Never fully dark: presence-controlled LED lighting with a safe background level for plantrooms and rooftop plant, evaluated with UK data from 2022 to 2026

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Abstract

Plantrooms and rooftop plant areas are visited for a few hours a week, yet their lighting is usually either left on permanently or switched off, so that staff enter dark spaces where slips, trips and falls are likely. This paper examines presence-controlled LED lighting that never switches fully off but dims to a background level chosen to keep the 20 lx average that HSE guidance gives for the movement of people. A lumen-method design for a 150 m² reference plantroom and an annual energy model were built in a spreadsheet and priced with UK electricity prices and carbon factors for 2022 to 2026. With 5 hours of occupancy a week, the proposed control used 783 kWh a year, 88% less than always-on twin T8 fluorescent lighting and 71% less than always-on LED. Keeping the room at a 20% background level cost 659 kWh a year more than switching off. The annual saving against fluorescent lighting rose from £1,167 in 2022 to £1,371 in 2026, while the carbon saving fell by 32% as the grid decarbonised. For battery luminaires on roofs, sensor standby power rather than light dominated the energy budget.

Keywords: lighting controls; presence detection; plantroom; rooftop plant; slips, trips and falls; LED retrofit; energy; carbon

1. Introduction

Every large building has spaces that hardly anyone sees. Boiler houses, pump rooms, switch rooms, ventilation plantrooms and the plant that sits on flat roofs are entered by maintenance staff, contractors and inspectors, usually for short visits and often alone, at night or in winter darkness. These spaces are full of trip hazards: pipework near the floor, raised plinths, cable trays, open drains, condensate on the floor and, on roofs, upstands, gutters and unguarded edges. Their lighting is rarely designed with the way they are actually used in mind.

In Great Britain, slips, trips or falls on the same level were the most common kind of non-fatal injury to employees reported under RIDDOR in 2024/25, at 30% of 59,219 reports, and falls from a height made up a further 8%. Falls from a height also caused 28% of fatal injuries to

workers between 2020/21 and 2024/25, an average of 38 deaths a year [1]. In the human health and social work sector alone, employers reported 11,157 non-fatal injuries to employees in 2024/25 [2]. These statistics do not record whether poor lighting played a part, but the link between lighting and trips is the reason the Workplace (Health, Safety and Welfare) Regulations 1992 require every workplace to have suitable and sufficient lighting [3], and HSE guidance HSG38 sets a minimum of 20 lx average and 5 lx minimum measured illuminance for the movement of people, machines and vehicles [4].

Plant spaces tend to fail in one of two ways. In the first, the lights are left on all the time, because the switch is in an awkward place, because nobody is responsible for switching them off, or because someone once decided it was safer that way. A plantroom that is occupied for perhaps 3% of the year then uses lighting energy for the other 97%. In the second, the lights are switched off at a single switch by the door, and the first person to enter walks into the dark or works by torchlight. Rooftop plant is often worse, because air handling units, extract fans and condensers may sit at the far end of a roof with no fixed lighting at all, and running a new lighting circuit across a roof means containment, roof penetrations and work at height.

The question behind this study came from the author's own work. Over five years in the electrical trade, much of it maintaining building services in large non-domestic buildings, the author has repeatedly found both failures: plantroom lights burning in rooms nobody had entered for days, and dark plantrooms and roofs where the only light on a winter call-out was a head torch. In 2024 the author began to sketch out a wireless, presence-controlled lighting arrangement for these places that would cut the wasted energy without ever leaving a person in the dark. This paper develops that idea and tests it with published data from 2022 to 2026, a period in which UK electricity prices rose sharply and then eased, fluorescent T8 lamps were withdrawn from sale in Great Britain [5], and the carbon intensity of grid electricity fell.

Occupancy-based lighting control is not new. A meta-analysis of published savings found an average of 24% for occupancy control and 38% where several strategies were combined [6], a field study in open-plan offices estimated that occupancy sensors alone would save about 35% [7], and reviews of control technologies report wide ranges depending on space type and use [8]. Recent work has added light sensing and user feedback to occupancy control [9]. Most of this evidence comes from offices, where occupancy is high and the baseline is manual switching, and Lowry has shown that savings claims are often inflated by comparing automatic control with lighting that is assumed to be on all day [10]. Plant spaces are different on both counts: occupancy is very low, and the baseline genuinely is often lighting that is on all the time. They are also different in what matters. In an office a sensor that switches off too early is a nuisance; in a plantroom it can leave someone kneeling behind a pump in darkness.

Lighting research gives some guidance on how much light is needed simply to move about safely. Laboratory studies of obstacle detection have shown that the ability to detect a trip hazard depends on illuminance [11], and for peripheral detection by pedestrians the improvement with illuminance levelled off at about 2.0 lx [12]. Those studies concern outdoor pedestrian lighting, but they support the idea that a modest background level, far below the level needed for maintenance tasks, can remove the worst of the risk of entering a dark space.

