Operational Energy & Infrastructure Risk in NHS Hospitals: Electricity as the Binding Constraint

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Introduction

The NHS operates one of Europe's largest and most complex public building portfolios, much of which is inherently difficult to decarbonise. Despite the 2040 net-zero commitment, no national empirical study has jointly examined how hospitals perform energetically and the physical state of the buildings that underpin them. This study fills that gap using two complementary open datasets, Display Energy Certificates (DEC) and the Estates Returns Information Collection (ERIC), analysed together at national scale for the first time. This is critical in the UK context, where buildings account for ~25% of carbon emissions and most 2050 stock already exists. Decarbonisation of the NHS estate therefore depends on targeted, evidence-based interventions within existing assets.

1,320	42%	109	£15.9bn	6%
hospital sites assessed	meet electricity benchmark	NHS Trusts (ERIC)	maintenance backlog	share of backlog addressed

Methods

DECs (MHCLG portal) provide Operational Ratings (OR) based on metered energy use, benchmarked against CIBSE TM46 (Ranked on A-G scale, OR = 100 (Band D) = typical performance). Metrics include OR, electricity and thermal intensity (kWh/m^2).

$$OR = \frac{BuildingCO_2e}{Area} \times \frac{100}{TypicalCO_2e/area}$$

Filtered from 554,858 national records to 1,320 NHS hospitals; 7,974 longitudinal certificates retrieved.

ERIC (NHS England) provides annual Trust-level data on energy use, maintenance backlog (£/m2, four risk tiers), building age, and capital investment, amongst other information. Cleaned, GIA-normalised, inflation-adjusted. Final sample: 109 acute Trusts.

Interpretation Constraints

No clinical context (DEC): Tertiary and district hospitals fall under the same benchmark → Interpreted via regional patterns, not direct comparison.

No shared building ID (DEC ↔ ERIC): DEC at building-level, ERIC at site-level, incompatible linkage → analysis conducted at aggregated levels.

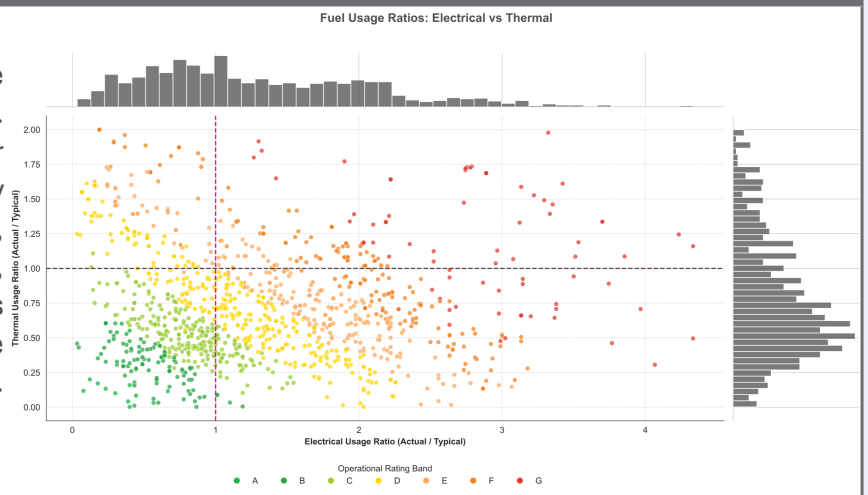
OR is carbon-weighted (energy is not): OR shifts with grid decarbonisation, independent of performance → Used kWh/m^2 to assess true energy drivers.

No link between DEC recs ↔ investment: DEC advisory reports not tied to outcomes → Focus on system-level patterns over causal claims.

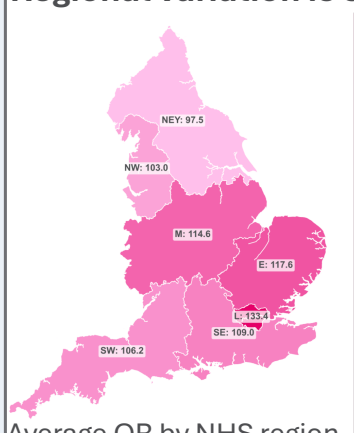
Results

Electricity is the binding constraint

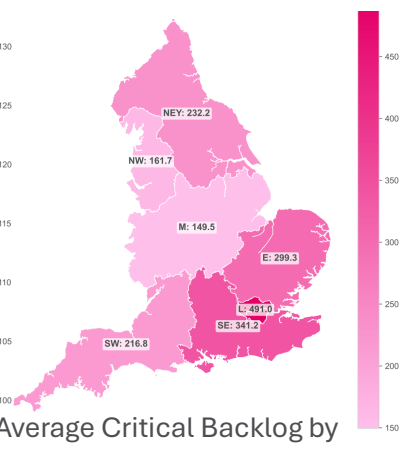
Most sites cluster in the "worse electricity, better thermal" quadrant. Electricity, not heating, drives poor Operational Ratings: median electricity use is 102 kWh/m^2 (vs 90 benchmark), with only 42% of sites compliant, compared to 262 kWh/m^2 thermal (vs 420) and 76% compliance. Top decile electricity use exceeds 215 kWh/m^2. Drivers include 24/7 equipment & HVAC.



