Energy Masterplanning & Net Zero Retrofitting on the FHE Estate

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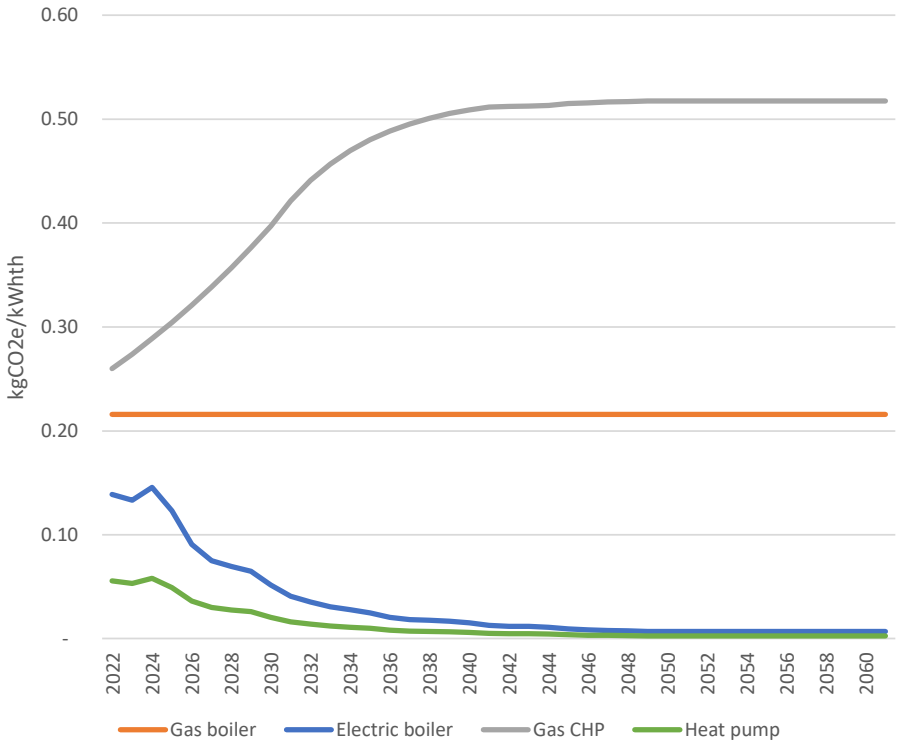
Key points

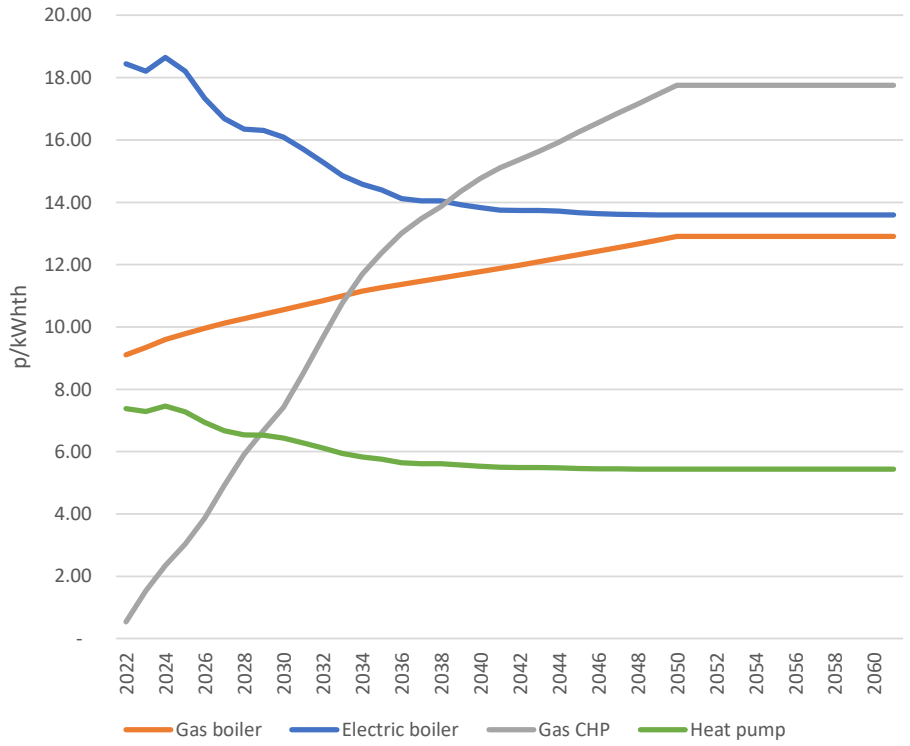
- Why business as usual is no longer an option
- How to develop a decarbonisation strategy/masterplan that offers optimal value for money
- The input required to steer through the fog of options that exist:
  - Fabric & MEP surveys
  - Cost information
  - Energy modelling
  - Stakeholder engagement
- Lessons learned from modelling outputs
- Creating a holistic business case and deliverable plan

Why BAU is not an option

GHG emissions

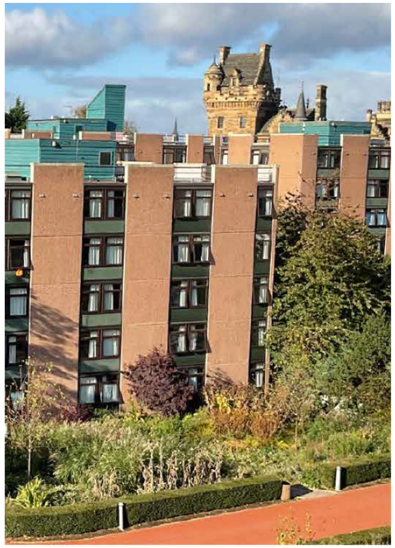


Fuel cost, including cost to offset

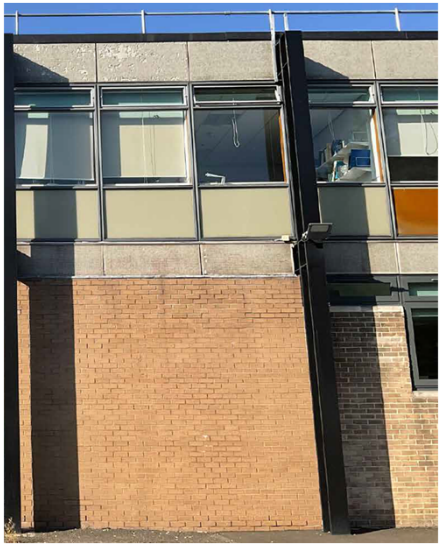


Planning for Net Zero

Supporting strategic decision-making on the fabric upgrade of existing built assets and their future carbon cost







Building Fabric Assessments - Survey Outputs

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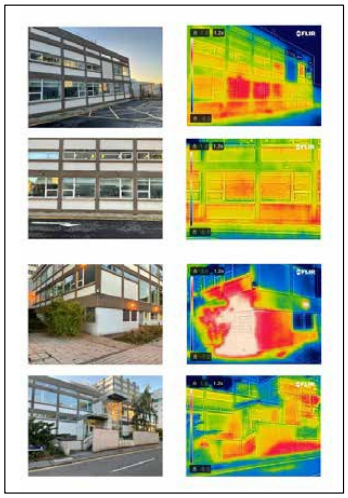
Photographic survey