This paper therefore treats the background (standby) level of a presence-controlled system as a safety design parameter rather than an energy-saving afterthought. It asks four questions. (i) How much energy, cost and carbon do the common ways of lighting a plantroom use,

compared with presence control that dims to a background level instead of switching off? (ii) What background level is needed to keep the HSG38 movement level, and what does it cost? (iii) How did the case for this control change between 2022 and 2026? (iv) For rooftop plant with no supply, what limits the design of self-contained, battery-powered luminaires? National NHS estates data are used to show how much of a large public estate still lacks LED lighting.

2. Method

2.1 Approach and reference space

The study is a desk-based engineering appraisal. No measurements were taken in any building and no information from any employer was used. All calculations were carried out in a single Excel workbook in which every result is a formula linked to a labelled input, so that any value can be changed and the results update; the workbook is provided as Supplementary Material S1. Inputs are listed with their sources in Table 1.

The reference space is a ventilation or heating plantroom of 15 m × 10 m (150 m²), with luminaires surface-mounted below a 4 m soffit at an effective mounting height of 3.5 m above the floor. The floor is taken as the working plane because the main risk is to people moving about it. The design maintained illuminance for open plantroom floors was taken as 100 lx, the value given in the SLL Lighting Handbook [13] as summarised in manufacturer guidance, which also gives 200 lx on vertical surfaces at control panels and valves [14]. Task lighting at panels was outside the scope of this study. BS EN 12464-1 gives requirements for comparable interiors [15].

2.2 Lighting design

The number of luminaires was found with the lumen method:

$$N = E\,A / (\Phi \times UF \times MF) \qquad (1)$$

where E is the design maintained illuminance (lx), A the floor area (m²), Φ the luminaire flux (lm), UF the utilisation factor and MF the maintenance factor. N was rounded up and the installed maintained illuminance recalculated. The room index, $LW/(H_m(L + W))$, was 1.71. A utilisation factor of 0.45 was assumed for a cluttered room with dark surfaces and pipework obstruction, with 0.35 to 0.55 tested, and a maintenance factor of 0.8. The minimum illuminance was estimated from an assumed uniformity of 0.4. The lumen method cannot represent the shadows cast by large plant, and a real design would need a point-by-point calculation; the method was used here because the comparison between scenarios depends mainly on installed load, which it captures.

Two luminaires were compared. The LED option is a 1500 mm IP65 anti-corrosive batten with an integral microwave sensor and corridor (dim) function, rated at 52 W and 7,300 lm [16]; two similar products are rated at 52 W and 7,800 lm and at 50 W and 7,000 lm [17,18]. The fluorescent option is a 1500 mm twin 58 W T8 anti-corrosive luminaire with high-frequency control gear, the type still found in many plant spaces. Its output was taken as two 5,200 lm lamps with a light output ratio of 0.615 [19], giving 6,396 lm, and its input power as 104 W from a twin 58 W electronic ballast data sheet [20]. That ballast drives the lamps below their rated power, so the fluorescent flux is, if anything, overstated, which makes the comparison conservative.

Table 1. Inputs and their sources. Values marked † are assumptions tested in the sensitivity analysis.

Input	Value	Source or basis
Reference plantroom	15 m × 10 m, mounting height 3.5 m	Assumed
Design maintained illuminance (floor)	100 lx	SLL Lighting Handbook [13,14]
HSG38 movement of people: average / minimum	20 lx / 5 lx	HSG38 [4]
Utilisation factor †; maintenance factor; uniformity	0.45; 0.8; 0.4	Assumed
LED batten: power, flux	52 W, 7,300 lm	Data sheet [16]
Twin 58 W T8 HF: power, flux	104 W, 6,396 lm	Data sheets [19,20]
Sensor standby power (microwave)	0.5 W per luminaire	Data sheet (<0.5 W) [21]
Hold time	20 min	One of the settings listed [21]
Background level †	20% of full output	Proposed in this study
Driver overhead when dimmed †	5% of full power	Assumed
Occupancy †	5 h/week in 3 visits	Assumed
Manual switching: share of empty time left on †	0.5	Assumed
Electricity price, 2022–2026	20.86, 27.20, 26.29, 24.34, 24.51 p/kWh	DESNZ [22]
Carbon factor, 2022–2026	0.211, 0.225, 0.225, 0.196, 0.144 kgCO_2e/kWh	DESNZ [23]
Rooftop luminaire: power; visits; share in darkness †	10 W; 2 × 1 h per week; 0.5	Assumed
Low-power PIR standby †	0.05 W	Assumed
Battery: autonomy; depth of discharge; cold factor	5 days; 0.8; 0.8	Assumed

HF: high frequency; PIR: passive infrared.

2.3 Control scenarios

Five scenarios were compared for the reference plantroom:

S1 Twin T8 fluorescent luminaires on continuously.

S2 LED luminaires on continuously (a like-for-like lamp or luminaire replacement with no change to control).

S3 LED luminaires on a manual switch, on whenever people are present and left on for a share *f* of the remaining time.

S4 LED luminaires with presence detection that switches them off after the hold time.

S5 LED luminaires with presence detection that dims them to a background level after the hold time (the proposed arrangement).

