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Federation of  
European Heating,  
Ventilation and  
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Associations

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## Level(s)

### European Framework for Sustainable Buildings







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# Level(s)

**M**r. Kestutis Sadauskas, Director for Circular Economy and Green Growth at the European Commission's Directorate-General for the Environment (DG ENV) explains about Level(s): "Level(s) is a broad framework, which covers key areas during the full life cycle of buildings, carbon, material, water, but also health and comfort, resilience to climate change and risk and value."

Level(s) is aiming at a common language for stakeholders and professionals across Europe, aiming to create a more innovative, sustainable and user-friendly built environment.

This is an ongoing activity as we notice from an open letter to JRC, involved in the development. There is work to do to properly interconnect Level(s) with the terminology, definitions and holistic approach included in the set of EPB standards and the results of related H2020 project such as ALDREN and CEN-CE.

Additional to this: Circularity, which is part of Level(s) is addressed in several articles.

## EPBD: THE NEED FOR A REVISION UNDER THE RENOVATION WAVE

An intermedial status report about this ongoing revision. The previous revision of the EPBD (April 2018) introducing an obligation on EU Member States to develop national renovation strategies to achieve a decarbonised building stock by 2050 and stricter requirements for the use of EPB standards and inspection, among other provisions. A new revision was originally planned for 2026 but the EU Commission assessed that the EPBD would need to be strengthened again in order to meet the objective of at least doubling the annual renovation rate of buildings by 2030.

## Oversight of many European projects related to EU policy implementation.

More than 10 EU projects, ongoing and some finished, in which REHVA and/or its members are involved are shortly described. Their interrelation and the connection to the EPBD implementation is demonstrated.

## VENTILATION AND IEQ

May 13 2021 a group of 36 scientists under leadership of prof. Lidia Morawska published an article in SCIENCE\* with the title: "A paradigm shift to combat indoor respiratory infection, building ventilation system must get much better" This article closes with the statement: "*The COVID-19 pandemic has revealed how unprepared the world was to respond to it, despite the knowledge gained from past pandemics. A paradigm shift is needed on the scale that occurred when Chadwick's Sanitary Report in 1842 led the British government to encourage cities to organize clean water supplies and centralized sewage systems. In the 21st century, we need to establish the foundations to ensure that the air in our buildings is clean with a substantially reduced pathogen count, contributing to the building occupants' health, just as we expect for the water coming out of our taps.*"

Sufficient reason for our REHVA community of experts to take up this challenge. The editorial Board of the RJ welcomes articles to reflect on this outcry and present concrete steps towards a healthier indoor environment. The 2021-06 (December 2021) issue will be reserved for this! To be more specific: we should develop new models and new standards that are more performance based, that try to find a good balance between energy use (related to ventilation) and health/comfort on the other side, that addresses also the risk for transmission of infectious diseases via the air etc. ■



**JAAP HOGELING**  
Editor-in-Chief  
REHVA Journal

\* <https://science.sciencemag.org/content/372/6543/689.abstract>





Daniel Dinuzzo / unsplash

# EU drives sustainable buildings with Level(s)

As the EU works towards its ambitious climate goals, it has launched a series of strategies. Level(s) underpins these strategies by facilitating data collection, comparison and collaboration among stakeholders, including REHVA members, in order to transition to a new, green way of thinking when it comes to buildings and construction.

## Bringing Level(s) to life

The European Commission began working on Level(s) in 2015, and officially launched the reporting framework in October last year. By improving data collection, the innovative platform aims to enhance communication between all stakeholders involved in the development of sustainable buildings. It introduces a common language to the industry and works towards



**KESTUTIS SADAUSKAS**

Director; Circular Economy and Green Growth (ENV.B)

the European Union's ambitious climate goals. The strategic policies in place under the EU Green Deal are supported by Level(s), a new building methodology focusing on sustainable growth.

The new pan-European framework underpins policy in the building sector. It is designed to support data collection to accurately measure and assess the

sustainability of buildings over their full life cycle, taking into account design, materials, performance, deconstruction and reusability.

“Level(s) is a broad framework, which covers key areas during the full life cycle of buildings, carbon, material, water, but also health and comfort, resilience to climate change and risk and value,” explains Kestutis Sadauskas, Director for Circular Economy and Green Growth at the European Commission’s Directorate-General for the Environment (DG ENV). “Member States are gradually looking at how to incorporate aspects like these, and we believe Level(s) can be the answer to many of their questions.”

Level(s) provides a common language for stakeholders and professionals across Europe, aiming to create a more innovative, sustainable and user-friendly built environment. “The concept behind the Level(s) framework started to take form once the building sector became a key area of action for the European Commission in terms of resource efficiency, circular economy and whole life carbon,” says Sadauskas. “We realised that, to truly achieve sustainable transformation in the building sector, we need a common language that not only could be used across the building chain, but also help with data comparison across different countries. This work was a natural continuation of objectives set out in the Roadmap to a Resource Efficient Europe, a few years earlier.”

Since the conception of Level(s), awareness around the carbon impact of buildings’ entire life cycles has drastically increased. “The timing for the launch of Level(s) could not be better,” explains Sadauskas. “We now find ourselves in a situation where more and more Member States realise that in order to reach their carbon objectives, it is necessary to look at the full life cycle of buildings. An enormous peak of carbon is emitted already before the building starts being used, through, for example, material production, transportation and construction. Design based on circularity, with lifespan extension, adaptable and flexible buildings, assembly and disassembly of building elements, deconstruction as opposed to demolition and clever low carbon design solutions – this has the potential to reduce these embodied carbon emissions significantly. This is at the core of Level(s).”

### Who can use Level(s)?

Level(s) provides a simple platform to discuss and analyse the performance of buildings throughout

their lifespan, with indicators that can be applied at every life cycle stage. It helps building designers, investors and policymakers to transform the built environment into a sustainable and circular one. The indicators can be used to improve building and sustainability standards by encouraging different building professionals to work together to reach common sustainability objectives, comparing various design options and supporting the monitoring of building performance. They also support future EU policy and allow public authorities to develop and implement policies prioritising sustainable buildings. Investors, property owners and landlords benefit from Level(s) – the platform enhances dialogue between design, technical and financial stakeholders and ensures European buildings are futureproofed. Tracking the performance of buildings across their whole life cycle increases accountability in the industry and enables investors to have confidence in buildings.

The development of Level(s), which included a substantial test phase across the EU, has been a great collaboration between building professionals, national and regional authorities and the European Commission. “It has been fantastic to witness the enthusiasm of the building sector, with companies and authorities from the start to the end of the building chain, in developing and testing Level(s) as a reliable, future-proofed framework,” remarks Sadauskas. “It bodes well for a sustainable future in the building sector, and for the adoption of Level(s) across Europe, now that the final version of the framework has been launched.”

Level(s) is not a certification scheme. It is a tool for those looking to measure, understand and improve a building’s sustainability over its entire life cycle. It helps to analyse and compare data against environmental objectives and targets by focusing on the different impacts of each material and use, informing the design and functionality of the building. Furthermore, many certification schemes have been involved in the development of Level(s) and are now looking at how they can align with and incorporate the framework’s common language indicators. But first and foremost, Level(s) brings circularity and lifecycle thinking to the mainstream market. It consists of a minimum number of indicators with maximum leverage to deliver sustainability.

### What’s in it for REHVA members?

Level(s) indicators consider every aspect of sustainable buildings and construction. As well as assessing



buildings' energy performance, water consumption and resilience to climate change, the indicators measure comfort and wellbeing aspects of buildings in their internal environment.

Creating buildings that are attractive to live and work in and that protect human health is a priority as occupant satisfaction is a critical parameter for the success of a building. **Indoor air quality, lighting, heating, ventilation and air conditioning** are all assessed in order to maximise the health and comfort of the occupier. For example, thermal comfort throughout the year, such as increased heating in summer or inadequate heating in winter, could significantly impact the user's health and comfort levels.

## The road to greater sustainability and accountability

Level(s) has been met with enthusiasm and support from industry professionals and continues to gain traction as it evolves. A great example is the LIFE Level(s) project (<https://lifelevels.eu/>) run by Green Building Councils, which aims to mainstream sustainable buildings in Europe by working closely with stakeholders to explore how Level(s) can be implemented on a European scale. It is currently developing a comprehensive mapping system and a web-based reporting template to further its work in the building sector.

Further emphasising the importance of Level(s), the European Commission recently adopted legislation supporting sustainable investment. Within the Sustainable Finance and EU Taxonomy package, the EU Taxonomy Climate Delegated Act aims to attract private investment to green activities. It does so by defining which economic activities most contribute to the EU's environmental objectives and provides guidance on measuring their contribution to climate change mitigation.

The Act encompasses construction and real estate activities, and sets out criteria for new buildings to steer sustainable investment. Among other criteria, the life cycle Global Warming Potential (GWP) resulting from the construction phase will need to be calculated and made available to be disclosed, in the case of new buildings larger than 5 000 m<sup>2</sup>. The Level(s) methodology is referred to for this assessment.

“With Level(s) helping to define metrics and methods, people can now talk about the targets instead of

discussing the ‘best’ calculation or assessment methods,” explains the Director of Research and Development at the German Sustainable Building Council (DGNB), Anna Braune, who was involved in testing Level(s) on the Knauf Insulation training centre in Slovenia, a collaboration with Knauf Insulation and the Slovenian Ministry of the Environment and Spatial Planning. Anna believes that the widespread adoption of Level(s) will be primarily motivated by the desire and commitment of Member States to contribute to a greener future. “First, public authorities and decision makers must say: yes, we want to decarbonise our building activities over the whole life cycle and promote low carbon buildings today. Yes, we want to contribute to the shift towards a real circular economy, and we will do this by securing healthy and comfortable spaces, resilient and adaptable for future climate, without excessive future costs, at low risks,” she explains. “Once they commit to these objectives, they will use Level(s) – or tools which incorporate Level(s) indicators – on their own activities, and include it as a basic requirement for permits or funding attribution for all cities, regions, and countries.”

## Looking to the future with Level(s)

“The end goal is that, by using Level(s), users are investing in a cost-effective framework that helps them future-proof their building projects in line with circular economy, whole life carbon performance and other green policy goals,” explains Sadauskas. “We know from the great collaboration in the last six years, that the building sector sees this as a common language. In a way, we are not just harmonising data and metrics. We are also harmonising the built environment's vision of a sustainable future. This is something that we would like to see reflected in the implementation of the national Recovery and Resilience Plans.”

Level(s) will continue to push and lead the conversation around whole life carbon, sustainable building and circular economy. In turn, it will help Member States to reach their carbon objectives, supporting the work towards meeting the EU's energy and climate targets for 2030 and 2050. ■

### Useful links

Level(s) website:

[ec.europa.eu/environment/topics/circular-economy/levels](https://ec.europa.eu/environment/topics/circular-economy/levels)

LinkedIn group: [www.linkedin.com/groups/12501037/](https://www.linkedin.com/groups/12501037/)

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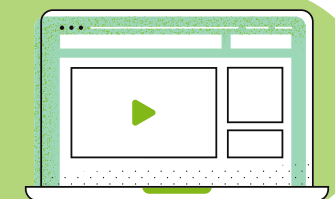
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# Level(s) and EU standards – tighten cooperation



**JOHANN ZIRNGIBL**

Convenor CEN TC371/WG1,  
CEN TC228/WG4, ISO TC 205/WG9  
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Level(s), the common EU framework of core indicators developed by the European Joint Research Center (JRC), wish to develop a common language of sustainability for buildings. The European standardisation and European funded H2020 project ALDREN have the same goal. Responsible experts from these three entities met together to harmonise the common language on the Level(s) indicator 1.1 related to the use stage energy performance. The main discussion points are reported hereafter.

**Keywords:** Renovation wave, Taxonomy, EU standards, Buildings Energy efficiency, Common sustainability indicators

## Context

Developed as a common EU framework of core indicators by the European Joint Research Center (JRC) for the sustainability of office and residential buildings, Level(s) provides a set of indicators and common metrics for measuring the performance of buildings along their life cycle.

Level(s) is an important step towards a common EU framework of core indicators. This common language should enable actions, to be taken at building level, that can make a clear contribution to broader European environmental policy objectives and support the EU taxonomy.

Level(s) completes, and is completed, by additional work done in European standardisation (especially under mandate M/480<sup>1)</sup>) and European funded H2020 projects (e.g. ALDREN <https://aldren.eu/>, CEN-CE <https://www.cen-ce.eu/>) which are providing more detailed methods, practical tools for application, training and certification of experts within the common framework comparable with Level(s).

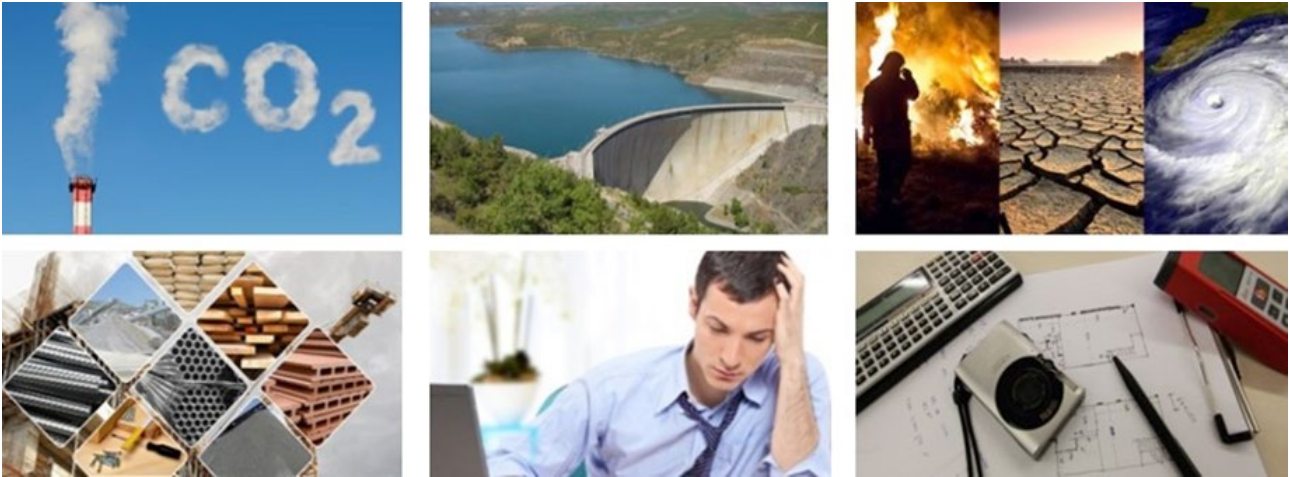
The goal of Level(s) is to create a common language. Therefore, it is extremely important that all this complementary work done in Level(s), the EU standards and the EU funded projects, use the same vocabulary (e.g. definitions, procedures, etc) to be well understood by the building professionals. Only if Level(s) is as much as possible in line with CEN and ISO standards (the technical tools of building professionals) and with common indicators already widely used, the goal of a common language will be reached and “spoken” between the main actors involved in building energy and sustainability performance.

Level(s) is structured around:

- an overarching set of 6 macro-objectives in areas such as energy, material use, waste management, water and indoor air quality;
- a set of 16 common indicators.

**1)** The EU Commission gave mandate (M480) to CEN and financed the development of a set of EPB ISO/CEN standards for the calculation of energy performance of buildings. Some of these standards are referenced in the EPBD.





The set of 6 macro-objectives in Level(s).

One of the Level(s) indicators is Level(s) indicator 1.1: Use stage energy performance. Primary energy use is the required metric for reporting on the energy performance of buildings across the EU. The energy performance of a building, expressed in primary energy, is used for both compliance with minimum energy performance requirements and for the Energy Performance Certificates (EPCs)

The primary energy use is also the main indicator developed in EN ISO 52000-1 “Energy performance of buildings — Overarching EPB assessment — Part 1: General framework and procedures”.

In the European H2020 project ALDREN, a proposal for a European Energy Performance Certificate, the ALDREN EPC, has been developed.

Therefore, following an open letter addressed by CEN/TC 371 Energy Performance of Building to JRC, the leadership from CEN/TC 371, EPB Center, the ALDREN project and the JRC expert involved met together trying to cross fertilise and harmonise the different approaches in the JRC Technical Reports on Level(s) indicator 1.1 (actually under revision).

Instructions for three Levels:

### ❖ Level 1

This level is for those users who would like to:

- Understand the energy uses associated with the type of building they are working on, and
- Know where they can focus attention in order to reduce the primary energy use associated with the building’s delivered energy during the use stage.

### ❖ Level 2

This level is for those users who are at the stage of needing to calculate the delivered and primary energy use of a building for the purpose of design comparisons, building permitting or tendering.

### ❖ Level 3

This level is for those users who would like to:

- Collect metered data in order to understand the energy use associated with the building they are working on, and
- Carry out testing of the building in use in order to identify any performance issues with the building fabric and technical services.

Due to the short time, **proposals for future harmonisation are focussed on level 2** (to calculate the energy needs and primary energy use).

### The main discussion points

Hereafter are resumed the main discussions. The crucial issues were:

- common definitions (e.g. energy needs, energy use, delivered energy, primary energy);
- sharing the same concept (e.g. only one assessment boundary);
- define the unit of measurement (e.g. non-renewable primary energy);
- precise the boundary conditions and hypothesis (e.g. treatment of exported energy).

Level(s)	Comment	Proposal
<b>Introductory briefing</b>		
1 <a href="#">Unit of measurement (page 7)</a> <b>total</b> primary energy demand in the use stage of a building	<p>More and more Member States move from <b>total</b> to <b>non-renewable</b> primary energy.</p> <p>If in some countries on-site renewable energy is subtracted from the total primary energy, total primary does not <b>valorise renewable energy production e.g. at “nearby” level</b> (e.g. biomass at district heating).</p> <p>Using total primary energy will also require <b>separate valuation of use of ratio of RES</b>.</p> <p><i>Note: See Recommendation for NZEB by European Commission (2016) referring to EPBD Concerted Action III book, 2016:</i></p> <p>It is indirectly recommended to use <b>non-renewable primary energy factors</b>:</p> <p><i>“The concept of NZEB reflects the fact that renewable energy and efficiency measures work together.... Therefore, higher and more demanding requirements for highly efficient NZEB will also drive an increased use of on-building renewables and should result in adaptation of primary energy factors for off-site energy carriers, taking their renewable energy content into account.”</i></p>	Change to “ <b>non-renewable</b> ” primary energy
2 <a href="#">System boundary (page 7)</a> assessment boundary is the <b>building</b>	The “ <b>functionality</b> ” of “assessment boundary” is essential to understand 5200-1	<b>Add definition</b> of the “assessment boundary” <i>boundary where the delivered and exported energy are measured or calculated</i>
3 <a href="#">System boundary (page 7)</a> <b>Inside</b> the assessment boundary, <b>primary energy factors</b> shall apply to all forms of energy generation that supply the delivered energy <b>needs</b> of the building, as well as any exports	<p>According to 52000-1:</p> <p><b>Primary energy factors</b> are used <b>outside</b> the assessment boundary to take into account the outside losses of the energy chain and to convert delivered energy into primary energy.</p> <p><b>Inside</b> the assessment boundary the energy losses are calculated explicitly.</p> <p>Energy “<b>needs</b>” are defined as e.g. for heat the energy delivered (“needed”) to a thermally conditioned space to maintain the set point temperature. This make the difference with “energy use” and “delivered energy”. The losses of the technical systems are not considered in “needs” but are considered in the energy use (energy needs + system losses = energy <b>use</b>).</p>	<p>Change “inside” to “outside”</p> <p>Delete “<b>needs</b>”</p> <p><b>Check the use of “needs” in the whole document.</b></p> <p>The definitions of the ISO/ CEN standards should be used.</p>
4 <a href="#">Scope (page 7)</a> The minimum scope of the indicator reflects those energy <b>needs</b> defined by the Energy Performance of Building Directive - heating, cooling, ventilation, domestic hot water and (built-in) lighting and other technical building systems.	See comment before	<p>Replace “<b>needs</b>” by “<b>delivered energy and the losses of the whole energy chain</b>”</p> <p><i>Note:</i> <i>Sometimes “energy demand” is used in general sentences that does not refer to a specific indicator but to service.</i></p>
5 <a href="#">Calculation method and reference standards (page 7)</a> ...they must be compliant with the EN ISO <b>52000-1</b> series	EN ISO 52000-1 is the overarching standard (one standard). The series of EPB standards in ISO the 52000 family. see for a complete overview of the set of EPB standards <a href="https://epb.center/documents/">https://epb.center/documents/</a>	Delete “-1”



Level(s)	Comment	Proposal
<b>Instructions for Level 2 (p 11)</b>	<b>for those users who are at the stage of needing to calculate the energy needs and primary energy use...</b>	
6 <u>L2.2 Step-by-step instructions</u> <b>Point 8.</b> Apply primary energy factors to the energy carriers used for the calculated <b>energy needs</b> in order to obtain the <b>total</b> primary energy.	It is recalled that the energy “ <b>needs</b> ” are without the technical system losses. Therefore, the primary energy factors cannot be applied on the energy needs	Replace “energy needs” by “ <b>delivered energy</b> ”
7 <u>L2.3 What do you need to make an assessment? (page 11)</u> An appropriate calculation software tool that is compliant <b>with the national or regional calculation method for the relevant Member State</b>	In “ <i>Options for ensuring the consistency of the energy calculation method used</i> ”(p19) <b>compliant options</b> available to users of the Level(s) framework across the EU are indicated including standards developed under mandate M/480	Complete “...for the relevant Member States... <b>or compliant options based on CEN standards developed under mandate M/480</b> ”. Complete it in whole level(s).
8 <u>L2.5 Ensuring the comparability of results (page 12)</u> The primary energy factors associated with extraction / generation and transport of energy carried to the building	There are many other boundary conditions related to the primary energy factors like related to the time horizon, net or gross calorific values, conventions related to energy conversion etc. All these choices are reported in CEN EN 17423.	Replace “...PEF associated with extraction...” by “ <b>the choices related to primary energy factors should be reported according to EN 17423</b> ”.
9 L2.7 Format for <b>reporting</b> the results of an assessment (P12) Delivered energy <b>needs</b> assessment	See comments related to “needs” before. The reporting format is very limited and not sufficient to provide a clear picture of the energy performance of a building. The ALDREN EPC provide a complete set of indicators and reporting.	Replace “Energy needs” by “ <b>Energy use</b> ”. Take over the reporting of the ALDREN EPC
10 <u>L2.7 Format for <b>reporting</b> the results of an assessment (P12)</u> exported energy is missing	In “L2.2 – Steps 1-2: The calculation methodology to be used” (p20) it is mentioned “It is important to note that exported renewable energy is to be reported separately”.	<b>add “energy export” to the reporting table</b>
11 <u>L2.7 Format for <b>reporting</b> the results of an assessment (P13)</u> L2.2 <b>Unregulated</b> total primary energy	Unregulated total primary energy (e.g. plugin loads, lifts, etc) is mostly not taken into account in national regulation, neither in the 52000 series.	<b>Make the reporting</b> of unregulated total primary energy <b>optional</b> .

Level(s)	Comment	Proposal
<b>Guidance and further information for using the indicator – for using level 2</b>		
12 <a href="#">L2.2 – Steps 1-2: The calc. methodology to be used (p 19)</a> ...national calculation methods .... <b>shall</b> be the <b>main reference</b> methods for reporting .... <b>Compliant options</b> available to users of the Level(s) framework across the EU include...	Levels clearly state to principle of <b>“equivalences”</b> . Why introduce a hierarchy between options? There is not transparency and comparability between national calculation methods. In some MSs even seasonal method can be used and some systems are not included (e.g. cooling).	Replace “shall be the main reference” by “could be used as reference “
13 <a href="#">L2.2 – Steps 1-2: The calc. methodology to be used (p 20)</a> The <b>primary energy factors</b> represent the <b>overall system efficiency</b> of the building’s technical systems ...and the fuels and energy carriers used.	The primary energy factors <b>only represent</b> the efficiency of the energy chain outside the assessment boundary and therefore not the “overall system efficiency”.	Replace “...the overall system efficiency of the building’s technical systems (HVAC installation, heat and power generation, domestic hot water supply, built-in lighting installation) and the fuels and energy carriers used” by <b>“...the efficiency of the energy chain outside the assessment boundaries”</b> .
14 <a href="#">L2.2 – Steps 1-2: The calc. methodology to be used (p20)</a> This <b>energy use</b> can then potentially be <b>disaggregated into its non-renewable and renewable components</b> .	Sentence and following bullets point not understood and <b>not in line with EN ISO 52000-1</b> . It is the “delivered energy” which can be disaggregated.	Replace “energy use” by “delivered energy.
15 <a href="#">L2.2 – Steps 1-2: The calc. methodology to be used (page 20)</a> <u>It is important to note that <b>exported renewable energy</b> is to be reported separately.</u>	The calculation step is not defined in the whole document while it is essential particularly for calculation of exported energy. <b>The conventions adopted concerning the exported energy will change completely the indicator.</b>  <i>Note: The time step is determining for the calculation of exported energy and auto consumption. The hourly time step is recommended in CEN/ISO standards. A smaller time step is mentioned also in Recommendation for NZEB (European Commission 2016).</i>	Provide information on the calculation of exported energy  Add: The conventions adopted concerning the exported energy will change completely the indicator.
16 <a href="#">Table 4. Specification of the main data requirements and potential sources (page 21)</a> EN ISO 13790 (Annex G) EN ISO 15603 (Annex E) EN ISO 13790 (Annex j) ... etc	Standard EN ISO 13790 and EN 15603 referenced in table 4 and in the whole text are replaced by new standards. See for current the set of EPB standards ( published by 2017-2018) <a href="https://epb.center/documents/">https://epb.center/documents/</a>	Replace these references by the new standards



### Further information and recommendations

#### ❖ Reference calculation methods

Levels requires that national calculation methods shall be the main reference methods for reporting (because mandatory) but that compliant options or equivalences could be used. The figure below shows an analysis of conformity to annexe 1 of EPBD of the 34 national and regional calculation methods. The red dots signal non-conformity.

This report only focussed on the items related to annex 1 and even not on the quality of the calculation methods.

To ensure the comparability of results, the calculation methods must have a comparable quality.

Mentioning national calculation methods without any quality check as main reference methods for reporting seems to be risky.

Therefore, we would propose to change the reference calculation method as follows.

- Calculation method: Compliant with standards developed under Mandate M/480

#### ❖ Boundary conditions

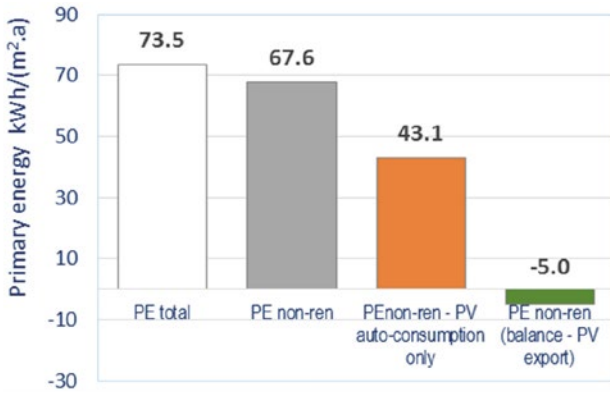
The value of an indicator (e.g. total primary energy use) is directly linked to the calculation procedure (see before) and the boundary conditions.

Hereafter are shown the results on the primary energy use for the same building, using the same calculation method, but with different boundary conditions only related to the use of PV. The numeric indicators vary from 75,5 kWh/m<sup>2</sup>year of total primary energy use (or 67,6 non-renewable primary energy use) to - 5 kWh/m<sup>2</sup>year of non-renewable primary energy use.

The same building may be qualified either as a “energy consuming building” or as an “energy positive building”.

Qst	Methodology	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Scr	
5.1	All build. cat. covered?	y	n	n	n	y	y	y	y	y	y	y	y	p	p	y	y	y	p	p	y	y	y	p	y	y	y	y	y	y	y	y	y	p	y	y	y	-12
1.1	Building definition fits?	y	p	p	p	y	y	y	y	y	y	y	y	p	p	y	y	y	p	p	p	y	y	y	p	y	y	y	y	y	y	y	y	y	y	y	y	-8
1.2	Is the EP determined?	y	y	y	y	y	y	y	y	y	y	y	y	p	y	y	y	y	p	p	p	y	y	y	p	y	y	y	y	y	y	y	y	y	y	y	y	-4
1.3	All build. services incl.?	y	p	p	p	y	p	y	y	y	y	y	p	p	y	y	y	y	p	p	y	y	p	y	y	p	y	y	p	y	y	p	y	y	p	y	y	-12
1.4	Typical use addressed?	y	y	y	y	p	y	y	p	p	p	y	p	p	p	y	p	y	p	y	y	y	p	y	p	y	y	p	y	y	p	p	p	p	y	y	-15	
2.1	Can EP be compared?	y	p	p	p	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	-3	
2.2	EP indicator defined?	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	p	p	y	y	y	y	y	y	y	y	y	y	-1	
2.3	PE indicator defined?	y	y	y	y	p	y	y	y	y	y	y	p	p	y	y	y	y	y	y	y	y	y	p	p	p	y	y	n	y	y	n	n	n	n	n	-15	
3a.1	Thermal charact. consid?	y	p	p	p	y	y	y	y	y	y	y	p	y	y	y	p	y	y	y	y	y	p	p	y	p	p	y	p	p	y	p	p	p	p	p	-15	
3b.1	Hating inst. considered?	y	y	y	y	y	p	y	y	y	y	y	0	y	y	y	y	y	y	y	y	y	p	y	y	y	y	y	y	y	y	y	y	p	y	y	-3	
3b.2	DHW inst. considered?	y	p	p	p	y	p	y	y	y	y	n	n	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	p	p	y	y	p	y	y	-8	
3c.1	HVAC inst. considered?	p	y	y	y	p	y	y	y	y	y	y	p	y	y	y	p	n	n	n	p	y	y	p	y	y	y	y	p	y	y	p	y	y	y	y	-13	
3d.2	Natural vent. syst. ?	y	y	y	y	p	y	y	y	y	y	y	y	y	y	y	y	y	n	n	n	n	y	y	n	y	y	y	n	y	n	p	n	n	n	n	-20	
3d.3	Mech. Vent. Syst. ?	y	y	y	y	p	y	y	y	y	y	y	n	n	y	y	y	n	n	n	p	y	y	p	y	y	y	p	y	y	p	y	y	p	y	y	-11	
3e.1	Built in lighting inst. ?	p	p	p	p	y	p	y	y	y	y	p	p	y	y	p	y	n	n	p	p	y	y	p	y	p	p	y	p	y	p	p	p	p	p	p	-19	
3f.1	Build. Design consid.?	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	-1	
3f.2	Build. Position consid.?	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	p	y	-1	
3f.3	Outdoor climate?	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	-1	
3g.1	Passive sol. Sys. Consid	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	n	y	y	-2	
3g.2	Solar protection?	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	n	y	-2	
3h.1	Indoor climate?	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	p	y	y	y	y	y	y	y	y	y	y	p	y	y	y	-2	
3i.1	Internal loads	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	n	y	y	-2	
4a.1	Local solar exposition?	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	p	y	y	-1	
4a.2	Active solar systems?	y	y	y	y	p	p	y	y	y	y	y	p	y	y	y	y	y	y	n	y	y	y	p	y	y	y	p	y	p	y	y	p	y	y	y	-8	
4a.3	Other renew. heat. syst.?	y	y	y	y	p	p	y	y	y	y	y	0	y	y	y	y	y	y	p	y	y	y	y	y	y	y	y	y	y	y	y	p	y	y	y	-4	
4a.4	Other renew. Elect. Syst?	n	y	y	y	p	n	y	y	y	y	y	0	y	n	n	y	y	y	n	y	p	y	n	n	y	n	y	n	n	n	n	n	n	n	n	-24	
4b.1	Cogeneration?	n	y	y	y	p	p	y	y	y	y	y	n	y	y	y	y	y	n	n	p	n	y	n	n	n	y	n	n	y	n	p	n	y	y	-24		
4c.1	District or block heating?	y	y	y	y	p	y	y	y	y	y	y	0	y	y	y	y	y	y	n	y	y	n	y	n	y	n	n	y	n	n	n	n	p	p	p	-16	
4c.2	District or block cooling	n	p	p	p	y	n	n	y	y	y	p	n	y	n	n	n	n	n	n	n	p	n	y	n	n	n	n	n	n	n	n	n	n	n	n	p	-46
4d.1	Natural lighting?	y	p	p	p	p	n	y	y	y	p	p	n	p	p	p	p	n	p	p	n	n	p	y	n	n	n	n	p	n	n	n	n	y	y	y	-39	
	Score Annex I	-8	-10	-10	-10	-10	-17	-2	-1	-1	-2	-1	-5	-20	-3	-5	-5	-5	-16	-14	-10	-15	-6	-14	-12	-6	-12	-10	-13	-10	-10	-14	-36	-8	-7	-7		

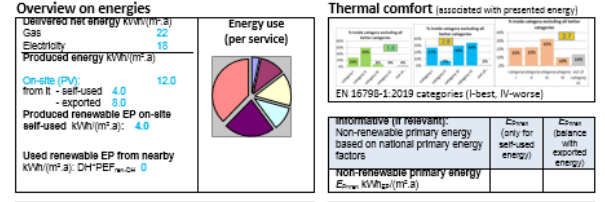
Technical assessment of national/regional calculation methodologies for the energy performance of buildings. (Source: Service contract number: ENER/C3/2013-425/SI2.679523, Final report 2015)



Example of numeric indicator of primary energy use for the same building. (Source: ALDREN project)

