INSIGHT

Lighting in the net zero journey: circularity, efficiency and daylight for sustainable buildings

Introduction

BRE published its first guides for architects to assess daylight in buildings in 1940 when Britain was at war.[1] Maximising the health-giving benefits of sunlight and achieving energy and resource efficiency in lighting were urgent necessities at that time.

Today, as we work towards net zero, we have the tools and science to take a much more sophisticated approach to improving human wellbeing in buildings, while delivering high quality, efficient lighting produced with reduced environmental impacts.

Energy Efficiency
The last twenty years has seen the roll out of low energy lighting: a success story that's benefited nearly every household in the country. Modern LED lighting delivers very high levels of efficacy – meaning the amount of useful light obtained from a light source for each watt of electricity.

Efficacy is just one part of overall energy efficiency. There is a large potential for lighting controls to deliver further energy savings, part of the wider transition to smart energy use in buildings.

Circularity
Circularity is increasingly a major focus for the lighting industry. Reuse, remanufacture and recycling can tackle the carbon cost and wastage in the manufacture and disposal of lighting equipment.

Daylight
BRE's 1940 guidance reflected an understanding of the wellbeing benefits of daylight and sunlight; in the 21st century, major progress has been made on the science behind this. Applying modern, good daylighting design to sites and buildings delivers for health, productivity and sustainability.

BRE's role in the lighting transition
BRE therefore continues to produce widely used lighting guidance and provides expert lighting consultancy. BREEAM – BRE's building certification scheme that recognises the world's most sustainable buildings – also incorporates the latest science on efficiency, product circularity and wellbeing, to drive improvement.

This paper outlines progress and priorities for lighting with a focus on efficiency, circularity and daylighting, as we transition our buildings to net zero and beyond.

1. Lewis, A. (2017). The Mathematisation of Daylighting: a history of British architects' use of the daylight factor. Journal of Architecture, 22(7), 1155-1177.

Headline recommendations for government

Energy efficient and smart lighting

- At least 98% of homes are now using low energy lighting. Empirical research is needed to provide better data on how the successful rollout of low energy lighting has impacted energy use in homes and business buildings.
- Extending building regulations requirements for lighting controls in our buildings should be considered for both homes and offices. Potential energy savings from installing lighting controls in buildings are usually stated as around 30-50%[2] but could be significantly higher, especially in commercial buildings when applying multiple well-designed lighting control strategies as part of energy management systems.

Embodied carbon and circularity

- A trajectory should be set for buildings regulations in England to address embodied carbon emissions, including those from lighting.
- With over 100,000 tonnes of new lighting equipment sold in the UK last year, lighting manufacturing and markets need to be designed for circularity. The use of sustainability certifications for buildings that recognise reuse of materials, like BRE's BREEAM, can help change markets and supply chains.

Daylight and sunlight

- As the government plans for an increase in housebuilding, the planning process should emphasise the benefits of daylight. Planning authorities can deploy the systematic approach to site and building design for daylight for homes, non-domestic buildings and refurbishments from the recently updated guidance BRE Report BR209: Site layout planning for daylight and sunlight.
- For building owners and users, industry and government should consider the development of a building daylight indicator (like other consumer sustainability indicators, such as the Energy Performance Certificate rating) to allow easy comparison between buildings and allow consideration of daylight against other aspects of sustainability.

The low energy lighting roll out is a net zero success story. It's time for a policy focus on the next steps in the sustainable lighting transition.