Annual electricity use for S4 and S5 was calculated as

$$W = N\,P\,t_{on} + N\,P\,k\,(8760 - t_{on}) + N\,P_{sb}\,8760 \qquad (2)$$

where P is the luminaire power (W), t_{on} the hours a year at full output, k the power fraction at the background level (zero for S4) and P_{sb} the sensor standby power. Full-output hours were the occupied hours plus one hold time per visit: 52 × (5 + 3 × 20/60) = 312 h a year. The power drawn when dimmed was taken as the light fraction plus a driver overhead of 5% of full power, so that k = 0.25 at a 20% background level. The background level was chosen as the smallest

common setting that keeps the HSG38 average of 20 lx (Section 3.3). Figure 1 shows how the three LED scenarios behave over a day with a single visit.

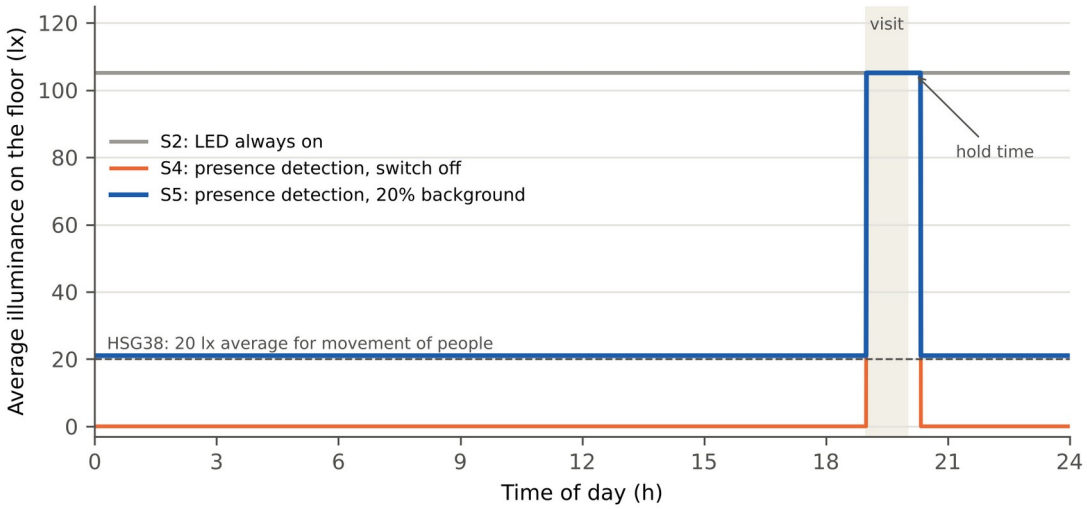

Figure 1. Average floor illuminance in the reference plantroom over a day with one 1-hour visit at 19:00, for LED always on (S2), presence detection that switches off (S4) and presence detection with a 20% background level (S5). The dashed line is the HSG38 average for the movement of people.

2.4 Occupancy

No published data were found on how long plantrooms are occupied, and occupancy varies widely between buildings. The central case of 5 hours a week in 3 visits represents a plantroom that receives routine checks and planned maintenance; it is about 3% of the year. Occupancy from 1 to 40 hours a week was tested. For the manual switching scenario, the share of empty time for which lights are left on was varied from 0 to 1.

2.5 Prices and carbon factors, 2022 to 2026

Each scenario was priced with the average UK non-domestic electricity price, including the Climate Change Levy, for each calendar year from 2022 to 2025 and with the provisional second-quarter average for 2026, all from DESNZ Table 3.4.2 [22]. As a check, the average price paid by NHS sites in England was calculated from ERIC returns as total electricity cost divided by total electricity consumed [24]. Emissions were calculated with the UK Government conversion factor for electricity consumed, including transmission and distribution losses, for each reporting year [23]. The 2026 factor is based on 2025 grid data rather than the usual two-year lag, which partly explains its fall [23]. Results were also expressed as the capital that the annual saving would repay within a three-year simple payback, to give a sense of scale without assuming installation costs.

2.6 Self-contained luminaires for rooftop plant

For a rooftop route to plant with no electrical supply, a self-contained luminaire with its own battery and a wireless or integral sensor avoids running a circuit across the roof. Its design is limited by the energy it uses each day:

$$E_{day} = P_r \, n \, (d + h) \, f / 7 + 24 \, P_{sb} \qquad (3)$$

where P_r is the luminaire power (10 W), n the visits a week (2), d the visit duration (1 h), h the hold time, f the share of visits needing artificial light (0.5, with a daylight sensor holding the light off otherwise) and P_{sb} the sensor standby power. Two sensors were compared: a microwave sensor at 0.5 W [21] and an assumed low-power passive infrared (PIR) sensor at 0.05 W. The battery capacity for 5 days without recharge was $E_{day} \times 5 / (0.8 \times 0.8)$, allowing for usable depth of discharge and cold-weather capacity. Solar module sizing depends on site irradiance in the darkest month and was not attempted.

