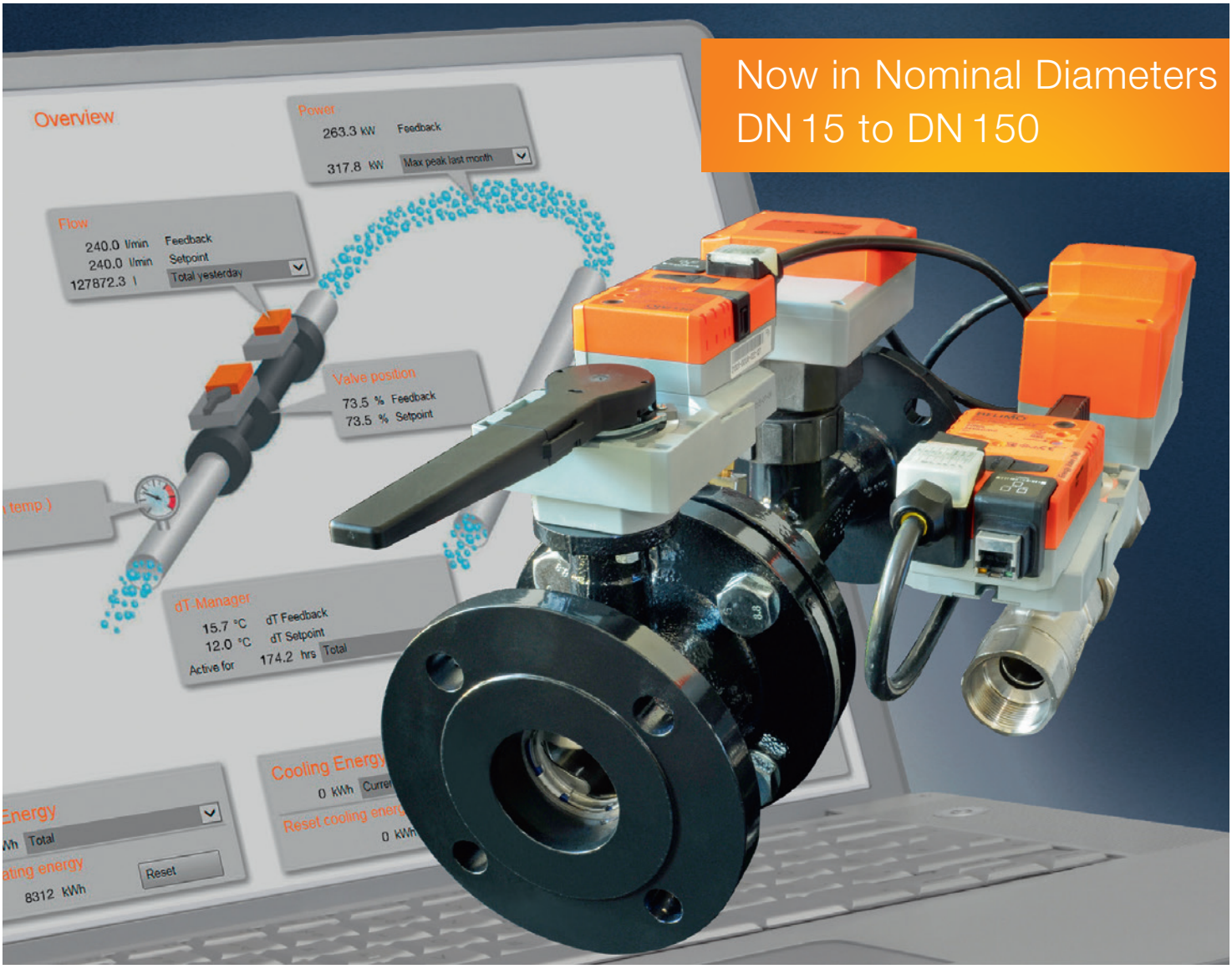
- Held every two years and host around 1,500 participants.
- This year's topic is Residential Building Ventilation.

The CCHVAC Conference sets academic exchanges, showcase new technologies, information dissemination, public meetings four in one show wisdom, to expand its influence, enhance the degree of recognition that the best way and most effective platform resources cooperation. It is China's largest HVAC and influential industry event.

