ECD Architects
ENERGY CONSCIOUS DESIGN

Climate Neutral Estates

Retrofitting Existing Buildings to Improve Energy Performance

EAUC 7th October 2021

Alistair Cameron

Climate Neutral Districts Vision – 10 projects

1. Introduction to ECD
2. Climate Change & Net Zero
3. Passivhaus
4. Climate Neutral Estate
5. Case Studies

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An introduction to ECD Architects

60+ EMPLOYEES

ARCHITECTS
MASTERPLANNERS
INTERIOR DESIGNERS
URBAN DESIGNERS
PASSIVHAUS DESIGNERS
BIM MANAGERS
RETROFIT COORDINATORS
POST OCCUPANCY EVALUATORS
FIRE SAFETY RISK ASSESSORS

FOUNDED IN **1980**

41 YEARS OF SPECIALIST EXPERIENCE

SECTORS

EDUCATION **HEALTHCARE**
CONSERVATION **SCIENCE**
RESEARCH & TECHNOLOGY
RESIDENTIAL **COMMERICAL**
GOVERNMENT **RECREATION & LEISURE**
DISTILLERIES

2 UK STUDIOS

LONDON
GLASGOW

1000+ COMMISSIONS

PROJECT VALUES

£100K TO £80M

AWARD WINNING PRACTICE

20+ GREEN CERTIFIED PROJECTS

SUSTAINABILTY

FOUNDING MEMBERS OF THE **PASSIVHAUS TRUST UK**

EUROPES **LARGEST** PASSIVHAUS ENERPHIT PROJECT

Project Examples

Bellsmyre Regeneration (Net-Zero Energy)
Caledonia HA (Site start May 2021)

Drymen (Passivhaus)
Hanover (Scotland) Housing Association (Site start May 2021)

Wilmcote House (EnerPHit)
Portsmouth City Council (Complete)

RamPHaus (Passivhaus + Energiesprong
Croydon Council

Thornhill Primary School (Passivhaus)
Central Bedfordshire Council (On-Site)

Carpenters Estate (Net-Zero Energy / EnerPhit)
London Borough of Newham (Planning)

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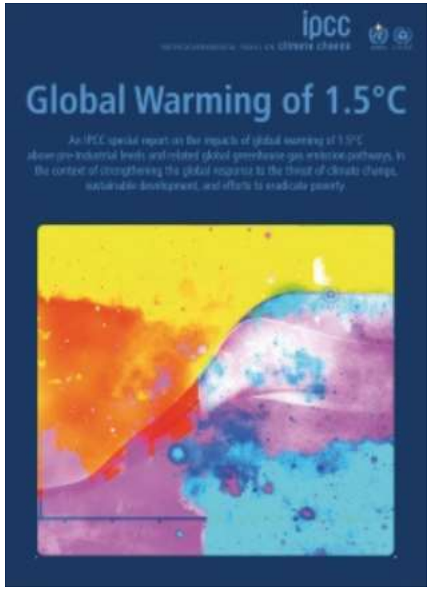
Climate change mitigation & net-zero carbon

Net-zero drivers

UK Carbon Emissions

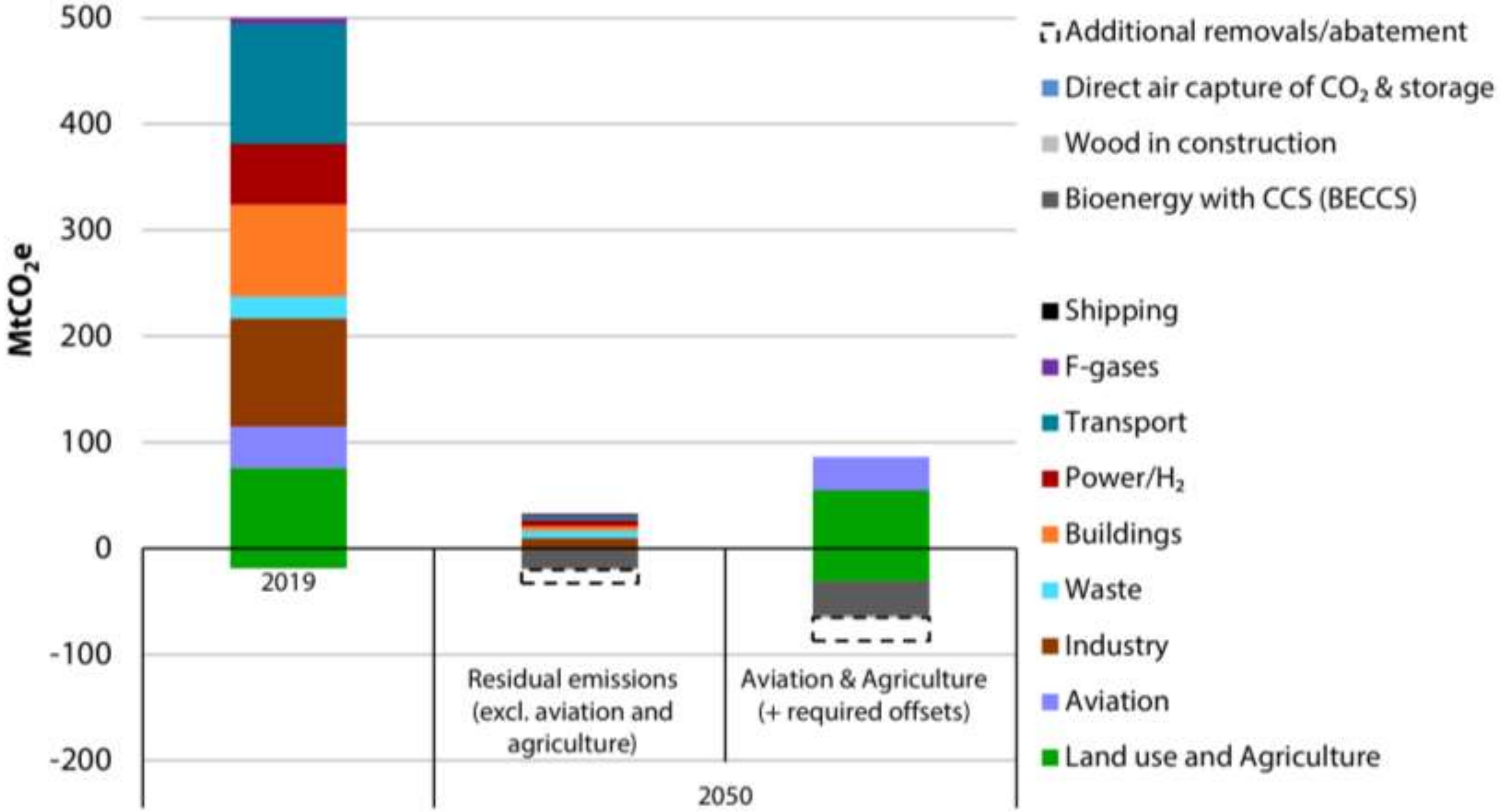
Drivers for change…



The net-zero challenge

UK Carbon Emissions

The scale of the challenge…

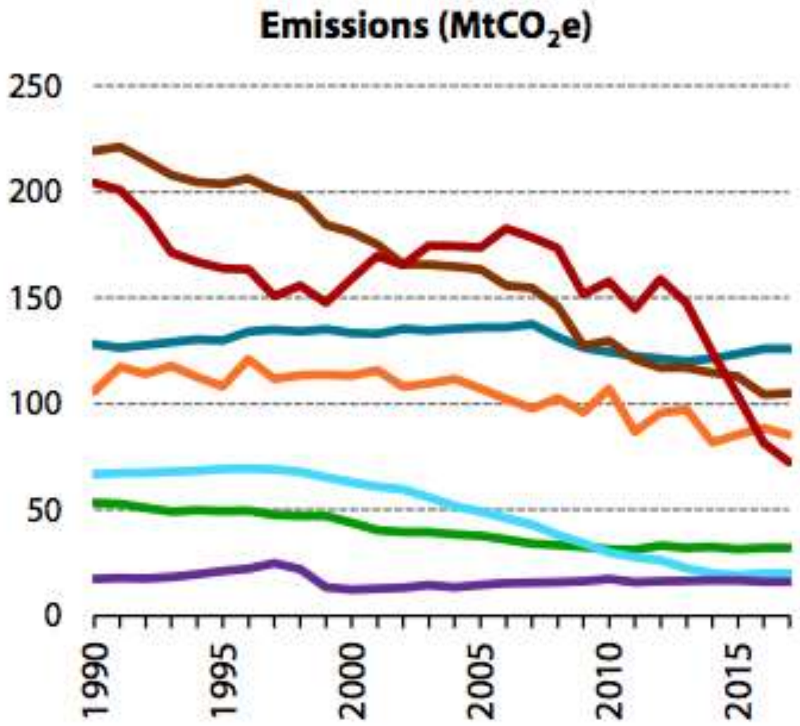


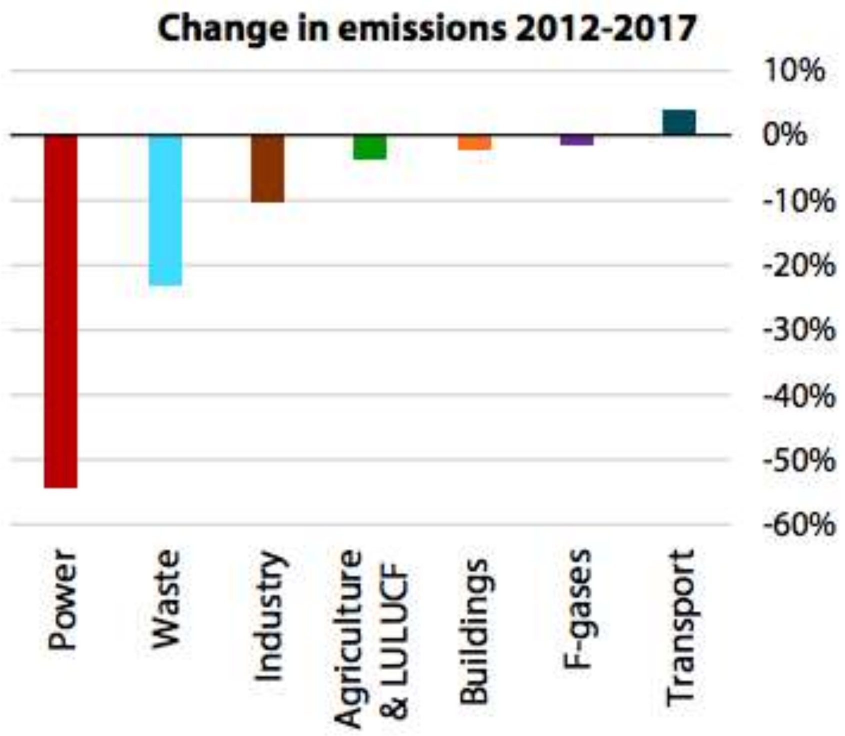
Source: UKCCC Reducing UK emissions – 2018 Progress Report to Parliament, Published 28 June 2018

Progress towards net-zero

UK Carbon Emissions

Progress so far…

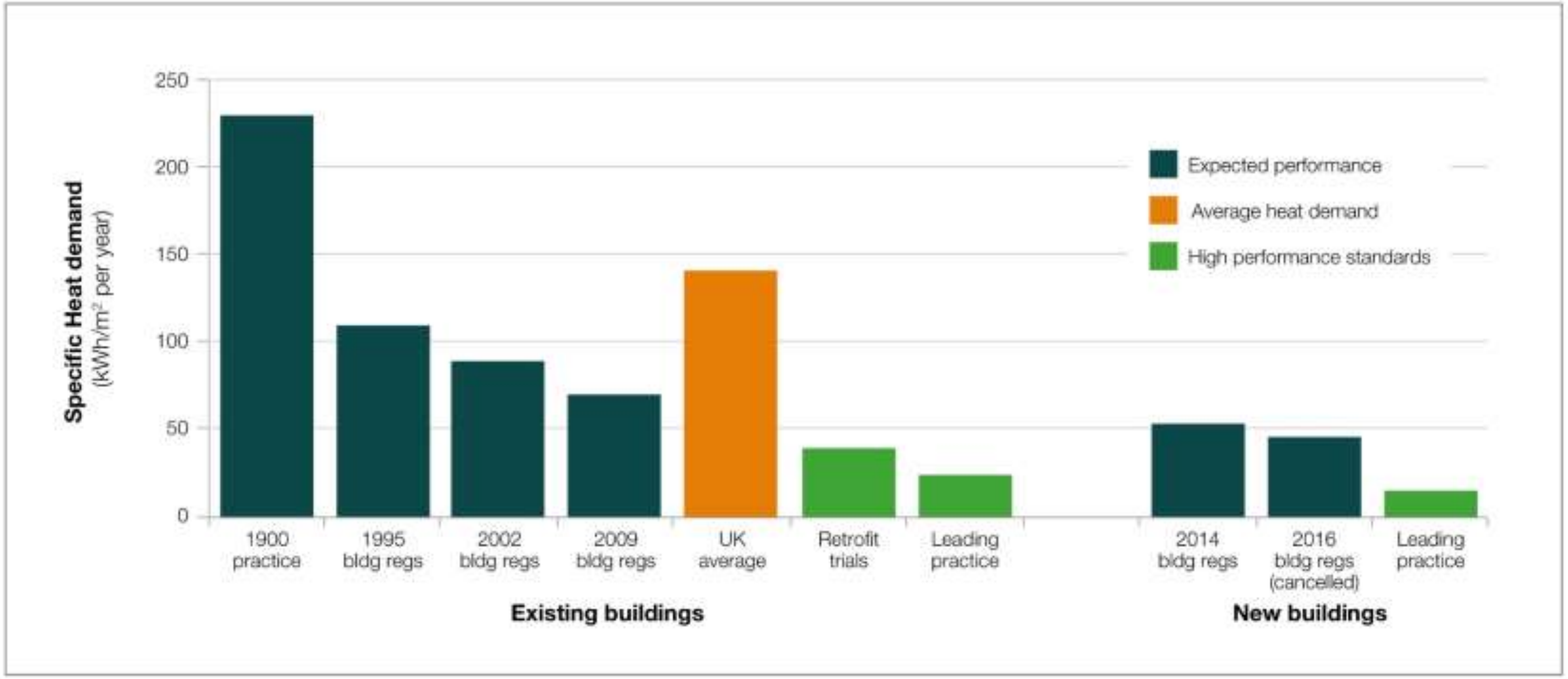




Source: UKCCC Reducing UK emissions – 2018 Progress Report to Parliament, Published 28 June 2018

Existing building performance

- **What is the heating demand of an ‘average’ building?**
- **How do we measure heating demand?**



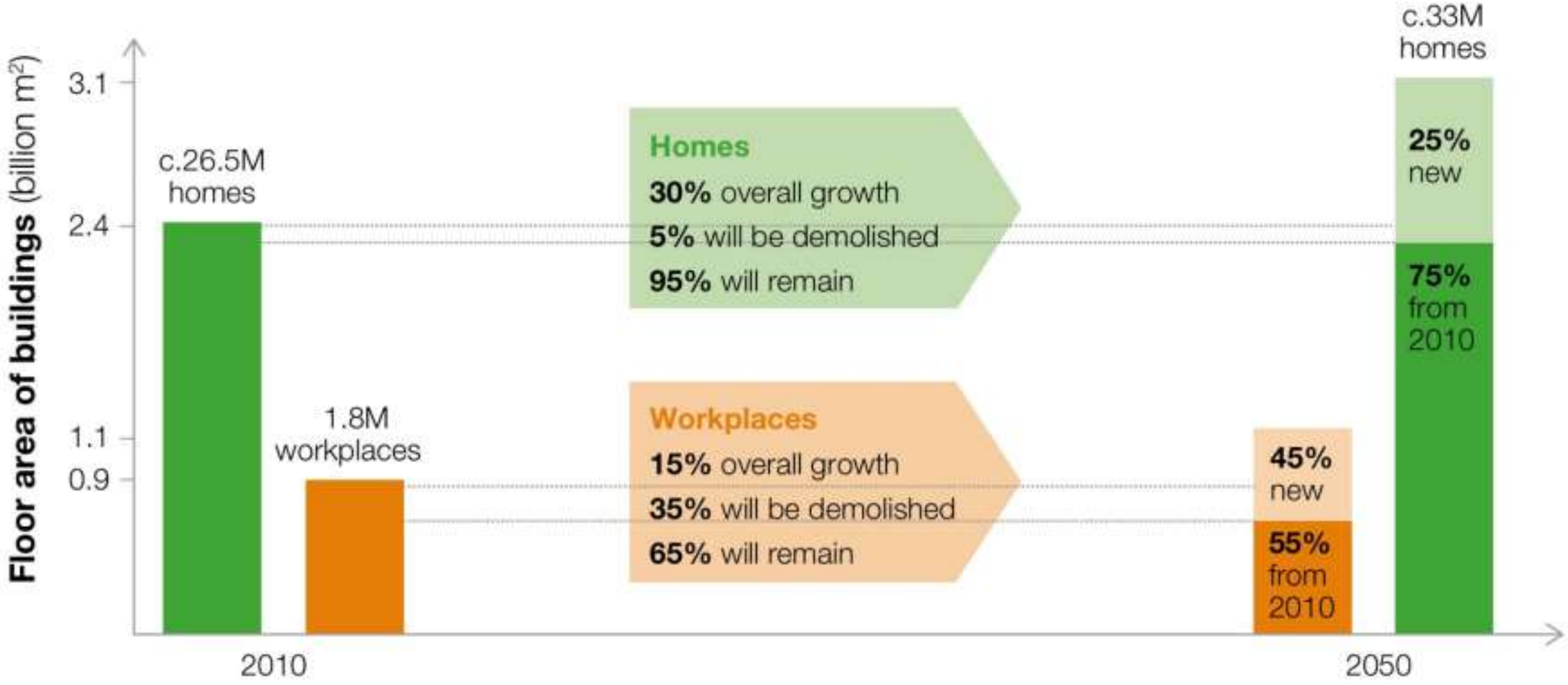
Source: Energy Research Partnership

Existing buildings

UK Carbon Emissions

Can we ignore our existing buildings?

How do we tackle our existing buildings?

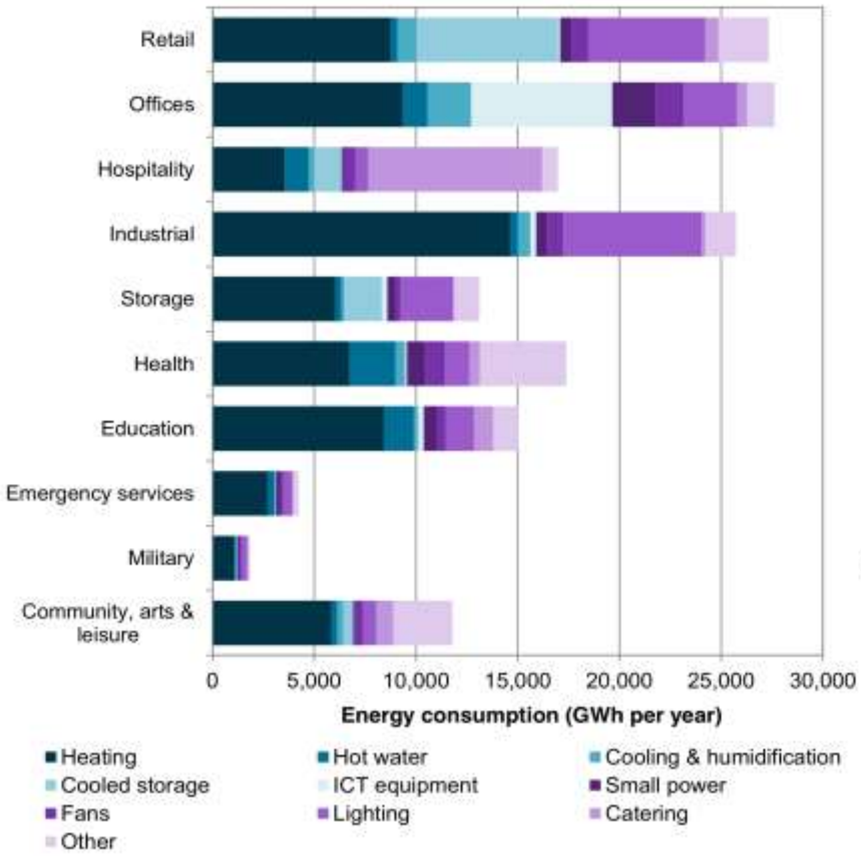


Source: Energy Research Partnership

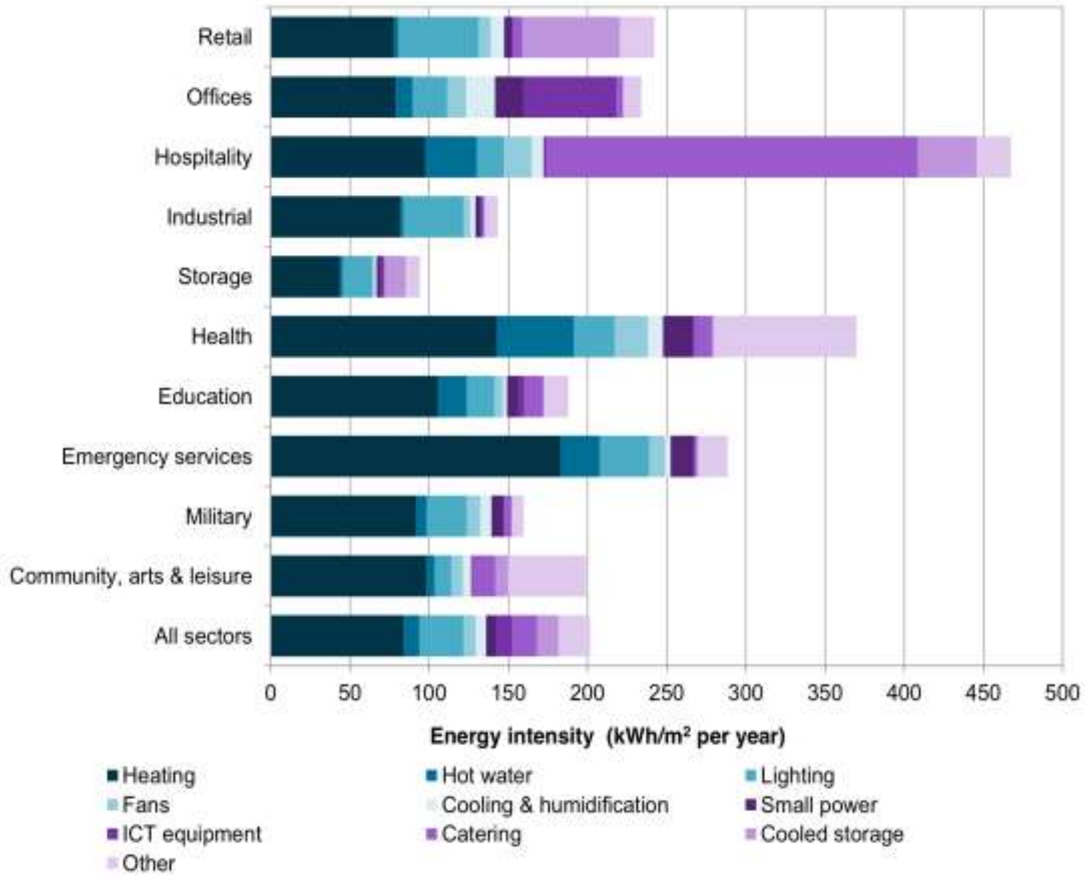
Commercial Buildings

UK Carbon Emissions

Total Energy Consumption per sector



Total Energy Use Intensity (EUI) per sector



Commercial Buildings

UK Carbon Emissions

Are you getting what you paid for?

