Healthy Buildings Barometer 2024

How to deliver healthy, sustainable, and resilient buildings for people

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Foreword

The Healthy Buildings Barometer 2024 is the latest in a series of pan-European reports that track the state of European buildings to shine a light on how the European building stock can better benefit people, society and the planet. Since the first Healthy Homes Barometer was launched in 2015, we have worked with accredited research partners to highlight the current state of our buildings in terms of indoor health and wellbeing.

We do this because we believe that healthy buildings should be the only kind of buildings in which people live, learn, work, play or recover. One in four Europeans live in buildings where indoor air quality falls below national standards. Ensuring all Europeans have access to healthy buildings should be a political priority, and one of the aims of this report is therefore to substantiate and measure the benefits of healthy buildings as part of an overall, holistic approach. Only then can we truly unlock all the benefits of a decarbonised, energy efficient building stock.

The 2024 edition is the eighth Barometer, and this edition has been extended to cover four main building types: homes, workplaces, schools and hospitals. Financed by the VELUX Group, the Buildings Performance Institute Europe (BPIE), a leading independent centre of expertise on energy performance of buildings, has taken a novel approach in their research and analysis, departing from the notion of a holistic approach.

Since our last edition was released, buildings have climbed even further up the political agenda. So has the understanding of what buildings and building regulation can deliver, going beyond a focus on energy efficiency to also include sustainability, resiliency, nature, and indeed health.

With the backdrop of the Energy Performance of Buildings Directive recast, the Chaillot declaration that followed the Global Buildings and Climate Forum and 2024 being a big year of both national and EU elections, the adage that 'it has never been more relevant than now' once again holds true: the impetus of urgency to deliver healthy homes, workplaces, schools and hospitals as part of a more holistic policy framework is accompanied by a real opportunity to do so.

We hope this report will become a useful tool to guide those in the built environment on how to create more healthy, sustainable and resilient homes. Not just by identifying the size of the issue, and the potential of addressing it, but also by providing a way forward.

Lars Petersson
CEO of the VELUX Group

The majority of our days, indeed our lives, are spent indoors. Buildings have a profound influence over our emotions, well-being and productivity, often beyond our conscious awareness. The term 'healthy building' summarises these influences, but does it truly capture the complexity of the matter? In fact, can a building actually be healthy, or is this just simplified language for a much more complex question? In this report, we plunged into the pool of existing knowledge to find out what an answer could look like. The findings are ambiguous.

While evidence suggests that new constructions and renovation of existing buildings can provide measurable improvements for occupants, comprehensive data collection in any European country, which would allow us to monitor the health of our buildings over time, remains conspicuously absent. This is quite surprising given the many scientific studies which document the impact of buildings on humans. However, we decided not to be discouraged by the situation and developed a framework which allows us to be as correct in our conclusions as possible. When we get more comprehensive data in the future, this Healthy Buildings Barometer will become more exact than it is today.

But even with the findings of the present report, we already know that much can be improved with our buildings. And this is where the opportunities align: We know we must invest in our buildings to make them more energy efficient and less climate damaging. As we are tackling this task, we should also ensure that healthy buildings criteria - which we are suggesting in this report - are embedded in the renovation investment decision. And if we accept reality and act to make our buildings more resilient against the increasing extreme weather events due to a changing climate, we will benefit from a triple win for the investment we are making.

The Healthy Buildings Barometer is designed to support decisions in favour of a human-centric and future-proof building stock which is ready for the challenges ahead of us. It provides guidance to investors on criteria to consider in their decision-making, and it delivers recommendations to policymakers which policy and data gaps should be closed urgently.

Oliver Rapf
Executive Director of BPIE (Buildings Performance Institute Europe)

Contents

The Healthy Buildings Barometer approach

The Healthy Buildings Barometer follows a five step methodological approach as described below. By following these five steps, the report arrives at a new framework, how it was tested, ending with policy recommendations for building industry stakeholders and policymakers.

Step		What does each methodological step involve?
1	Literature review	• Review of existing literature on healthy buildings to identify current status quo • Identify research and policy gaps for healthy buildings
2	Framework development	• Development of healthy buildings framework responding to research gaps • Validation of framework through review by external experts
3	Linking data to indicators	• Search for existing data on the EU and Member State level for all indicators • Assess data availability, completeness, and frequency of data collection at the EU and Member State level • Track progress for the EU and the seven highlighted countries from 2015 until now using consistent and complete data
4	Country-based assessment of framework	• Asses the framework using best practice case studies for seven countries within the EU • Evaluate each case on coverage of indicators and dimensions • Determine the ratio of indicators covered per healthy building dimension in each case
5	Formulate policy recommendations	• Match indicators and associated data to policy gaps identified in the review • Establish policy recommendations based on the policy gaps • Connect recommendations to stakeholders and timeline

Executive summary

Since 2015, the **Healthy Homes Barometer**[1] has been tracking the state of European Union (EU) homes. The 2024 edition has been renamed as the **Healthy Buildings Barometer (HBB)** to reflect the fact that it now extends to all major building types, giving us significant insights into all our buildings and their users' health. The 2024 edition also includes a comprehensive framework for healthy buildings based on scientific research and illustrated through 12 case studies from across the EU[2]. Policy makers at national and EU levels, as well as building sector stakeholders, can use this Healthy Buildings Barometer and its framework as a guide to achieving healthy and sustainable buildings across Europe.

The EU is not on track to reach the 2050 climate targets for energy and renovations [1]. Recognising the importance of healthy buildings, the Healthy Buildings Barometer introduces a framework for tracking at the EU level. This informs policy recommendations to collectively align initiatives for healthy buildings with the 2050 decarbonisation objectives of the Paris Agreement. Climate policies must put people first, which this healthy buildings framework does.

The Healthy Buildings Barometer identifies three core messages for policy makers.

These messages – see boxes below - help policy makers at local, national and EU level to identify what is needed in order to change the current policy framework. Stakeholders within the building industry can then implement the changes needed, while the non-profit and research sector, as well as building users, can keep track of progress to ensure accountability.

The lack of a commonly accepted comprehensive definition of what constitutes a healthy building hinders progress towards achieving healthy buildings. Better building health means multiple positive impacts, such as financial viability, sustainability, and resilience to climate impacts. Above all, all buildings in which people can live, learn, work, play, and rest should be healthy buildings. This year's Healthy Buildings Barometer provides policy makers and the building and construction industry with a new framework for promoting the urgent need for healthier buildings. The framework clearly defines what a healthy building is: **Healthy buildings emphasise occupants' health and well-being, safeguard and enhance sustainability, and enable transformation through empowerment and resilience**[3].

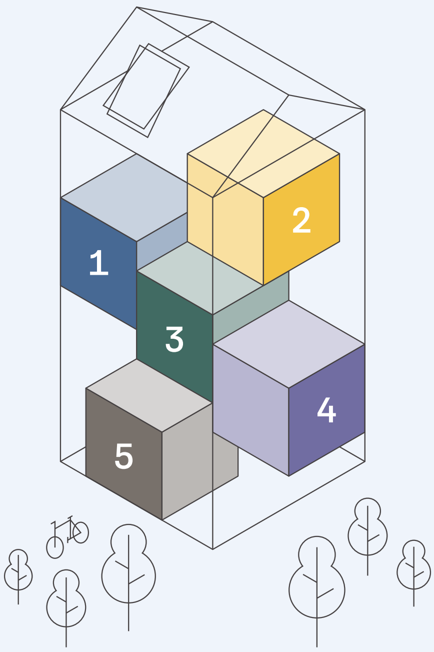
1

Accelerate adoption of a comprehensive definition and framework of healthy buildings to drive progress

Healthy buildings are multi-faceted and cannot be understood by focusing exclusively on one dimension or individual characteristics. The framework for healthy buildings can only become a reality through five interrelated dimensions:

1. Improving mental and physical health
2. Designed for human needs
3. Sustainably built and managed
4. Resilient and adaptive
5. Empowering people

Each dimension is composed of a set of indicators, with a total of 24 indicators across the five dimensions. These indicators help to see what is required to achieve truly healthy buildings.



2

Prioritise high-quality data that tracks building health and occupant well-being

Using EU-level data to implement the new framework developed in the Healthy Buildings Barometer on case studies is challenging – as the section 'The lack of data and challenges for implementation tools' shows in detail. EU-level data on buildings are often not available, incomplete, or not measured regularly. Data on building occupants are mostly associated with residential buildings. In addition, data availability and quality also vary substantially across Member States. This makes it very challenging to get a holistic picture of the health of buildings in line with the new framework presented in this Barometer. It further illustrates the need for healthy buildings to become an interest area for EU-level data collection, utilising existing sources as well as creating new data collection pathways.

What has changed in the health of buildings and their users in the EU since the publication of the first Healthy Homes Barometer in 2015 and the Paris Climate Agreement[4]?
Surprisingly, key statistics[5] on public health and buildings at the EU-level indicate that the health of buildings and their users have not changed. Buildings still consume too much energy, emit more GHGs, and there are fewer investments in renovation, resulting in lower renovation rates. Absence rates in workplaces are also increasing, suggesting a deterioration of the health of people, perhaps also due to the buildings they occupy.

What do healthy buildings look like in 12 best practice cases in the EU?
Findings show that healthy buildings can be financially sustainable investments, support people's health, and have lower environmental impact.

EU data highlights

0.2% average annual deep **renovation rate** in 2019 [2] vs 3% recommended annual renovation rate. A boost of 1400% is required [3]

3% recommended

+1400% **required**

0.2% in 2019

Accumulated **investments in renovations** in 2020 were 40% lower than required to reach EU goals [2]

-40%

1 in 4

Europeans live in buildings where **indoor air quality** falls below national standards [4]

+18% CO_2 emissions

CO_2 emissions are 18% higher than target to reach EU goals in 2020 [1]

30m citizens[6]

affected by **insufficient daylight** in their homes (EU-SILC 2020[7] data)

Case study highlights[8]

The Netherlands

↑11.5% ROI over 40 years[9]

↓2% sick days[10]

Belgium and Germany

Measureable improvements in social connections[11]

Sweden

30% lower climate impact[12]

3

Integrate health, sustainability and resilience into building policy

Immediate political action at the EU and Member State level is needed to introduce policies and regulations that integrate a multidimensional focus on health, sustainability and resilience as key components of decision-making processes.

