

Energy and Sustainability Audit of a London Restaurant to Reduce Energy Consumption, and Carbon Footprint



Contributors and Authors:

Dr Ali Badiei, Senior Lecturer, Brunel University of London

Harshul Singhal, Research Associate, Brunel University of London

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Background

Beit El Zaytoun is a high-occupancy Lebanese restaurant located in Park Royal, London (15–17 Barretts Green Road, NW10 7AE), operating from a single-storey building of approximately 656 m², originally constructed circa 1970–1980 and subsequently refurbished for hospitality use.

Since opening in 2016, the venue has expanded from an initial 60-seat configuration to an estimated 250-seat layout, with extended operating hours (up to 14 hours per day, seven days per week). This intensive occupancy profile, combined with catering equipment loads and comfort conditioning demands, results in high annual energy consumption.

The building envelope reflects typical late-20th-century construction standards, with uninsulated cavity walls ($U \approx 1.19 \text{ W/m}^2\text{K}$), an uninsulated roof ($U \approx 3.84 \text{ W/m}^2\text{K}$), and single-glazed UPVC windows ($U \approx 4.8 \text{ W/m}^2\text{K}$). HVAC provision is heterogeneous: space heating is predominantly gas-fired (BAXI boiler with wet radiators and direct gas patio heaters totalling 72 kW in one zone), limited cooling is provided only in a single seating core area, and domestic hot water is generated by a high-capacity gas-fired unit (~176 kW heat input). Kitchen, store, and ancillary spaces are largely untreated.

Based on metered data for June 2024–May 2025, the site consumes 413,895 kWh/year, corresponding to an Energy Use Intensity (EUI) of 631 kWh/m²-yr and annual operational emissions of approximately 75,020 kgCO₂e. The current fuel split is approximately 72% gas and 28% electricity. While this performance sits between typical and best-practice restaurant benchmarks (per CIBSE TM46), it remains materially above trajectories consistent with UK net zero ambitions.

Energy modelling (OpenStudio calibrated to annual utility data) demonstrates that a coordinated retrofit package—including fabric improvements, LED lighting with controls, air source heat pumps (ASHP), and roof-mounted photovoltaic (PV) generation—could reduce operational emissions by up to 24%, lowering annual emissions to ~56,700 kgCO₂e. However, this reduction still leaves substantial residual emissions.

The Core Challenge

Despite technically viable energy efficiency and electrification measures, Beit El Zaytoun exemplifies the structural decarbonisation challenge faced by hospitality buildings—particularly food-led premises.

Process-Dominated Energy Profile

The most significant barrier to deep operational decarbonisation is the dominance of catering process loads. In the baseline condition, approximately 57% of total annual

energy demand is attributable to kitchen equipment and associated process loads. Under the most optimised retrofit package (heating-only ASHP + PV), this proportion increases to ~74%, as building-related loads are reduced while cooking-related energy remains largely unchanged.

Even after electrification of space heating and installation of PV, the site retains:

- ~167,317 kWh/year of gas demand (primarily cooking)
- ~66,603 kWh/year of electricity for kitchen and back-of-house equipment

These loads are intrinsic to restaurant operation and cannot be materially reduced without fundamental changes to catering technology, fuel-switching strategies, or menu/process redesign. This represents a practical ceiling for building-services-led decarbonisation.

Electrification Constraints

Transitioning from gas-based heating to ASHP significantly reduces gas consumption and improves comfort (with heating-only ASHP scenarios achieving up to 21.3% energy reduction prior to PV). However, electrification introduces several constraints:

- Increased peak electrical demand and potential need for supply upgrades
- External plant siting challenges (acoustics, planning, landlord consent)
- Interaction with kitchen extract/make-up air systems
- Dependence on grid carbon intensity for residual emissions

Furthermore, extending cooling to previously untreated zones increases electricity demand and partially offsets carbon gains, highlighting the importance of demand reduction and passive measures before system expansion.

