

Building 4 People:
Quantifying the impact of a better indoor environment in schools, offices and hospitals

Across Europe, **90 million children and young people** spend their weekdays in schools, colleges and universities. More than **one in three of the working population are office-based.** And every year, **90 million patients** spend more than a week on average in hospitals. Yet the impact of the indoor environment on people's health, well-being and performance is not well understood or adequately addressed in EU policy.

EU climate and energy goals require us to **accelerate the renovation of Europe's ageing building stock,** most of which will still be standing in 2050 and beyond, towards **nearly zero energy levels.** Crucially, these renovations need to also improve indoor environmental quality in order to:

Boost labour force productivity by up to 12%, worth up to €500 billion a year across the EU

Accelerate educational performance of students by up to two weeks a year

Reduce the average length of stay in hospitals by 11% (around one day), potentially saving the European health sector €42 billion annually

Cut CO_2 emissions, reduce energy bills, alleviate fuel poverty, improve energy security and boost innovation in the construction industry.

We spend 90% of our time indoors[1] – at home, in schools, at work, and occasionally receiving treatment in hospitals. Office workers, patients and students are often exposed to overheating during increasingly frequent summer heatwaves, draughty conditions caused by ill-fitting windows, inadequate insulation or poorly controlled ventilation, poor lighting or excessive noise. This all has a negative impact on European citizen's health, well-being and performance.

[1] Klepeis, N.E. et al. 2001. The national human activity pattern survey. Journal of Exposure Analysis and Environmental Epidemiology, vol. 11, no. 3, pp. 231–252.

ABOUT THIS PROJECT

On behalf of Buildings 2030, BPIE undertook extensive research into both published and unpublished studies which quantified one or more benefits from building renovations that improved the indoor environment in offices, schools or hospitals. For details of the analysis, including all reference sources, please refer to the accompanying methodology report [Buildings 4 People].

Lighting, air quality, thermal comfort, noise and other building parameters impact people's physical and mental health, well-being and performance.

Air pollution in buildings originates both from outside (e.g. traffic, industry) and inside sources (e.g. equipment, furnishings, furniture, building materials), as well as from occupants themselves (e.g. breathing out CO_2).

Hospitals, schools and offices – account for nearly half of the total floor area of non-residential buildings in Europe. These buildings will still be with us for decades to come, yet the vast majority need to be renovated to improve their energy performance and indoor climate. We need to reshape how we think about designing, operating, renovating and investing in these existing buildings – and more importantly, how buildings affect the people who occupy them.

The European clean energy transition presents a key opportunity to **invest in people** alongside improving building performance. Implementing the revised 2018 Energy Performance of Buildings Directive (EPBD) will require the building stock to be renovated to reach near-zero energy performance levels by 2050. A **new requirement is to optimise health, indoor air quality and comfort levels when calculating a building's energy needs,** and also when reporting the benefits arising from long term renovation strategies. That will entail renovation of building envelopes; improving heating, cooling and ventilation systems; installing renewable energy systems; and better building automation and control systems. Doing this will cut energy use and, at the same time, improve the indoor environment for building occupants. While the improvement of each parameter - lighting, acoustics, thermal comfort or air quality - on its own would lead to an improvement, the ideal scenario addresses all the elements in a holistic manner to ensure maximum impact for the building users, owners, and society as a whole.

This research takes an important step towards **defining, measuring, quantifying and monetising the impact of indoor environmental quality in schools**, hospitals and offices.

SCHOOLS

On average, students receive around 700 hours of formal education a year. Optimising the indoor climate improves performance, so students could achieve the same results two weeks faster. The time gained could be used for extracurricular activities, holidays or to raise the educational performance further.

Potential beneficiaries (millions):
90

Main benefit:
Approximately two weeks faster learning per year

OFFICES

Each European working in an office generates an average value of €52,000 annually. With 80 million people working in offices in Europe, better indoor environmental quality could stimulate productivity benefits worth up to €500 billion annually, helping to boost the European economy and increase international competitiveness.

Potential beneficiaries (millions):
80

Main benefit:
Up to €500 billion gross value added

HOSPITALS

Improved indoor environmental quality can reduce average time spent in hospitals by 11% - about one day. Across 90 million patients annually, that is a societal benefit worth around €42billion. Patients get better more quickly and can return to their normal daily activities sooner. It also leads to a healthier work environment for staff.