Thermal Envelope Report

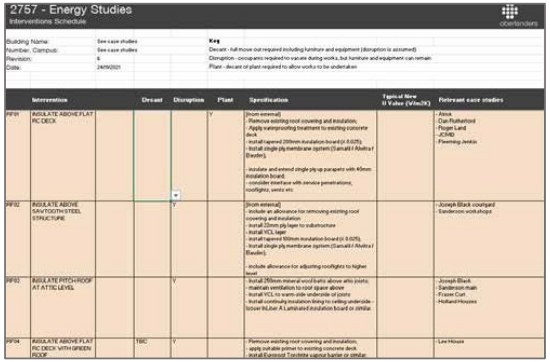


Retrofit Opportunities and Constraints Report

Thermal and Fabric Area Model

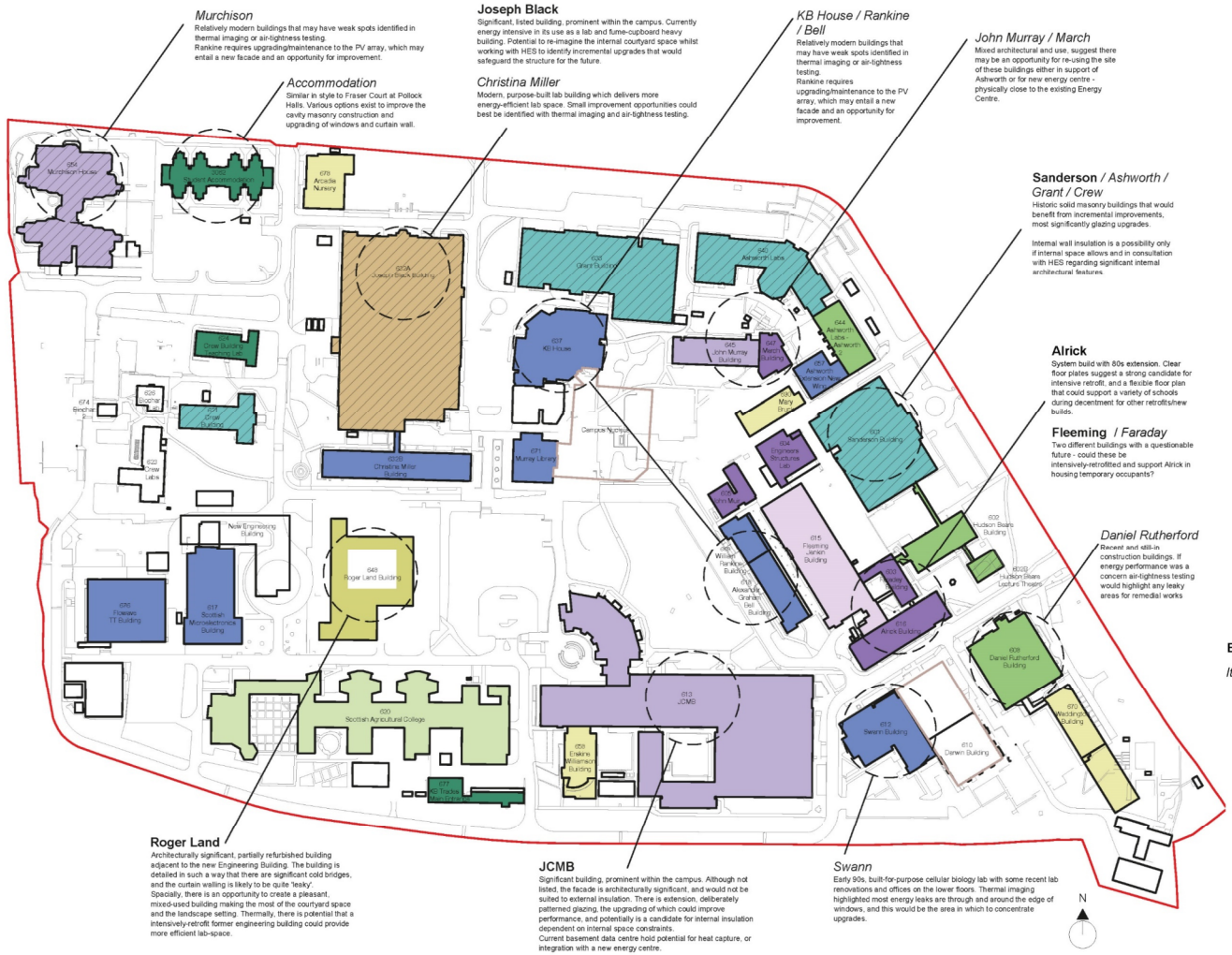
NAME	LEE HOUSE	BUILDING VOLUME M3						PREFERRED INTERVENTION		
NUMBER	842, POLLOCK HALLS	GROSS INTERNAL FLOOR AREA M2					3366			
TYPE	STUDENT RESIDENTIAL	SPACE AND WATER HEATING kWh/m2.a					461			
Current Areas and U-Values								Interventions		
Item	Type	U Value W/m2K	Area (N) m2	Area (S) m2	Area (E) m2	Area (W) m2	Total m2	Code	New U Value W/m2K	%
Ground Floor	RC slab, no insulation	3.62	845.0				845.0	F01F03	0.11	3%
Exposed Floor							0.0			#DIV/0!
Wall Type 1	Conc panel, cavity, concrete sandwich panel, plaster	0.91		262.9	265.0	321.4	322.7	1172.0	W04/W05	0.21	23%
Wall Type 2	Curtain wall insulated box-out	0.36		63.8	66.8	126.2	121.6	378.4	G08	0.85	236%
Wall Type 3							0.0				#DIV/0!
Wall Type 4	Timber cladding on plant room w all - uninsulated	2.40		33.6	34.2	52.5	56.7	177.0	W04/W05	0.21	9%
Basement wall							0.0				#DIV/0!
Flat Roof inc rooflights	Felt, insulation, concrete deck	0.23	844.9				844.9	RF01	0.11	48%
Pitched Roof inc rooflights							0.0				#DIV/0!
Glazing Type 1	Curtain wall double glazing	3.30		68.2	64.0	135.1	137.7	405.0	G08	0.85	26%
Glazing Type 2							0.0				#DIV/0!
Doors - solid	Timber	3.00				6.0	6.0	G08	0.85	28%

Fabric Interventions Library



Risk and Mitigation register

Site Plan of Kings Buildings Construction Typologies



Building Construction Typologies

TYPE 1
Solid Masonry
Late 19thC - 1930s

Listed Buildings:

- **601 - Sanderson Building**
- *621 - Crew Building*
- *633 - Grant Building*
- *640 - Ashworth Labs*

TYPICAL RETROFIT OPTIONS

WAL
Ł W01 - Internal Wall Insulation (IWI)

ROO
F RF01 - Insulate above flat RC deck
- RF03 - Insulate pitch roof at attic level

GLAZIN
G G01 - High performance double glazing
- G03 - Shutter
- G04 - Secondary

ROOFLIGHTS
- RL01 - High performance commercial roof-light

TYPE 2
Brick Cavity Masonry
1930s

Listed Buildings:

- **632A - Joseph Black Building**

TYPICAL RETROFIT OPTIONS

WAL
Ł W01 - Internal Wall Insulation (IWI)
- W02 - External Wall Insulation (EWI)
- W03 - External Wall Insulation (EWI) Render

ROO
F RF01 - Insulate above flat RC deck
- RF02 - Insulate above steel sawtooth structure

GLAZIN
G G01 - High performance double glazing
- G06 - High performance solid door

ROOF-LIGHTS
- RL01/02 - High performance commercial/flat roof-light

TYPE 3
Brick Cavity Facing Masonry
1970s

Listed Buildings:

- *654 - Murchison House*

Unlisted Buildings
- **613 - JCMB**
- *645 - John Murray Building*

TYPICAL RETROFIT OPTIONS

WAL
Ł W01 - Internal Wall Insulation (IWI)

ROO
F RF01 - Insulate above flat RC deck

GLAZIN
G G01 - High performance double glazing
- G05 - High performance glazed door
- G06 - High performance solid door
- G07 - High performance double glazed curtain

ROOF-LIGHTS
- RL02 - High performance flat roof-light

TYPE 4
Block Cavity
1930-70s

Unlisted Buildings:

- *620 - Scotland's Rural College (SRUC)*
- *624 - Crew Building Teaching Lab*

TYPICAL RETROFIT OPTIONS

ROO
F RF01 - Insulate above flat deck
- RF03 - Insulate pitch roof at attic level

GLAZIN
G G01 - High performance double glazing
- G02 - Enerphit standard triple glazing
- G07 - High performance double glazed curtain wall