"Coordination innovation network sharing" 8-12 November 2016, the country's 31 provinces, the authority of experts and scholars municipalities and autonomous regions HVAC industry, industry authorities and other stakeholders will gather in Haikou City, Hainan Province, China Lovers HVAC industry "academic feast."

REHVA will organize a Seminar during the CCHVAC Conference.

For more information:
http://chinahvac.com.cn/cn/english/cchvac.html



Belimo Energy Valve™.
Know where the energy is going.

Measuring, controlling, balancing, shutting and monitoring energy – the Belimo Energy Valve™ combines five functions into a single installation-friendly unit. Also unique are functions such as Delta-T manager or the possibility of direct power control. This provides clarity, increases efficiency and cuts costs.

- Quick and certain dimensioning, simple commissioning
- Time-savings through automatic, permanent hydraulic balancing
- Ensuring the correct volume of water with differential-pressure changes and partial loads
- Transparency with respect to energy consumption for heating and cooling

Find out now about this trend-setting valve technology for maximum comfort with minimum energy consumption.

Water is our element: www.belimo.eu

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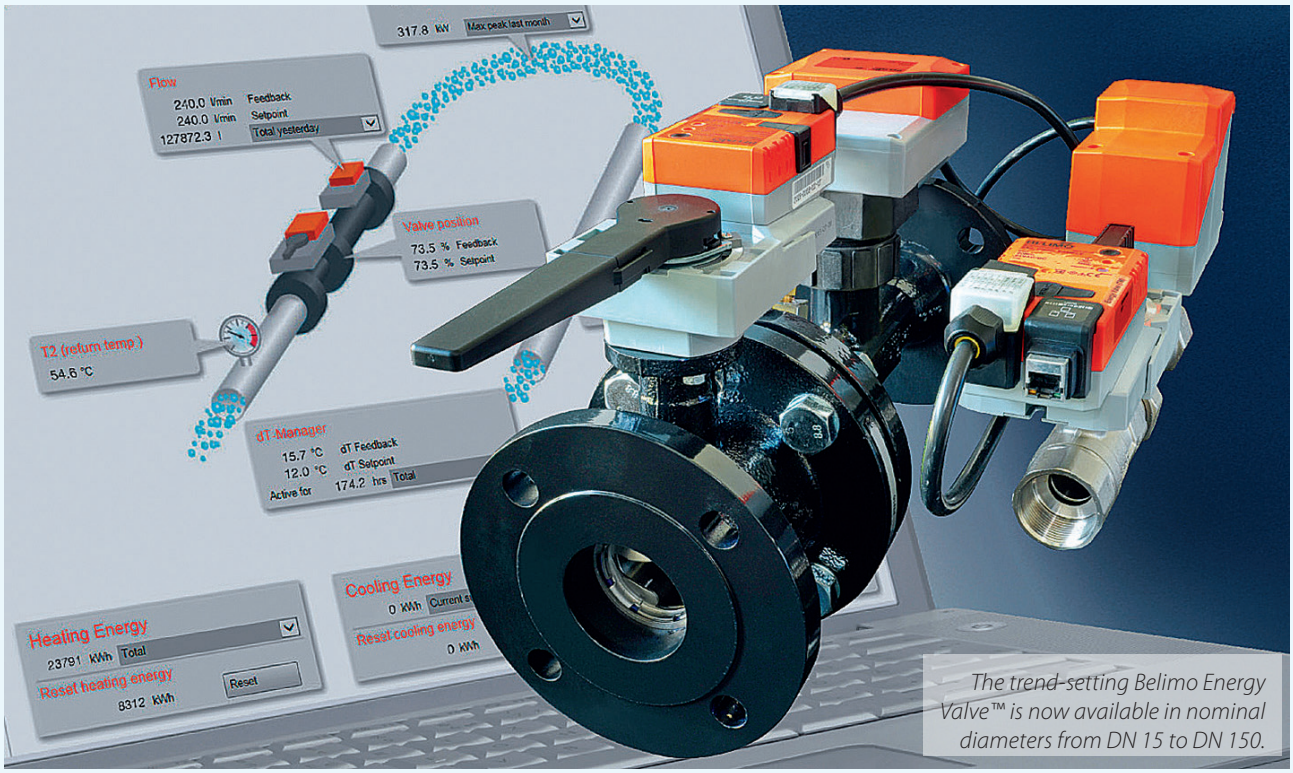
BELIMO®

Belimo Energy Valve™ with Delta-T manager product information

Know where the energy is going

The Belimo Energy Valve™, which consists of a 2-way characterised control valve, volumetric flow metre, temperature sensors and an actuator with integrated logic, combines the five functions of measuring, controlling, balancing, shutting and monitoring energy into a single installation-friendly unit. This revolutionary valve is now available in the nominal diameters from DN 15 to DN 150.