Potential beneficiaries (millions):
90

Main benefit:
Lenght of hospital stay reduced by up to 11%

As most of Europe's offices, schools and hospitals will still be standing for decades to come, holistic renovation is not only necessary from an energy and cost saving point of view, but essential to improve the health, well-being and performance of people.

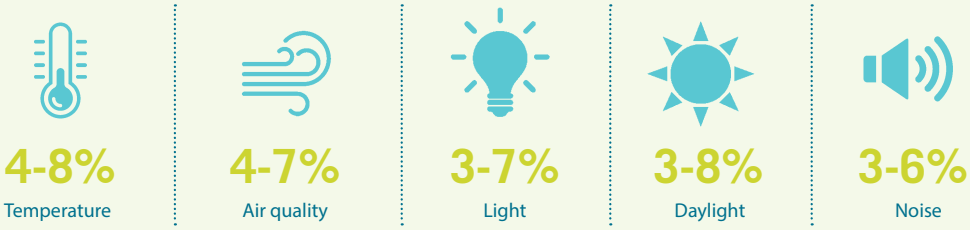
According to the WHO (2017), asthma is the most common non-communicable disease among children. It arises from inhaled substances and particles in bedding, carpets and furniture, and air pollution. Urbanisation has been associated with an increase in asthma.

BETTER SCHOOL BUILDINGS: BOOSTING STUDENTS' ACADEMIC PERFORMANCE

Children are more vulnerable to their environment than adults, so it is vital that schools are designed and refurbished with the aim of maximising all dimensions of indoor environmental quality. Better school buildings bring about better student results. Improved indoor environmental conditions can alleviate adverse health symptoms (such as asthma[2], allergies or headaches) and improve performance: thermal comfort improves attention[3]; removing indoor air pollutants increases cognitive performance[4]; reduced noise aids concentration and memory abilities[5]; and good natural and electric lighting boosts alertness and motivation[6].

Our research modelled the annual impact on learning performance of the main indoor environmental parameters averaged across Europe. We found improvements ranging from 3% to 8% (Figure 1).

Figure 1 Educational performance increase resulting from individual components of improved indoor environmental quality



BETTER OFFICES: ENHANCING PRODUCTIVITY AND WELLBEING

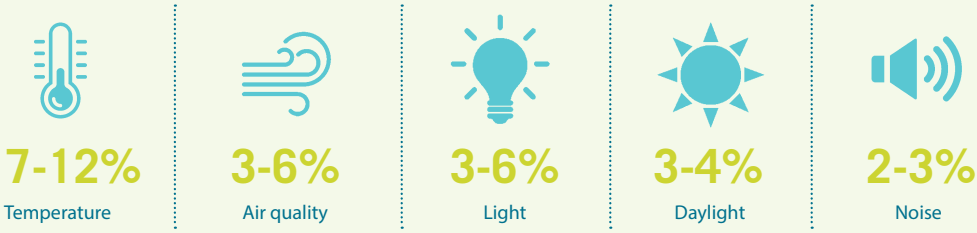
Light should be bright enough for all visual tasks performed by employees of all ages. As well as light intensity, lighting design should take account of the amount of daylight, glare and reflection, light distribution and spectral distribution.

Improving the indoor environmental quality of offices leads to significant improvements in health, well-being and workers' performance:

- Suitably heated, cooled and ventilated offices reduce drowsiness, helping people to stay focussed and perform better.
- Achieving and even improving on recommended levels of CO2, particulate matter and volatile organic compounds reduces symptoms of "sick building syndrome" such as coughing and headaches.
- Optimal, human-centric lighting improves health and well-being; it raises the performance of employees, increases concentration and reduces fatigue.
- Both internal and external noise factors have effects on performance and well-being. Noise attenuation enables us to focus better and alleviates stress.

Improving the indoor environment, and the ability to control it, can raise the performance of office employees by up to 12%, as illustrated in Figure 2.

Figure 2 Employee performance improvements resulting from individual components of improved indoor environmental quality.



[2] WHO. 2017. www.who.int/news-room/fact-sheets/detail/asthma
[3] Wargocki, P. and Wyon, D.P. 2017. Ten questions concerning thermal and indoor air quality effects on the performance of office work and schoolwork. Building and Environment vol. 112, pp. 359–366.
[4] Allen, J.G. et al. 2016. Associations of cognitive function scores with carbon dioxide, ventilation, and volatile organic compound exposures in office workers: A controlled exposure study of green and conventional office environments. Environmental Health Perspectives vol. 124, no. 6, pp. 805–812.
[5] S. Pujol et al. 2014. Association between Ambient Noise Exposure and School Performance of Children Living in An Urban Area: A Cross-Sectional Population-Based Study. Journal of Urban Health vol. 91, no. 2, pp. 256–271.
[6] Schulte-Markworth, M. et al. 2010. "Effect of Light in Schools" vol. CIE x035:2, pp. 229–231, 2010.