Regional variation is substantial



Average OR by NHS region

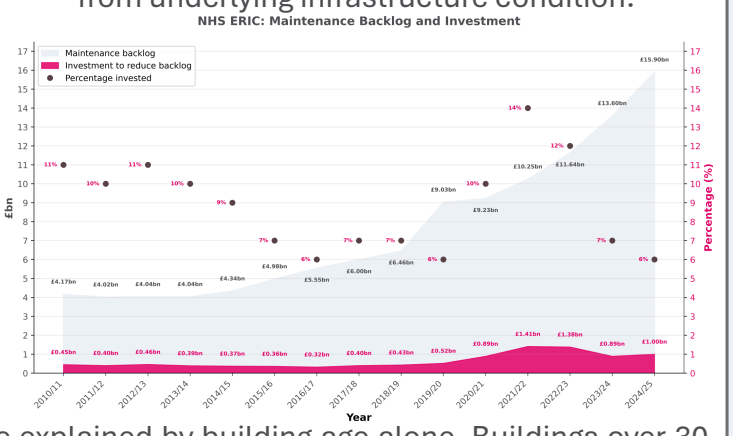


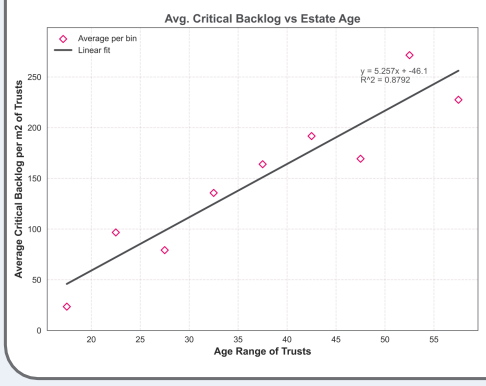
Average Critical Backlog by NHS region (£/kWhm^2)

London: median OR >130, critical backlog >£490/m^2. North West and North East & Yorkshire: OR ~100, lowest backlog. Despite a 3-4x backlog gap, OR differences remain modest, suggesting performance is not driven by condition alone. Regional contrasts likely reflect high-acuity tertiary activity, compounded in dense urban estates with higher electricity load demand per m^2. DEC + ERIC cannot disentangle service intensity from underlying infrastructure condition.

Infrastructure risk is widening

Critical backlog has almost quadrupled in real terms since 2010/11. Investment into backlog now covers just 6% of need, falling by 30% from 2021/22 to 2024/25.





The age-backlog relationship is strong: **$R^2 = 0.88$** meaning ~88% of the variation in backlog can be explained by building age alone. Buildings over 30-35 years show steep escalation as HVAC, envelope, and electrical systems reach end-of-life simultaneously. While 71% of Trusts remain broadly stable, 29% show accelerating backlog growth, indicating underinvestment relative to lifecycle needs.

Actionable Heuristics

(i) Prioritise electricity at Band D/E sites

Target >150 kWh/m^2. Focus on HVAC controls, LEDs, plug loads & BMS to improve OR without major capital works.

(ii) Fabric first at worst performers

E-G sites with critical backlog > £300/m^2: reduce demand before system upgrades; then pair electrification with controls.

(iii) Align with lifecycle inflection points

Target buildings aged 30-40 years: piggy-back energy retrofits onto planned critical system replacements.

Conclusions

Electricity, not thermal demand, is the binding constraint on NHS hospital performance, with only 42% of sites meeting the electricity benchmark versus 76% for thermal. Infrastructure risk is escalating: the maintenance backlog has tripled to £13.6bn while investment coverage has declined. Building age strongly predicts condition (R^2 = 0.88), with an inflection at 30–35 years, requiring lifecycle-aligned retrofit. TM46 fails to distinguish clinical function. This study is the first to link DEC and ERIC nationally, proving open data can inform targeted retrofit.

What's Next?

1. Deep-dive in a single, complex Trust: high-resolution energy analysis.
2. Integrate decision-making insights to understand how retrofit priorities are set.
3. Scale to national level by generalising findings for estate-wide decarbonisation.