ROOF-LIGHTS
- RL02 - High performance flat roof-light

AIR-TIGHTNESS MEASURES

TYPE 5
Block Cavity
1980-90s

Unlisted Buildings:

- *3062 - Student Accommodation*

TYPICAL RETROFIT OPTIONS

FLOOR
- F03 - Apron perimeter insulation
- F04 - Insulate over exposed floor

WAL
Ł External Wall Insulation (EWI) with rainscreen or render finish

ROO
F RF01 - Insulate above flat deck
- RF03 - Insulate pitch roof at attic level

GLAZIN
G G01 - High performance double glazing
- G02 - Enerphit-standard triple glazing
- G08 - Enerphit-standard triple glazed curtain wall

ROOF-LIGHTS
- RL02 - High performance flat roof-light

AIR-TIGHTNESS MEASURES

TYPE 6
System Build Concrete
1960s

Listed Buildings
- *602B - Hudson Beare Lecture Theatre*

Unlisted Buildings:
- *602 - Hudson Beare*
- *644 - Ashworth 2*

TYPICAL RETROFIT OPTIONS

FLOOR
- F01 - Reinstate solid floor with insulation
- F03 - Apron perimeter insulation

WAL
Ł EWI with rainscreen, render or living wall

ROO
F RF01 - Insulate above flat deck

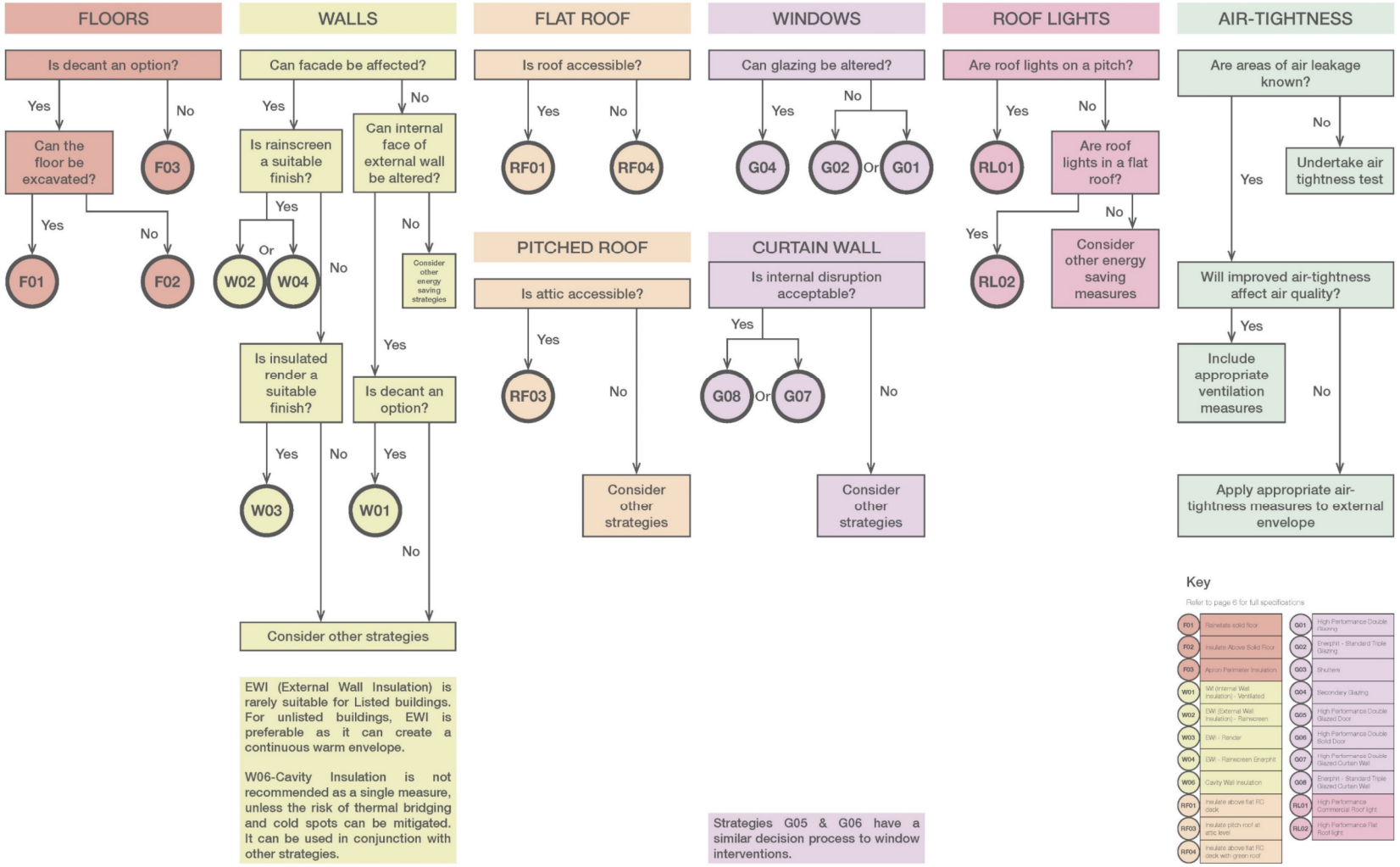
GLAZIN
G G08 - Enerphit-standard triple glazed curtain wall

ROOF-LIGHTS
- RL02 - High performance flat roof-light

AIR-TIGHTNESS MEASURES

KEY:
Case Study Building
Non case study building

High Level Options Appraisal



EWI (External Wall Insulation) is rarely suitable for Listed buildings. For unlisted buildings, EWI is preferable as it can create a continuous warm envelope.

W06-Cavity Insulation is not recommended as a single measure, unless the risk of thermal bridging and cold spots can be mitigated. It can be used in conjunction with other strategies.

842 - Lee House

Five storey student accommodation tower.
The building was constructed in the late 1960s as part of the Athlete's Village for the 1970 Commonwealth Games. It is very similar to 4 other residences (836 - Baird, 838 - Ewing House, 840 - Grant House & 844 - Turner House)

The construction is 'system build' concrete panel, block and curtain wall, with concrete floor slabs.

Eastern (left) and Southern Facade, with Entrance Porch (bottom left) Facade

Thermal image of eastern and southern facade and entrance porch. Indicates various temperature changes across the existing building fabric. Refer to Thermal Imaging Report for formal analysis.

Building Type (see pg. 3-4): Type 6 - System-Build Concrete - 1960s
Building Age: 1960s
Heritage Listed: -
Notable Features: Vertical Curtain Wall strips down all facades. Large accessible flat roof
Previous Retrofits: -

Item	Light	Medium	Intensive
Ground Floor	General Maintenance	General Maintenance	F03/F04 Insulate Floor & Apron Perimeter Insulation
Walls - North Facade	General Maintenance	W04 EWI - Rainscreen Enerphit	W04 EWI - Rainscreen Enerphit
Walls - South Facade	General Maintenance	W04 EWI - Rainscreen Enerphit	W05 EWI - Living Wall
Walls - East & West Facades	General Maintenance	W02 EWI - Rainscreen	W02 EWI - Rainscreen
Roof	RF01 Insulate above Flat Roof Deck	RF01 Insulate above Flat Roof Deck	RF04 Insulate above Flat Roof Deck with Green Roof
Glazing & Curtain Wall	General Maintenance	G07 High performance Double Glazed Curtain Wall	G08 Enerphit-Standard Triple Glazed Curtain Wall
Roof Lights	General Maintenance	RL02 High performance flat roof light	RL02 High performance flat roof light
Ventilation	General Maintenance	Improved	E01 MVHR
Air Tightness	A01 Seal Service Penetrations	A01 & A02 Parge Coat to Masonry	ALL STRATEGIES

Preferred

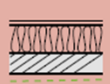
Preferred Option

Lee House is a heavy energy user and thus is appropriate to consider for intensive retrofit. Significantly the curtain walls and walls are a large area, and improving the performance of these elements will save the most energy. Similarly, the roof is likely to be a poor insulator, so improving it should be a high priority.