BETTER HOSPITALS: FACILITATING BETTER AND FASTER HEALING

Every year, 90 million patients spend more than a week on average in hospitals.

In hospitals, an improved ventilation system will reduce the risk of infections, while controlling the temperature is important as different rooms and people require different settings. Improving hospital environments will increase organisational productivity and improve the healing process, while reducing stress and risks for patients, personnel and visitors. Patients recovering in good acoustic environments are generally less stressed, have more stable blood pressure and better quality sleep. Proper lighting and acoustics are also important to minimise the risk of mistakes made by doctors and other personnel. Furthermore, access to daylight, coupled with an attractive view, has a strong correlation with how quickly patients recuperate.

Among the quantified benefits of improved indoor environmental quality in hospitals, we found:

- Patients' length of stay can be reduced by 11%
- Medication costs are reduced by up to 21%
- Mortality rate in one children's hospital was reduced by up to 19%
- Employee turnover is reduced by up to 20%
- Reducing noise levels has positive effects on heart-rate, pulse, respiration and sleep.

FILLING GAPS IN THE KNOWLEDGE BASE

Our research has revealed significant gaps in the literature and in our knowledge of the full impact of indoor environmental quality on the health, well-being and performance of building occupants. More research is needed across the EU, particularly newer Member States. We note in particular:

1. There is a lack of holistic, longitudinal studies set in real environments that measure all indoor environment parameters and their impact on people.
2. Performance or productivity is defined and measured very differently, making it difficult to compare results. The duration of studies also differs, which results in lack of consistency. Few studies quantify the impact over a full year to account for seasonal changes.
3. Technologies are not evenly represented in the research, with most studies to date on temperature, indoor air quality and light in schools and offices.
4. The impact on patients and personnel in hospitals remains under-represented.
5. Most European studies have been undertaken in western countries, with very few in newer Member States.

MORE RESEARCH IS NEEDED ACROSS THE EU

POLICY RECOMMENDATIONS

If EU policy-makers wish to secure the substantial societal benefits identified in this study, they should:

1. **Align climate, energy, building, and health policy threads to ensure that indoor environmental quality is fully integrated into national long-term renovation strategies** and other building-related policies, with specific targets and indicators to measure progress. Tools such as **building renovation passports** should be promoted and implemented to ensure that measures supporting health and well-being are integrated into renovation plans. A **cross-departmental committee should be established** to ensure that the energy and health agendas related to building policies are developed holistically.

2. **Establish a "Healthy Buildings Observatory"** to provide a sound evidence base and a good model on which to develop future policies. The observatory should gather, analyse and communicate data, information, studies and other relevant research so that the health, well-being and performance benefits from energy renovation of our buildings can be more widely recognised, at both EU and Member State level. In particular, it should fill the knowledge gaps identified above. Policy-makers should also ensure there are appropriate links to the work of EU-OSHA, the European Agency for Safety and Health at Work.

3. **Revise the cost optimality guidelines required by the EPBD** such that the value of the benefits in health, well-being and performance count alongside energy cost savings when calculating minimum energy performance requirements.

4. **Provide clear and specific guidance to Member States** on how to address indoor environmental quality issues alongside improved energy performance within long-term renovation strategies. Exchange of best practices among EU countries, for example through Concerted Action, will be essential in this respect.

5. **Make public funding for building renovation**, e.g. from EU structural funds, **conditional on achieving improved indoor environmental quality.** Monitoring of such projects post-renovation will help build up experience and the knowledge base.

Furthermore, we call on **policy-makers at Member State level to lead by example** by accelerating the renovation of their public buildings towards nearly zero energy levels – not only administrative offices, schools and hospitals, but also the myriad of other buildings, from libraries and leisure centres to prisons and defence establishments. They should also be exemplary when it comes to tracking, analysing and understanding the impact of renovation on occupants.

Implementing these recommendations will help boost the European economy through improved workforce productivity, enhanced learning ability and faster recovery from illness, at the same time as contributing to combating climate change, helping to alleviate energy poverty, reducing energy dependency and boosting local job creation.

More on the study can be found at www.bpie.eu and www.buildings2030.com

The project is sponsored by:

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