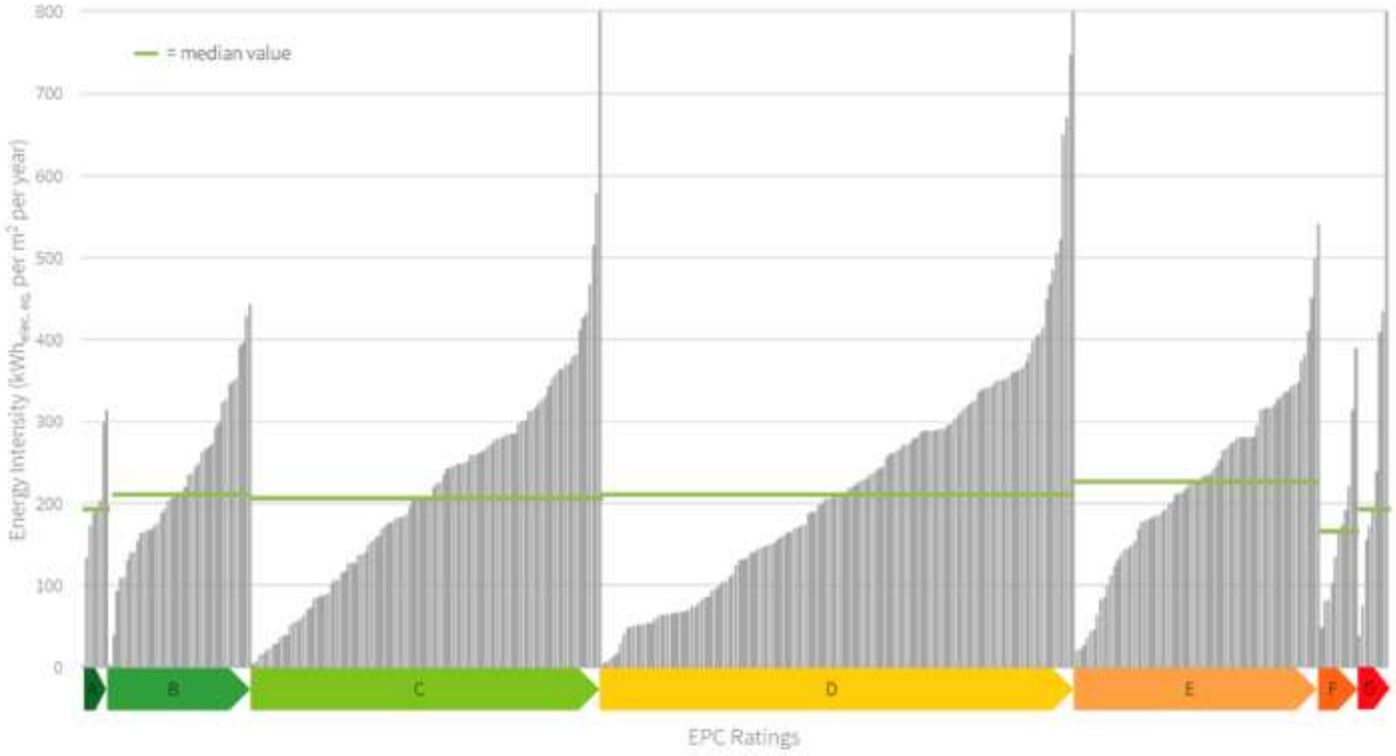


Figure 1 Office energy intensity (kWh$_{elec. eq.}$ per m² (NLA) per year) by EPC rating. Each grey bar represents a single office building's energy intensity over the course of a year. (Source Real Estate Environmental Benchmark 2017, Better Buildings Partnership)

New properties emit 4x more CO_2 emissions than Building Regulations.

An A-rated EPC does not guarantee better actual performance than an F-rated property.

BMS/HVAC operation is a major factor, which means occupant comfort will also suffer.

Achieving net-zero

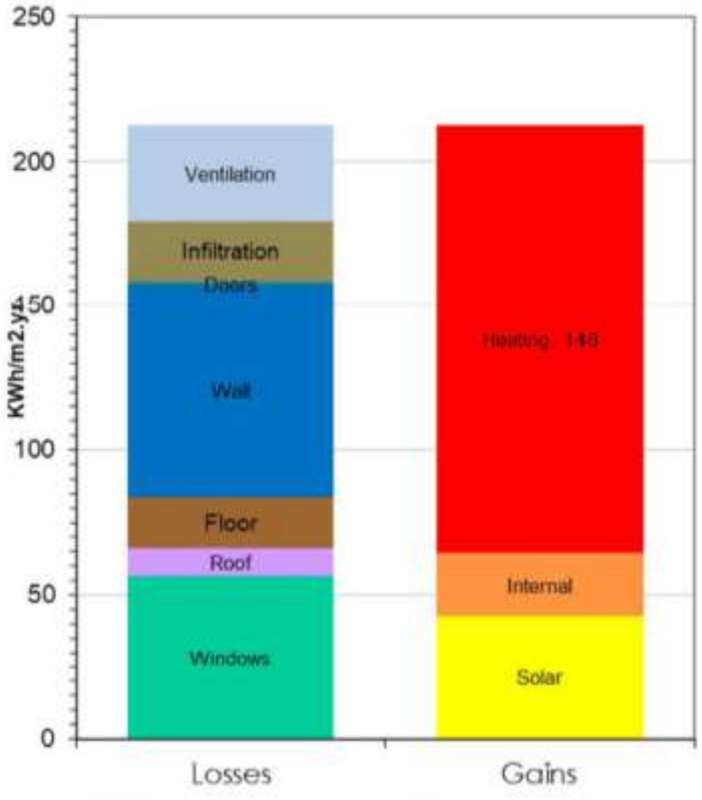


Figure 35 - Energy Balance of Existing Building

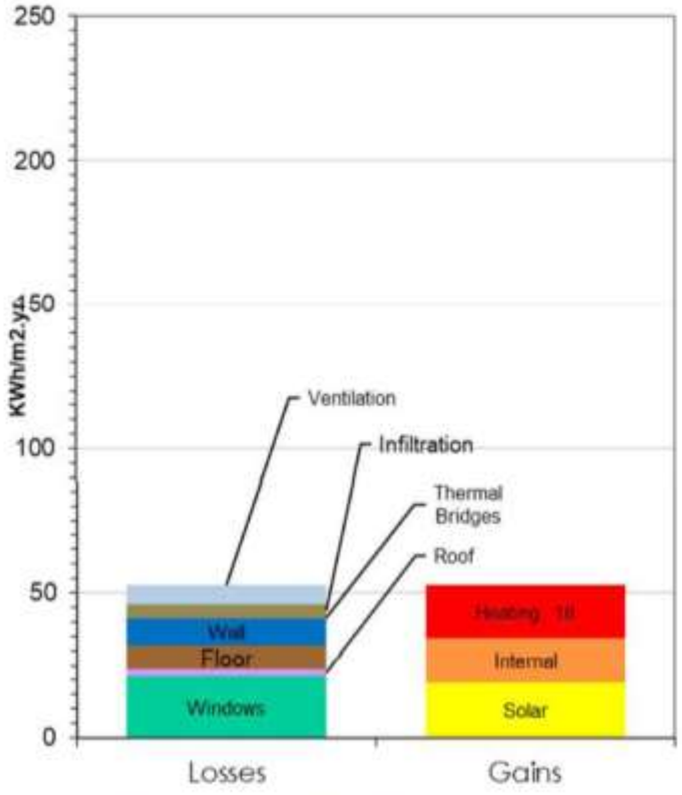
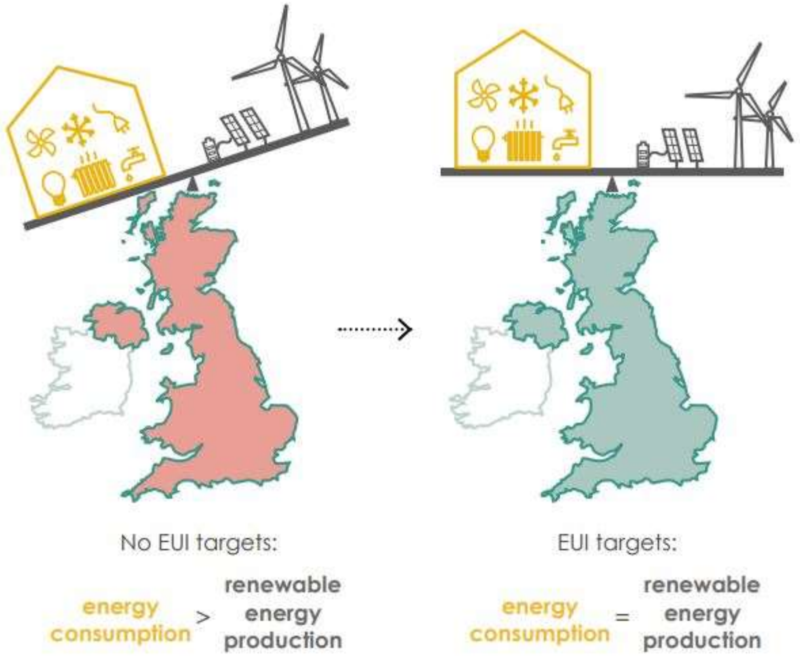


Figure 36 - Energy Balance of Retrofit Proposal

Energy Use Intensity

Energy use intensity = space heating + hot water demand + regulated energy loads

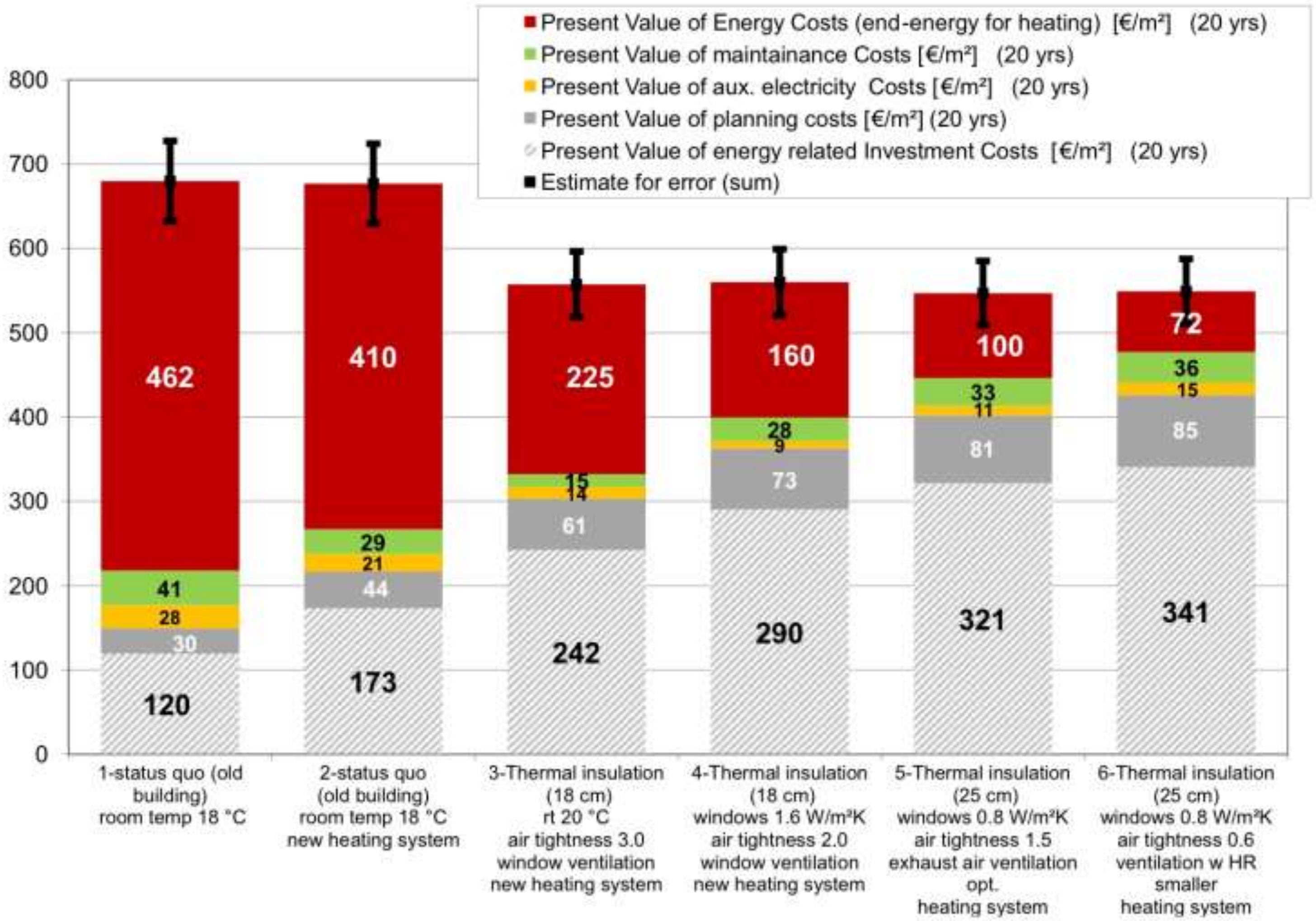


Source: LETI (London Energy Transformation Initiative)

Funding Deep Retrofit

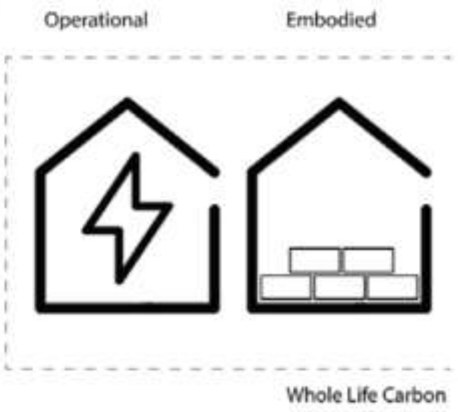
What does it cost in the long term?

Can the cost of your energy and Carbon saving be recovered?



Source: Passivhaus Institute

Net-zero targets



Net Zero Operational Carbon

Ten key requirements for new buildings

By 2030 all new buildings must operate at net zero to meet our climate change targets. This means that by 2025 all new buildings will need to be designed to meet these targets. This page sets out the approach to operational carbon that will be necessary to deliver zero carbon buildings. For more information about any of these requirements and how to meet them, please refer to the: UKGBC - Net Zero Carbon Buildings Framework; BBP - Design for Performance initiative; RIBA - 2030 Climate Challenge; GHA - Net Zero Housing Project Map; CIBSE - Climate Action Plan; and, LETI - Climate Emergency Design Guide.

Low energy use

1. Total Energy Use Intensity (EUI) - Energy use measured at the meter should be equal to or less than:
   - **35 kWh/m²/yr** (GIA) for residential[1]

   For non-domestic buildings a minimum DEC B (40) rating should be achieved and/or an EUI equal or less than:
   - **65 kWh/m²/yr** (GIA) for schools[1]
   - **70 kWh/m²/yr** (NLA) or **55 kWh/m²/yr** (GIA) for commercial offices[1,2]
2. Building fabric is very important therefore space heating demand should be less than **15 kWh/m²/yr** for all building types.

Measurement and verification

3. Annual energy use and renewable energy generation on-site must be reported and independently verified in-use each year for the first 5 years. This can be done on an aggregated and anonymised basis for residential buildings.

Reducing construction impacts

4. Embodied carbon should be assessed, reduced and verified post-construction.[3]

Low carbon energy supply

5. **Heating and hot water should not be generated using fossil fuels.**
6. The average annual carbon content of the heat supplied (gCO_2/kWh) should be reported.
7. On-site renewable electricity should be maximised.
8. Energy demand response and storage measures should be incorporated and the building annual peak energy demand should be reported.

Zero carbon balance

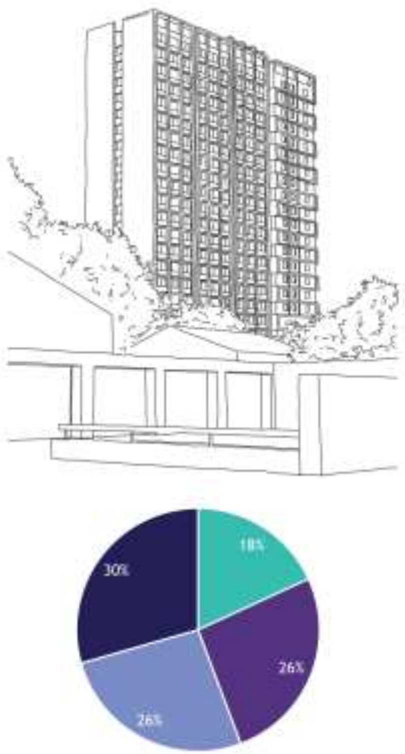
9. A carbon balance calculation (on an annual basis) should be undertaken and it should be demonstrated that the building achieves a net zero carbon balance.
10. Any energy use not met by on-site renewables should be met by an investment into additional renewable energy capacity off-site OR a minimum 15 year renewable energy power purchase agreement (PPA). A green tariff is not robust enough and does not provide 'additional' renewables.