2.7 National context

ERIC site returns for 2023/24, 2024/25 and 2025/26 were used to describe LED lighting coverage across the NHS estate in England and the number of estates and facilities incidents reported under RIDDOR [24]. LED coverage is reported by each trust as a percentage for each site. Results are given for all sites and for general acute hospitals. Floor area not yet lit by LED was estimated as gross internal floor area multiplied by one minus the coverage fraction, which assumes coverage applies evenly to floor area. ERIC does not record which rooms are LED-lit, nor where or why incidents occurred, so these data provide context rather than evidence of an effect of lighting.

3. Results

3.1 Lighting design

The reference plantroom needed 6 LED luminaires or 7 twin fluorescent luminaires to reach 100 lx maintained (Table 2). Because both counts were rounded up, the installed illuminance was 105.1 lx for LED and 107.5 lx for fluorescent. The LED luminaire's efficacy of 140 lm/W, against 61.5 lm/W for the fluorescent luminaire, cut the installed load from 728 W to 312 W, a reduction of 57%.

Table 2. Lumen-method design for the 150 m² reference plantroom (UF 0.45, MF 0.80).

Quantity	LED batten	Twin T8 fluorescent
Luminaire flux (lm) / power (W)	7,300 / 52	6,396 / 104
Luminaire efficacy (lm/W)	140.4	61.5
Luminaires needed (exact / installed)	5.71 / 6	6.51 / 7
Installed maintained illuminance (lx)	105.1	107.5
Estimated minimum illuminance (lx)	42	43
Installed load (W)	312	728
Power density (W/m²)	2.08	4.85
Normalised power density (W/m² per 100 lx)	1.98	4.52

3.2 Annual energy, cost and carbon

Table 3 and Figure 2 give the annual results at 2026 prices and carbon factors. Leaving fluorescent lighting on all the time (S1) used 6,377 kWh a year, or 42.5 kWh/m². Replacing the luminaires with LED but leaving them on (S2) cut this by 57%, to 2,733 kWh. Presence detection with a 20% background (S5) used 783 kWh, 88% less than S1 and 71% less than S2, and presence detection that switches off (S4) used only 124 kWh. In both always-on scenarios 96% of the energy was used while nobody was in the room.

Table 3. Annual results for the reference plantroom at 2026 prices (24.51 p/kWh) and carbon factor (0.144 kgCO_2e/kWh), with 5 h/week occupancy.

Scenario	Load (W)	Energy (kWh/yr)	Energy (kWh/m²/yr)	Cost (£/yr)	Emissions (kgCO_2e/yr)	Saving vs S1	Saving vs S2	Illuminance when empty (lx)
S1 Fluorescent, always on	728	6,377	42.5	1,563	918	–	–	107
S2 LED, always on	312	2,733	18.2	670	393	57%	–	105
S3 LED, manual (f = 0.5)	312	1,407	9.4	345	203	78%	49%	0 or 105
S4 LED, presence, switch off	312	124	0.8	30	18	98%	95%	0
S5 LED, presence, 20% background	312	783	5.2	192	113	88%	71%	21

For S3 the room is either fully lit or dark when empty, depending on whether the lights were left on.

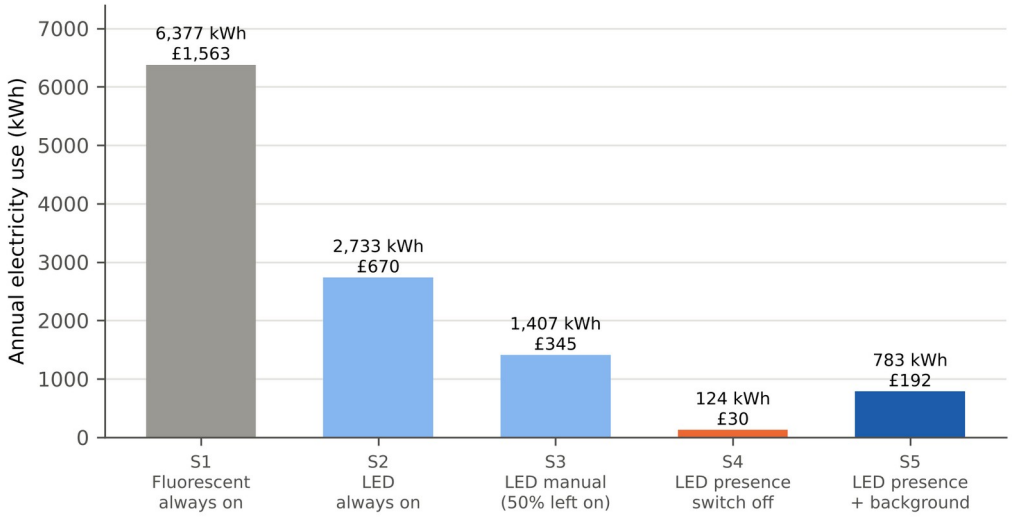

Figure 2. Annual electricity use and cost (2026 prices) of lighting the 150 m² reference plantroom under the five scenarios, with 5 h/week occupancy.

Manual switching (S3) depends entirely on behaviour. If the last person out always switched off, it would use 81 kWh, less than any other scenario; with the lights left on for half the empty time it used 1,407 kWh. S5 used less energy than S3 whenever the lights were left on for more than 26% of the empty time. In the author's experience of plant spaces that threshold is easily exceeded, but no data were found to confirm it, and manual switching also leaves the first person in to find the switch in the dark.

