

Casambi Whitepaper

Wireless lighting control for: Retrofit and Refurbishment



Updated: January 2025

CASAMBI

Introduction

In most developed countries today, almost three quarters of the building stock that will still be in use by 2050 has already been built. According to the International Energy Agency ⁽¹⁾ 50% of all these existing buildings must be retrofitted with greener technologies by 2040 if we are to achieve zero carbon-ready levels according to the UN's Paris Agreement and other such climate action plans. Refurbishment and retrofit projects have become pivotal in the pursuit of sustainability, energy efficiency, and improved user experiences within these built environments. The integration of smart lighting controls is proven to play a vital role. This whitepaper explores how Casambi's innovative wireless lighting control system, which is easily retrofittable, can significantly enhance efficiency, reduce energy consumption and offer unparalleled adaptability in transforming existing spaces into future-proof intelligent environments.

Four key global trends are driving the uptake of lighting refurbishment initiatives and the adoption of smart lighting controls:

- **Sustainability Imperatives:** Buildings account for approximately 40% of global energy consumption and contribute nearly 33% of greenhouse gas emissions ^{(2) (3)} . The way we light buildings can help reduce these numbers. Smart lighting controls, using occupancy and daylight sensors and adaptive dimming systems, offer potential energy savings of up to 50–60% on lighting costs (US Department of Energy, Building Performance Institute Europe).
- **Digital Transformation:** The proliferation of the Internet of Things (IoT) and interconnected systems has revolutionized how spaces are envisioned and utilized. Smart lighting, integrated with sensors and automation, embodies this digital shift, providing dynamic control and analytics that can constantly optimize energy use and operational efficiency in refurbished structures ⁽⁴⁾ .
- **User-Centric Environments:** The paradigm shift toward user-centric design emphasizes occupant comfort, productivity, and well-being. Smart lighting controls, adaptable to individual preferences and needs, significantly contribute to creating personalized and comfortable spaces, enhancing occupants' overall experience ⁽⁵⁾ .
- **Flexibility and Adaptability:** Modern interior spaces today serve diverse purposes and accommodate multifaceted functions. Casambi's wireless and scalable lighting control technology, seamlessly integrate into existing infrastructures, providing full flexibility and reducing installation complexities and costs (Casambi Case Studies, LightingEurope).

Casambi's versatile platform aligns with such global trends, offering wireless, scalable, and adaptive solutions that optimize energy consumption, integrate seamlessly into IoT ecosystem, provide personalized lighting experiences, and simplify integration into existing infrastructures for refurbishment projects.

Legislation and Incentives Driving Refurbishment Around the World

- **Energy Efficiency Standards and Regulations:** Many countries have implemented stringent energy efficiency standards and building codes that necessitate improvements in existing structures. These regulations often mandate the adoption of energy-efficient technologies, including smart lighting controls (US Department of Energy).
- **Financial Incentives and Rebates:** Governments and utilities worldwide offer financial incentives, rebates, or tax credits to encourage building owners to undertake energy-efficient retrofits. These incentives aim to offset the initial costs of implementing smart technologies, making them more financially viable (Energy Star - US EPA).
- **Green Building Certifications:** Certifications such as LEED (Leadership in Energy and Environmental Design) or BREEAM (Building Research Establishment Environmental Assessment Method) incentivize and recognize sustainable retrofit projects. These certifications often require the integration of smart technologies, including advanced lighting controls, contributing to the overall efficiency of the buildings (US Green Building Council - LEED, BRE Group - BREEAM).
- **Public-Private Partnerships:** Collaborations between governments, private entities, and non-profit organizations foster innovation and investment in retrofit projects. These partnerships often lead to the development of pilot programs and initiatives that promote the adoption of smart technologies in existing buildings (European Public Private Partnership Program - EeB PPP).

These legislative measures, financial incentives, and collaborative efforts are instrumental in incentivizing building owners and stakeholders to embark on refurbishment and retrofit projects, encouraging the adoption of smart lighting solutions and other sustainable technologies.