BRE expert measuring electric lighting in a building

2. See, e.g. Carbon Trust (2017) Lighting Overview Guide

Energy Efficiency

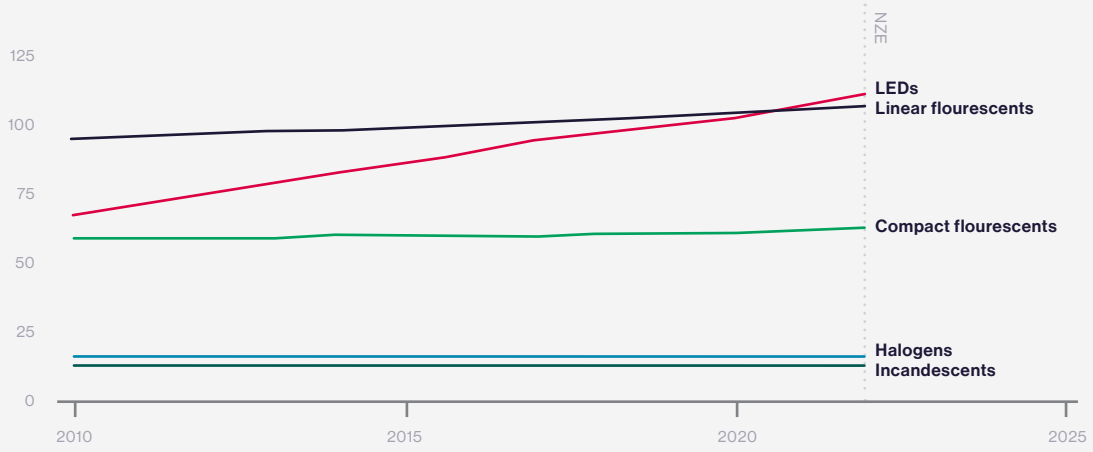
The way we light our homes and business buildings has been transformed. According to the English Housing Survey, in 2001, less than 3% of homes were using low energy lighting. At that time, homes principally relied on traditional General Lighting Service incandescent lamps (what consumers would call light bulbs) alongside slightly more efficient halogen incandescent lamps. By 2021, 98% of homes were using low energy lighting.[3]

While the transition isn't complete – around half of homes in 2021 were still using some incandescent lamps – this large-scale switch in lighting technology has been one of the most significant steps towards energy efficient and low carbon buildings.

Compact fluorescent lighting was the first generation of low energy lighting in most homes; linear fluorescent lighting (strip lighting) had long been used in many commercial settings. Today, LEDs (light emitting diodes) dominate sales for both businesses and homes. Modern LEDs can produce around ten times as much useful light per unit of energy as the old-fashioned incandescent lamps. The energy performance of LEDs between 2009 and 2015 more than doubled, while prices dropped.[4]

The improvement in efficacy has been driven by a combination of rapid advances in technology, alongside effective policies: support programmes, regulations, labelling programmes and government–retailer agreements to steadily phase out old-style lighting.

Traditional incandescent lamps were phased out from sale in the UK from 2009 to 2011, with retailers agreeing to stop selling the products ahead of a European Union ban. Government programmes supported huge giveaways and discounts of low energy light bulbs in advance of the ban.[5] Further phase-outs, restricting the market to ever more efficient products, have continued since then, though not the giveaways. Most recently, a fluorescent lighting ban – which has stopped the production or import of linear fluorescent strip lighting – took effect in Europe last year and in Great Britain earlier this year (2024).



IEA (2023), Lighting efficacy by technology in the Net Zero Scenario, 2010-2030, IEA, Paris
https://www.iea.org/data-and-statistics/charts/lighting-efficacy-by-technology-in-the-net-zero-scenario-2010-2030, Licence: CC BY 4.0

3. UK Government, English Housing Survey, Energy Report 2021-22, Annex Table 4.17 & Homes Report 2011 Annex Table 4.20
4. European Commission data cited in UK Government (2022) Raising minimum energy performance standards for lighting products Impact Assessment Page 6.
5. House of Commons Library (2010) Research Briefing: The Phasing Out of Incandescent Lightbulbs

The government estimates that, in 2022, 22% of electricity use in commercial buildings came from lighting and 14% in homes.[6] This is modelled data and there is a need for new empirical data on current electricity use for lighting in buildings. Improved efficacy of light sources will be delivering major savings, but some of the benefits of low energy lamps will have been spent in so-called 'rebound': more light sources, in more homes and offices, that are left on for longer due to insufficient or inappropriate lighting controls.

To understand the progress we've made, new studies should be commissioned. The government carried out detailed energy use monitoring of lighting and other appliances in 250 homes in the Household Electricity Survey in 2014.[7] A decade later it is time that was repeated.