The policy recommendations outlined in 'Gaps & policy recommendations' span the EU, national and local levels. Recommendations include enhanced collaboration and the integration of healthy building aspects into existing policies, better building regulations, data collection, financing, life cycle and biodiversity, as well as support for local communities. In the context of the EU Green Deal and the revised EPBD, this report's recommendations also act as guidance to reach climate and indoor environmental quality objectives.

This Barometer tells us about the current state of our buildings. It also looks ahead to identify what needs to be done to ensure all people get the healthy homes, workplaces, schools and hospitals that they deserve.

Areas of action

- **Broaden the regulatory focus** to include the concept of healthy buildings and occupants.
- **Ensure access to data** so that the buildings' health, sustainability, and resilience can be tracked over time.
- **Increase cross-functional collaboration** and information-sharing between actors within and outside the construction sector.
- **Use decision-making tools effectively** for an integrated focus on sustainability, and resilience of buildings.
- **Put people at the centre** and involve them throughout the lifecycle of buildings.

Shaping a healthy, sustainable, and resilient future

This year's Barometer shifts the focus beyond homes to health in all buildings.

Setting the scene

Lack of focus on health and well-being

Indoor environmental quality (IEQ) and health impacts of buildings are mentioned in the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency First (EE1) guidelines[13] as an important co-benefit to energy efficiency. The revised EPBD introduces a definition of IEQ and an obligation for Member States to set requirements for IEQ standards. However an integrated, strategic approach to ensuring the health of building occupants is still missing.

Renovation urgency

An integrated renovation approach for the EU building stock is necessary to meet climate targets. The European Commission Renovation Wave[14] initiative proposes doubling the renovation rate, but with this approach, it would take more than a century to decarbonise our building stock [6]. Building on the EPBD[15] recast and the role of buildings in reaching the EU targets for 2030 and 2050 [7], both the depth and rate of renovation rates must increase. The current deep renovation[16] rate of 0.2% across the EU is only making a minimal positive impact on climate targets.

Closing the renovation gap

The European Union recognises the need to reduce emissions and resources to become climate-neutral through its EU Green Deal[17]. Investments in renovation must bridge a gap of €1.4bn between actual renovation rates and those needed to achieve climate neutrality [1].

Resource-intensive construction

Resource-intensive materials such as steel and concrete, fossil fuel electricity and heating [1] and wastage of building materials [8] must be controlled to tackle the 43% share of total buildings' energy use [9], and the 35% of the EU's energy-related greenhouse gas emissions [10]. By 2030, all new buildings, according to the revised EPBD[18], must be zero-emission, ready for renewables, and have their life-cycle Global Warming Potential (GWP) calculated.

The impact of unhealthy buildings

Europe's built environment is falling short of safeguarding the health of its occupants. During the Covid-19 pandemic, many people suffered under lockdown in unhealthy homes[19] [11-13]. Issues such as overcrowding[20] and social isolation negatively impacted people's mental and physical health [12].

Poor indoor air quality from inadequate air exchange and/or improperly managed HVAC systems, even when automated and smart, can increase pollutants such as radon, toxic volatile organic compounds (TVOCs) and microbes [14]. Nearly 100,000 Europeans lost their lives to indoor air pollution in 2012 alone [4]. Renovation work to increase insulation and air tightness without proper consideration of air exchange can also lead to issues like dampness and mould [15].

Deadly heat in the form of more frequent and severe heatwaves – an estimated 15,000 people died from the 2022 heatwave across Europe[21] [16] – has highlighted a lack of adaptation to overheating in the summer [16-17], alongside problems of staying warm in winter due to inefficient thermal building envelopes [18]. Inadequate building envelopes can also lead to uncomfortably hot homes, as more than a quarter of Europeans suffered from overheating inside their dwellings during summer in 2012[22].

Building health effects extend beyond structural concerns, manifesting in mild to severe health issues in infants, adults, and older people, with ill effects ranging from respiratory and skin problems, headaches and allergies to serious mental health concerns and life-threatening heat or cold [15, 19, 20]. There is also a significant lack of buildings that adapt to people's varying physical needs and requirements [21].

Added to this are increasing building energy costs and inflation. Across the EU, people struggle financially to manage energy bills, rents, and mortgages - 30% of low-income households[23] and 10% of the population spend more than 40% of their income on housing-related costs[24]. In the Eurobarometer survey (2022) more than 80% of respondents reported that rising energy prices have a significant impact on their purchasing power [22].

“Healthy buildings emphasise the health and well-being of their inhabitants, safeguard and enhance sustainability, and enable transformation through empowerment and resilience.”

Benefits of healthy buildings

The benefits of healthy buildings are immense and support the general welfare. Between 200,000 and 500,000 jobs annually across the EU could be created through well-designed renovation programmes [23]. If general repairs were carried out on all inefficient housing stock in the EU, the cost would be recovered in just two years, and could save €194 billion in equivalent societal goods such as fewer sick days or less frequent hospital visits [38]. The healthcare sector alone could save more than €45 billion annually (around 10% of the annual EU healthcare costs) if well-designed efficiency measures were implemented in all hospitals [23].

Renovating all residential buildings in the EU to energy-efficient standards[26] could save 44% of final energy for space heating [18]. Furthermore, decarbonising the new build sector is feasible; a 41% reduction in

Benefits of healthy buildings for the EU across four building types

Homes

Renovating homes to make them healthier leads to a range of benefits

Construction sector employment per year

↑22%

Energy savings from retaining heat

↑44%

Return on investment from health benefits[28]

↑75%

Costs recouped from mental health benefits[29]

↑20%

Health improvements after health-focused renovation

Savings per household after retrofitting home

€400

per year[30]

Workplaces

A healthier workplace is good for workers and the economy

Performance from higher exposure to daylight

↑10%

Productivity from greater access to nature

↑6-12%

Performance from every -1°C in overheating

↑3.6%

Performance for every increase in ventilation

↑1%

Performance due to better lighting

↑0.8%

per year

Value added to the European economy[31]

€40bn

per year

Sources: BPIE, 2018a [26]; BPIE, 2018b [27]; Brown, et al., 2020 [29]; European Commission, 2018 [6]; IEA, 2015 [28], te Braak et al, 2020 [30] embodied carbon through design for new builds cuts costs by 9%, and increased construction efficiency can reduce costs by 15% [25].

Benefits can also be considered in terms of specific improvements for occupants in different buildings. Research on the multiple benefits[27] of healthy buildings spans homes, workplaces, schools, and hospitals as well as neighbourhoods. In each building type, people benefit in different ways such as increased performance at work, better concentration in schools, faster recovery time in hospitals, or improved thermal comfort and respiratory health from efficient renovations at home [6, 26, 27, 28]. Across all four building types (homes, workplaces, schools and hospitals), significant economic value can be added, turning healthy buildings into financially viable projects with a high benefit-cost ratio [29].

Schools

Making schools healthier also makes them better places to learn

Performance from higher exposure to daylight

↑9-18%

Performance from better lighting

↑2.9%

Performance from every -1°C in overheating

↑2.3%

Performance for every increase in ventilation

↑1%

Performance from 1 decibel less of noise

↑0.7% per year

Boost to EU GDP from better learning environments

€173m per year

Hospitals

Renovating hospitals has many positive knock-on effects for patients

In-patients visits

↓11%

Employee turnover

↓20%

Medical costs

↓21%

Mortality rate

↓19%

Potential savings from improved daylighting

€42bn per year

Potential savings from improved indoor air quality

€38bn per year

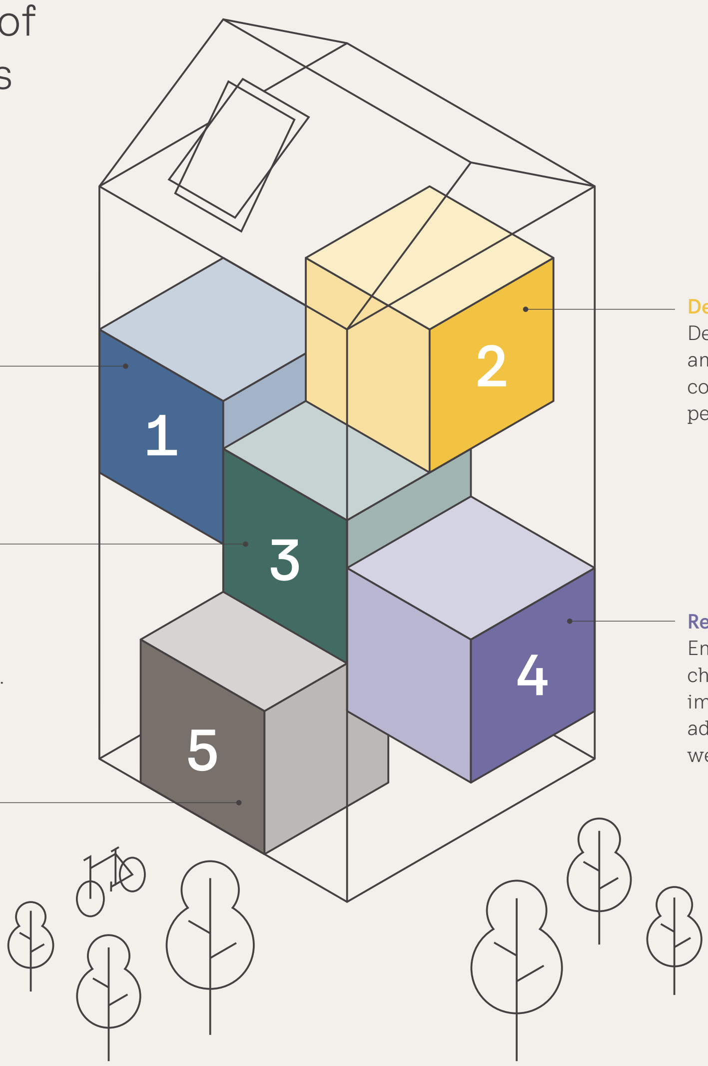
A solution for a healthy buildings framework

The Healthy Buildings Barometer provides a fresh, truly multidimensional, and actionable framework for healthy buildings. Following the previous Barometers, it continues to draw on the vast scientific knowledge of healthy buildings and synthesises this information to become a catalyst for action. At the same time, this framework emphasises the integration of three domains of **health**, **buildings**, and **climate**. Too often, only some aspects of these important domains are considered in building projects – and without any guidance or framework for stakeholders on how to integrate them. The objective of this framework is to bring these domains together by providing a new definition of healthy buildings that is enacted through the following five main dimensions.