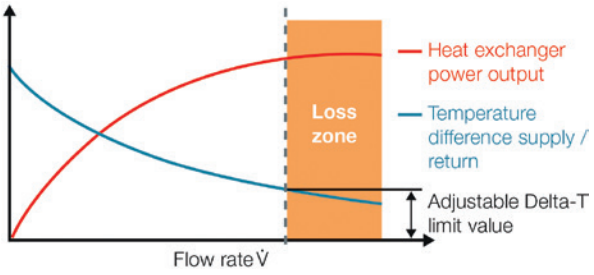
The trend-setting Belimo Energy Valve™ is now available in nominal diameters from DN 15 to DN 150.

Its trend-setting technology ensures maximum comfort, provides transparency, enhances efficiency and lowers operating costs. In addition, it offers the following advantages:

- Quick and certain dimensioning, simple commissioning
- Time-savings through automatic, permanent hydraulic balancing
- Automatic ensuring the correct volume of water with differential-pressure changes and partial loads
- Optional direct power control, independent of differential pressure and water temperature
- No leakages thanks to the air-bubble-tight characterised control valve

The web server that is integrated into the actuator records all system data of the preceding 13 months. Simple to evaluate on a PC, optimisation potentials can be identified and the system can be modified accordingly. The integrated Delta-T limitation is also unique. If cooling or heating coils are operated at an excessively high flow rate and thus at an excessively low differential temperature, above a certain operating point the energy consumption of the pumps and of the cooling and heat generators will rise – without increasing the power output. The Delta-T manager ensures automatically that an adjustable differential temperature limit value is not fallen below. Flooding of the heat exchanger is therefore no longer possible.

Operations optimisation with Delta-T manager



The Delta-T manager that is integrated into the Belimo Energy Valve™ ensures that an adjustable differential temperature limit value is not fallen below.

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

Daikin achieves the highest peak in chiller technology

Industry-leading air conditioning manufacturer, Daikin Europe has launched the next generation in high efficiency chillers. The new water cooled EWWD-VZ, offers the highest ESEER ratings in its class, minimising running costs and CO_2 emissions to make it the most efficient in the market.

The launch is the latest in a range of innovative products developed by Daikin to help specifiers and end users stay one step ahead of EU legislation and rising energy costs.

The extremely compact VZ chiller series incorporates a number of advanced technology features that are unique in the market. Presenting a 40% reduction in footprint, the new chiller offers a low noise solution with outstanding flexibility to match any specific application.

Top class efficiency

The advanced design of the new VZ delivers perfect balance: Achieving high cooling capacity with reduced power inputs and is especially efficient while running at part load, typically 97% of the operating time. Operating up to 15% more efficiently than other systems on the market, the new chiller achieves an EER of 5.7 at full load, with an ESEER of up to 8.3 at part load.

Green building design

The new VZ chiller series has been developed to achieve maximum efficiency and is future-proofed to comply with existing design and regulatory standards as well as longer-term EU energy goals.

With the EU low carbon roadmap now targeting an 80% reduction overall in CO_2 emissions by 2050 and F-Gas legislation driving a reduction in direct emissions, there is more demand than ever for high efficiency HVAC systems that reduce consumption in use. With up to 50% of building energy usage accounted for by HVAC equipment, the new VZ can help boost the environmental credentials of buildings to achieve a high BREEAM or LEED score with lower running costs, making assets more attractive to building owners and tenants.

Driving technology advances

The new chiller is the result of applied innovation combined with new technology advances. The new chiller's unique design uses Daikin single screw compressor together with inverter technology with a high efficiency flooded type heat exchanger that offers a 60% improvement in heat transfer if compared to previous chiller series The series offers a wide range of capacity with single compressor models from 450 kW to 1,100 kW and the larger dual compressor dual circuit models with an output between 1,200 kW to 2,100 kW at nominal Eurovent conditions.