Notes:

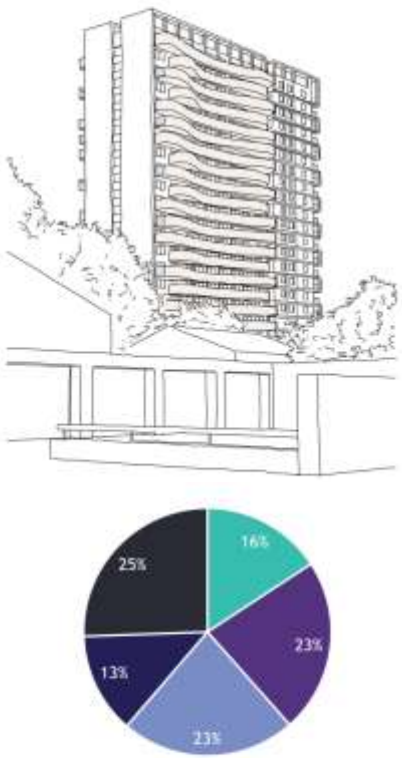
UK GBC
BBP BETTER BUILDINGS PARTNERSHIP
Good Homes Alliance
RIBA Architecture.com
CIBSE

Embodied Carbon

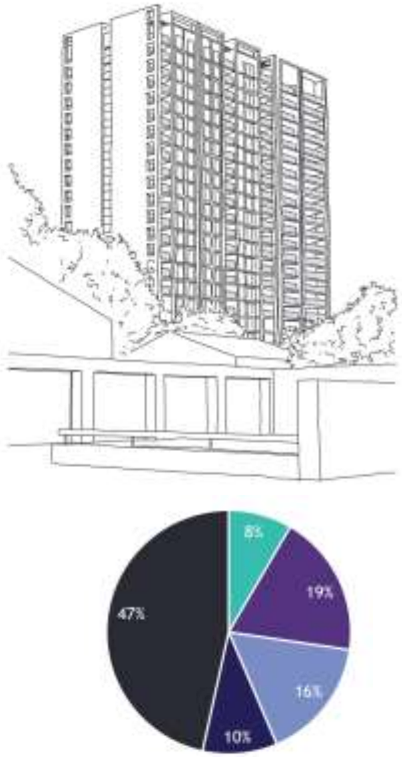
Opt 01: Thermal Wrap



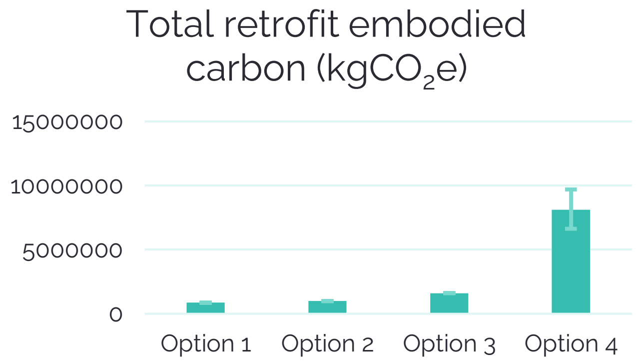
Opt 02: Thermal Wrap
& New Amenity



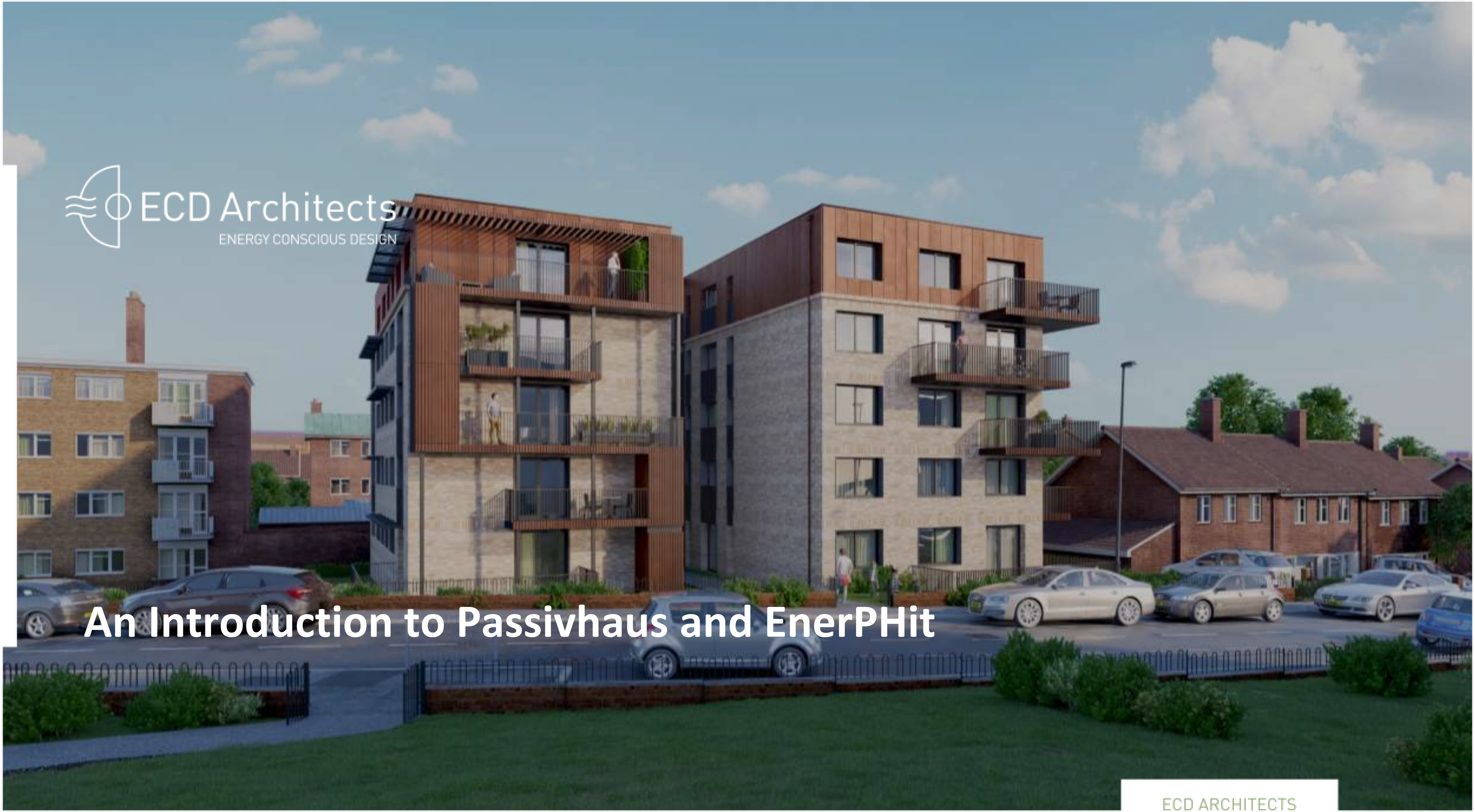
Opt 03: Façade Extension



Opt 04: Demolition &
New Construction



Pas 2035.. and now 2038!



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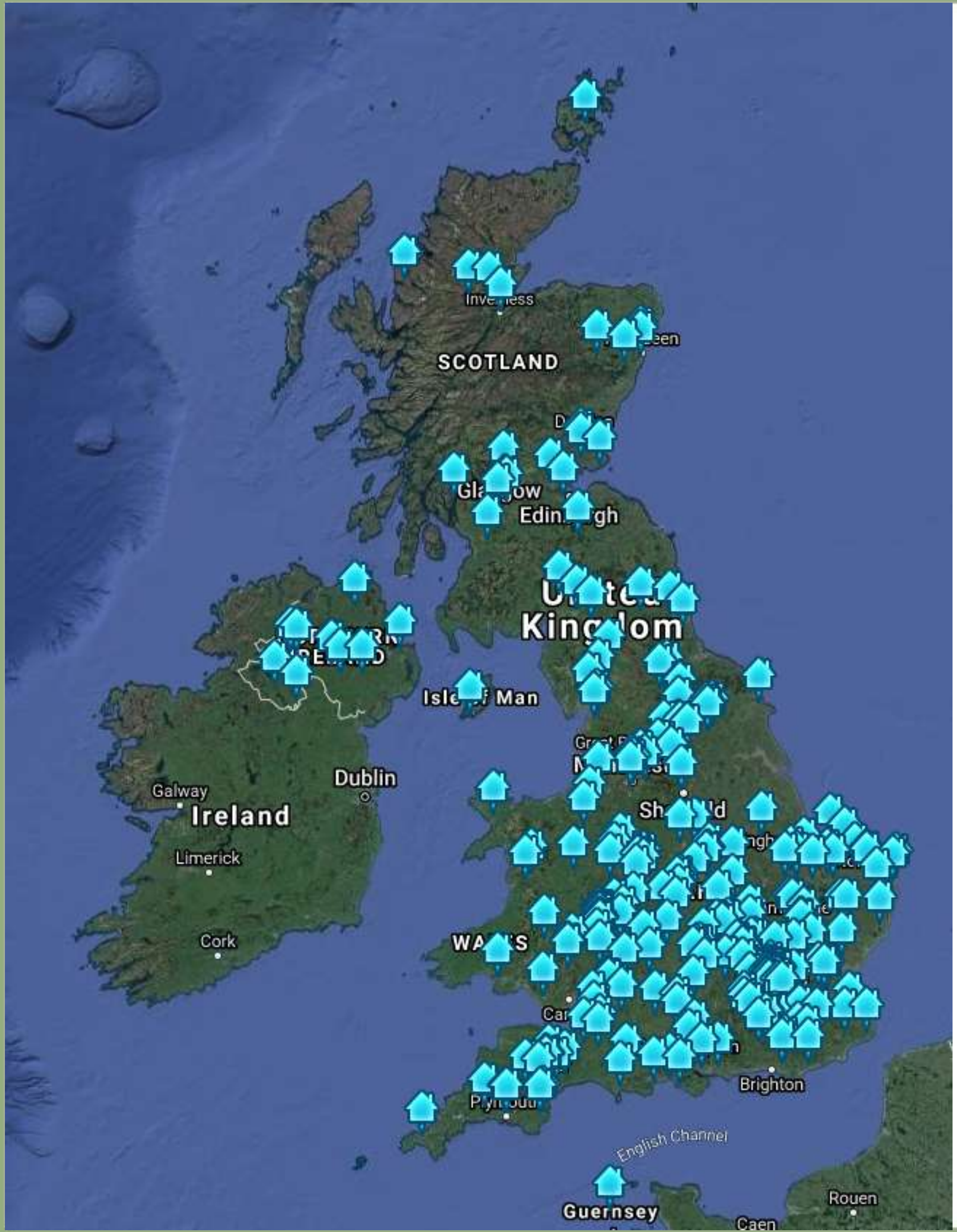
An Introduction to Passivhaus and EnerPHit



Introduction

- First Passivhaus building completed over 25 years ago
- 65,000 Passivhaus buildings globally, over 1000 in UK.

Source: Passivhaus Trust

Introduction

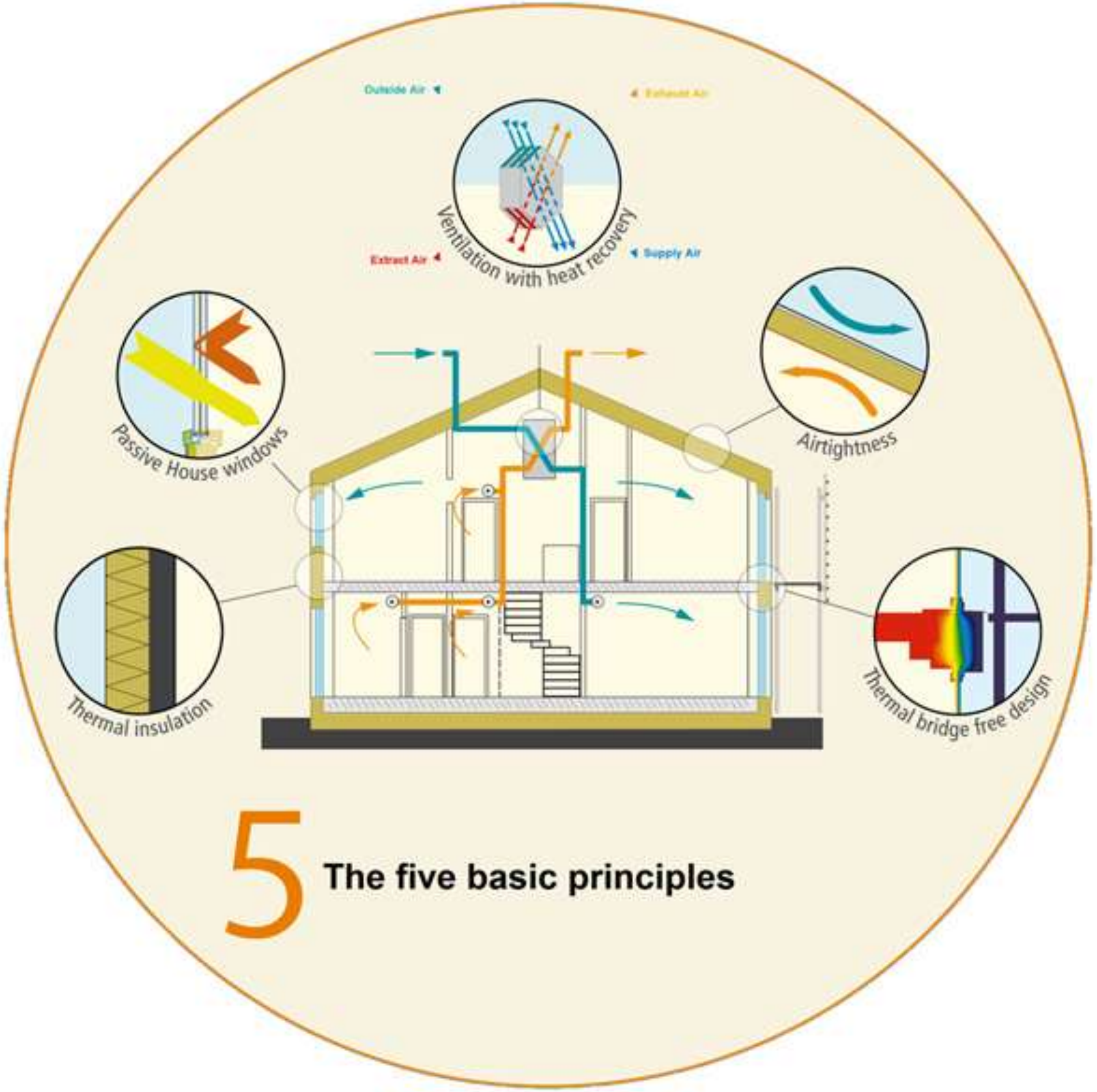
What is Passivhaus?

1. **Fabric First**
   - 25 kWh/m² (EnerPHit)
   - Reduced operational energy

2. **Comfort standard**
   - No overheating
   - Consistent temperature
   - No draughts

3. **Quality standard**
   - Air quality
   - Design quality
   - Build quality

…a well-designed building

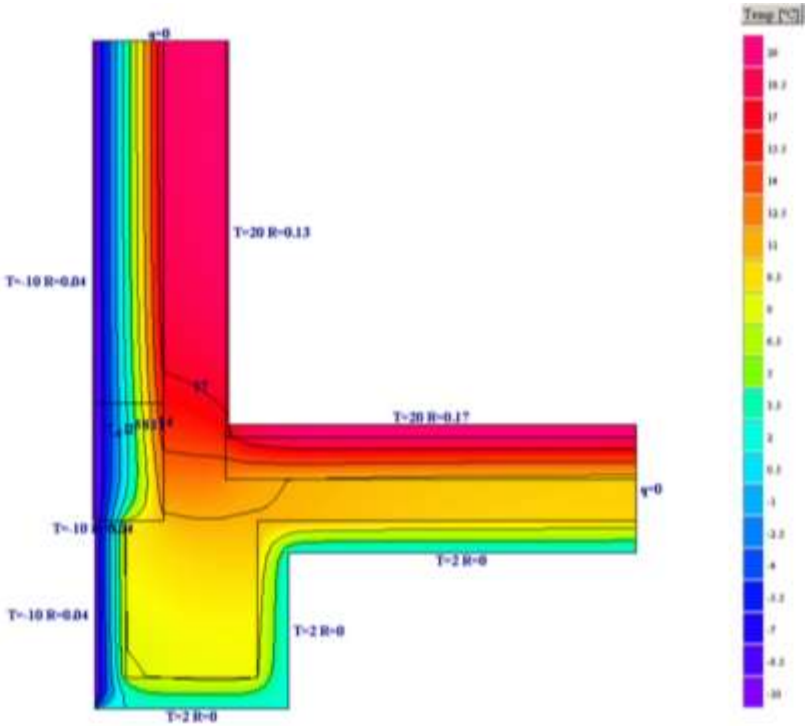


Source: Passivhaus Trust

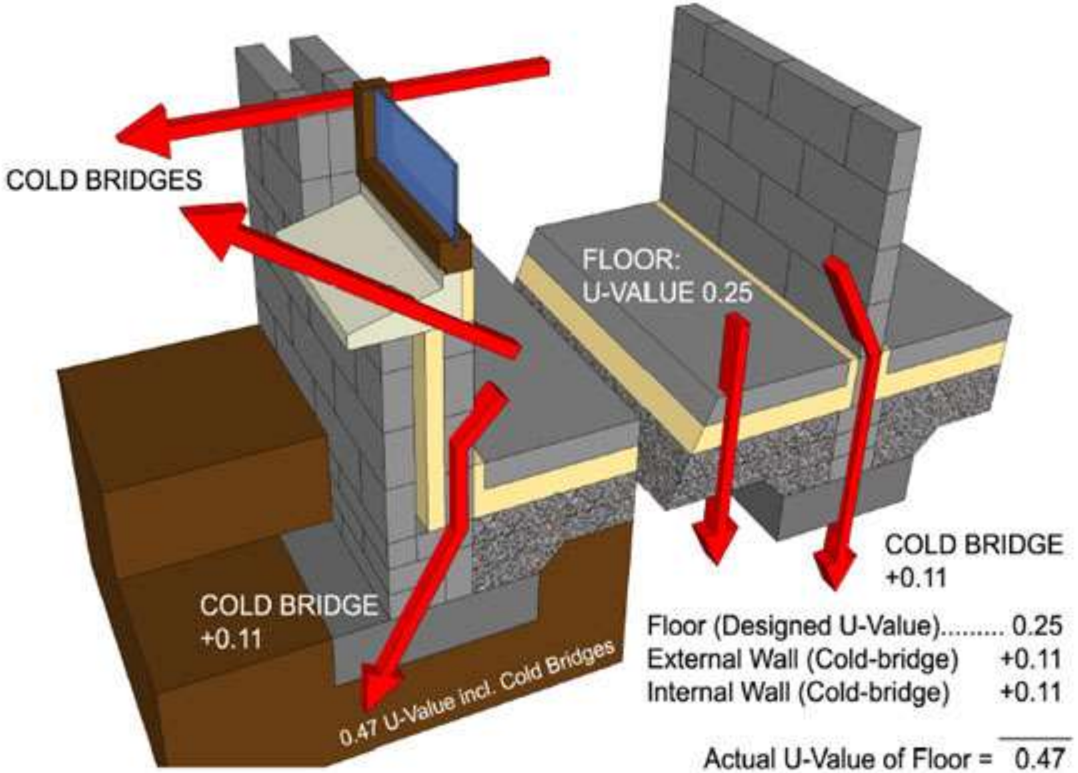
EnerPhit Challenges – Thermal Bridging

As insulation thickness increases, the heat loss due to thermal bridges becomes very significant, leading to cold patches that cause condensation and mould growth.