Five dimensions of healthy buildings

The five dimensions are derived and developed based on extensive literature review as well as adjacent frameworks and projects, including the Compass model[32], developed by The VELUX Group and EFFEKT Architects. Each dimension can be assessed through a set of indicators described in the next section.

Five dimensions of healthy buildings



Improving mental and physical health
Provide better physical and mental health from social, economic, emotional, and environmental aspects via a healthy indoor climate and comfort measures.

Designed for human needs
Design and understand human needs and behaviours with an inclusive and collaborative approach to suit the people using the building.

Sustainably built and managed
Prioritise sustainable measures across the building life cycle, considering climate protection, resource usage, energy consumption, and carbon emissions.

Resilient and adaptive
Ensure adaptability to climate change and minimise environmental impact while being contextually adaptable to local climate zones as well as changes in building use.

Empowering people
Empower people with knowledge of healthy buildings through education and communication throughout a building's whole life cycle.

1

Improving mental and physical health

Healthy buildings are designed to enhance the health and well-being of their occupants, both physically and mentally. This dimension encompasses several fundamental indicators that collectively contribute to creating a healthy indoor environment[33].

Key indicators to improve mental and physical health in healthy buildings

Indoor environmental quality

Indoor air quality

Improving indoor air quality and comfort through building design. Technical and natural solutions must provide needed air exchange and ensure that the air inside is conducive to the health and well-being of occupants. The key indicators to lower health risks are ventilation rate and CO_2 levels.

Thermal comfort

Maintaining indoor levels of comfort and monitoring occupants' perception of warmth. Ensuring year-round thermal comfort using passive and active measures like natural ventilation and solar shading[34].

Daylight, lighting and visual comfort

Providing sufficient daylight during daytime, and appropriate electric light without glare or flickering for visual comfort and improved productivity and mood of occupants. Overall lighting should meet individual needs, ensuring visual comfort, performance, and safety without posing health risks.

Acoustics comfort

Providing silent and active spaces, empowering occupants to adjust and control sounds by opening/closing windows, and ensuring that sound pressure levels from inside or outside are at acceptable and comfortable levels.. This also means avoiding noise reverberation for satisfying acoustics.

Connectedness to nature

Designing outdoor areas for easy access to help occupants spend time in green spaces, bringing nature into the interior space and ensuring occupant satisfaction by incorporating natural elements like greenery, fresh air, sounds, and colours within the building.

Social connections

Encouraging meaningful connections between people and providing opportunities to be part of communities. Apart from social, economic, and environmental benefits this enhances well-being, reduces anxiety, and fosters overall health.

Design appeal

Employing affective design principles to prioritise human needs. This encompasses architectural and design choices related to aesthetics, daylight, colours, textures, and layout which influence the psychological and emotional responses of occupants.

Affordability

Considering the financial aspect of well-being in buildings. This involves affordable housing design and shared living to address rising urban housing costs and unlock housing for those in need.

2

Designed for human needs

The second dimension prioritises a human-centric design approach to creating healthy buildings, aligning with architectural principles deeply rooted in human-centric design. This approach encompasses methodologies like user-centred, inclusive, and universal design (see [21, 31], with a particular focus on universal design's relevance in the context of healthy buildings[35]).

Key indicators for human needs in healthy buildings

Universal design
Ensuring that the design is equally and easily usable and navigable for everyone, provides clear visual, verbal, and tactile information, integrates flexibility in design to accommodate diverse preferences and needs regardless of ability, age, language, or mobility.

Human-centred interaction
Implementing a collaborative process that includes input from stakeholders, especially users of buildings. Ensuring that the design process integrates perspectives and expertise from various disciplines.

Community design
The built environment surrounding the designed spaces must incorporate aspects that promote socialising for the building community.

Intelligent building design
Integrating smart features that enhance daylight exposure, provide adaptive electric lighting for healthy illumination, and temperature control for comfort and energy efficiency.

3

Sustainably built and managed

The third dimension emphasises the responsible use of natural resources throughout a building's life cycle to maximise benefits for current and future generations, focusing on energy, water, materials, and responsible resource management[36]. People spend a lot of time indoors, therefore the quality of construction materials, and buildings with healthy indoor principles and materials is important so that buildings do not make us sick, but healthier.

Key indicators for sustainably built and managed healthy buildings

Energy and carbon emissions

Focusing on optimising energy use in buildings by employing passive heating and cooling techniques, energy-efficient systems, and measures to reduce both operational and embodied energy such as using renewable energy sources. These strategies aim to enhance energy efficiency and minimise the carbon emissions footprint across the building's life cycle.

Material and circularity

Fostering sustainable material practices that involve selecting bio-based[37] and other low-carbon, durable materials, promoting reuse, recycling, and reduction of building components. Designing for waste minimisation, reducing environmental impact while extending the lifespan of materials. This extension includes exploring options for extending the life of products through proper servicing and the ability to exchange spare parts rather than replacing the entire product.

Water

Deploying sustainable water management that integrates efficient plumbing fixtures to minimise wastewater, implements water recycling and reuse methods, and collects greywater for on-site non-potable use. These practices aim to conserve water resources and reduce consumption.

Management

Implementing building management that includes the right maintenance to ensure the optimum performance of buildings and technologies over the buildings' lifetime. It also encompasses high-quality construction, costs, efficient construction processes, repair, renovation, demolition practices, and waste management.

4

Resilient and adaptive

The fourth dimension focuses on building design and construction that withstands environmental challenges like natural disasters and climate change. It includes resilient cooling, nature-based solutions, and automated indoor climate. This dimension also emphasises the adaptability of buildings to accommodate changes in building use, ensuring their longevity and relevance over time. Tailored emergency response features for new and existing buildings are also integral to this dimension.

Key indicators for resilient and adaptive healthy buildings

Resilient to natural hazards

Designing building structures such as foundations and frames to withstand earthquakes, minimising damage, and ensuring occupant safety. Taking measures to protect against severe weather conditions such as floods, hail, rain, snow, storms, and heatwaves, enhancing building resilience.

Integrated resilient cooling and ventilation systems

Integrating resilient cooling systems that encompass both active (mechanical) and passive (natural) methods to adapt to climate change and unforeseen challenges like pandemics, ensuring occupant comfort and well-being. The design emphasises swift transitions from mechanical to natural ventilation to enhance buildings' adaptivity and resilience.

Blue and green infrastructure

Outdoor elements designed to cool the air and act as water retention systems, referred to as 'blue infrastructure', include features such as ponds and reflective surfaces. The incorporation of exterior[38] greenery, termed "green infrastructure," aims to cool and purify the air, restore ecosystems, and manage water through permeable surfaces.

Advanced smart and/or automated features

Implementing smart features like solar shading, blinds, and locks to enhance safety and optimise indoor comfort. Power management adjusts electricity usage based on the grid load, while monitoring and control features are cognisant of user health, giving users control. Connected emergency response services ensure the safety of occupants.

5

Empowering people

The fifth dimension highlights the importance of raising awareness and equipping individuals with the knowledge and skills needed to create and maintain healthy buildings. It recognises that building users, including residents, staff and professionals, play a crucial role in enhancing both their health and well-being and the sustainability of the buildings they live or work in. This emphasis on promoting the well-being of people is essential to achieving a more sustainable future, as explicitly featured in the UN Sustainable Development Goals.

Key indicators for empowering people in healthy buildings

Skills and knowledge

Improving expertise and capacity in healthy building practices. This involves integrating health components into existing education programs and providing informative materials, including case studies, to bridge knowledge gaps and promote skills development.

Effective communication among stakeholders[39]

Fostering open dialogue among stakeholders by encouraging effective interaction between stakeholder groups, from construction companies to government agencies and local authorities, using diverse communication channels to ensure that all voices are heard and integrated into the decision-making process.

Occupant behaviour and control

Encouraging healthy behaviour with personal control that involves occupants actively adjusting physical indoor parameters, and thereby fostering a healthier indoor environment.

Information access and sharing

Facilitating and safeguarding information access and sharing, building management systems provide options for occupants to utilise sensor data, energy usage statistics, and indoor comfort (temperature, daylight and fresh air).

The lack of data and challenges for implementation tools

The indicators under each dimension of the healthy buildings framework can be broken down into specific sub-indicators, as shown in the Appendix. Data associated with each indicator/sub-indicator may then be analysed in order to gain insight into the state of healthy buildings in the EU. Therefore, a two-step approach was taken to identify and assess data linked to these indicators, by:

1. **Checking the EU databases to match them with the indicators, and**
2. **Using the available data for assessing the indicators/sub-indicators on case study buildings.**

For the first step, existing data in EU databases, such as EUROSTAT, BSO, and ODYSSEE, were investigated to find datasets that match the healthy buildings framework indicators[40]. A critical issue is that most data are only collected at the household level (e.g. through large-scale surveys such as EU-SILC) which only cover residential buildings, and are not regularly collected each year. This makes the consistent tracking of all building types for each year almost impossible.

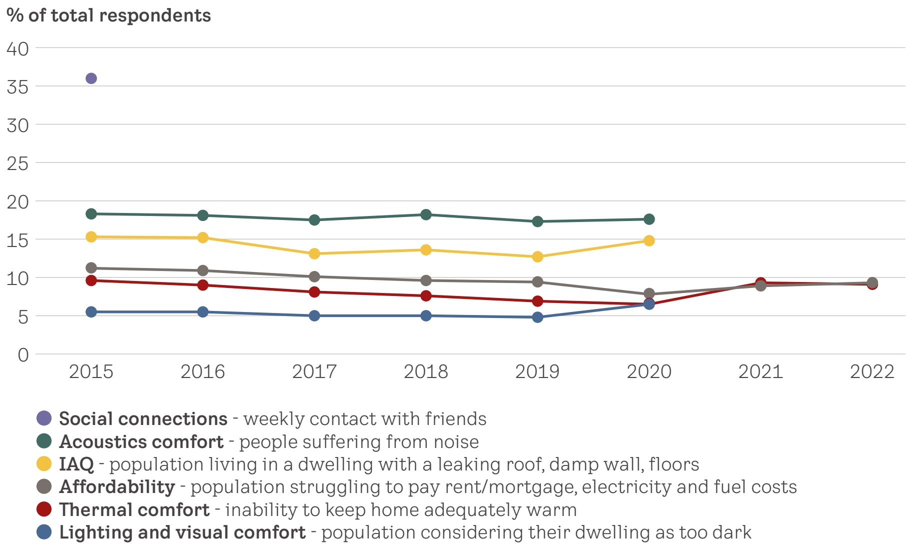
Initial analysis suggested that for about half of the indicators, data do not exist. For the remaining half of the indicators, 40% have incomplete datasets[41]. Therefore, only 30% of the data required can be tracked over time. Indicators such as 'ventilation' or 'information access and sharing' do not have associated data. Indicators such as thermal comfort (measured as overheating) have only been surveyed once for all Member States, and that survey was some years ago, in 2012. To give an idea of availability issues, data for six of the mental and physical health indicators are shown in the following graph[42]. This provides a snapshot only but illustrates the issues when trying to track healthy buildings across time. The extensive data mapping exercise (which is not exhaustive and should be updated continuously to reflect updates in data collection at the EU level) across all dimensions is described in the Appendix.