Designed for compactness

The new VZ width has been reduced to the minimum levels thanks to a unique design with new single pass counter-flow condenser and an oil separator integrated into condenser shell.

The slimline design of the unit, is also available with an optional knockdown panel, makes it ideal for installation through existing doorways.

Application flexibility

The new chiller boasts the widest operating conditions in its range, offering not only cooling, but hot water production up to 65°C. Its unique design incorporates Daikin Variable Volume Ratio (VVR) technology, which optimizes unit performances by adjusting the discharge pressure of the compressor to the condensing pressure. No under or over-compression phenomena (common in traditional compressors) are experienced, thus efficiency losses are reduced to minimum.

Suitable for use even in noise-sensitive environments, a high performance sound proof compressor cabinet option offer noise levels as low as at 81 dBA at full load and 66 dBA at part load at a distance of one metre.

With active harmonic filtration and an automatic transfer switch to backup generator, the new chiller series offers a comprehensive solution for data centres applications.

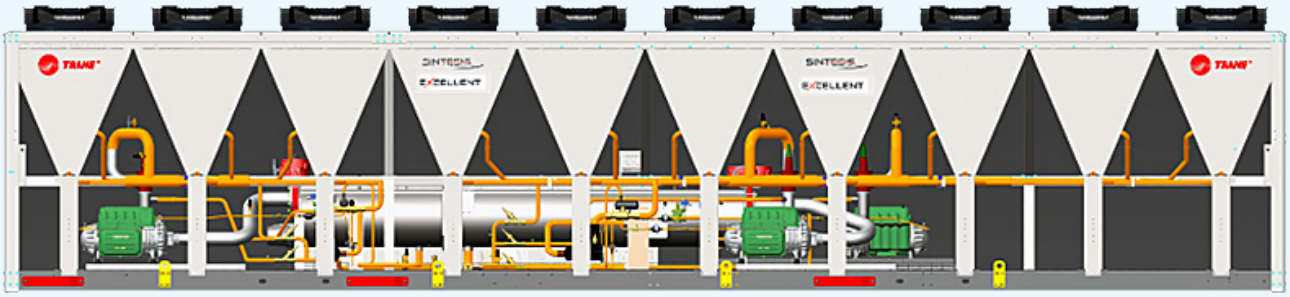
Enabled for operation via the Daikin On Site platform the VZ can be monitored remotely, allowing the system to be accessed with one click for system optimization and preventative maintenance.

Efficiency that makes business sense

With an environmental profile that outperforms the market and delivering outstanding versatility, the new chiller also delivers on cost-effectiveness, as well as innovation. If compared to a traditional non-inverter product, the Daikin VZ can achieve a 25% reduction in running costs with return of investment in less than two years.

For more information on the Daikin VZ chiller series please visit **www.daikineurope.com/**

Trane Introduces New Range of Sintesis™ Air-Cooled Chillers for Significant Reduction of Energy Use and Greenhouse Gas Emissions



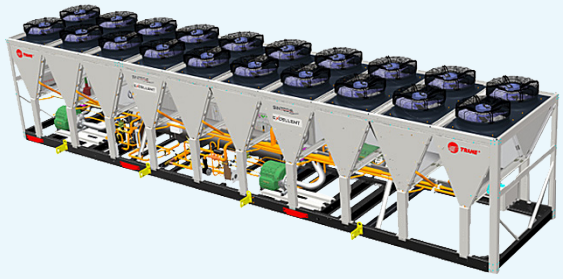
New range has market-leading Energy Efficiency Ratio (EER) and European Seasonal Energy Efficiency Ratio (ESEER), and is designed to use a next generation refrigerant and part of Ingersoll Rand® EcoWise™ product portfolio.

Brussels, May 9, 2016 – Trane, a leading global provider of indoor comfort solutions and services and a brand of Ingersoll Rand, now offers building owners additional choices for meeting their energy efficiency, comfort and process cooling needs with the introduction of Sintesis™ eXcellent in Europe.

Trane eXcellent is a new model range within the Sintesis family of air-cooled chillers and part of the Ingersoll Rand EcoWise™ portfolio of products designed to lower their environmental impact with next-generation, low global warming potential (GWP) refrigerants and high-efficiency operation.