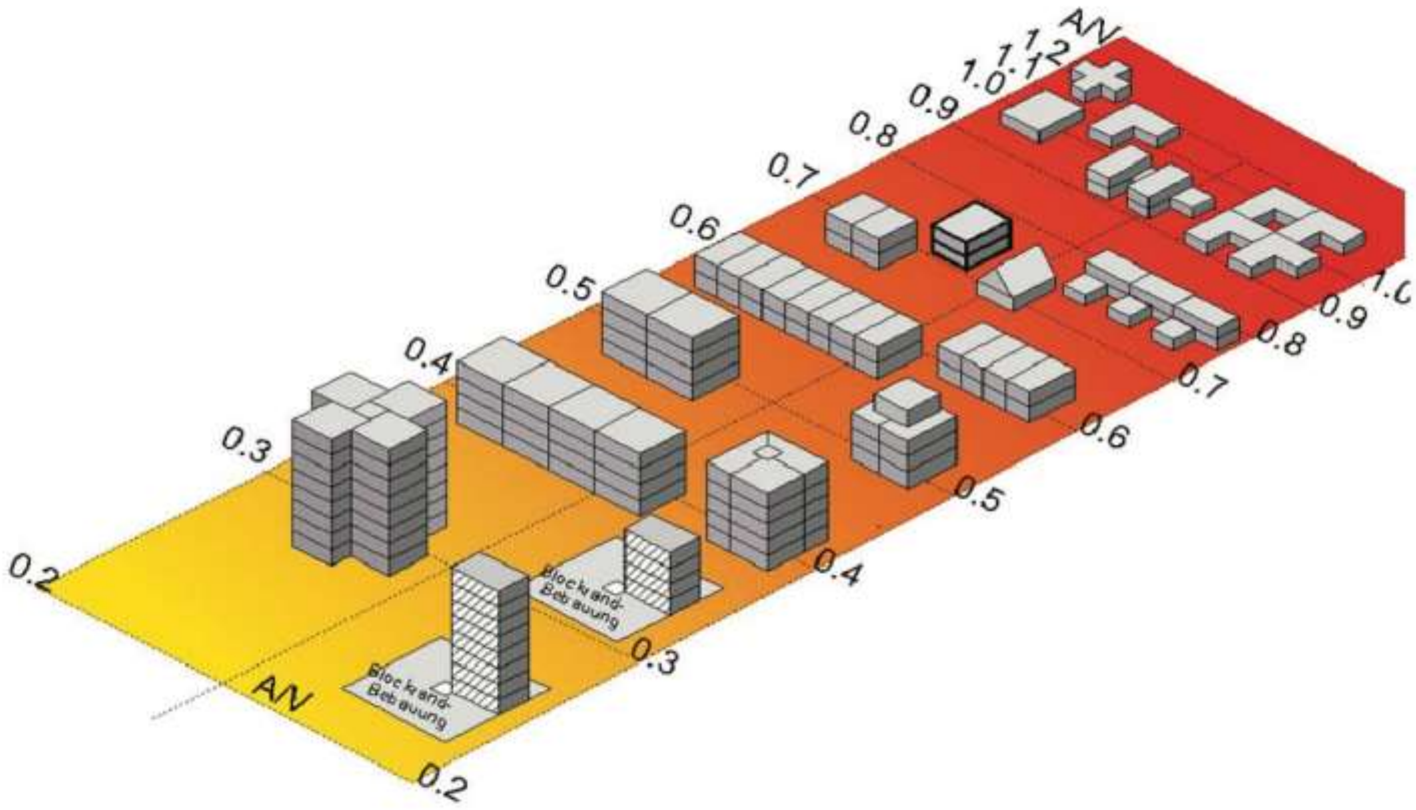
Thermal bridge free



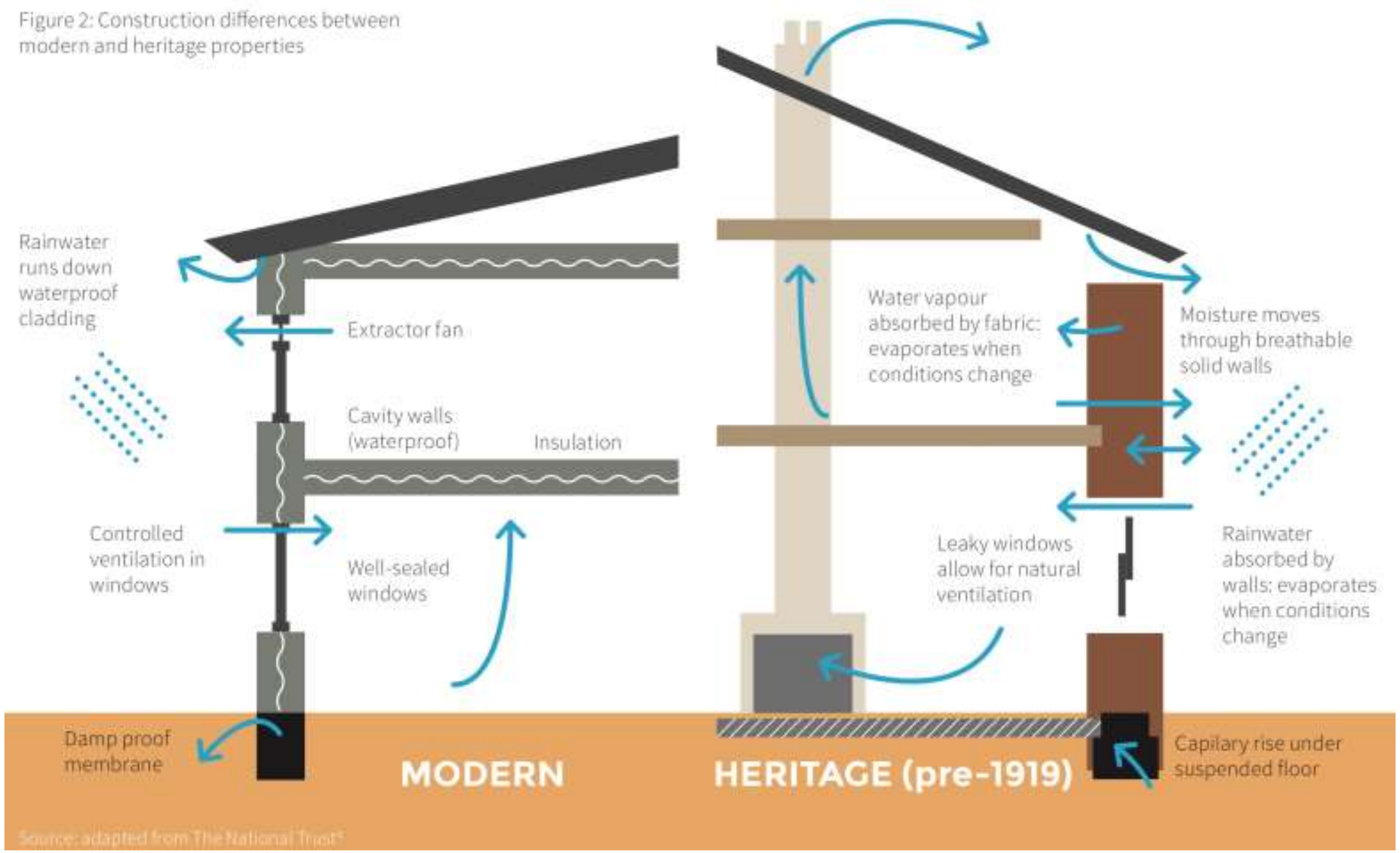
Typical thermal bridges



Form factor



EnerPHit Challenges



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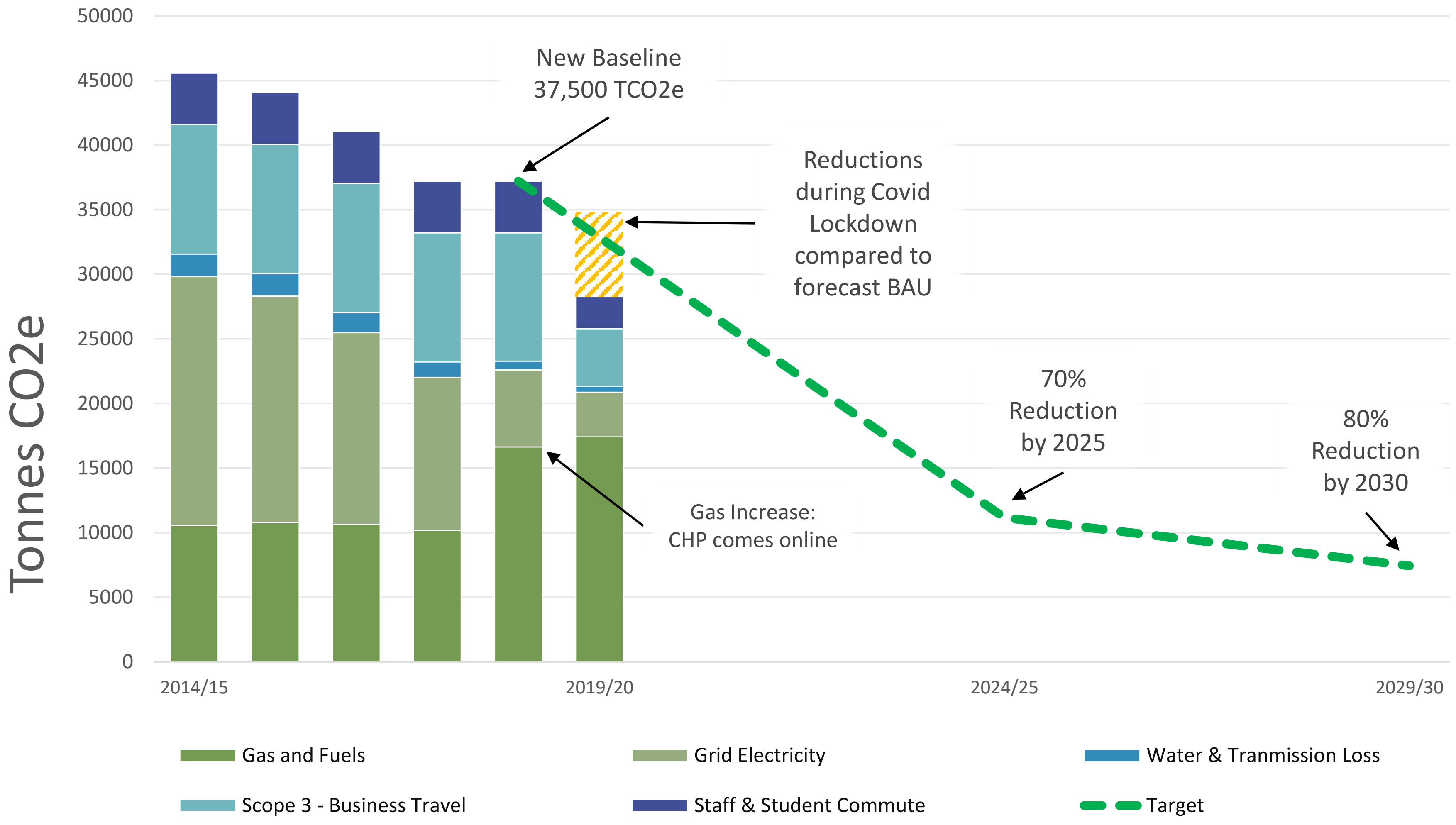
University of Strathclyde – Climate Neutral Estate

Vision 2025 - Net Zero Trajectory



ECD ARCHITECTS

University of Strathclyde: Climate Change and Social Responsibility Plan

Aim 1:
Tackle Climate Change, Ensure Resilience & Reduce Resource Use

- 1.1 – Delivering a Net Zero Estate
- 1.2 – Collaboration and Community Engagement
- 1.3 – Climate Adaptation and Resilience
- 1.4 – Action on Resource Use

Aim 2:
Be Socially Responsible

- 2.1 – Inclusive Campus Environment
- 2.2 – Responsible Procurement and Investment
- 2.3 – UN Sustainable Development Goals

Aim 3:
Collaborate with Others to Embed Sustainability Across the Institution

- 3.1 – Impactful Research
- 3.2 – SDG's in the Curriculum
- 3.3 – Building Capacity and Talent

Aim 4:
Share Learning and Knowledge to help ensure Continuous Improvement

- 4.1 – Accessible, Active Campus, and flexible working.
- 4.2 – Sustainable Procurement
- 4.3 - Circular Economy

Approach

a) ‘Fabric First’ – improvements in fabric and building systems to improve efficiency and enabling the existing estate systems to connect to low carbon heat.

b) Net zero and adaptation solutions using a whole systems approach and collaboration at city and region scale to enable the large scale transformation needed.

c) Creating the right investment environment for this work – identifying solutions that align with University plans; city and region plans; deliverable solutions; de-risking the investment; creating the right metrics.

d) Aligning with the UN SDGs e.g. 7, 11, 12, 13, 17

Climate Neutral Districts Vision – 10 projects

1. Glasgow City Innovation District
2. National Manufacturing Institute Scotland (NMIS)
3. Stepps – Heat from former Cardowan Colliery
4. Ross Priory Community Solar Array
5. Net Zero Pathway – John Anderson Campus, AFRC, PNDC, Stepps, Ross Priory
6. Management of Net Emissions – Invest/Divest/Sequester
7. Climate Adaptation – implementation of our Climate Adaptation Strategy
8. Sustainable Procurement gap analysis
9. Last Mile Delivery consolidation and circular economy
10. Monitoring, Measuring and Reporting

Project Team

- **University of Strathclyde**
- **ECD Architects** (Lead Consultant)
- **WSP** (M&E Consultant)
- **Currie & Brown** (Cost Consultant)
- **Architecture Department** (KTP Partners)

Key Deliverables

- Gap Analysis
- Communications Plan
- Visual Mapping of Building Energy Flows (Sankey Diagram)
- Digital Twin of John Anderson Campus
- Climate Change Risk and Vulnerability Assessment
- Costed Plan for Data Capture of Energy & Emissions Data
- Ranking of Costed Technical Solutions
- Emissions Reduction Pathway
- Financial Delivery Model
- Final Report

Study Buildings

- Royal College
- TIC
- Thomas Graham Building
- Robertson Wing
- Curran Building
- Graham Hills
- James Weir
- Stenhouse Building
- John Anderson Building
- Hamnett Wing
- Student Union

- AFRC
- Stepps
- Ross Priory
- PNDC

Methodology

Agree Brief
- Regulatory
- Define net zero
- What is in?
- Regulated
- Unregulated
- Transport
- Offsets
- Communications

Baseline
- Metering
- Reports
- Condition report
- Plans / Drawings
- Surveys

Analysis
- **Interventions**
  - Efficiency
  - Generation
  - Control
  - Fuel-switch
  - Offsets
  - DHN Study
  - Wind Study
- **Cost Analysis**

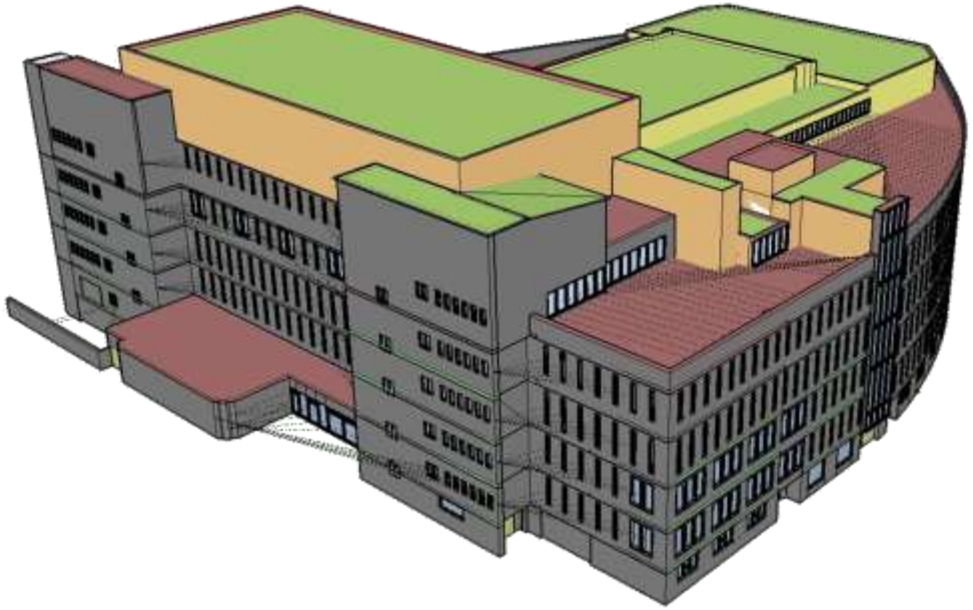
Engage
- **Prelim Results**
  - Feasibility
  - Costs
  - Context
- **Agree responses**

Strategy
- **Results**
- **Recommendations**
  - Practical Action
  - Timescales
  - Funding
  - Responsibility

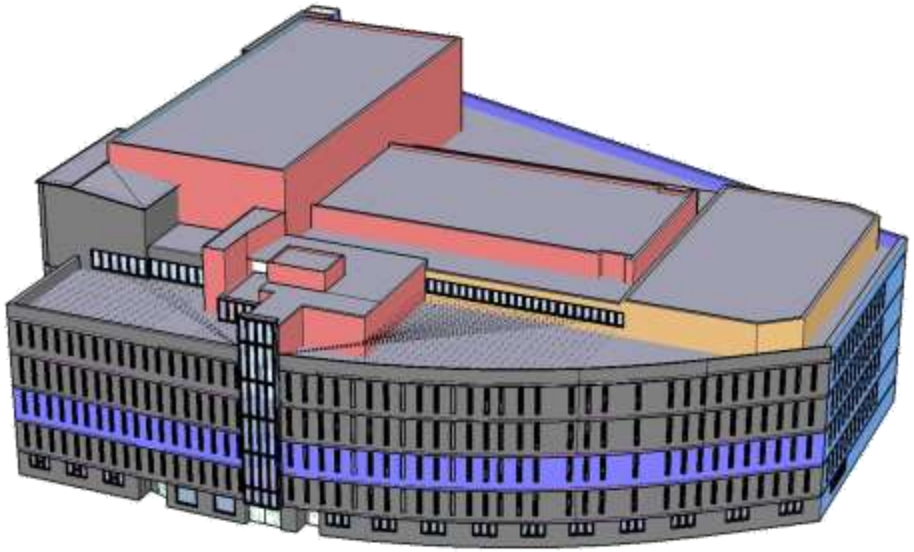
Implement
- **Results**
- **Recommendations**
  - Practical Action
  - Timescales
  - Funding
  - Responsibility

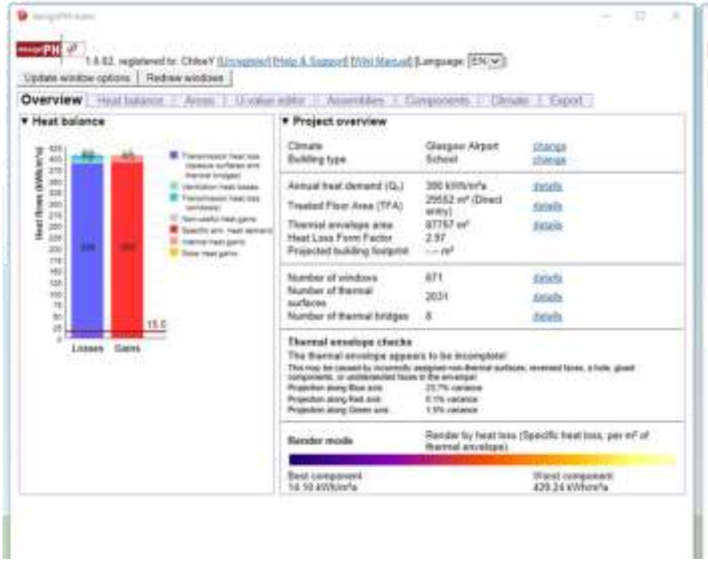
360⁰ Energy Model

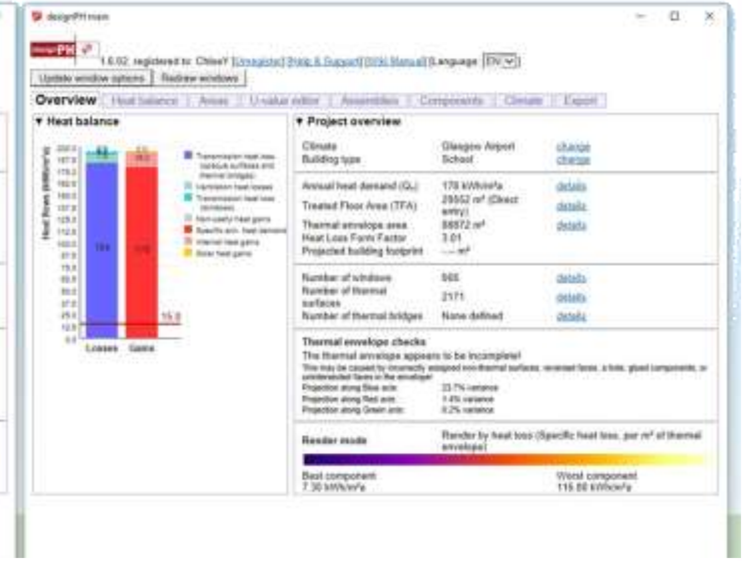
Energy Modelling



Curran Building Existing







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Case study – Wilmcote House


Portsmouth
CITY COUNCIL

Existing

REPORT FROM PORTSMOUTH CITY COUNCIL (2012)

1. One third of residents suffer from condensation problems
2. Windows are at the end of their serviceable life
3. Increased maintenance responses for the past 2 years
4. Roof needs replacing
5. Water ingress problems in staircores
6. No gas allowed, only costly electric
7. Concrete repairs are required to future-proof the building

Demolition?

Demolition?