OVERVIEW OF ENERGY PERFORMANCE					
Delivered energy, exported energy, thermal comfort					
Service technical systems description	Energy need kWh(m².a) / expenditure factor**	Energy carrier		Delivered energy per energy carrier	
		Description	$f_{exp} / f_{exp}^{ref}$	Amount kWh/a	Amount kWh/(m².a)
Space heating: <input type="checkbox"/> Humidification	$Q_{h,nd} = 20$ $\epsilon = 1.2$	gas	1.1/0.11	$E_{gas}$	22
		electricity	2.30/2.0	$E_{elec}$	2
		Carrier j		$E_{carrier,j}$	
		<b>Total use</b>			<b>24</b>
Cooling: <input type="checkbox"/> dehumidification	$Q_{c,nd} =$ $\epsilon =$	Carrier 1		$E_{carrier,1}$	
		Carrier j		$E_{carrier,j}$	
		<b>Total use</b>			
Ventilation	$Q_{v,nd} =$ $\epsilon =$	Carrier 1		$E_{carrier,1}$	
		Carrier j		$E_{carrier,j}$	
		<b>Total use</b>			
Air-conditioning may be also represented by the inclusion of energy for Humidification (or dehumidification under Heating and Cooling respectively)	$Q_{ac,nd} =$ $\epsilon =$	Carrier 1		$E_{carrier,1}$	
		Carrier j		$E_{carrier,j}$	
		<b>Total use</b>			
Hot water preparation:	$Q_{hw,nd} =$ $\epsilon =$	Carrier 1		$E_{carrier,1}$	
		Carrier j		$E_{carrier,j}$	
		<b>Total use</b>			
Lighting:	$Q_L = 18$ $\epsilon = 1.0$	electricity	2.30/2.0	$E_{elec}$	18
		<b>Total use</b>			<b>18</b>
Other:		Carrier 1		$E_{carrier,1}$	
		Carrier j		$E_{carrier,j}$	
		<b>Total use</b>			<b>40</b>
<b>Total final energy use</b>	$Q_{f,nd} = 38$ $\epsilon = 1.11$				
Renewable energy production (on-site) $E_{p,rs}$		PV	0.1/1	$E_{p,pv}$	-12.0
Renewable energy production by on-site production self-used $E_{p,rs,sel}$		PV	0.1/1	$E_{p,pv,sel}$	-4.0
Sum of produced renewable energy (self-used) $E_{p,rs,sel}$		Carrier j		$E_{p,carrier,j,sel}$	-4.0
Exported produced renewable energy (on-site) $E_{p,rs,exp}$		PV	2.30/2.0	$E_{p,pv,exp}$	-8.0
		Carrier j		$E_{p,carrier,j,exp}$	
Sum of exported produced renewable energy $E_{p,rs,exp}$					-8.0

\*\* $f_{exp}$  = electricity = 2.3, gas = 1.1, wood = 1.2, solar = 1  
Kcal/kg kWh electricity = 0.42, gas = 0.22, wood = 0.04, solar = 0  
\*\*\*The expenditure factor  $\epsilon$  is the reciprocal value of the efficiency



COMMON EUROPEAN VOLUNTARY ENERGY PERFORMANCE CERTIFICATE				
ALDREN		AWARD (only for classes A, B, C):		<b>A</b>
ENERGY PERFORMANCE RATING Building category: Office building				
Climate: Moderate	Ratio to Ref	$E_{Prisen}$ (only for self-used energy)	$E_{Prisen}$ (balance with exported energy)	
Town: Bratislava				
Most efficient				
Energy +	< 0			
A	≤ 0.35 Ref		<b>A</b>	
B	≤ 0.50 Ref		<b>B</b>	
C	≤ 0.71 Ref			
D	REFERENCE* ≤ 1.00 Ref			
E	≤ 1.41 Ref			
F	≤ 2.00 Ref			
G	> 2.00 Ref			
Least efficient				
*Reference energy performance (Ref) =	<b>130</b>	0.43 Ref	0.29 Ref	
SRI indicator	45%	$E_{Prisen}$ (balance with exported energy)	$E_{Prisen}$ (balance with exported energy)	
Non-renewable primary energy $E_{Prisen}$	kWh <sub>exp</sub> /(m².a)	<b>56</b>	<b>38</b>	
Total primary energy use $E_{Ptot}$	kWh <sub>exp</sub> /(m².a)	<b>63</b>	<b>51</b>	
CO <sub>2</sub> emissions	kg/(m².a)	<b>10.7</b>	<b>7.4</b>	
Produced renewable energy (on-site) $E_{p,rs}$	kWh/(m².a)	<b>4.0</b>	<b>8.0</b>	
Final energy use (exported energy is not counted) $\epsilon = 1.1$		<b>40.0</b>	kWh/(m².a)	
Renewable energy ratio of total primary energy $RER$ (including only self-used energy produced from RES on-site or nearby)		<b>11%</b>		
Energy needs related to fabrics and geometry (heating, cooling, lighting) kWh/(m².a)	Evaluated Building = 35.9 (0.89 Ref)	Thermal environment for standard use (I=best, 4=worse)		
	Ref $\epsilon_{ref} = 40$ (green certificate)	Season	Occupied hours	Score
		Winter	1215	1.9
		Summer	735	2.8
		Spring/Fall	501	2.7
		Overall thermal comfort		<b>2.3</b>
Year of construction / Last renovation:	19/07/2014	Number of floors	3	
Reference floor area (GIA) m²	5000	Climate locality, city (TMY)	Bratislava (IRC TMY)	
Net internal floor area (NIA) if relevant m²	4730	Latitude, Longitude, Altitude	48° 14', 17° 10', 141 m a.s.l.	
Building volume (related to GIA) m³	20 000	HELY CODE (IRC, Eurostat)	2791730	
Building: Covent Garden		Parcel No:	1200/1	
Address: Rue de mot 24, Bratislava, Slovakia		Date:	18.4.2020	
		Cadaster:	Bratislava	
		Validity:	18.4.2030	
Issued by: ENBEE s.r.o.			Signature	
Contact: +421 905 383 824				
No. of energy certificate: 00001/SK_0001/2019				

Page 1 – ALDREN Energy performance certificate and Energy label.

Page 2 – Overview of energy performance

It is fundamental to define the calculation method and the boundary conditions.

Recast EPBD request Member States to describe their national calculation methodology following the annexes of the overarching standards, developed under mandate M/480 given by the Commission to the European Committee for Standardisation (CEN). These descriptions include the boundary conditions.

But these descriptions can only efficiently be used if the national calculation methods follow the calculation procedure of the CEN standards (e.g. the calculation on the exported energy defined by an exporting factor  $k_{exp}$ ).

To ensure a minimum level of the comparability of results the Level(s) reporting table should be completed by topics as on-site produced renewable energy (differentiated by self-used and exported) (see ALDREN EPC). ■



# Renovation Strategies: The road to sustainable recovery



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As Europe embarks on a road to climate-neutrality and post-COVID economic recovery, a strong and ambitious national renovation strategy is key to impactful spending of recovery funds available to Member States. This should prompt Member States to improve upon their Long-term renovation strategies.

**Keywords:** long-term renovation strategy, Renovation Wave, economic recovery, climate-neutrality, decarbonisation, buildings, EPBD, European Commission

**B**uildings are responsible for 36% of greenhouse gas (GHG) emissions in the EU; reaching our climate targets requires a clear roadmap to decarbonising our living and working spaces. Currently, the EU is aiming to be climate-neutral by 2050. The European Commission proposed to raise the EU 2030 climate target from 40% to at least 55% below 1990 levels, an ambition which has been discussed and is now endorsed by the European Parliament and the Council. And with the ‘Renovation Wave’ Strategy, the Commission aims to double annual energy renovation rates in the next ten years.

Beyond climate goals, the pandemic and resulting economic crisis has recently brought EU buildings into sharper focus: renovation offers a unique opportunity to rethink, redesign and modernise our buildings and homes, and to boost renewables supply to make them fit for a greener and digital society, better prepare them for

future climate impacts and sustain the economic recovery. Within this context, ambitious national Long-term renovation strategies are foundational to achieving not only climate goals, but also sustainable economic recovery and smart, efficient spending of EU recovery funds.

## What are Long-Term Renovation Strategies?

The Energy Performance of Buildings Directive 2010/31/EU (EPBD), amended in 2018, together with the Energy Efficiency Directive 2012/27/EU (EED), is meant to trigger policies in the EU-27 towards achieving a highly energy efficient and decarbonised building stock by 2050, while providing a stable environment for investment decisions and enabling consumers and businesses to make more informed choices to save energy and money.

A key pillar of the EPBD are national Long-term renovation strategies (LTRS), which should enable implementation of these efforts on the ground through strategic planning, effective policies and financial support at Member State level.

As prescribed in the EPBD, Member States are required to (within their LTRS) develop and measure progress, provide indicative milestones for 2030, 2040, and 2050, as well as estimate the expected energy savings and wider benefits, and the contribution of building renovation to the Union’s energy efficiency target. It is also an important input to the “Renovation Wave” -strategy [1] for buildings, announced as part of the European Green Deal.

According to the European Commission, national Long-term renovation strategies must include:

- an overview of the national building stock;
- policies and actions to stimulate cost-effective deep renovation of buildings;
- policies and actions to target the worst performing buildings, split-incentive dilemmas, market failures, energy poverty and public buildings;
- an overview of national initiatives to promote smart technologies and skills and education in the construction and energy efficiency sectors.

The strategies must also include a roadmap with:









- measures and measurable progress indicators;
- indicative milestones for 2030, 2040 and 2050;
- an estimate of the expected energy savings and wider benefits and the contribution of the renovation of buildings to the Union’s energy efficiency target.

On March 10, 2020, EU Member States were expected to submit their third LTRS, in line with requirements of the EPBD.

### Missing the mark

By September of the same year, BPIE found that less than half of Member States’ strategies had been submitted [2] and of those, few were compliant with EU legislation. Now approaching the middle of 2021, well over a year since the submission deadline, a small number of national strategies are still missing. Late submission appears a symptom of a broader malaise when it comes to prioritising the building stock. BPIE’s most recent analysis of 2020 strategies [3] shows that the majority of submitted LTRS are not in full compliance with the EPBD objective of achieving a highly efficient and decarbonised building stock by 2050.

The analysis, representing over 50% of the EU population (covering seven EU Member States and one region, Flanders, Belgium), shows that the majority of Member States fail to provide sufficient detail over the entire period to 2050, to enable an evaluation of whether the supporting policies and financial arrangements are adequate to meet the goals. Most strategies appear to put more effort towards decarbonising energy supply systems and greenhouse gas emissions reduction, rather than actively improving the energy performance of buildings, reducing overall the energy consumption in this sector.

Country/region	Base year	2050 Decarbonisation objective: Reduction in CO <sub>2</sub> emissions
 <b>BELGIUM FLANDERS REGION</b>	2005	Non-residential: 100% Residential: 74%
 <b>CZECHIA</b>	2020	40%
 <b>ESTONIA</b>	2020	89%
 <b>FINLAND</b>	2020	90%
 <b>FRANCE</b>	2015	94%
 <b>GERMANY</b>	1990 <sup>12</sup>	No target set for 2050
 <b>THE NETHERLANDS</b>	1990	95%
 <b>SPAIN</b>	2020	98.8%

<sup>12</sup> 1990 is the baseline year used by the federal government in at least 55% by 2030

Figure 1. Results of BPIE’s



Highly energy efficient building stock objective: Reduction in energy use by 2050	Total investment required	Conclusions
Non-residential: 33% Residential: 70%	€200 bn	Both objectives fall short of EPBD requirement, since energy use in the non-residential sector remains high, while the residential sector is not fully decarbonised
23.5%	€33 bn	Both objectives fall far short of the EPBD requirement
59%	€21.6 bn	Both objectives, while broadly in line with EPBD, are dependent on funding that has not yet been secured and hence do not represent a clear objective to which the government has committed
55%	€24 bn	Objectives in line with EPBD
41%	Not provided	Insufficient effort is directed to improving the energy performance of the building stock
No target set for 2050	Not provided	LTRS fails to meet minimum requirement of a clear 2050 decarbonisation objective
Not specified	Not provided	Energy targets need to be set for 2050
Non-residential: 36% Residential: 37%	€143 bn inclusive of financing costs (residential sector only)	Insufficient effort is directed to improving the energy performance of the building stock

setting its objective of reducing national GHG emissions in Germany by at

analysis [4] of several European LTRS.

Half of the analysed strategies (Spain, Finland, France, and the Netherlands) include an objective at or above 90% GHG emissions reduction, which is in line with the legal requirement of EPBD Article 2a, which requires Member States to set a long-term 2050 goal of reducing GHG emissions in the EU by 80-95% compared to 1990.

However, none of the eight strategies targets 100% decarbonisation of the building stock, which is needed to achieve climate neutrality. This means that the substantial increase in renovation activity that is required – a deep renovation rate of 3% annually by 2030 [5] – is unlikely to be achieved. Given the new political developments since the 2018 EPBD recast, including a strengthened EU 2030 climate target and 2050 climate-neutrality law, it is clear that even strict adherence to the LTRS as defined in the EPBD is now insufficient.

While both decarbonisation and energy efficiency are clearly needed, a greater focus on energy performance would bring with it many economic, environmental and societal benefits, such as improved indoor air quality, better health, job creation and alleviation of energy poverty.

### What to do?

There is now a clear misalignment between LTRS and the EU 2050 Climate targets, which must urgently be addressed. This will require concerted effort from both Member States and the European Commission.

To start, Member States should now seek to increase the ambition of their renovation goals to 100% decarbonisation of the building stock and revise their strategies to ensure effective delivery. This could be done through a reworking of their 2020 strategies in the near future, but certainly no later than the deadline for the next iteration, in 2024.

The European Commission, in turn, should use the opportunity of legislative revisions in 2021, to ensure a full revision of the EPBD (and LTRS), in line with the 'Renovation Wave' and the new 2030 Climate Target. The 2021 revisions should also ensure an revision of EPBD Article 2a, to require full decarbonisation of the building sector by 2050, with most of the effort to be directed to improving building energy performance and the delivery of a highly energy efficient, nearly zero-energy building stock.

The Commission should furthermore assess all Member State LTRS not only in accordance with the legal text of EPBD Article 2a, but also in view of aligning the full directive with the climate-neutrality objective by 2050 (meaning a higher decarbonisation objective and stronger emphasis on reducing the energy demand in the buildings sector), and guide Member States accordingly for their LTRS update which is due by 2024 at the latest. The ‘Renovation Wave’ ambition should also be adjusted, to deliver a 3% annual deep renovation rate by 2030, the required rate to fully align the buildings sector with the climate-neutrality objective by 2050.

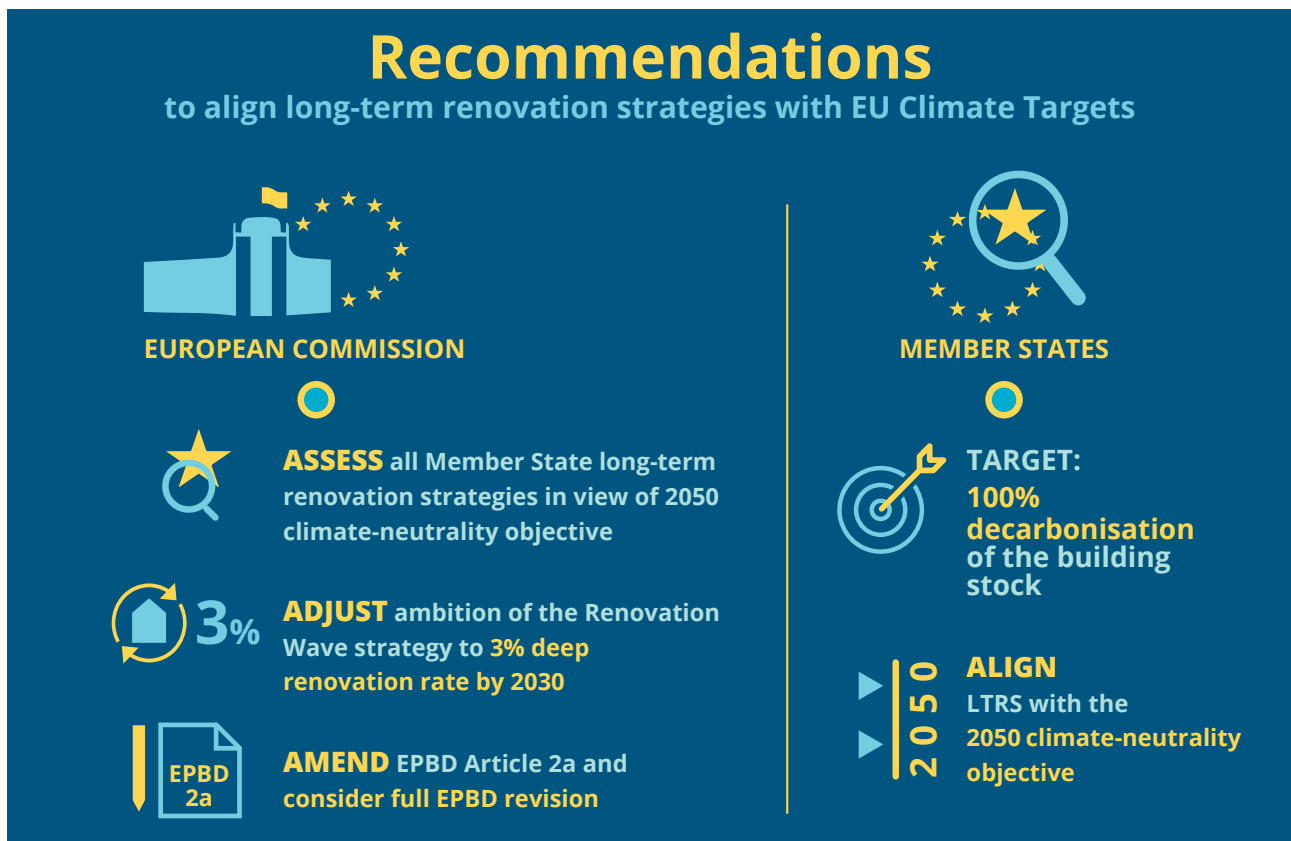
## Recovery and resilience – building back concrete results on the ground

While aligning legislation and strategies with Europe’s climate targets represents a real challenge, we know that the climate won’t wait. We also know that the European Union’s Recovery and Resilience Facility (RRF) will channel some €672.5 billion in loans and grants to support reforms and public investments undertaken by Member States, and minimum 37% of Member State RRF allocation must go towards climate priorities. Member States therefore have every reason

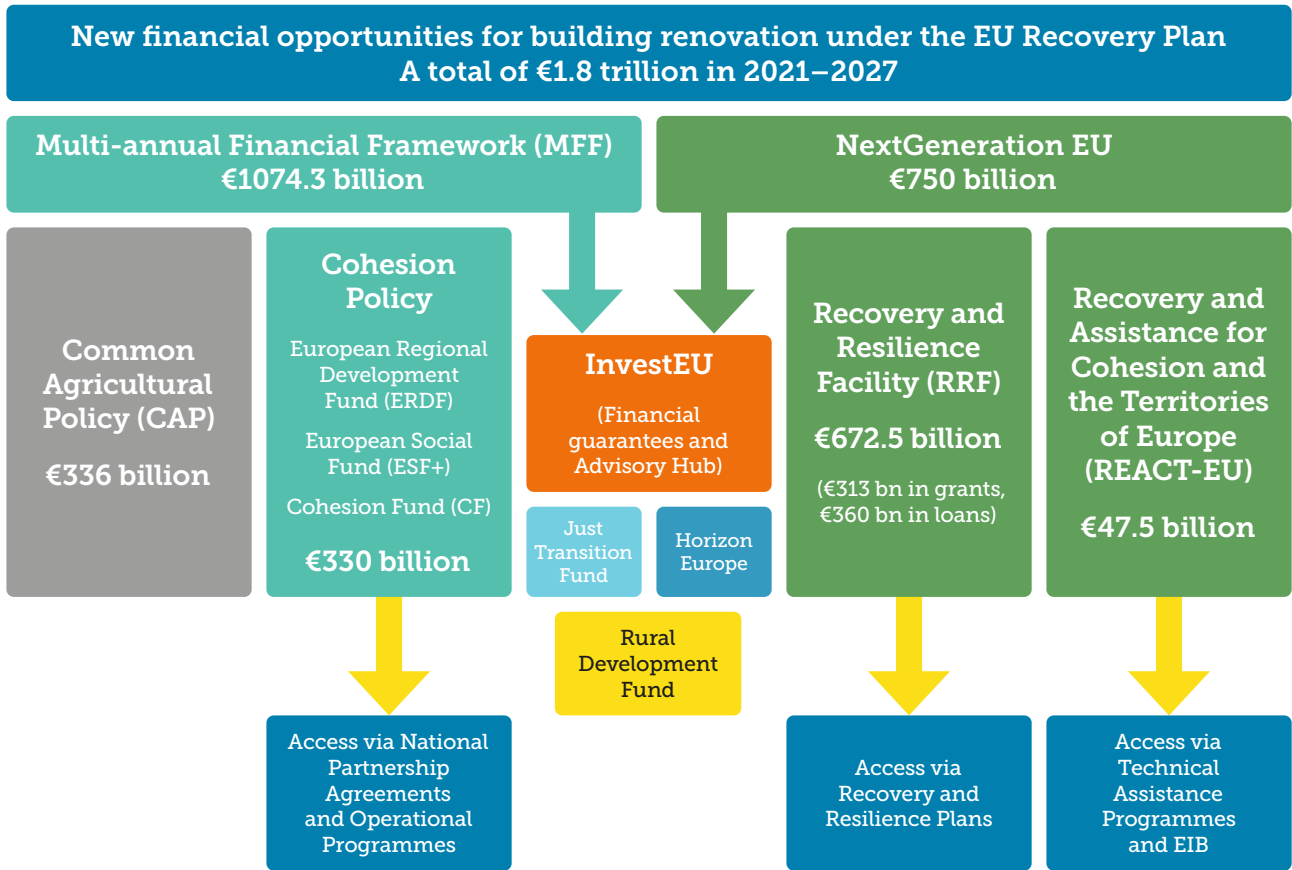
to align their LTRS with the climate-neutrality objective, as this should also guide effective spending of recovery funds to stimulate both short- and long-term economic growth.

The European Commission first proposed the RRF in May 2020, and by September, issued a guidance to Member States on how to draft their Recovery and Resilience Plans (RRP). The guidance identifies seven ‘thematic flagship’ areas suitable for spending the recovery money. ‘Renovate’ is the second flagship mentioned as an area the Commission “strongly encourages” Member States to include as an area to foster economic growth and job creation. The RRF entered into force [7] in February 2021, with end of April 2021 being the deadline for Member States to submit their national Recovery and Resilience Plans (RRPs). At the time of writing in May 2021, almost all RRFs have been submitted, showing that most Member States are largely on track and have been able to respect the deadline.

The speed at which Member States have submitted their recovery plans, particularly in comparison to their LTRS, highlights the political – and existential – weight that is, understandably, given to economic recovery.



**Figure 2.** Recommendations to align LTRS with EU climate targets. (Source: BPIE report “The road to climate-neutrality: are long-term renovation strategies fit for 2050?” [6])



**Figure 3.** Overview of the EU Recovery Plan including the MFF 2021–2027 and the NextGeneration EU budget, BPIE’s illustration based on EU Council infographic.

While the pandemic, and the myriad of economic, mental and physical health impacts on Europe’s population have been great, the context of recovery is a game changer – more money is now available for building renovation than over the last five years altogether including Regional and Cohesion Funds.

Member States should therefore not be quick to dismiss improving upon their LTRS (or submitting – for those who are still late). A strong and ambitious national renovation strategy is the key to impactful spending. The recovery money, in turn, offers an unparalleled opportunity to implement the Renovation Wave on the ground. ■

**Endnotes**

- [1] The Renovation Wave intends to create the necessary conditions to scale up renovations and reap the significant saving potential of the building sector. ([https://ec.europa.eu/commission/presscorner/detail/en/fs\\_19\\_6725](https://ec.europa.eu/commission/presscorner/detail/en/fs_19_6725)), [https://ec.europa.eu/commission/presscorner/detail/en/IP\\_20\\_1835](https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1835)
- [2] <https://www.bpie.eu/publication/a-review-of-eu-member-states-2020-long-term-renovation-strategies/>
- [3] <https://www.bpie.eu/publication/the-road-to-climate-neutrality-are-national-long-term-renovation-strategies-fit-for-2050/>
- [4] [https://www.bpie.eu/wp-content/uploads/2021/03/BPIE\\_LTRS-10-1.pdf](https://www.bpie.eu/wp-content/uploads/2021/03/BPIE_LTRS-10-1.pdf)
- [5] <https://www.bpie.eu/publication/on-the-way-to-a-climate-neutral-europe-contributions-from-the-building-sector-to-a-strengthened-2030-target/>
- [6] [https://www.bpie.eu/wp-content/uploads/2021/03/BPIE\\_LTRS-10-1.pdf](https://www.bpie.eu/wp-content/uploads/2021/03/BPIE_LTRS-10-1.pdf)
- [7] <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R0241&from=EN>



# The 3rd Revision of the Energy Performance of Buildings Directive (EPBD)



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With the adoption of the Renovation Wave strategy on 14 October 2020 [1], the European Commission set the ambition to at least double the annual renovation rates of Europe's building stock in the next ten years, with a special focus on increasing deep renovations. One of the key legal acts to achieve this is the Energy Performance of Buildings Directive (EPBD) which opened up for a third revision in early 2021. This article provides an update on the process and an overview of the stakeholder workshops organised by a consortium to support the Commission with collecting feedback and impact assessment, as well as the position that REHVA is advocating in this process.

## The need for a new EPBD revision under the Renovation Wave

The previous revision of the EPBD [2] demanded Member States, by 10 March 2020, to develop national renovation strategies to achieve a decarbonised building stock by 2050 and stricter requirements for the inspection of heating, ventilation and air conditioning systems, among other provisions. The next review was originally planned for 2026 but the Commission assessed that the EPBD would need to be

strengthened again in order to meet the objective of at least doubling the annual renovation rate of buildings by 2030.

Three focus areas have been identified for the policy and financing efforts under the Renovation Wave:

- a) Tackling *energy poverty and worst-performing buildings*, ensuring access to healthy housing for all households.
- b) There is a strong need for *renovation of public buildings*, e.g. healthcare, educational and administrative facilities, so that public buildings can lead by example.
- c) *Decarbonisation in heating and cooling* which are currently responsible for 80% of energy consumed in residential buildings.

The ongoing revision of the EPBD will likely impact all three but corresponds mostly to the first area on improving the worst-performing buildings. The actions of the Commission in the Renovation Wave focus on strengthening information, legal certainty and incentives for public owners and private tenants to encourage more renovations. To accomplish this the Commission is currently considering different measures, such as a phased introduction of minimum energy performance standards (MEPS) [3], an improvement of Energy Performance Certificates (EPC), and possible introductions of a 'deep renovation standards', Digital Building Logbooks and Building Renovation Passports.

## Process of the third EPBD Revision

The Commission is currently preparing to adopt a new proposal on the third revision of the EPBD, foreseen for the end of 2021 (Fit for 55 legislative package [4]). Complementary to this, the Commission is in the process of gathering inputs from stakeholders in order to present a robust EPBD proposal. This process for feedback opened on 22 February 2021 when the Commission published a roadmap [5] to assess the best approach for the EPBD to fulfil the Renovation Wave objectives. Stakeholders were invited to share their feedback on the roadmap up until 22 March - to which ultimately 243 contributors responded, REHVA being one of them (see further for REHVA's response).

The second phase of the feedback process ran as a public consultation from March 30th until June 22nd. A consortium of consultants has been contracted by the Commission to provide support with the stakeholder consultation process and impact assessment. This phase consisted of a public consultation questionnaire and a series of stakeholder workshops with 170 to 250 participants per workshop. DG Energy provided introduction and closing remarks for each workshop. It was interesting to note that representatives from multiple Member States were spotted in the

participants list, who were following the discussions in listening mode.

Below a brief summary is provided on the topics of the first four workshops and the results to the most relevant poll questions. The fifth and final workshop – on accessible and affordable financing – from June 3rd has not been included in this overview as it was yet to take place at the time of writing.

### Workshop 1: Setting a vision for buildings and a decarbonised building stock

The first workshop took place on 31 March 2021 and aimed to assess the overall priorities related to the EPBD among stakeholders from across the field. The first poll question asked if the introduction of a new EU-harmonized GHG metric for measuring building performance should be prioritised. With 74% a large majority of the respondents answered “yes” to the question.

The second poll question asked stakeholders which instruments within the EPBD are a priority for revision. As seen in **Figure 1**, the priorities according to stakeholders were the MEPS, EPC and Long-Term Renovation Strategies (LTRS) from Member States.

Question 2. In the frame of the EPBD revision, which instrument would you consider as the priority because its revision or addition could make a difference towards the 55% target, you? (n=133)

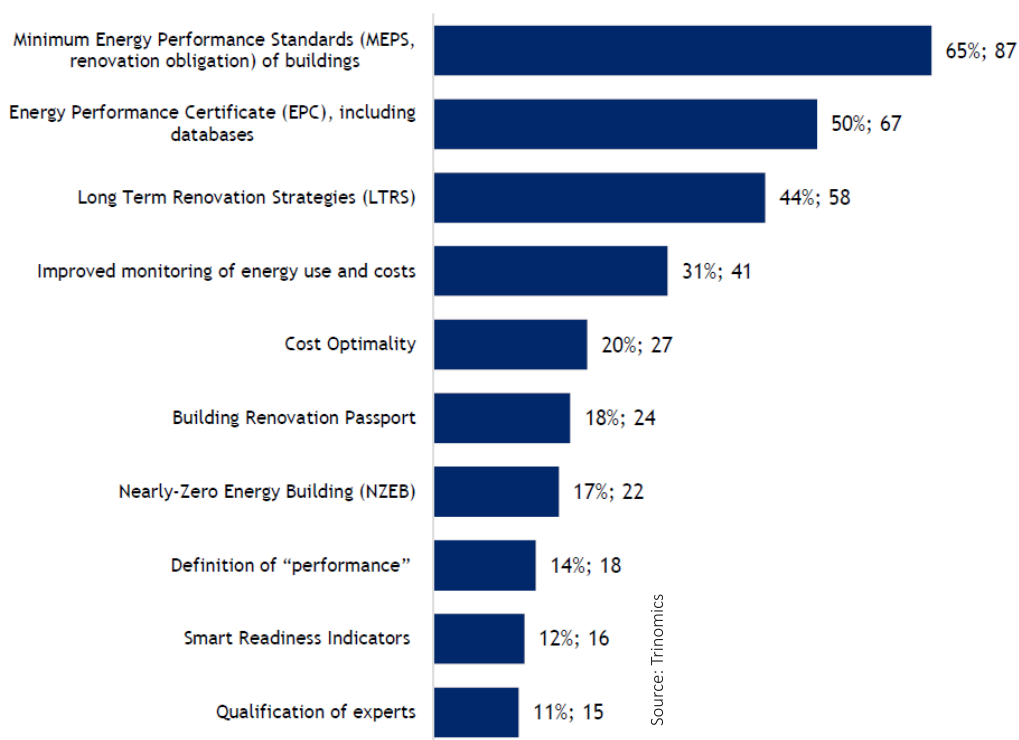


Figure 1. Poll results on the priority of instruments to be revised within the EPBD according to participants in Ws 1.

**Workshop 2: Minimum Energy Performance Standards [6] (MEPS) for existing buildings**

The second workshop, focused on amending the MEPS within the EPBD as a way to tackle the worst-performing buildings in Europe. The first poll question during this workshop asked about the key elements to guarantee a successful implementation of MEPS by Member States. As can be seen in **Figure 2**, many respondents thought a phased introduction of MEPS was crucial as well as links to LTRS, EPC and Building Renovation Passports (BRP).

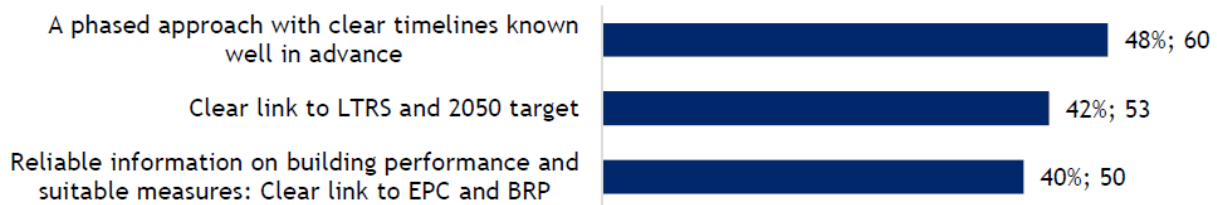
The last poll question in this workshop asked which should be the main criteria to identify buildings for which mandatory MEPS should be applied. A strong majority (68%) of the respondents answered that this should be based on “performance level”, making clear that MEPS are an instrument to tackle the worst-performing buildings.

**Workshop 3: Strengthening building information tools (with focus on EPC)**

On 29 April the third workshop took place which had the information role, quality and scope of EPCs as the main topic of discussion. When respondents were asked about the most important aspect to improve in EPCs, the most popular answer - by a large margin - was to improve the “quality and reliability of EPC”. The concerns of reliability were confirmed in the poll results of a later question when participants were asked what was needed to improve the quality of EPC. **Figure 3** shows that the most popular answer to this question was that the energy performance gap (calculated vs. metered data) needed to be addressed to increase the data reliability of EPCs.

Another poll question made it clear that almost half of the respondents thought that a “comparison with current building regulations or future objectives” would strongly strengthen the information role of EPCs.