Ideally, all indicators in the framework are associated with data to keep track of healthy buildings in the EU. However, certain indicators, especially those within the 'designed for human needs' dimension, present challenges in quantification as they are more qualitative in nature. These aspects often relate primarily to the building's design stage, making direct measurement challenging. Despite the inclusion of detailed indicators in the framework, it's crucial to recognise that data availability for all indicators may be limited. Some inherently involve subjective assessments, particularly during the design phase of the building.

The European Commission recognises[43] the issues of lack of coordination and limited amount of good quality data collected on the health of buildings [32]. This framework therefore helps to put not just buildings, but healthy buildings at the forefront of decision-makers' minds. The table in the Appendix helps to understand where data could be linked to indicators, where data gaps are, and where data collection effort is required.

For this Barometer, the reference year for the available data is 2015, when the first Healthy Homes Barometer was published and the Paris Agreement was formulated. For future Barometers, a steady improvement in data availability is expected, in turn yielding an increasingly full picture of the state of healthy buildings in the EU.

Impact of six healthy building issues in the mental and physical health dimension across the European Union



Overview of best practice cases

The case studies presented here are real building projects, assessed using the new Healthy Buildings Barometer framework.

Each case was assessed across all five dimensions, resulting in a grade for each dimension. Each case study was graded on whether works completed fulfilled the requirement of each indicator associated with the dimensions[44] (for example, 'ventilation system installed' is a measure for the sub-indicator 'ventilation and air filtration', and 'installing roof and façade windows' is a measure for the sub-indicator 'lighting and visual comfort'). This grading enables stakeholders (including those in the building industry) to evaluate how different project measures contribute to the five dimensions of a healthy building.

For each of the countries presented on the following pages, some selected datasets from the table in the Appendix are shown. These datasets compare the seven countries over the time period from 2015 up until the latest available date. Considering the data limitations outlined previously, these serve as illustrations of how healthy buildings could be tracked, and underline where new data is most needed [45]. Two datasets are represented per country. Some relate to the country context in terms of climate, while other datasets relate to the case studies. With more data availability, this approach can be used to better monitor and evaluate buildings' health.

The European Union building stock is diverse in terms of building types, age of stock, and climate zones. To effectively represent different parts of the buildings stock, the case studies in this report span public, commercial, and residential buildings across different climate zones[46] – a renovated school in Denmark, a newly built residential roof extension in France, a renovated barn house and music academy in Germany, newly built social housing apartments in the Netherlands, a renovated single-family detached house in Slovakia, a renovated market hall in Spain, and a newly built office building in Sweden[47].

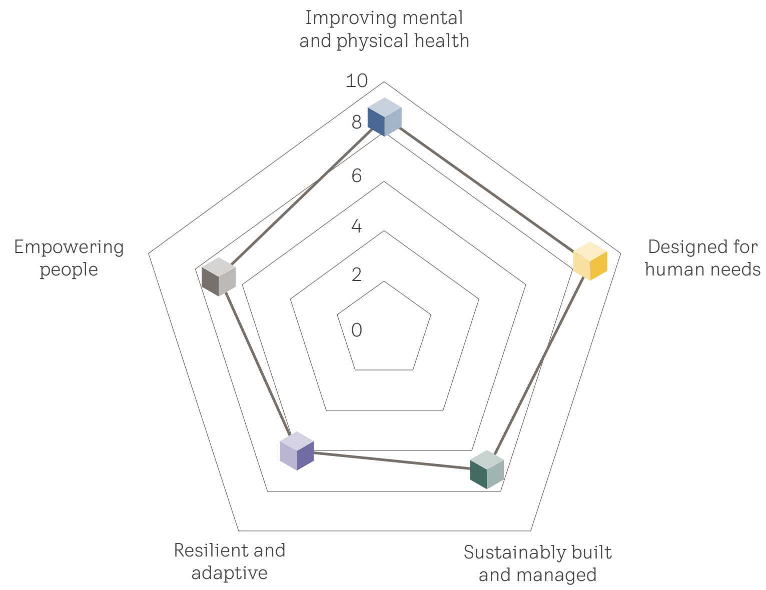
Lessons learned from case studies

The best practice cases are concrete examples of how a vision of healthy buildings can be made real through actual building projects. Healthy buildings remain the exception across the EU, however these cases show that we can turn them into the reference standard for all buildings. Sustainability, resilience, and affordability can be simultaneously realised. Across residential, public, and commercial buildings, innovative and different approaches are possible and achievable.

As can be seen in the radar chart, the consolidated average grades for all five dimensions from the case studies[48] demonstrate how stakeholders in the building industry, as well as policy makers, can use the framework to evaluate the health of buildings and consequently of occupants. The framework can support stakeholders in the early stages of the project to ensure that the measures proposed (for new building or renovations) are tackling the five dimensions. If sufficient data are available, a second assessment using the framework could be done, providing a post-occupancy evaluation (POE) to assess how healthy the final building is. The framework could also be used simply to evaluate any other existing building or building stock.

The following pages feature case study highlights from the seven countries.

How well do the case studies meet the five dimensions?



Consolidated grades for each dimension averaged across case studies

Strengths of cases	Weaknesses of cases	Data and indicators matching issues	Further testing of framework
• Efficient and creative management processes for renovation and new builds means better integration of healthy building dimensions • Working with everyone involved in the project, including building users, to ensure all needs are met • IAQ addressed in all cases, especially with the combination of daylight and ventilation	• How users are informed of data usage and sharing not clearly identified across cases • Resilience and adaptability of cases could be improved. In particular, blue/green infrastructure integration could be strengthened to fully reap benefits for people and environment • Demonstration of user control for thermal comfort not clear in all cases	• Data available at household level, more data required across all building types • Important indicators (e.g. overheating) either not measured, or not measured over time • Develop methodology to collect qualitative indicators in a framework that could be measured at EU and Member State level	• Test framework on more cases across all building typologies • Include all countries within the EU (where case are available) • Incorporate feedback from case study partners to develop framework further • Test framework at early design stage of building projects

Denmark
Case study: Langebjerg School

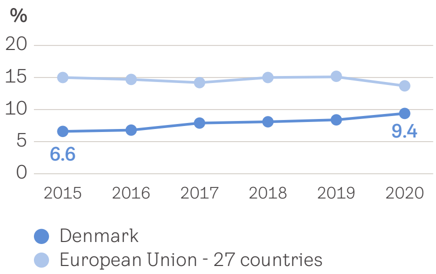
Fresh air and daylight improves concentration at Langebjerg School

About the case study
Langebjerg School was renovated to bring daylight to dimly lit classrooms and to increase indoor air quality. The students and teachers reported difficulties with concentration because their classrooms were too dark and not sufficiently ventilated. The renovation strategy included installing large roof windows to let in more natural light, and improving thermal comfort and indoor air quality through automatic CO_2 and temperature detectors. Resource efficiencies include the reuse of wooden rafters in the renovation, while the solar window shades help to maintain comfortable indoor temperatures in all weathers. The project has been integrated into the lesson plans, enhancing the building users' knowledge - students and teachers alike. Changing just a few elements of the building can lead to wide-ranging benefits that contribute to the dimensions of a healthy building.

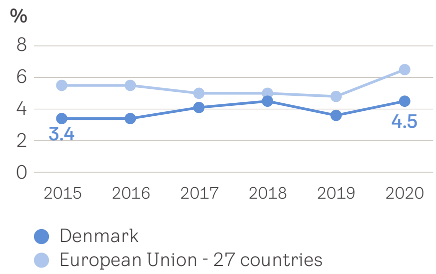
Data insights for Denmark
Data limitations constraint analysis across all case studies and countries. Here, two data attributes for which data are available and which are related to two of the indicators, 'IAQ' and 'Lighting and visual comfort' of the Improving mental and physical health dimension, are presented.

Indoor conditions-related data are usually only collected for households, and there is a clear need to collect better data for other types of buildings. Since no data are available for indoor pollutants, the outdoor pollution rate is used instead in this case. In Denmark, the rate of pollution[49] has increased since 2015, indicating the importance of measures such as those introduced in Langebjerg School. With regard to the 'Lighting and visual comfort' indicator, more than 5% of Danish people consider their dwellings too dark[50], with an increase since 2015. Better daylighting and exposure to light, as addressed by Langebjerg School, are pressing issues to be tackled. Both data sets show a worrying trend, which is that neither outdoor pollution nor lighting issues have made progress since 2015.

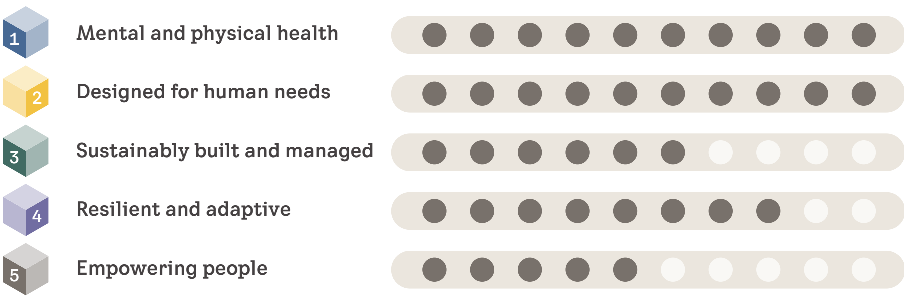
Outdoor pollution rate



Perception of dwellings too dark



Dimensions addressed in case study



Key facts for Denmark

42%
Increase in pollution rate for Denmark from 2015 to 2020.