"Heating, ventilation and air-conditioning (HVAC) systems are important long-term investments that can significantly reduce a building's carbon dioxide (CO2) emissions and improve efficiencies," said Jose La Loggia, general manager of Trane in Europe. "Building owners focus not only on energy and operational efficiencies when making decisions about the system to purchase, but are more often raising the important question about the system's environmental impact. We develop solutions that give our customers peace of mind to ensure our designs meet and exceed efficiency and GWP regulations and reduce the impact on the environment."

The new eXcellent model uses next generation refrigerant Honeywell Solstice® ze (R1234ze), which has a GWP value of less than one when used in this design. The eXcellent range also uses the most efficient heat exchangers available on the market along with additional energy saving options such as partial and total free



cooling. With capacities from 500 kW to 1 260 kW, the eXcellent range is suited for critical environments like data centers, hospitals, large office buildings and industrial process applications.

The introduction of the Trane eXcellent range is a contribution to the commitment made by Ingersoll Rand to significantly increase energy efficiency and reduce environmental impact from its operations and product portfolio by 2020. This new solution exceeds current F-Gas legislation requirements and helps customers reduce their CO2 emissions through the combination of the extreme efficiencies reaching Net ESEER values of 5.71 and Net EER values of 3.88, and the use of the Honeywell Solstice® ze (R1234ze) refrigerant.

The new chillers use less refrigerant than traditional tube/fin and flooded heat exchanger technology due to the micro-channel condenser coil and the compact, high-performance, integrated, low charge (CHIL) evaporator design known from the Trane Sintesis family.

For more information on the Ingersoll Rand Climate Commitment, visit our website*.

* http://company.ingersollrand.com/ircorp/en/discover-us/sustainability/our-climate-commitment.html

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

Events in 2016 - 2017

Conferences and seminars 2016

Sept 12-14	37th AIVC - ASHRAE- IAQ joint Conference	Alexandria, VA, USA	http://goo.gl/52Ypv5
Sep 20-24	For Therm - PVA EXPO PRAGUE	Prague, Czech Republic	http://for-therm.cz/en/
Sep 21-23	International Conference on Solar Technologies & Hybrid Mini Grids to improve energy access	Frankfurt, Germany	www.energy-access.eu
Sep 27-30	Eurovent Summit	Krakow, Poland	http://www.eurovent-summit.eu/
Oct 11-12	2016 Euroheat & Power District Energy Days	Brussels, Belgium	https://www.euroheat.org/events/16ehpautumn/
Oct 23-26	IAQVEC 2016: international conference on indoor air quality, ventilation & energy conservation in buildings	Seoul, South Korea	www.iaqvec2016.org
Nov 8-12	CCHVAC Conference	Hainan, China	http://chinahvac.com.cn/cn/index.html
Nov 30 - Dec 2	47th International HVAC&R Congress and Exhibition	Belgarde, Serbia	http://goo.gl/n5QKjS