Building Fabric Limitations

The building's envelope performance is poor by modern standards, but fabric interventions are constrained by:

- Leased tenancy status (landlord consent required)
- Structural verification requirements
- Intrusive survey needs (cavity suitability, moisture risk)
- Limited roof area for PV deployment

While cavity insulation and roof upgrades offer measurable heating reductions (~8% standalone savings), their absolute impact on whole-building carbon is moderated by process energy dominance.

Spatial and Structural Constraints on Renewables

PV feasibility analysis indicates that approximately 55 m² of roof area could support an ~11 kWp system, generating ~11,025 kWh/year and offsetting ~2.7% of baseline emissions. Although financially viable, PV contribution is inherently limited by:

- Available roof geometry and loading capacity
- Shading and structural constraints
- Grid export arrangements
- The scale of underlying catering demand

Thus, on-site renewables function primarily as an offsetting mechanism rather than a transformative decarbonisation lever.

Strategic Significance

Beit El Zaytoun sits within the Park Royal industrial and food systems cluster, a location strategically aligned with wider net zero food supply chain ambitions. As such, it represents:

- A live case study of hospitality-sector decarbonisation limits
- A demonstrator for integrated fabric + electrification + renewables pathways
- A platform to explore next-generation low-carbon catering technologies
- A testbed for measurement and verification frameworks (TM54/IPMVP aligned)

The project therefore extends beyond a single premises retrofit. It addresses a systemic challenge: how to decarbonise energy-intensive food-led commercial buildings where operational processes dominate energy use.

Framing the Research/Implementation Challenge

The fundamental challenge is not merely improving building performance but redefining the boundary of decarbonisation in hospitality environments.

Building-focused measures can deliver approximately 21–24% operational carbon reduction under current assumptions. Achieving deeper reductions would require:

- Electrification or alternative fuels for commercial cooking
- High-efficiency kitchen equipment retrofits
- Heat recovery from kitchen extract systems
- Integrated ventilation-heat pump optimisation

- Behavioural and operational interventions
- Potential future grid decarbonisation or off-site renewable procurement

The site therefore highlights the “residual carbon problem” in process-dominated commercial buildings—a critical research and policy gap if the UK’s legally binding 2050 net zero target is to be achieved across the hospitality sector.

Approach and methodology

The approach adopted for the decarbonisation feasibility study of Beit El Zaytoun follows a structured, evidence-based methodology combining calibrated energy modelling, technology appraisal, carbon accounting, and implementation risk assessment. The methodology is designed to provide decision-grade feasibility outputs while clearly distinguishing between feasibility-stage assumptions and detailed design requirements.

Item 1: Baseline Definition and Performance Assessment

- a. Data Collection and Building Characterisation A comprehensive

baseline was established using:

- **Utility data (June 2024 – May 2025)** to determine annual electricity and gas consumption (413,895 kWh/year total; 75,020 kgCO₂e/year operational emissions).
- Site inspection and photographic survey to document:
 - Envelope construction (uninsulated cavity walls, single glazing, uninsulated roof)
 - HVAC configuration (gas boiler, gas patio heaters, limited split cooling)
 - DHW system (packaged gas-fired unit ~176 kW heat input)
 - Lighting typologies and connected loads
- Zoning and occupancy analysis reflecting restaurant operational hours and seating expansion.

Envelope U-values were referenced from CIBSE Guide A standards pending intrusive verification, including:

- Walls: 1.19 W/m²K
- Roof: 3.84 W/m²K
- Glazing: 4.8 W/m²K

The baseline Energy Use Intensity (EUI) was calculated at 631 kWh/m²-yr, benchmarked against CIBSE TM46 restaurant benchmarks

b. Energy Modelling and Calibration

A dynamic whole-building energy model was developed in OpenStudio/EnergyPlus, incorporating:

- Verified geometry (≈656 m² floor area)
- Envelope thermal properties
- Lighting power densities
- Catering and internal equipment gains
- Ventilation and extract assumptions
- Existing HVAC configuration

The model was calibrated at annual level against metered electricity and gas consumption. Calibration provided a robust comparative platform for option testing, with explicit acknowledgement that:

- Monthly calibration and sub-metering would improve confidence.
- Catering and extract loads introduce uncertainty.
- Outputs are suitable for feasibility-stage decision support rather than detailed design.