32%
Increase in Danish people considering their dwellings too dark from 2015 to 2020.

See project details here
https://cdn-marketing.velux.com/-/media/marketing/master/professional/cases/langebjerg%20school%20-%20denmark/501279-01%20v14417-040-012-004_langebjerg-skole_booklet_eng.pdf?

France
Case study: Malakoff raise-the-roof apartments

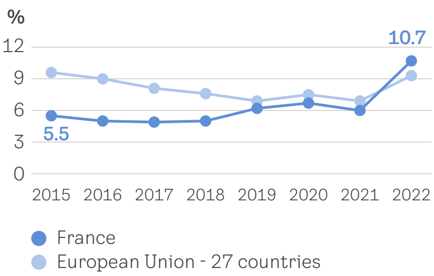
Designing roof extensions for thermal comfort with sustainable building materials

About the case study
This raise-the-roof project added two new apartments on top of an existing building. It demonstrates how sustainability (use of lightweight bio-based construction materials, i.e. timber), climate resilience (passive cooling through roof window ventilation and window shades, and insulation), and great indoor air quality (use of non-toxic materials [33], good ventilation) are achieved in a well-designed roof extension. This is a perfect space solution for densely populated areas. Using off-site construction meant minimal disruption for the building occupants.

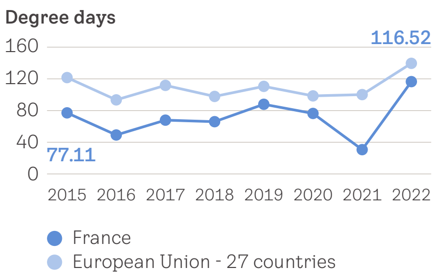
Data insights for France
Monitoring thermal comfort in buildings will become increasingly important given the unpredictability of Europe's future climate. Therefore, for the dimension Improving mental and physical health, the 'Thermal comfort' indicator is analysed during winter and summer through two data sets: 'Inability to keep home warm' and 'Cooling degree days'[51].

EU data tracking the ability of people to keep their homes adequately warm[52] and cooling degree days[53] (the need to cool on hot days) since 2015 show that the number of cooling degree days has increased in recent years, and the ability to keep homes warm is getting worse, especially in France. Healthy building projects such as the raise-the-roof project in France can help people adapt to changes in temperatures.

Inability to keep home warm

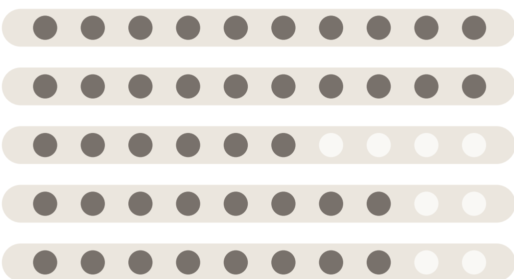


Cooling degree days



Dimensions addressed in case study

1 Mental and physical health
2 Designed for human needs
3 Sustainably built and managed
4 Resilient and adaptive
5 Empowering people



Key facts for France

95%
Increase in inability to keep home adequately warm in France from 2015 to 2022.

51%
Increase in number of cooling degree days for France from 2015 to 2022.

See project details here
https://www.construction21.org/france/case-studies/h/surelevation-a-malakoff.html

Germany
Case study: Dortmannhof + Hammelburg Musikakademie

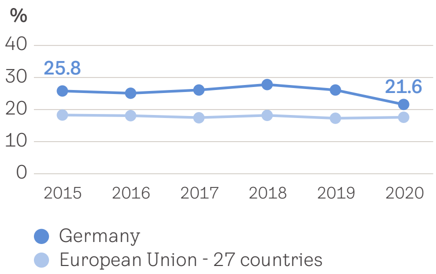
Balancing traditional aesthetics and modern function

About the case study
Two historical buildings were renovated with very similar intentions: retaining the beauty of the historical features in the buildings, while adding comfort and lowering energy consumption. The residential house (Dortmannshof), which was an agricultural barn, received energy upgrades only to the living areas to keep changes to a minimum. Local regulations due to historical building protected status restricted any external modifications to the outside of the house, therefore, windows were added from the inside. For the music academy, the local authority saw the benefit of renovating the former monastery and allowed significant changes. The project team kept the original features, but extended façade windows and added roof windows, and converted the courtyard into a dining and meeting hall. For both buildings, acoustics were important, therefore design teams adjusted the buildings through space isolation or sectioning. The end results are more comfortable, brighter, and energy-efficient historical buildings.

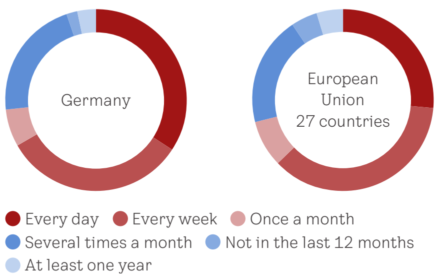
Data insights for Germany
As both case studies feature acoustics elements and social interactions, two data attributes for which the data are available and which are related to the indicators 'Acoustics comfort' and 'Social connections' of the Improving mental and physical health dimension are presented.

Data solely focuses on household noise pollution[54] across EU countries, neglecting other building users. German data underscores the necessity for acoustically comfortable homes like Dortmannshof. Additionally, the 'social connections' indicator was analysed as spending time with family and friends[55], which has only been collected once in 2015. While this dataset again shows the limitations of data collection, it can be seen that contact with friends is important to most Europeans, including Germans. Projects such as the Dortmannshof and the music academy showcase how paying attention to creating spaces that allow for meaningful connections is possible.

Households suffering from noise



Frequency of contact with friends, measured in 2015



Dimensions addressed in case study

1 Mental and physical health
2 Designed for human needs
3 Sustainably built and managed
4 Resilient and adaptive
5 Empowering people

Key facts for Germany

16%
Decrease in number of people suffering from noise in Germany from 2015 to 2020.

29%
More Germans like to meet friends every day, compared to EU average.

See project details here
Dortmannhof case: https://assets.foleon.com/eu-central-1/de-uploads-7e3kk3/49490/de_dortmannhof-sigurdlarsen.c9c33782bfb9.pdf
Hammelburg Musikakademie case: https://assets.foleon.com/eu-central-1/de-uploads-7e3kk3/49490/de_musikakademie.bd69bfd15761.pdf

The Netherlands
Case study: Nijverdal social housing apartments

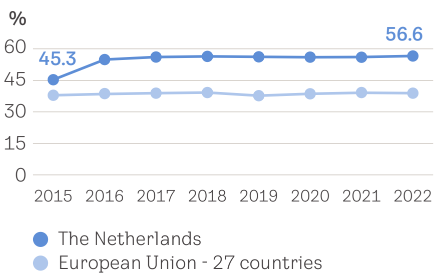
Smarter construction processes for affordable housing

About the case study
This newly built social housing apartment block was developed with ActiveHouse Alliance[56] principles, one of the primary design guidelines in the Netherlands. It aims to create sustainable, affordable, and comfortable housing, featuring many of the indicators of the healthy buildings framework. A novel integrative construction process using off-site construction and circular materials was created that focused on early-staged multidisciplinary collaboration, knowledge-sharing, and genuinely paying attention to everyone's interests in the value chain. This led to a higher product quality and significant cost reductions due to efficiency gains. The use of bio-based materials decreases the carbon footprint of this building, and together with creating affordable social housing, the five dimensions of health are integrated in a highly efficient way.

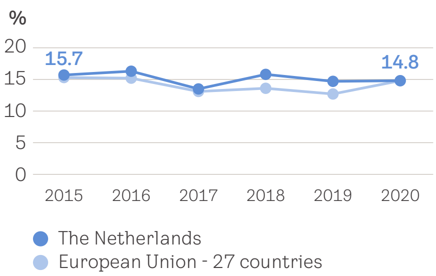
Data insights for the Netherlands
Here, two data sets linked to the 'IAQ' indicator from the Improving mental and physical health dimension and the 'Blue and green infrastructure' indicator from the Resilient and adaptive dimension are presented. Healthy building projects must be adaptable to wet weather conditions in order to avoid problems with damp. Moreover, the Netherlands has an urban population[57] of 30-40%, so it's necessary to find innovative ways to utilise building space effectively and to integrate nature.

Damp issues are particularly important in social housing projects, whose occupants might not have enough disposable income to keep their homes warm enough to prevent damp. The Netherlands is above the EU average when it comes to people experiencing issues associated with damp: for people on low incomes, more than 22% had damp issues in 2020[58]. Projects such as this case can successfully deal with both the affordability as well as damp issues. A key factor in the project was to ensure that the least amount of space was used (for example, no parking spaces for cars are provided to save space).

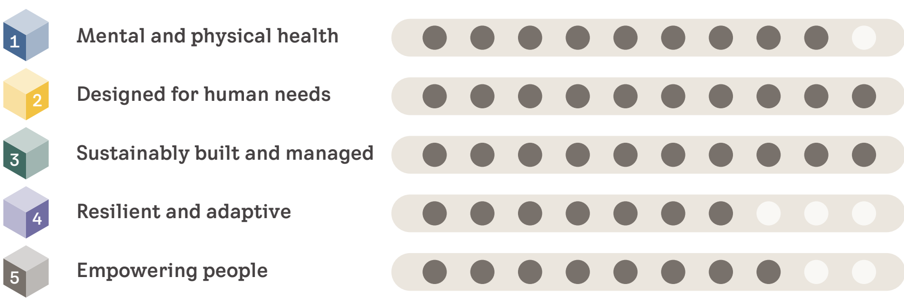
Population living in urban areas



Population living in a damp dwelling



Dimensions addressed in case study



Key facts for the Netherlands

25%
Increase in population living in urban areas in Netherlands from 2015 to 2022.

6%
Decrease in population living in damp dwellings in Netherlands from 2015 to 2020.