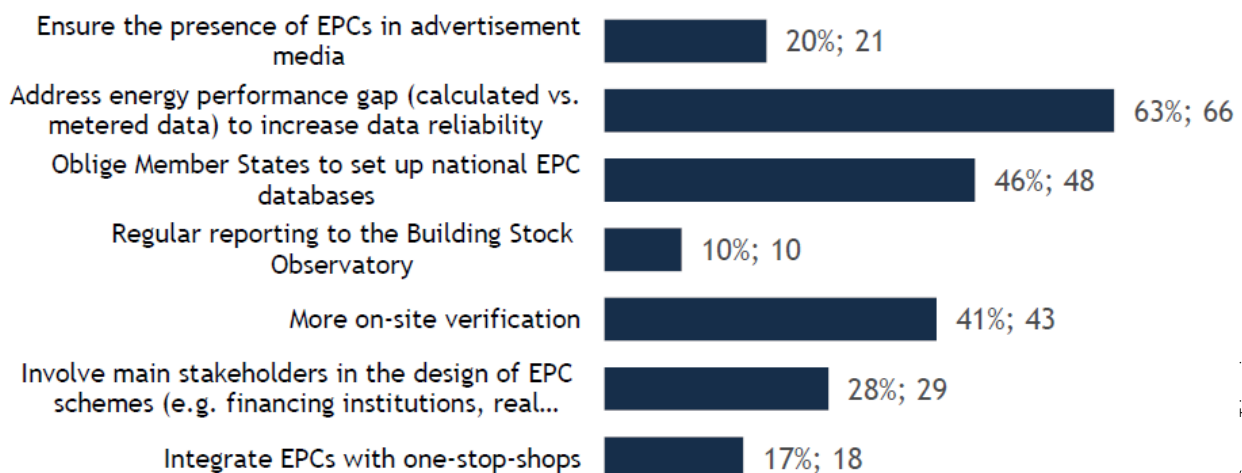
**Question 1. What are the key elements to guarantee a successful implementation by MS? (n=126)**



Source: Trinomics

**Figure 2.** Three most popular poll results on the key elements of a successful implementation of MEPS according to participants in Ws 2.

**Q4. What is needed to improve the quality of EPC? (n=105)**



Source: Trinomics

**Figure 3.** Poll results on what is needed to improve the quality of EPCs according to participants in Ws 3.

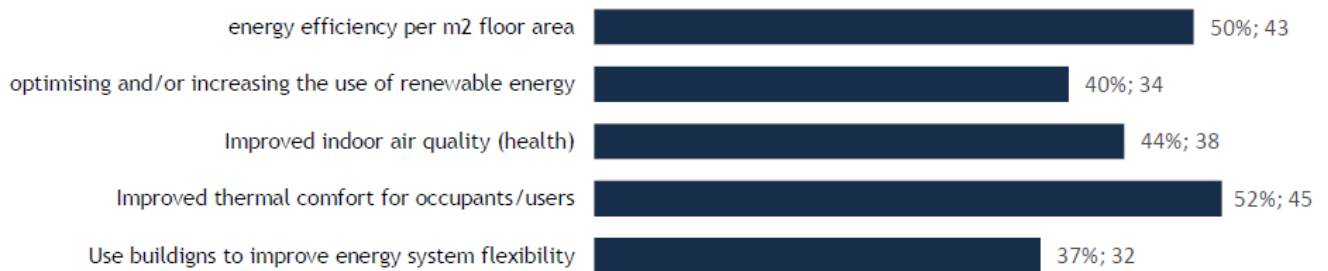


**Workshop 4: Fostering the green and digital transitions**

The 4th workshop had a larger variety of items to discuss – among them smart buildings and BRPs. As can be seen in

**Figure 4**, participants were asked what the most important indicators are that smart building systems could provide. Improved thermal comfort and IAQ were among the most popular answers according to respondents.

S1 - Q1. What are the most important indicators smart building systems can provide and should be addressed in the EPBD? (n=86)



**Figure 4.** Poll results on the most important indicators smart building systems can provide according to participants in Ws 4.

Source: Trinomics



Photo: Alexander Steamaze / Shutterstock

## REHVA Position and Contribution to Revision Process

At the time of writing, REHVA is preparing a response to the public consultation questionnaire together with its Member Associations. Earlier this year REHVA published a position paper [7] in response to the roadmap. REHVA supports the policy option for a revision of the EPBD to foster deep renovation that delivers healthy and energy efficient buildings while boosting digitalisation in the construction and building renovation sectors. Consistent with the previous EPBD revision REHVA continues to advocate for more attention to be paid to improved indoor air and environmental quality (IAQ & IEQ) resulting from deep renovations. IEQ and ventilation requirements should be integrated into renovation policies within the scope of the EPBD. Furthermore, EPCs should contain an IEQ indicator according to the EN/ISO EN 16798-1 standard [8]. The ALDREN-Tail indicator [9] can be used as good practice to rate the IEQ of buildings undergoing deep renovation. The EPBD review should also keep the ‘energy efficiency first’ principle for deep renovation with primary energy as its key metric.

In parallel, REHVA has been active in the above-mentioned stakeholder workshops stressing also the importance of a both qualitative and quantitative Smart Readiness Indicator (SRI) as a market-pull instrument to support the digital transformation of buildings. Furthermore, REHVA leveraged its involvement in 2 of the 7 active projects of the Horizon 2020 ‘Next Generation EPC Cluster’ [10], providing overall support in the evolution of energy performance assessment and certification across the EU and paving the pathway to measured and operational building performance.

### Next steps

With the end of the public consultation round on 22 June, we now have to wait for the Commission to publish the proposal for the third EPBD revision which is foreseen at the end of 2021. After that the European Parliament and the Council of the European Union will discuss and amend the proposal (so-called “trialogues”), until an inter-institutional agreement can be found for the final text. The length of this process depends on the negotiations, during the previous revision (between 2016 and 2018) the inter-institutional negotiations lasted 18 months. ■

### Endnotes:

- [1] [https://ec.europa.eu/energy/sites/ener/files/eu\\_renovation\\_wave\\_strategy.pdf](https://ec.europa.eu/energy/sites/ener/files/eu_renovation_wave_strategy.pdf)
- [2] Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L\\_.2018.156.01.0075.01.ENG](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.156.01.0075.01.ENG)
- [3] These “standards” should be interpreted as a set of minimum requirements to which existing buildings would have to adhere to
- [4] [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_20\\_1940](https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1940)
- [5] [https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12910-Energy-efficiency-Revision-of-the-Energy-Performance-of-Buildings-Directive\\_en](https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12910-Energy-efficiency-Revision-of-the-Energy-Performance-of-Buildings-Directive_en)
- [6] These “standards” should be interpreted as a set of minimum requirements to which existing buildings would have to adhere to
- [7] [https://www.rehva.eu/fileadmin/user\\_upload/REHVA\\_feedback\\_EPBD\\_review\\_long.pdf](https://www.rehva.eu/fileadmin/user_upload/REHVA_feedback_EPBD_review_long.pdf)
- [8] <https://epb.center/documents/en-16798-1/>
- [9] <https://www.rehva.eu/rehva-journal/chapter/application-of-aldren-tail-index-for-rating-the-indoor-environmental-quality-of-buildings-undergoing-deep-energy-renovation>
- [10] <https://youtu.be/ILibLOEXDdo> (Next Generation EPCertificates H2020 cluster ~5 min pitches)



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# The smart readiness indicator for buildings: current status and next steps



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The Smart Readiness Indicator (SRI) for buildings was introduced in 2018 by the Directive amending the Energy Performance of Buildings Directive (2018/844/EU) [1]. Since Autumn 2020, following the intensive development and extensive stakeholder consultation activities of the two SRI technical support studies contracted by the European Commission's (EC) Directorate General for Energy (DG ENER), the first Smart Readiness Indicator version is ready. Furthermore, the so-called SRI legal acts (EU regulations) have entered into force across the EU's Member States on January 10th, 2021. By design the SRI is a voluntary scheme so it is now up to the Member States of the European Union to decide how to implement the SRI at national level and as desired only after undergoing a no commitment national testing exercise.

**Keywords:** digitalization, digital transformation, smart buildings, performance, qualitative assessment, certification, renovation, people-centred, indoor environmental quality, health, well-being energy optimization, energy flexibility

## Not at all familiar with the SRI?

The 2018 revision of the European Energy Performance of Buildings Directive (EPBD) aims to further promote smart building technologies, in particular through the establishment of a Smart Readiness Indicator (SRI) for buildings (**Figure 1**). This indicator will allow for rating the smart readiness of buildings, i.e. the capability of buildings (or building units) to adapt their operation to the needs

of the occupant, also optimizing energy efficiency and overall performance, and to adapt their operation in reaction to signals from the grid (energy flexibility). The smart readiness indicator should raise awareness amongst building owners and occupants of the value behind building automation and electronic monitoring of technical building systems and should give confidence to occupants about the actual savings of those new enhanced functionalities.

**Current status**

On 22 September 2020 the final results (final report and summary) of the second SRI technical study have been officially published by the EC’s Publication Office [2]. On the official website of the second SRI technical support study the final report and summary are furthermore accompanied by:

- Two annexes in excel sheet format (Annex C - simplified service catalogue, Annex D - detailed service catalogue) [3]
- SRI Topical Group C 1st recommendations report [4] prepared by a self-managed group of stakeholders that advocates the SRI should be future proof and evolve to a data-driven assessment

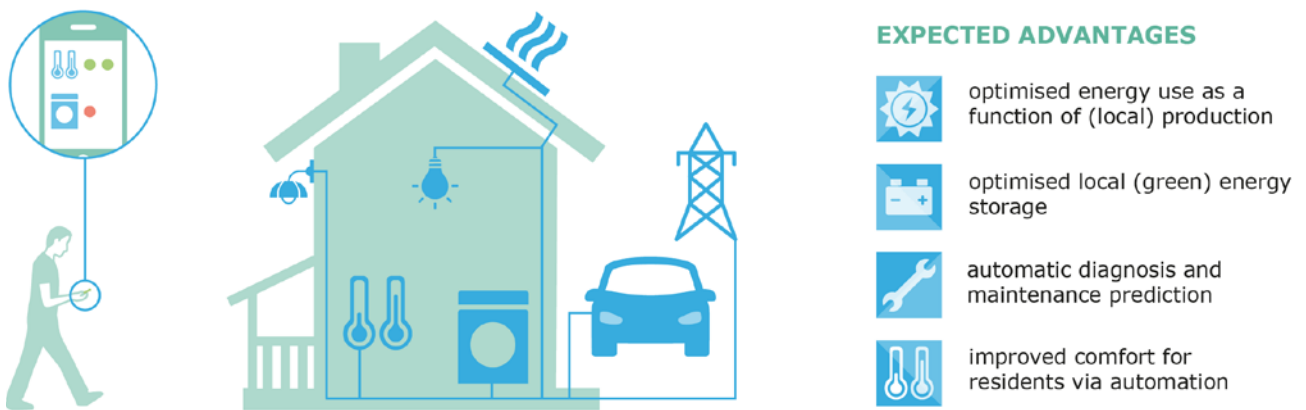
Alongside, the SRI legal acts (SRI delegated act, SRI implementing act), after a prior official European Commission feedback round during Summer 2020 [5] have been published in the Official Journal of the

European Union on December 21st, 2020 and have entered into force on January 10th, 2021:

- SRI delegated act [6] (*Regulation establishing an optional common Union scheme for rating the smart readiness of buildings that is to say the definition of the smart readiness indicator and a common methodology by which it is to be calculated. The methodology consists of calculating smart readiness scores of buildings or building units and deriving smart readiness rating of buildings or building units*)
- SRI implementing act [7] (*Regulation detailing the technical modalities for the effective implementation of an optional common Union scheme for rating the smart readiness of buildings established in the SRI delegated act*)

The first SRI version is basically a qualitative assessment of the smart readiness of a given building with 3 key functionalities at centre stage (**Figure 2**).

**SMART BUILDING**



**Figure 1.** Expected advantages of smart technologies in buildings (SRI technical support studies).

**MEASURE THE TECHNOLOGICAL READINESS OF YOUR BUILDING**



**Figure 2.** Three key functionalities of smart readiness in buildings (SRI technical support studies).

For each key functionality of smart readiness in buildings there are one or several impact criteria (e.g. the readiness to facilitate maintenance and efficient operation has two criteria energy savings and maintenance and fault prediction) based on which the smart services (from the SRI service catalogue) available in a given building receive scores structured within 9 domains (i.e. heating, domestic hot water, cooling, ventilation, lighting, electricity, electric vehicles, dynamic envelope, monitoring and control) as illustrated in **Figure 3**.

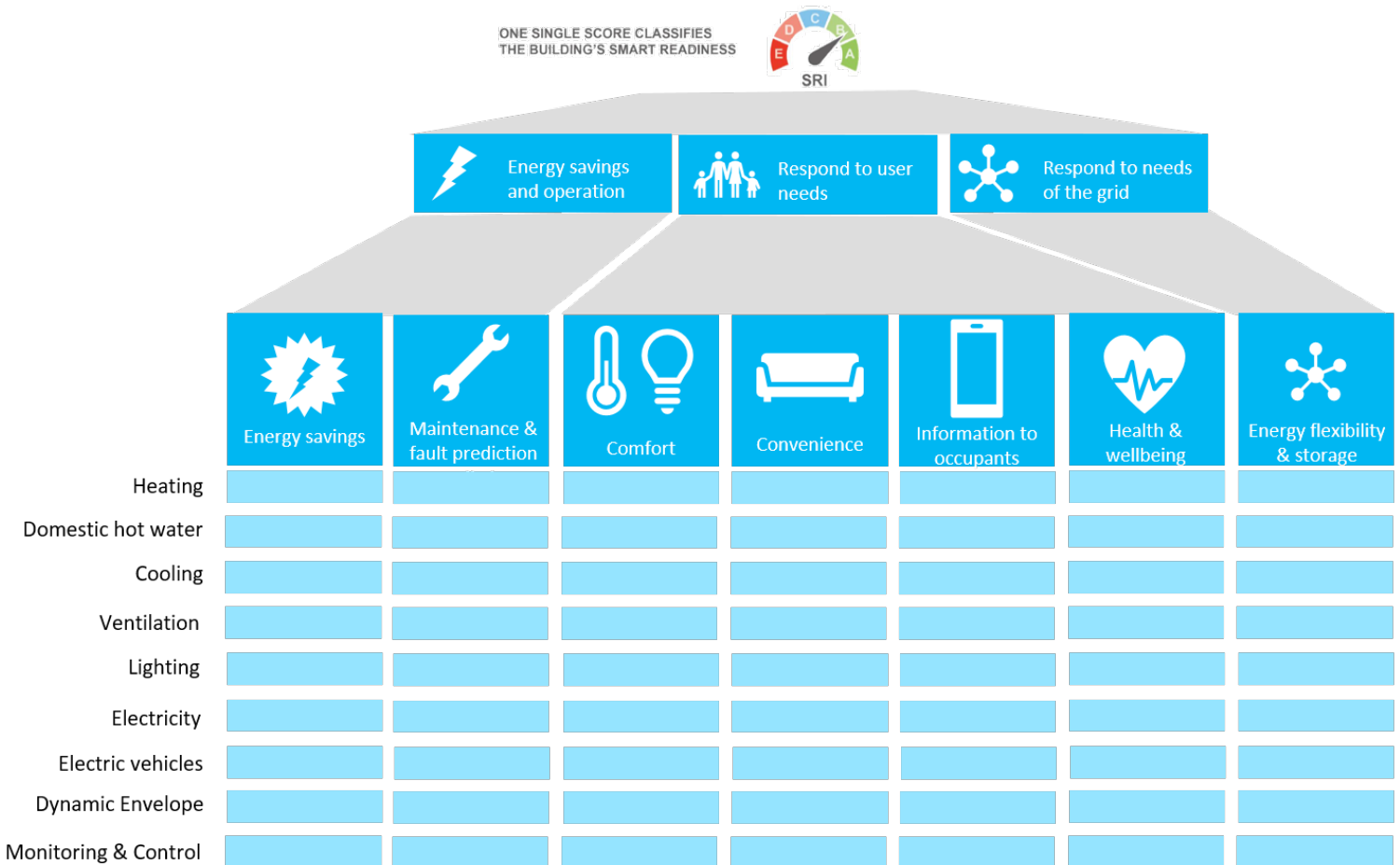
The results of the SRI qualitative assessment could be displayed either as a single score, three scores, one for each key functionality of smart readiness in buildings (**Figure 4**) or in a matrix detailed view enabling to visualize the scores of all SRI domains against the SRI impacts criteria (**Figure 5**).

The SRI assessment covers all smart services available in a given building, so the detailed view is practically

possible for any assessed building. The SRI scores can be aggregated per impact criterion, per key functionality or in a single score thanks to the usage of weighting factors (**Figure 6**).



**Figure 4.** Example of Tri-partite mnemonics to convey the overall SRI score/rank and sub-score/ranks for the three SRI key functionalities (SRI technical support studies).



**Figure 3.** Proposed structure of domains and impacts criteria (SRI technical support studies).



IMPACTS

DOMAINS		Energy efficiency	Maintenance and fault protection	Comfort	Convenience	Health and well-being	Information to occupants	Energy flexibility & storage	<b>SRI</b>
	<b>Total</b>		<b>39%</b>	<b>18%</b>	<b>60%</b>	<b>71%</b>	<b>48%</b>	<b>59%</b>	<b>0%</b>
Heating		32%	18%	62%	55%	24%	74%	0%	
Sanitary hot water		17%	0%	45%	70%	67%	83%	0%	
Cooling		65%	51%	78%	72%	61%	55%	0%	
Controlled ventilation		41%	0%	55%	60%	34%	44%	0%	
Lighting		85%	14%	90%	100%	83%	15%	0%	
Dynamic building envelope		10%	0%	31%	56%	22%	46%	0%	
Electricity		10%	0%	-	-	-	68%	0%	
Electric vehicle charging		-	38%	-	82%	-	84%	0%	
Monitoring and control		52%	43%	62%	72%	45%	64%	0%	

Figure 5. Matrix showing SRI scores by domain and impact criterion, aggregate scores per impact criterion and the overall SRI score (SRI technical support studies).

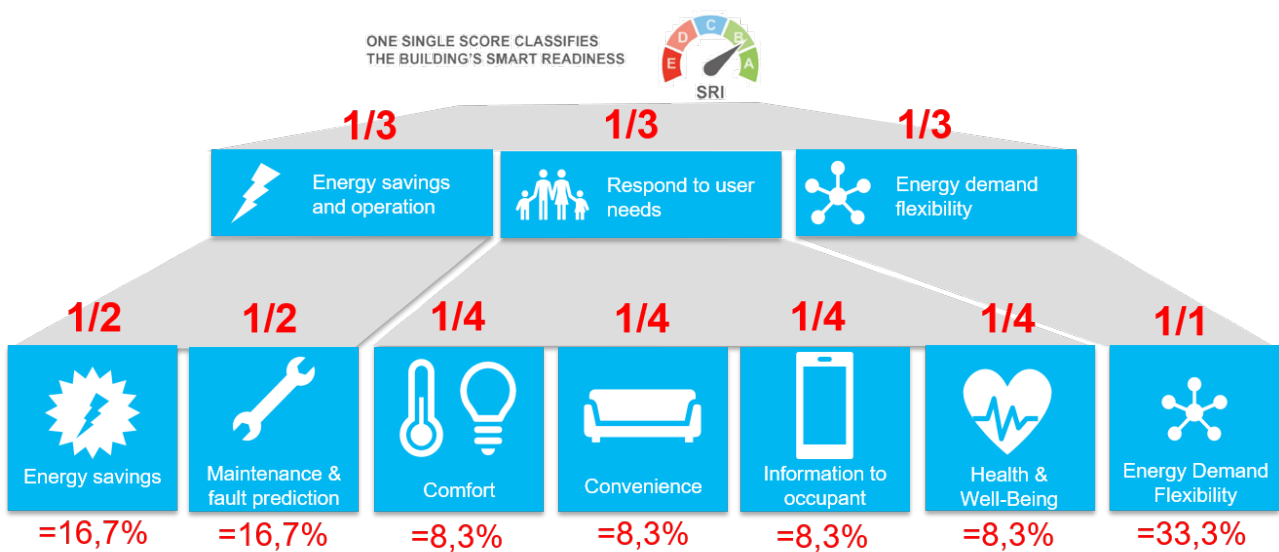


Figure 6. Aggregation of impact scores to three key functionalities or to a single score (SRI technical support studies).

*“The smartness of buildings should be a means to an end and not a goal in its own right. Smartness should serve the purpose of providing with a better building in terms of energy performance, health, convenience, etc. There are some examples of buildings where technology enthusiasts have gone so far in automation that the technologies become gimmicks or are so experimental only the person who installed it knows how to operate it.”* stated Stijn Verbeke, senior researcher at EnergyVille/VITO and University of Antwerp, in a recent expert interview on BUILD UP (The European Portal for Energy Efficiency in Buildings) [8]. Stijn was the principal investigator in the first SRI technical support study and the coordinator of the consortium of the second technical support study commissioned by the European Commission’s DG ENER.

## NEXT steps

Being a voluntary scheme by design the Member States of the European Union are now in the process of deciding how to implement the SRI at national level. Under the European Union’s principle of subsidiarity, the Member States have the right to make national level choices for many aspects of the SRI e.g. weighting factors, functionality levels, smart services catalogue. As per usual procedures they need to report and justify back to the European Commission.

- One can assume there will be only few if any Member States who go for a full implementation of the current SRI now. It’s more likely that Member States consider only a national test phase where possibly no certificates will be issued. In the national test phase, it’s highly likely that Member States might need to adapt the methodology to national preferences and needs to ensure national acceptance of the concept.
- Although there is no explicit timeline (start, end, duration) for the national testing exercise, the Member States do need to inform the European Commission what they are planning to do and submit an official report the latest 6 months after the testing phase is closed. In contrast, what is clear is that the two SRI legal acts (EU regulations) will be reviewed, as appropriate by 1 January 2026, in the light of the experience gained and progress made during its application.

A third SRI technical support service has been contracted by the European Commission during Spring 2021 (Call for tenders ENER/2020/OP/0015: Technical Assistance for Testing and Implementation of the Smart Readiness Indicator under the Energy Performance of Buildings Directive [9]) which will enable and facilitate the needed means of sharing experiences between Member States during the national testing phase, subsequent implementation phase and make further steps towards future proofing the SRI under the umbrella of the soon to be formed “SRI platform”. The coordination kick-off event between Member States took place during a couple of SRI dedicated sessions as part of the Concerted Actions Energy Performance of Buildings [10] plenary 26-28 May 2021.

During 2020 the SRI Topical Group C (SRI TGC) members have prepared a 1st recommendations report with the support of REHVA Technology and Research Committee members and involved stakeholders [11] (published in June 2020, however kept under embargo till the publication of the final report). Many of these recommendations have also been inserted as copy-paste in the final report by the SRI study team [12].

The scope of the SRI TGC self-managed (volunteer based) working group is to discuss and identify future pathways of updating the existing methodology and furthermore implementing the assessment method C of SRI, which is based on measured data of the actual performance of buildings. Within the scope the SRI Topical Group C experts also analyse how to make the transition to an in-use/performance-based SRI exploring the most effective means on one hand for automating the checklist evaluation process and on the other hand for leveraging measured data and define an additional in-use SRI methodology.

With regards to the upcoming national testing phase, the following recommendations are worth highlighting:

- The most meaningful insights would be attained if the Member States would rank their national level priorities “Energy performance and operation”, “Response to the needs of the occupant”, “Flexibility of a building’s overall electricity demand” and “All 3 of equal importance” at the beginning of the SRI testing/implementation process.

- A convergent and consistent approach between the actual assessment and final SRI scores at EU level is instrumental.
  - The Member State tailoring of the SRI qualitative assessment methodology should be either minimal (only if/as needed) and/or should be always possible to automatically convert to the EU SRI (default) to be able to compare the smart readiness level in different Member States and regions.
  - EU-wide programs to train and certify the assessors should be put in place. Importance should be given to the section “expert advices to users”, in which the assessor should give suggestions on how to further improve the smart readiness of the building. Site visit, interview with the Building Operator/Owner/Tenant and proof for high-score functionality should be mandatory for SRI method B assessment.
  - For fully reaping the benefits of the SRI qualitative assessment (methods A and B) an SRI quantitative assessment (method C) measuring actual smart performance is required and could fit within the scope of the national testing. The SRI’s potential needs to be captured into achieved outcomes (EU Green Deal, Renovation Wave Strategy) showing the real effect of

smart building technology relying on actual building performance data.

As soon as the third SRI technical support service kick-starts its activities, most likely in Autumn 2021, the SRI TGC members shall resume activities and take further their work in full synchronicity with the national testing phase and ongoing and upcoming EU funded projects (e.g. Horizon 2020, Horizon Europe, Life) that include activities related to SRI, especially testing, demonstration, further development and market uptake e.g.

- SmartBuilt4EU H2020 project [13], The EU Smart Building Innovation Platform
- Next Generation Energy Performance Certificates cluster of H2020 projects
  - (Closed) ALDREN: ALLiance for Deep RENovation in buildings Implementing the European Common Voluntary Certification Scheme, as back-bone along the whole deep renovation process. (project website [14]).
  - (Ongoing) Seven EPC sister projects covered in the EU news article “The Evolution of Building Energy Performance Assessment and Certification Scheme in Europe” included in REHVA Journal issue 01/2021 [15] at page 82. ■

## Endnotes:

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- [3] <https://smartreadinessindicator.eu/milestones-and-documents>
- [4] <https://smartreadinessindicator.eu/stakeholder-consultation>
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- [12] <https://www.rehva.eu/news/article/final-report-smart-readiness-indicator-sri-for-buildings>
- [13] <https://cordis.europa.eu/project/id/956936>
- [14] <https://aldren.eu/>
- [15] <https://www.rehva.eu/rehva-journal/detail/01-2021>





investment. For owners and property managers, EPCs should be a reference for assessing the existing condition of the building and support informed decision making in building maintenance, renovation, and management. Finally, for institutions on regional, national and European level, EPCs are conceived as a reference for assessing the overall qualities of the building stock and related policies.

At least in theory, it all sounds great. But does it really work? Is the value implied in theory supporting the implementation of policies and legislation behind EPC schemes being realised? How did the originally foreseen purpose of EPCs translate into reality? And what do people – from homeowners to EPC scheme developers and everyone in between – really think about the EPCs? In search of answers, experts and researchers from BEUC, the European Consumer Organisation[2], and seven Horizon 2020 sister projects of the Next Generation EPCertificates cluster came together in a web workshop to share their knowledge. This event came to crown two months of prior exchange of insights and experience as an attempt to make a collective step towards people-centred EPCs.

### What do people think about EPCs?

People clearly have very different perceptions and often also contrasting opinions regarding EPCs, much depending on the different roles they assume and knowledge they possess. It goes without saying, that experts with considerable background knowledge will understand EPCs better and think about them differently from people with little idea about the systems, concepts, and parameters that bring EPCs into existence. What is also clear is that there is mounting evidence indicating that EPCs – as they exist today – fail to have much tangible impact on the ground or create real value for their users. In contrast, they are often seen as little more than a self-serving document, needed to meet the requirements enshrined in policies.

Participants of the web workshop[3] had a privilege to learn about these issues first hand, from Mr. Guillaume Joly, Sustainable Buildings Officer at BEUC. He presented conclusions from BEUC's sustainable housing position paper[4], a document that dives deep into the EU's current and future policies on energy efficiency in buildings from the consumers' perspective. Firstly, BEUC believes EPCs



Figure 1. Focus group participants annotating and discussing elements of EPCs. (IRI UL).

should not be a standalone tool, but should function as a marketing tool integrating a wide scope of advice and support services for customers. Secondly, their members describe implementation of existing EPCs as “diverse” and its adaptation to consumers’ profile as “sometimes questionable”. He argued there is a need to improve the reliability of the concept, particularly in terms of consistency and trustworthiness of energy performance assessments, and supported his claims with research observations by BEUC associate members from Austria, France, Portugal, and the UK, some of which are also described in the paper.

**“EPCs are meant to remain marketing tools and should not be considered as substitutes for energy audits. Improving the reliability and content of EPCs does not and should not have to mean more technical content and significantly higher prices.”** (Guillaume Joly, BEUC)

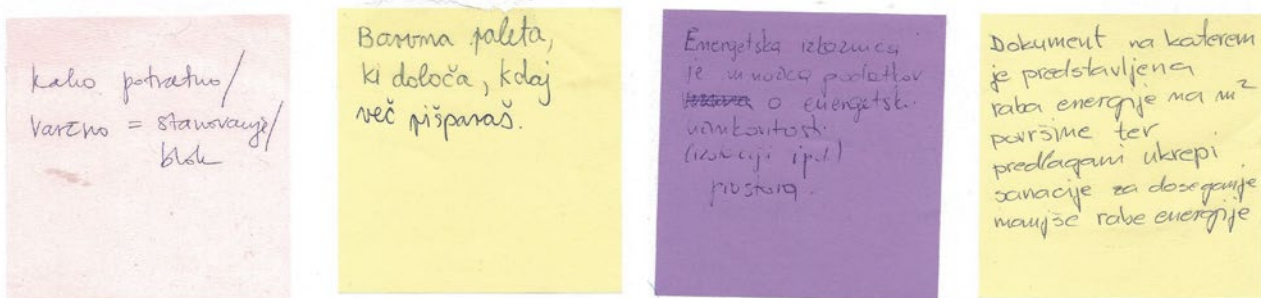
Looking to the future, BEUC sees the need for EPCs to guide users towards both easily attainable energy renovation goals, affordable also for low-income households, as well as more advanced options, that require higher investments but also bring higher long-term returns. **EPCs should also be more comprehensive, and particularly less “technical”**, Mr. Joly noted. Presentation of data and information should be easy to read and understand for anyone – consumers, installers, experts, and public authority representatives alike. In addition, EPCs should enable (and prompt) people to act in a timely and informed manner, both from the technical and financial point of view. In this regard, Mr. Joly specifically highlighted the need for EPCs to present a solid reference for meaningful comparison of costs related to energy use (and management) as well as costs related to energy renovation measures, both in their locally specific market context.

BEUC’s reflections on existing EPC schemes therefore imply the need for simplicity *and* for content-rich certification services – both at the same time. Thinking these two qualities as complementary in the frame of existing EPC schemes might seem as contradiction in expectations. In the light of future development, however, this is better framed as a challenge. If customizable balance between people-friendliness and depth of information once could be dismissed as science-fiction, today it is discussed as a goal within reach. Calls for further digitalization of the EPC is a common feature of the projects focused on development of EPC schemes, as we shall see later in this article. Their goals, aims, and research-based conclusions not only support BEUC’s expectations but indicate they are becoming increasingly viable. U-CERT team, for example, argues for a **modular customization of EPCs according to the user profile and background knowledge** (see **Figure 3**). All this leads to a conclusion, that next generation EPCs should be developed not only with consideration of the variety of data they will entail, but the variety of people that will be using them.

## EPC sister projects

The meeting thus continued with a series of presentations by the Next Generation EPCertificates cluster – U-CERT[5], QualDeEPC[6], X-tendo[7], ePANACEA[8], EPC RECAST[9], D<sup>2</sup>EPC[10], and E-DYCE[11]. Although each project has its own particular focus and approach to improving the existing EPC schemes, they share a number of goals and principles:

- User-friendliness of EPC related products and services,
- Support decision making for energy renovations,
- Innovation in the area of indicators and data handling/use (comfort, sustainability, Smart Readiness, financial etc.),
- Enhancement of EPC assessment, certification, and verification,



**Figure 2.** Definitions of EPCs shared by focus group participants in Slovenia. (IRI UL).



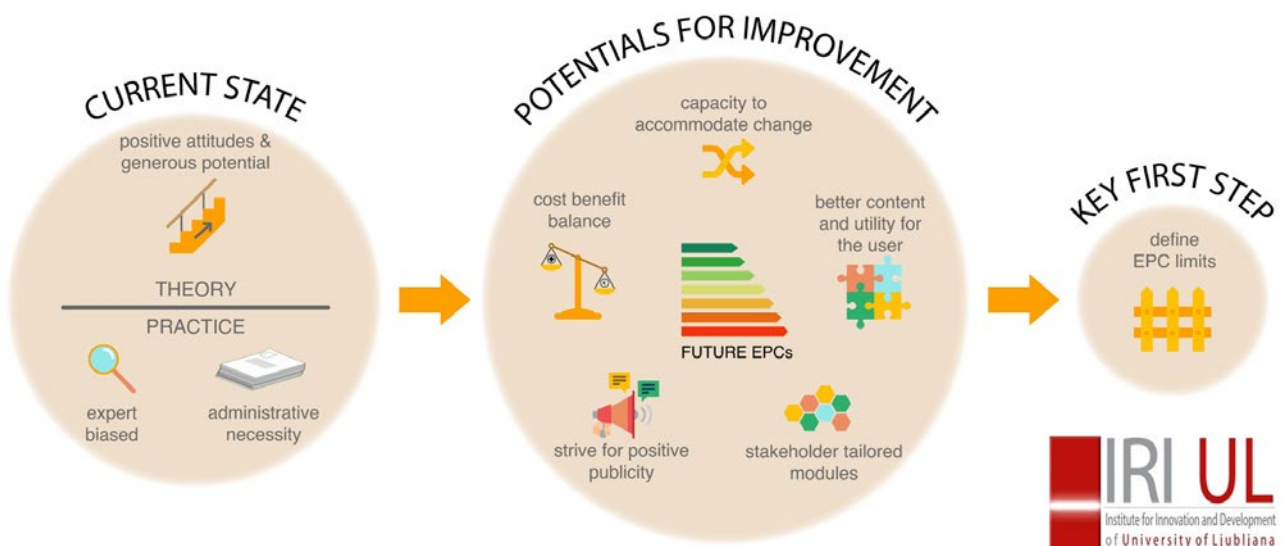
- Exchange of knowledge and experiences,
- Improved links between EPCs and (deep) energy renovation planning,
- Enhanced quality and reliability of EPCs,
- Economic feasibility of EPC schemes,
- Development in direction of dynamic and responsive EPCs,
- Compatibility and comparability of EPCs in the wide EU framework based on the EPB standards (M/480 mandate),
- Enhanced interaction between people and the built environment for conscious building use and management,
- Support to assessors and issuers (training, tools, methodologies etc.),
- Compliance and comparability based on international standards, etc.