The walls have also been shown to leak energy with thermal imaging. A living wall on the sunlit south facade will also make aesthetic improvements, in addition to better insulating the residence.

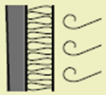
Ground floor insulation and improvements to air tightness will be possible when implementing an intensive retrofit. Safe access to the floor solum is to be confirmed.

PREFERRED OPTION INTERVENTIONS



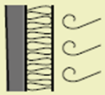
F04 - XPS insulate to underside suspended concrete floor (assumes safe access to underside).

ACHIEVED U VALUE: 0.11W/m²K



W04 - Rainscreen cladding system over 200mm mineral wool insulation slab mechanically fixed to on existing wall.

ACHIEVED U VALUE: 0.15W/m²K

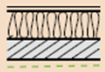


W05 - Living wall modular cladding system on support frame over 100mm mineral wool insulation on existing wall.

ACHIEVED U VALUE: 0.25W/m²K

W02 - Rainscreen Cladding System on 50mm cavity over 150mm insulation on existing wall.

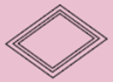
ACHIEVED U VALUE: 0.20W/m²K



RF04 - Remove existing roof covering & insulation, apply primer to concrete deck, install vapour barrier, 200mm insulation board, universal underlay, drainage layer and 100-150mm lightweight growing medium with rolled turf.
ACHIEVED U VALUE: 0.11W/m²K

G08 - Assume glazed and solid panels with average U value suitable for Enerphit, triple glazed.

ACHIEVED U VALUE: 0.85W/m²K



RL02 - High performance flat roof dome

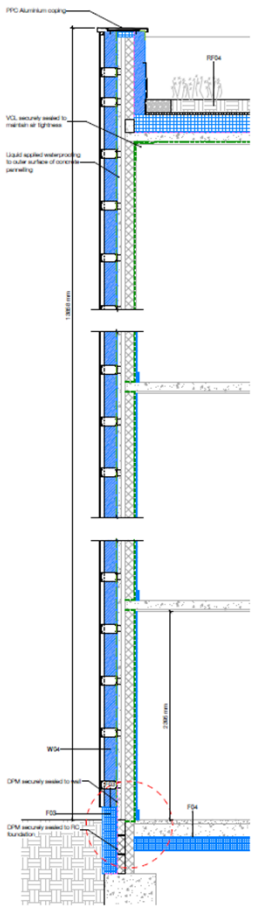
ACHIEVED U VALUE: 1.40W/m²K

E01 - Installation of whole-building mechanical ventilation with heat recovery. Assume use of high performance MVHR. Ductwork to be insulated and taped.

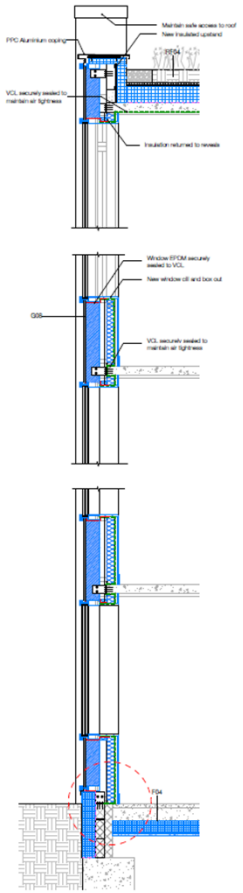
ALL STRATEGIES -
A04 - EDPM layer taped to window reveals
A03 - Air tight layer
A02 - Parge Coat to Masonry
A01 - Seal Service Penetrations

Reduced to:
1.0 m³/(h.m²) @ 50Pa

Detail



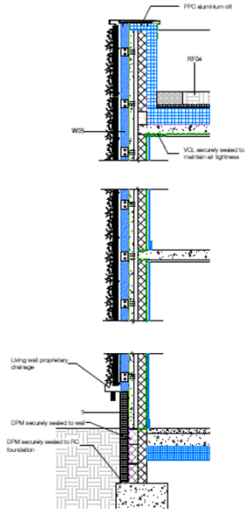
Section 1
1 : 20



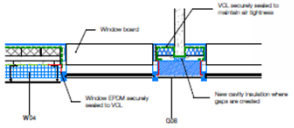
Section 2
1 : 20

The Pollock Hall Towers offer the potential for an 'Enerphit' standard retrofit, which would significantly decrease the operational energy costs of the buildings.

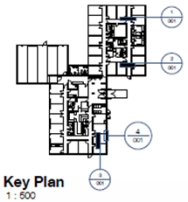
As Enerphit compliance is partly determined by a detailed energy balance calculation, the specifier can be very specific in the amount of insulation required, e.g. we have assumed that the south facing facades would required less insulation than the north.



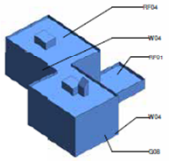
Section 3
1 : 20



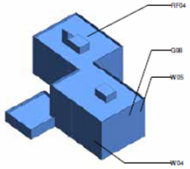
Jamb Detail
1 : 20



Key Plan
1 : 500



Axonometric diagram 1



Axonometric diagram 2

Rigid insulation - roof and solid floor
Mineral wool insulation - slab
Mineral wool insulation - loose
Single ply membrane
Damp proof membrane
EPDM
VCL
Thermal bridging analysis required at junction

oberlanders

University of Edinburgh
Energy Studies
Lee House

842 - Lee House - Proposed Interventions

PRELIMINARY

2757-OBE-842-001

11/10/21

As indicated

Costs

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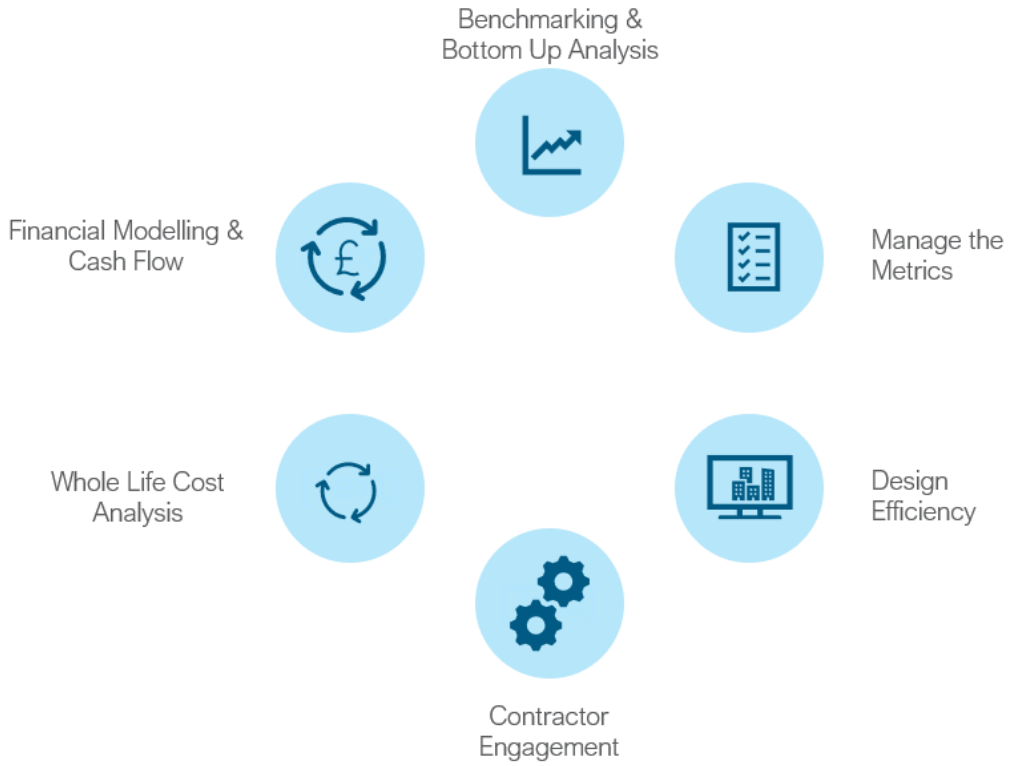
Costs