See project details here
Bouwen met wat de natuur ons geeft. (sheltr.nl)

Slovakia
Case study: Sala single-family home

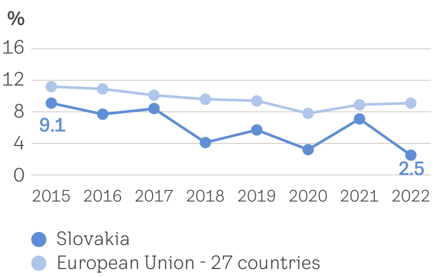
Sustainable improvement of space, air, and daylight for a happy family life

About the case study
With this renovation, a young family living in a single-family square house in Slovakia are now able to be as sustainable as possible by reducing their material and carbon footprint, as well a saving on their energy bills. A chimney-style air tunnel from the ground floor through the stairway up to the roof windows leads to better air-circulation improving indoor air quality and gaining more daylight access through the large windows. The provision of solar window shading means thermal comfort is ensured on hot summer days. Insulating the walls and roof significantly reduced the energy consumption of the building.

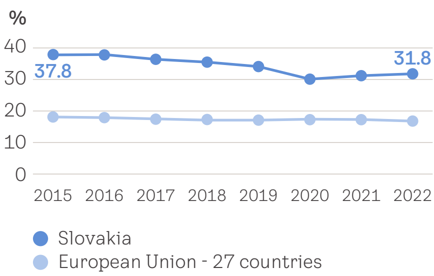
Data insights for Slovakia
As energy costs are still increasing across the EU, energy savings as achieved in this project become ever more important. Here, two datasets linked to the 'Affordability' indicator from the Improving mental and physical health dimension and the 'Universal design' indicator from the Designed for human needs dimension are presented.

Data on how much of one's income is spent on rent/mortgage, utilities and heating fuels is available at the EU level (called the household cost overburden rate[59]), and it shows that Slovakia has a higher spending burden than the EU average. Slovakia also has an issue with too little housing space, as it is experiencing far higher overcrowding[60] rates than other countries in the EU. Since no progress has been made since 2015 to reduce the issue of overcrowding, this healthy buildings project can be a useful guide for how more space can be created while considering other healthy buildings aspects.

Housing cost overburden rate



Overcrowding rate



Dimensions addressed in case study

Dimension	Score (filled dots out of 10)
1 Mental and physical health	10
2 Designed for human needs	7
3 Sustainably built and managed	6
4 Resilient and adaptive	3
5 Empowering people	8

Key facts for Slovakia

73%
Reduction in housing cost overburden rate in Slovakia from 2015 to 2022.

16%
Reduction in overcrowding rate in Slovakia from 2015 to 2022.

See project details here
https://renovactive.sk/en/downloads

Spain
Case study: Valladolid market

Renovating a historical market with contemporary techniques for year-round use

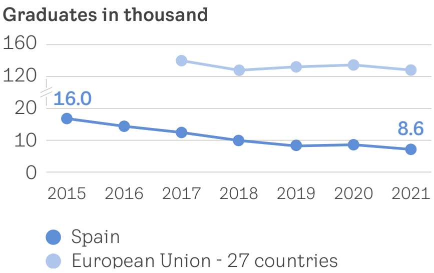
About the case study
The market hall in Valladolid, Spain, was built in 1882 and last renovated in the 1980s. This latest renovation project[61] aimed at tackling multiple improvements at once, including: better insulation, a geothermal heating system, natural ventilation through the roof windows (making use of hot air currents to actively ventilate the hall throughout the year), and building an on-site waste treatment plant. The style of the building was kept, preserving the aesthetic appeal of this beautiful market hall. The changes to the building create a more comfortable market hall in all seasons, with better air quality and using far less energy and resources.

Data insights for Spain
Two datasets related to the 'Skills and knowledge' indicator from the Empowering dimension and 'IAQ' indicator from the Improving mental and physical health dimension are presented.

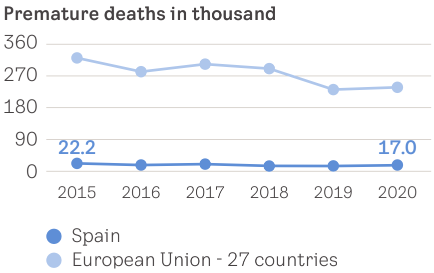
Since 2015, the number of graduates working in the construction sector in Spain has decreased[62]. This is an alarming trend, as the Renovation Wave can only happen with skilled labour in all Member States. Complex projects like this market hall renovation exemplify what highly skilled people can achieve. A major concern for the market renovation was to increase air quality through ventilation.

Ventilation is not measured at the EU level, but several other data sources can be used to extrapolate issues with air quality, such as premature deaths from air pollution[63]. Thankfully, the number of premature deaths from air pollution has decreased since 2015 for Spain and across the EU.

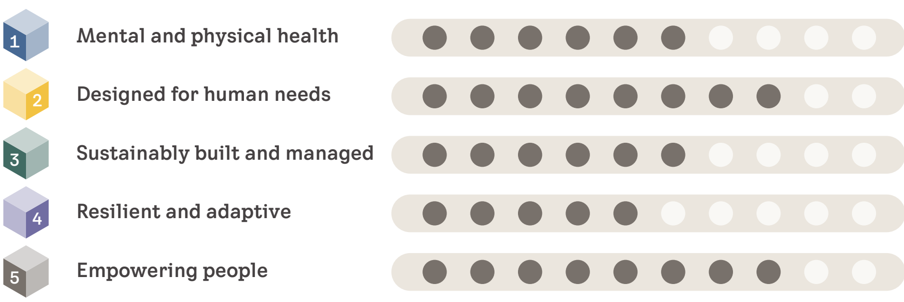
Graduates in architecture/ construction



Total number of premature deaths



Dimensions addressed in case study



Key facts for Spain

47%
Decrease in graduates in architecture/ construction in Spain from 2015 to 2021

23%
Decrease in premature deaths due to air pollution in Spain from 2015 to 2020

See project details here
https://www.renovate-europe.eu/reday/reday-2019/online-resources/valladolid-spain-e20/

Sweden
Case study: Kvartetten office complex

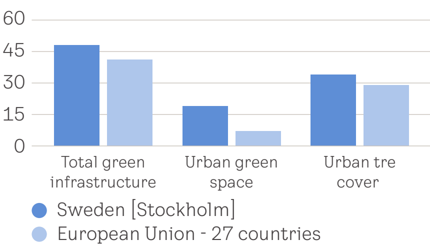
Bio-climatic design principles improving workers' well-being

About the case study
The Kvartetten office near Malmö is healthy for both people and better for the planet. The building received four different environmental and energy certifications[64]. The design withstands Sweden's cold winter temperatures and won't overheat in summer. Close collaboration with different partners and clients involved meant that expectations were met. This office is a good example of bio-climatic [34] and biophilic [35-36] design principles. Bio-climatic design principles work with natural energy systems like sun exposure in the local climate, using local and natural materials. Biophilic design principles try to maximise our natural affinity towards nature by integrating blue and green infrastructure [37]. Such design approaches lead to greater health and well-being and increase indoor air quality through reduced leaching of toxins [33].

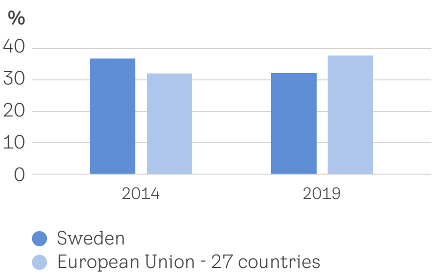
Data insights for Sweden
Two datasets linked to the 'Blue and green infrastructure' indicator from the Resilient and adaptative dimension and 'Social connections' from the Improving mental and physical health dimension are presented.

Data on tree coverage across capitals[65] in the EU is the closest match to blue and green infrastructure, it shows the lack of greenery across capital cities. Another important design consideration for the Kvartetten office was space to socialise and relax. As this is not directly measured, the indicator of perceived social support[66] could be seen as a proxy indicator, providing a valid cause to collect more health-related data specifically for workplaces.

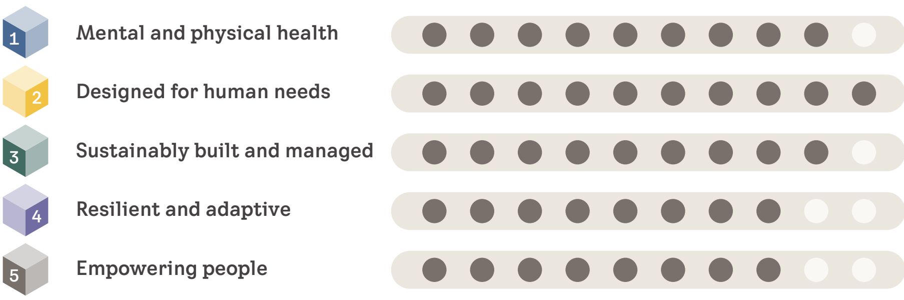
Space cover of green infrastructure



Overall perceived social support



Dimensions addressed in case study



Key facts for Sweden

171%
More urban green space in Sweden compared to EU average.

13%
Decrease in perceived social support in Sweden from 2014 to 2019.

See project details here
https://www.wihlborgs.se/en/projects/malmo/kvartetten-malmo

"Investing in healthier, more efficient and resilient buildings is a triple win strategy which puts people at the centre of the transformation to a sustainable society.

Oliver Rapf,
Executive Director at BPIE

A call for action: Gaps & policy recommendations

The HBB framework can take the pulse of healthy buildings in the European Union. However, there are issues with the availability, quality, and completeness of data. The next step is to outline how policymakers and stakeholders in the building industry can best apply the HBB.

The policy gaps outlined to the right take into account the assessment of the framework through the case studies and EU data analysis, and specifically, the necessity of a more integrated approach to healthy buildings - so that all five healthy building dimensions are addressed simultaneously.

The EU building stock performance is set to improve as momentum builds towards the 2050 climate neutrality targets driven by the implementation of various policies and regulations. Tracking progress towards medium and long-term goals is therefore a high priority. To track the decarbonisation progress, the EU Buildings Climate Tracker reported the progress using indicators such as final energy consumption, greenhouse gas emissions, renovation investments, and household energy expenditure and found that we are not on track to achieve our ambition of climate neutrality. A similar approach is needed to track healthy buildings at EU level. This can only be achieved by making healthy buildings an interest area for EU-level data collection and utilising existing sources as well as creating new data collection pathways.