**U-CERT**

Large part of the workshop was devoted to the presentation of U-CERT’s approach to people-centred research and development. U-CERT aims to enable evaluation of building energy performance in a holistic and cost-effective manner. During the presentation of their ethnographic research case, U-CERT team illustrated how qualitative research can provide deep insights into the backdrop of everyday-life in which products and services developed within Horizon 2020 projects are destined to exist. Deep qualitative insights, they argued, has the power to keep the focus of project developments on course by verifying (or falsifying) the existing research questions, and opening new ones that previously might not be considered or were considered less relevant.

**Is enforcement by means of policy and legislation really the only way to implement minimum building performance requirements, and particularly the EPCs? Or is there a way to realize them in a way for everyone to recognize them as meaningful and complementary to everyday life?**  
 (Domen Bančič, U-CERT)

U-CERT researchers from 11 countries together conducted 101 interviews and 11 focus groups. In total, 191 research participants from both expert (88) and non-expert (103) background were engaged in an extensive collaborative process resulting in wealth of qualitative data and information on People’s perceptions regarding EPC schemes[12]. The research revealed a discrepancy between the theory surrounding EPCs and how they are in practice often experienced as an “administrative necessity” designed for expert use. **Various avenues for potential improvement of the concept were identified** (see **Figure 3**), all revolving around one key aspect – creating user-centred value. U-CERT representatives rounded up their presentation by suggesting the key first step in development of next generation EPCs is to specify the limits of the concept, both with regard to how it relates to and how it differs from other evolving concepts and tools, such as (overarching) BIM, Energy Audits, Inspections, Building Renovation Passports, Digital Building Logbooks etc.



**Figure 3.** Infographic outline of the ethnographic research outcomes by U-CERT. (IRI UL).



## QualDeEPC

QualDeEPC is focused on quality and convergence of EPC schemes across the EU, as well as stressing the link between EPCs and deep renovation. They maintain an intensive dialogue with key stakeholders, using methods such as interviews and workshops to identify gaps in current EPC schemes[13]. Their development priorities are focused around seven key points:

1. Improved recommendations for building renovations,
2. An online tool connecting EPC recommendations to deep energy renovation,
3. Deep renovation network platforms,
4. Improved training for EPC assessors,
5. User-friendliness of EPCs,
6. Guidelines for effective promotion and advertisement of EPCs, and
7. Ensuring use of EPCs in real estate advertisements – not only by advocating for stricter policies regarding compliance, but also proactively, by providing concrete advertisement guidelines.

## X-tendo

X-tendo is supporting public authorities to implement the next generation EPCs properly, and support them with best possible management and organisation. To optimize their work with regard to the needs of the people, they carried out a survey[14] for understanding end-users' needs and expectations in five countries – Poland, Portugal, Greece, Romania, and Denmark. The sample took in more than 500 people per country, and included homeowners, landlords and tenants. The survey was tailored to deepen the project's understanding of people's perception towards the development of the following 10 features of EPCs:

- Smart-Readiness
- Comfort
- Outdoor air pollution
- Real Energy Consumption
- District Energy
- EPC Databases
- Building Logbook
- Tailored recommendations
- Financing options
- One-Stop-Shop

## ePANACEA

ePANACEA works towards modular EPC schemes based on machine learning, automatization, and

digitalisation. In their research, they make use of intense dialogue with EPC users and other stakeholders as a feedback loop on project developments. By the end of March 2021, they have done 63 interviews and 6 user-needs workshops in 5 pilot countries – Spain, Belgium, Finland, Austria, Greece and Germany. Similar to the findings presented by BEUC and U-CERT team, participants of ePANACEA research characterized existing EPCs in a variety of ways – as “obligatory document”, “completely standardized”, “the only document mapping the as-built situation”, “policy instrument for the energy transition in the building sector” etc.

**“Prospective buyers of a building ask for the EEC [Energy Efficiency Certificate, e.i. the EPC] without evaluating the actual meaning.”** (mechanical engineer, Greece)

On the basis of these interactions, ePANACEA concludes EPCs are used for contractual actions, and not as a document that would support any kind of decision making. In their report on Stakeholder Analysis[15], the ePANACEA researchers note an important fact – people's worldview is dynamic. Their perceptions, attitudes, needs and wants, are prone to change. This is why ePANACEA will continue working with people for the duration of the project, particularly on the topic of user acceptance, to ensure project developments stay on the right track.

## EPC RECAST

The aim of EPC RECAST[16] is to support the work of EPC assessors. They focus on innovative on-site data collection methods, use of measured data, public databases, quality check procedures, and model calibration

**“Our goal is not to replace professional EPC assessors, but instead to better and further support their work in order to achieve improved EPC reliability, comparability in between building assets, user-friendliness and to ultimately generate an impact for owners and occupants to engage them on a tangible pathway to efficient energy retrofit.”**  
(EPC RECAST team)

– all to improve the overall reliability of EPCs. The pathway to their goal, which is to develop a prototype cloud system toolbox for EPC assessors, is being

mapped through an iterative co-design approach. This involves both building owners and assessors working together with EPC RECAST experts on development

## Follow the ongoing Horizon 2020 projects!



### ePANACEA

Website: <https://epanacea.eu/>

LinkedIn: <https://www.linkedin.com/company/h2020epanacea/>

Twitter: <https://twitter.com/H2020ePANACEA>



### EPC RECAST

Website: <https://epc-recast.eu/>

LinkedIn: <https://www.linkedin.com/showcase/epc-recast/about/>

Twitter: <https://twitter.com/EpcRecast>

FB: <https://www.facebook.com/epcrecast>



### E-DYCE

Website: <https://edyce.eu/>

LinkedIn: <https://www.linkedin.com/company/e-dyce/>

Twitter: <https://twitter.com/Edyce3>

FB: <https://www.facebook.com/edyce2020/>



### D^2EPC

Website: <https://www.d2epc.eu/en>

LinkedIn: <https://www.linkedin.com/company/d2epc/>

Twitter: <https://twitter.com/D2Epc>



### QualDeEPC

Website: <https://qualdeepc.eu/>

LinkedIn: <https://www.linkedin.com/in/qualdeepc/>

Twitter: <https://twitter.com/QualDeEPC>



### U-CERT

Website: <https://u-certproject.eu>

LinkedIn: <https://www.linkedin.com/showcase/u-cert-project/>

Twitter: [https://twitter.com/cert\\_u](https://twitter.com/cert_u)

FB: <https://www.facebook.com/ucertproject/>



### X-tendo

Website: <https://x-tendo.eu/>

LinkedIn: #Xtendoproject <https://www.linkedin.com/company/buildings-performance-institute-europe-bpie->

Twitter: #Xtendoproject [https://twitter.com/BPIE\\_eu](https://twitter.com/BPIE_eu)

FB: #Xtendoproject <https://www.facebook.com/BPIEeu>

of an optimal EPC assessment process and outputs. EPC RECAST also has a strong emphasis on connecting EPCs with building renovation, particularly by including improved recommendations on possible renovation measures in the next generation EPCs and linking EPC input/output information with digital logbooks.

## D<sup>2</sup>EPC

For D<sup>2</sup>EPC[17], the key are dynamic EPCs based on multi-parameter assessment and innovative indicators. These will support people's deeper understanding of their interaction with the built environment and drive decision making for improvement of energy performance. The project's focus is on BIM-based Digital Twins in combination with a state-of-the-art IoT ecosystem for the near-real time asset and operational energy assessment of the building. They also aim to improve assessment recommendations by means of AI designed to enhance conscious energy consumption and support optimized balance of comfort and energy efficiency. Part of their strategy is also turning EPC registries into a mechanism that informs policy making, specifically by integrating geolocation and "polluter pays" practices into the next generation EPC concept. To steer the development of the project, D<sup>2</sup>EPC used desk research and questionnaires to identify a set of challenges and recommendations for the next generation EPCs. They focused on drawbacks of existing EPCs and relevant future trends, all from the standpoint of both experts and users.

## E-DYCE

E-DYCE[18] is focused on development of EPC calculation methodology. It is focused on dynamic certification based on openly available resources and tools. They aim to empower EPC users with accurate and clear feedback functionalities designed to increase people's awareness of building operation. They see timing as essential – providing tenants, owners, and management authorities with the information necessary to make correct interventions to optimize building performance in real time. To pave the way to success, E-DYCE plans to install monitoring equipment in dedicated demonstration buildings to explore people's acceptance and understanding of the purpose of monitoring the indoor environment and energy consumption, which will enable informed identification of barriers that state-of-the-art energy certification methods, tools, and technologies are facing in the real-life environments.

## Takeaways

The presentations ended with a short debate that gave rise to some interesting discussion points:

- *"How do we set the limits of EPCs? Where do EPCs end and where do other concepts, like Building Logbooks, start?"* (Jure Vetršek, U-CERT)
- *"Should it [an EPC] give guidance in the moment when there is a real estate transaction? Should this be the main starting point or should it [...] be giving more advice regarding renovation activities, even regarding energy related behaviour?"* (Lukas Kranzl, X-tendo)
- *"Expert recommendation is to separate the EPC-scheme from a tool to provide feedback about real energy consumption."* (Laura Muhr, ePANACEA)

Questions were unfortunately left largely unanswered, in part also due to time restrictions. One thing, however, is clear – the EPCs are gradually gaining on significance. One could say that such conclusion should come as no surprise since EPCs are, after all, enshrined in the national legislation. In this regard, EPCs are not so much a technical but a political (regulatory) tool, and an important one indeed. We *need* to reach Carbon emission targets, and for that – for better or for worse – we need legislation that sets due direction for the future.

What we also need, however, are significant improvements of the existing certification schemes. The workshop in itself is both a proof and a statement of confidence that EPCs are evolving and that such positive change is at our doorstep. Interdisciplinary teams of experts and scientists from across the EU demonstrated that we are – collectively – working our way towards improvements. On this way, we deal with similar dilemmas, and come to complementary conclusions. These prove that EPCs could – and should – be more than just an "administrative necessity", and that they can be a meaningful tool in the effort for making buildings healthier, energy efficient, carbon neutral, and environmentally sustainable on the long run. In the light of such prospects, EPC schemes deserve our attention and efforts to enhance their positive impact.

Most importantly, however, we must continue to work our way towards these goals by putting people first. Issues related to specific technical, methodological, or

theoretical aspects clearly are important and need to be addressed. Nonetheless, the **everyday-life perspective of experts, users, policy makers, and other people that give meaning to EPCs simply must not be neglected**. Good ideas such as the existing EPC and all of its potential future improvements, no matter the quality of expertise or science that conceives them, are otherwise less likely to prosper in practice. Experiences shared by the workshop participants indicate that including people in interactive interdisciplinary research and development processes leads towards development of meaningful solutions in favour of the environment and the people. Join us on our journeys of addressing the challenges of today to co-create people-centred EPCs and buildings of the future. ■

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# QUEST- Certified Quality Management Services for De-Risking Building Performance Investments



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The key objective of the QUEST Project is to promote private investment and financing in projects aimed at enhancing building performance and sustainability through certified quality management services. A simple toolkit has been developed for de-risking the design, construction and operations of energy-efficiency and sustainability projects, thus boosting investment profitability.

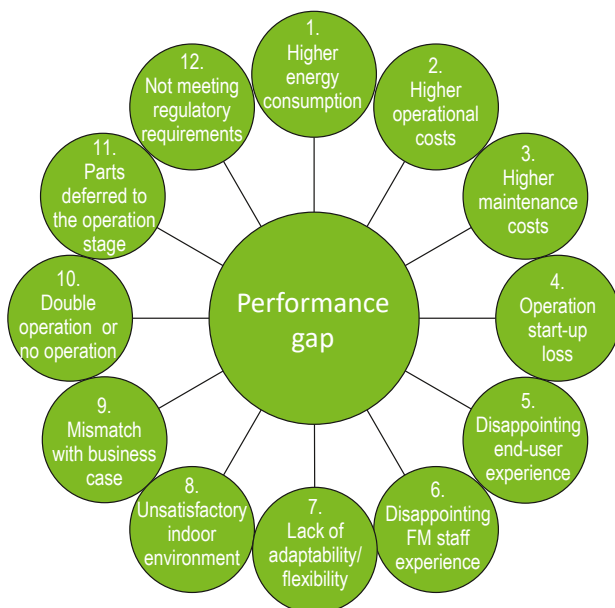
**Keywords:** QUEST Model, QUEST Tool, Quality Management, De-risking, Investments, EU Taxonomy, Buildings, Building Performance, Real Assets, Financial Performance

## Introduction

Non-compliance with predicted, contracted or otherwise required aspects and levels of building performance can result in a wide range of problems, including excessive energy use, excessive emissions of carbon and other green-house-gases, increased maintenance and operational costs, operation start-up loss, sub-par quality of building functions and services, unsatisfactory indoor environmental quality, component and system faults, difficulties in achieving targeted building certification levels, disappointing end-user experience, mismatch with business case, lack of adaptability and flexibility, expenses changed from capital expenditure (CAPEX) to operational expenditure (OPEX), facility not meeting regulatory requirements, as well as increased risk and liability. This is often referred to as “The Performance Gap, see **Figure 1**, (Rasmussen and Jensen, 2020).

Recent studies indicate that only about 25% of new Swedish multifamily buildings (including those designed for high-energy-performance) comply with predicted energy use (Martinac, 2017; Kempe, 2020). Similar examples of non-compliance with predicted performance have been extensively documented by previous research (Månsson et al., 1997; Fisch et al., 2007; Fraunhofer ISE, 2011; Baumann, 2005; Plesser et al., 2012; Franzke and Schiller, 2011; Crowe et al., 2020; Coyner and Kramer, 2017; Wen et al., 2019).

Compliance with ambitious levels of resource efficiency, energy performance, decarbonisation and circularity



**Figure 1.** A facilities manager’s typology of performance gaps in new buildings (Rasmussen and Jensen, 2020).

goals, as well as other key objectives defined by the EU Taxonomy for sustainable activities (European Commission, 2021) will be essential criteria for the sustained future success of businesses throughout the building sector.

### EU Taxonomy

The EU Taxonomy is a classification system, establishing a list of environmentally sustainable economic activities. The EU taxonomy is an important enabler to scale up sustainable investment and to implement the European Green Deal. Notably, by providing appropriate definitions to companies, investors and policymakers on which economic activities can be considered environmentally sustainable, it is expected to create security for investors, protect private investors from greenwashing, help companies to plan the transition, mitigate market fragmentation and eventually help shift investments where they are most needed (European Commission, 2021).

## Quality management in buildings

Different industries have dealt with non-performance and non-compliance issues through **quality management**. In engineering, “quality” relates to the degree to which a set of inherent characteristics of an object comply with requirements. Building owners should get what they pay for.

“Quality management” is thus a process of supporting the fulfilment of specified requirements. In the building sector, Technical Monitoring and Commissioning have evolved as reliable quality management services for buildings and are becoming increasingly popular. Technical Monitoring (TMon) applies procedures to compare measured values from building operation versus design target values providing a transparent result to the owner. TMon can predominantly be carried out digitally. Commissioning (Cx) allows the owner to check in detail whether the building delivered complies with the Owners’ Project Requirements. Cx requires to a significant extent skilled expert work. Since quality management starts with the definition of requirements, it obviously should start in the earliest stages of any project. Although quality management can be applied even after a building is completed,

building owners should not wait until they incur the problems and costs of a failing project. Both TMon and Cx are most powerful and cost effective when initiated in the very beginning of a project. (REHVA (1), 2019 and REHVA (2), 2019).

## QUEST Project

Investments in building performance, including energy efficiency, can generate substantial economic and environmental benefits, while also increasing financial returns. The main goal of the EU-funded QUEST project (European Commission, 2019) is to promote private investments and financing in sustainability and energy-efficiency projects. To do so, it has developed a simple toolkit that will enable financial institutions to determine relevant factors that influence risk in the design, construction and operations of energy-efficiency and sustainability projects. This will allow them to reduce risk and significantly increase investment.

The QUEST Consortium consisting of financial stakeholders, academic, engineering and certification experts was created to solve this problem. The consortium uses independent research and empirical data to create statistical algorithms that predict risk impact on asset value. Building on the Quest Model, it packages these algorithms into a QUEST Tool to predict value-add of different certified quality management services for specific construction and real estate investment projects.

To introduce the QUEST method to building owners, the QUEST team offers Environmental, Social and Government (ESG) Due Diligence to assess the buildings in a portfolio based on selected parameters, creating a larger base for data-gathering. Building owners can learn about the implications of the EU Taxonomy for their portfolios, about investments needed to manage the improvement of the quality of the buildings and the value-add of quality management services. QUEST uses building data for continuous improvement of the QUEST Tool and data base. Interested building owners please contact us at [plessers@synavision.net](mailto:plessers@synavision.net).

## The QUEST Model and its impact on real estate financial performance

An increase in the financial profitability of real estate investments is a key financial motivation for implementing the QUEST model. Due to the large size of the real estate assets, and the many important economic and sustainable finance linkages between the real estate markets, the debt and financial markets, and the wider society, the importance of accurate assessments of the linkage between buildings' technical and financial performance are key for increasing the flow of funds and other resources necessary for the sustainable development of real estate and financial markets.

Lower technical risk should be transmitted to improved financial performance of real estate investments. Therefore, buildings that have successfully implemented building quality management activities that de-risk a building's technical performance should also be reflected in a decline of financial risks and consequently result in improved financial performance.

However, currently the investment community has difficulty quantitatively (statistically) evaluating technical risk on specific construction and real estate investments and the impact of innovative quality management services on real estate financial performance. An analysis of real estate financial performance must consider how technical risk impacts on the profitability by increasing revenues, lowering costs, and by lowering the risks and uncertainties regarding the size of future revenues and costs.

The QUEST model contributes with transparency in relation to what it costs to handle the technical risks through quality management on the individual construction project and on the return on investment of this investment.

## QUEST Tool: Value-add Impact of Certified Quality Management Services

Within the context of the QUEST Project, the QUEST Tool was created to evaluate the quantitative impact of certified quality management services on value-add of real estate financial performance. While a particular situation may have an innate level of technical risk, that risk can be reduced by application of standardized and verifiable processes. In order to achieve internationally replicable, scalable and trusted technical risk modulation via Quality Management, QUEST relies on **Certified Quality Management Services**. These are international third-party building certification

processes (conforming with eg EN ISO 17065) that can impact building Capital and/or Revenue:

- **Certified Technical Monitoring**  
that verifies correct functioning and operation of installed technical systems
  - Example: COPILOT Digital Technical Monitoring Certification (Copilot, 2021)
- **Certified Building Commissioning**  
that verifies compliance with Client Project Requirements through planning, design, construction/renovation & installation, and initial operation of a new or existing building.
  - Example: COPILOT Building Commissioning Certification
- **Certified Sustainable (or Green) Building**  
mainly a desk-top exercise that verifies compliance with environmental and related standards with some form of Commissioning process involved to ensure that the good intentions also become a reality.
  - Example: BREEAM2 (BRE Global Ltd)

The QUEST-Tool applies an algorithm to technical and financial data of investments into these Certified Quality Management Services. Investors can risk-grade investments and select the most profitable quality management services to de-risk projects. **Figure 2** shows a schematic illustration of the algorithm. A main feature and important contribution of the QUEST Tool is to integrate detailed information about how different levels of technical risk, which typically is excluded from real

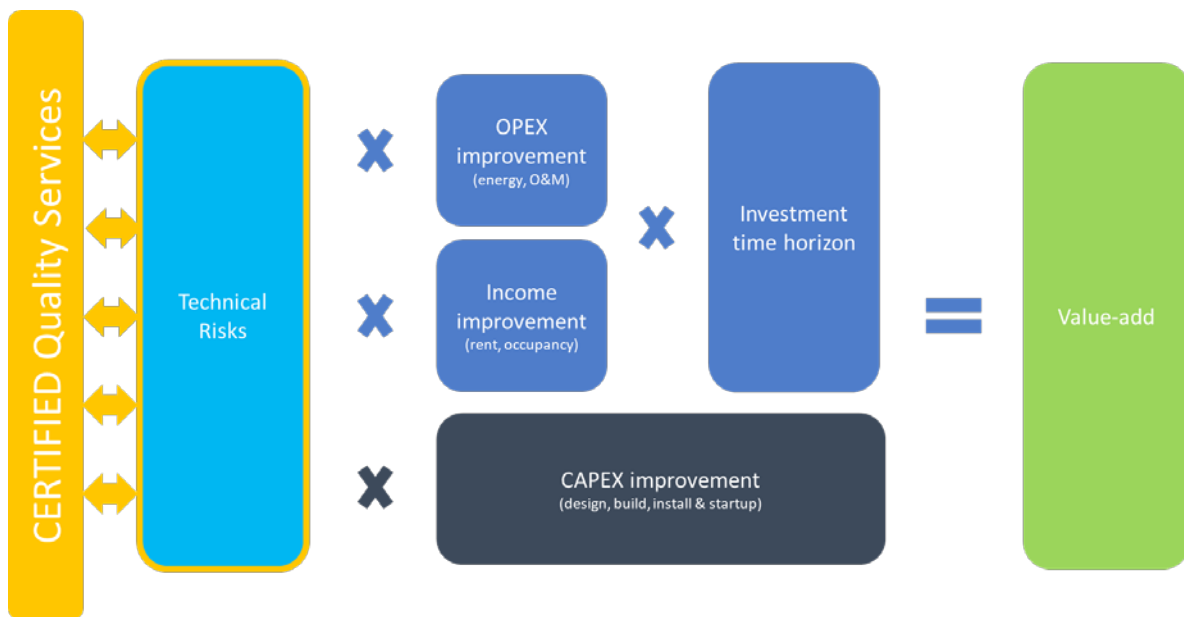
estate financial analysis calculations. Even when technical risk is considered, it is often limited to aggregated and standard figures, and thus do not reflect the true technical risks and how they should be translated into the financial performance or real estate investments.

As shown in **Figure 2**, investments in certified quality management services result in positive value-add effects through lowering technical risks, which in turn result in lower and more stable annual operating expenses (in the figure denoted OPEX Improvement), higher and more stable annual revenues (in the figure denoted Income Improvement) and finally lower and more stable construction and renovation costs (in the figure denoted CAPEX Improvement). The investment time horizon is time factor in year units that is multiplied with the OPEX and Income effects. This time factor takes into account the fact that an initial certified quality service investment might have effects on revenues and costs for several years ahead.

**Technical risk indicators**

A key innovation of the QUEST methodology is to include numerical figures of technical risk indicators. Initially the risk inputs relied on self-assessment of different technical risks in a building or building project:

- Technical risk impact on energy consumption and costs
- Technical risk impact on operation & maintenance work and costs
- Technical risk impact rental income
- Technical risk impact on occupancy rate



**Figure 2.** Schematic illustration of the algorithm(s) applied to technical and financial data of investments into Certified Quality Management Services.



In order to reduce variability of this self-assessment, QUEST has decided to propose technical risk profiles which depend on user feedback regarding:

- Building type (ex. laboratory deemed higher risk profile than residential property)
- User confidence/experience in the technical teams managing the project

QUEST is designing a solution for financial stakeholders who do not have the expertise to directly assess building technical risk. However, they can evaluate their risk perception of technical management teams based on their experience and/or confidence in these teams. Work together on, and results from, past projects can contribute to this assessment.

### Inputs to QUEST Tool (Figure 3)

The QUEST Tool users input six project characteristics:

- Building type
- Experience/confidence in the technical teams
- Project build cost → Capital saving calculation
- Building systems operating cost → Cost improvement calculation
- Rental income → Income improvement calculation integrating rent and occupancy impacts
- Time horizon of investment → Capital saving calculation

The Tool proposes default values for each element in case the user fails to enter their values.

Your building project	
DE-RISK INVESTMENTS IN CONSTRUCTION & SUSTAINABLE BUILDINGS	Input values
What is the type of building?	Office
How do you rate the experience in the technical teams managing the project?	Medium confidence
What is the estimated project cost (per m <sup>2</sup> )? (Build/renovation/refurbishment/technical installation including design work)	1 000 €
What are the expected operating expenses per m <sup>2</sup> per year (OPEX/ m <sup>2</sup> / year)? (Energy, operation & maintenance)	20 €
What is the expected rental income (per m <sup>2</sup> per year) If there is no rent value (ex. hospital or public building), use local Office rent values and adjust upwards to reflect sophistication of the building	400 €
Define the time horizon that the rating should consider for your QM-investment (5 to 20 years; the value is used to capitalise annual savings)	10

Figure 3. Inputs to QUEST Tool.

**Output of QUEST Tool Output (Figure 4)**

Based on these elements, the Tool predicts value-add of different Certified Quality Services. The following value-add forecasts are available:

1. Value-add prediction based on **OPEX** improvement from energy and operation & maintenance savings;
2. Value-add prediction based on **rental income and occupancy rate** improvements from better buildings;
3. Value-add prediction based on **all cost and revenue** improvements in 1 and 2 above.

The Tool also provides indicative investment costs for Certified Quality Services including expert audit costs and certification fees.

**On-going data analysis to improve QUEST model’s financial impact and QUEST Tool**

To empirically establish the causal effect of QUEST model and quality management on real estate market valuations, hedonic panel data analysis based on the real-world observations from the real estate market will

be developed. The main goal is to estimate the causal effect of the level of Quality management services on value-add of real estate financial performance.



De-risking solutions		Value-add (per m <sup>2</sup> ) over investment lifetime of 10 years		
CERTIFIED SERVICES*	Investment cost**	OPEX improvement	Rent & Occupancy improvement	TOTAL: OPEX + Rent & Occupancy improvement
Certified Technical Monitoring (ex. COPILOT)	1 €	4 €	52 €	57 €
Certified Building Commissioning (ex. COPILOT)	10 €	36 €	139 €	175 €
Certified Green Buildings (ex. LEED)	20 €	4 €	157 €	161 €

\* Certified quality services provided by independent third parties to approved certification rules

\*\* indicative costs (verification by accredited expert + certification fees) based on Building > 2000 m<sup>2</sup> with significant project cost (costs/m<sup>2</sup>)

Figure 4. Outputs from Quest Tool.

The variation in the financial performance between real estate assets is determined by several characteristics, such as building characteristics, quality management characteristics, neighborhood characteristics, and locational characteristics. In addition, many urban, regional and macroeconomic variables also influence real estate financial performance. The QUEST Consortium therefore has started the development of a real estate panel data set will consisting of repeated observations on the same properties over time. For projects with and without Certified Quality Management Services, property characteristics information (including quality management service level and sustainability characteristics), and estimated financial and technical risk performances are collected annually. ■

## Acknowledgements

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### QUEST – Quality Management Investments for Energy Efficiency



REHVA website:

<https://www.rehva.eu/eu-projects/project/quest>

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# A Circular economy from an HVAC perspective



## OLAF OOSTING

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The circular economy is everywhere. The strive for less waste and having the possibility of using instead of buying things is becoming more visible. The European Commission developed and announced several policies in the last decade to promote circularity. In this article I present my opinion about the short-term focus and possibilities of the Circular Economy for the HVAC industry and relate them to the Circle Economy Action Plan and future Ecodesign guidelines.

**Keywords:** Materials, Circular economy, As a Service, Design for Disassembly, Product Passports, Circular Economy Action Plan, Ecodesign

## Circular Economy: Where it started for me

I was inspired by the possibilities of a Circular Economy in 2015 due to an advertisement[1] by a multifunctional supplier which described a circular office. In addition to various, more or less circular products, the advertisement also mentioned a solar panel, a windmill and an ATEs (Aquifer Thermal Energy Storage) as part of this office. The lack of a supplier for these products prompted me to investigate what the circular economy could mean for the building services industry. This led to the creation of the TVVL Community Circular Installations. Together we formulated three strategies to achieve circularity in our business:

- A circular design - how can an (installation) design be as flexible and adaptive as possible? A Design for Disassembly (DfD) of the various installation components must be guaranteed in order to keep the potential interchangeability as great as possible in the near future.
- A circular product - where the (installation) design must facilitate circularity, a product must be implemented that consists of fewer or different virgin

materials. Both the origin and the future of materials are important here.

- A circular business model - in order to actually guarantee material flows and improve the quality or lifespan of products, a change of ownership is necessary. The manufacturer of a product is pre-eminently the best party to design, build and maintain a product in such a way that it can be optimally utilized in use as well as in reuse.

As perhaps can be inferred from the above strategies, my focus is on (virgin) materials and products and not directly on the CO<sub>2</sub> emissions associated with this. For me, this is a conscious choice. The circular economy is also described by Nederland Circulair[2] as: a circular economy is an economic system in which value is preserved or created by reusing products and raw materials and minimizing the destruction of raw materials.

## Energy vs virgin materials from a construction perspective

In the Circle Economy Action Plan (CEAP)[3], Circular Building is mentioned as one of the themes.



The built environment requires about 50% of the required raw materials. The emissions related to construction in 2019 were about 10% of the total amount. (25% of the share of the built environment). What is also striking is that 10% [4] of the emissions are caused by 5% of the energy demand. Assuming that emissions are entirely caused by energy consumption, it can be concluded that the construction industry also does this inefficiently compared to other sectors. This applies to construction as a chain.

In the construction of an office, between 75% (small office) and 90% (large office) of the mass comes from the concrete, according to the EIB in collaboration with Metabolic and SGS Search [5]. Cement is an important raw material and is responsible for about 6% of global CO<sub>2</sub> emissions. This is a significant share, and it explains the attention paid to circular ideas in relation to limiting CO<sub>2</sub> emissions and the resulting climate change. For example, the CEAP indicates that up to 80% can be saved on these construction-related emissions as a result of better material efficiency. And rightly so, because this will save 4 to 5% of total emissions in absolute terms in the example of cement. In the short term, quick steps can be achieved with this. However, a concrete shell has a lifespan of 75 years. In the medium term, more structural thinking will have to be done and the focus will shift to the other components. Installations are an important part of this. As we have seen, the share of installations in the building, in kilograms, is very limited. When we take into account the amount of metals in the building, this is largely due to the HVAC industry. Moreover, after 15 years,

installations have a high demand for replacement or renovation. On balance, this means five installations against one concrete shell, which puts the proportions in a different perspective. This is confirmed in the aforementioned study by the EIB. Installations only amount to 1% of the mass, but count for 9% in the ECI for new construction, based on figures from 2014. Here too, the energy demand during the use phase counts significantly, but if we do not take into account the energy consumers, the ECI per ton of product is greatest for, for example, water, electricity and heat distribution. With increasing sustainability requirements, this share will have increased: over the years we have started installing more and more solar panels. This perspective on installations is in my opinion still insufficiently reflected in legislation and regulations like CEAP.

### Energy vs materials for HVAC manufacturers: Product Passports

Where for me personally the scarcity of materials is at the top of the list when it comes to circularity, I understood from some suppliers of energy-consuming HVAC products that material efficiency is lower on the list of priorities. From the perspective of these suppliers, energy efficiency is much more important, also from the circularity principle. The reason for this stems from the energy consumption in the use phase of, in particular, the air handling units and heating and cooling generators. Binnenklimaat Nederland (BN, former VLA) mapped the environmental performance of air handling units [6] in 2016 on the basis of a LCA.