Cost Accuracy



Success for you

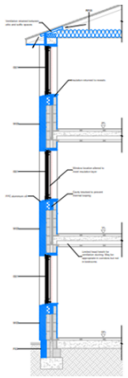
- Informed Design Decision
- Accurate Cost Modelling
- Real Time Optioneering
- Value for Money Focus
- Lifecycle Cost Analysis (Net Present Value)

Costs

Cost Modelling Data

W: WALL INTERVENTION			
W01	IWI - VENTILATED	[from external] - existing wall (strip lath and plaster if required); - apply 6mm lime parge coat/equalising coat; - Gypframe *70 S 50 C* studs, insulated between with 50mm *Isoroll*; - 12.5mm T/E VCL-backed plasterboard (*Gyproc WallBoard Duplex*), skim coat, decoration. - 25mm *Rockfloor* insulation layer returned to floors and internal partitions by 1m to reduce thermal bridge impact; - strap out internal walls to match insulated zone, plasterboard, skim, decorate; - remove floor screed to allow 1m perimeter installation of *Rockfloor*, allowance for reinstating floor finish on 22mm ply on *Rockfloor*; - VCL continued and sealed to concrete floor slab / internal partitions. - allow for reinstating window cills, reveals, skirting etc	- Sanderson - Alrick - JCMB
W02	EWI - RAINSCREEN	[from external] - Rainscreen cladding system (*Equitone* or similar); - metal cladding rails to form 50mm cavity; - *Stotherm Mineral* 150mm 'Rotofix' mechanically-fixed to existing wall; - primed existing wall; - cavity edge blocked to create still air layer, perpend drains maintained; - internal parge coat to inner block/masonry for air tightness; - 25mm battened service zone; - 12.5mm T/E VCL-backed plasterboard (*Gyproc WallBoard Duplex*), skim coat, decoration. - careful sealing of penetrations, eaves, gutters to ensure no water ingress; - adjustment of downpipes etc to new external face. - works to maintain roof ventilation at soffit; - external window cills extended; - to flat roofs extension of coping	- Lee House west and east facades - Roger Land (assumes reuse of existing mosaic panels)
W03	EWI - RENDER	[from external] - Sto render system - Stotherm Mineral 150mm adhesive to; - primed existing wall; - cavity edge blocked to create still air layer, perpend drains maintained; - internal parge coat to inner block/masonry for air tightness; - 25mm battened service zone; - 12.5mm T/E VCL-backed plasterboard (*Gyproc WallBoard Duplex*), skim coat, decoration. - careful sealing of penetrations, eaves, gutters to ensure no water ingress; - adjustment of downpipes etc to new external face. - works to maintain roof ventilation at soffit; - external window cills extended; - to flat roofs extension of coping	- Fraser Court - Alrick
W04	EWI - RAINSCREEN ENERPHIT	[from external] - Rainscreen cladding system (*Equitone* or similar); - *Stotherm Mineral* 200mm 'Rotofix' mechanically-fixed to existing wall; - primed existing masonry wall; - cavity edge blocked to create still air layer, perpend drains maintained; - internal parge coat to inner block/masonry for air tightness; - 25mm battened service zone; 12.5mm T/E plasterboard, skim coat, decoration. - careful sealing of penetrations, eaves, gutters to ensure no water ingress; - adjustment of downpipes etc to new external face. - works to maintain roof ventilation at soffit; - external window cills extended; - to flat roofs extension of coping	- Lee Tower north facade
W07	FRAME OUT / EWI	- remove existing curtain wall/box out - install 140mm frame fi-fi insulated with mineral wool bat - *Pro-Clima intello* air-tightness layer installed to internal face of framing - strap out internal face 25mm and line with VCL-backed plasterboard, skim, decorate (*Gyproc WallBoard Duplex*) - 9mm OSB external sheathing - breather membrane - [from external applied across facade] - *Sto render system* - *Stotherm Mineral* 100mm mechanically fixed to framing and existing structure. AND - Sto sytem as above applied direct to masonry cavity wall areas.	- Fleeming Jenkin

W01	IWI - VENTILATED	
	- existing wall (strip lath and plaster if required);	8.00
	- apply 6mm lime parge coat/equalising coat;	25.00
	- Gypframe 70 S 50 C studs, insulated between with 50mm Isoroll	64.20
	- 12.5mm T/E VCL-backed plasterboard (Gyproc WallBoard Duplex), skim coat, decoration.	37.50
	- 25mm Rockfloor insulation layer returned to floors and internal partitions by 1m to reduce thermal bridge impact;	32.00
	- strap out internal walls to match insulated zone, plasterboard, skim, decorate;	
	- remove floor screed to allow 1m perimeter installation of Rockfloor, allowance for reinstating floor finish on 22mm ply on Rockfloor;	10.00
	- VCL continued and sealed to concrete floor slab / internal partitions.	8.00
	- allow for reinstating window cills, reveals, skirting etc	40.00
	- Adjustments may be required to RWPs	
		£ 224.70