We need more research to understand how the huge uptake of low energy lighting over the last twenty years has changed patterns of energy demand

Controls

Key to maximising the benefits of low energy lighting are control technologies and smart systems. These include presence and daylight sensors, timers, and, increasingly, networked sensors and controllers linking to energy management across the building. In 2019, the US Government estimated that the most advanced connected lighting systems could cut a third of lighting energy use in homes and even 70-85% in some commercial building sectors.[8]

In BRE's experience (laid out in our guidance Selecting Lighting Controls) the critical issue is careful design of control systems for building and occupant requirements. Inappropriate or insufficient controls can achieve no or minimal savings.

The priority for regulations, which have successfully driven such improvements in the efficacy of light sources, is now to promote uptake of controls to deliver overall energy efficiency of lighting in buildings.

Looking beyond low energy light fittings, regulators need to focus on smart controls in our buildings

From 2027, large existing buildings in the EU will be required to install zonal lighting controls and occupancy sensors

In new homes and businesses

Since 2014 building regulations for non-domestic buildings have allowed the LENI (Lighting Energy Numerical Indicator) to show compliance with the regulated energy efficiency standards. LENI reflects overall lighting efficiency: the energy required to provide sufficient illumination across the building over the year. But for new homes, the building regulations assessment is still based only on efficacy and is measured by light output per watt.

In existing buildings

Existing, as well as new buildings, could also be a focus. Under a new European Union directive, the largest non-domestic buildings in Europe will be required from 2027, where technically and economically feasible, to install automatic lighting controls that are zoned and capable of occupancy detection. Medium-sized non-domestic buildings will follow suit from 2029.[9] A similar approach could be considered in the UK.

6. UK Government (2023) Energy Consumption in the UK, ECUK 2023: End Use Tables
7. https://www.gov.uk/government/collections/household-electricity-survey
8. US Department of Energy (2019) Energy Savings Forecast of Solid State Lighting in General Illumination Applications Table F4, P.112
9. Building size determined in terms of HVAC capacity: large buildings over 290kW, medium buildings over 70kW. Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast)

Circularity

Over 100,000 tonnes of lighting equipment was placed on the UK market in 2023,[10] with a significant carbon and wider environmental cost for its manufacture and disposal.

Regulations already tackle some of the wider sustainability impacts of lighting equipment. The recent ban on fluorescent lighting, which uses mercury in its manufacture, was motivated as much by energy saving as by a global effort to protect human health and the environment from the toxic metal.

BREEAM certification

BRE's BREEAM certification recognises the highest standards of sustainability in new and refurbished buildings, including the whole life carbon impacts and reuse of materials. One recent BREEAM "Outstanding" building, Entopia, a fully refurbished office building in Cambridge, shows what is possible.

The Entopia refurbishment focused on whole life impacts throughout the project and included the reuse of LED light sources another building. To ensure performance and safety, this reused lighting equipment was fully tested and re-warranted.[11] Alongside other reused equipment this delivered a saving of 21 tonnes of carbon emissions in the finished project. Meanwhile, the whole lifetime carbon impact of the building was calculated over a 100-year period, considering the building's operation alongside the carbon cost of the materials and equipment used in construction.[12] For BREEAM, this data will be used alongside similar data from other buildings to set future benchmarks for buildings' embodied carbon performance.

Supply chains and regulation need to be structured to promote this circularity in the lighting market.

Industry action

Some of the change will come from within industry: the End Cat A campaign is led by the property industry. It aims to end – or at least limit – the practice of installing lighting in newly built business buildings; lighting that is often immediately replaced by an incoming business tenant. In 2023, FIS Ltd., the representative body for the £10 billion finishes and interiors sector in the UK, began a one-year pilot project storing lighting products for re-use.

Environmental Product Declarations – issued by BRE and others for products including lighting – enable manufacturers to provide data on a product's life cycle assessments including its potential for reuse and recycling. The lighting market is moving to meet client demand for this information: Signify, the world's largest lighting company, announced in March 2024 that it had released more than 2000 EPDs covering 70,000 product variations.[13]

Measuring and regulating the sustainability impact of lighting

Currently, national building regulations in England still do not require builders to assess construction products' whole life cycle impacts in new buildings. For BRE this is a key issue that the new government should address. In France, since 2022, a national products database has powered a set of national building regulations which set standards for whole life carbon emissions from buildings. The UK urgently needs to do the same: setting its trajectory for building regulations to address embodied carbon emissions, including those from lighting.