Global share of buildings and construction final energy and emissions, 2019

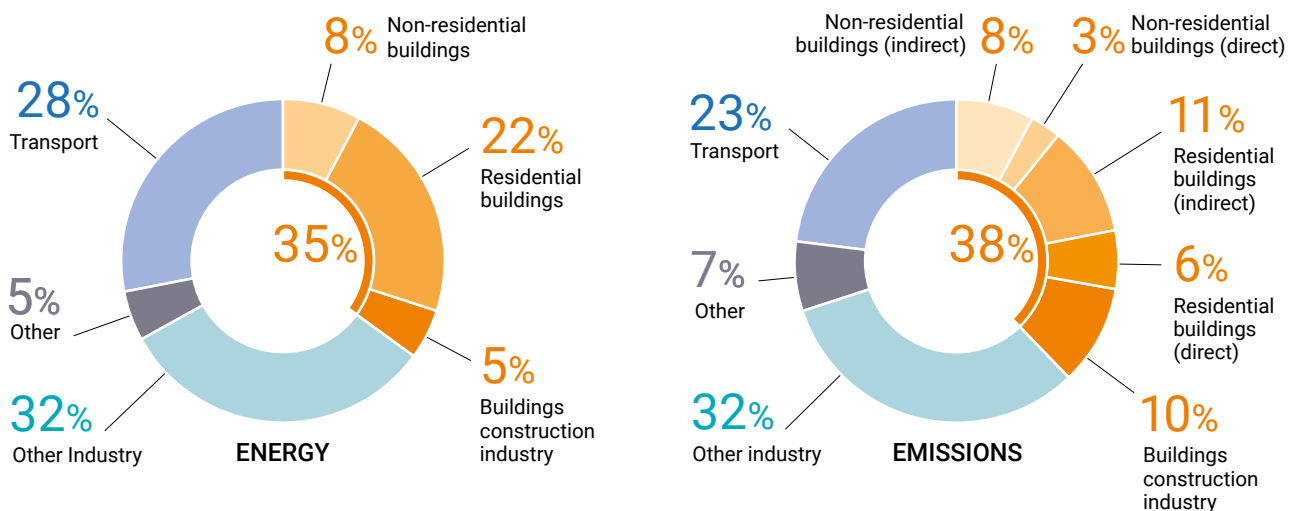


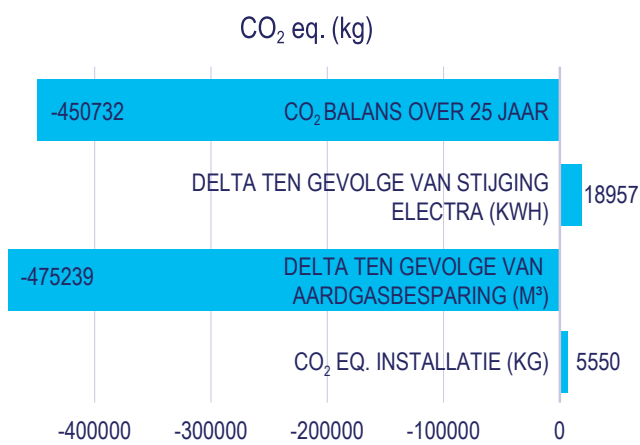
Figure 1. Global share energy and emissions of buildings and construction (source: 2020 Global status for buildings and constructions)

BN has had it calculated that the application of a rotary heat exchanger costs 5.5 tons of CO<sub>2</sub> as a result of the extra materials and 19 tons of CO<sub>2</sub> in extra electricity demand, but in the use phase the amount of CO<sub>2</sub> saved for 25 years compared to a variant without heat recovery, leads to 475 tons of CO<sub>2</sub> savings. A simple choice, but that does not directly contribute to the circularity of the product.

The fact that BN has determined the impact of the extra materials is a good step forward. Our HVAC industry is lagging behind with regard to circularity and circular products compared to construction as an industry. The supply chain is many times longer and, moreover, a large part of our products consists of other products supplied by third parties, or semi-finished products. As a result, many manufacturers have insufficient insight into the Bill of Materials of their product. This makes the origin of raw materials unclear, but it also provides insufficient insight into the future of materials in the products and their potential value, but also into possible risks in business operations. Product Passports are not an end goal, but a very useful tool in creating insights in the material flows and environmental impacts of HVAC products.

### Focus on Design for Disassembly (DfD)

From a circularity perspective, it is important with examples such as BN to look at the materials and choice of materials. After a publication by the Netherlands Environmental Assessment Agency, the Dutch newspaper het Financieel Dagblad[7] describes



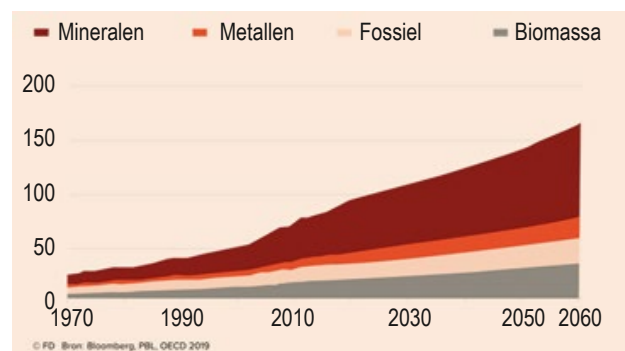
**Figure 2.** CO<sub>2</sub> balance over 25 years for air handlers with a rotary heat exchanger compared with an air handler without a heat exchanger (source: BN, Duurzamere luchtbehandeling in gebouwen, 2016).

that problems are already arising due to a lack of raw materials to make the energy transition happen. And the demand will rise in the future. Recycling is of course an opportunity to reuse the raw materials. But recycling tends to use a lot of energy and cannot continue indefinitely. The implementations of the DfD philosophy in products can be a key here. Critics think that DfD is a way of advancing the possibilities to the future. Design for Disassembly means that not eventually less virgin materials are used in buildings. This is a valid argument compared to a detachable concrete hull. Simply dismantling and reusing a skeleton in 75 years will not contribute to solving the climate problem. But here too, a different perspective applies due to the relatively short lead time for Buildings Services or components. With the relatively short lead time, it pays for HVAC manufacturers to focus more on the DfD in the design (the simple disassembly of a product) and on the product itself (for the replaceability of parts).

DfD in the design also offers the possibility to replace products that are currently not yet circular for a circular variant at a later stage. You increase the circular potential of an installation or building; it also offers the possibility to build in existing or already used products when a circular variant is available, without losing energy or materials.

### Renewed Ecodesign guidelines

The Ecodesign Directive, published in 2009, was supposed to steer the energy demand of energy-related products. Ecodesign thus ties in with the first part of my argument, the focus was mainly on climate change. At the end of January this year, amendments[8] were adopted by the European Parliament to ensure that the Ecodesign Directive is amended so that products



**Figure 3.** Demand of materials in the past and in the future, (source: het Financieel Dagblad based on Bloomberg, PBL and OECD).

placed on the EU market perform well, are durable, are not toxic, can be upgraded and recycled, contain recycled content, are resource - and energy-efficient, are reusable, and can be easily repaired. Not only does this mean that a bill of materials must be drawn up to map the structure, the environmental impact and the toxicity of a product, but also the product passport is mentioned as a next step. The origin and degree of recyclability of products and materials come into play here. These are good steps towards a circular product. And with the latter two, reusable and the right to repair, DfD also emerges indirectly. A product must be easy to dismantle, so that it can actually be repaired, without causing damage to other parts and without requiring a lot of valuable time from installers to prevent such an operation becoming too expensive and replacement for a new product is cheaper economically. The right to repair also directly endorses the need to think further about the way in which we design our products and how we can repair them during the use phase: the amendments also describe the right to the availability of spare parts.

## Circular opportunities

In the above, the circular product and design were discussed in particular. The Amendments, as adopted

and thus also part of regulations in the future, offer not only a great deal of effort to map out product specifications and environmental impact, but also opportunities for new and circular business models. A business model is not the immediate goal, but it helps to achieve a circular economy in which no virgin materials are used. When the right to repair means an obligation for the suppliers, this offers a good incentive to no longer sell the product, but to offer it, for example, in an As a Service model or with a buy-back guarantee. This shifts the value thinking about a product and offers a different light on the possible residual value at the end of life. Mitsubishi has been offering this for its elevators for several years and Halton has recently introduced this model for commercial kitchens. I expect that the insight into the structure and materialization of a product, in combination with future material scarcity, will lead to a new way of designing products, in which the origin of materials and the way in which DfD is guaranteed, will lead to a fully circular economy. An economy in which Ecodesign requirements are not only a burden to HVAC suppliers, but also offer sufficient opportunities to show how decisive we are in delivering comfort in buildings in a material and energy-efficient way. ■

### Endnotes:

- [1] See [https://www.werktrends.nl/app/uploads/2015/06/NRC\\_ricoh-hr-def-poster\\_opt.pdf](https://www.werktrends.nl/app/uploads/2015/06/NRC_ricoh-hr-def-poster_opt.pdf).
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# EYE ON 2030



# Next generation sustainable product legislation



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As a major consumer of energy, HVACR technologies are extensively regulated under energy efficiency laws worldwide. The next generation of sustainable product legislation in the EU will extend beyond energy-use and focus on circularity aspects of products. This article explores some of the major ongoing policy developments in this area.

**Keywords:** Circular economy, European Green Deal, Sustainable Product Initiative, Ecodesign, MEERp, Energy-related products.

## Introduction

Energy efficiency action traces its origins to the 1970s, when consecutive disruptions in the supply of oil caused worldwide concerns over energy security. Many countries enacted energy conservation laws, including minimum energy performance standards for consumer products. In Europe, these were gradually harmonised to enable the free movement of goods in the Single Market. Directives were enacted with harmonised efficiency requirements for boilers (1992), refrigerators (1996) and lighting (2000), and labelling requirements for household appliances (1992).

After the Kyoto Protocol, concerns over climate change became the main driver behind tightening energy efficiency requirements. Eventually, EU-wide product performance requirements were subsumed in the first Ecodesign Directive (2005), which was primarily cast as a measure to reduce greenhouse gas (GHG) emissions. The Ecodesign Directive was recast in 2009, with a scope extension from ‘energy-using products’

(EuP) to ‘energy-related products’ (ErP) – the first step towards more holistic sustainable products legislation.

## The European Green Deal

Product sustainability concerns are becoming more pressing by the day. Humanity’s ecological footprint is estimated to be around 1.6 planet Earths and growing, with around 60% of it accounted for by carbon emissions which are heating the planet [1].

The European Union’s response to the global climate and ecological crises is the so-called European Green Deal (EGD). The EGD is a set of policy initiatives developed by the von der Leyen Commission with the aim to fit the European economy within planetary boundaries and decouple economic growth from resource use. At the centre of it is the aim of making Europe climate neutral by 2050 with the intermediary target of 55% GHG emissions reduction by 2030.

Under the EGD, the next generation of Ecodesign requirements is expected to explore new frontiers for energy savings to help achieve the more ambitious targets. These new frontiers include new product groups, system approaches, and requirements related to the smartness and connectivity of products. That said, where the Commission really intends to break new ground is in resource efficiency, with important implications for product design and manufacturing.

### The Circular Economy Action Plan

On 11 March 2020, the Commission published the new Circular Economy Action Plan (CEAP) outlining its approach to resource efficiency. The problem the CEAP aims to tackle is easy enough to understand: from 1970 to now, the annual rate of material extraction across the globe has tripled [1]. Around half of total GHG emissions are estimated to come from resource extraction and processing [2]. Only 12% of materials are recovered and fed back into the economy [3]. In brief, humanity is using resources and generating waste faster than our ecosystem can renew, with a big impact on the environment.

In answer to these issues, the Commission aims to reduce waste and close the loop on productive cycles by ensuring that products last longer, and are more easily remanufactured and recycled. Some of the major elements in the new CEAP include strengthening

waste legislation, promoting the use of environmental footprint methodologies for products and business, tackling the issue of misleading claims about the sustainability of products, extending producer responsibility via alternative business models like take-back schemes and product-as-a-service, enabling the ‘right to repair’, introducing minimum recycled material rates, and addressing the issue of planned obsolescence.

The Commission suggests targeting the most problematic sectors first: electronics and ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food and water, and intermediary products such as steel, cement and chemicals. HVACR products make up only a small volume of total manufacturing and typically have quite long lifetimes and relatively innocuous material compositions. They are therefore not a priority sector for the Commission’s circular economy measures. Nevertheless, the actions developed under the CEAP will have a major impact on our sector as well.

Indeed, the core policy ambition introduced by the CEAP is the so-called Sustainable Product Initiative. In essence, the Commission is proposing to extend the scope of the Ecodesign Directive to non-energy-related products and regulate under Ecodesign all environmental impacts of products, not just their impact on energy consumption. The preparatory study for this initiative is currently underway.

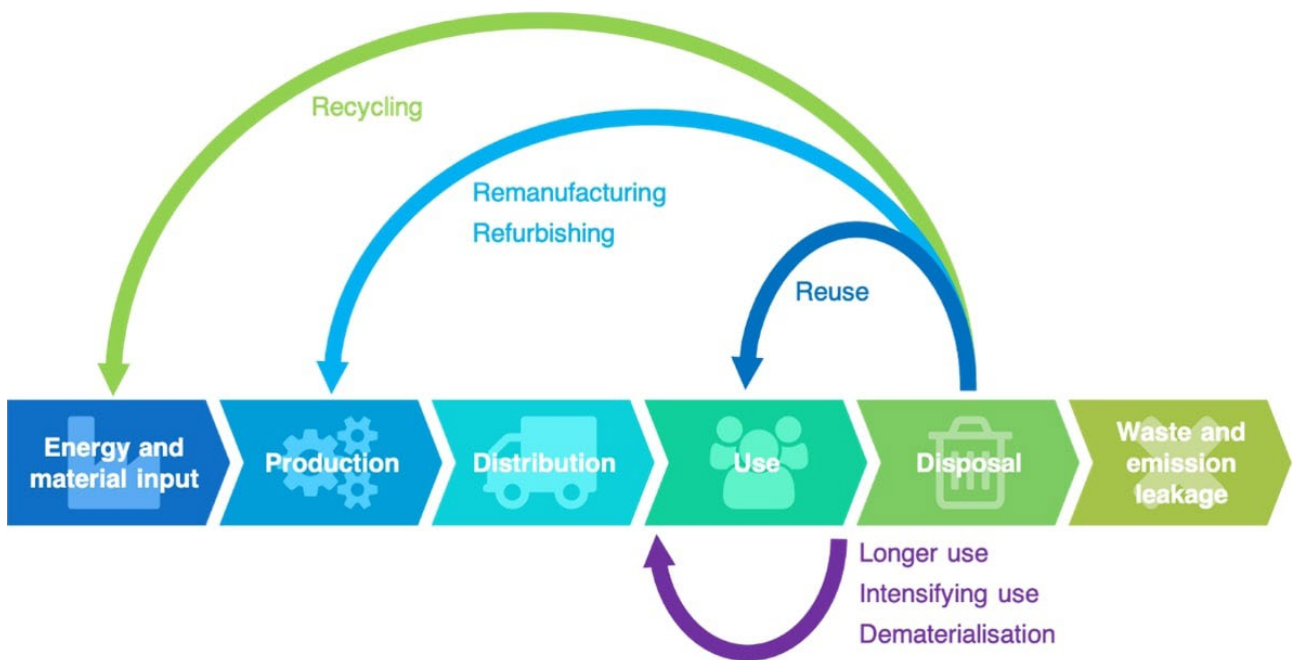


Figure 1. Circular economy [4].

The extension of the Directive to whole new sectors of the economy is likely to disrupt established workflows and the policy ecosystem in which we are used to work. Frequent delays in the regulatory process and insufficient market surveillance are already preventing the Ecodesign Directive from being as successful as it could be. The industry has therefore expressed concerns over the proposed extension, which risks stretching the Commission's resources even more thinly, further exacerbating these issues.

Of greater relevance for product manufacturers is that the Commission is proposing to consistently include requirements related to material efficiency, reusability, reparability, upgradability, durability, recoverability, recycled content, and recyclability in implementing measures under Ecodesign. Although foreseen by the legal text of the Directive itself, the roll-out of such requirements for HVACR products has so far been limited. That is about to change.

### State of play

Every four years or so, the Commission develops an Ecodesign Working Plan to take stock of progress made so far, and to plan further work on new measures or the

revision of existing ones. Whether and how to include measures under Ecodesign is determined according to the Methodology for the Ecodesign of Energy-related Product (MEErP), which provides a harmonised framework to assess the impact of a measure across several environmental criteria. The Commission prioritises measures where significant improvements are feasible.

The 2016-2019 Ecodesign Working Plan was a game-changer for product circularity requirements. For the first time, the Commission considered the possibility of establishing more circularity requirements such as minimum lifetime of products, availability of spare parts and repair manuals, ease of removal of certain components, marking of plastic parts, and avoiding incompatible plastics, for example.

The Commission also proposed to develop a circular economy toolbox to assess the margin for improvement in material efficiency requirements in a more systematic way across product groups, and to develop a standardisation request regarding material efficiency aspects for Ecodesign. This mandate was taken up by CEN-CLC/TC10, which developed the EN 4555x series of standards published in 2020.

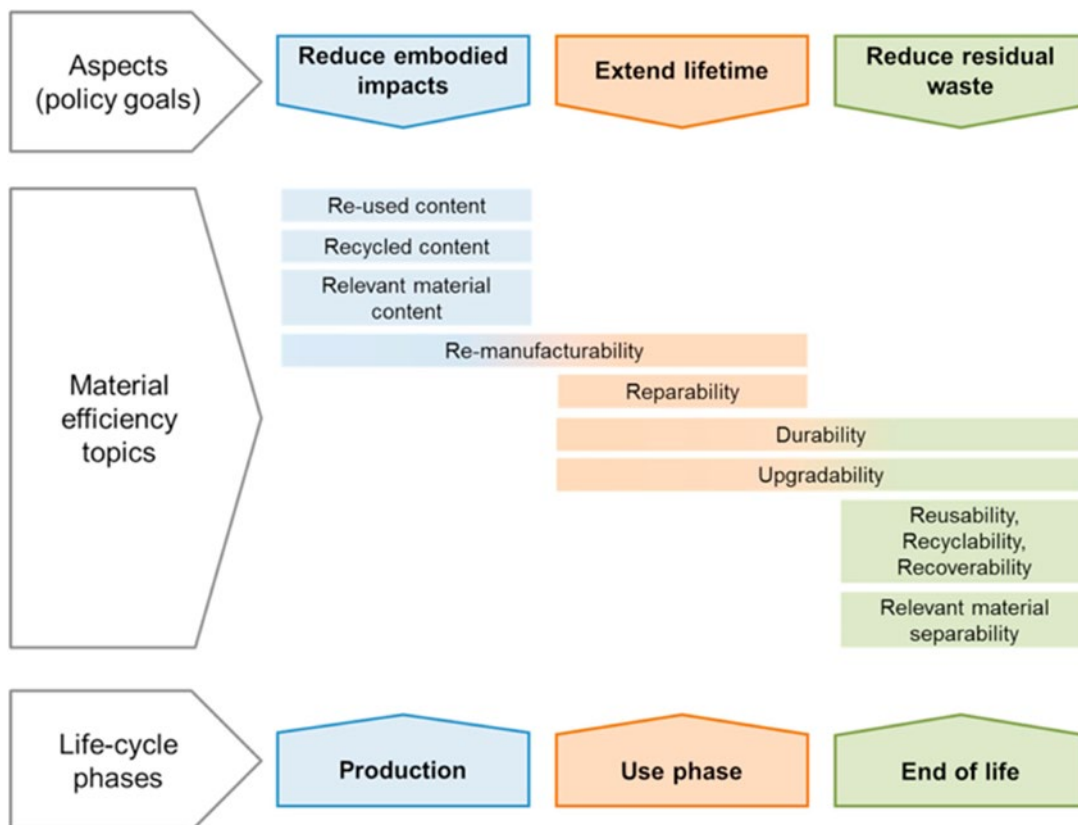


Figure 2. Design aspects for circularity [5].

**Table 1.** *The EN 4555x series of standards.*

Standard	Topic
EN 45551:2020	Standards use guide
EN 45552:2020	Durability
EN 45553:2020	Ability to re-manufacture
EN 45554:2020	Ability to repair, reuse and upgrade
EN 45555:2020	Recyclability and recoverability
EN 45556:2020	Proportion of re-used components
EN 45557:2020	Proportion recycled material content
EN 45558:2020	Use of critical raw materials
EN 45559:2020	Methods for providing information

Based on the 2016-2019 Working Plan, circular economy requirements were ultimately included in numerous implementing measures. For example, the regulation covering refrigerators with a direct sales function (published in 2019) requires manufacturers to keep certain spare parts available for at least 8 years, to ensure access to repair and maintenance information for professional repairers, and to make certain components easily removable with the use of commonly available tools. It is expected that similar requirements will be mainstreamed into most implementing measures. They have already been proposed for ventilation units, the regulations for which are currently under review.

## Circularity on the horizon of Ecodesign

Circular economy aspects are sure to be further strengthened in the next Ecodesign Working Plan (2020-2024), which is currently under development with publication expected in the third quarter of this year. The preparatory study concluded in April with the publication of the final task reports. The study assessed the feasibility of six additional circular economy aspects, namely (i) light weighting, (ii) recycled content, (iii) ecological profile, (iv) durability, (v) scarce and critical raw materials, and (vi) firmware and software. The preparatory study's assessment of these measures is comprehensive, and it remains to be seen when and how each of these measures will be considered and implemented for each product group. The landscape of ErP is complex and a one-size-fits-all approach is unlikely to be fruitful. Moreover, the Ecodesign policy cycle is characterised by frequent delays. However, sooner or later these aspects will become the norm for all products.

The MEErP is currently also being reviewed, with the preparatory study carried out by the Commission's Joint Research Centre (JRC). It is expected that the review will focus on better addressing circular economy aspects in the MEErP, including better harmonisation with Product Environmental Footprinting and with the provisions of the newly published EN 4555x series, including tools to assess durability, recyclability, reusability, and other such aspects. This should allow the Commission to assess the introduction of new circularity requirements for existing products and extending Ecodesign to new products beyond ErP.

## Conclusions

The 2020-2024 Ecodesign Working Plan may well be the last Working Plan as we know it. It is expected that after 2024, the Ecodesign Directive will have been extended to non-ErP and the workflows are certain to change. It is anybody's guess at this point what the effects of the Sustainable Product Initiative will be on the policy cycle, review priorities, market surveillance, and other considerations. In any case, our industry should start to reckon with the circularity measures that will inevitably come their way and be prepared to innovate under the new conditions imposed by the extension of the Ecodesign Directive. ■

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# Implications of COVID-19 pandemic for application of natural ventilation



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The present COVID-19 crisis has increased the attention for health and hygiene indoors. Ventilation plays a significant role in the spread of COVID-19. According to the WHO (2020) transmission can occur more easily in situations where the “Three C’s” apply:

- Crowded places with many people nearby;
- Close-contact settings, especially where people have close-range conversations;
- Confined and enclosed spaces with poor ventilation.

In this article we provide an update on the link between ventilation, the transmission of coronavirus SARS-CoV-2 and the potential advantages and/or risks of natural ventilation, based on scientific literature. The term ‘natural ventilation’ refers to airing through operable windows as well as background ventilation with natural air supply, e.g. through natural air intake grilles (window vents).

We answer the following questions:

- How does ventilation system design influence the transmission of coronavirus SARS-CoV-2?
- What are potential advantages and risks of natural ventilation compared to mechanical ventilation in relation to the transmission of SARS-CoV-2?

## Airborne transmission

Although there’s still an academic discussion ongoing on the importance of airborne transmission of SARS-CoV-2 (Tang et al, 2021), many studies related to the spread of COVID-19 indoors concluded that the role of transmission via aerosols is significant especially when people spent considerable amounts of time together in poorly ventilated spaces (e.g. Singh, 2020; Buonanno et al, 2020a; Li et al., 2020; Miller et al., 2020).

Persons with COVID-19 that breathe, talk or sing spread aerosols that contain viruses (Buonanno et al, 2020b). Increasing the ventilation rate is believed to reduce cross infection of airborne transmitted diseases by removing (exhaust ventilation) or diluting pathogen-laden microdroplets (airborne droplet nuclei) from a room. A higher ventilation rate can dilute the contaminated air inside spaces more rapidly and decreases the risk of cross infection (**Figure 1**). A higher ventilation rate will also transport contaminants (viruses) away from the space more rapidly. This is also relevant for other types of infectious respiratory diseases than COVID-19.

Persons with COVID-19 can be regarded as ‘indoor sources’ that spread pollutants. More specifically: viruses or virus infected (micro)droplets. The question is: how much of those pollutants enter the breathing

zone and possibly the airways of other persons? One speaks of the ventilation diluting effect in this context. The more ‘forceful’ a space is ventilated, the lower the aerosol/virus concentration will be in the breathing zone of non-infected people and the smaller their chance of becoming infected. Current findings indicate that one needs to be exposed to a certain concentration of infected microdroplets for a certain time before becoming infected. In this context the susceptibility of those exposed also matters, which differs from person to person and is e.g. related to age and medical condition.

### Impact of the ventilation system

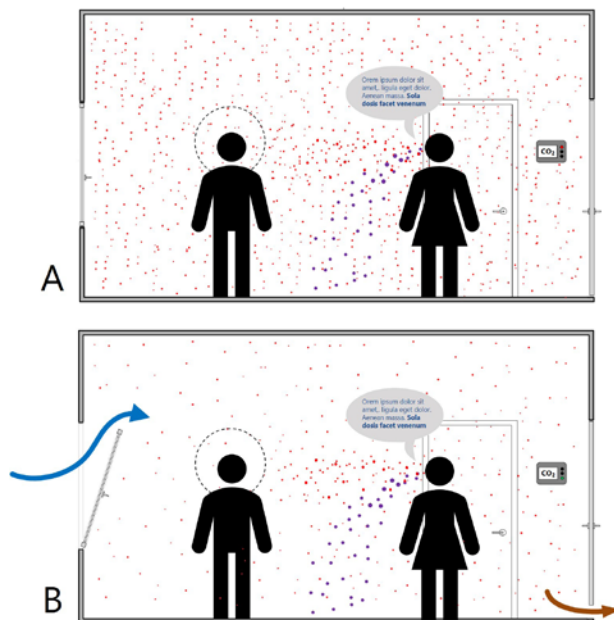
As shown in the previous paragraph, ventilation is of the highest importance to avoid airborne transmission of COVID-19. Besides the amount of fresh air supply, there are some other factors related to the ventilation of buildings that influence the infection risk. We have listed the most important ventilation-related factors regarding airborne transmission of SARS-CoV-2 in the ‘COVID-19 hexagon for ventilation systems’ (Figure 2). In the paragraphs below we explain these factors.

For more general recommendations to prevent the spread of the COVID-19 through adequate building service system design and operation\*.

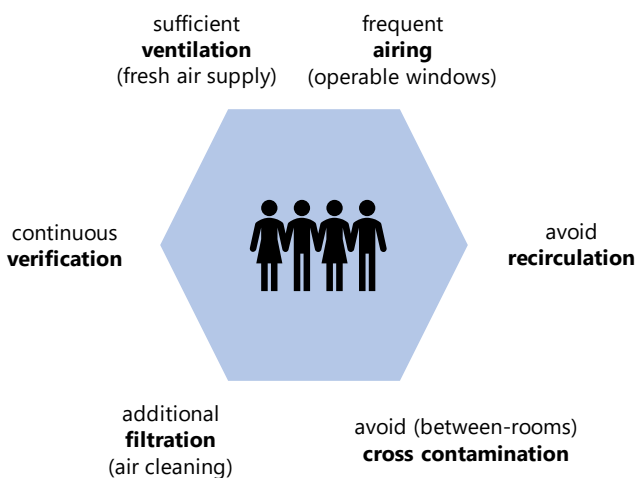
First of all, sufficient **ventilation** (fresh air supply) must be guaranteed. In this context devices are needed that guarantee background ventilation (e.g. trickle ventilation, mechanical supply or operable windows). In terms of COVID-19 risks, however, we need to change the way we are used to look at ventilation. Traditionally all occupants within a space are considered as a pollution source (that spreads e.g. CO<sub>2</sub>). We normally ventilate in order to exhaust all the pollutants produced by the occupants and replace indoor stale air by fresh outdoor air. In the case of aerosol transmission of respiratory diseases, we need to look at ventilation in a completely different way as we only have one or maybe a few sources of pollution (infected persons) in an indoor space. Ventilation is needed in order to **dilute** the virus concentration and decrease the exposure of the uninfected occupants to virus particles spread by others.

Next to background ventilation, frequent **airing** is very important to reduce the risk of airborne transmission of COVID-19. Airing, simply by opening windows or

external doors, allows for rapid air refreshment. Within 10-15 minutes the contamination load in the room can be reduced substantially. This is relevant, for example, after a room has been used, to make sure that the air is fresh before new users come in. Ventilation rates that can be achieved by airing are generally much higher than the ventilation rate of mechanical ventilation systems.



**Figure 1.** Aerosol / virus exposure in the breathing zone of a non-infected person (left) due to an infected (talking) person (right). The purple dots symbolize the spread of infected droplets. Red dots symbolize the spread of infected microdroplets (aerosols). The exposure is relatively HIGH in an insufficiently ventilated room (A). The exposure is much LOWER when a room is well-ventilated (B). (bba binnenmilieu, Stijn van der Horst).



**Figure 2.** COVID-19 hexagon for ventilation systems (both natural and mechanical).

\* <https://www.rehva.eu/activities/covid-19-guidance/rehva-covid-19-guidance>.

Building ventilation should be designed in such a way that between-rooms **cross contamination** cannot take place. Due to pressure differences, air will flow through a building in a certain direction. These pressure differences can be caused by either mechanical ventilation, wind pressure or stack effects. If the air flows from one room into another, the infection risk for the occupants will increase for example if the upstream room is contaminated. In, for example, apartment buildings, nursing homes and office buildings, avoiding the air flow between rooms is important in order to limit the spread of infections. This especially applies in situations with open windows and high-rise buildings (that might have strong vertical air flows).

**Recirculation** of exhaust air is ideally avoided. If centralized air handling units are equipped with a recirculation sector, exhaust air can be mixed with the fresh outdoor air for the purpose of energy efficient heating. If infected microdroplets are present in the exhaust air, there is a chance that they will re-enter the building. Therefore, central recirculation should be avoided (especially during a pandemic) to keep the infection risk as low as possible. Moreover, certain types of heat recovery devices, such as a rotary heat exchanger / enthalpy wheel, may carry over virus attached to microdroplets from the exhaust air side to the supply air side via leaks. More information about this topic can be found at the website\*\*.

**Filtration** by room air cleaners can be useful to reduce the spread of COVID-19 (Elias & Bar-Yam, 2020). These local filtration systems remove microdroplets from air and can provide a similar dilution effect compared to ventilation. The use of this equipment is independent from the type of ventilation system in the building. To be effective, filters need to have at least the efficiency of HEPA filters (Elias & Bar-Yam, 2020; Ontario Medical Advisory Secretariat, 2005).

Other air cleaning techniques, such electrostatic precipitators or UVGI, often work quite well too (ASHRAE, 2020). However, many types of room air cleaners generate undesirable by-products, such as ozone, aldehydes and ultrafine particles, during operation (Zhang et al, 2011). Filtration systems ideally should be selected taking into account and avoiding such side-effects.

\*\* [https://www.rehva.eu/fileadmin/user\\_upload/REHVA\\_COVID-19\\_specific\\_guidance\\_document\\_-\\_Limiting\\_internal\\_air\\_leakages\\_across\\_the\\_rotary\\_heat\\_exchanger\\_.pdf](https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_specific_guidance_document_-_Limiting_internal_air_leakages_across_the_rotary_heat_exchanger_.pdf)

Mechanical ventilation systems are normally equipped with filters, though not as efficient as HEPA filters. Supply air filters are placed near the outdoor air inlet, while virus-contaminated air is generally inside the building. These filters therefore won't help to reduce the risk of virus transmission. Return air filters, on the other hand, could reduce the number of microdroplets that re-enter the building in case of HVAC systems that work with central recirculation or heat recovery equipment that allows for some leakage. Though, these filters normally are of much lower quality than the main (outdoor air inlet) filters and thus are even more inefficient in filtering out microdroplets from the air.

Continuous **verification** or monitoring of the indoor air quality (e.g. with CO<sub>2</sub> sensors in each room) helps users to operate the ventilation devices optimally and gives facility managers insight in the performance of ventilation systems.

## Advantages and risks of natural ventilation

According to the formal definition, natural ventilation, unlike mechanical or fan-forced ventilation, uses the natural forces of wind and buoyancy to provide fresh air into buildings. Natural ventilation can be used for both background ventilation and airing (rapid air refreshment). In this article, we consider ventilation by natural air supply and mechanical exhaust as 'natural ventilation' as well.

There may be the perception that natural ventilation is hard to control compared to mechanical ventilation systems. Hence, mechanical ventilation systems are often preferred by system designers to reduce infection risks. However, natural ventilation systems certainly have strengths.

Very **high ventilation rates** can be achieved by airing. The ventilation rate that can be achieved depends on the window design (number, size and position of the windows, size of the opening) or the length and capacity of natural air intake grilles. In order to maintain sufficient ventilation, generally not all windows or natural air intake grilles have to be opened (depending of course upon the wind conditions). Airing by opening extra windows is a simple way to boost ventilation rates. Moreover, opening windows can provide **ventilative cooling** and thus extra ventilation is stimulated in summer.





**Figure 3.** Very high ventilation rates can be achieved by opening windows (airing) (Photo: Jesper Jørgen).

Another advantage of natural ventilation is that it is **easy to understand** for the end-user. It is clear if a window is open or not and if fresh air is able to enter the room straight from outside. It gives people control over their indoor environment and the quality of the air they breathe, which is even more important in times of COVID-19. Studies have shown that when people have control (or perceive to have control) over their indoor environment, they are more productive, feel more comfortable and have less building related symptoms (Boerstra, 2016).

It is possible to combine natural ventilation with **filtration** by room air cleaners with HEPA filters to capture (virus containing) microdroplets in room air.

Natural ventilation also has some weaknesses. While high ventilation rates are possible with operable windows, it's hard to achieve a steady situation. With natural ventilation it can be more difficult to maintain a high enough ventilation rate continuously as the actual ventilation rate depends on **user behaviour**: if windows and natural air intake grilles stay closed the air supply will be limited. If they are overused (open all the time) this might lead to draft and temperature problems, especially in winter. However, automated systems that

use e.g. CO<sub>2</sub> concentration to control window openings can reduce this weakness. The use of 'traffic light style' CO<sub>2</sub> monitors (**Figure 4**) can also help to remind end-users to open grilles and windows in a timely manner.



**Figure 4.** CO<sub>2</sub> monitor (Aranet4) with traffic light indication.



Moreover, **outdoor conditions**, such as the weather (wind speed, wind direction and temperature) and the outdoor environment around the building (traffic noise, outdoor pollution sources) influence the correct use of natural ventilation devices. Finally, safety can be an issue, e.g. related to burglary or the risk for falling out of windows.