Each country has its own set of energy performance programs aimed at enhancing energy efficiency in buildings. Here are some examples from across the world:

European Union:

- **European Energy Performance of Buildings Directive (EPBD) 2024/1275 :** In May 2024, the EU published a major revision of its Energy Performance of Buildings Directive (EPBD), bringing new requirements for the building industry. The directive requires all non-residential buildings with a rated energy output of over 290kW to implement building automation systems latest by 31 December 2024. Same buildings must also implement automatic lighting controls by 31 December 2027. The automatic lighting controls must be suitably zoned and capable of occupancy detection. Similarly, non-commercial buildings with a rated output of over 70kW are required to implement building automation systems and automatic lighting controls latest by 31 December 2029. For the first time, the revised EPBD defined and mandated European member states to set standards for healthy indoor air quality. Smart technologies are recognised as crucial for effective indoor environmental quality monitoring and reporting through the extension of building automation capabilities, with the need to implement latest by 29 May 2026.

Australia:

- **National Australian Built Environment Rating System (NABERS):** NABERS is a performance-based rating system for existing buildings across various sectors, including offices, retail, and hotels. It rates the energy efficiency, water usage, and environmental impact of buildings, offering a comprehensive assessment that includes lighting and other energy-related aspects (NABERS - Australian Government).
- **Building Energy Efficiency Certificate (BEEC):** BEEC is part of the Commercial Building Disclosure (CBD) Program in Australia, requiring sellers and lessors of commercial office spaces over a certain size to obtain a BEEC. The certificate includes a NABERS Energy star rating, which can encourage energy-efficient lighting and building upgrades (Australian Government - CBD Program).

United Kingdom:

- **NABERS UK:** NABERS UK measures and rates the energy use of offices, helping building owners to accurately track the energy performance of their assets. It also helps identify areas for savings and improvements. <https://bregroup.com/products/nabers-uk/>
- **BREEAM (Building Research Establishment Environmental Assessment Method):** BREEAM is a leading sustainability assessment method for master planning projects, infrastructure, and buildings. It sets the standard for best practices in sustainable design and significantly influences global construction by evaluating areas like energy and water use, materials, pollution, ecology, and integrated technologies such as smart lighting controls. It offers a holistic framework for measuring and enhancing sustainability performance.
- **Energy Performance Certificates (EPCs):** EPCs are mandatory for buildings in the UK and provide an energy efficiency rating from A (most efficient) to G (least efficient). They are required for both domestic and commercial properties when built, sold, or rented. EPCs also provide recommendations for improving energy efficiency, including lighting upgrades (UK Government - Energy Performance Certificates).
- **Minimum Energy Efficiency Standards (MEES):** Introduced in England and Wales, MEES set a minimum energy efficiency standard for privately rented properties. Landlords must meet certain energy performance requirements to legally rent out their properties, which may involve improving lighting and other systems (UK Government - MEES).

United States:

- **ENERGY STAR for Buildings:** The ENERGY STAR program by the U.S. Environmental Protection Agency (EPA) includes benchmarking tools and certifications for buildings based on their energy performance. ENERGY STAR scores help building owners and managers assess and compare their buildings' energy efficiency, including lighting systems, against national averages (ENERGY STAR - US EPA).
- **Building Energy Codes:** The U.S. Department of Energy (DOE) supports the development and implementation of building energy codes across states. These codes set minimum energy efficiency standards for new construction and major renovations, including requirements for lighting systems, aiming to improve overall building performance (US DOE - Building Energy Codes Program).
- **Better Buildings Initiative:** Led by the DOE, this initiative aims to make commercial, public, industrial, and residential buildings 20% more energy-efficient by 2027. It provides resources, technical assistance, and recognition for organizations implementing energy-saving measures, potentially including lighting upgrades (Better Buildings Initiative - US DOE).
- **LEED (Leadership in Energy and Environmental Design):** Though it's a voluntary program by the U.S. Green Building Council (USGBC), LEED certification sets standards for sustainable buildings, including energy-efficient lighting, based on various criteria. It encourages and rewards the use of efficient lighting technologies and controls (USGBC - LEED).
- **PACE (Property Assessed Clean Energy) Financing:** PACE programs enable property owners to finance energy efficiency and renewable energy improvements, including lighting upgrades, through a special property tax assessment, promoting investments in efficient building systems (PACE Nation).