3.3 The cost of never being in the dark

The difference between S4 and S5 is the cost of keeping a plantroom lit to a safe movement level while it is empty. In the reference room it was 659 kWh a year, or £162 at 2026 prices, about £1.08 per square metre of plantroom. Figure 3 shows how the annual energy of S5 rises with the background level. With the installed illuminance of 105.1 lx, a 10% background gave 10.5 lx, below the HSG38 average of 20 lx, and a 20% background gave 21.0 lx, with an estimated minimum of 8.4 lx, above the 5 lx minimum. The 15% setting met the minimum but not the average. A 20% background therefore met both HSG38 values while still saving 71% against always-on LED. Each further 5% step added about 132 kWh a year.

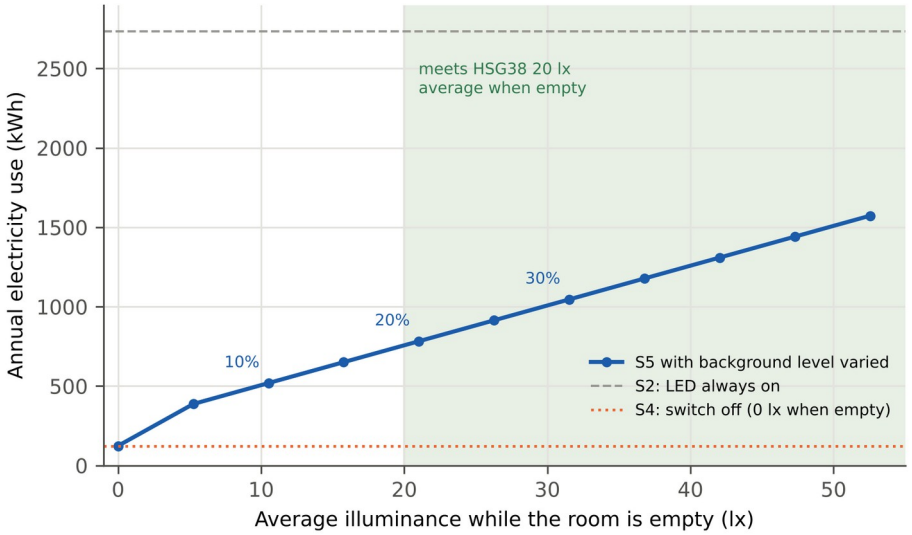

Figure 3. Annual electricity use of presence control (S5) in the reference plantroom against the average illuminance kept while the room is empty. Labels give the background level as a fraction of full output. The shaded area meets the HSG38 average of 20 lx for the movement of people.

3.4 How the case changed from 2022 to 2026

Electricity prices for non-domestic users rose from 20.86 p/kWh in 2022 to 27.20 p/kWh in 2023 and eased to 24.51 p/kWh by the second quarter of 2026 (Table 4). The prices paid by NHS sites, calculated from ERIC, were close to this series: 28.19, 25.80 and 24.90 p/kWh in 2023/24, 2024/25 and 2025/26. Over the same period the carbon factor for consumed electricity fell from 0.211 to 0.144 kgCO_2e/kWh, most of the fall coming in 2026.

Because the scenarios differ only in energy use, all costs moved with the price and all emissions with the carbon factor (Figure 4). The annual cost saving of S5 against S1 was £1,167 in 2022, peaked at £1,522 in 2023 and was £1,371 in 2026, 17% higher than in 2022. The carbon saving went the other way, from 1,181 kgCO_2e in 2022 to 805 kgCO_2e in 2026, 32% lower. Over a three-year payback, the 2026 saving against fluorescent lighting would repay £686 per LED luminaire installed; against always-on LED, the saving from adding presence control would repay £239 per luminaire.

Table 4. Annual cost and carbon of three scenarios in the reference plantroom, priced with each year's electricity price and carbon factor.

Year	Price (p/kWh)	Carbon factor (kgCO_2e/kWh)	S1 cost (£)	S2 cost (£)	S5 cost (£)	Saving S1–S5 (£)	Saving S1–S5 (kgCO_2e)
2022	20.86	0.21107	1,330	570	163	1,167	1,181
2023	27.20	0.22500	1,735	743	213	1,522	1,259
2024	26.29	0.22535	1,677	719	206	1,471	1,261
2025	24.34	0.19553	1,552	665	190	1,362	1,094
2026	24.51	0.14396	1,563	670	192	1,371	805

Prices are DESNZ averages for all non-domestic users including the Climate Change Levy: calendar years for 2022–2025 and the provisional Q2 average for 2026. Carbon factors are for the reporting year, including grid losses.