Also mechanical supply systems have weaknesses. The strengths and weaknesses of both natural and mechanical ventilation solutions are summarized in **Table 1**.

This comparison might be read by some as if one solution (either natural or mechanical ventilation) is better than the other. We believe that a **COMBINATION** of natural ventilation and mechanical ventilation actually is the preferred outcome. When designing a new office building, school, nursing home, single family home, apartment complex or hotel, it would be in many cases best (in terms of infection risk management) to combine the two. For example, a combination of (well-designed, e.g. wind pressure reactive) natural air intake grilles (figure 5) with mechanical exhaust directly inside the living spaces. Ventilation system designs that use a



**Figure 5.** Self-regulating natural air intake grilles (DUCO).

**Table 1.** Summary of strengths and weaknesses of natural ventilation and mechanical ventilation.

	<b>Natural ventilation (natural supply and exhaust)</b>	<b>Mechanical ventilation (mechanical supply and exhaust)</b>
<b>Strengths</b>	<ul style="list-style-type: none"> <li>✓ Very high air change rates can be achieved by airing.</li> <li>✓ Due to by ventilative cooling extra ventilation is stimulated in summer.</li> <li>✓ Room air cleaners with HEPA filter can be used.</li> <li>✓ Easy to understand; direct user feedback and personal control.</li> </ul>	<ul style="list-style-type: none"> <li>✓ Ventilation rate is independent from wind conditions and outdoor temperature.</li> <li>✓ Ventilation can be maintained during absence without safety consequences.</li> <li>✓ Direction of air flow is clear.</li> <li>✓ Room air cleaners with HEPA filter can be used.</li> </ul>
<b>Weaknesses</b>	<ul style="list-style-type: none"> <li>✗ Ventilation rate depends on user behaviour.</li> <li>✗ Ventilation rate depends on outdoor conditions (e.g. weather, traffic noise).</li> <li>✗ Use of ventilation facilities depends on the building design (usability, safety).</li> <li>✗ Direction of air flow depends on indoor and outdoor conditions.</li> </ul>	<ul style="list-style-type: none"> <li>✗ Increasing the air change rate by airing is not possible.</li> <li>✗ If centralized air handling units are equipped with a recirculation sector, virus particles can re-enter the building.</li> <li>✗ No user feedback from mechanical ventilation.</li> </ul>

combination of air supply via natural air intake grilles and mechanical exhaust directly in the space are far more robust when it comes to guaranteeing sufficient fresh air supply. Another combination is for example mechanical supply and exhaust in the living spaces and additional operable windows for airing purposes.

When using natural ventilation solutions, attention should be paid at the design stage to thermal comfort (e.g. draft risks), usability of ventilation facilities (e.g. ease of operation, safety issues), cross contamination risks and restrictions due to the outdoor environment. Monitoring of ventilation (CO<sub>2</sub>) is recommended to stimulate the proper use of ventilation facilities.

## Conclusion

COVID-19 should not restrain from the application of natural ventilation systems in buildings. In fact, mechanical and natural ventilation systems complement each other. In other words: especially the combination is gold. Mechanical ventilation systems

create a constant hygienic air change rate while natural ventilation provides additional air change required to dilute air sufficiently, e.g. when spaces are used (temporarily) more intense or longer than normal. Moreover, ventilation by operable windows and natural air intake grilles is easy to understand for end-users and delivers immediate feedback. Therefore, in order to achieve a comfortable and healthy indoor environment and full user satisfaction, mechanically ventilated buildings should also be equipped with operable windows for personal control. When buildings are designed with natural air inlet grilles one can really boost the robustness of the design by additionally deciding for mechanical exhaust directly in the rooms. ■

## Acknowledgements / Declarations

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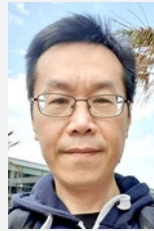
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# New approach in Ventilation Performance Metrics



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In the review of the existing Ecodesign and Energy labelling Regulations on Ventilation Units an important aspect is ventilation performance, i.e. the right ventilation rate at the right time and place. Both in the context of the announced renovation wave and of the role of ventilation in the ongoing corona crisis it is time to move ahead in better controlling indoor air quality.

**Keywords:** Residential ventilation systems, Ecodesign and Energy Labelling Regulations, Review Study, Ventilation Performance Metrics

## Introduction

The existing Ecodesign regulation (EU 1253/2014) and Energy Labelling regulation (EU 1254/2014) for ventilation units were published in 2014 and are applicable since 2016. The Ecodesign regulation sets minimum requirements that ventilation units need to comply with before being allowed on the EU-market. The Energy Labelling Regulation enforces the identification and communication of the energy performance of ventilation units. Both regulations are based on strictly defined assessment methods, described in the regulation text and related annexes.

In February 2019, the European Commission started a review study that was concluded in September 2020 (see <https://www.ecoventilation-review.eu>). In the final Report [1] the review study advocates that for the residential sector, greater emphasis on ventilation performance is needed. With the scheduled renovation wave (increasing insulation and airtightness levels of the building stock) and with the ongoing Covid-19 pandemic showing higher contamination rates in poorly ventilated spaces, the review study urges to include ventilation performance as a crucial parameter in the revised future regulations.

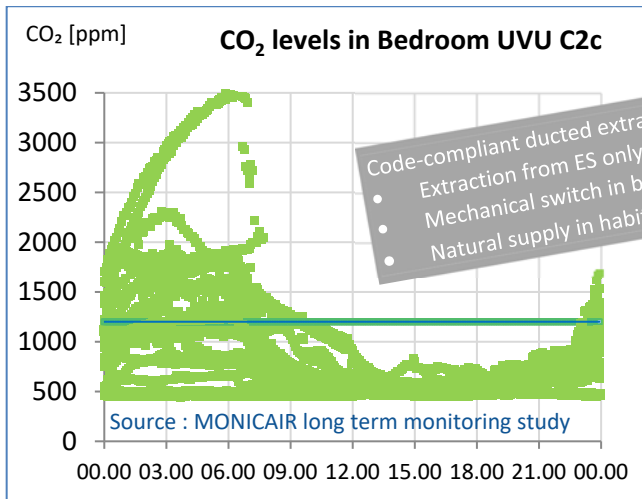
## Review Study

The preparatory study and impact assessment study that was performed for the 2014 regulations already attempted to include ventilation performance into the assessment methods. Because a methodology and commonly accepted performance denominators were lacking at the time, only a cautious approach could be used by linking the so-called *CTRL*-factors to the energy performance of the ventilation units (see associated regulation text). The review study however indicates that a more prominent role for ventilation performance would be imperative for any revised regulation.

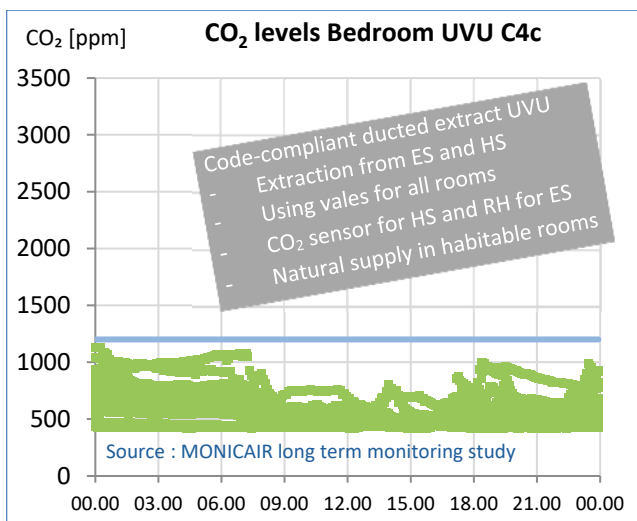
Several long-term monitoring studies in various EU member states performed over the last six to seven years demonstrate, that building code compliant ventilation systems do not always bring the required ventilation performance. Moreover, the ventilation system that is most commonly applied throughout the EU (a central mechanical extract ventilation (MEV) unit that extracts air from extract spaces (ES) only and is controlled by a mechanical switch in kitchen or bathroom) does not bring the required air exchanges to the occupied rooms during many days of the heating season. Some examples are in **Figures 1 and 2**.

**Figure 1** illustrates that in a bedroom occupied by two persons, such a code-compliant central extract UVU with a mechanical switch (extracting air from wet spaces only) does not achieve the required ventilation airflows during a larger part of the heating season. As a consequence, CO<sub>2</sub> concentrations may rise to values above 3500 ppm. **Figure 2** on the other hand shows that another code-compliant extract UVU (a unit extracting air from all wet spaces and habitable spaces that uses valves for all rooms and is controlled by either a RH-sensor for ES or a CO<sub>2</sub>-sensor for HS), performs considerably better. Throughout the heating season the CO<sub>2</sub> concentrations remain below the pre-set threshold of 1200 ppm CO<sub>2</sub>. In the Task 2 report on ‘Markets’ the review study estimates that the largest share by far (around 70% of all ventilation units sold) consists of these ducted UVUs with a mechanical switch extracting air from ES only.

The monitoring data not only show that there are large differences in ventilation performance between the various types of ventilation units/systems, they also demonstrate that the existing building codes do not suffice to ensure adequate ventilation performance. In general, building codes prescribe the ventilation capacity that needs to be installed in each room (either naturally or mechanically driven) but whether these capacities are actually achieved when needed is no topic and remains unaddressed in building legislation. The report on ‘Use-phase Impacts’ gives information on the impact poor ventilation has on human health and productivity, and shows that poor indoor air quality plays a crucial role in the annual 500 000 premature deaths and over two million disability adjusted life years (DALYs) attributed to air pollution. It also negatively affects cognitive functions and productivity of office workers. Clearly, these impacts come with huge economic costs.



**Figure 1.** Long-term monitoring results ducted extract UVU C2c.



**Figure 2.** Long-term monitoring results ducted extract UVU C4c.



Till today, these differences in ventilation performance are not addressed and communicated with the market. In general, it is implicitly assumed that complying with buildings codes results in an adequate ventilation performance. The Task 4 report on technologies, indicates that manufacturers over the last five to six years have diligently been working on further improving the ventilation systems and related controls and are aware of the situation outlined above. Several manufacturers have even adjusted their market approach. From a company that produces and delivers a system component to a wholesaler, some are moving towards a company that supplies all crucial ventilation system components and facilitates the installation and final commissioning of the ventilation system. All with the aim of ensuring a good working ventilation system. Unfortunately, manufacturers encounter difficulties when selling these systems with improved ventilation performance. Project developers in charge of renovation and new building projects often opt for cheaper and simpler code-compliant systems. Legally this suffices, and the fact that their ventilation performance is poor is often not known and even considered a topic for the future inhabitants. Without legislative guidance, these purchase patterns will persist and the problem of poor ventilation remains unaddressed.

### Ventilation Performance Metrics – Status

Since 2014 progress has been made on the topic of ventilation performance due to several scientific research projects. Performance-based approaches that have been proposed, are primarily consider metrics relating to the exposure to indoor generated pollutant concentration levels (usually CO<sub>2</sub>) and condensation risk [2]. They prescribe ventilation strategies requiring the following constraints:

- Default airflows based on the size of the dwelling, number and type of occupants or combinations thereof;
- Minimum airflows during unoccupied periods;
- Short-term forced airflows to dilute and remove source pollutants generated by activities such as cooking, showering, cleaning, etc.

Several countries already prepare for using performance-based approaches in their national regulations. Generally, this ventilation performance is to be demonstrated by simulations using either MATHIS, CONTAM or COMIS multizone modelling software. However, the exposure thresholds (IAQ-indicators) that are proposed show large differences between countries.

E.g. France uses a threshold limit of 2000 ppm CO<sub>2</sub> and allows a cumulative CO<sub>2</sub> exposure limit of 400 kppmh above 2000 ppm per room during the heating season. According to the latest EPB standard EN16798-1:2019 this threshold value of 2000 ppm CO<sub>2</sub> corresponds to the lowest performance category IV. The cumulative exposure limit value of 400 kppmh implies for instance that, with an average exceeding of 200 ppm over 2000, the concentration levels may exceed the 2000 ppm threshold for 2000 hours (almost half of the heating season!) in each room. Spain uses a threshold value of 1600 ppm CO<sub>2</sub> (corresponding to Category III performance according to a EN16798-1) and applies a cumulative exposure limit value of 500 kppmh above 1600 ppm per room over the whole year, indicating that Spain also allows long periods of exposure to values above 1600 ppm CO<sub>2</sub>. The Netherlands uses a threshold value of 1200 ppm CO<sub>2</sub> (corresponding to Category II performance according to a EN16798-1) and proposes a cumulative exposure limit value of 30 kppmh above 1200 ppm per person during the heating season. With an average of e.g. 200 ppm exceeding 1200 ppm, the concentration levels may exceed this 1200 ppm threshold during 150 hours.

The differences in CO<sub>2</sub> exposure metrics between countries are strikingly high and cannot be explained by differences in dwellings, building materials or inhabitants. The question arises as to why countries use different and also relatively high threshold values that correspond to low ventilation performance levels and why countries would allow inhabitants to be exposed to even higher concentrations for such long periods? Allowing low performance levels for ventilation of course does imply that the minimum requirements as regards the energy performance of dwellings (following the EPBD-calculations) are easier to achieve. In that sense low performance metrics for ventilation can be seen as an effective administrative step towards achieving the EPBD goals for an energy neutral building stock in 2050. But this is not the way forward.

Another topic that requires attention in this context is the fact that the proposed performance-based approaches are all built on simulations. But simulations do not necessarily represent the real world. The ventilation unit showed in **Figure 1** for instance may comply with the French and Spanish performance metrics (as will probably any other ventilation unit), but not with the Dutch performance metrics. For years, this particular unit was qualified as a well-performing unit in the Netherlands. The qualification was based on simulations with multizone modelling software.

Input for these simulations were exemplary behaving inhabitants that always open the ventilation grids in the rooms they occupy and close them again when leaving; they also go to the bathroom to switch the ventilation to high when someone is present in the dwelling. Monitoring data demonstrate that this does not reflect the average behaviour of inhabitants. In real life ventilation grids often remain open or closed and the ventilation is only switched higher during showering and cooking. This example merely shows that if simulations are to be used to demonstrate compliance with performance metrics, it is crucial that the input parameters are a valid representation of the real world.

In June 2020 the new IEA-EBC Annex 86 on “Energy Efficient Smart IAQ Management for residential buildings” was approved. The goal of this Annex is to propose an integrated rating method for the performance assessment and optimisation of energy efficient strategies of managing the indoor air quality (IAQ) in new and existing residential buildings. The annex is currently in its 1-year preparation phase and will start its 3-year operation phase in June 2021. Experts from different fields including mechanical engineering, buildings science, chemistry, data science and environmental health will work together with other stakeholders towards consensus on the basic assumptions on which a performance assessment method, and related guidelines and tools will be built [3]. The final reports are expected in 2024.

In summary, one can conclude that performance-based approaches are indeed under investigation and under development, but not yet in the required status for a practical application in the revised ventilation unit regulation.

### Proposal on how to include ventilation performance in revised Regulations

In anticipation of these developments, the review study proposes a practical method to include ventilation performance in the revised regulation for residential ventilation units by adjusting the method for determining the *CTRL*-factor that is to be used when calculating the energy performance of the ventilation unit. The practicality of the method is essential here, because market surveillance authorities need to be able to easily check the claims made by the manufacturer.

In the existing regulations this *CTRL*-factor is determined on the basis of the type of controls that are co-supplied with the ventilation unit (see **Table 1**).

The new proposal uses a more sophisticated approach to draw up a new table where the *CTRL*-factor of a ventilation units relates to the average airflow rate this specific unit needs to achieve reference ventilation performance. By doing so, the energy performance calculations all relate to a specific reference ventilation performance which allows for a valid comparison of the energy performance between systems. For this approach the following principles were formulated:

1. Ventilation performance is defined as ‘the ability of a ventilation unit (and any co-supplied valves and/or controls) to induce the right air-exchanges in the right place at the right time’.
2. Reference ventilation airflows are taken from EN16798-1 [4] and relate to the Category II performance level for extract spaces (ES) and for habitable spaces (HS); for habitable spaces Category II performance relates to 800 ppm CO<sub>2</sub> above outdoor concentration during presence and to the values for basic ventilation rates during absence.
3. The ventilation units including attached system components, comply with applicable national building codes and ventilation regulations, and are installed following the manufacturers’ instructions.
4. The average EU-dwelling was defined as having a heated surface area of 92 m<sup>2</sup>, 3 extract spaces (open kitchen, bathroom, toilet) and 3 habitable spaces with an overall airtightness of n50 = 2.
5. The average EU-occupancy schedule was defined indicating that during 63% of the day one or more of the inhabitants are in one or more of the habitable spaces of the dwelling of which 14% one or more of the extract spaces are also occupied; on average 50% of the habitable space is occupied and during occupation 75% of the inhabitants are on average present.
6. The distinctive technical characteristics of a ventilation system that largely determine the ventilation performance were defined. Not only the type of ventilation unit (with its internal leakages and flow-balance control features) and the related additional system components needed to build a building code compliant ventilation system are

*Table 1. Control factor of existing regulations.*

Type of control	CRTL-factor
Manual	1.00
Clock	0.95
Central VDC	0.85
Local VDC	0.65

important here, but also the level at which valves are applied (central, zonal or local), the type and level of controls that are applied and their suitability for the room type they are used for.

Together with the IAQ taskforce of EVIA (European Ventilation Industry Association), the University of Ghent and VHK a Ventilation Performance Assessment Tool (VPAT) was developed, that enables the assessment of 'the ability of a ventilation unit (and any co-supplied valves and/or controls) to induce the right air-exchanges in the right place at the right time', based on the technical characteristics of the ventilation unit and its co-supplied valves and controls for a default average EU setting. In **Figure 3**, the technical input parameters are listed as well as the output parameters. The VPA-Tool is fully described in a reference document [5].

A preliminary and partial representation of the newly proposed CTRL-factors based on this VPA-Tool is given in **Table 2** for ducted UVUs and BVUs without flow-balance control and internal leakages above 3%, and in **Table 3** for ducted BVUs with flow balance control and internal leakages of 3 % or below.

With this adjusted CTRL-factor, the energy performance calculations (SEC-values) all relate to a specific reference ventilation performance which allows for a valid comparison of the energy performance between systems. In addition to that, it is proposed to introduce the Ventilation Performance Index (VPI), which is the ratio of the average airflow the ventilation unit (and its co-supplied valves and controls) needs for achieving reference ventilation performance (Category II of EN16798-1) and the theoretical minimal airflow that is needed to achieve

**INPUT**

- Dwelling size, number of ES and HS
- Airtightness: n50-value
- Occupation Schedule
- Ventilation System Type  
For all ES and HS
- Type of supply provisions/installed capacity and type of controls
- Type of exhaust provisions/ installed capacity and type of controls



**OUTPUT**

- Air Exchange Performance (AEP) for ES and HS, during presence and absence
- Overall AEP
- Average ventilation rate needed to achieve reference AEP (EN16798-1)
- CTRL-factor to achieve reference AEP
- Ventilation Performance Index

**Figure 3.** Schematic view of the Ventilation Performance Assessment Tool.

**Table 2.** Proposed control factors for the revised regulation for ducted UVUs and BVUs without flow balance control and internal leakages higher than 3%.

Type of VU	Type of controls								
	no control	manual	clock	central VDC-ES	central VDC-HS	zonal VDC-ES	zonal VDC-HS	local VDC-ES	local VDC-HS
UVU - no valves	1.00	1.00	0.95	0.95	0.90	0.90	0.85	0.85	0.80
UVU + zonal valves	1.00	0.95	0.90	0.95	0.90	0.80	0.75	0.75	0.65
UVU + valves for all rooms	0.95	0.95	0.85	0.95	0.90	0.80	0.75	0.70	0.45
BVU1 - no valves	0.95	0.95	0.90	0.90	0.85	0.85	0.80	0.80	0.65
BVU1 + zonal valves	0.95	0.90	0.85	0.90	0.85	0.75	0.70	0.70	0.60
BVU1 + valves for all rooms	0.95	0.80	0.75	0.90	0.85	0.75	0.70	0.70	0.50
BVU2 - no valves	1.20	1.20	1.10	1.10	1.00	1.00	0.95	0.95	0.80
BVU2 + zonal valves	1.20	1.05	1.00	1.10	1.00	0.95	0.90	0.90	0.75
BVU2 + valves for all rooms	1.20	0.95	0.90	1.10	1.00	0.95	0.90	0.80	0.70

**Table 3.** Proposed control factors for the revised regulation for ducted BVUs with flow balance control and internal leakages  $\leq 3\%$ .

Type of VU	Type of controls								
	no control	manual	clock	central VDC-ES	central VDC-HS	zonal VDC-ES	zonal VDC-HS	local VDC-ES	local VDC-HS
BVU1 - no valves	0.80	0.75	0.70	0.70	0.65	0.65	0.60	0.60	0.50
BVU1 + zonal valves	0.80	0.75	0.65	0.70	0.65	0.60	0.55	0.55	0.45
BVU1 + valves for all rooms	0.80	0.65	0.60	0.70	0.65	0.60	0.55	0.55	0.35
BVU2 - no valves	1.00	1.00	0.90	0.90	0.85	0.85	0.80	0.80	0.65
BVU2 + zonal valves	1.00	0.95	0.85	0.90	0.85	0.80	0.75	0.75	0.60
BVU2 + valves for all rooms	1.00	0.90	0.80	0.90	0.85	0.80	0.75	0.65	0.50

#### Legend/explanation:

- UVU = unidirectional ventilation unit (MEV-unit combined with natural supply grids in habitable spaces)  
 BVU1 = Bidirectional ventilation units, extracting air from wet spaces and supplying air in habitable spaces  
 BVU2 = Bidirectional ventilation units, extracting air from all ES and HS and supplying air in connecting spaces  
 Local = at the level of each individual room  
 Zonal = at the level of two and maximum three (combined) rooms  
 Central = at the level of the whole dwelling  
 VDC-HS = ventilation demand control device typically intended for habitable spaces (e.g. CO<sub>2</sub>-sensor)  
 VDC-ES = ventilation demand control device typically intended for extract spaces (RH-sensor for bathroom/ kitchen, VOC for toilet/kitchen, PIR for toilet)

this. As such, the VPI-figure is an indicator for *‘the actual ability of a ventilation unit to induce the right air-exchanges in the right place at the right time’*. It is proposed to display this VPI-figure on the energy label because it provides useful and very relevant information to consumers and other stakeholders. This can help guiding the market towards better performing ventilation systems and help changing the purchase habits.

#### Forthcoming

The European Commission, based on the results of the review study, put forward a draft proposal on how to translate the recommendations into legal acts. Stakeholders were consulted in a consultation forum in March 2021 and the legal process will continue from there. ■

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**Swegon**

# Downflow ventilation system ensures healthy and safe air in elevator cabins



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The safe and unrestricted use of spaces in buildings has suddenly been compromised due to the transmission risks of the SARS-CoV-2 virus. By following guidelines such as avoiding crowded rooms, maintaining a 1.5 m distance, cleaning hands, increasing the amount of ventilation and opening windows, the risk of transmission is minimized. However, in some building areas these guidelines cannot be easily followed, such as in elevator cabins where maintaining distance will considerably affect the transportation capacity. At the same time cabin ventilation is usually limited. The development of a new unidirectional downflow ventilation system, called Eleminair, offers a solution to this problem.

**Keywords:** Elevator, lift, SARS-CoV-2, COVID-19, downflow ventilation system

## Airborne virus transmission and health risks

The airborne spread of viruses in buildings has long been a topic of scientific research. As early as the 19th century, it was understood that proper ventilation has an impact on human health. Around 1930, a more fundamental basis about airborne virus spread in rooms was established by the work of Wells [1]. The 2002 outbreak of the SARS-CoV epidemic in China increased scientific research on the mechanisms

of airborne virus spread in buildings. The current outbreak of the SARS-CoV-2 virus has led to a major acceleration of further research on this topic. It has become clear that there is an airborne route by which virus particles are transmitted from person to person. Virus-laden airborne particles emitted from the nose and mouth by exhalation, speaking, coughing, or sneezing play a vital role. Depending on the size of the particles referred to as aerosols or droplets. The emission rate varies from up to about 1 m/s for

exhalation and speaking to 5 m/s for loud speaking and singing to more than 10 m/s for screaming, coughing and sneezing [2]. However, the exact quantity of harmful virus particles emitted by an infected person, the size of those particles, the quantity that results in infection, what distance is safe, what ventilation rate is appropriate, etc., is not yet certain [3]. As a result, the current practice is to minimize the received dose as far as reasonably achievable.

## Elevator cabins

An inventory of the current elevator cabin ventilation solutions in the Netherlands shows a limited presence of ventilation facilities to supply fresh air to the cabin. In this light, it is not surprising that recent research by the University of Amsterdam indicates that concentrations of virus particles can hover in the elevator cabin up to 20 minutes after use [4]. The shortcomings in elevator ventilation combined with current COVID-19 guidelines, e.g. maintaining distance, have resulted in a strongly limited or sometimes even forbidden use. Especially in high-rise situations this is far from desirable as it effectively blocks the use of the upper floors.

A solution to this problem should meet at least the following conditions:

1. Contaminated air (virus-laden particles) should be removed from the elevator cabin effectively and efficiently.
2. The airflow pattern must ensure that elevator passengers are always inhaling clean and safe air, also when they are positioned at a relatively short distance from each other.

These conditions can be fulfilled by applying vertical displacement ventilation, either downflow or upflow. The more practical solution is to supply fresh air from the cabin ceiling and to discharge air near the floor, as with this configuration the supply diffuser remains clean. The supply air should be evenly distributed over the ceiling area and the downflow should force the exhaled, potentially contaminated air, along the body towards the floor. The principle is known from laboratories, cleanroom environments and operating rooms.

## Downflow ventilation requirements

Nielsen [5] studied the airflow around thermal manikins in climate chambers. Findings show that

a thermal plume around a person has an upward velocity of approximately 0.25 m/s. This implies that a downward velocity of 0.30 m/s should be sufficient to achieve a stable downward directed airflow. For cleanrooms, values between 0.20 and 0.45 m/s are generally used, depending on the specific procedures taking place. In a study on particle transfer in downflow isolation chambers, Yang [6] recommends a velocity between 0.20 and 0.25 m/s, depending on the position of the manikin.

To get more insight in the safe distance between elevator passengers in relation to the downflow velocity, a simple plume model [7] was used to calculate the downward deflection of the emitted airflow from the mouth/nose at different conditions (quiet exhalation 1.0 m/s, loud speech 5.0 m/s and coughing/sneezing 10.0 m/s) in dependence of the downward air velocity (0.02 m/s, 0.20 m/s and 0.30 m/s) at a flow opening of  $\varnothing$  20 mm. The calculation results are shown graphically in **Figure 1**.

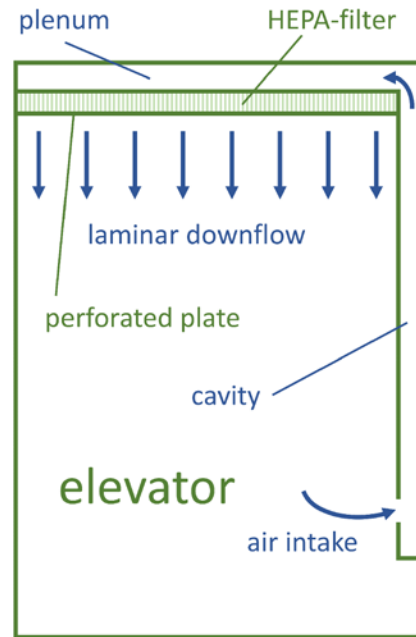
Based on these indicative calculations, we concluded that for loud speech (5.0 m/s) and a downflow velocity of 0.30 m/s, a distance between persons of approximately 0.5 m can be considered safe. These values were used as the starting point for the design. Note that additional safety is obtained by wearing face masks as these substantially reduce exhalation speed.

## Technical prerequisites

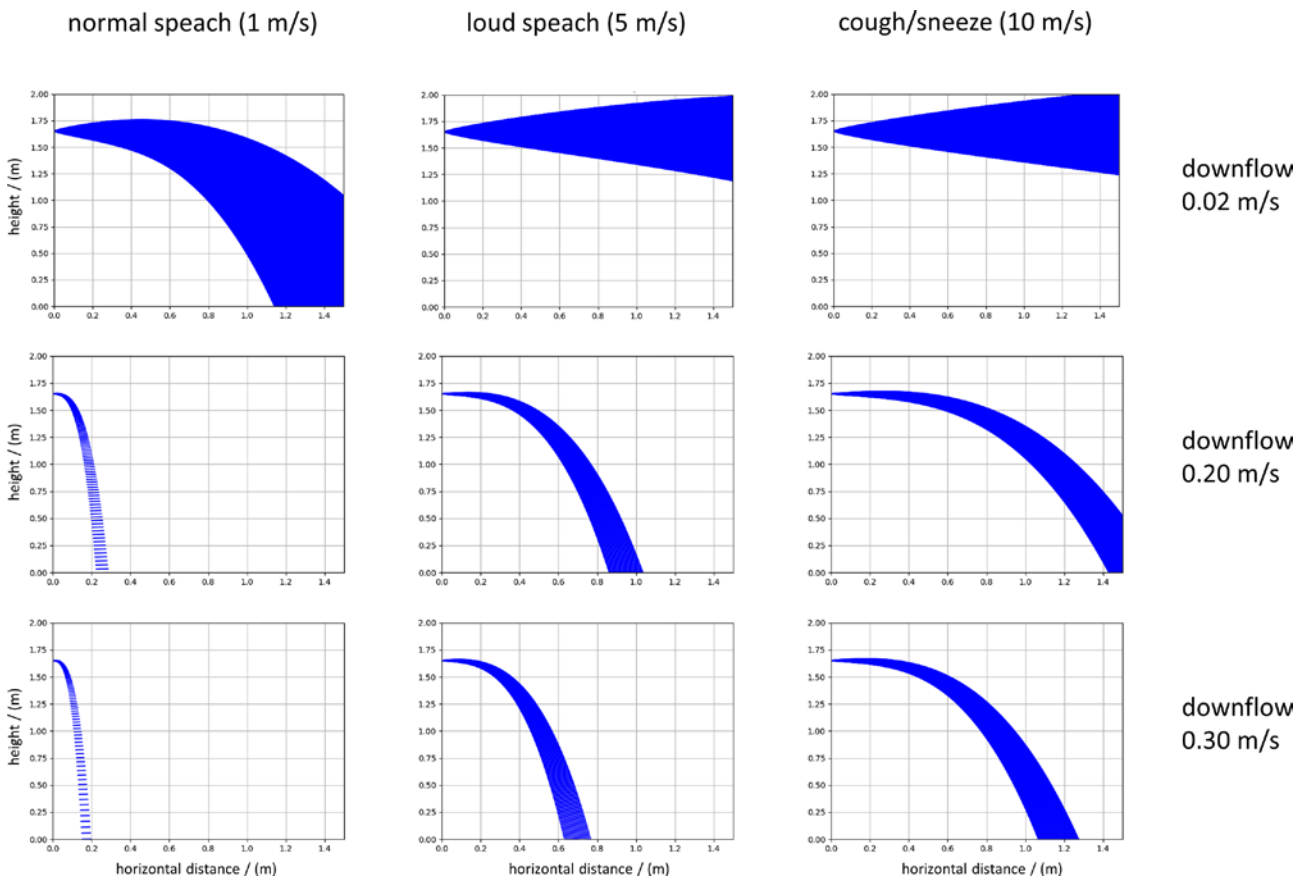
The compact dimensions of typical elevator cabins, in height, length and width, pose design limitations, permitting little room for additional installations. In addition, elevator systems are subject to the regulations of EN 81-20 and EN 81-50, which primarily address the safe use and maintenance of elevator systems. Elevators are periodically inspected and are subject to certification for safe operation. Preferably, a solution should not invoke extensive re-inspection or recertification. Therefore, changing the structural elements and safety components is not allowed. Furthermore, a solution may only add to or change the interior of the cabin and stay within a certain weight increase. The control panel, which is usually located in the elevator cabin, should remain untouched and unimpeded. Given these prerequisites, the envisaged design solution should cover only one wall surface in absence of the control panel and should reduce the ceiling height as little as possible.

The principle of the design is shown in **Figure 2**. To obtain a uniform distribution of the downward airflow in the elevator cabin, the air must be supplied from the ceiling in an evenly distributed manner. The required air is extracted from the elevator cabin using centrifugal fans at one of the cabin walls, which in the prototype are located about 0.5 m above the floor, and subsequently directed towards a ceiling plenum. The supply diffuser in the ceiling consists of a perforated metal plate with a flat HEPA filter mounted on top. For the prototype elevator cabin on which experiments were carried out, a 35 mm thick E12 filter with 99.5% efficiency was chosen, corresponding to a pressure drop of 100 Pa and a downward air velocity of 0.4 m/s.

Due to height restrictions in the cabin, the plenum height should be as small as possible. A mathematical model for airflow in a manifold, as developed by Wang [8], was used to describe the airflow and pressure distribution in the plenum. A comparison with measurement results obtained from a mock-up showed that theory and experiment are in good agreement. With this model, the distribution of the air supply across the ceiling surface can be predicted.