These programs and regulations aim to improve energy efficiency in buildings, often addressing lighting systems as a key component for achieving better energy performance. They encourage the adoption of energy-efficient lighting technologies, such as LEDs and smart lighting controls, to meet the specified energy standards and ratings.

Fluorescent ban precedes new intelligent beginnings:

The European Commission's ban on the production and sale of new fluorescent lighting stock as of 2023 has significantly influenced retrofit and refurbishment projects in Europe. This regulatory measure, driven by the Energy Efficiency Directive (EED) and Eco-design regulations, accelerated the adoption of energy-efficient LED lighting for retrofitting existing buildings (European Commission - Energy Efficiency Directive, Eco-design Regulations - European Commission). It is estimated that roughly 250 million units of already-installed stock (estimates for T5 and T8) will need replacing across Europe alone over the next six years.

Incorporating Casambi wireless lighting controls into LED retrofits can significantly boost the energy efficiency of an existing system while enhancing the overall user experience.

Retrofitting with Casambi: A Transformative Approach

Casambi transforms lighting refurbishment projects by specifically addressing and mitigating challenges inherent in pre-existing infrastructures.

- **Interoperability concerns:** Existing buildings often have diverse lighting systems comprising various luminaires and control technologies. Achieving compatibility between older systems and modern smart lighting controls poses a significant challenge. Casambi's adaptability to various lighting sources and universal compatibility with other standards such as DALI, DALI-2, D4i, DMX, phase-cut dimming, and PWM alleviate these compatibility hurdles without the need for extensive rewiring or system overhauls. Through a Cloud Gateway or an Ethernet Gateway, Casambi systems can also communicate with existing Building Management Systems or other third-party systems and protocols such as BACnet or MQTT.
- **Infrastructure Limitations:** Retrofitting within the constraints of an existing building's infrastructure can be daunting. Casambi's wireless technology eliminates the necessity for extensive modifications or rewiring, preserving the structural integrity of the building while seamlessly integrating with the current lighting setup. This significantly reduces the disruption typically associated with retrofitting projects.
- **Cost and Complexity of Installation:** Retrofit projects often face budgetary constraints and downtime concerns. Traditional retrofitting involving rewiring or installing new systems can be expensive and time-consuming. Casambi's wireless solution streamlines the installation process, minimizing costs and reducing the time required for implementation. This simplicity also results in minimal disruption to daily operations during the retrofit phase.
- **Adapting to Diverse Architectural Designs:** Existing buildings vary in architectural designs and layouts, which can pose challenges in deploying uniform smart lighting solutions. Casambi's scalable solution caters to buildings of various sizes and layouts. Its modular design allows for tailored installations that accommodate diverse architectural elements, ensuring a seamless integration that complements the existing design aesthetics.
- **User Acceptance and Familiarity:** Retrofitting often involves introducing new technologies to occupants accustomed to traditional lighting controls. Ensuring user acceptance and ease of use is crucial. Casambi's user-friendly interface and compatibility with conventional switches and sensors provide occupants with a familiar experience while offering enhanced smart functionalities.

Casambi's adaptability, simplicity, and compatibility significantly mitigate the challenges inherent in retrofitting existing buildings, making the transition to smart lighting controls smoother and more efficient.

Harmonizing Innovations: Casambi's Integration with Existing DALI Networks

The Casambi DALI Gateway (CBU-DCS) enables the extension of existing DALI networks with wireless Casambi networks, particularly useful in retrofit scenarios or when adapting established DALI setups. This provides all the benefits and flexibility of wireless Casambi Bluetooth® Low Energy Mesh networks while retaining all DALI functions and controls. Any device that exists in the Casambi network appears as standard DALI to the wired DALI controller software. These devices can be controlled both by the Casambi App and the DALI controller software.