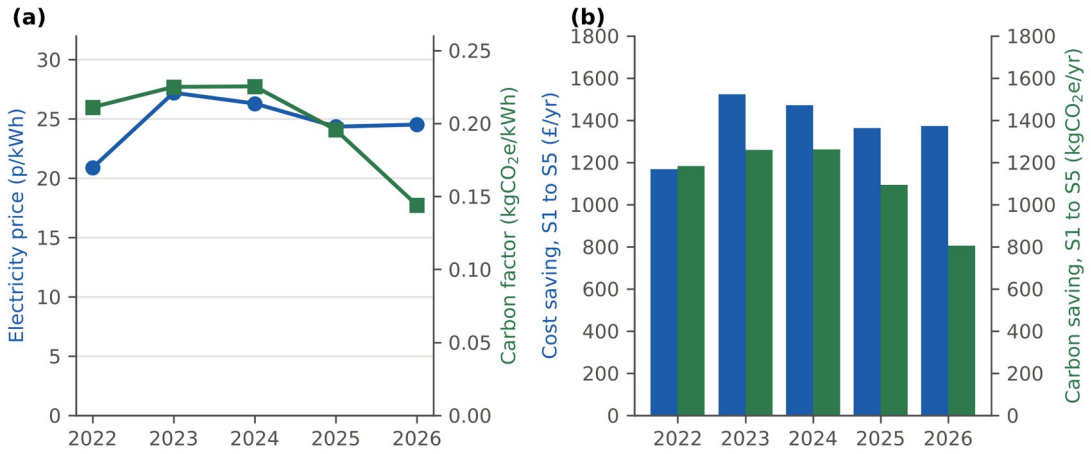

Figure 4. (a) UK non-domestic electricity price and carbon factor for consumed electricity, 2022 to 2026. (b) Annual cost and carbon saving of presence control with a 20% background (S5) against always-on fluorescent lighting (S1) in the reference plantroom.

3.5 Sensitivity

Occupancy had the largest effect on the relative saving of the proposed control (Table 5). Between 1 and 40 hours a week, S5 saved 80% to 89% against S1 and 54% to 73% against S2. At low occupancy, energy at the background level dominated: in the central case 88% of the energy of S5 was used while the room was empty. The utilisation factor changed the number of luminaires but hardly changed the relative saving against S1, which stayed between 86% and 88%. A driver overhead of 0% to 15% when dimmed changed the saving against S2 from 76% to 62%.

Table 5. Effect of occupancy on annual energy and savings in the reference plantroom.

Occupied (h/week)	Visits per week	Full-output hours per year	S4 energy (kWh/yr)	S5 energy (kWh/yr)	S5 saving vs S1	S5 saving vs S2	S4 saving vs S2
1	1	69	48	726	89%	73%	98%
2	2	139	70	742	88%	73%	97%
5	3	312	124	783	88%	71%	95%
10	5	607	216	852	87%	69%	92%
20	10	1,213	405	993	84%	64%	85%
40	15	2,340	756	1,257	80%	54%	72%

3.6 Self-contained luminaires on roofs

For the rooftop luminaire, the light was needed for only 0.19 hours a day on average, using 1.9 Wh. A microwave sensor drawing 0.5 W continuously used 12.0 Wh a day, 86% of the total (Figure 5). With a low-power PIR sensor at 0.05 W, standby fell to 1.2 Wh and the total to 3.1 Wh a day. The battery needed for five days without recharge fell from 109 Wh to 24 Wh, a reduction of 78%. Either way, the luminaire used about 5 kWh a year or less, against 87.6 kWh if the same luminaire were wired and left on.

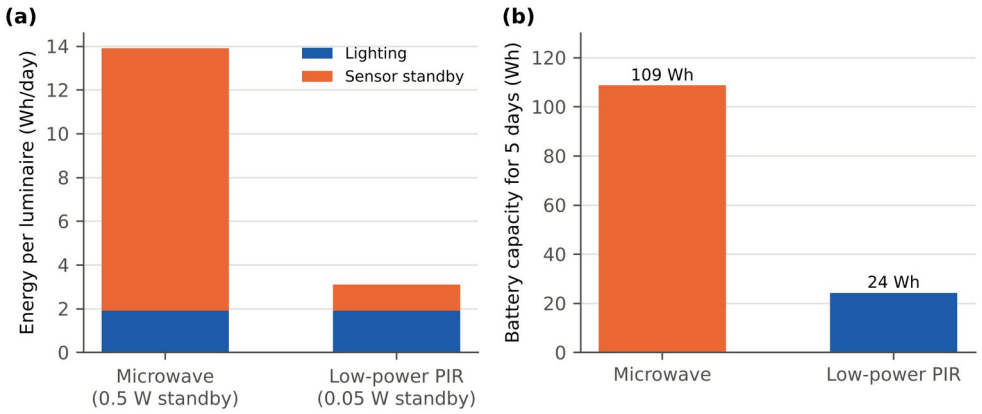

Figure 5. Self-contained rooftop luminaire (10 W, two 1-hour visits a week, half needing artificial light): (a) daily energy for light and for sensor standby with a microwave or low-power PIR sensor; (b) battery capacity for five days without recharge.