Carbon calculations used UK Government 2025 GHG conversion factors:

- Electricity: 0.177 kgCO₂e/kWh
- Natural gas: 0.183 kgCO₂e/kWh

These factors were applied consistently across baseline and improvement scenarios.

Item 2: Option Development and Technology Appraisal

a. Energy Efficiency Measures (EEMs) – Technical Modelling

A structured “one-at-a-time” and cumulative package modelling approach was used to evaluate Energy Efficiency Measures (EEMs):

Step 1 – Standalone Scenarios

Each intervention was applied individually to quantify isolated impact:

- Wall and roof insulation
- Double glazing upgrade

- LED lighting and controls
- Air Source Heat Pump (heating-only and heating + cooling variants)
- Roof-mounted PV (~11 kWp)

This allowed identification of direct savings, interaction risks, and relative effectiveness.

Step 2 – Cumulative Packages

Measures were layered sequentially to simulate realistic retrofit pathways and capture interaction effects such as:

- Reduced heating loads influencing plant sizing
- Electrification shifting fuel split
- PV offsetting residual electricity demand

The optimised package (ASHP heating-only + PV) reduced annual energy to 314,734 kWh and carbon emissions to ~56,700 kgCO₂e (≈24% reduction).

This staged modelling approach ensured:

- Transparent attribution of savings
- Avoidance of double counting
- Realistic representation of system replacement impacts

Importantly, ASHP scenarios were treated as **system replacement plus revised service coverage**, not strict like-for-like swaps.

b. Costing, Feasibility and Risk Assessment

Each measure was evaluated using a multi-criteria framework including:

1. **Capital Cost (indicative industry rates)**
2. **Annual Energy and Carbon Savings**
3. **Simple Payback**
4. **Operational Impacts**
5. **Implementation Constraints**

Financial estimates were based on current industry benchmarks, acknowledging market variability.

Feasibility assessment explicitly addressed:

- Landlord consent requirements (leased premises)

- Structural capacity (PV loading, plant support)
- Electrical infrastructure adequacy for electrification
- Acoustic and planning constraints (external condensers)
- Cavity suitability and moisture risk for insulation
- Interaction with kitchen ventilation and extract systems
- Risk categorisation was aligned with RIBA Stage 2–3 progression requirements.

Item 3: Residual Energy Analysis and System Boundary Assessment

a. End-Use Disaggregation

The model disaggregated end-use energy to identify structural decarbonisation limits. Results demonstrated:

- ~57% of baseline energy attributable to catering process loads
- ~74% of total energy attributable to process loads in optimised scenario This analysis highlighted that:
 - Building services measures have diminishing marginal returns.
 - Residual emissions are dominated by cooking equipment and extract systems.
 - Deep decarbonisation requires process-level intervention beyond envelope/HVAC upgrades.

b. Monitoring and Verification Framework

A Measurement & Verification (M&V) framework was proposed to support postimplementation validation:

- Whole-building electricity and gas metering
- Sub-metering of kitchen/catering loads where feasible
- Dedicated metering for heat pumps and cooling circuits
- Weather-normalised monthly KPI tracking

The framework aligns with principles of TM54, ASHRAE Guideline 14, and IPMVP (as referenced in the study)

Results and Impacts

The Results and Impacts section synthesises the calibrated modelling outputs, comparative scenario analysis, and financial appraisal presented in the feasibility study. Reference is made to the key tables and graphs within the report to anchor the findings in quantified evidence.

Results

Baseline Performance and Energy Profile

The calibrated baseline (June 2024–May 2025 utility data) establishes the current operational performance as follows:

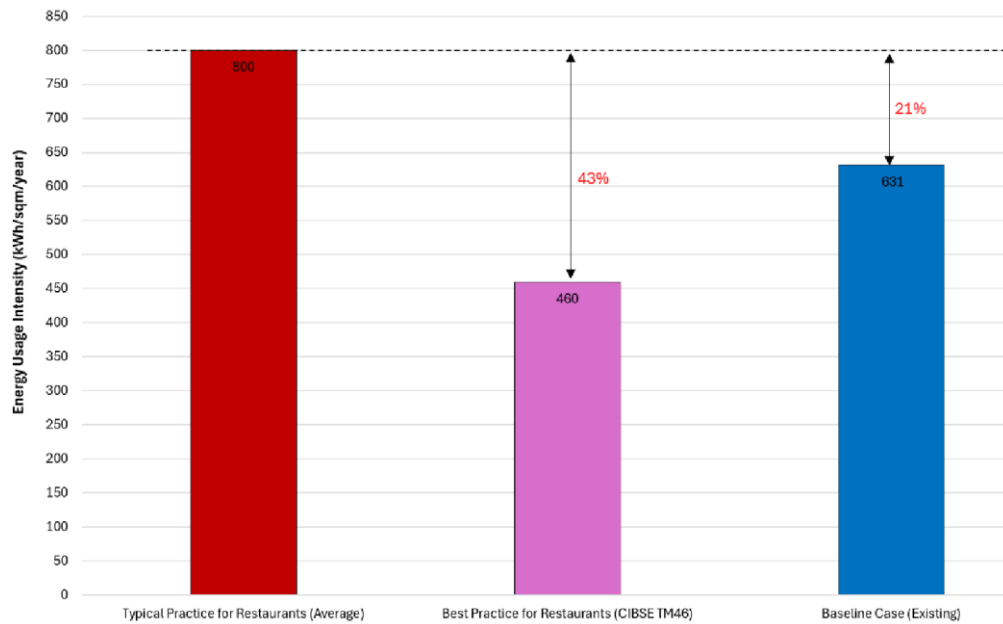
- **Total annual energy:** 413,895 kWh
- **Energy Use Intensity (EUI):** 631 kWh/m²-yr
- **Annual operational emissions:** 75,020 kgCO₂e

These figures are presented in **Table 1 (Total Energy Consumption and Carbon Emissions)** and visually benchmarked in **Graph 1 (Baseline Energy Usage Comparison with Industry Practices)**.

Table 1. Total Energy Consumption and Carbon Emissions.

Annual Energy Demands (Existing Baseline) - Beit El Zaytoun			
	Total Consumption	Emissions Factor (kgCO ₂) per unit	Carbon Emissions (kgCO ₂ /annum)
Electricity (kWh/annum)	117,008	0.177	20,710
Gas (kWh/annum)	296,886	0.183	54,309
Total	413,895	0.181	75,020

Graph 1 shows the site performing between “typical practice” (~800 kWh/m²-yr) and “best practice” (~460 kWh/m²-yr) benchmarks for restaurants, confirming that while not inefficient by sector standards, significant decarbonisation potential remains.



Graph 1. Baseline (Exis5ng) Case Energy usage comparison with industry prac5ces

The baseline fuel split is:

- 28% electricity
- 72% gas

This reflects heavy reliance on fossil fuels for heating, domestic hot water, and cooking.