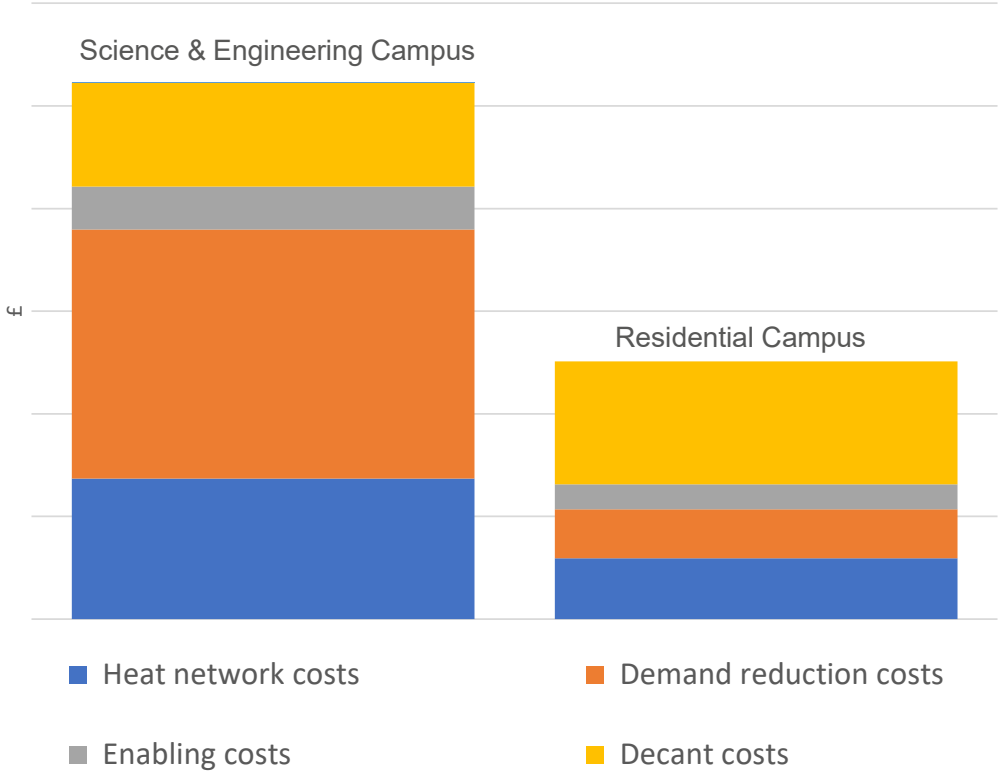
Costs

Practical Considerations

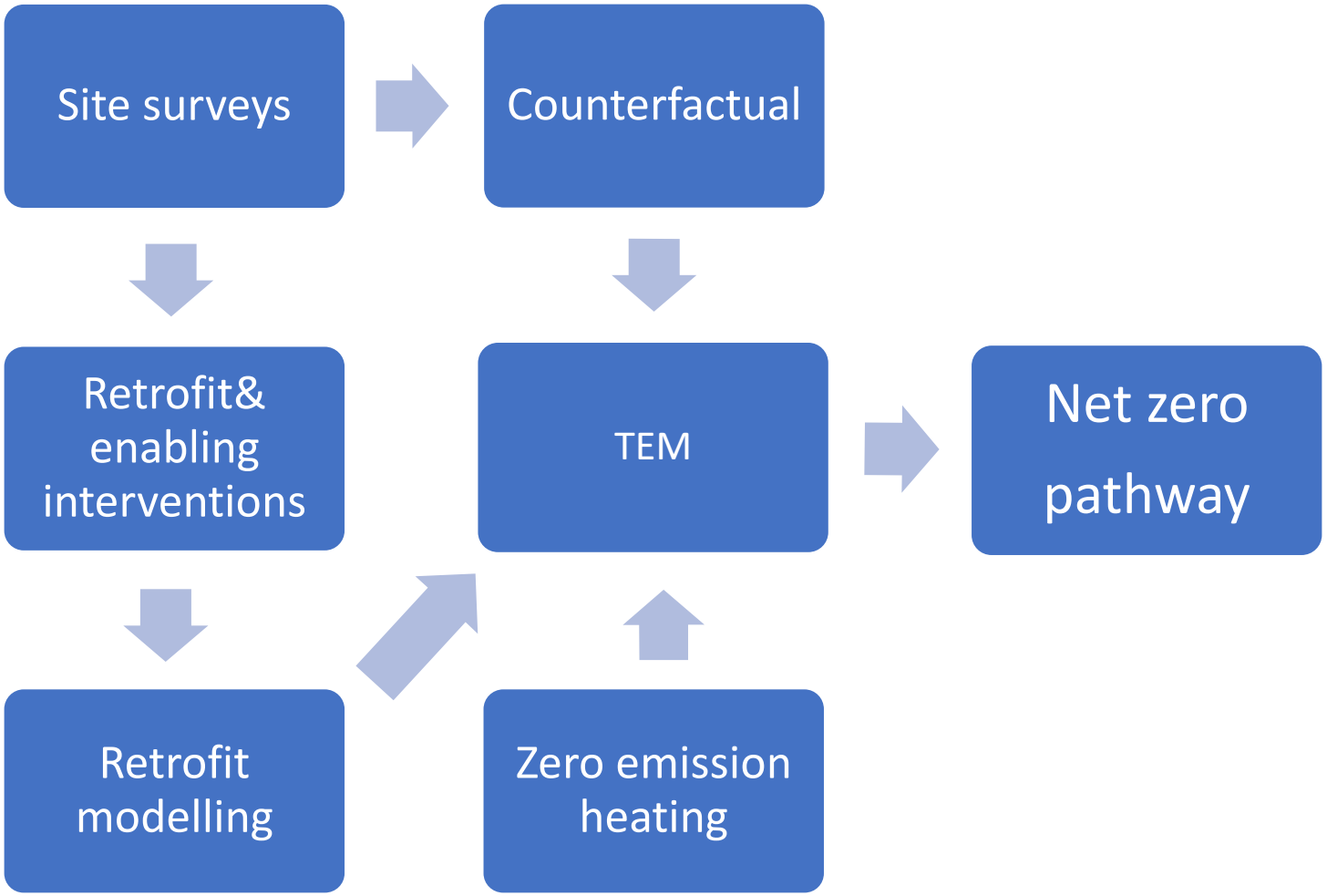
Decant costs

Typology	Cost £/m2 per month
Office	N/A
Teaching	5.5
Lab	50
Residential	Individual building case

Capital cost breakdown



Retrofit Modelling



Fabric Interventions

- Additional roof insulation
- Additional wall insulation
  - External or internal (dependent on condensation risk)
  - Not feasible for listed buildings
- Additional floor insulation
- Improved glazing
  - Replace single to double and double to triple
  - Secondary glazing for listed buildings
- EnerPhit?

MEP Interventions

- LED lighting
- Lighting controls
- CO2 controlled ventilation (VAV)
- Replace DHW storage with instantaneous water heaters
- VAV fume cupboards (auto sash closers)
- Increased energy submetering and monitoring
- eTRVs
- Heating zone valves
- Adding heat recovery to ventilation systems
- Power factor correction
- Fit shower restrictors
- Waste water heat recovery from communal showers

Probable Interventions (based on payback)

Fabric Interventions

- Additional roof insulation
- Additional wall insulation
  - External or internal (dependent on condensation risk)
  - Not feasible for listed buildings
- Additional floor insulation
- Improved glazing
  - Replace single to double and double to triple
  - Secondary glazing for listed buildings
- EnerPHit?

MEP Interventions

- LED lighting
- Lighting controls
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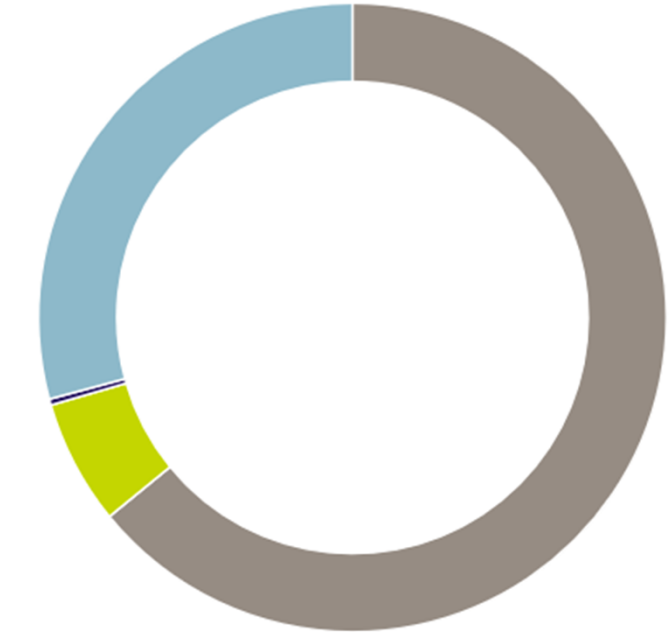
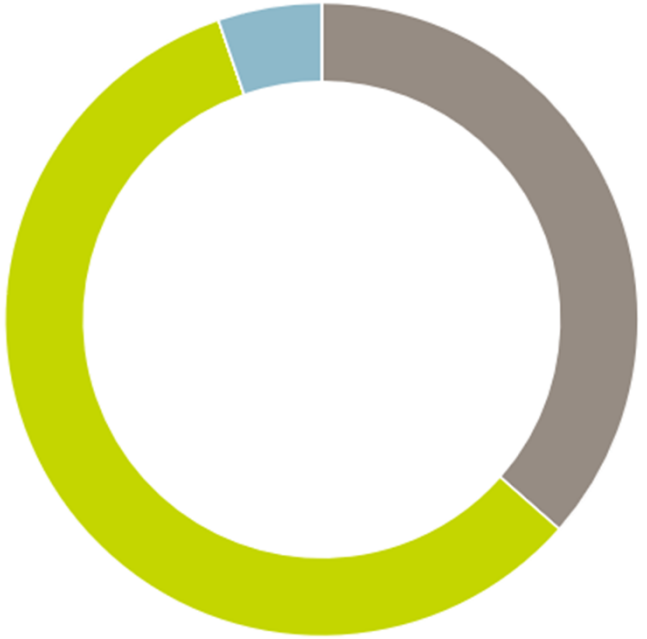
- VAV fume cupboards (auto sash closers)
- Increased energy submetering and monitoring
- eTRVs
- Heating zone valves
- Adding heat recovery to ventilation systems
- Power factor correction
- Fit shower restrictors
- Waste water heat recovery from communal showers