3.7 National context

Across all NHS sites in England, median LED coverage rose from 25% in 2023/24 to 60% in 2025/26, and at general acute hospitals from 60% to 80% (Table 6, Figure 6). Weighted by floor area, coverage rose from 52% to 65%, which leaves an estimated 9.6 million m² of floor area still to be converted in 2025/26. A quarter of general acute sites still reported 58% coverage or less. ERIC does not say which spaces make up the remainder, but in the author's experience plantrooms and roof areas are usually among the last to be converted because they are out of sight. Estates and facilities incidents reported under RIDDOR fell from 751 to 679 over the three years; these cover all causes and cannot be linked to lighting.

Table 6. LED lighting coverage, electricity price and estates incidents in ERIC site returns for NHS England.

Measure	2023/24	2024/25	2025/26
Sites reporting (general acute)	2,869 (228)	2,901 (219)	2,923 (219)
Median LED coverage, all sites (%)	25	50	60
Median (IQR) LED coverage, general acute (%)	60 (25–85)	70 (42–90)	80 (58–91)
Floor-area-weighted LED coverage, all sites (%)	51.9	59.1	65.5
Floor area not on LED (million m²)	13.2	11.4	9.6
Sites at 100% LED (%)	17.7	23.5	28.6
Average electricity price paid (p/kWh)	28.19	25.80	24.90
Estates and facilities RIDDOR incidents (No.)	751	718	679
RIDDOR incidents per million m² GIFA	27.3	25.9	24.3

IQR: interquartile range; GIFA: gross internal floor area. Source: ERIC site data [24]; calculations in Supplementary Material S1.

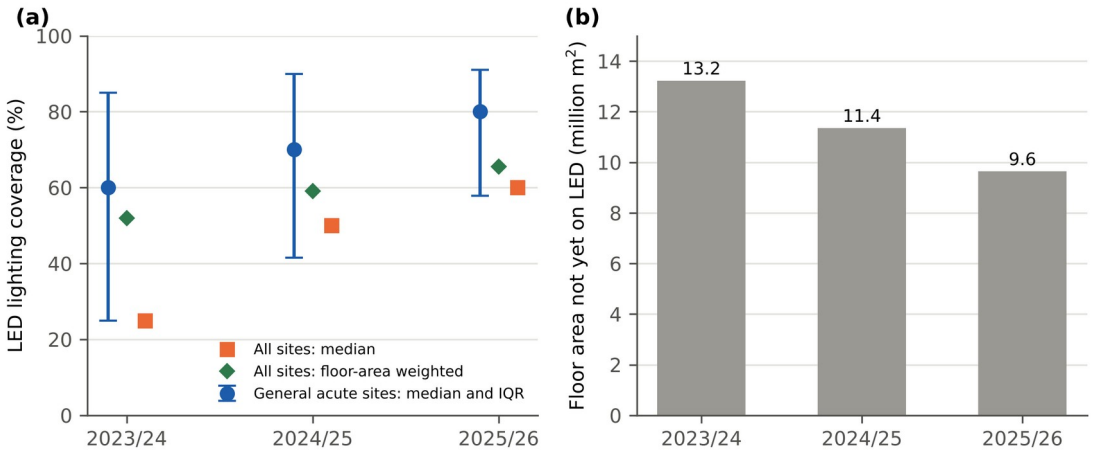

Figure 6. LED lighting coverage reported in ERIC site returns, 2023/24 to 2025/26: (a) median and interquartile range for general acute hospitals, median for all sites and floor-area-weighted coverage for all sites; (b) estimated floor area not yet lit by LED.

4. Discussion

4.1 The background level as a safety parameter

The main point of this study is simple. In a space that is empty about 97% of the time, almost all the energy of conventional lighting is spent on nobody, and presence detection removes most of it. The more interesting question is what the lighting should do when nobody is there. Switching off (S4) gives the lowest energy, but it means the safety of the person in the room depends on the sensor seeing them. Plantrooms are a hard environment for detection: people work behind and under large items of plant, kneel or lie still for long periods, and may be out of the sensor's view for most of a visit. When a switch-off sensor times out in those conditions the result is sudden darkness. A background level changes the failure mode, so that a missed detection drops the room to a level at which a person can still see the floor and find the way out.

Treating the background level as a design value, rather than accepting the factory setting, gives a clear rule: the background fraction should be at least the HSG38 average for movement divided by the installed illuminance. For the reference room this was 20 lx divided by 105 lx, or about 19%, so the 20% setting is the smallest common step that works. A room designed to a higher task illuminance would need a lower fraction for the same background, and an over-lit room a lower one still. The extra energy is modest, 659 kWh a year in the reference room, and it buys a room that is never dark. It is also well above the levels at which obstacle detection by pedestrians has been found to level off [11,12], although those studies were outdoors and did not involve plant rooms, so a direct transfer should be treated with care.

The background level is not emergency lighting. Emergency luminaires to BS 5266-1 are still needed for escape and for the safe shutdown of equipment if the supply fails [25], and the background level should not be counted towards them.

4.2 Comparison with published savings

The savings found here, 54% to 73% against always-on LED, are much higher than the averages reported for occupancy control in offices [6–8]. That is expected rather than surprising: the baseline is lighting that genuinely is on all the time, and occupancy is far lower. Lowry's warning about inflated baselines [10] still applies, which is why the manual switching scenario

was included. If staff reliably switched off, manual switching would beat every automatic option on energy. The break-even found here, about 26% of empty time left lit, gives estates teams a practical test: if plantroom lights are found on during more than about a quarter of routine checks, presence control with a background level will use less energy than the switch, and it removes the walk to the switch in the dark.