Demolition option considered but rejected by client

1. It would take at least 18-24 months to decant the block
2. Over 100 families would have to be relocated
3. 3 Bedroom properties are in high demand locally
4. Rebuild costs would be prohibitive

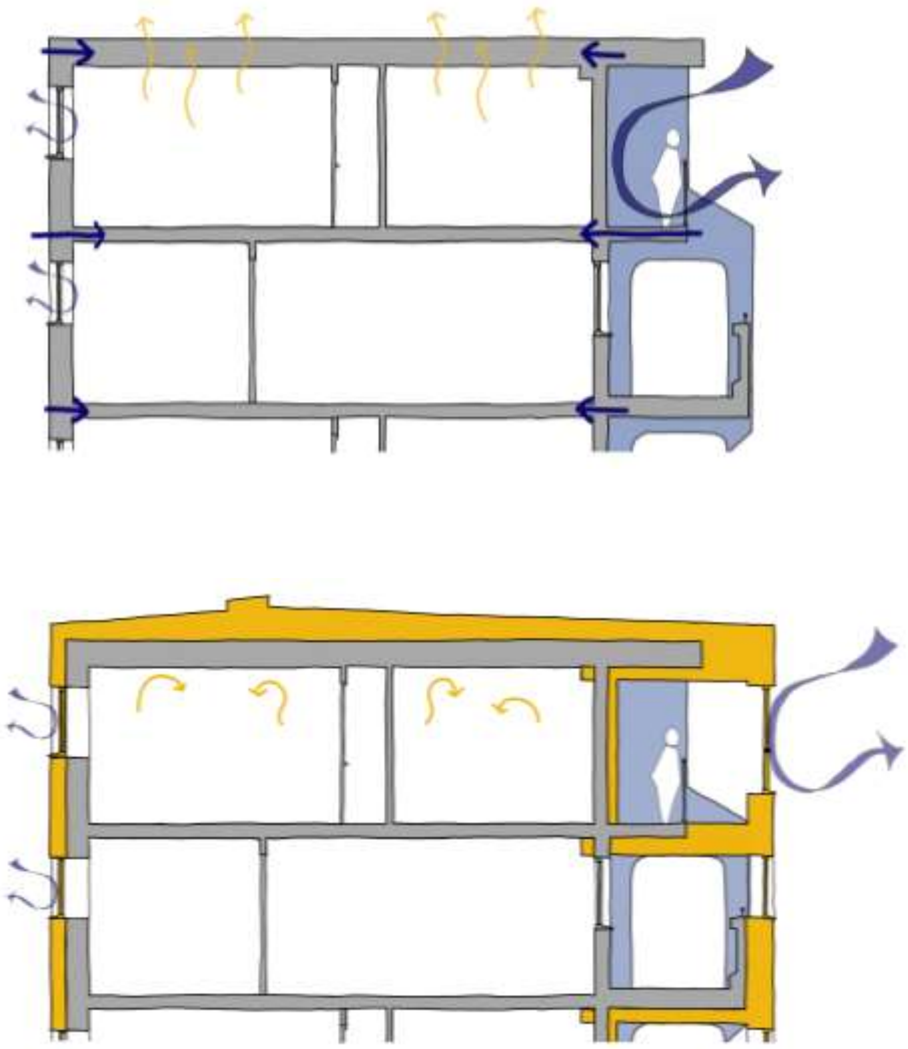
Capital Cost Differential Models

- Building regulations equivalent (Part L 2010)
- Passivhaus specification (as tendered)

Pre-retrofit

Lower level

Upper level



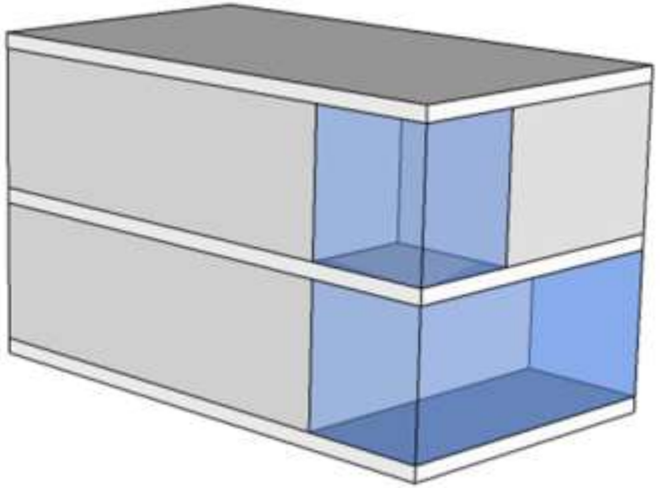
Retrofit Strategy

Construction strategy

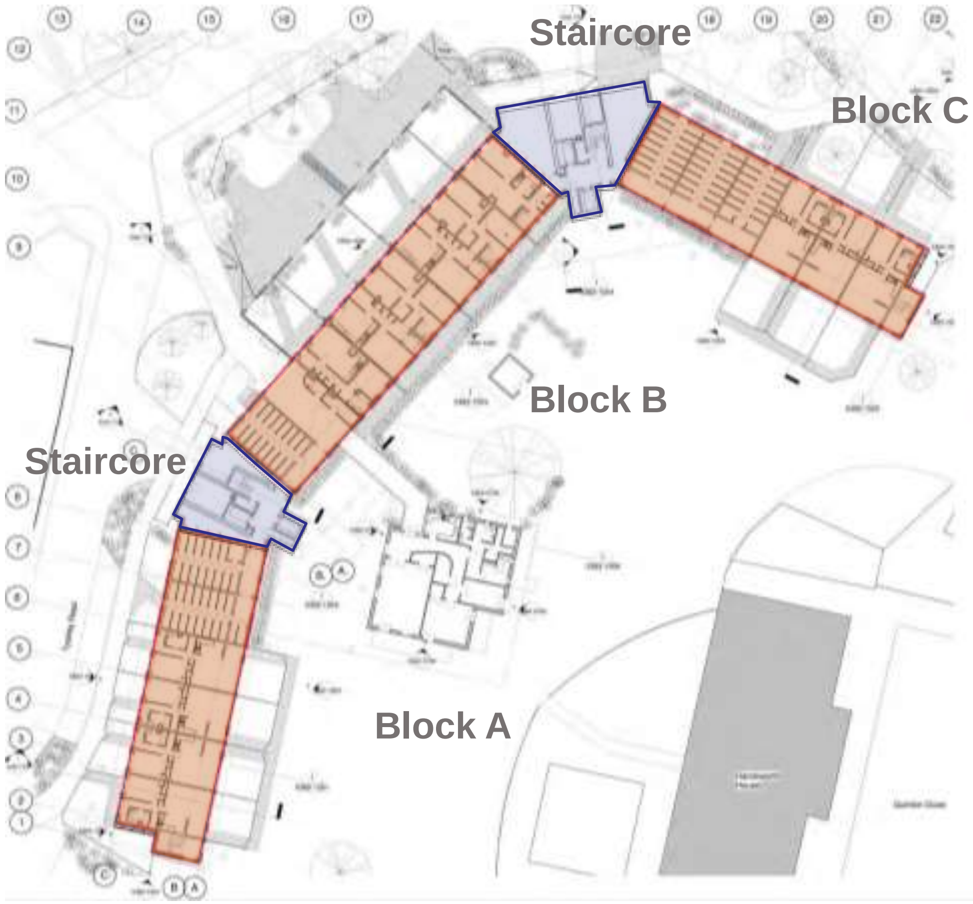
Enclosed walkways

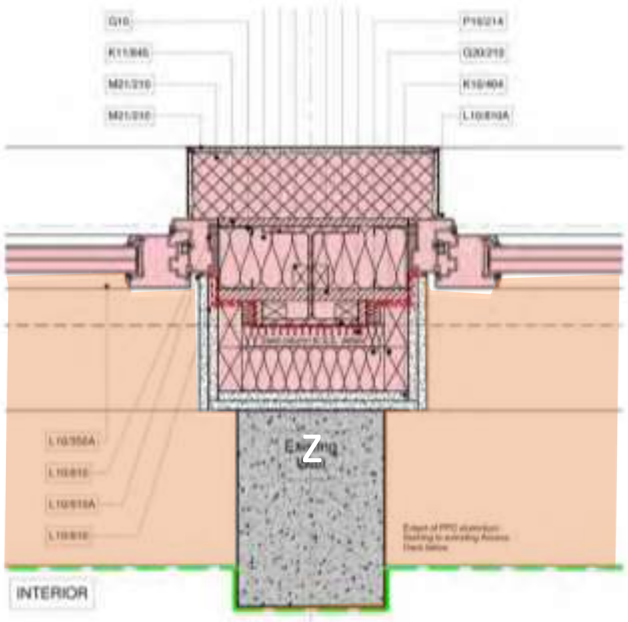
Enlarged enclosed sun-space

Enlarged living room



Overcladding strategy





Overcladding detail – External wall

Capital cost breakdown

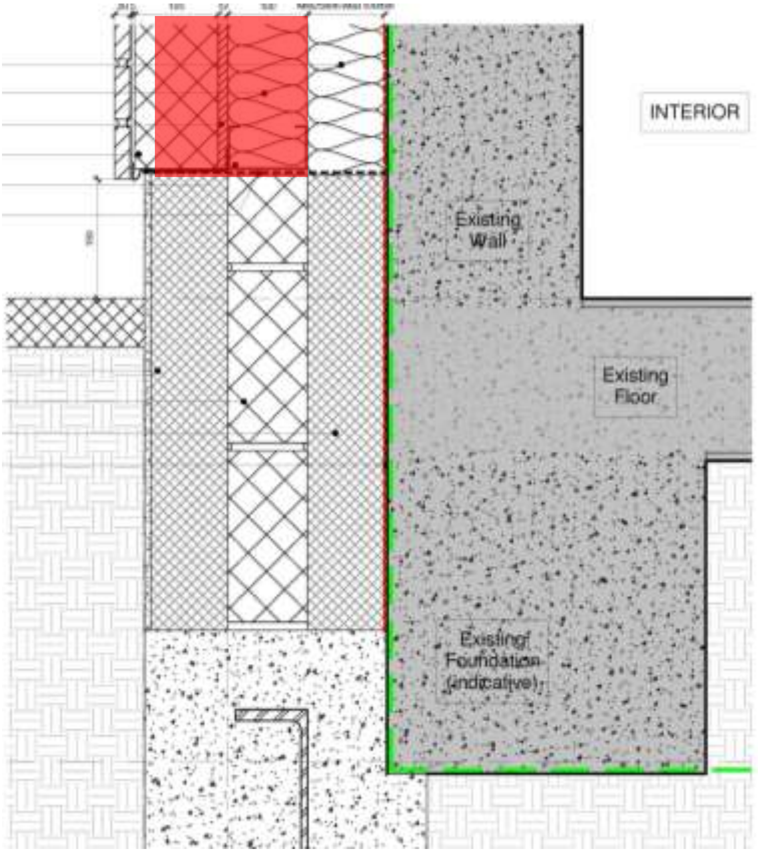
- Foundations
- Below DPC
- Internal Wall Insulation
- External Wall Insulation
- Roof Insulation
- Thermal break pads
- Windows
- MVHR/Extract
- Strip out existing ducts
- Strip out asbestos
- Airtightness and quality control
- Prelims, design fees & risk, bond, contingency