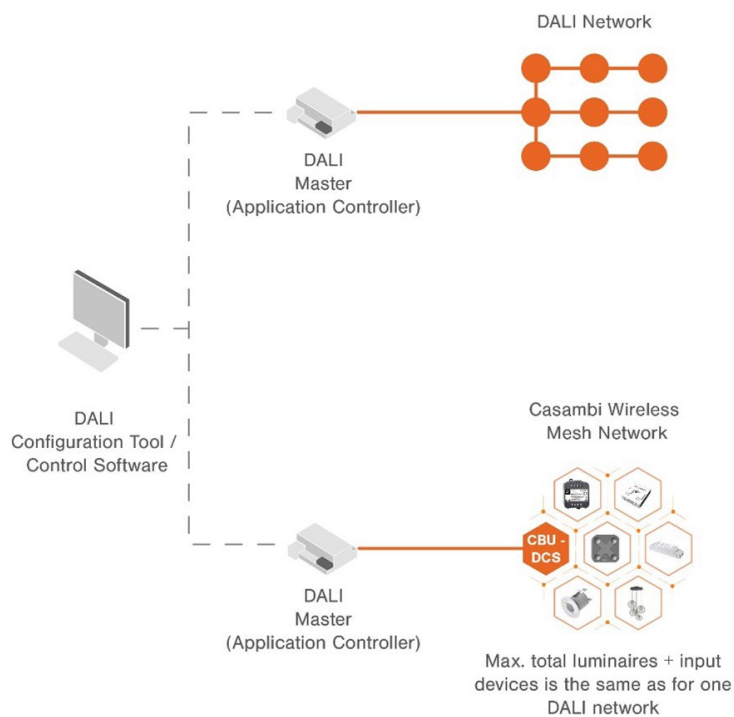


Figure 1: Casambi wireless mesh network can be connected and controlled by a DALI Controller via the Casambi DALI Gateway (CBU-DCS).

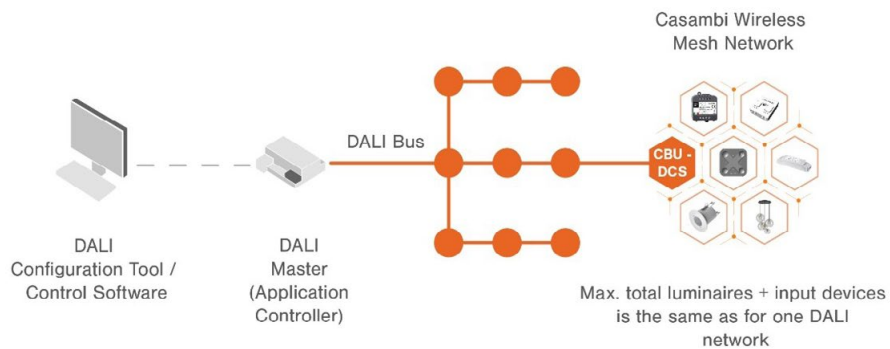


Figure 2: Existing DALI networks that have the capacity to add more DALI devices can be extended by simply adding the Casambi DALI Gateway to the DALI bus.

The latest addition to Casambi's DALI integration options is the Salvador, which allows programming and control of up to 64 DALI luminaires individually from the Casambi App. Similar to the CBU-DCS, Salvador enables the extension of existing DALI networks and creation of hybrid networks that consist of both Casambi ready and DALI devices. The main difference is that with Salvador, all DALI luminaires are programmed and controlled like normal Casambi ready devices via the Casambi App. This gives the possibility to incorporate Casambi's user-friendly user interface into wired DALI installations. All DALI luminaires that are connected to the Salvador appear the same way as Casambi devices on the Casambi App, and can be individually programmed and controlled.

Multiple Salvadors that are controlling DALI luminaires can also be wirelessly connected to form a single Casambi mesh network. One Casambi network can allow up to 250 nodes, regardless of whether they are DALI or Casambi ready. For example, three Salvadors that each control 64 DALI luminaires can be connected together, forming a single Casambi mesh network.