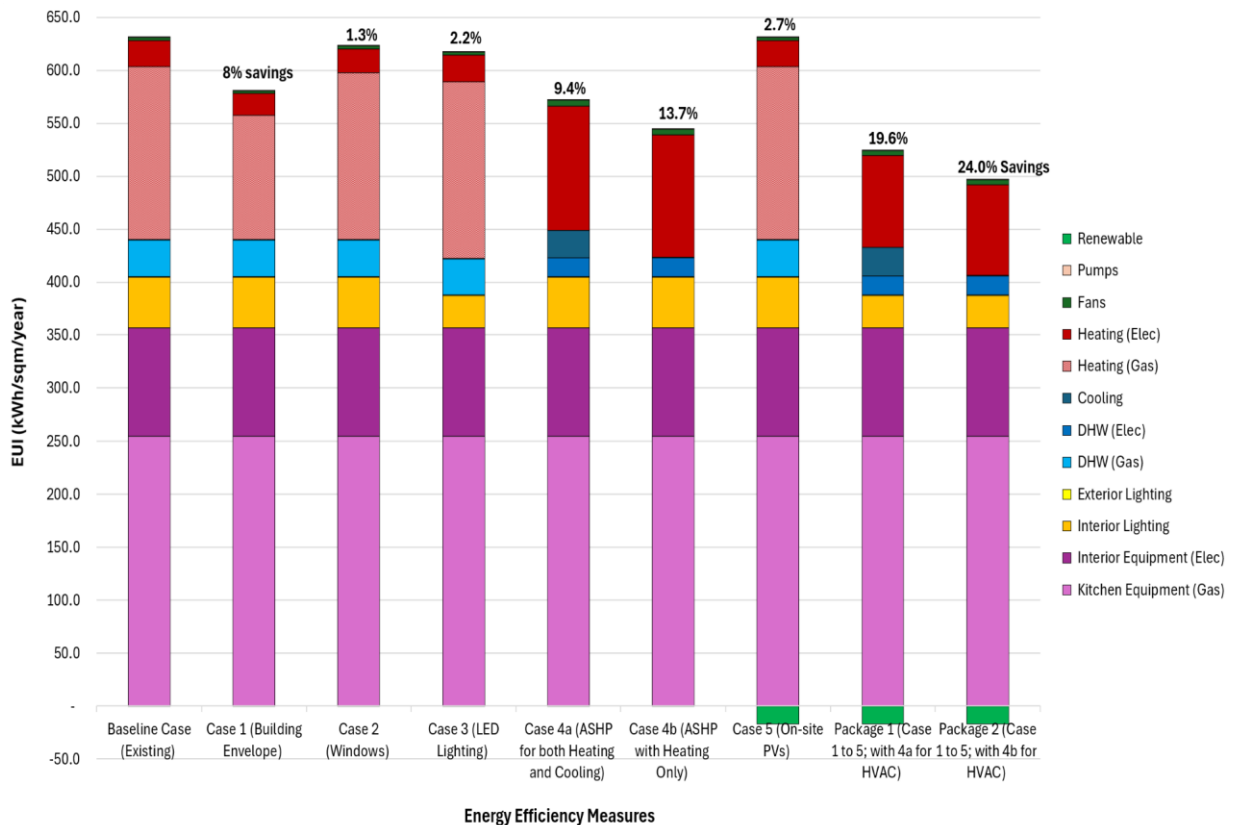
A critical structural finding from the end-use breakdown is that catering and process loads account for approximately **57% of total annual energy demand**, setting a practical constraint on building-services-led decarbonisation.

Standalone Energy Efficiency Measure (EEM) Results

1. Fabric Upgrades (Walls and Roof)

- Energy reduction: 8.0%
- Total energy reduced to 380,825 kWh/year
- Primary impact: heating gas reduced from 107,125 → 77,017 kWh/year

Graph 2 clearly shows the reduction in heating gas demand relative to baseline. While meaningful, whole-building impact is moderated by dominant kitchen loads.



Graph 2. Standalone EEM measures (one-at-a-time) Scenario Savings

2. Windows Upgrade

- Energy reduction: 1.3%
- Total energy reduced to 408,592 kWh/year

The limited impact reflects the relatively small share of total demand attributable to fabric heat loss in a process-heavy building.

3. LED Lighting and Controls

- Energy reduction: 2.2%
- Lighting energy reduced from 31,594 → 20,261 kWh/year

Graph 2 confirms the modest whole-building effect despite substantial lighting efficiency gains. Financially, however, lighting demonstrates one of the shortest payback periods (see Savings Summary Table below).

Table 2. Savings summary for Beit El Zaytoun

Item	Incremental Capital Cost (£)	Revenue Savings (£/yr)	ROI (Years)	kgCO ₂ Savings/yr	kgCO ₂ Savings (%)	Cost per % CO ₂ Savings
Building Envelope Upgrade	£31,699	£3,119	10.2	6,032	8.0%	£3,967
Windows Improvement	£21,105	£678	31.1	961	1.3%	£16,473
LED Lighting	£9,837	£2,510	3.9	1,571	2.2%	£4,548
ASHP with Heating and Cooling	£15,000	-£11,380	-	7,665	9.4%	£1,593
ASHP with Heating Only	£15,000	-£7,122	-	10,805	13.7%	£1,095
On-site PVs	£16,000	£2,646	6.0	1,951	2.7%	£6,007
Total (with heating and cooling)	£93,641	-£2,426	-	18,180	19.6%	£4,788
Total (with heating only)	£93,641	£1,832	51.1	21,320	24.0%	£3,909