4.3 What changed between 2022 and 2026

Two things changed in opposite directions. Electricity prices rose by about 30% from 2022 to 2023 and have since eased, but in 2026 they remained 17% above 2022, so the cost saving remained higher than in 2022. Meanwhile the carbon factor fell by 32% between the 2022 and 2026 reporting years, and the carbon saving fell with it. For an organisation that justifies lighting work mainly on carbon, the case for controls in plant spaces is weaker in 2026 than it was in 2022 or 2024; on cost it is still strong. Over a three-year payback the 2026 saving against fluorescent lighting would cover roughly £686 per luminaire, a figure an estates team can compare directly with supplier and contractor quotations; equipment and installation costs were not assessed here. The withdrawal of 600 mm, 1200 mm and 1500 mm T8 lamps from the GB market from 1 September 2023 [5] adds a practical driver, because the fluorescent luminaires in many plant spaces will need replacing anyway as lamp stocks run out.

4.4 Rooftop plant and wireless luminaires

For rooftop plant without a supply, the energy needed for light is small because the light is needed so rarely. The rooftop results show that the design of a self-contained luminaire is limited by the sensor rather than the lamp: with a 0.5 W microwave sensor, standby used about six times the energy of the light itself. Choosing a sensor with very low standby power cut the battery needed by about three-quarters. This has a direct consequence for specification. Manufacturers' data sheets for battery and solar luminaires should state standby power, and buyers should ask for it. Microwave sensors also respond to movement through thin non-metallic surfaces and to vibrating or rotating plant, which can keep lights on for no reason in a plantroom and drain a battery on a roof. A passive infrared sensor avoids most of this, at the cost of a narrower view.

The comparison with a hard-wired circuit was left in general terms, because cable route lengths, containment and roof-access costs vary too much between sites for a single figure to mean much. The break-even route length is the extra cost of the self-contained luminaires divided by the installed cost per metre of the wired circuit, including roof penetrations and access, and on a long roof route that cost per metre is high. Wireless control of mains-fed luminaires in plantrooms is a separate option that removes the need for switch drops and allows a group of luminaires to light together when anyone is detected, which helps where plant blocks one sensor's view.

4.5 Wider relevance

Although the data are from the UK, the problem is not. Plant spaces in hospitals, universities, offices and industrial buildings worldwide share the same pattern of rare, short visits, high trip risk and lighting that is either always on or off. The method needs only a design illuminance, a luminaire's power and flux, an occupancy estimate, a local electricity price and a carbon factor,

all of which are available in other countries, and the background-level rule works with any national guidance that sets a minimum illuminance for movement.

4.6 Limitations

This is a calculation study, and its main limitations follow from that. No plantroom was measured. Occupancy was assumed, and although a wide range was tested, real data from access logs or sensor records would sharpen the results. The lumen method ignores the shadows of large plant, which affect both the illuminance and the sensor's view. The power drawn when dimmed was modelled as the light fraction plus a fixed overhead, which should be checked against measured driver data. The fluorescent comparison used one ballast's input power and one luminaire's light output ratio. The national price series is an average across all non-domestic users, although it agreed closely with the prices NHS sites reported paying. The national data cannot show whether better lighting in plant spaces reduces injuries, and no injury data specific to plant spaces were found. A field trial that logs occupancy, sensor behaviour and energy in a set of plantrooms, ideally with staff feedback on the background level, would be the natural next step.

5. Conclusions

Plantrooms and rooftop plant areas are lit wastefully and, at times, unsafely. For a 150 m² reference plantroom occupied for five hours a week, presence-controlled LED lighting that dims to a background level instead of switching off used 88% less electricity than always-on fluorescent lighting and 71% less than always-on LED, while never letting the room fall below the HSG38 movement level. Setting the background at 20 lx divided by the installed illuminance, 20% here, cost about 659 kWh a year more than switching off. Between 2022 and 2026 the cost saving held up while the carbon saving fell by about a third as the grid decarbonised. For battery luminaires on roofs, sensor standby power is the dominant design constraint. Estates teams can use the workbook provided to repeat the calculation with their own rooms, occupancy and prices.

Declarations

Declaration of generative AI use

The author used Claude (Anthropic, Claude Opus 5.5) to help locate and check published sources, to build the spreadsheet structure and figures, and edit the text. The research idea, the choice of scenarios and the interpretation are the author's own. The author checked every source, input and result and takes full responsibility for the content.

Declaration of conflicting interests

The author works in healthcare estates engineering in England. The study was carried out independently of that employment and uses no data from any employer. The author has no financial or other relationship with any manufacturer of lighting or controls named in this paper.

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Ethics

The study used only published data and involved no human participants.

Data availability

The Excel workbook containing every input, formula and result, including the ERIC columns used, is provided as Supplementary Material S1. ERIC data are publicly available from NHS England [24].

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