(64 nodes + 1 Salvador = 65 nodes each x 3 = 195 nodes.)

The extraction and usage of D4i data from the DALI network is still possible with the Salvador. In this case, data is communicated across the Casambi mesh to the Casambi Cloud via the Casambi Cloud Gateway. The data can then be utilized by other 3rd party systems or solutions via the Casambi API. This provides an easy and cost-effective way to connect a DALI system to the cloud, and integrate with other systems.

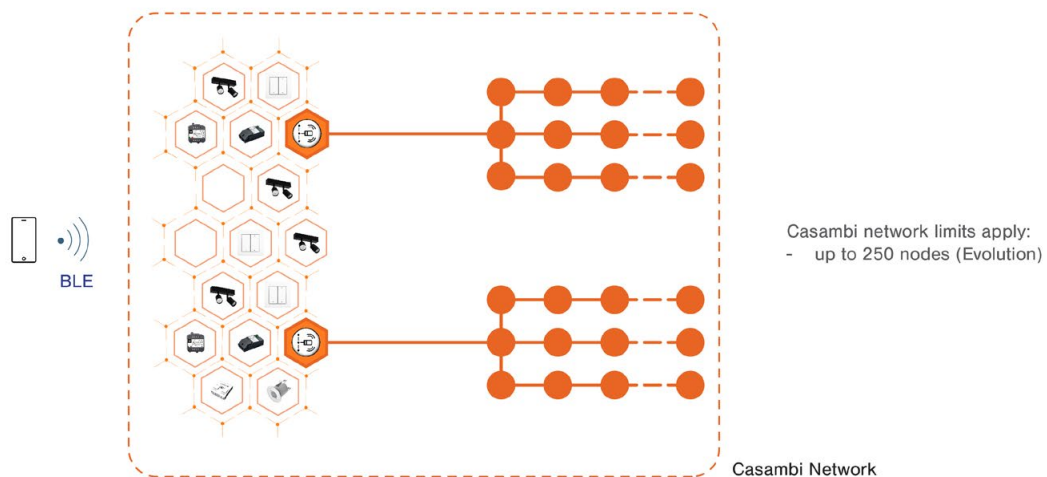


Figure 3: Casambi Salvador enables the extension of existing DALI networks and creation of hybrid networks that consist of both Casambi ready and DALI devices.

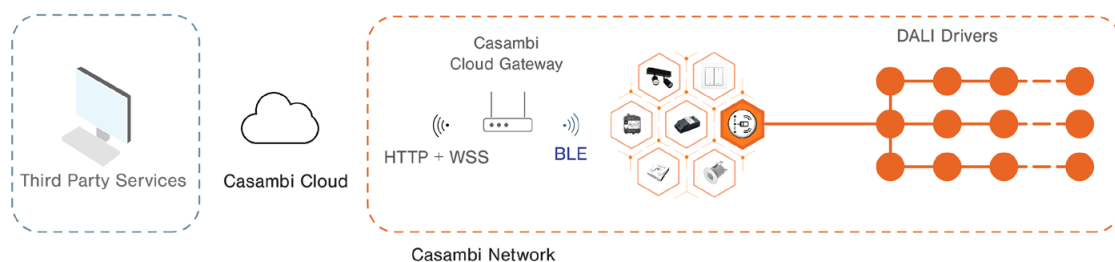


Figure 4: Salvador provides an easy and cost-effective way to connect a DALI system to the Cloud using the Casambi Cloud Gateway and integrate with other systems via the Casambi API.

Casambi X DALI

Casambi offers users unparalleled flexibility with wireless, wired, and hybrid options. Whether leveraging entirely wireless capabilities or opting for traditionally trusted wired solutions, users can effortlessly mix and match to tailor lighting networks to specific project requirements.

A hybrid solution might entail control of luminaires through wired DALI means alongside wireless Casambi Ecosystem products in the same lighting controls system. This adaptability ensures that Casambi remains applicable across diverse settings, empowering users to choose the most fitting configuration for their needs.