Air Source Heat Pumps (ASHP) Two

variants were modelled:

ASHP – Heating + Cooling

- Energy reduction: 9.4%
- Carbon saving: 7,665 kgCO₂/year

ASHP – Heating Only

- Energy reduction: 13.7%
- Carbon saving: 10,805 kgCO₂/year

As shown in **Graph 2**, the heating-only configuration performs better because it avoids introducing significant new cooling demand.

This demonstrates that controlled electrification delivers the largest standalone decarbonisation impact.

4. Solar Photovoltaics (11 kWp)

- Annual generation: 11,025 kWh

- Carbon offset: ~2.7% of baseline

PV provides predictable offsetting but cannot materially shift total energy dominance due to roof area constraints.

Cumulative Package Performance

The layered retrofit results are presented in:

- Table 3 (Cumulative End-Use Breakdown)
- Graph 3 (Cumulative EEM Scenario Savings)
- Table 2 (Savings Summary Table)

Optimised Scenario (Case 5b – Heating-Only ASHP + PV)

- Total energy reduced to 314,734 kWh/year
- Energy reduction: 24.0%
- EUI reduced from 631 → 480 kWh/m²·yr
- Carbon reduced from 75,020 → 56,700 kgCO₂e
- Total carbon saving: 18,320 kgCO₂e/year

Graph 3 visually demonstrates the progressive decline in total energy across cumulative scenarios, with Case 5b delivering the most substantial reduction.

Table 3 quantifies capital cost, carbon savings, and payback periods across measures, confirming that while glazing has longer payback, lighting and ASHP deliver stronger financial and carbon returns.

Table 3. End-use breakdown (kWh, EUI, kgCO₂ and cost) for cumulative run cases

ENERGY (kWh) - Cumulative EEM Scenarios								
Energy End Use	Baseline Case (Existing)	Case 1 (Building Envelope)	Case 2 (Windows)	Case 3 (LED Lighting)	Case 4a (ASHP for both Heating and Cooling)	Case 4b (ASHP with Heating Only)	Case 5a (Case 4a + On-site PVs)	Case 5b (Case 4b + On-site PVs)
Heating (Elec)	16,397	13,650	10,978	11,214	57,175	56,197	57,175	56,197
Heating (Gas)	107,125	77,017	72,678	74,878	-	-	-	-
Cooling	408	542	544	478	17,419	192	17,419	192
Interior Lighting	31,594	31,594	31,594	20,261	20,261	20,261	20,261	20,261
Exterior Lighting	217	217	217	217	217	217	217	217
Interior Equipment (Elec)	66,603	66,603	66,603	66,603	66,603	66,603	66,603	66,603
Kitchen Equipment (Gas)	167,317	167,317	167,317	167,317	167,317	167,317	167,317	167,317
Fans	1,778	1,433	1,433	1,433	3,103	3,103	3,103	3,103
Pumps	11	8	8	8	8	8	8	8
DHW (Gas)	22,444	22,444	22,444	22,444	-	-	-	-
DHW (Elec)	-	-	-	-	11,861	11,861	11,861	11,861
Renewable	-	-	-	-	-	-	11,025	11,025
Total Energy	413,895	380,825	373,817	364,853	343,964	325,759	332,939	314,734
Total Gas (kWh)	296,886	266,778	262,439	264,639	167,317	167,317	167,317	167,317
Total Electricity (kWh)	117,008	114,047	111,378	100,214	176,647	158,442	165,622	147,417
Energy Savings (kWh)	-	33,069	40,078	49,042	69,931	88,136	80,956	99,161
Energy Savings (%)	-	8.0%	9.7%	11.8%	16.9%	21.3%	19.6%	24.0%
Total Utility Cost (£)	£51,833	£48,714	£47,726	£45,222	£55,781	£51,411	£53,135	£48,765
Cost Savings (£)	-	£3,119	£4,107	£6,610	-£3,948	£422	-£1,302	£3,064
Gas CO ₂ (kgCO ₂ /year)	54,309	48,802	48,008	48,410	30,607	30,607	30,607	30,607
Elec CO ₂ (kgCO ₂ /Year)	20,710	20,186	19,714	17,738	31,267	28,044	29,315	26,093
Carbon (kgCO ₂ /Year)	75,020	68,988	67,722	66,148	61,874	58,651	59,922	56,700
CO ₂ Savings (per Year)	-	6,032	7,298	8,872	13,146	16,368	15,097	18,320