Bill of quantities – relevant items

Item cost	£££
Total Cost to summary	**£££**
Running total	**£££**

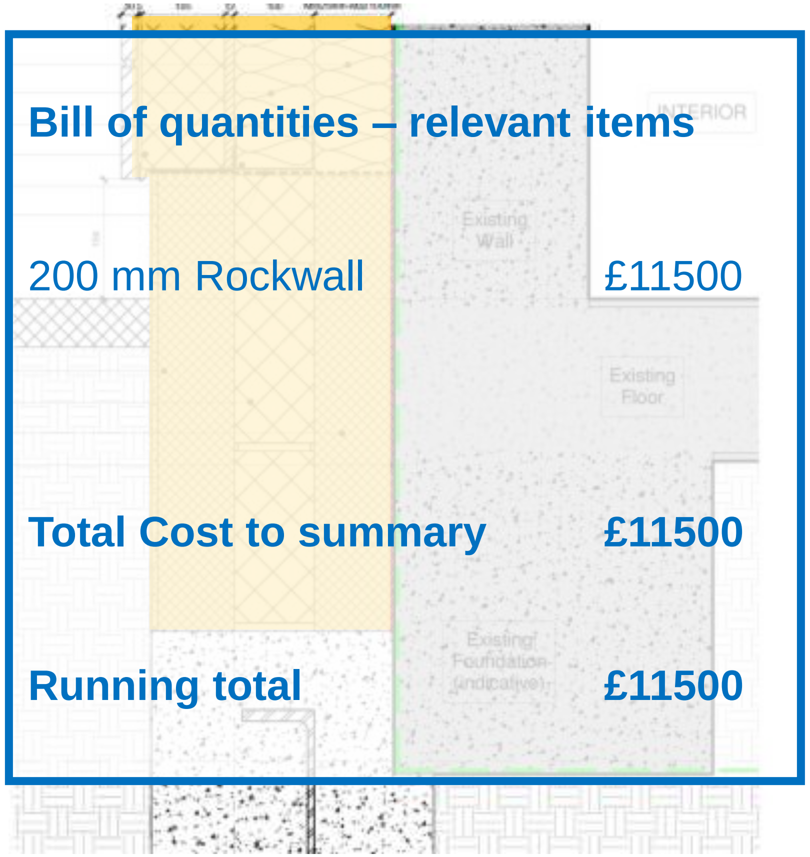
Foundations

Passivhaus requirements



Part L 2010 equivalent

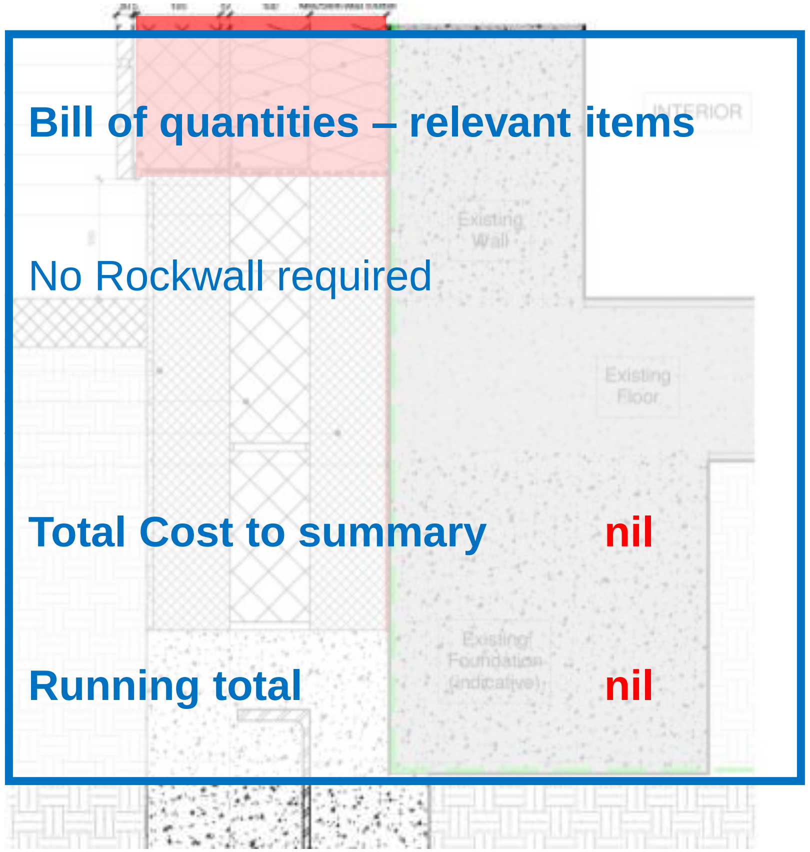
Foundations



Bill of quantities – relevant items

200 mm Rockwall	£11500
Total Cost to summary	**£11500**
Running total	**£11500**

Passivhaus requirements

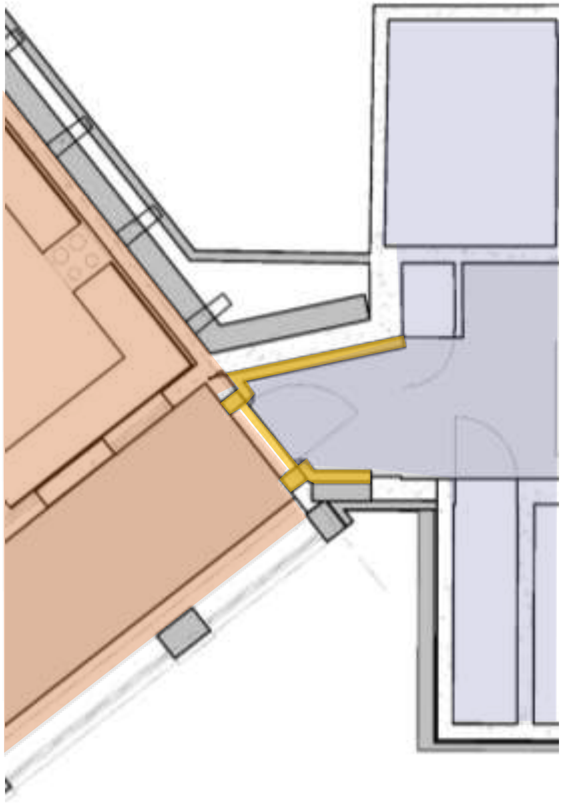


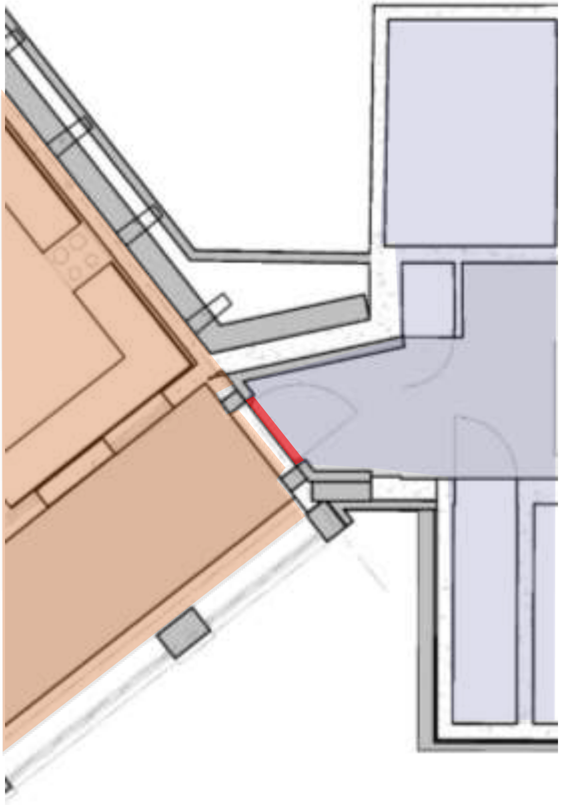
Bill of quantities – relevant items

No Rockwall required	
Total Cost to summary	**nil**
Running total	**nil**

Part L 2010 equivalent

Internal wall insulation

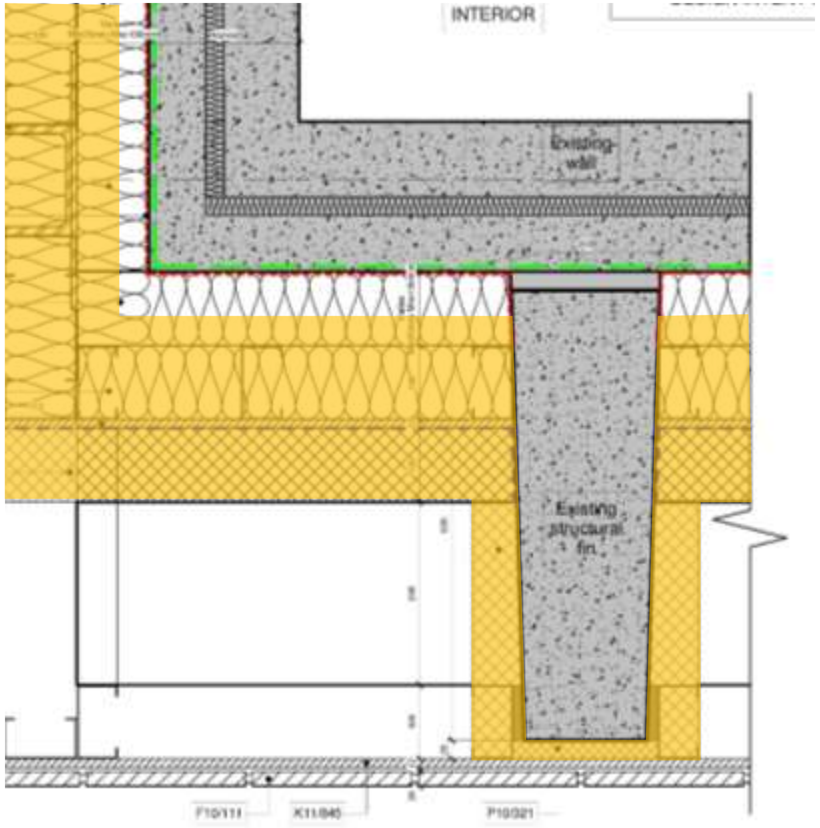




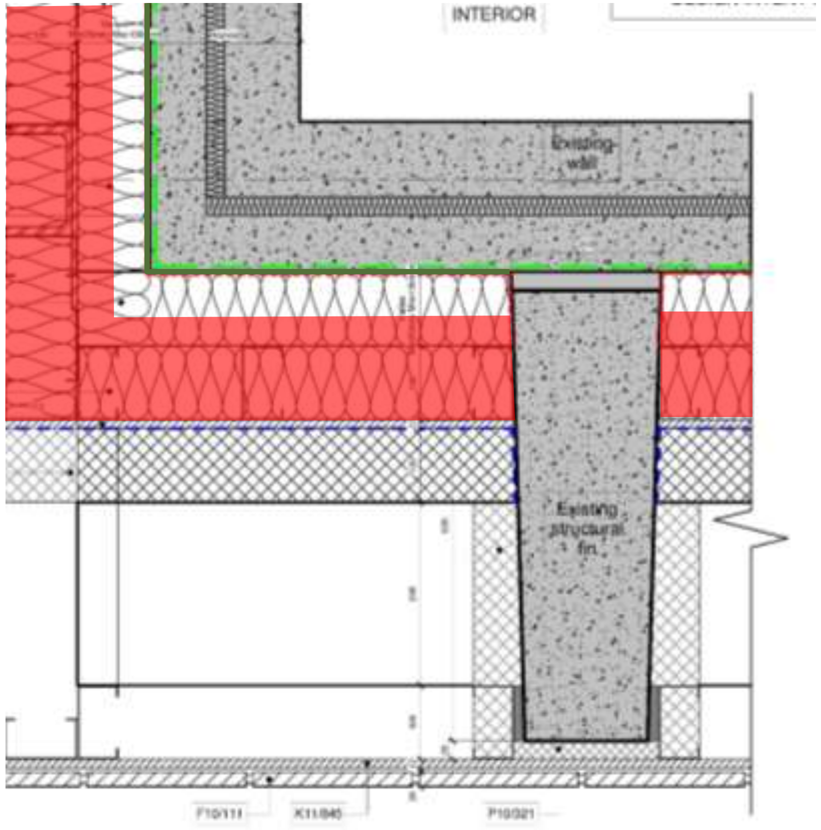
Passivhaus requirements

Part L 2010 equivalent

External wall insulation

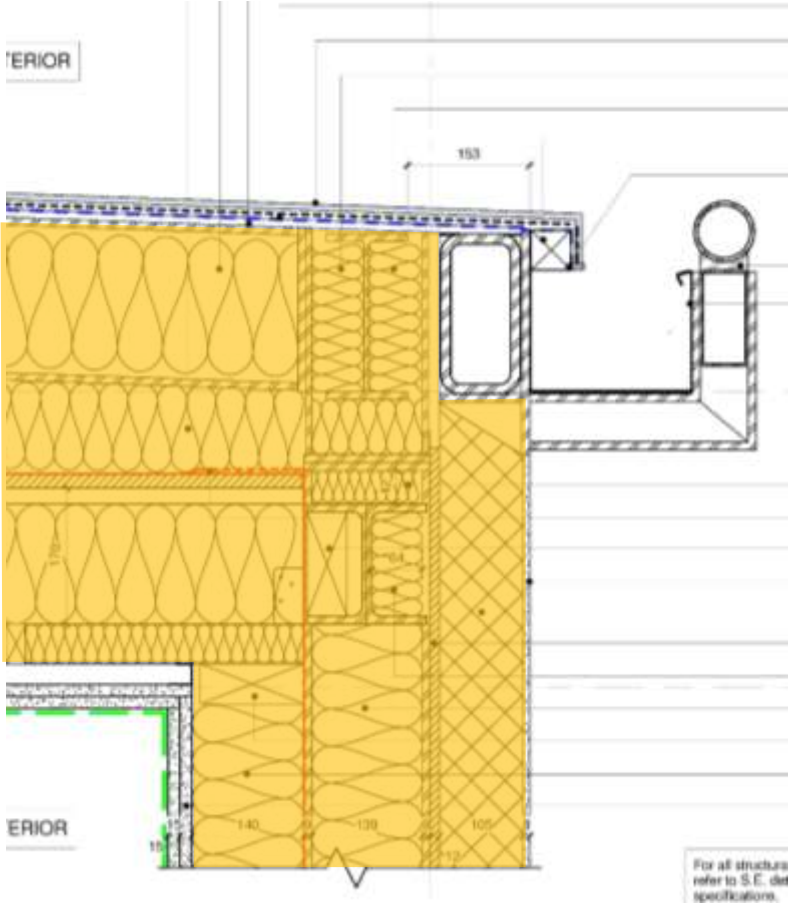


Passivhaus requirements

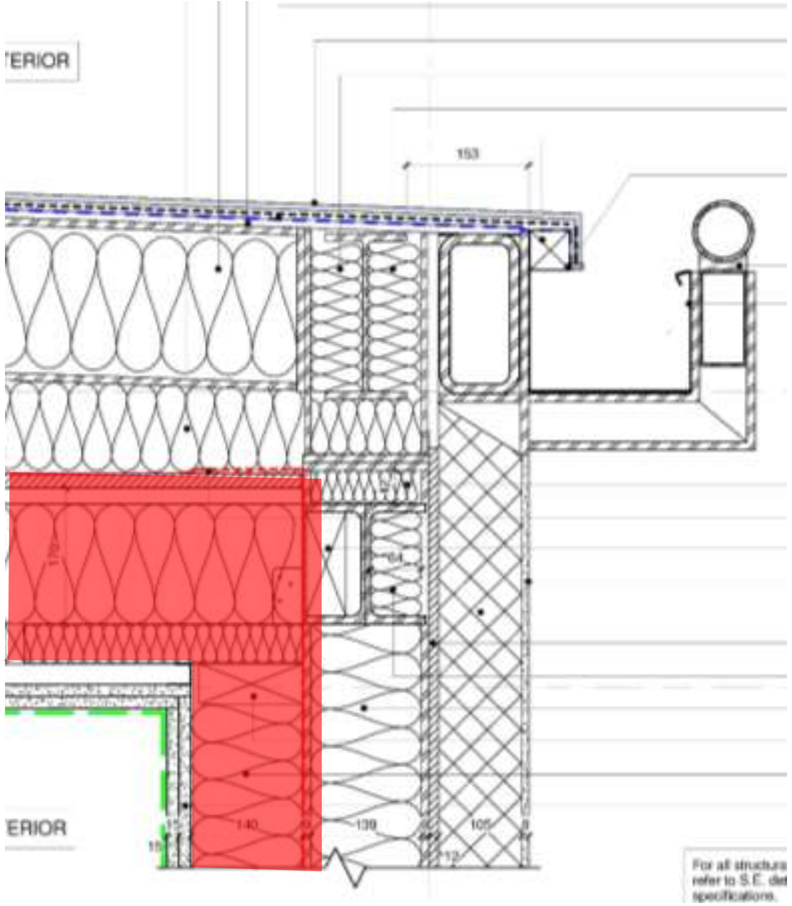


Part L 2010 equivalent

Roof insulation

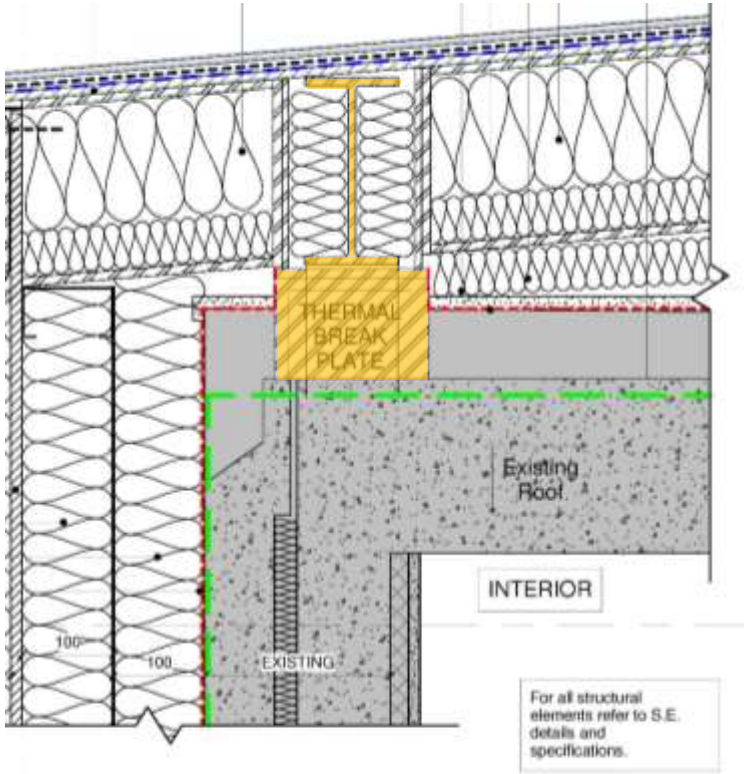


Passivhaus requirements

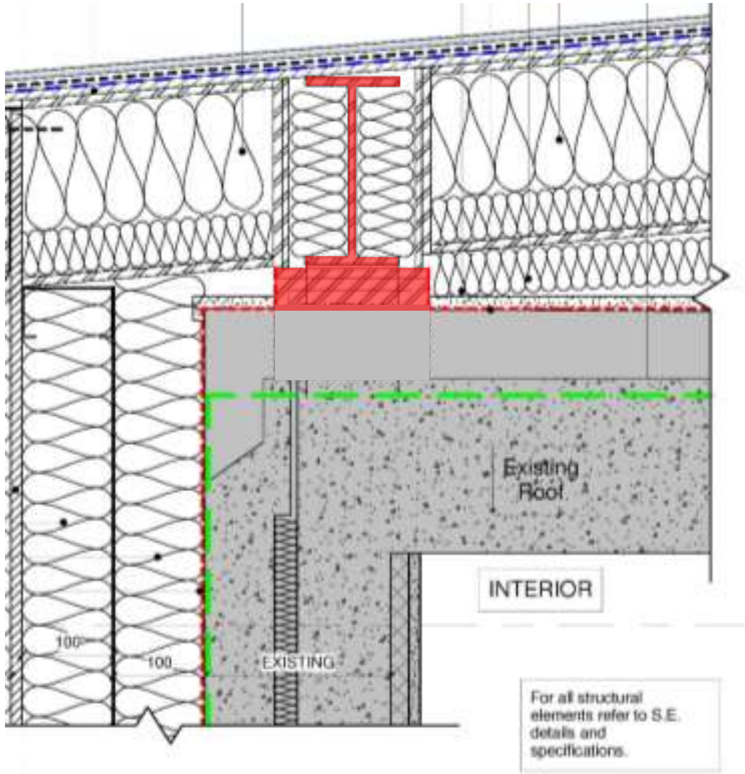


Part L 2010 equivalent

Thermal breaks

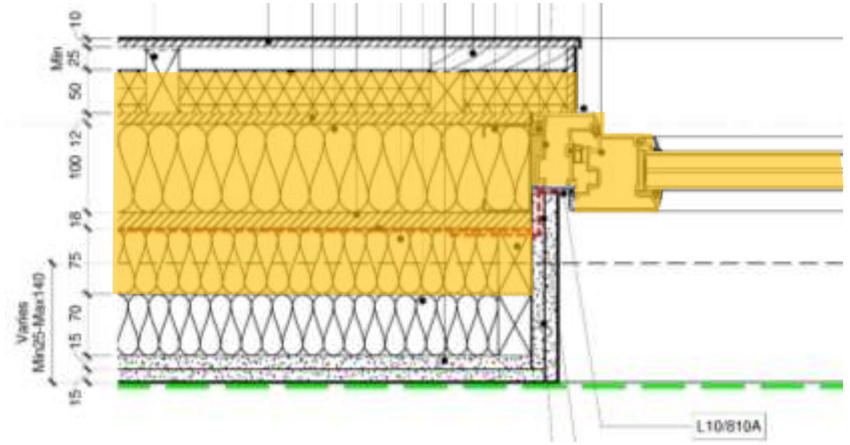


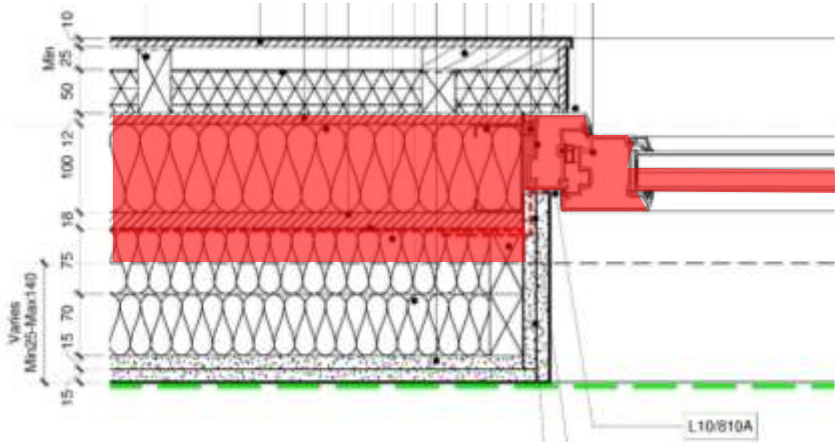
Passivhaus requirements



Part L 2010 equivalent

Windows

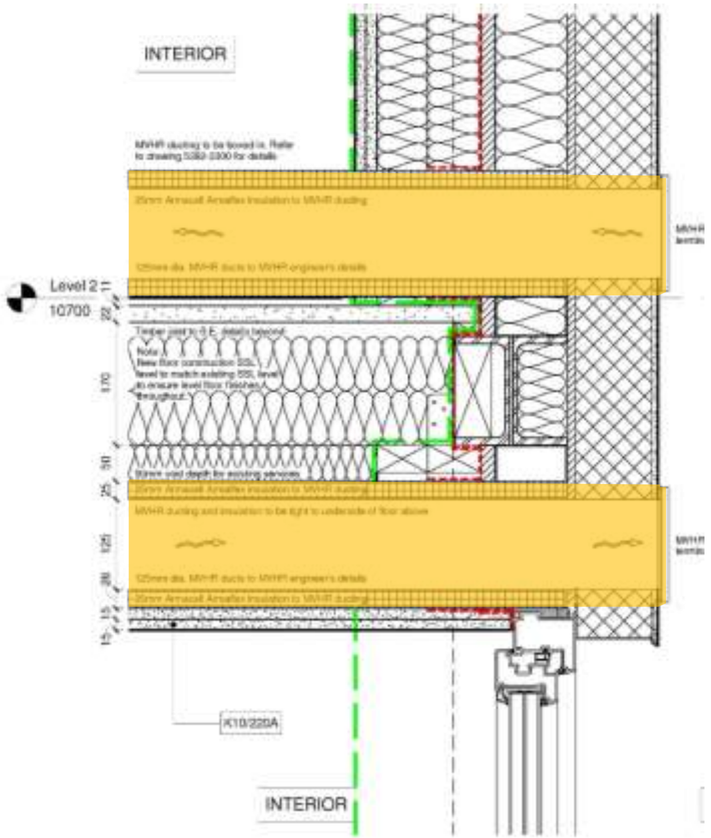




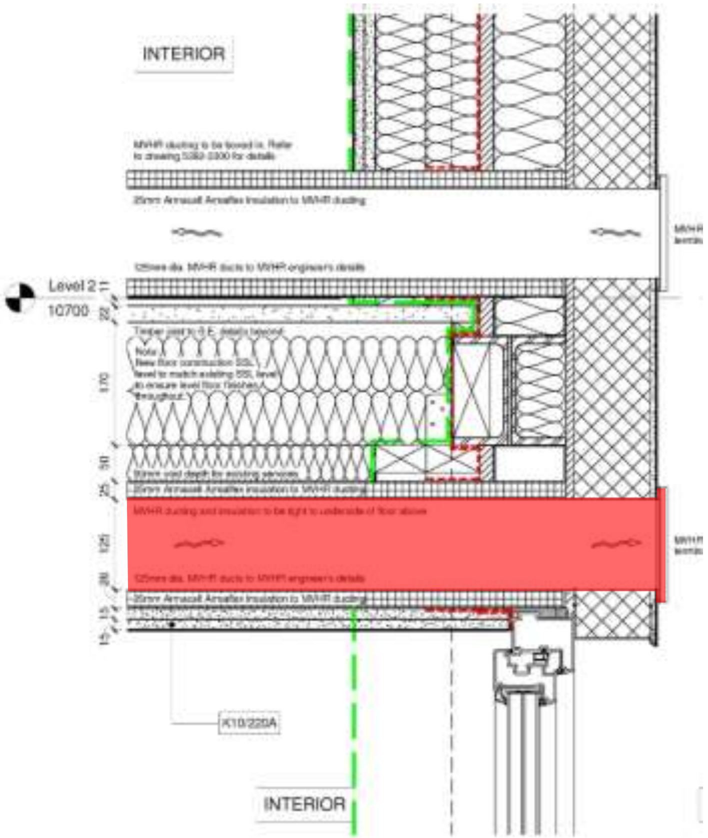
Passivhaus requirements

Part L 2010 equivalent

MVHR/Extract

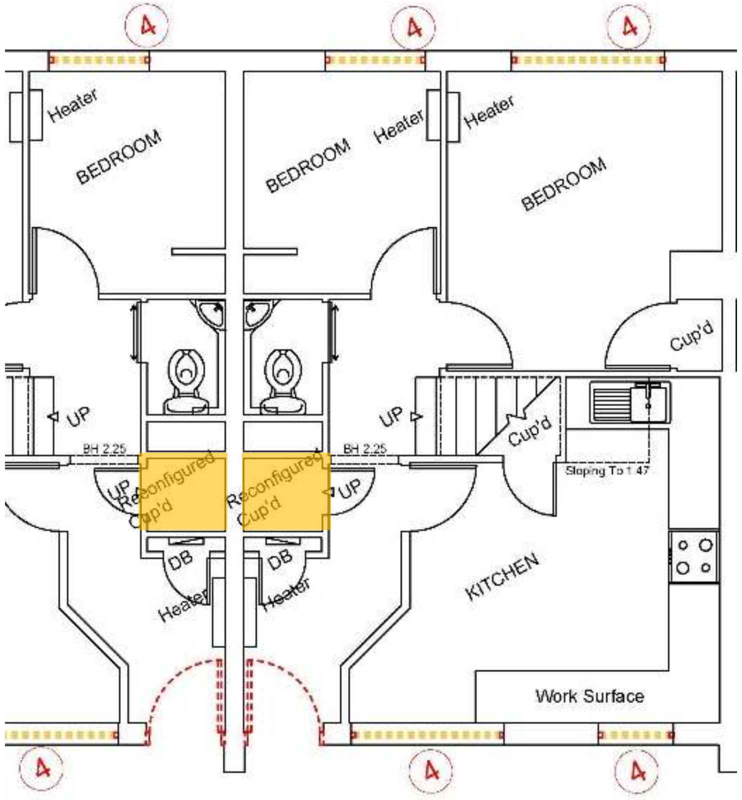


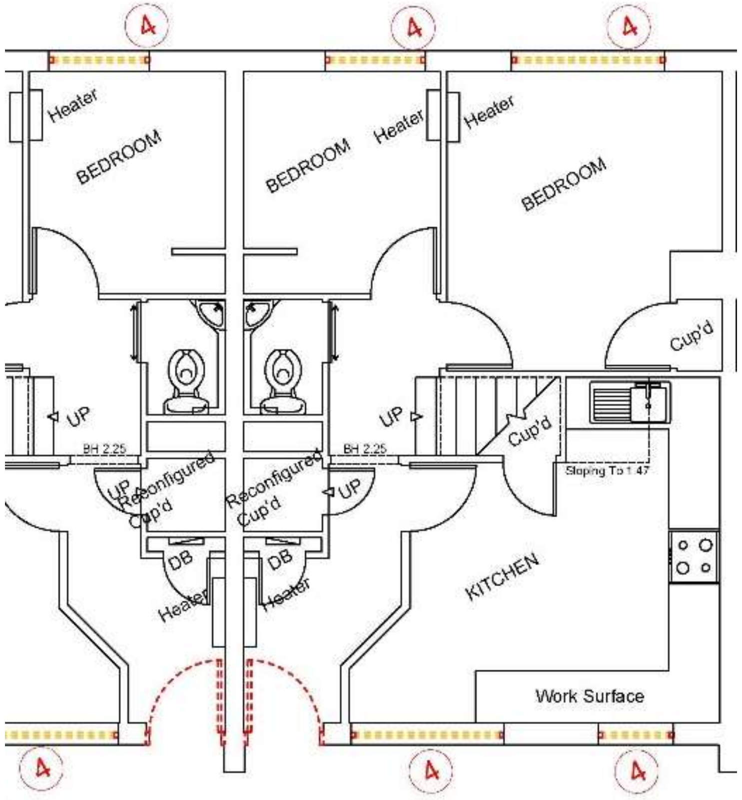
Passivhaus requirements



Part L 2010 equivalent

Existing ducts





Passivhaus requirements

Part L 2010 equivalent

Asbestos

Passivhaus requirements

Part L 2010 equivalent

Total construction costs

Summary	
Adjusted works	£2 765 534
Non adjusted works	£5 909 907
	£8 675 441
Oncosts	£4 252 015
Total	**£12 927 456**
Additional Cost	**£1 090 536**

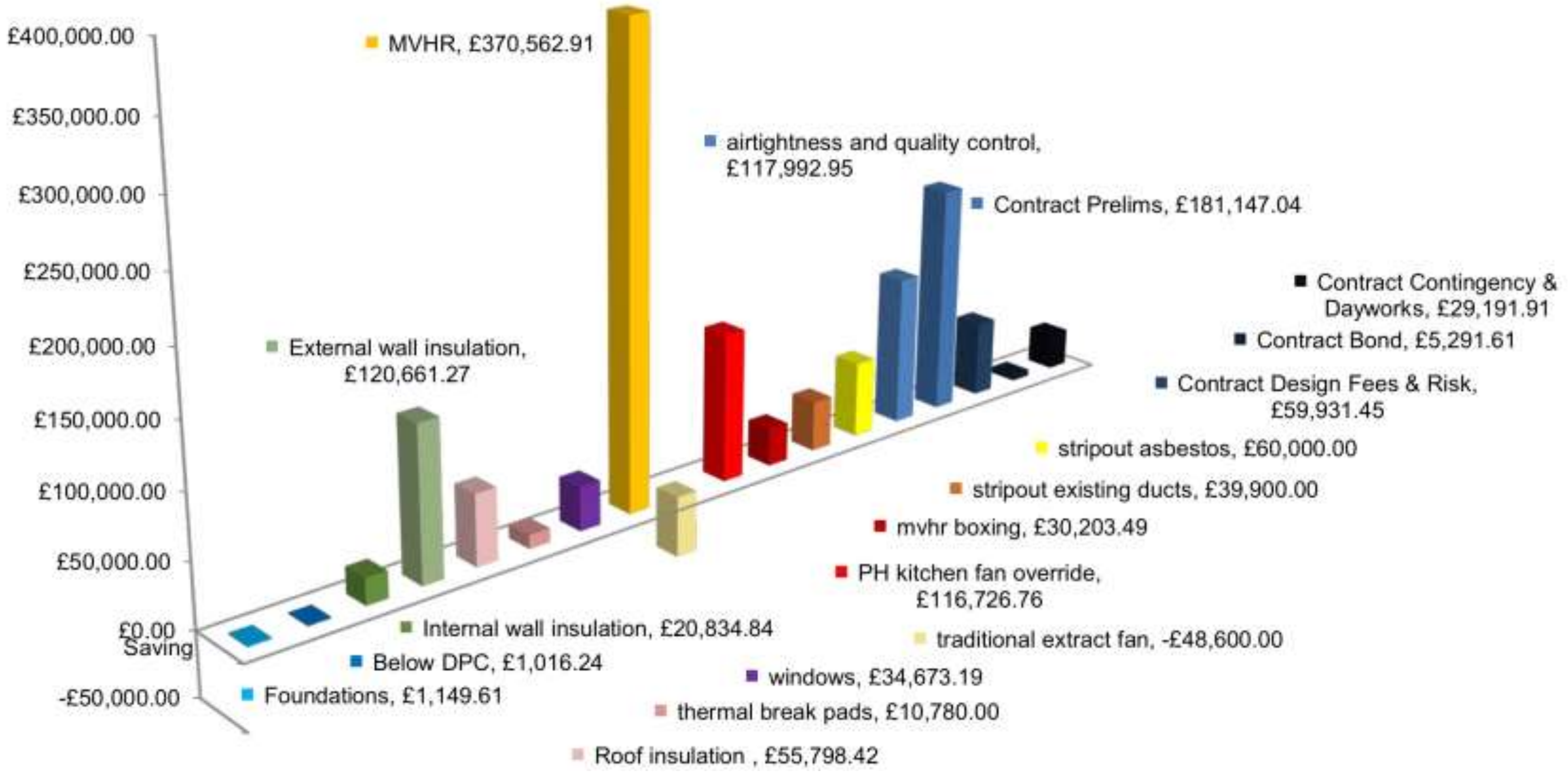
Passivhaus

Summary	
Adjusted works	£1 950 561
Non adjusted works	£5 909 907
	£7 860 468
Oncosts	£3 976 452
Total	**£11 836 920**
Additional Cost	**9% £1 090 536**