The latest addition to Casambi's DALI integration options, Salvador seamlessly integrates wired DALI drivers into the Casambi system, with a single unit capable of controlling up to 64 DALI drivers. DALI luminaires, when incorporated, will appear in the Casambi network as virtual luminaires, where they are programmed and controlled in the same way as Casambi Ready devices via the Casambi App. Salvador enables the extension of existing DALI networks and the creation of hybrid networks that consist of both Casambi Ready and DALI devices. Multiple Salvadors that are controlling DALI luminaires can be wirelessly connected to form a single Casambi mesh network. Notably, this product supports industry standards such as DALI D4i, DALI DT6, and DALI DT8. Additionally, Salvador features an integrated power supply, an internal Real-time clock (RTC) with backup energy storage, and cable strain relief to facilitate a smooth installation process.

Wireless emergency lighting

Modern emergency lighting systems must meet strict maintenance and testing requirements, including advanced control and communication functions.

There are several wireless emergency lighting solutions based on Casambi technology. These systems support DALI DT1 standard devices, meaning reliable interoperability with DALI self-contained emergency control gear, and enable wireless communication without the need for additional hardware or traditional DALI wiring. Emergency devices are easily paired using the Casambi App, allowing for an easy wireless upgrade for existing luminaires without a change of layout. Users can easily view the luminaires' signal strength and identify emergency devices from within the Casambi App.

These solutions provide automatic testing of individual luminaires, standard-compliant logs that available to download or access from cloud, and central monitoring via iPad or PC-based graphical user interfaces.

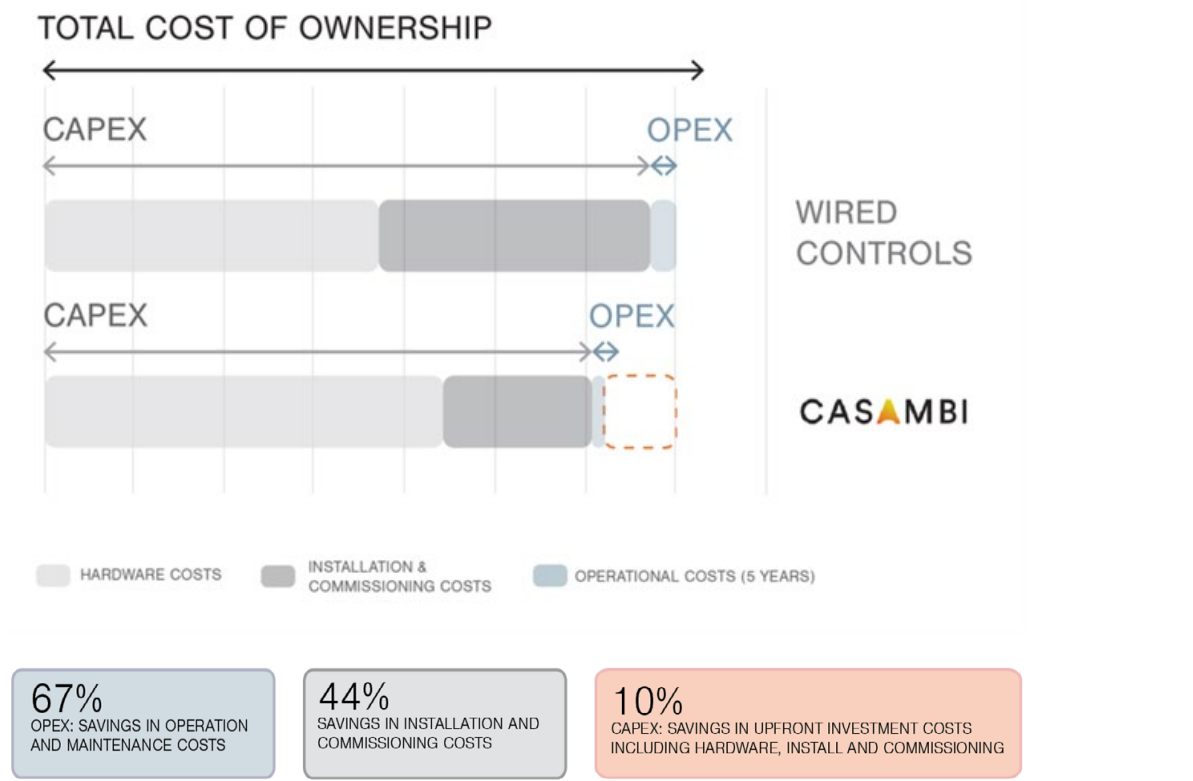
For more information on the wireless emergency systems based on Casambi technology, please refer to the Ecosystem section inside Casambi website.