ENERGY Usage Intensity (kWh/sqm/yr) - Cumulative EEM Scenarios								
Energy End Use	Baseline Case (Existing)	Case 1 (Building Envelope)	Case 2 (Windows)	Case 3 (LED Lighting)	Case 4a (ASHP for both Heating and Cooling)	Case 4b (ASHP with Heating Only)	Case 5a (Case 4a + On-site PVs)	Case 5b (Case 4b + On-site PVs)
Heating (Elec)	25.0	20.8	16.7	17.1	87.2	85.7	87.2	85.7
Heating (Gas)	163.3	117.4	110.8	114.2	-	-	-	-
Cooling	0.6	0.8	0.8	0.7	26.6	0.3	26.6	0.3
Interior Lighting	48.2	48.2	48.2	30.9	30.9	30.9	30.9	30.9
Exterior Lighting	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Interior Equipment (Elec)	101.6	101.6	101.6	101.6	101.6	101.6	101.6	101.6
Kitchen Equipment (Gas)	255.1	255.1	255.1	255.1	255.1	255.1	255.1	255.1
Fans	2.7	2.2	2.2	2.2	4.7	4.7	4.7	4.7
Pumps	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DHW (Gas)	34.2	34.2	34.2	34.2	-	-	-	-
DHW (Elec)	-	-	-	-	18.1	18.1	18.1	18.1
Renewable	-	-	-	-	-	-	16.8	16.8
Total Energy	631.1	580.7	570.0	556.3	524.5	496.7	507.7	479.9
Total Energy Savings (EUI)	-	50.4	61.1	74.8	106.6	134.4	123.4	151.2

Fuel Switching and Residual Energy

The Electricity vs Gas Split shows a fundamental system transformation:

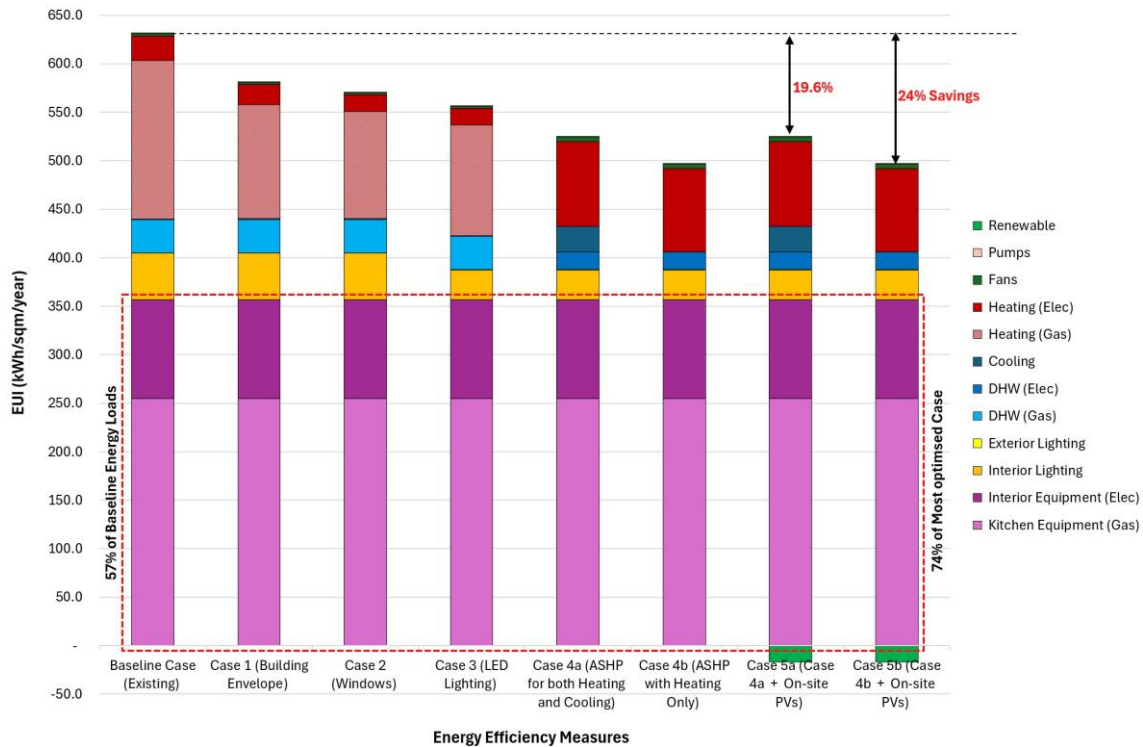
- Baseline: 72% gas / 28% electricity
- Optimised: ~47% gas / 53% electricity