This Barometer has developed a set of policy recommendations to align collective and coordinated action for healthy buildings with the decarbonisation goal of the Paris Agreement by 2050. These recommendations have been developed to address the ten policy gaps identified in this Barometer and listed in the following pages. The policy gaps and recommendation address one or more of the areas of action outlined below and show the implementation level at which these need to be enacted by responsible stakeholders, and the time horizon by which each of the recommendations needs to be achieved. The national implementation of the EPBD recast represents a concrete opportunity to introduce such holistic building measures and requirements, which take into consideration energy, decarbonisation and social parameters at the same time.

Areas of action

Broaden the regulatory focus to include the notion of healthy buildings and occupants.

Policy makers must broaden the focus on buildings beyond energy performance and CO_2 emissions to introduce the notion of healthy buildings. Policy influencers including those in the construction sector and civil society must broaden their attention to outcomes beyond energy efficiency and reducing CO_2 emissions to include health along with sustainability parameters as well as resilience and adaptability to a warming climate with more extreme weather.

Ensure access to data so that the buildings' health, sustainability, and resilience can be tracked over time.

Authorities must agree on, and ensure adequate/appropriate and consistent data collection on healthy, sustainable, and resilient building indicators to identify gaps and patterns and track progress accurately.

Increase cross-functional collaboration and information sharing between actors within and outside the construction sector.

Actors within and outside the construction sector must collaborate more closely to ensure a holistic approach to buildings that benefits health, sustainability, and resilience. This includes a better exchange of information and communication on innovative design strategies as key elements to healthy buildings projects.

Use decision-making tools effectively to integrate the health, sustainability, and resilience of buildings.

Decision-making tools (such as building-specific tools like building information modelling, building renovation passports, or strategic and procedural tools) should be integrated as appropriate (also digitally) in all phases of a building's life to maximise performance in terms of health, sustainability, and resilience.

Put people at the centre and involve them throughout the lifecycle of buildings.

Design of sustainable buildings must take its starting point in human needs, putting the user at the centre of the design, and involving them in optimising the operation of the building, including smart automisation and guidance during the lifetime of the building.

The ten policy gaps

1

Coherent policy framework
Core gap: There is no coherent and well-functioning policy framework for buildings, capturing all relevant parameters, including health, sustainability/climate and energy.

2

Weak legislation
Weak legislation to provide access to high-quality, healthy, affordable, and environmentally sustainable buildings.

3

Defining IEQ
Focus on IEQ aspects such as indoor air quality monitoring, daylight strategies, passive thermal design solutions, or ambient noise regulations not clearly defined and enforced.

4

Low-carbon options
Too little promotion of low-carbon design principles and materials to minimise the overall carbon footprint of buildings.

5

Climate-responsive buildings
Lack of integrated climate-responsive building design strategies to protect against severe weather conditions and improve thermal comfort in national building regulations.

6

Automation of building components
No existing holistic framework for automation of building components, services, and control has been established by national bodies.

7

Capacity building
Lack of capacity building of professionals and policy makers on the needs and requirements of healthy buildings.

8

Biodiversity preservation
Bio-diversity preservation and accessibility to nature through national planning regulations too weak.

9

Community support schemes
Lack of community support schemes to improve the quality of renovation advice and financial support through local authorities and social institutions.

10

Participatory design
Lack of participatory design through local and national planning departments.

Policy recommendations

How to tackle each of the ten policy gaps to make healthy buildings the norm.

by 2030

1 Coherent policy framework

Policy recommendations
Increased collaboration between different actors at the EU and Member State levels to develop more holistic regulations and standards for healthy buildings beyond energy performance.

Enacting stakeholders
Regulators[68] - EU level first, then national level

Areas of action
- Regulatory focus
- Cross-functional collaboration

2 Weak legislation

Policy recommendations
Include healthy buildings indicators in the building stock observatory (BSO) and integrate them in national policy instruments (e.g. legislation, advisory, financing, building tools, renovation plans).

Enacting stakeholders
1st step: Regulators at national level take initiative

2nd step: Construction industry, architects, designers, urban planners

Areas of action
- Regulatory focus
- Access to data
- Decision-making tools
- People at the centre

3 Defining IEQ

Policy recommendations
Implement new EPBD provisions on IEQ (Art 11 and Annex V on EPCs) at national level and broaden scope of Building Renovation Passports and National Building Renovation Plans to integrate IEQ assessments and quality control checks in new builds, renovations (Annex II and VIIa).

Enacting stakeholders
1st step: Regulators at national level take initative

2nd step: Architects, designers, construction companies, on-site auditors, energy auditors

Areas of action
- Regulatory focus
- Access to data
- People at the centre

4 Low-carbon options

Policy recommendations
To avoid national fragmentation, introduce harmonised EU framework to calculate life cycle assessment (LCA) and set mandatory carbon emission thresholds at EU level based on LCA for new buildings, as requested in EPBD recast.

Enacting stakeholders
1st step: Regulators at EU level take initiative

2nd step: Architects, designers, developers, contractors, auditors, material re-use companies

Areas of action
- Regulatory focus
- Access to data
- Decision-making tools

5 Climate-responsive buildings

Policy recommendations
Introduce more holistic buildings legislation, which factors in the operation of a building throughout the year, factoring in both summer and winter comfort parameters, and incorporating the use of future climate date.

Enacting stakeholders
1st step: Regulators at national level take initiative

2nd step: Architects, designers, construction companies, urban planners[69]

Areas of action
- Regulatory focus
- People at the centre
- Decision-making tools

6 Automation of building components

Policy recommendations
Include healthy buildings indicators to promote smart building technologies such as Building Automation, Sensing, Building Information Modelling and Digital Twins (DBL).

Enacting stakeholders
1st step: Regulators at EU level take initiative

2nd step: Construction industry, architects, urban planners, energy auditors, energy companies

Areas of action
- Regulatory focus
- Access to data
- Decision-making tools
- People at the centre

by 2040

7 Capacity building

Policy recommendations
Provide sufficient education and training opportunities for professionals and policy makers on how to integrate the new indicators for healthy and sustainable buildings in existing processes.

Enacting stakeholders
Universities and training providers, building associations, public and social institutions, educational ministries.

Areas of action
- Cross-functional collaboration
- People at the centre

8 Biodiversity preservation

Policy recommendations
Include biodiversity rules in and around buildings within national building regulations and urban policies.

Enacting stakeholders
1st step: Regulators at national level take initiative

2nd step: Urban planners, public and social institutions[70]

Areas of action
- Regulatory focus

9 Community support schemes

Policy recommendations
Advance and secure public financing and support for integrated one stop shop services.

Enacting stakeholders
1st step: Regulators at EU level take initiative

2nd step: Regulators at local level, social institutions, building trades, energy companies[71]

Areas of action
- Regulatory focus
- Cross-functional collaboration
- People at the centre

by 2050

10 Participatory design

Policy recommendations
Promote adaptability, flexibility, and user involvement in the process of design of buildings and their surroundings to allow for more people-centric approach.

Enacting stakeholders
Architects, designers, urban planners, local authorities[69]

Areas of action
- Cross-functional collaboration
- People at the centre

Conclusion

The aim of the Healthy Buildings Barometer 2024 is to assess the current health of European buildings and their users and to illustrate the significant benefits we can derive as a society from addressing the current shortcomings of buildings.

This report presents an integrated approach for getting on track with delivering the EU's climate commitments, including the renovation rate of its existing building stock. It dives into the specifics of an area that is central - yet has so far often been overlooked: the impact on health and well-being for the users of the buildings. And how this element, in turn, ties in with the overall resilience and sustainability of Europe's building stock.

It proposes a framework for tackling these health and well-being aspects by properly integrating them as part of a broader, holistic approach to buildings - whether newbuilt or renovated - as well as some concrete policy recommendations for bringing this approach alive.

There have been recent, significant events when it comes to recognising the importance of the built environment in creating a sustainable future - both in the economic, social and environmental sense.

Most notably the Buildings Breakthrough Initiative launched at COP28 in Dubai in December 2023, which serves as an action-oriented response to the Global Stocktake, with the goal to make near-zero emission and resilient buildings the new normal by 2030. The Global Buildings and Climate Forum hosted by the French government and UNEP in March 2024 followed up on this pledge by launching the Chaillot declaration, signed by 70 countries, including many in Europe. In addition, the revised EPBD, referenced throughout the report.

The Healthy Buildings Barometer was written against this backdrop - to provide not just the data points on why health impact is an integral metric when it comes to buildings, why we need to ensure that we measure it much more accurately going forward, but also go on to define what 'a healthy building' means, and what can and should concretely be done in legislative terms to ensure all buildings move towards becoming one. With that, the aim is to tackle the biggest obstacle we face today: translating the theoretical concerns and challenges into a concrete set of actions.

Appendix

The table below shows the links between indicators and sub-indicators for the five dimensions and associated data by name, frequency of collection, and latest year data were updated.

Dimension	Indicators/sub-indicators		Linked data [unit]	Frequency	Last updated [year]
Improving mental and physical health	IAQ	Indoor air pollutants[72]	Pollution rate [%]	Annual	2020
			Premature deaths [number of deaths]	Annual	2020
			Years life lost [number of years lost]	Annual	2020
		Ventilation	N/A	N/A	N/A
		DMC	Population living in damp dwellings [%]	Annual	2020
	Thermal comfort		Population living in a dwelling not comfortably cool during summer [%]	Once	2012
			Inability to keep home adequately warm [%]		2022
			Heating and cooling degree days [degree days]	Annual	2022
			Surface temperature [Celsius]	Annual	2022
	Daylight, light and visual comfort		Population considering dwelling too dark [%]	Annual	2020
	Acoustics comfort		Population suffering from noise [%]	Annual	2020
	Connectedness to nature		Urban tree cover/green infrastructure in Europe [%]	Once	2018
			Distribution of population by degree of urbanisation [%]	Annual	2022
	Social connections		Frequency of contact with friends [%]	Once	2015
			Frequency of contact with family [%]	Once	2015
			Perceived social support [%]	Once	2019
	Design appeal		N/A	N/A	N/A
	Affordability		Housing cost overburden rate [%]	Annual	2022
			Medical cost savings from repairs [GBP]	Once	2016
Designed for human needs	Universal design		Overcrowding rate [%]	Annual	2022
	Human-centred interaction		N/A	N/A	N/A
	Community design		N/A	N/A	N/A
	Intelligent building design		N/A	N/A	N/A