Evaluating Investment: Wireless Lighting Controls in Retrofit Projects

In retrofit projects, the capital expenditure (CAPEX) for lighting controls can vary significantly based on several factors, such as the selected control solution and the complexity of infrastructure inside the building. In general, the overall CAPEX for wireless controls in refurbishment or retrofit projects could potentially be lower than wired controls due to reduced installation, labor, and material expenses. Additionally, wireless solutions offer benefits in terms of flexibility, adaptability, and futureproofing, which can impact the overall project cost-effectiveness in the long run. Factors like the size of the project, the building’s structure, and specific technology choices will significantly influence the cost comparison between wired and wireless lighting controls.

A recent Casambi case study revealed that the CAPEX for implementing Casambi in the refurbishment of an office building spanning 4.400 square meters in Germany is 10% lower than the cost of a wired lighting control system providing comparable functionality. The CAPEX calculation includes the hardware costs and all installation and commissioning costs related to lighting controls.

Taking into account both the CAPEX and Operational Expenses (OPEX) over a 5-year lifespan, the total cost of ownership associated with Casambi was found to be 11% lower when compared to wired controls.



Reduction in embodied carbon: 2.630 kg or CO2 eq, which equals the CO2 absorption of 125 full-grown trees per year

In addition to cost savings, eliminating controls wiring also contributes to the reduction of embodied carbon of the lighting installation. Embodied carbon is the greenhouse gas emissions associated with the manufacture of a product, its installation, maintenance, repair, replacement and end of life. For the Casambi case study in this paper, it is estimated that the use of 3.552 meters of 1,5mm² 2-core wiring was avoided. Global Warming Potential (GWP-total) (kgCO₂eq/m) value (0,75162 kg CO₂ eq/m) was taken from the EPD of Prysmian Draka PRSuper 500V 2x1,5/1,5mm² ER.

A full-grown tree absorbs approximately 21kg CO₂ per year.

Implementing smart lighting controls reduces energy use, especially when multiple control strategies combining occupancy detection, daylight harvesting and smart time scheduling are deployed.

Lighting Energy Savings ⁽⁶⁾:

up to 60% *with Daylight Harvesting*

up to 44% *with Presence Detection*

49-63% *with Presence Detection and Daylight Harvesting*

Future Trends and Considerations

Looking ahead, the future of lighting control systems promises innovation and adaptability to meet evolving needs in retrofit and refurbishment projects.

- **Integration of AI and IoT Technologies:** The convergence of Artificial Intelligence and the Internet of Things is set to redefine refurbishment projects. AI-driven analytics and predictive capabilities integrated into IoT-enabled systems will optimize building operations, including lighting controls, by anticipating user needs and enhancing energy efficiency ^{(7) (8)}.
- **Enhanced Energy Management:** A continued emphasis on sustainability will drive advancements in energy management systems. Smart lighting controls, augmented by advanced sensors and analytics, will play a pivotal role in achieving deeper energy savings and reducing carbon footprints in buildings (World Green Building Council, International Energy Agency).
- **Flexible and Modular Solutions:** Future refurbishment trends will prioritize adaptable, modular solutions that cater to changing needs and technologies. Smart lighting systems, exemplified by Casambi's scalable infrastructure, will evolve to offer even greater flexibility and ease of integration into diverse building structures (Casambi Technology Trends).
- **Human-Centric Design and Wellness:** User-centric design principles will continue to guide refurbishment projects, focusing on enhancing occupant well-being and productivity. Smart lighting controls will advance further to personalize lighting experiences, considering factors like circadian rhythms and individual preferences (Harvard Business Review, National Institutes of Health).
- **Market Growth:** The global smart building market, including retrofit and refurbishment segments, is projected to grow at a CAGR of over 20% in the coming years, driven by increased demand for energy-efficient solutions and technological advancements (Market Research Future).
- **Energy Savings Potential:** The adoption of advanced smart lighting controls and IoT technologies in refurbishment projects has the potential to achieve additional energy savings of up to 30–40% beyond current levels, significantly contributing to global energy conservation goals (US Department of Energy).