Exhibitions 2016

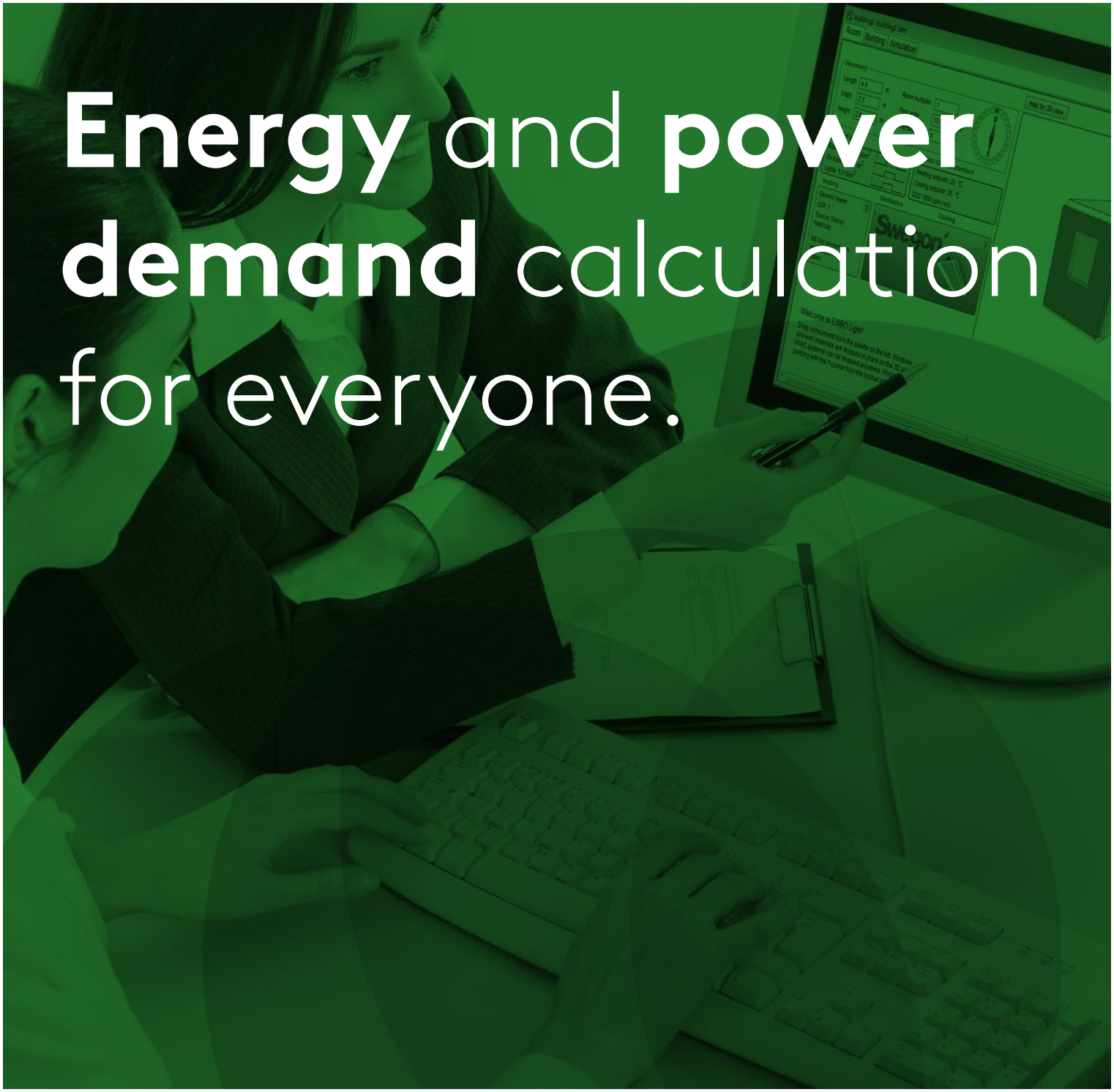
Aug 31 - Sep 2	ISH Shanghai & CIHE	Shanghai, China	www.ishs-cihe.hk.messfrankfurt.com
Oct 11-13	Chillventa	Nuremberg, Germany	www.chillventa.de/en
Oct 12-14	FinnBuild	Helsinki, Finland	www.messukeskus.com/Sites1/FinnBuild/

Conferences and seminars 2017

Jan 28 - Feb 1	ASHRAE Winter Conference	Las Vegas, NV, USA	http://ashraem.confex.com/ashraem/w17/cfp.cgi
Mar 1-3	World Sustainable Energy Days 2017	Wels, Austria	http://www.wsed.at/en/world-sustainable-energy-days/
May 10-11	50th International Congress "Beyond NZEB retrofit of existing buildigs"	Matera, Italy	
May 12-13	Climamed 2017 Conference "Historical buildings retrofit in the Mediterranean area"	Matera, Italy	
May 15-18	12th IEA International Heat Pump Conference	Rotterdam, The Netherlands	http://hpc2017.org/
Aug 7-9	Building Simulation 2017	San Francisco, USA	www.buildingsimulation2017.org

Exhibitions 2017

Jan 30 - Feb 1	2017 AHR Expo	Las Vegas, NV, USA	www.ahrexpo.com
Feb 23-25	ACREX 2017	New Delhi, India	http://www.acrex.in/