**Figure 2.** Schematic representation of elevator cabin with the downflow air system.



**Figure 1.** Calculated plumes for different combinations of exhalation velocity and downflow velocity.



### Air velocity measurements

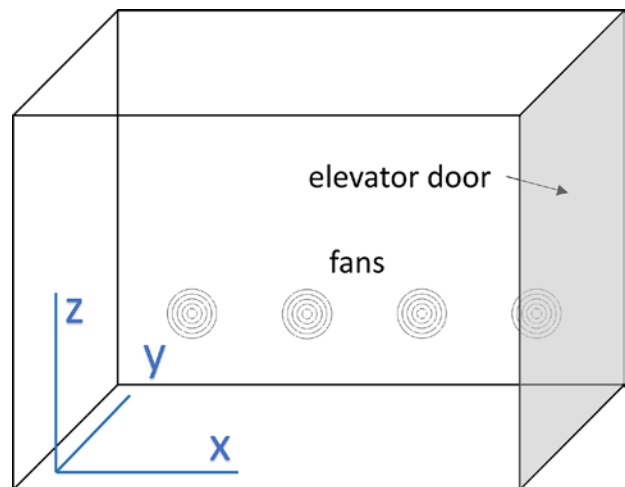
Using acoustic measurement equipment by Innovation Handling, see **Figure 3**, the flow field in the elevator was spatially mapped. To present the measurement



**Figure 3.** Test elevator cabin with setup for air velocity measurements. On the right side of the picture four centrifugal suction fans in the wall cavity are visible.

results, a cartesian xyz coordinate system was defined as shown in **Figure 4**. The elevator door is located on the right side of the figure. Results for vertical air velocity are presented in the xy plane at a height of 1.5 m, in the XZ plane at the centre of the elevator ( $y = 0.55$  m) and in the yz plane at two positions ( $x = 0.6$  m and  $x = 1.2$  m). With the elevator door closed, see **Figure 5**, these measurements show a uniform and downward velocity field from about 0.6 m above the floor. The vertical air speed is between approximately 0.25 m/s and 0.40 m/s. When the elevator is occupied by passengers, the air velocity is higher due to the smaller flow area. With an open elevator door, the air velocity is still downward but due to exchange through the doorway, the values are significantly lower than with a closed door. Finally, a duration measurement was performed with the sensors at a fixed height positioned in the centre of the elevator. These measurements were divided into three periods: 1) activity with people entering/leaving and the elevator door opening and closing regularly, 2) elevator door closed with two people inside, and 3) activity as in the first period with an average of four people in the elevator. The results in **Figure 6** show the vertical air velocity as a function of time at different heights.

It follows from these measurements that at a height  $> 0.7$  m above the floor, the air velocity and direction of the flow is in all cases directed downward and has a velocity of at least 0.25 m/s.



**Figure 4.** Schematic representation of elevator cabin and imposed coordinate system (origin in the corner).

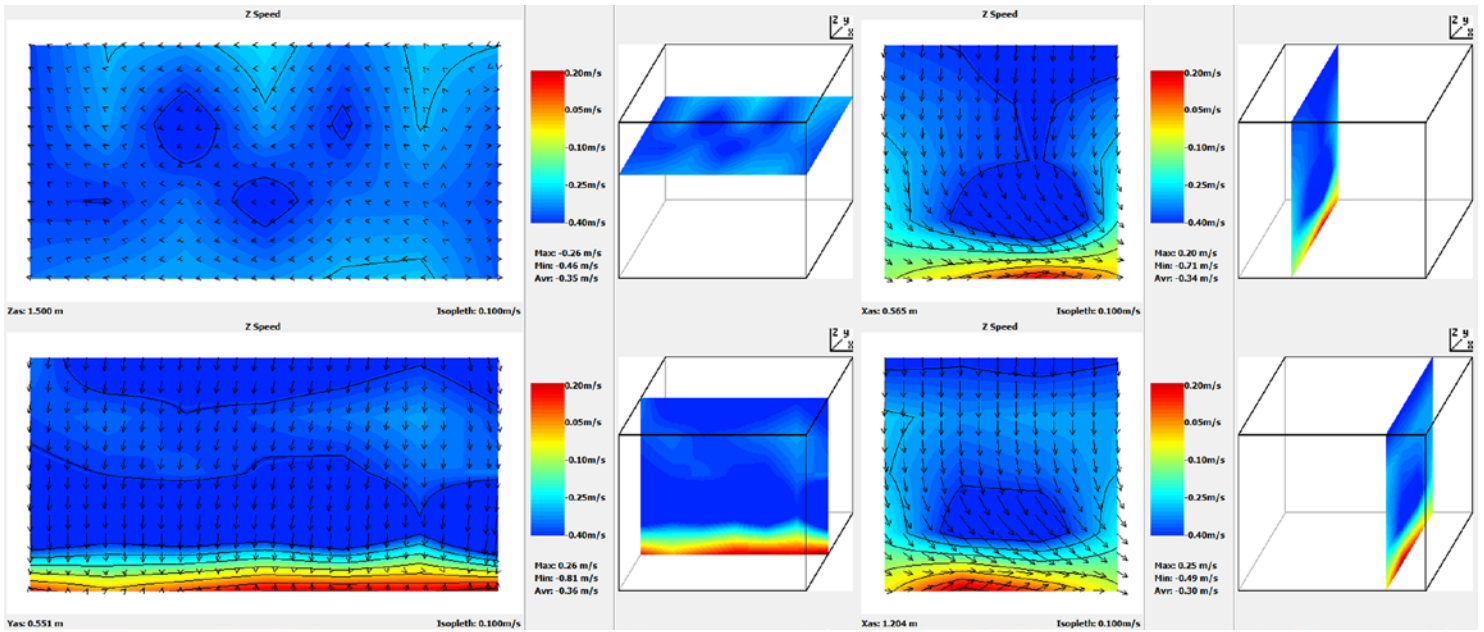


Figure 5. Measured vertical air velocity in the elevator with the elevator door closed.

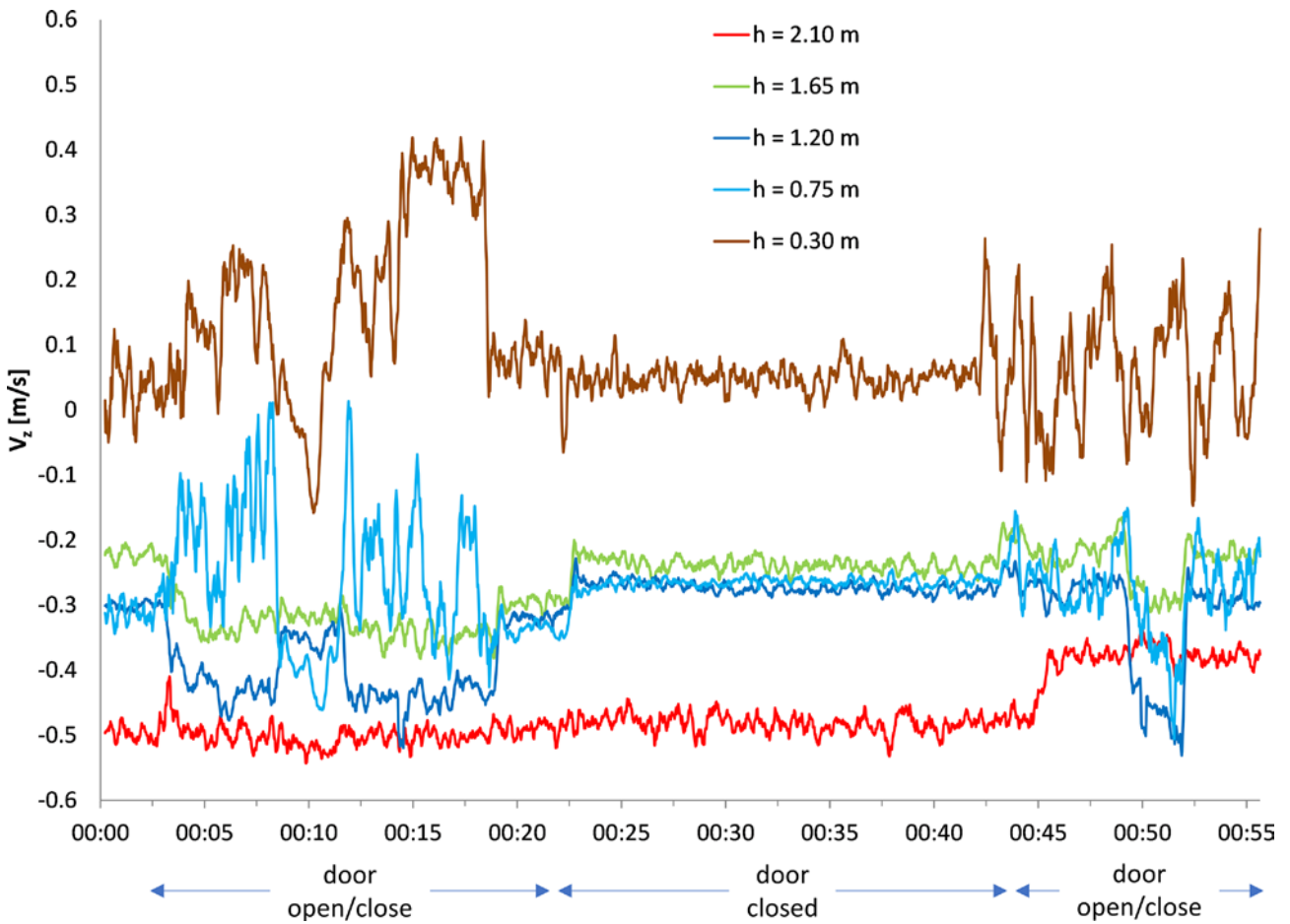


Figure 6. Measured vertical air velocity in the elevator as a function of time at different activities.

## Aerosol measurements

To validate the system's ability to remove aerosols emitted by elevator passengers, and thus its ability to limit airborne contamination, several experiments using artificially generated aerosols were carried out.

### Aerosol persistence experiments

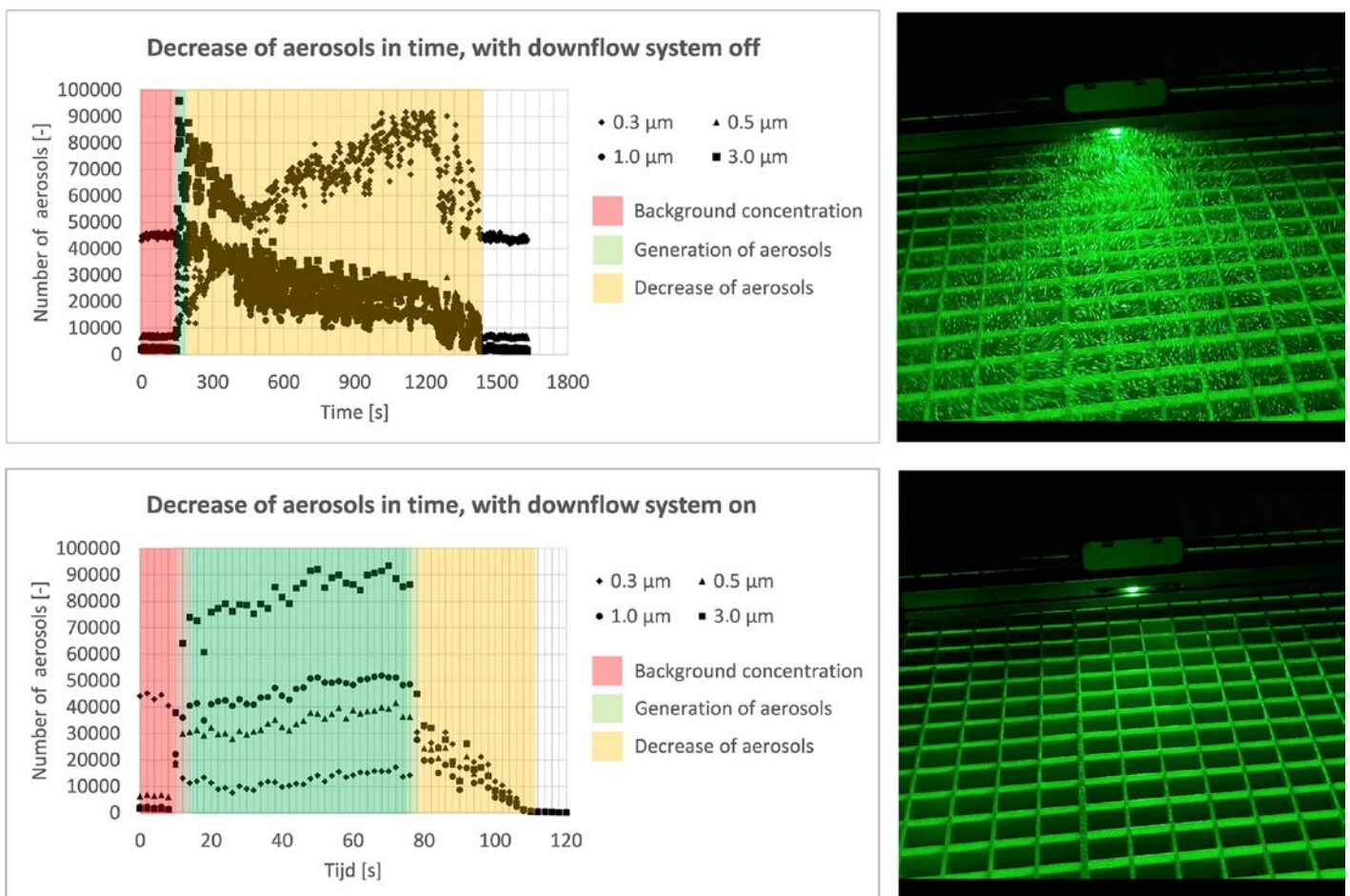
In these experiments a large quantity of aerosols was generated/released in the prototype elevator cabin at the start of a measurement. Subsequently the number of aerosols in particles size bins was measured as a function of time. These measurements were carried out by Prof. Daniel Bonn of the Institute of Physics, University of Amsterdam.

Aerosols were generated using an atomizer/spray bottle filled with an ethanol-glycerol mixture and fitted with a special spray nozzle, which generates aerosols like those released by people when talking or coughing. The

generation rate of aerosols equals several people talking or coughing. Aerosols were measured using two methods:

- Laser diffraction. In this setup a laser sheet (laser beam in frame) is used to track the aerosols. Aerosols falling through the frame light up due to the laser light. The number of illuminated pixels is a measure of the number and volume of aerosols. Using a CCD camera and image analysis software, images can be made.
- Portable particle counter. This device draws a small amount of air from the elevator cabin by means of a probe, and the number of aerosols in the air sample is counted in size bins centred at 0.3  $\mu\text{m}$ , 0.5  $\mu\text{m}$ , 1.0  $\mu\text{m}$ , 2.0  $\mu\text{m}$ , 5.0  $\mu\text{m}$  and 10.0  $\mu\text{m}$ . The sample time used was 2 s.

Figure 7 visualizes the main results. The upper graph and picture show the decrease in aerosols over time in the elevator cabin with the downflow air system off.



**Figure 7.** Results of the aerosol persistence measurements. Above left: change of counted aerosols over time, test elevator cabin with downflow air system off. Above right: photo of laser sheet with aerosols visible. Below left: change of counted aerosols over time, test elevator cabin with downflow air system on. Below right: photo laser sheet with no aerosols visible.



The lower graph and picture show the same measurements, but with the downflow air system active/on.

The following periods are indicated in the graphs:

- Red: background concentration is being measured (downflow system off in both cases).
- Green: aerosols are being generated using atomizer/spray bottle.
- Orange: decrease of aerosols is being measured. For the test with the downflow system off, the number of aerosols decreases due to deposition, evaporation, etc. For the test with the system on, the decrease is mainly due to the capture by the HEPA filter.

Based on these measurements, a characteristic decay time of 333 s was determined with the downflow system off, and 11 seconds with the downflow system on [9].

**Aerosol falling curve measurements**

The aerosol falling curve measurements were used to obtain insight into the falling curve and the horizontal distance that aerosols emitted by passengers can travel. More specific, these measurements indicate the necessary distance between people in an elevator cabin to limit possible airborne transmission.

With a constant aerosol source placed in the elevator cabin, the number of aerosols at various distances from the source were determined. The used aerosol generator atomizes a NaCL 0.9% solution and mainly produces aerosols smaller than 1.0 µm. These were released in the elevator cabin with the hose outlet located at 1.5 m height. The number of generated aerosols corresponds to several people talking and coughing. The aerosols were measured using the described portable particle counter with a sample time of 5 s and sorted into 6 bins.

**Figure 8** visualizes the main results. The graph shows the number of aerosols in the 0.3 µm bin at the source location and at a horizontal distance of 25, 50, 75 and 100 cm from the source. Measurements were performed at downflow air velocities of 0.2 m/s, 0.3 m/s and 0.4 m/s. Besides all the individual measurements (data points), the data for each downflow air velocity are also averaged (lines).

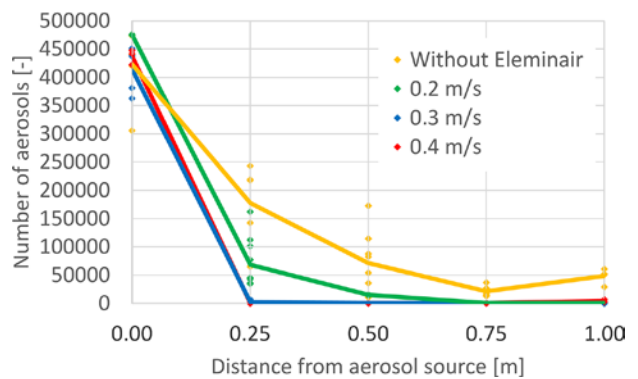
The figure shows that the number of aerosols decreases from approximately 500,000 at the source to almost zero at 0.25 m distance, for a downflow air velocity >0.3 m/s. These measurements therefore show that

a distance of 0.25 m or more between persons will greatly reduce the risk of airborne transmission.

**Implementation in a building**

The first Eleminair system has recently been installed in ‘The Edge’ building in Amsterdam, see **Figure 9**. Three 0.58 m wide modules were installed side by side with a ceiling plenum length of 2 m. In comparison

**Decrease of aerosols in 0.3 µm bin with distance**



**Figure 8.** Results of the aerosol falling curve measurements.



**Figure 9.** Implementation of the Eleminair system in an elevator in ‘The Edge’ building.



to the prototype, the ventilators have been positioned at a higher position, yielding a sleeker design and thus more clearance in the passenger zone. Furthermore, a pre-filter in the wall cavity has been included to limit fouling of the HEPA filter. The modules are equipped with lighting and sensors that monitor airflows and check the contamination levels of the filters. One of the modules is equipped with a central display indicating the operation of the system. An alarm message is displayed in case of a malfunction. In addition, a notification can be sent to the BMS and the installation can be monitored and managed remotely, for example to signal in time filter replacements. After installation

of the system, the maximum allowed occupancy of the elevator increased from 2 to 8 persons, i.e., a fourfold increase in the vertical transportation capacity.

### Conclusions

Based on the experimental results described in this paper, it is concluded that the Eleminair system meets the set requirements and that an elevator cabin with this system installed can be used in a safe manner if a minimum distance of approximately 0.5 m between elevator passengers is observed. A European patent application has been filed for the system. ■

### Literature

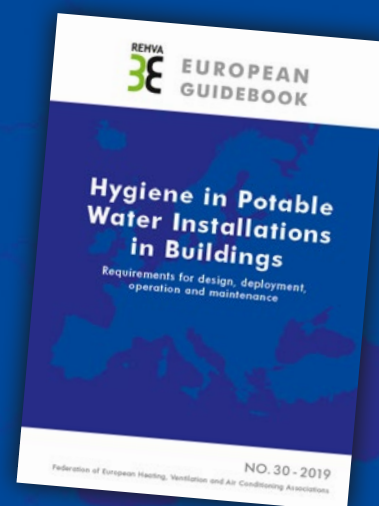
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## Hygiene in Potable Water Installations in Buildings

– Requirements for design, deployment, operation and maintenance

### REHVA EUROPEAN GUIDEBOOK No.30

The interrelationships between water quality, health and the well-being of users require that all parties involved have a specific responsibility for aspects of hygiene in specifying the requirements for potable water installations in buildings. This guidebook gives an overview about the fundamentals of hygiene and water quality and contains main information's on the design, installation, start-up, use, operation and maintenance of potable water installations in buildings. It gives also suggestions for the practical work (maintenance, effects on microbiology, potential causes and measures in practical work, checklists).



# Local Heating Networks: Low-Temperature Networks with High-Performance Pipes as Energy Efficiency Drivers



**MICHAL VIMR**

Director Product Marketing LHD,  
Uponor GmbH, Frankfurt

With the EU looking into becoming carbon-neutral by 2050 and the Paris Agreement aiming to limit the global rise in temperature to under 2 °C, climate-friendly and carbon-neutral solutions are important points of focus across all industries. Heating plays an important role in Europe's path to carbon neutrality: More than a third of EU's greenhouse gas emissions originate from building energy use. With central heat generation, low-temperature distribution and flexibility regarding the energy source, local heating networks that are equipped with high-performance pre-insulated pipes constitute a useful approach to making heating more energy-efficient and sustainable.

The heating and cooling of buildings is one of the main contributors to CO<sub>2</sub> emissions and overall energy consumption in the European Union. Local and district heating networks offer many advantages in terms of the buildings' energy efficiency and convenience for the occupants. They are particularly suitable for urban, densely populated areas, and considering 74.3 percent of the European population lives in cities, heating networks offer a promising solution. However, only about 12 percent of EU citizens—mostly in Northern, Central, and Eastern Europe—are currently served by local and district heating systems. This is well below the feasible market share, which is estimated to lie between 60 and 80 percent of the heat market in various countries. In comparison, local and district heating networks

cover more than 50 percent of the heating demand in Scandinavian and Baltic countries. On the contrary, the biggest opportunity for network growth is mainly in Central and South-West European countries. Consequently, district and local heating networks offer a large but untapped potential in improving the climate and energy performance of European communities, especially when they operate on low temperatures.

## Low-temperature Local Heating Networks: A Prime Example of Energy Efficiency

The impact of community-level energy systems on the level of sustainability and energy efficiency of buildings has recently been the subject of an increasing amount

of research, in particular by the International Energy Agency's Energy in Buildings and Communities (IEA BCS) and District Heating and Cooling (IEA DHC) programmes. Particularly interesting is the IEAs research on the optimised performance of energy supply systems. It outlines a low-exergy approach, meaning a heat supply from sustainable energy sources and through efficient systems, for communities, and related considerations to optimise energy supply. According to the IEA's findings from 2019, climate-neutral heating consists of three main technological elements:

1. Energy-efficient buildings whose clever design, improved insulation levels, and smart heating controls reduce the overall heat demand and minimise thermal losses.
2. Efficient heating networks, designed to use a maximum of renewable energy sources and enable the heat generator to operate at maximum

efficiency. In addition, insulation, smart management, and low temperature levels minimise thermal losses.

3. Sustainable energy sources: Supplying the heat from centralised or decentralised renewable low-carbon or carbon-neutral heat sources.

Appropriately designed local and district heating networks meet these criteria, especially in densely populated urban areas. In particular, the most promising and efficient supply technologies are the ones that allow a flexible supply of different heat demands with a maximal share of low-valued, local, and renewable energy sources. A common feature of these heating networks is that they operate at as low temperatures as possible, without increasing flow rates and pumping energy in amounts that would offset the benefits of thermal efficiency. Low-temperature local heating networks are a prime example of such efficiency in action.

## Pipe System Crucial in Heating Network's Efficiency

Together with energy source and heat generator, the pipe system that connects them with the buildings lies at the heart of every heating network. Its capacity and insulation performance are crucial factors in the system's overall energy efficiency. In general, the size of the network and the temperature at which it operates determine the choice of pipe material. For large-scale district heating networks that operate at high temperatures of 120 °C or even higher, steel pipes with big diameters are the industry standard. Local heating networks, in comparison, usually operate on low temperatures of a maximum of 80 °C, which together with the shorter distances help to minimise thermal losses. The industry standard for these small and medium-sized local networks are pre-insulated PE-Xa plastic pipes, insulated by PE-x (soft) or PUR (hard) foam. Pre-insulated plastic pipes boast a good thermal loss performance, are durable since they do not corrode, and are flexible and easy to install. This also makes them the ideal solution for renovation purposes, where a part or a whole network needs to be renewed. In addition, lower temperatures also extend the plastic pipes' expected lifetime: At an operating temperature of 80 °C, the pipe is expected to last more than 30 years, at 70 °C more than 50 years and at an operating temperature below 60 °C, the expected lifetime even exceeds 100 years, according to European standards.



Source: Uponor

*Due to their compact insulation material and low bending radius, the new Ecoflex VIP pipes are particularly flexible and easy to install on site.*



## High-Performance Pipes for Efficient Networks

With the pre-insulated Ecoflex Thermo VIP pipes, Uponor recently launched an industry innovation that takes these advantages one step further. Thanks to their unique hybrid construction, Ecoflex Thermo VIP pipes have an improved thermal loss performance of up to 60 percent compared to soft-foam insulated pipes with a comparable outer diameter and up to 38 percent compared to hard foam insulated products. This is mainly due to its innovative insulation material, the vacuum insulation panels (VIP) with a Lambda value of only 0.004 W/mK, the lowest on the market. The panels do not only boost thermal insulation performance in the pipes, but also reduce their outer diameter by up to 30 percent compared to conventional soft-foam insulated products. Consequently, Ecoflex Thermo VIP pipes allow for faster installation due to their flexibility and low bending radius. Installers can

save up to 20 percent of installing time compared to stiff pre-insulated pipes and up to 60 percent compared to the installation of steel pipes.

## Low-Temperature Local Heating Networks: the Path to Energy Efficiency

With optimised heat generation, low-temperature distribution and flexibility regarding the energy source used, local heating networks constitute a major factor in making heating more energy-efficient and sustainable. Together with high-performance pipe systems like Ecoflex VIP with its outstanding insulation performance, they can make an important and positive contribution towards the EU's net-zero goals. All in all, low-temperature local heating networks show much potential to become the standard sustainable heating solution in urban areas. ■

## Customer Reference: District Heating Scheme, Scunthorpe

Originally built in the 1960's, the Market Hill housing estate in Scunthorpe is made up of ten maisonette blocks, each home to eight flats, and three high rises with 76 flats each. Heating and water is supplied to all the properties by a district heating system, but due to excessive corrosion and leaks, the piping needed replacing. This full system refit had to be undertaken with minimum disruption to the 350 residents and with no relocation into temporary accommodation. Due to its increased lifespan and potential for long, joint-free runs, which makes it quicker and easier to install, Uponor's Ecoflex pre-insulated pipe system was a perfect fit for Market Hill. Another reason for choosing Uponor's plastic piping over a steel alternative was that its system could be run alongside the existing mains, and work in tandem with old mains that were still active. This flexibility meant that the



Source: Uponor

***Due to its increased lifespan and flexibility, which made it easier to install in confined spaces, Uponor's Ecoflex pre-insulated pipe system was the perfect fit to update the heating network at Market Hill housing in Scunthorpe, UK.***

building work disruption was kept to a minimum and residents could remain in their properties. Overall, 1,500 metres of pipes were installed, and the residents in Scunthorpe now benefit from a community-level, efficient heating network with high-performance pipes that operates at a flow temperature of 80 °C.



WHAT WHO WHY



HEALTHY HOMES  
design competition

Design competition  
for young professionals  
and students of engineering  
and architectural engineering

DESIGN  
THE HEALTHY HOME  
OF THE FUTURE  
AND WIN

50000€



2022



Franck Boston / Shutterstock

# Healthy Homes Design Competition

## THE CHALLENGE

Urban population in our major cities is rapidly growing, increasing the demand for dwellings and thus, the prices. This will likely lead to the “urbanization” of the suburbs, where many people will be willing to move to get affordable housing, areas with suboptimal outdoor air quality. Apart from that there is a need of designing new houses and redesigning existing ones in a new way to meet the demand of different type of users, to comply with the necessity for comfortable, sustainable and resilient buildings and not least, to provide the users with quality of life and enhanced wellbeing.

Reducing the environmental impact buildings have on our planet is a well-recognized issue among both practitioners and researchers. It has a large influence on the way buildings are designed today and will certainly

continue to inform future developments in efforts to mitigate climate change. An equally important issue lies in understanding how buildings affect people’s health and wellbeing.

With this design competition we want to stimulate the minds of young and future building designers and engineers to identify innovative solutions that help create good indoor air quality, adequate thermal comfort and stimulating light and acoustic environments in dwellings also taking into account energy efficiency and e.g. climate resilience.

## THE PROJECT

Imagine you have a plot in Rotterdam, on the edge of the city, close to an industrial area; but still, you and your teammates are determined to create an above-average

healthy & comfortable apartment complex for 20 households, that tunes in with present-day challenges. What would you build on that plot? How would you shape a new way of living at this suboptimal location? How will you make the best out of it? And how would you make this dwelling complex healthy and comfortable but also energy-efficient and climate-resilient?

As a healthy home, the focus of the project is on the indoor environment – the health and well-being of the occupants. The indoor air quality, as well as thermal, acoustical, and visual comfort play an important role in the design. The project should present the solutions applied to achieve the best level of comfort, in terms of indoor climate and daylight. A specific focus should be set on the contemporary and future challenges faced by both designers and end-users e.g., related to climate change. Also, the design should tune in with the specifics of the (virtual) building site. The future healthy homes are expected to be sustainable and resilient to climate change. Sustainability can be seen in many different aspects, mainly related to the environment, economy and society. The project should use the most

appropriate level of technologies according to the building use, considering hybrid ventilation, active and passive solutions where possible and have a clear sustainable direction in its energy consumption while maintaining high indoor climate quality. The buildings and systems should also be ready to adapt or resist the climate challenges of tomorrow.

## CATEGORIES



STUDENTS



YOUNG PROFESSIONALS

## THE COMPETITION

The REHVA Healthy Homes Design Competition 2022 encourages and challenges students and young professionals working within the field of building design, building physics, and buildings service systems design to explore the theme of healthy living – and to create a deeper understanding of indoor environmental quality as well as exploring the impact of future climate changes. The award celebrates and promotes excellence in projects with focus on people’s health & comfort and indoor climate solutions in their living environments and at the same time balancing energy use. The award encourages projects that celebrate the privilege of being a student or young professional; with curiosity and with the willingness to think “out of the box” in the approach to the indoor environmental dimension of future living. All teams that participate will receive a certificate for their participation.

## THE PRIZE

In each category, three nominees will be appointed by the international jury.

The 6 nominee teams will be invited to come to the **CLIMA 2022** conference in Rotterdam, the Netherlands (accommodation paid for two members of the team; with free access to the conference) and present their projects.

Winning team of each category will receive **€ 5000**.

For more information and to download the competition brief go on the website:

[www.healthyhomesdesigncompetition.com](http://www.healthyhomesdesigncompetition.com) ■



## TIMELINE





# HVAC World Student Competition 2020

Sponsored by EUROVENT, on May 27th 2021, in collaboration with ISHRAE, the HVAC World Student Competition 2020 took place online. The competition was held between the competitors representing ASHRAE (United States), ISHRAE (India), CCHVAC (China), SAREK (South Korea), and REHVA (Europe). The jury team members, Manuel Gameiro da Silva (REHVA), Jun Choi (SAREK), Joe Firrantello (ASHRAE), Narayanan Srikantan Chandrasekar (ISHRAE), and Angui Li (CCHVAC) were assigned to judge the performance and quality of the work of the competitors.

The competitors presented their work for 12 minutes and the jury members had a time to discuss and debate for 3 minutes. In addition, the competitors had already delivered an article and a poster about their work that, according to the competition rules, should be the outcome of a Master or Bachelor thesis. After the competition, the jury team graded the participants based on a guideline criteria of 8 points. Each jury member graded all the competitors except the one

representing their own association. Evaluating the total quality of the work and the student's performance during the presentation and the discussion, a ranking list was delivered. All competitors received a certificate of participation. It goes without saying that all participants have already been the winners of their country associations.

The results of the competition are as follows:

- 1st Place: **Maaïke Leichsenring** (REHVA, Netherlands, Europe)
- 2nd Place: **Jianyun Wu** (CCHVAC, China)
- 3rd Place: **Song Yong Woo** (SAREK, South Korea)

The best poster prize was awarded to:

- **Maaïke Leichsenring** (REHVA, Netherlands, Europe)

The winner with 1st place, Maaïke Leichsenring, graduated from the Faculty of Mechanical, Maritime, and Materials Engineering, Delft University of Technology, the Netherlands. The title of her winning thesis is "Flow visualization of downward condensing ammonia in a gasketed plate heat exchanger". This is the 2nd time that REHVA's representative wins the 1st prize of the world student competition. REHVA's first 1st prize in the HVAC World Student Competition was won in 2016 by **Arash Rasooli**, also from the same faculty and university, at CLIMA 2016, Aalborg, Denmark. He is now the coordinator of RCYP (REHVA Community of Young Professionals), attracting the student competitors as well as other young professionals in the fields of REHVA. ■

The 3 winners received a certificate for winning the competition in addition to financial prizes.





# REHVA General Assembly 2021 – an online success!

On 19 April 2021 was held the 65th REHVA General Assembly, this year again in an online format with 69 participants and 25 out of 26 REHVA Member associations present. The REHVA president Frank Hovorka has hosted the General Assembly with an overview of REHVA's 2020 main activities and the plan of strategic activities for the upcoming years.

Parts of the conversation, including the Covid-19 research activities, started between the REHVA board and Members already the Friday before the GA in the members plenary meeting. The president announced a new REHVA collaboration, the Climate Positive Europe Alliance <https://www.cpea.eu/> where REHVA figures as a co-founding organization.