Space heating gas is largely eliminated; remaining gas (~167,317 kWh/year) is primarily associated with cooking.

However, End-Use Breakdown reveals that in the optimised scenario:

- Process loads rise proportionally to ~74% of total demand
- ~66,603 kWh/year electricity remains for kitchen equipment
- ~167,317 kWh/year gas remains for catering

This establishes a structural decarbonisation ceiling under current scope.



Graph 3. Cumulative EEM measure Scenario Savings

Impacts

Comfort and Operational Impacts

Beyond energy reduction, modelling indicates:

- Significant reduction in unmet heating hours under ASHP scenarios
- Improved winter comfort due to reduced heat loss (fabric improvements)
- Enhanced lighting control flexibility
- Potential for reduced peak heating capacity through demand reduction

These qualitative benefits are not directly represented in kWh tables but are critical to operational resilience.

Financial and Strategic Impact

The financial summary (see **Table 2 – Savings Summary**) demonstrates:

- Lighting: short payback (~3.9 years)
- ASHP heating-only: strong carbon return
- PV: moderate payback (~6 years)
- Fabric: longer payback but comfort-driven justification

Collectively, the retrofit provides:

- ~24% operational carbon reduction
- Reduced fossil fuel exposure
- Electrified heating pathway aligned with UK Net Zero trajectory
- Data-calibrated basis for funding applications or landlord negotiations

Overall Impact

The integrated modelling framework demonstrates that:

- Building-focused interventions can achieve meaningful reductions.
- Electrification is the dominant decarbonisation lever.
- Process loads define the practical carbon floor.

The most significant impact of the study is therefore dual:

1. Delivering quantified, implementable carbon reduction of 18,320 kgCO₂e/year.
2. Clearly identifying the next-phase challenge—decarbonising catering process energy in hospitality environments.

This evidence-based assessment provides a replicable methodology for similar food-led commercial buildings operating under lease, spatial, and operational constraints.

Next steps

The immediate next step is to progress from feasibility-stage modelling to detailed design and verification (RIBA Stage 2–3 equivalent). This should include intrusive fabric surveys to confirm wall and roof build-ups and cavity suitability, detailed electrical capacity assessment to support heat pump electrification, structural appraisal of roof loading for the proposed ~11 kWp PV array, and acoustic/planning review for external ASHP units. Concurrently, updated U-value calculations, refined HVAC zoning strategy (particularly defining whether cooling remains limited or expanded), and confirmation of the domestic hot water solution should be incorporated into an updated calibrated energy model to de-risk performance assumptions before procurement. Capital cost estimates should be validated through supplier quotations to refine payback projections.

In parallel, a structured Measurement and Verification (M&V) plan should be established prior to implementation, including sub-metering of kitchen/catering loads and heat pump circuits, to enable post-retrofit performance validation against the June 2024–May 2025 baseline. Given that process energy represents the dominant residual load, a second phase workstream should be initiated to assess low-carbon catering technologies, heat recovery from kitchen extract systems, and potential fuel-switching strategies for cooking.

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