Demand Reduction Trends

Science & Engineering Campus



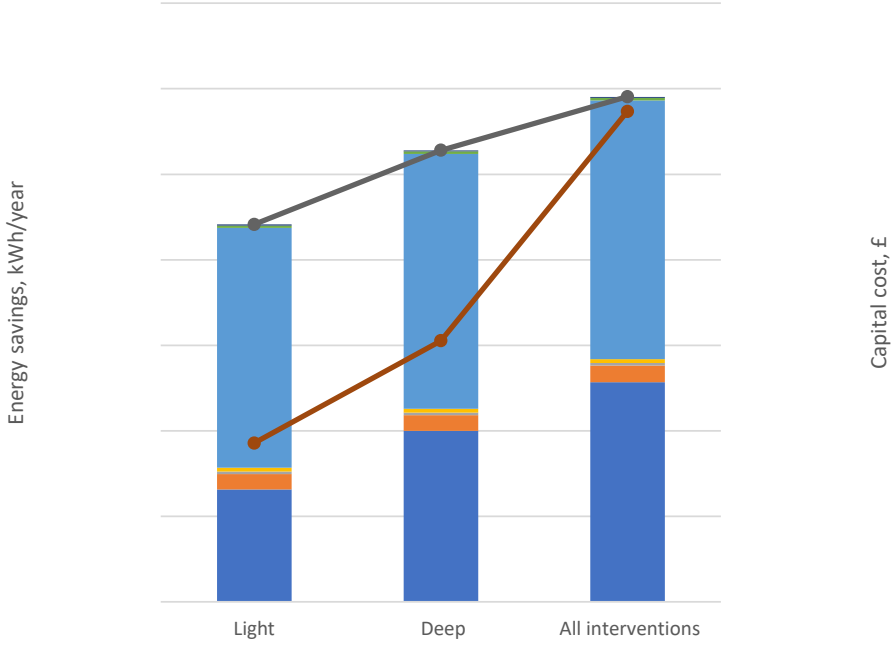
Residential Campus



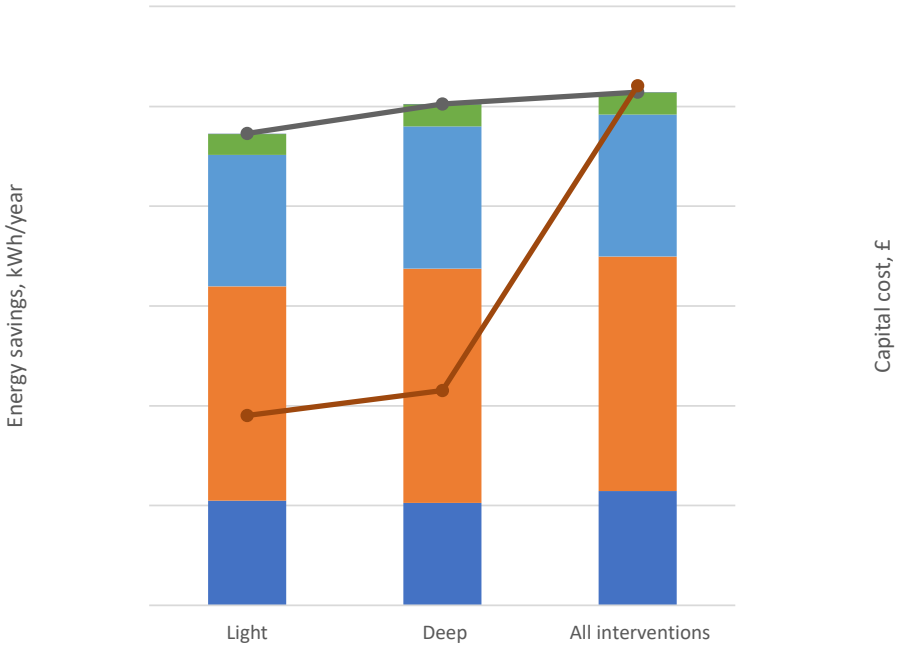
Space heating
Domestic hot water
Space cooling
Electricity

Additional demand reductions versus capital cost

Science and Engineering campus

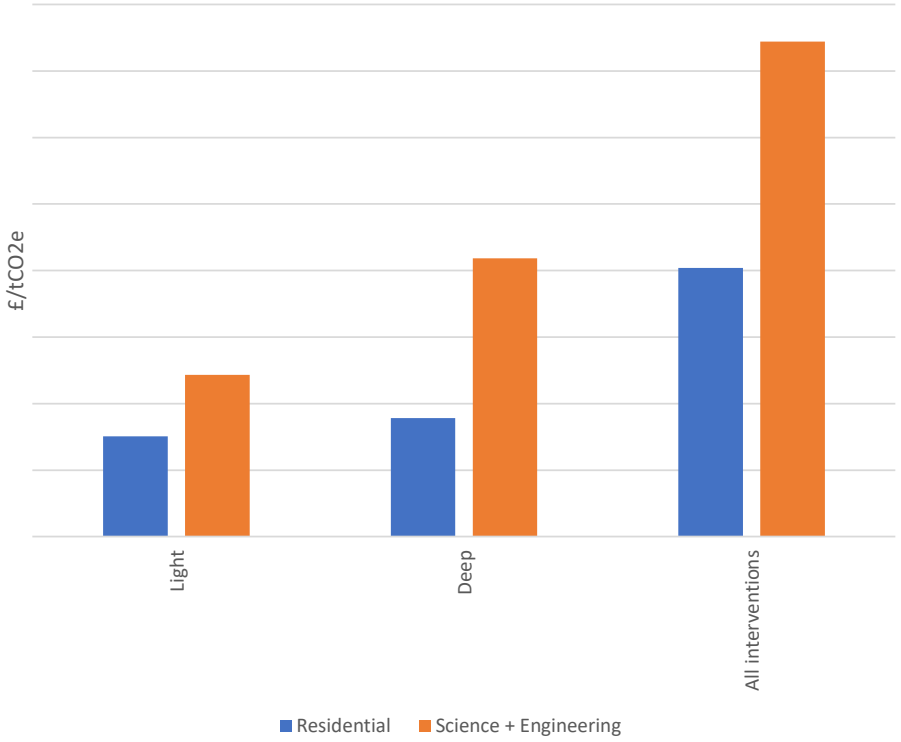


Residential campus

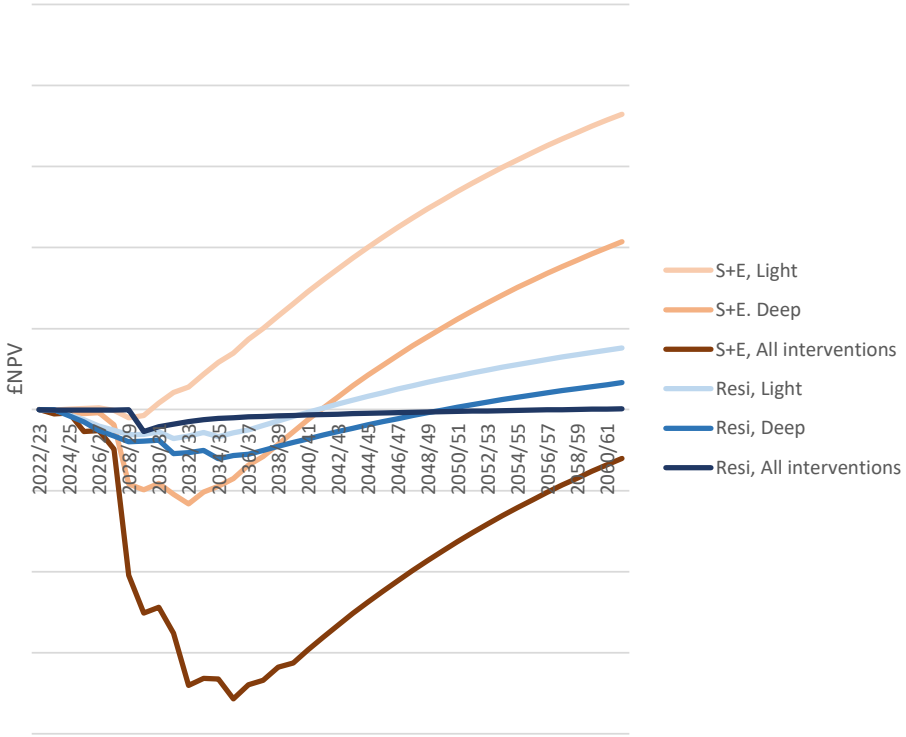


Metrics used to compare options

£/tCO2e



NPV, comparing against counterfactual



Making it happen

Masterplanning

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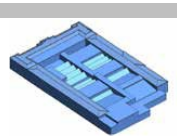
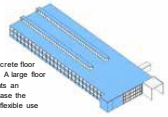


Joseph Black

Significant, listed building, prominent within the campus. Currently energy intensive in its use as a lab and fume-cupboard heavy building. Potential to re-imagine the internal courtyard space whilst working with HES to identify incremental upgrades that would safeguard the structure for the future.