Part L 2010 equivalent

Breakdown of capital costs

Enerphit Contract Sum	**£12,927,456**	**£889/m²**
Building Regulations	**£11,836,920**	**£814/m²**
Difference	**£1,090,536**	**£75/m²**



Lifecycle cost analysis

- Passivhaus specification (as tendered)
- Building regulations equivalent (Part L 2010)

Energy calculations

Treated floor area	4111.0	m²
Annual heating demand	23	kWh/(m²a)
Heating load	13	W/m²
ecific space cooling demand		kWh/(m²a)
Cooling load		W/m²
ncy of overheating (> 25 °C)	0.4	%
ig and cation, cooling, household electricity.		kWh/(m²a)
ating and auxiliary electricity		kWh/(m²a)
ction through solar electricity		kWh/(m²a)
Pressurization test result n_{50}	1.0	1/h

Passivhaus requirements

Treated floor area	4111.0	m²
Annual heating demand	93	kWh/(m²a)
Heating load	55	W/m²
ecific space cooling demand		kWh/(m²a)
Cooling load		W/m²
ncy of overheating (> 25 °C)	0.0	%
ig and ication, cooling, household electricity.		kWh/(m²a)
eating and auxiliary electricity		kWh/(m²a)
ction through solar electricity		kWh/(m²a)
Pressurization test result n_{50}	10.0	1/h

Part L 2010 equivalent

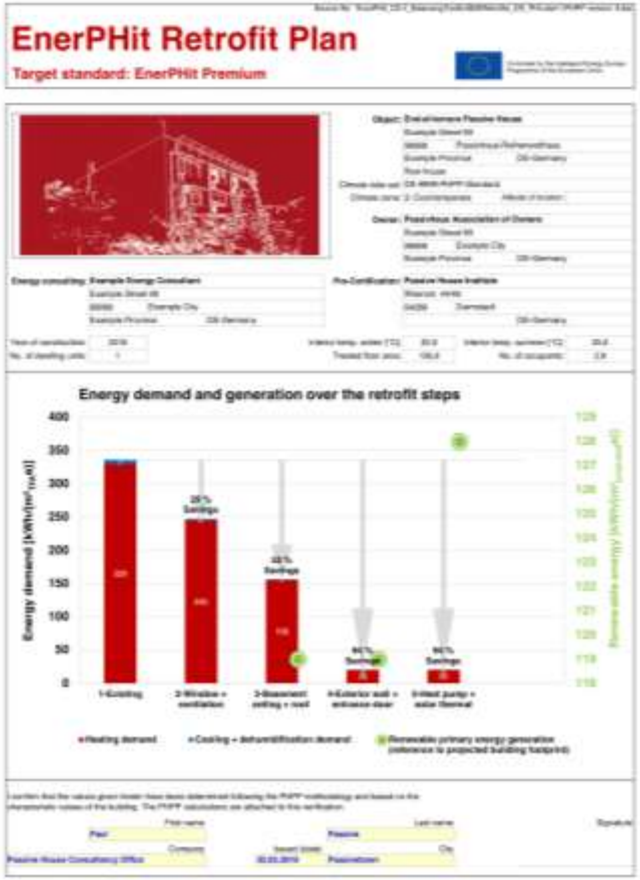
Phasing?

Step by Step - Annual space heating demand - modelling

Step 4 Option b. MVHR Installed, airtightness improvement to Enerphit

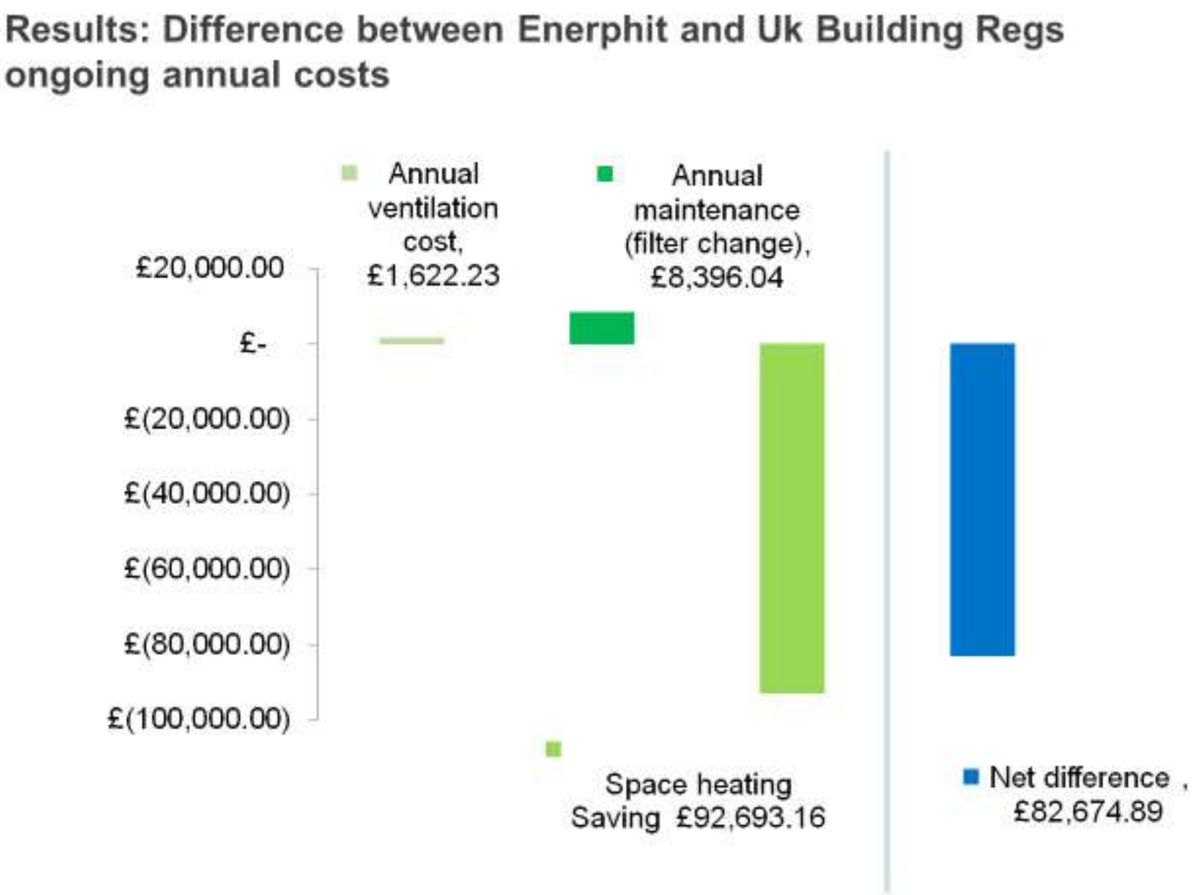
Specific building characteristics with reference to the treated floor area				Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area m²	3119.6				
Space heating	Heating demand kWh/(m²a)	13	≤	20	-	yes
	Heating load W/m²	9.7	≤	-	-	
Space cooling	Cooling & dehum. demand kWh/(m²a)	-	≤	-	-	-
	Cooling load W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C) %	3	≤	10		yes
	Frequency excessively high humidity (> 12 g/kg) %	0	≤	20		yes
Airtightness	Pressurization test result n_{50} 1/h	1.0	≤	1.0		yes
Non-renewable Primary Energy (PE)	PE demand kWh/(m²a)	151	≤	120		no
Primary Energy Renewable (PER)	PER demand kWh/(m²a)	70	≤	-	-	-
	Generation of renewable energy (in relation to projected building) kWh/(m²a)	0	≥	-	-	

[2] Empty field: Data missing; '-': No requirement



Step 1. Baseline space heating demand	80kWh (m2a)	Building regulations 2010 refurb
Step 2. Resulting space heating demand	72kWh (m2a)	Upgrade windows from double to triple
Step 3. Resulting space heating demand	57kWh (m2a)	Improve insulation levels
Step 4a. Resulting space heating demand	51kWh (m2a)	Install MVHR (no airtightness improvement)
Step 4b. Resulting space heating demand	13kWh (m2a)	MVHR with airtightness improvement

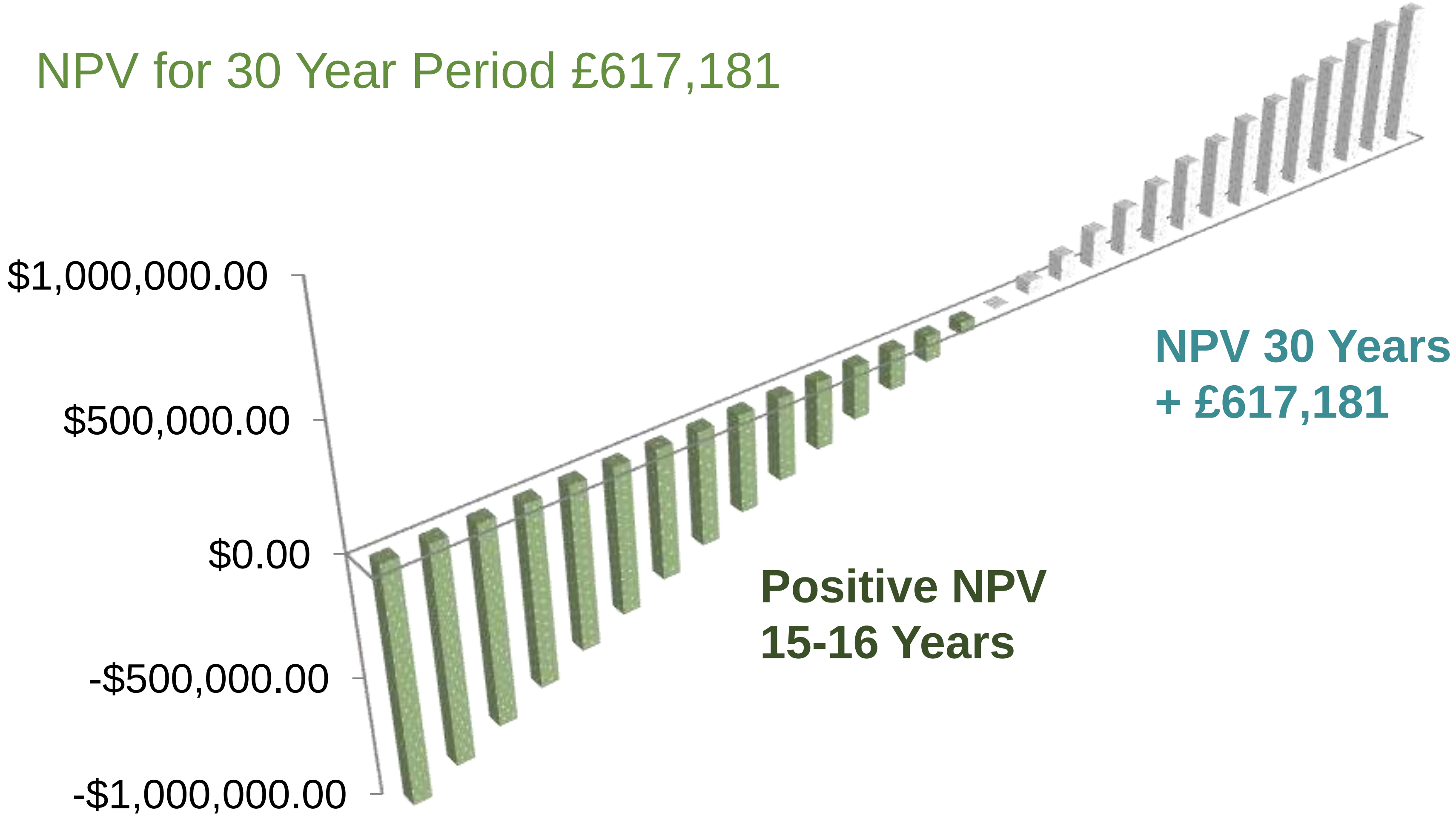
Energy cost differential



Life cycle costs

Positive NPV reached by close of 15th year

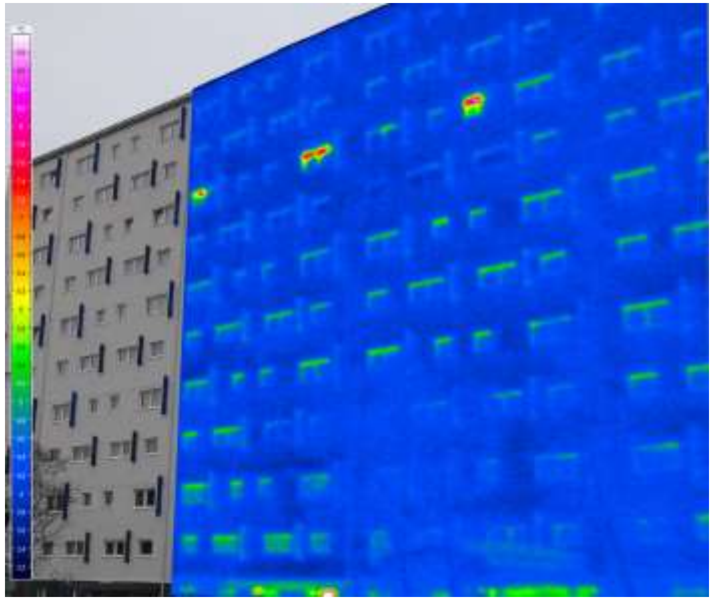
NPV for 30 Year Period £617,181



What it offers

Certified
Passive House
Passive House Institute

EnerPHit
Certified
Retrofit
Passive House Institute



Changing perceptions

Thornhill Primary School

ECD ARCHITECTS

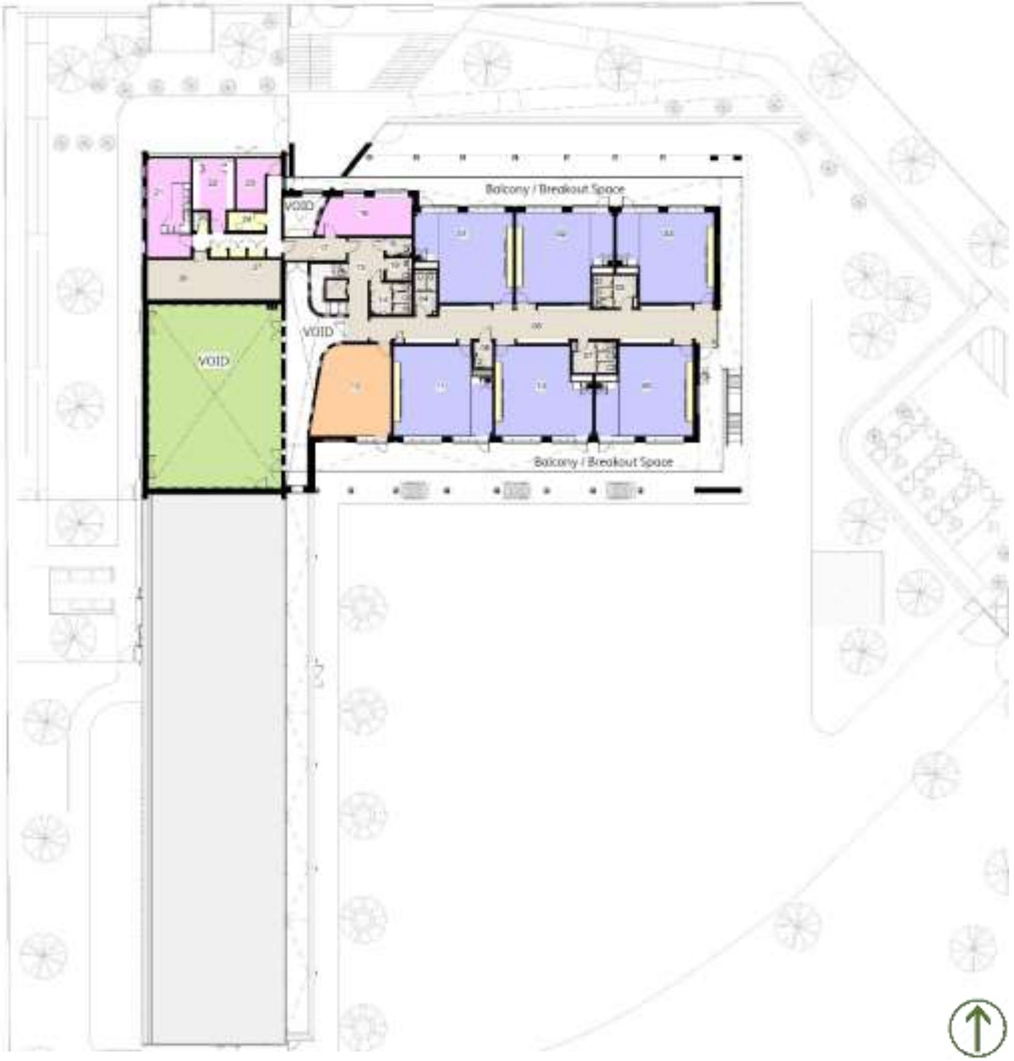
Introduction

Key Details:

- Cost: £7.5m
- Passivhaus: 4.3%of Cost
- Cross-Laminated Timber: 5.7%of Extra Over Cost
- Works to the Existing Building: 2% of Cost
- Landscape and External Works: 13.8% of Cost
- Gross Internal Area: 2,440m^2
- 2FE Expansion: 450 additional Students
- Completion Date: September 2021
- Traditional Form of Contract

Layout

Ground Floor Plan



First Floor Plan

Glazing Proportions

Concept Design - Northern Elevation

Developed Design - Northern Elevation

Notes:

1. Lift sill height to reduce:
   - Extend of glazing
   - Thermal bridging at ground level
   - Overheating risk
   - Reduce cost
2. Where possible increase frame to glazing ratio to improve the units u-value
3. Reduce the number of doors where possible as these are poor preforming elements
4. Minimise north facing glazing where possible