As buildings evolve to meet the demands of sustainability, technological innovation, and occupant well-being, Casambi is poised to play a pivotal role in shaping the future of intelligent and adaptive environments.

Case Study



The BBC upgraded 18,000+ fluorescent fittings across their UK sites with LED options, incorporating sensors and Casambi wireless control. This entailed replacing previous T5 fittings controlled by a 1-10v system without disrupting BBC News and radio stations. Today nine major sites – including the broadcaster’s London HQ - benefit from Casambi’s slick, intuitive, app-based lighting control harnessing Bluetooth Low Energy Mesh.

The eight-story Broadcasting House operates 24 hours a day and is home to BBC News – the world’s biggest TV news operation – and several radio stations, including the World Service. The installation at Broadcasting House was carried out during late evenings, and each area being upgraded had to be ready the following morning when staff returned to their desks, so there would be no disruption. Being completely wireless, Casambi was the ideal solution for quick and non-disruptive installation.

Sensors from Tridonic and Danlers have been installed to enable presence/absence detection and daylight dimming, ensuring lights are only on when they are needed. Energy-harvesting wireless switches from EnOcean have also been used, which provide another easy way for staff to control the lights.

Number of Casambi nodes: 10,000 +

Customer benefits:

- A wireless control system that enables the user to personalize their lighting via the intuitive Casambi App.
- A 1:1 replacement of the luminaires without changing the existing electrical installation.
- Energy savings using Casambi enabled presence/absence detection and daylight harvesting.
- Quick and non-disruptive installation.
- Improved lighting conditions with tunable white light.
- EnOcean energy-harvesting wireless switches, which provide another easy way for staff to control the lights.

References

1. IEA (2021). Net Zero by 2050. IEA. Paris <https://www.iea.org/reports/net-zero-by-2050>. License: CC BY 4.0
2. World Green Building Council (2019). Bringing Embodied Carbon Upfront. https://worldgbc-s3-eu-west-2.amazonaws.com/wp-content/uploads/2022/09/22123951/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf
3. UN Environment Programme (2022). 2022 Global Status Report for Buildings and Construction. <https://globalabc.org/our-work/tracking-progress-global-status-report>
4. European Construction Sector Observatory (2021). Digitalisation in the construction sector. <https://ec.europa.eu/docsroom/documents/45547>, <https://ec.europa.eu/docsroom/documents/45547/attachments/1/translations/en/renditions/native>
5. Garzia, F. et al. Meeting User Needs through Building Automation and Control Systems: A Review of Impacts and Benefits in Office Environments. *Buildings* 2023, 13, 2530. <https://doi.org/10.3390/buildings13102530>
6. Lighting Energy Savings in Offices Using Different Control Systems and Their Real Consumption. B. Roisin, M. Bodart, A. Deneyer, P.D'Herd, 2008
7. McKinsey & Company (2021). The Internet of Things: Catching up to an accelerating opportunity. <https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/iot%20value%20set%20to%20accelerate%20through%202030%20where%20and%20how%20to%20capture%20it/the-internet-of-things-catching-up-to-an-accelerating-opportunity-final.pdf>
8. Deloitte (2023). Using AI-Enabled Predictive Maintenance to help Maximize Asset Value. <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/deloitte-analytics/us-ai-institute-using-ai-in-predictive-maintenance.pdf>

CASAMBI

casambi.com