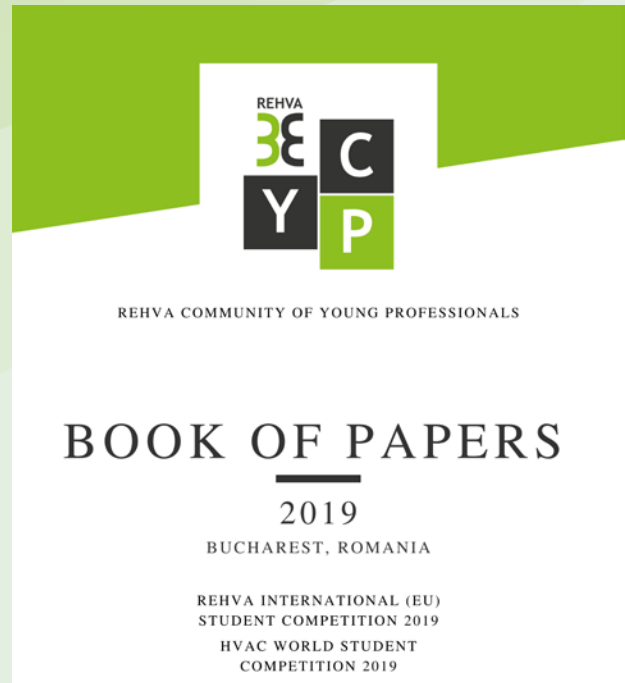


The mission of CPEA is to collaboratively accelerate market transformation towards more sustainable market practices by facilitating cross-sectoral dialogue and providing sectoral insights and tangible solutions for the most pressing challenges faced by the construction and real estate stakeholder community. This project is in line with the European Climate Pact launch in December 2020 by the European Commission. Another one of the future actions of REHVA is the enhancement of the REHVA Community of Young Professionals (<https://www.linkedin.com/groups/8928563/>) presented in the GA by Arash Rasooli.



The first outcome is the Book of Papers 2019, that compiles the works presented by students in Bucharest in 2019. This Book is the first created and will be implemented for upcoming editions of the REHVA Student Competition.

During the GA, **Atze Boerstra**, REHVA vice-president, and Peter Foldbjerg from Velux (REHVA Supporter company) announced the launch of the Healthy Homes Design Competition 2022 with the goal of designing the healthy home of the future.



**REHVA AWARDS & FELLOWS 2021**

REHVA Annual Meeting 2021 12-19 April

<p><b>REHVA PROFESSIONAL AWARD</b> to <b>Fatma Çölaşan</b> TTMD TURKEY for DESIGN</p>	<p><b>REHVA PROFESSIONAL AWARD</b> to <b>Michel Marino</b> AICVF FRANCE for DESIGN</p>	<p><b>REHVA PROFESSIONAL AWARD</b> to <b>Roberto Taddia</b> AICARR ITALY for DESIGN</p>	<p><b>REHVA PROFESSIONAL AWARD</b> to <b>Jose Manuel Pinazo</b> ATECYR SPAIN for EDUCATION</p>
<p><b>REHVA PROFESSIONAL AWARD</b> to <b>Kaido Hääl</b> EKVÜ ESTONIA for EDUCATION</p>	<p><b>REHVA PROFESSIONAL AWARD</b> to <b>Marcel Loomans</b> TVVL THE NETHERLANDS for EDUCATION</p>	<p><b>REHVA PROFESSIONAL AWARD</b> to <b>Marco Dell'isola</b> AICARR ITALY for SCIENCE</p>	<p><b>REHVA PROFESSIONAL AWARD</b> to <b>Livio Mazzarella</b> AICARR ITALY for SCIENCE</p>
<p><b>REHVA PROFESSIONAL AWARD</b> to <b>Metin Duruk</b> TTMD TURKEY for TECHNOLOGY</p>	<p><b>REHVA PROFESSIONAL AWARD</b> to <b>Michele Vio</b> AICARR ITALY for TECHNOLOGY</p>	<p><b>REHVA YOUNG SCIENTIST AWARD</b> to <b>Roel Loonen</b> TVVL THE NETHERLANDS Born: 06/06/1986</p>	<p><b>REHVA YOUNG SCIENTIST AWARD</b> to <b>Ece Kalaycıoğlu Özdemir</b> TTMD TURKEY Born: 18/10/1985</p>



## REHVA AWARDS & FELLOWS 2021



### REHVA SPECIAL RECOGNITION to *The Covid-19 Task Force Member*

In recognition of their commitment and substantial contribution to the REHVA COVID-19 Task Force work providing crucial guidance to HVAC professional and public health officials on the safe operation of buildings during the pandemic

#### Members of the Covid19 Task Force

- Jarek Kurnitski
- Frank Hovorka
- Atze Boerstra
- Juan Travesi
- Ivo Martinac
- Catalin Lungu
- Manuel Gameiro da Silva
- Livio Mazzarella
- Jaap Hogeling
- Francesco Franchimon
- Olli Seppänen
- Birgit Mueller
- Igor Sikonzczyk
- Lara Paemen
- Frederike Wittkopp
- Hywel Davies
- Francis Allard
- Martin Lenz
- Anders Berg
- Marija Todorovic
- Guangyu Cao
- Clemens Schickel
- Benoit Sicre
- Froukje van Dijken
- Mikael Borjesson
- Ioan Silviu Dobos
- Manuel Ruiz de Adana Santiago
- Pedro Gines Vicente Quiles
- Cristina Tanasa
- Ilinca Nastase
- Philippe Petit



REHVA FELLOW



**Murat Çakan**

TTMD  
Turkey



**John Rydberg**  
Gold Medal

Francis Allard



REHVA PARTNER ASSOCIATION AWARD

to SAREK  
50 years



REHVA SUPPORTER AWARD

REHVA warmly congratulates Friterm for its 40th anniversary and expresses its gratitude for being a true REHVA supporter for almost fifteen years



This REHVA project in cooperation with Velux Group is a completely new competition, and the award encourages projects that celebrate the privilege of being a student or young professional; with curiosity and with the willingness to think “out of the box” in the approach to the indoor environmental dimension of future living.

The very much awaited part of the annual meeting is the presentation of the Awards and Fellows.

This year REHVA gave out 16 awards, including a REHVA Fellow which was awarded to **Murat Çakan** from TTMD, REHVA Partner Association Award was announced for celebrating the 50th anniversary of SAREK and finally REHVA warmly congratulated Friterm for their 40th anniversary and for being a REHVA supporter for almost 15 years. The awards committee and the Board also decided to give a Special Recognition to the COVID-19 Task Force Members in appreciation of their commitment and substantial contribution to the REHVA COVID-19 Task Force work providing crucial guidance to HVAC

professional and public health officials on the safe operation of buildings during the pandemic. Frank Hovorka and all the REHVA family congratulates all the awardees of 2021.

And last but not least, the new REHVA president has been elected. For the first time, the president would be elected with an online election. The board members unanimously proposed the candidacy of **Catalin Lungu**, current vice-president and treasurer, as candidate for the position of the President-elect. The General Assembly accepted with a majority of votes cast Catalin Lungu as the President-elect for the position of President. His mandate will start in 2022. Congratulations to the new President-elect! ■





# REHVA GENERAL ASSEMBLY AWARDS

## 1. PROFESSIONAL AWARD IN DESIGN



**Fatma Çölaşan**  
TTMD  
Turkey



**Michel Marino**  
AICVF  
France



**Roberto Taddia**  
AiCARR  
Italy



## 2. PROFESSIONAL AWARD IN EDUCATION



**Jose Manuel Pinazo**  
ATECYR  
Spain



**Kaido Haal**  
EKVU  
Estonia



**Marcel Loomans**  
TVVL  
The Netherlands



## 3. PROFESSIONAL AWARD IN SCIENCES



**Livio Mazzarella**  
AiCARR  
Italy



**Marco Dell'Isola**  
AiCARR  
Italy



## 4. PROFESSIONAL AWARD IN TECHNOLOGY



**Metin Duruk**  
TTMD  
Turkey



**Michele Vio**  
AiCARR  
Italy



## 5. YOUNG SCIENTIST AWARD



**Ece Kalaycioglu Ozdemir**  
TTMD  
Turkey



**Roel Loonen**  
TVVL  
The Netherlands



**Murat Cakan**  
TVVL  
The Netherlands





7. COVID TASK FORCE MEMBERS



14

REHVA  
**3E** SPECIAL  
RECOGNITION

to *The Covid-19 Task Force  
Member*

in In recognition of their commitment and substantial contribution to the REHVA COVID-19 Task Force work providing crucial guidance to HVAC professional and public health officials on the safe operation of buildings during the pandemic



15

Members of the Covid-19 Task Force

- Francis Allard
- Anders Berg
- Atze Boerstra
- Mikael Borjesson
- Guangyu Cao
- Manuel Gameiro da Silva
- Hywel Davies
- Manuel Ruiz de Adana Santiago
- Ioan Silviu Dobosi
- Francesco Franchimon
- Jaap Hogeling
- Frank Hovorka
- Jarek Kurnitski
- Martin Lenz
- Catalin Lungu
- Ivo Martinac
- Livio Mazzarella
- Birgit Mueller
- Ilinca Nastase
- Lara Paemen
- Philippe Petit
- Pedro Gines Vicente Quiles
- Clemens Schickel
- Olli Seppänen
- Benoit Sicre
- Igor Sikonczyk
- Cristina Tanasa
- Marija Todorovic
- Juan Travesi
- Froukje van Dijken
- Frederike Wittkopp



8. REHVA PARTNER ASSOCIATION AWARD



24

REHVA  
**3E** REHVA  
 SUPPORTER  
 AWARD




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REHVA warmly congratulates Friterm  
 for its 40th anniversary and  
 expresses its gratitude for being a  
 true REHVA supporter for almost  
 fifteen years

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22

REHVA  
**3E** REHVA PARTNER  
 ASSOCIATION  
 AWARD

to **SAREK**




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50 years



**Integrated  
thermal energy  
management  
and billing made  
easier than ever.**



## **Belimo Energy Valve™ and Thermal Energy Meter**

Belimo, the leading manufacturer of damper actuators, control valves and sensors for heating, ventilation, and air conditioning technology, brings the worlds of “energy control” and “certified energy measurement and billing” together. The new range of Belimo Energy Valves™ and Thermal Energy Meters integrates energy metering, energy control, and IoT-enabled billing in one device.

Belimo brings together what belongs together.



**Find out more  
[belimo.com](https://www.belimo.com)**



# Thermal energy management and billing made easier than ever

Belimo, the leading manufacturer of damper actuators, control valves and sensors for heating, ventilation, and air conditioning technology, brings the worlds of “energy control” and “certified energy measurement and billing” together. The new range of Belimo Energy Valves™ and Thermal Energy Meters integrates energy metering, energy control, and IoT-enabled billing in one device.

The unity of the certified Belimo Energy Valve™ and Belimo Thermal Energy Meter allows for transparent thermal energy management. The two worlds of “energy control” and “certified energy measurement and billing” are being united in one single device. The new product range measures and monitor flows and energy consumption in heating and cooling systems with direct IoT-based cost accounting.

The new Belimo Thermal Energy Meters are certified according to EN1434/MID and are equipped for direct, or remote IoT-based billing. They are approved according to MID for heat metering in pure water systems and the permanent glycol monitoring means that an alarm can be triggered if glycol is present in the water, which would otherwise adversely affect energy readings. For non-MID meter options, Belimo’s patented automatic glycol monitoring and compensation ensures that measurement remains accurate, irrespective of the type or concentration of glycol.

The Belimo Energy Valve™ instantly controls the flow (pressure independent) and optimizes the energy supply to the consumer. With the unity of the certified Thermal Energy Meter and the enhanced Belimo Energy Valve™ Belimo is stepping into the integrated thermal energy management. It offers seamless and direct integration to the BMS or to IoT-based monitoring platforms, with IoT-based monitoring,



Thermal Energy Meter



Belimo Energy Valve™

performance improvement tools, and billing data. The delta T manager integrated in the Belimo Energy Valve™ continuously measures the temperature spread and compares it with the user defined fixed limit. Measuring and controlling the temperature spread between flow and return at each heat exchanger, is key to ensuring lowest possible pumping costs. Our integrated logic prevents the occurrence of low delta T at the heat exchanger, while retaining comfort.

The Belimo Energy Valve™ and the Thermal Energy Meters can be integrated using PoE. This allows the device to be powered and the data to be transmitted simultaneously via an Ethernet cable. This simplifies installation, avoids wiring errors and eliminates the need for a local power supply. A NFC interface (Near Field Communication) enables easy configuration and maintenance directly from a smartphone.

The connection to the Belimo cloud offers not just an extension of the guarantee by two years to seven years, but a whole host of benefits. By maintaining a digital twin of the Energy Valve in the cloud, authorized users are free to interact with the data directly or device owners can authorize a third party to provide billing or even analytical services.

The possibilities are endless and continue to grow daily. [www.belimo.com/energy-valve](http://www.belimo.com/energy-valve) ■



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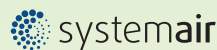
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Send information of your event to Ms Nicoll Marucciova [nm@rehva.eu](mailto:nm@rehva.eu)



# Exhibitions, Conferences and Seminars in 2021

## Conferences and seminars 2021

Due to the COVID19 circumstances, the dates of events might change. Please follow the event's official website

21 - 25 Jun	World Sustainable Energy Days 2021	Wels, Austria & <b>Online</b>	<a href="https://www.wsed.at/">https://www.wsed.at/</a>
25 - 26 Jun	12th International BUILDAIR Symposium	<b>Online</b>	<a href="https://www.buildair.eu/">https://www.buildair.eu/</a>
15 - 18 Aug	Ventilation 2021	Toronto, Canada	<a href="https://www.ashrae.org/conferences/topical-conferences/ventilation-2021">https://www.ashrae.org/conferences/topical-conferences/ventilation-2021</a>
25 - 27 Aug	8th International Buildings Physics Conference	Copenhagen, Denmark	<a href="https://www.ibpc2021.org/">https://www.ibpc2021.org/</a>
31 Aug - 2 Sep	ISH Shanghai & CIHE	Shanghai, China	<a href="https://ishs-cihe.hk.messefrankfurt.com/shanghai/en.html">https://ishs-cihe.hk.messefrankfurt.com/shanghai/en.html</a>
3 - 4 Sep	52nd AiCARR International Conference 2021	Vicenza, Italy	<a href="http://www.aicarr.org/Pages/Convegna/52%20CONV%20INTERNAZIONALE/presentaz_call_for_paper_ing.aspx">http://www.aicarr.org/Pages/Convegna/52%20CONV%20INTERNAZIONALE/presentaz_call_for_paper_ing.aspx</a>
13 - 15 Sep	IAQ 2020	Athens, Greece	<a href="https://www.ashrae.org/conferences/topical-conferences/indoor-environmental-quality-performance-approaches">https://www.ashrae.org/conferences/topical-conferences/indoor-environmental-quality-performance-approaches</a>
22 Sep - 24 Sep	Aquatherm Tashkent 2021	Tashkent, Uzbekistan	<a href="https://www.aquatherm-tashkent.uz/en/">https://www.aquatherm-tashkent.uz/en/</a>
29 Sep - 2 Oct	ISK Sodex 2021	Istanbul, Turkey	<a href="http://www.sodex.com.tr/">http://www.sodex.com.tr/</a>
29 Sep	Danvak Dagen 2021	København, Denmark	<a href="https://danvak.dk/produkt/danvak-dagen-2021/">https://danvak.dk/produkt/danvak-dagen-2021/</a>

## Conferences and seminars 2022

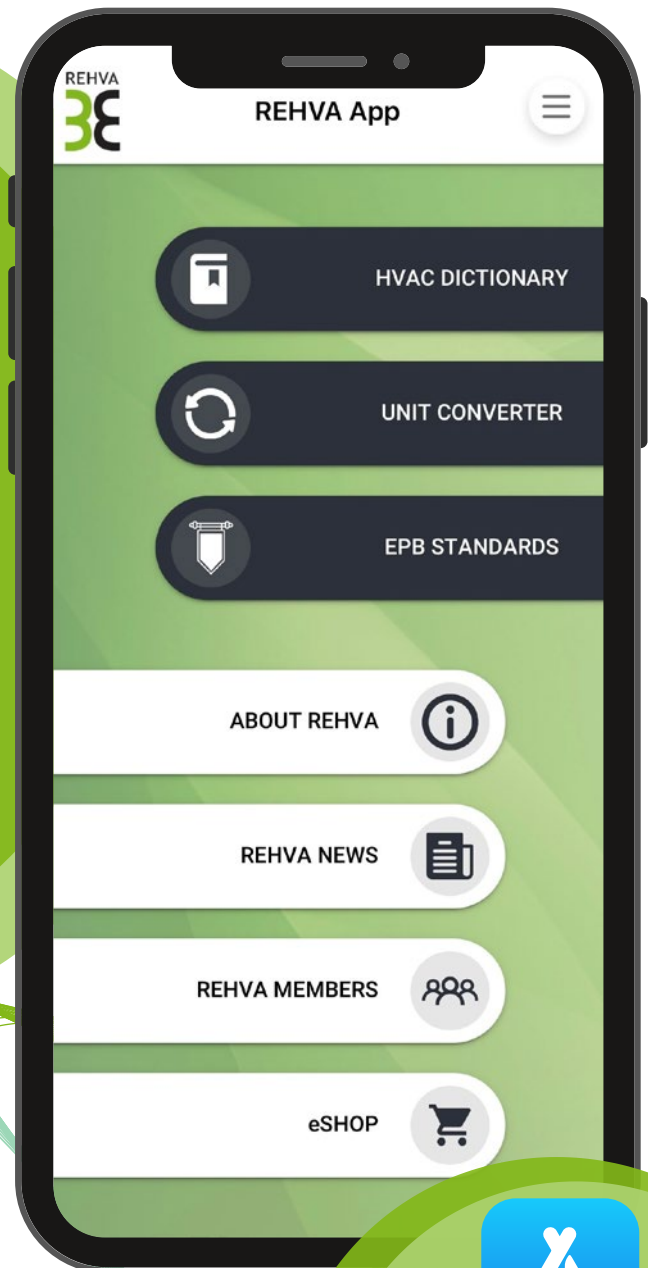
15-18 May	CLIMA 2022	Rotterdam, the Netherlands	<a href="https://clima2022.nl/">https://clima2022.nl/</a>
12 - 16 June	Indoor Air 2022	Kuopio, Finland	<a href="https://indoorair2022.org/">https://indoorair2022.org/</a>

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## Upcoming events



Healthy People in Healthy Indoor Environments

# INDOOR AIR 2022

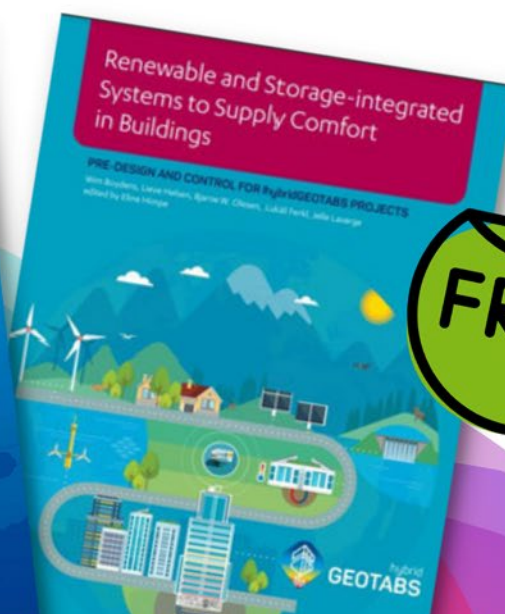
June 12<sup>th</sup> to 16<sup>th</sup>  
Kuopio FINLAND

Indoor Air 2022 conference will continue the conference series with a multidisciplinary and holistic view on indoor air science. The motto of the conference is “Healthy people in healthy indoor environments”. In general, the themes will cover health outcomes, exposures, sources and dynamics of the exposing agents, new materials and development of analytical tools and sustainability of buildings. The 17th International Conference of the International Society of Indoor Air Quality & Climate (ISIAQ) is organized together with the Finnish Society of Indoor Air Quality and Climate (FISIAQ) and the University of Eastern Finland (UEF). The organizers are hopeful that a scientists and professionals are finally able to meet face to face in Kuopio June 12th to 16th 2022.

The conference will be also a venue for the other activities like workshops organized by ISIAQ STCs. Traditionally in Indoor Air conferences, the ISIAQ Summer School has offered an important platform for young scientists and post-graduate students to network with each other and meet with international experts. In Indoor Air 2022, the Summer School will be organized prior to the conference on Saturday and Sunday 11th –12th of June. FISIAQ was originally founded to organize the Indoor Air 1993 conference and it is a great honor to host the conference for the second time after almost 30 years.

Keep up to date and order the conference newsletter from <https://indoorair2022.org/>

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# 'Eye on 2030':

## 14th REHVA HVAC World Congress CLIMA 2022

LAURE ITARD, Delft University of Technology (TUD)

LADA HENSEN CENTNEROVÁ, Eindhoven University of Technology (TU/e)

ATZE BOERSTRA, TUD & CEO BBA Binnenmilieu

### Eye on 2030

The 14th REHVA HVAC World Congress CLIMA 2022 (15-18 May 2022, Rotterdam, The Netherlands) challenges advances in technologies and standards for a smart energy transition, digitization, circularity and, most important, people's well-being and health in buildings.

- How can we create circular buildings, fully heated, cooled and powered by renewable energy?
- How can we design human-centered indoor environments while mastering life-cycle costs?
- Systems and techniques are changing rapidly, and more people must be educated to realize this transition. How can we accelerate the uptake and sharing of knowledge in our sector?

The focus is on buildings, the occupants, and the energy and comfort & indoor climate systems. It also includes integration into infrastructures for energy, health, data and education.

The challenges relating to energy transition, healthy buildings, digitization, circularity and learning are enormous and we need new perspectives, and integration of perspectives. This REHVA World Congress is yours, let's build the future together!

### Call for abstracts

The call for abstracts, which was open until June 18, has been extended until August 1 2021, to answer the demand of many academics and professionals. Contributions may be scientific and technical papers,

interactive sessions (discussion forums, seminars/webinars and courses) and invited sponsored CLIMA workshops. Submit your abstract as soon as possible on: [www.clima2022.org/submit/abstract-submission/](http://www.clima2022.org/submit/abstract-submission/)

All accepted papers will be compiled into the Digital Conference Proceedings. Agreements are also being made for additional publications in indexed journals.

### Exciting mix

Building on a long and fruitful tradition of REHVA World congresses bringing professionals, policy makers and researchers together in an enthusiastic and energizing environment, CLIMA 2022 will enable you to discuss the latest insights in science, technology and standardization and find answers to the questions society and our sector are dealing with. The congress will consist of a mixture of keynote speakers, scientific and technical sessions as well as interactive sessions, student activities, technical tours and sponsored REHVA workshops. Executive Scientific Committee members Marcel Loomans (TU/e), Martin Tenpierik (TUD), Froukje van Dijken (bba- binnenmilieu) and Lada Hensen Centnerová (TU/e) are working on an exciting mix of COVID-19-proof sessions – both in-person and online, with a lot of attention to interaction in discussion forums, webinars & seminars and courses, for which you can also submit an abstract.

For each of the congress themes, the executive scientific organization is in hands of a tandem representing both academia and HVAC professionals.

# Upcoming events

## Theme 1: Energy

Prof. **Jan Hensen** (TU/e) & **Jan Jaap Blüm** (CEO at Alba Concept):

“CLIMA 2022 considers **fossil-free energy use** in the built environment of vital importance. Development of building services systems using heat, cold and electricity from **renewable resources** is accelerating, creating a need for **flexibility** and therefore for **energy storage** and inter-building energy exchanges. Following this there is also a need for **innovative HVAC products** and for **performance optimization** via improved **design, operation** and **maintenance** of the various **integrated** mechanical and electrical sub-systems. This typically includes reduction and balancing of the **energy demands** for **heating, cooling** and **ventilation**. While this is not exactly trivial in new buildings, it poses huge technical, social, economic and political challenges for **existing buildings**. Obviously, the solutions will vary across countries. Exchanging experiences and learning from each other are the main objectives of CLIMA 2022. This is not limited to the technical aspects, but also includes **economic, cultural, juridical** and **organizational aspects**. The overall energy system is becoming more dynamic and is influenced by additional actors with non-traditional roles. When homes become small energy plants, or when large building complexes start to exchange

energy, or when **smart data** companies control **energy consumption**, then the government, grid operators, energy companies, financial institutions and our sector need to respond.”

CLIMA 2022 therefore welcomes original contributions that introduce, share, broaden and improve scientific and practical knowledge and experiences in these areas:

- Renewable and smart energy solutions for buildings and sites
- Design of Innovative HVAC systems for optimized operational performances
- Reduction and balancing of building energy demand
- Legislation, business models and shifting responsibilities

## Theme 2: Digitization

Associate Prof. **Pieter Pauwels** (TU/e) & **Jan Kerdèl** (Senior consultant Building Automation at Kerdèl Business Development):

“CLIMA 2022 considers digital solutions that encourage the **energy transition** in the built environment as a very important theme. Solutions are expected in the areas of **(predictive) digital twinning**,



The new AHoy Conference Centre, Rotterdam.



**data-driven smart buildings**, data management, and continuous commissioning. Nowadays digital solutions must be capable of handling a wide variety of HVAC systems and even be **self-learning** in detecting trends and process anomalies. Stand-alone (add-on) or embedded solutions are possible, but system architectures must include large scale deployment (wired and wireless solutions, IoT, cloud solutions, blockchain technologies). **Monitoring strategies** are needed that also bridge the gap between **Building Automation and Control Systems (BACS)** and **Building Information Modeling (BIM)**, and enable lifetime-cost control using system and building-contextual data. Large-scale **monitoring** of energy, comfort and life-cycle cost performances **at an affordable cost level** are needed in support of business cases and policies. Finally, the recent COVID pandemic has triggered research on digital-focused **design, monitoring and control** of ventilation systems, in relation to overall **comfort and health**. This includes AI algorithms for **fault detection and diagnosis, pattern recognition and anomaly detection.**”

CLIMA 2022 therefore welcomes original contributions on digital solutions supporting the building upgrading process and building (energy) management.

- Building Management Systems for Energy, Carbon, Comfort and Cost Performance:
- Design for Automation: From BIM Models to BACS
- Digitization in HVAC control & Health Monitoring
- Digitization for integration & Building upgrading

### Theme 3: Health & Comfort

Prof. **Philomena Bluysen** (TUD) & **AnneMarie Eijkelenboom** (EGM Architects):

“The achievement of **health and comfort** of people in the **built environment**, whether at home, at work, at school, or enjoying free time, is a **complex** subject that involves **physics, behaviour, physiology**, energy conservation, **climate change**, architecture, engineering and technology. The way people feel, experience and behave in their environment is related to the quality of their environment, described by the **thermal, air, lighting and sound qualities**, but also to the ability of the buildings and systems to respond to people’s changing needs and **preferences** and the ability of people to respond to new buildings and systems. As shown by the outbreak of the Covid-19 **pandemic**, building systems have to provide a **resilient** environment not only on the long term (as climate change is evolving) but also in the short term (for example during a pandemic). CLIMA 2022 challenges advances in **intelligent interfaces and interaction** between building, indoor climate systems and humans and welcomes contributions seeking to new approaches to health & comfort in relation to low-energy buildings and energy-efficient retrofit”:

- Ventilation to reduce infectious diseases
- Indoor Environmental Quality for well-being in energy-efficient & retrofitted buildings:
- Thermal comfort in energy-efficient buildings & retrofitted buildings
- Resilience and climate change



View on the Erasmus Bridge and the new high-rise development at the south bank of the New Meuse River in Rotterdam.



# Upcoming events

## Theme 4: Circularity

Prof. **Tillmann Klein** (TUD), **Bob Geldermans** (TUD) & **Olaf Oosting** (Managing director at Valstar-Simonis):

“As a result of a growing population worldwide and the need for comfortable and healthy indoor environments, a massive building challenge lies ahead with the development of new building projects as well as the need to upgrade the existing building stock. To ensure a **future-proof**, sustainable economy for future generations, the reduction of the use of **primary resources** is essential. **Circularity** aims at closing and connecting material, water and energy flows while eliminating waste and reducing the demand for primary resources. The HVAC sector has a particularly high potential to contribute to circularity. Cycling energy, air and water flows is its core business. Components are frequently subject to upgrades and change. The **retention and reuse of valuable materials** and components offer business opportunities. However, the associated benefits have not yet translated into a **large-scale market breakthrough**. The sector needs a clear **vision** on how to achieve **circularity goals**, based on **innovative strategies** and an integrated approach with regard to **circular design**, product technology, business models, and management. CLIMA 2022 considers circularity as a primary challenge for the coming decade. It is therefore inviting contributions that initiate, share, and improve scientific and practical knowledge and best practice examples in the following areas”:

- Circular Design
- Product Technology
- Business Models
- Management

## Theme 5: Learning & Education

Prof. **Christian Struck** (Saxion University) & Prof. **Laure Itard** (TUD):

“The European targets around the energy transition in the built environment are huge. To realize the **transition** towards an energy-efficient, circular, digitized and healthy built environment, an **upscaling** of solutions is urgently needed. **Dissemination** of technical **innovations and proven knowledge** and approaches is needed. The building services sector is essential for realizing this transition: next to delivering the **workforce** for designing, placing and maintaining all energy and indoor climate equipment in buildings and neighbourhoods, the sector also acts as **innovator** and is the axis between the **construction, energy, IT and health** sectors, **integrating knowledge** from these fields. Rapid changes in energy and HVAC engineering techniques and systems and in contracts and processes make it necessary to accelerate the uptake of knowledge in these areas. This means that **continuous professional development** of the current workforce and the education of new employees is necessary. There is a growing need for **in-company, sectoral and cross-sectoral learning communities**. CLIMA 2022 considers advances in Learning & Education as being essential to the sector and therefore welcomes original contributions demonstrating novel approaches and good practices in developing learning communities and curricula to attract and educate young professionals as well as train experienced practitioners digitally and on the job”.

- Learning communities
- Digital education
- Development of curricula
- Business models for Learning & Education



### Important dates:

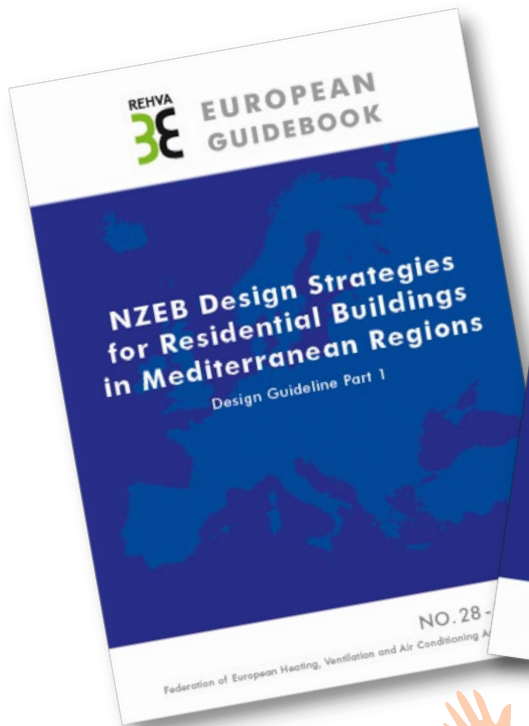
- Abstract submission opens: **1 April, 2021**
- Abstract Submission deadline: **18 June, 2021**
- Extended abstract submission deadline: **1 August, 2021**
- Notification of abstract acceptance: **5 September, 2021**
- Paper submission deadline: **28 November, 2021**
- Notification of acceptance: **15 January 2022**

We are very curious about your contributions and hope to see you in May 2022 in Rotterdam or online! ■



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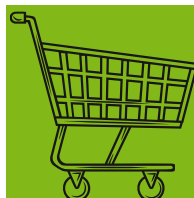
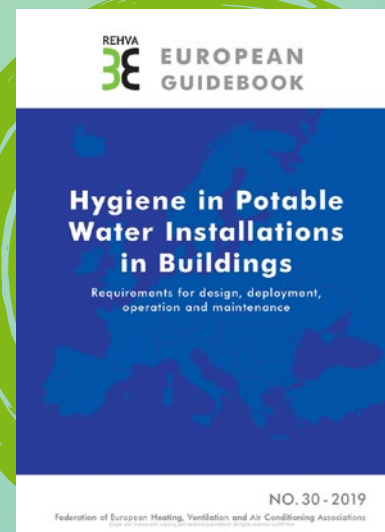
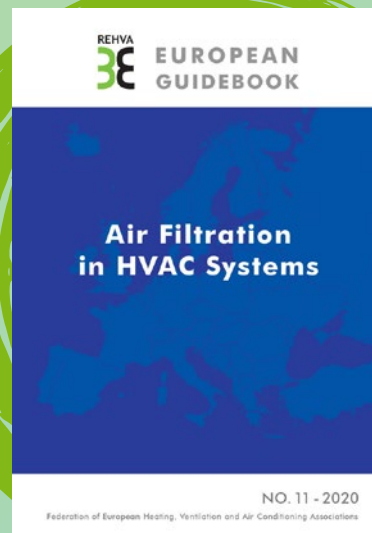
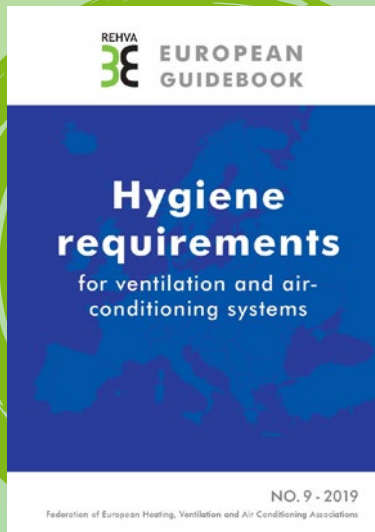
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