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DAIKIN
DencoHappel
Doset IMPEX
eneko
EPEE European Partnership for Energy and the Environment
ESSO EUROPEAN SOLAR-SHADING ORGANIZATION Energy Savings & Comfort
Eurovent Certita CERTIFICATION
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GRUNDFOS
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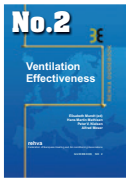
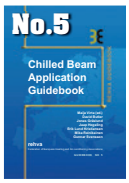
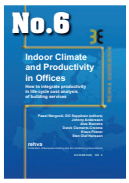
REHVA Guidebooks are written by teams of European experts



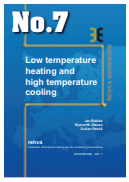
Ventilation Effectiveness. Improving the ventilation effectiveness allows the indoor air quality to be significantly enhanced without the need for higher air changes in the building, thereby avoiding the higher costs and energy consumption associated with increasing the ventilation rates. This Guidebook 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.



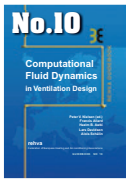
Chilled Beam Cooling. Chilled beam systems are primarily used for cooling and ventilation in spaces, which appreciate good indoor environmental quality and individual space control. Active chilled beams are connected to the ventilation ductwork, high temperature cold water, and when desired, low temperature 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.



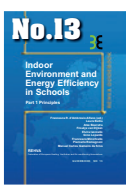
Low Temperature Heating And High Temperature Cooling. This Guidebook describes the systems that use water as heat-carrier and when the heat exchange within the conditioned space is more than 50% radiant. Embedded systems insulated from the main building structure (floor, wall and ceiling) are used in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



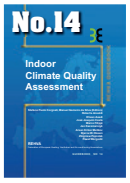
Computational Fluid Dynamics in Ventilation Design. CFD-calculations have been rapidly developed to a powerful tool for the analysis of air pollution distribution in various spaces. However, the user of CFD-calculation should be aware of the basic principles of calculations and specifically the boundary 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.

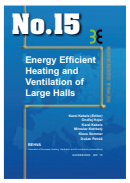
Solar Shading – ***How to integrate solar shading in sustainable buildings.*** Solar Shading Guidebook gives a solid background on the physics of solar radiation and its behaviour in window with solar shading systems. Major focus of the Guidebook is on the effect of solar shading in the use of energy 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.



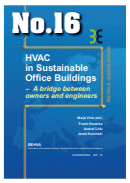
Indoor Environment and Energy Efficiency in Schools – *Part 1 Principles.* School buildings represent a significant part of the building stock and also a noteworthy part of the total energy use. Indoor and Energy Efficiency in Schools Guidebook describes the optimal design and operation of schools with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



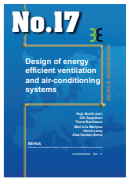
Indoor Climate Quality Assessment. This Guidebook gives building professionals a useful support in the practical measurements and monitoring of the indoor climate in buildings. Wireless technologies for measurement and monitoring have allowed enlarging significantly number of possible applications, especially in existing buildings. The Guidebook illustrates with several cases the instrumentation.



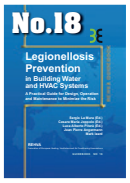
Energy Efficient Heating and Ventilation of Large Halls. This Guidebook is focused on modern methods for design, control and operation of energy efficient heating systems in large spaces and industrial halls. The book deals with thermal comfort, light and dark gas radiant heaters, panel radiant heating, 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.



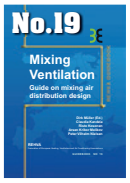
HVAC in Sustainable Office Buildings – ***A bridge between owners and engineers*.** This Guidebook discusses the interaction of sustainability and heating, ventilation and air–conditioning. HVAC technologies used in sustainable buildings are described. This book also provides a list of questions to be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



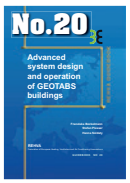
Design of energy efficient ventilation and air-conditioning systems. This Guidebook covers numerous system components of ventilation and air-conditioning systems and shows how they can be improved by applying the latest technology products. Special attention is paid to details, which are often overlooked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



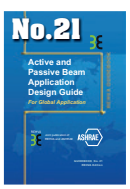
Legionellosis Prevention in Building Water and HVAC Systems. This Guidebook is a practical guide for design, operation and maintenance to minimize the risk of legionellosis in building water and HVAC systems. It is divided into several themes such as: Air conditioning of the air (by water – humidification), 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.

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