Dimension	Indicators/sub-indicators		Linked data [unit]	Frequency	Last updated [year]
Sustainably built and managed	Energy and carbon emissions	Passive heating and cooling	N/A	N/A	N/A
		Energy-efficient systems and technologies	Renovation rate [%]	Once	2016
			Renewables share for heating and cooling [%]	Annual	2021
		Operational energy	Final energy consumption for (households, commercial and public buildings) [thousand tonnes of oil]	Annual	2021
			EPC share [%]	Annual	2023
			Annual CO_2 emissions for (households, commercial and public buildings) [tonnes]	Annual	2021
		Embodied energy	N/A	N/A	N/A
	Material and circularity		N/A	N/A	N/A
	Water		Worst seasonal water scarcity condition [water exploitation index plus (WEI+)]	Once	2019
	Management	High-quality construction throughout the life cycle of the building	Medical cost savings from repairs [GBP]	Once	2016
		Construction and labour costs	Construction producer price [%]	Annual	2022
Resilient and adaptive	Resilient to natural hazards	Earthquake-proof	N/A	N/A	N/A
		Severe weather conditions protection	Annual economic losses caused by weather - and climate-related extreme events [EUR]	Bi-annual	2022
	Integrated resilient cooling and ventilation systems		N/A	N/A	N/A
	Blue and green infrastructure		Worst seasonal water scarcity condition [water exploitation index plus (WEI+)]	Once	2019
			Urban tree cover/green infrastructure in Europe [%]	Once	2018
			Distribution of population by degree of urbanisation [%]	Annual	2022
	Advanced smart and/or automated services		N/A	N/A	N/A
Empowering people	Skills and knowledge		Number of people in tertiary education for specific fields (like architecture, building, engineering)	Annual	2022
	Effective communication		N/A	N/A	N/A
	Occupant behaviour and control		N/A	N/A	N/A
	Information access and sharing		N/A	N/A	N/A

Glossary

CO	carbon monoxide
CO_2	carbon dioxide
CLT	cross-laminated timber
DALY	disability-adjusted life years
DMC	damp, mould, condensation
dB	decibels
EED	Energy Efficiency Directive
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
GDP	Gross Domestic Product
GHG	Greenhouse gas emissions
HBB	Healthy Buildings Barometer
IAQ	indoor air quality
IEQ	indoor environmental quality
Lux	unit of illuminance (lighting)
l/s/p	litre per second per person (indoor moisture)
$MtCO_2$	million tonnes of carbon dioxide
PM	particulate matter
POE	post-occupancy evaluation
ppm	parts per million
ROI	Return on investment
SDG	Sustainable Development Goals
SVOC	semi-volatile organic compounds
TVOC	toxic volatile organic compounds
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
U-value	technical measure for thermal transmittance
VOC	volatile organic compounds

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Notes

1. This is a VELUX-led project, carried out with different research institutes over the years: RAND Europe, Fraunhofer Institute for Building Physics IBP, Copenhagen Economics, Guidehouse (formerly Ecofys), and Humboldt University Berlin.
2. This report showcases only a few of these case studies. The full list with detailed explanations for each case can be found here: https://healthybuildings.velux.com
3. Empowerment is understood as the importance of raising awareness and equipping individuals with the knowledge and skills needed to create and maintain healthy buildings.
4. The Paris Agreement is a legally binding internal UN treaty under the UNFCCC: https://unfccc.int/process-and-meetings/the-paris-agreement
5. Limited availability of healthy buildings statistics due to lack of data collection at EU and Member State.
6. The EU population in 2019 was at 513 million. Source: https://ec.europa.eu/eurostat/documents/2995521/9967985/3-10072019-BP-EN.pdf/e152399b-cb9e-4a42-a155-c5de6dfe25d1
7. 2019 is the last available date when data were collected for all 27 EU states. Source: https://ec.europa.eu/eurostat/databrowser/view/ilc_mdho04__custom_10105150/default/table?lang=en
8. Not all case studies that were analysed as part of the findings are presented in this report, but details on each case can be found on https://healthybuildings.velux.com . This report highlights some of the cases only.
9. Dutch case study on Venlo City Hall, study results published by [5]. The ROI was calculated over a period of 40 years, indicating that the extra investment required for this building would yield a return of 11.5%. The case study is featured on https://healthybuildings.velux.com in more detail.
10. Dutch case study on Venlo City Hall, study results published by [5]. Please see https://healthybuildings.velux.com for more details on this case.
11. German and Belgian case studies. The Belgian case is presented on https://healthybuildings.velux.com, both German case studies are part of the illustrations in this report.
12. Swedish case study on office building, exact figures are 246 kg CO_2e of final emissions. This building also received the highest certifications in Sweden for energy efficient buildings (Miljöbyggnad and NollCO_2), as well as the WELL Core certification. More details on https://healthybuildings.velux.com.
13. https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-first-principle_en
14. https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en
15. https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en
16. While it has not yet been defined in legislation, the EPBD recast defines deep renovation : 'a renovation that transforms buildings into zero-emission buildings' https://www.europarl.europa.eu/meetdocs/2014_2019/plmrep/COMMITTEES/ITRE/DV/2024/01-15/11_AnnextoEPLetterEPBDfinaltext_EN.pdf
17. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
18. https://www.europarl.europa.eu/meetdocs/2014_2019/plmrep/COMMITTEES/ITRE/DV/2024/01-15/11_AnnextoEPLetterEPBDfinaltext_EN.pdf
19. Unhealthy homes are homes that have negative effects on people's mental and physical health (for example, sick building syndrome) due to one or more building faults, such as structural damage and safety issues (such as loose nails or cables), damp/mould, indoor air pollution, overcrowding, noise, or lack of light
20. "A person is considered as living in an overcrowded household if the household does not have at its disposal a minimum of rooms equal to: - one room for the household; - one room by couple in the household; - one room for each single person aged 18 and more; - one room by pair of single people of the same sex between 12 and 17 years of age; - one room for each single person between 12 and 17 years of age and not included in the previous category; - one room by pair of children under 12 years of age." (EUROSTAT definition)
21. Heat deaths can have multiple causes, including inadequately cooled buildings, various vulnerabilities of people, and the urban heat island effect, see [16]. Should be with Current Situation, 3rd paragraph, after 'heatwave across Europe(footnote 21) [16]'.
22. Source: https://ec.europa.eu/eurostat/databrowser/view/ilc_hcmp03/bookmark/table?lang=en&bookmarkId=28b028b5-a368-46f7-9dbe-c01614048bc4&page=time:2012"EUROSTAT Share of population living in a dwelling not comfortably cool during summer time by income quintile and degree of urbanisation – note that this statistic has not been updated since 2012 for individual Member States of the EU. Should be with Current Situation, 3rd paragraph, after 'during summer in 2012'.
23. Source: EUROSTAT
24. Housing-related costs include rent, mortgage, water, electricity and gas (and any other fuels)
25. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare_expenditure_statistics#Healthcare_expenditure_by_function
26. Based on U-values calculated for this project: [18]
27. See syn.ikia project on multiple benefits: https://www.synikia.eu/
28. When a whole home is retrofitted for a low-income household.
29. Costs from upgrading homes to better energy efficiency level for those in fuel poverty.
30. Savings compared to previous utility bills.
31. For every 1% improvement in employee performance from healthier offices.
32. https://buildforlife.velux.com/en/compass
33. See also the Compass model for synergies with this dimension
34. Solar protection device refers to ways in which you can modify the thermal - and visual indoor environment. A device can be applied to a window or a roof window, either inside, outside or in-between. More common devices are blinds, curtains, shutters and awnings, and they can either be manually or automatically operated.
35. See also the Compass model for synergies with this dimension
36. See also the Compass model for synergies with this dimension
37. Bio-based materials are made from renewable resources such as wood or other plant materials (hemp, straw, algae).
38. Greenery could also be added to the interior with attention to moisture management to prevent damp indoor conditions.
39. The Compass model has further synergies with this indicator
40. The cut-off point for data collection was the end of the year 2023.
41. This means that for 50% of the indicators, 40% have incomplete data, which is 20% of the total with incomplete data.
42. The six datasets were taken from the EUROSTAT database. The affordability indicator is defined as: "Percentage of the population living in a household where total housing costs (net of housing allowances) represent more than 40% of the total disposable household income (net of housing allowances)." (EUROSTAT definition)
43. See for example the work of the BSO: https://building-stock-observatory.energy.ec.europa.eu/database/
44. Based on feedback received from each project team
45. For more details on the methodology applied, please see https://healthybuildings.velux.com
46. https://www.eea.europa.eu/data-and-maps/figures/climate
47. This section only showcases some of the cases used to test the framework. A detailed description of all 12 case studies is here: https://healthybuildings.velux.com
48. The aggregated grade was calculated by taking the grade for each of the projects listed in the report, and averaging the score for each dimension. Every dimension has a different number of indicators, therefore the radar chart shows the number of indicators used to assess the grade. These have then been normalised to a score of 10 for better comparison between dimensions.
49. Pollution is measured by EUROSTAT as 'pollution, grime, and other environmental problems' resulting from the state of the local environment
50. Source: EUROSTAT
51. Cooling Degree Days measure the demand for energy needed to cool indoor spaces. Calculated by subtracting a base temperature (typically 65°F or 18.3°C) from the average of daily maximum and minimum outdoor temperatures, a positive result indicates the need for cooling. A higher number of Cooling Degree Days suggests increased demand for cooling energy during warmer periods
52. Source: EUROSTAT
53. Source: EUROSTAT
54. Source: EUROSTAT
55. Source: EUROSTAT
56. https://www.activehouse.info/
57. Source: EUROSTAT
58. Source: EUROSTAT, measured as share of population living in a dwelling with either a leaking roof, damp walls/floors/foundation, or rot in window frames
59. Source: EUROSTAT
60. Source: EUROSTAT
61. See https://www.renovate-europe.eu/reday/reday-2019/online-resources/valladolid-spain-e20/ for details on this project
62. Source: EUROSTAT
63. Source: EUROSTAT
64. See https://www.wihlborgs.se/en/projects/malmo/kvartetten-malmo/ for details on this project
65. Source: EEA
66. Source: EUROSTAT
67. BPIE EU building climate tracker [1]
68. Regulators refers to policymakers within the EU, national level, and local level, such as local authorities.
69. This also includes social housing providers, both attached to local authorities and as independent organisations
70. ibid
71. ibid
72. Ultrafine particles, CO_2, CO, VOCs and SVOCs, radon, lead, asbestos. More on: https://healthybuildings.velux.com

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