10. 104,356 tonnes (around 6% of all electrical and electronic equipment placed on the market by members of Producer Compliance Schemes) in 2023. UK Government (2023) WEEE data Electrical and electronic equipment placed on the UK market
11. Alliance for Sustainable Buildings Products Case study – CISL Entopia Building
12. Cambridge Institute for Sustainability Leadership, Building Entopia
13. Signify (2024) Signify releases 2000 Environmental Product Declarations (Press Release)

Balancing daylight and artificial lighting

The benefits and challenges of daylight in buildings
Access to daylight helps make a building energy efficient; effective daylighting will reduce the need for electric light, while winter heat gains from sunlight can reduce heating requirements. Access to daylight can improve task performance, educational attainment, mental health and wellbeing and recovery from physical illness. Daylight makes an interior look more attractive and interesting.

Homes and business buildings that maximise daylight can come in many different layouts. Modern designs and technologies such as internal light wells or high surface reflectance can maximise daylight inside buildings, even in urban settings where taller buildings closer together can block some of the daylight coming through windows.

However, despite its benefits, maximising effective daylight can be complex in building design terms. Effective use of daylight means a well-designed space and a building envelope with the right shading enabling large, glazed areas being installed. Without careful design, more daylight can make glare a risk, as well as increased heat gains in summer and heat loss in winter. Poor design can lead to detrimental impacts on comfort and wellbeing; sustainability benefits can be undermined as more energy is needed for heating and cooling.

BREEAM
BREEAM certification recognises the importance of daylight. In the case of the BREEAM "Outstanding" Entopia renovation, developers were able to use Cambridge Council's recent declaration of a carbon emergency to argue for a retrofit design that "maximised daylight values and reduced the demand for electric lighting and associated carbon emissions."[14]

Research on the benefits of daylight for health and wellbeing is growing. In recent years, researchers have identified how certain eye photoreceptors – separate from those used for vision – respond to specific wavelengths in the visible spectrum, to drive our circadian rhythms and hormonal systems [15]. This science is being incorporated into standards for types and levels of lighting in the next update of BREEAM.

Policy action – planning and building regulation
BRE Report BR209: Site layout planning for daylight and sunlight is the principal document supporting designers and developers when it comes to the use of daylight in buildings. The guide aims to ensure new buildings deliver both daylight and sunlight inside buildings and minimise loss of daylight and sunlight to existing properties and public areas and green spaces. It is used by many councils and other planning authorities to agree standards for daylighting with developers, particularly for new homes.

There are many steps that could be taken to strengthen the provision of daylight in our buildings. In Building Regulations, extending the use of the LENI indicator to homes would allow consideration of levels of daylight in the assessment of the artificial lighting provided.

Daylight and sunlight assessments need to continue to be an integral part of the planning process: digital daylighting modelling is transforming assessment and design processes in this area to be both rapid and effective.

The National Planning Policy Framework should directly reference the importance of daylight for healthy buildings and communities. Meanwhile, at the local council level, planning authorities can deploy the systematic approach to daylight from the BRE Report BR209 for domestic and non-domestic buildings, and increasingly for low carbon retrofit projects.

Finally, information on daylighting needs to be easier to access for building owners and users. One idea could be a building daylight indicator, developed by industry and government, that would work alongside other consumer-facing building sustainability metrics – like the Energy Performance Certificate rating.

14. Cambridge Institute for Sustainability Leadership, Building Entopia
15. Brown, Brainard, Cajochen et al (2022) Recommendations for daytime, evening, and nighttime indoor light exposure... PLoS Biol 20(3): e3001571.

BRE has been delivering science and best practice to improve the illumination of Britain's buildings for nearly a century. Today, lighting is a key aspect of our work on sustainability and the transition to net zero.

The major technical and policy efforts to improve the efficacy of lighting is a major success story in our global sustainable development journey. Progress in controls, circularity, and daylighting, now enable government, industry and building owners to invest in the next steps for fully sustainable lighting.

Well planned use of daylight in buildings can deliver sustainability and health and wellbeing benefits. However, large glazed areas must be carefully designed to deliver comfort and sustainability benefits.

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