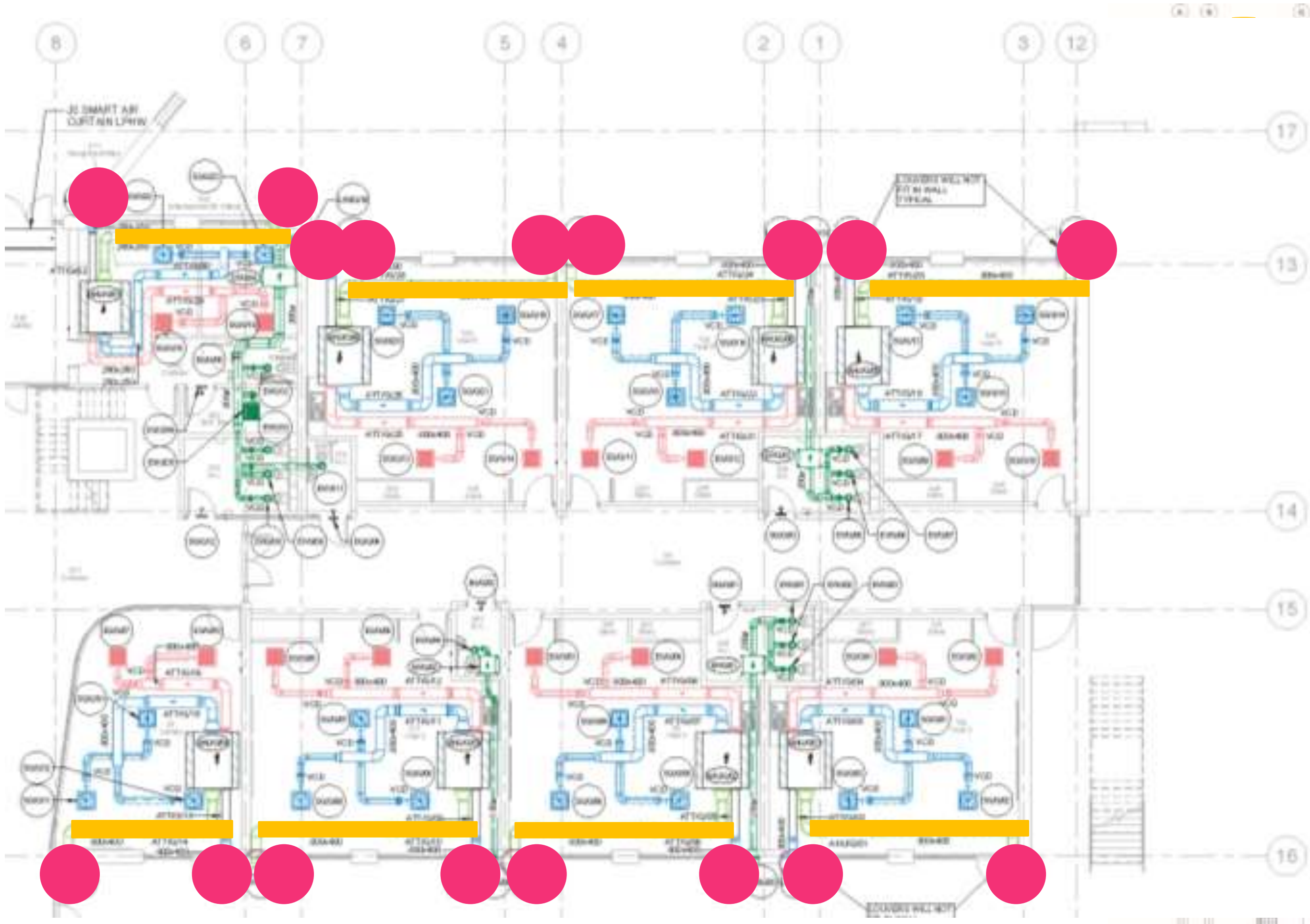
Airtightness

Airtightness Strategy Section

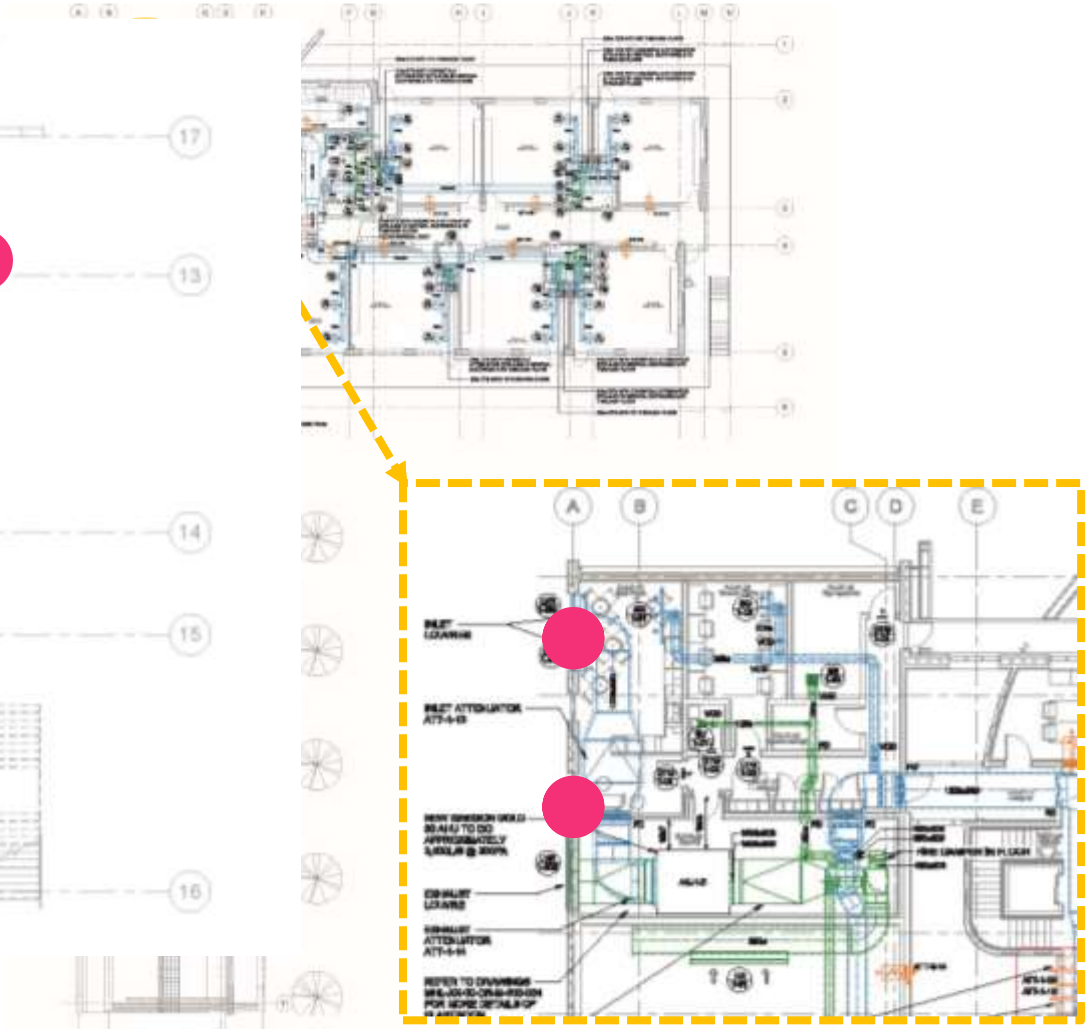
Airtightness Line

Weather Proofing Line

Ventilation Design – Selected Solution

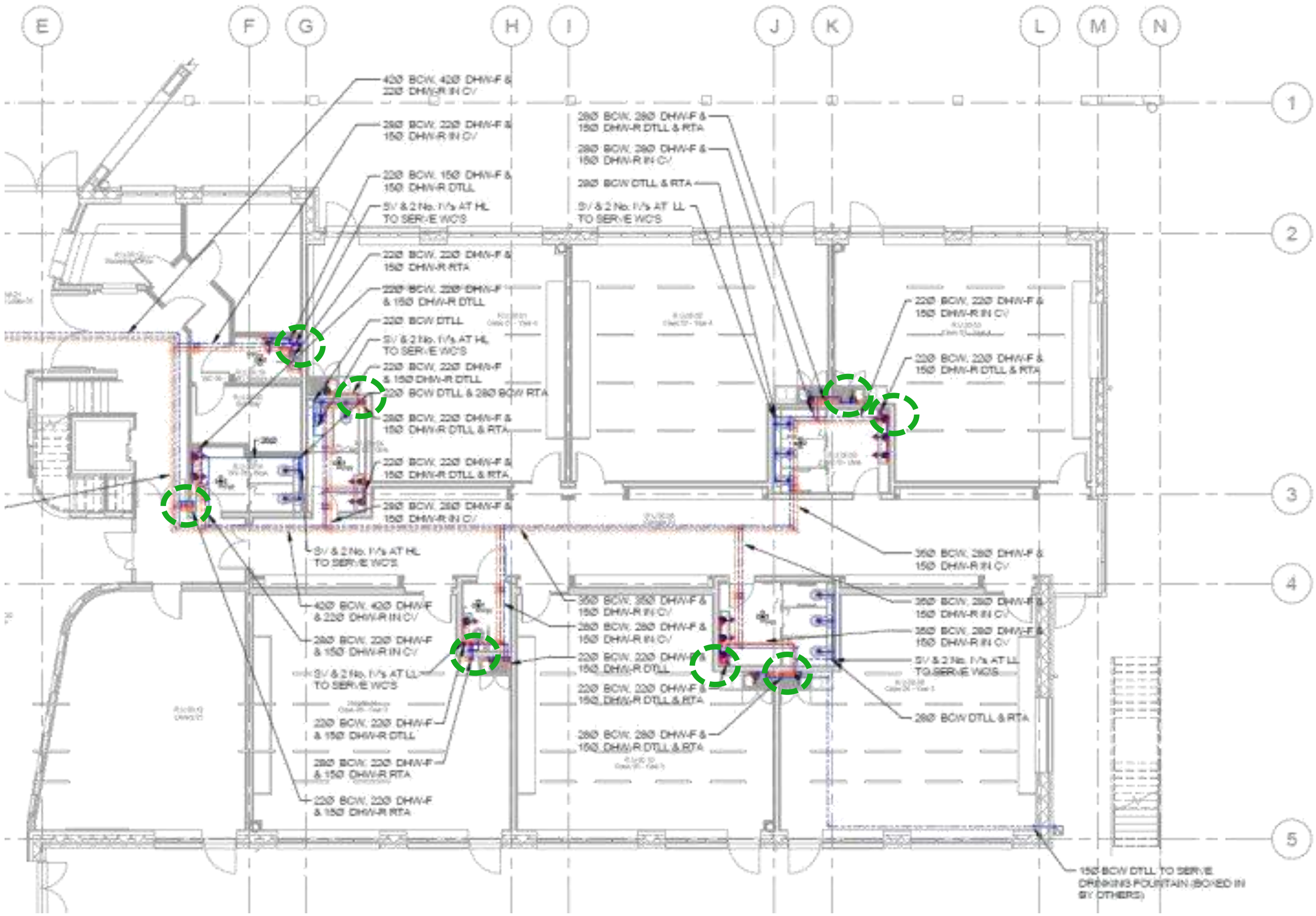


Ground Floor Ventilation Plan & 3D View



First Floor Ventilation Plan

Services Distribution

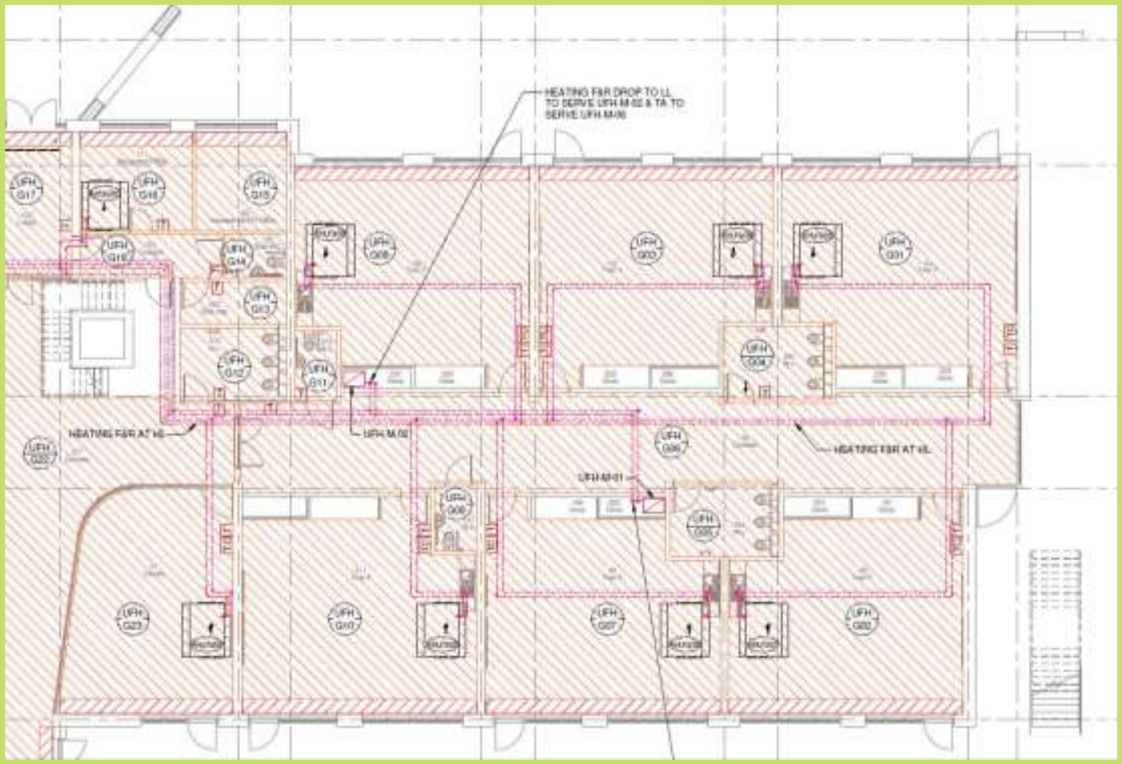


Callout of Ground Floor – DHW Distribution

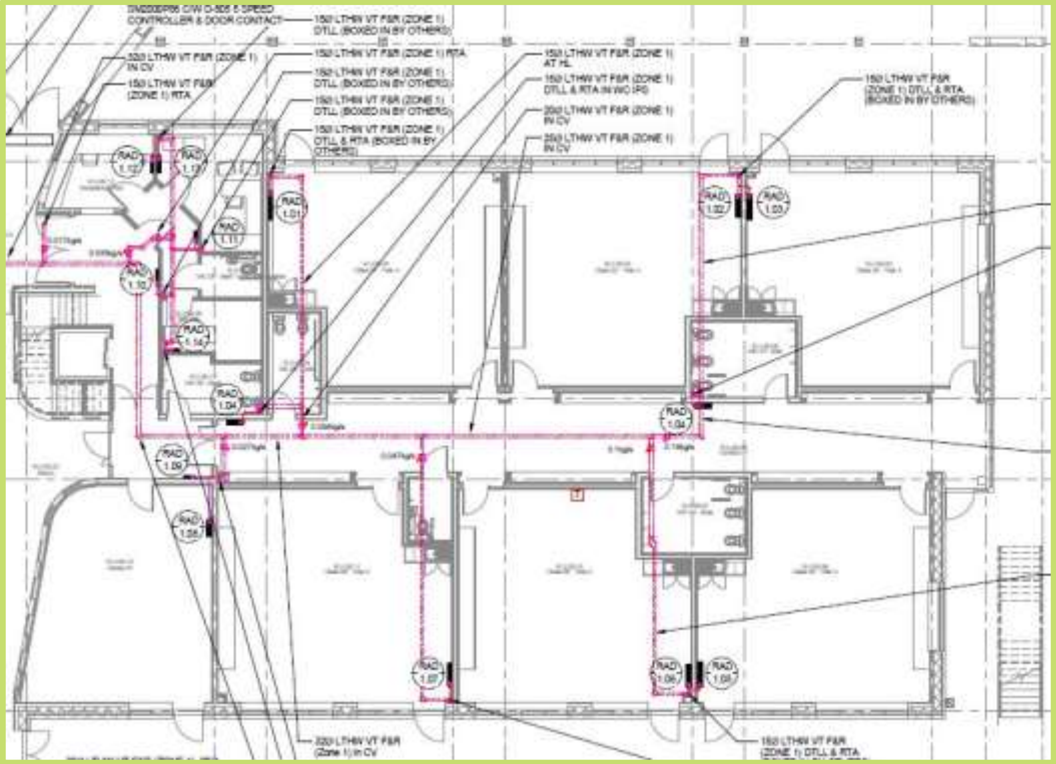
Notes:

- Both hot and cold water pipe work requires approx. 2.5 to 3 times the pipe diameter of insulation.
- Resulting in the typical 15mm diameter pipework drops increasing to 90mm
- Requiring significantly more coordination by the design team.

Heat Strategy



Ground Floor – Initial UFH Option



Ground Floor – Selected Radiator Scheme

- Significant amount of additional equipment
- Increased costs
- Increased risk of overheating

- Only one small radiator required within each room.
- Reduced construction cost
- Reduced overheating risk

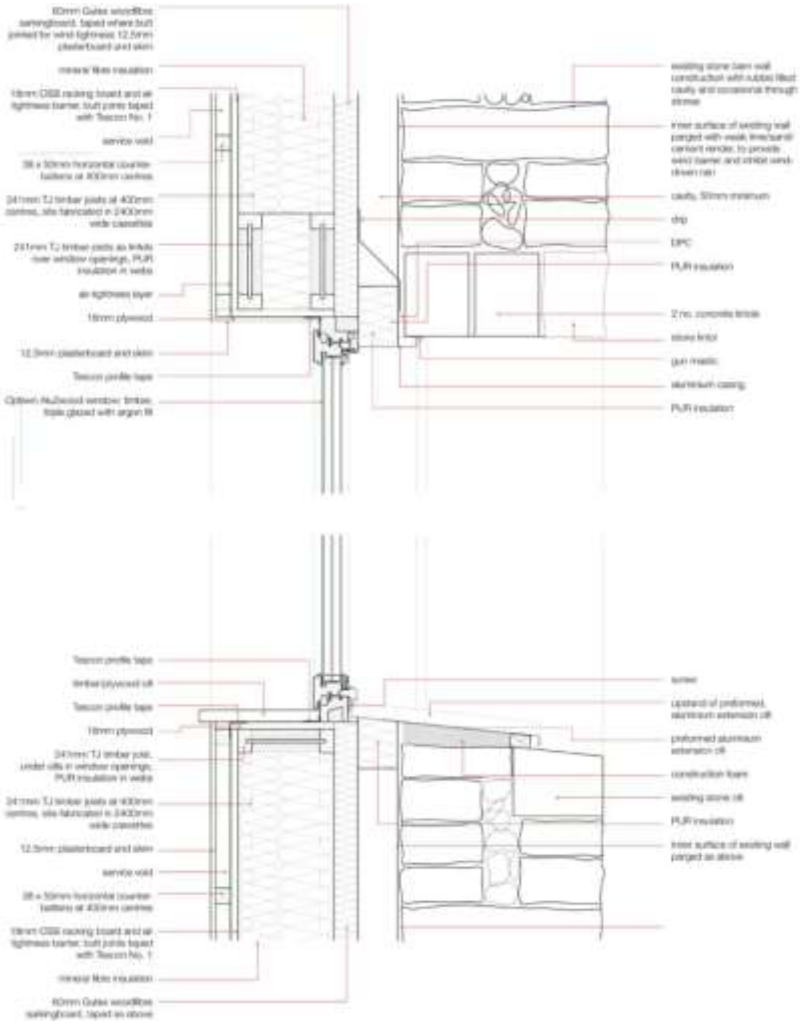
Achieving EnerPHit in Historic Properties

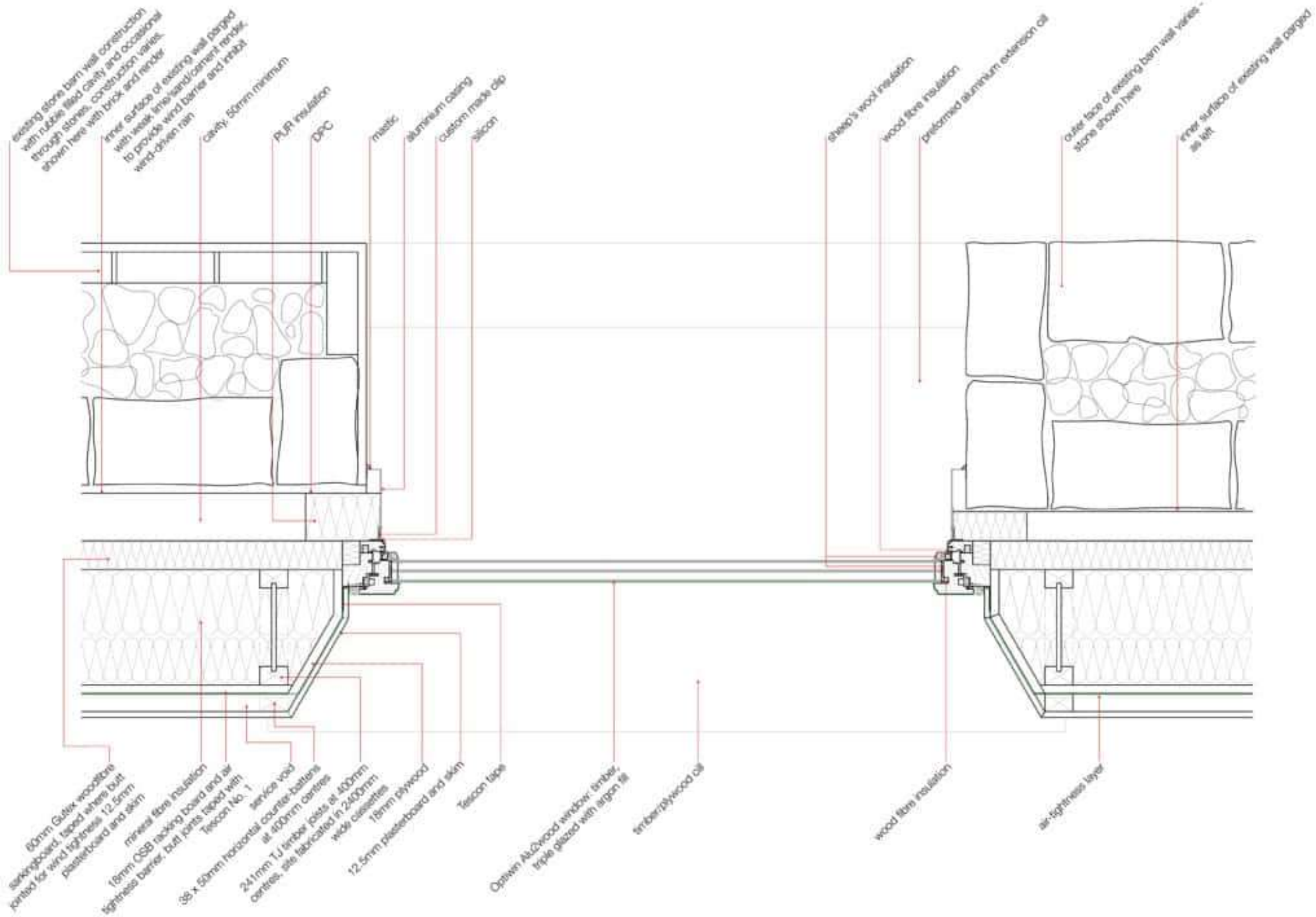
Cre8 Barn, Huddersfield

Images: Green Building Store

ECD ARCHITECTS

Cre8 Barn, Huddersfield





Images: Green Building Store

ECD Architects
ENERGY CONSCIOUS DESIGN

Retrofit

Achieving EnerPhit at Scale

Thank you

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T: 0141 204 7855 www.ecda.co.uk