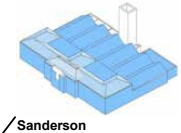
Christina Miller

Modern, purpose-built lab building which delivers more energy-efficient lab space. Small improvement opportunities could best be identified with thermal imaging and air-tightness testing.



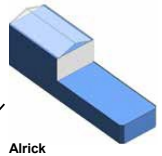
Fleeming Jenkin

A steel-frame building with concrete floor slabs, and aged curtain walling. A large floor plate and flexible facade presents an opportunity to significantly increase the energy efficiency while offering flexible use options.



Sanderson

A listed sandstone building with teaching spaces and sawtooth workshops to the rear. A good example of a solid masonry building with various areas for upgrade and a number of complex junctions.



Alrick

System build with 80s extension. Clear floor plates suggest a strong candidate for intensive retrofit, and a flexible floor plan that could support a variety of schools during decentment for other retrofits/new builds.

Roger Land

Architecturally significant, partially refurbished building adjacent to the new Engineering Building. The building is detailed in such a way that there are significant cold bridges, and the curtain walling is likely to be quite 'leaky'. Spacially, there is an opportunity to create a pleasant, mixed-used building making the most of the courtyard space and the landscape setting. Thermally, there is potential that a deep-retrofit former engineering building could provide more efficient lab-space.

JCMB

Significant building, prominent within the campus. Although not listed, the facade is architecturally significant, and would not be suited to external insulation. There is extensive, deliberately patterned glazing, the upgrading of which could improve performance, and potentially is a candidate for internal insulation dependent on internal space constraints. Current basement data centre holds the potential for heat capture, or integration with a new energy centre.

Site Plan

KEY

- Listed Buildings - retrofit will be largely constrained to internal improvements in consultation with Historic Environment Scotland (HES).
- Intensive Retrofit - potential for significant wholescale fabric and/or servicing upgrade.
- Medium Retrofit - likely to be unsuitable for wholescale refurbishment, but significant improvement potential through discrete packages of work
- Light Retrofit and Remedial Works - likely to be identified through further tests such as air tightness and thermal imaging which will highlight problem areas.
- New build
- Likely demolition in <5 years
- Possible demolition in <10 years
- Potential Energy Centre locations for discussion with University stakeholders

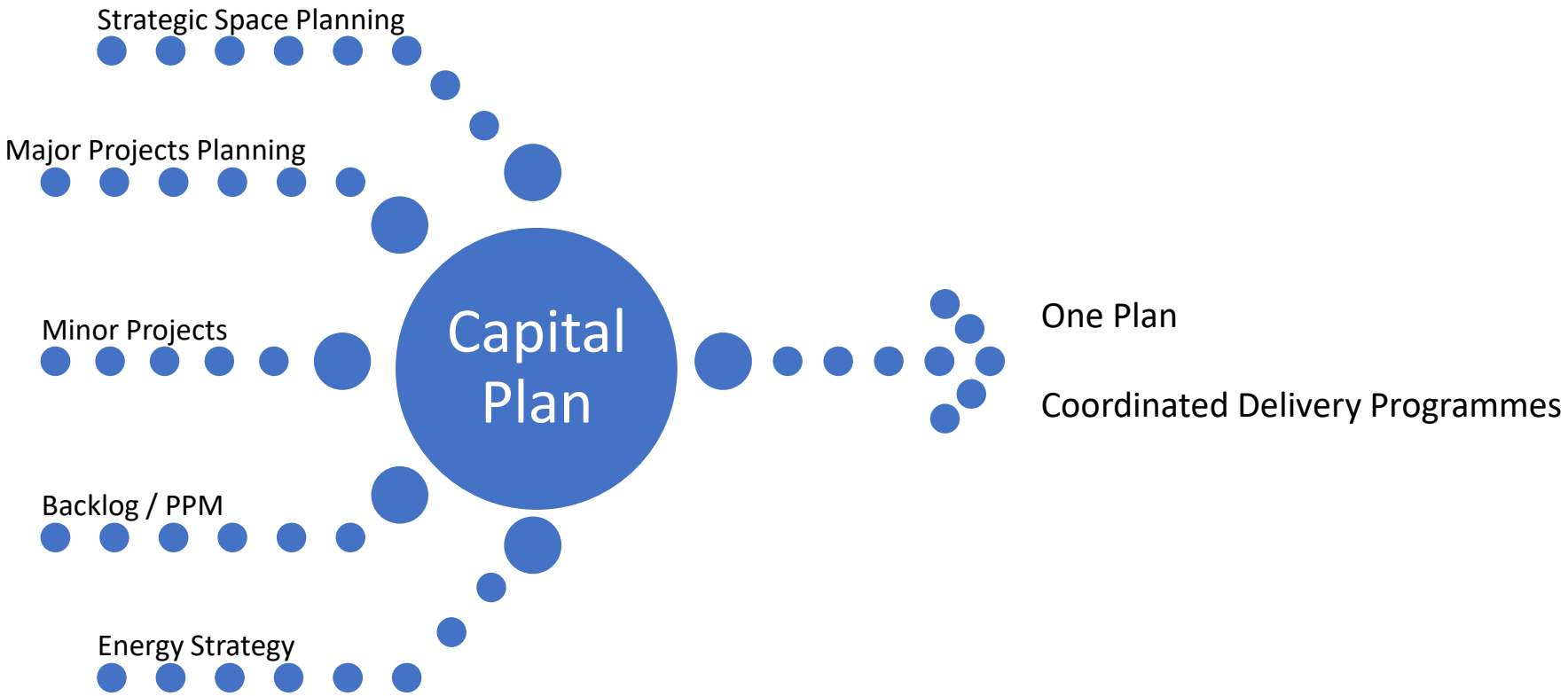
Bold Case Study

Italics Non Case Study

Stakeholder Engagement

- Estates Development Managers
- Construction Managers
- Building Services Leads
- Building Surveyors
- ICT Leads
- Maintenance Leads
- Space Planners
- Energy Services Company Board
- School and College Liaisons
- Academic Leads
- Building Managers
- Third Party Tenants
- Municipal Planners
- Business Planning and Development Leads
- Finance Business Partners

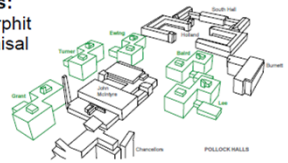
Holistic Plan



Opportunities Beyond Energy

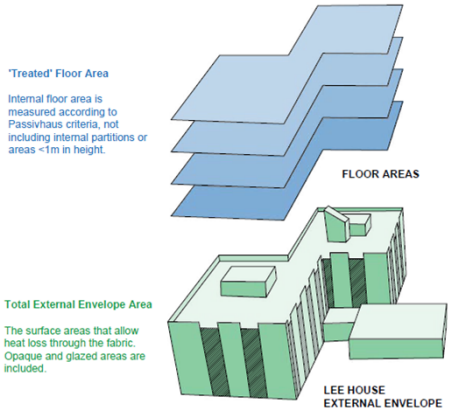
Certain buildings will offer the opportunity to achieve excellence in the field of energy, along with improving user experience and promoting wellness.

Pollock Towers:
Suitability for Enerphit
Form factor appraisal



'Form Factor' For Enerphit, <3 would be the optimum form factor.

Total External Envelope Area
divided by
'Treated' Floor Area = **1.1**



Q&A

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If you have any further questions on the content or queries about decarbonisation and energy master planning please feel free to contact us at:

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