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Practical Retrofit | In difficult Buildings



Why?

We are in both a climate and a cost of living crisis.

Our aim as a company is to reduce the environmental impact of the built environment radically and responsibly for the benefit of both the building occupants and society as a whole.

How?

We combine Building Physics and Engineering to reduce the operational energy demand of buildings

What?

- Tools and services do we use and provide to do this:

- Passivhaus Design
- Dynamic Thermal Modelling
- Mechanical and Electrical Services Design
- Moisture Risk Analysis
- 2D & 3D Thermal Bridging

Design Principles – Physics First

Designing using Physics First principles results in buildings that:

- Are comfortable to be in

- Are good for your health

- Lowered Energy Demand

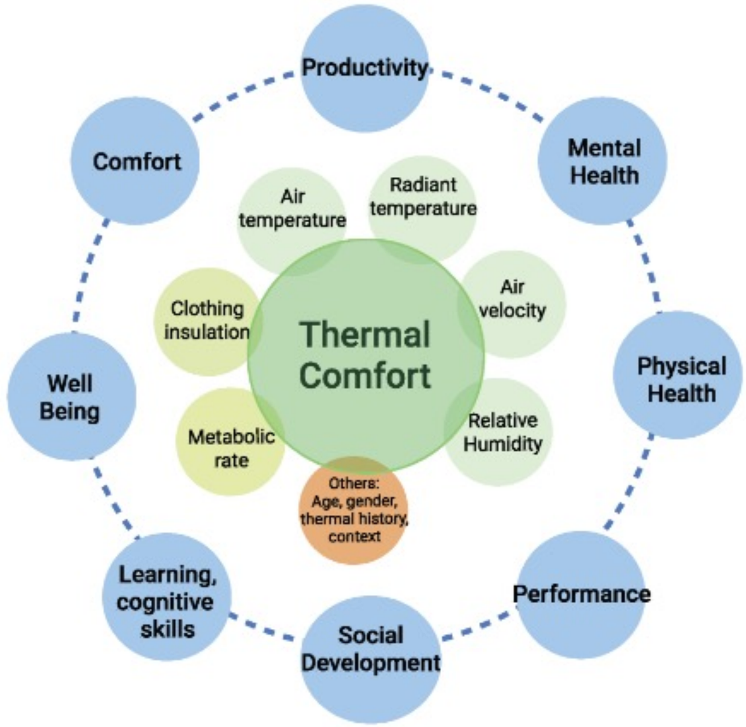


Diagram indicating the factors impacting thermal comfort (inner circle) and those which are impacted by thermal comfort (outer blue circle). Source: ala, B.; Hagishima, A. A Review of Thermal Comfort in Primary Schools and Future Challenges in Machine Learning Based Prediction for Children. Buildings 2022, 12, 2007.

Design Principles – Physics First

Reducing Energy Demand

- Form Factor
- Insulation
- Air Tightness
- Thermal Bridging
- Balanced Ventilation
- Windows

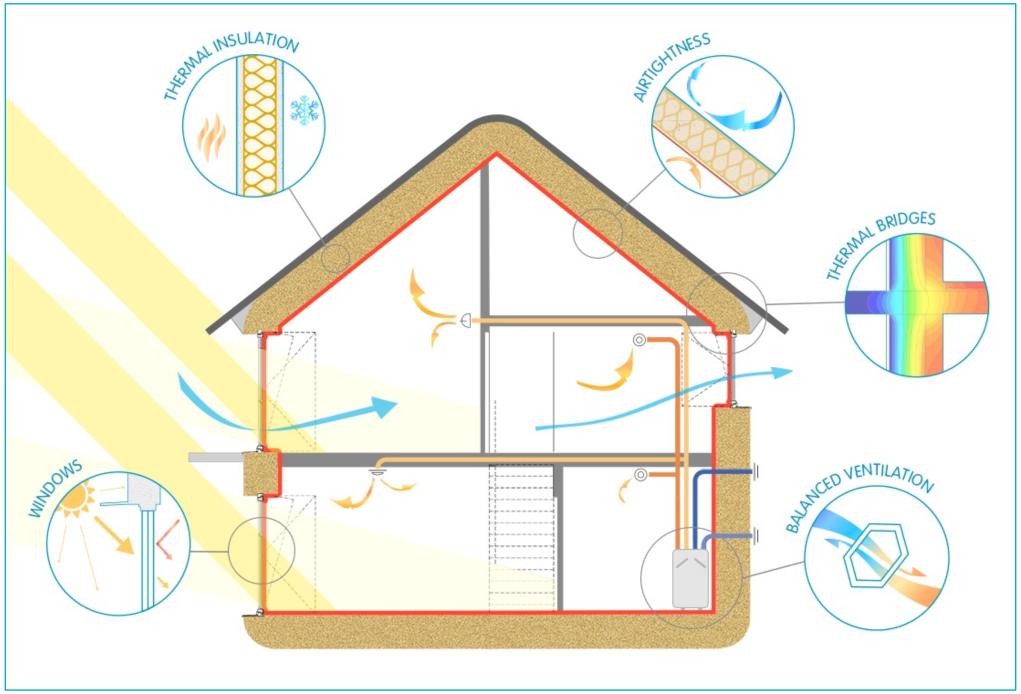


Image – Passivhaus Trust - https://www.passivhaustrust.org.uk/

Design Principles – Physics First

Compromises will be needed in a Heritage or Retrofit project

The skill is balancing the decisions:

- Conservation
- Building Safety/Robustness of design
- Energy performance
- Cost
- Aesthetic

Hop Pole Inn

-Inn dating back to the 16th Century

-Grade II Listed Building

-Looking to be brought back into use and into the 21st Century

-Respect the existing fabric and historic significance

-Aim to improve building fabric and therefore performance

Hop Pole Inn

-Establishing the existing building

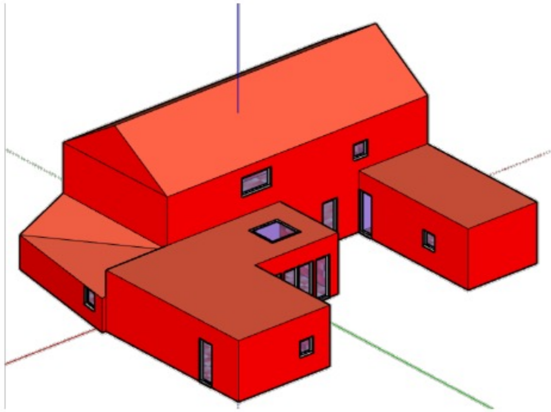
-Data gathering

- -Fuel bills?
- -Condition survey
- -Air tightness!!
- -Construction
- -Heritage assets

Design Process - Modelling

-Created a Model using Design PH & Passivhaus Planning Package (PHPP)

-Geolocate the building and input values for the different variables within the building



	Type	Form Factor	Efficiency
	End mid-floor apartment	0.8	Most efficient
	Mid-terrace house	1.7	
	Semi-detached house	2.1	
	Detached house	2.5	
	Bungalow	3.0	Least efficient

Hop Pole

Form factors for various building types. Courtesy of the NHBC foundation.

Design Process - Modelling

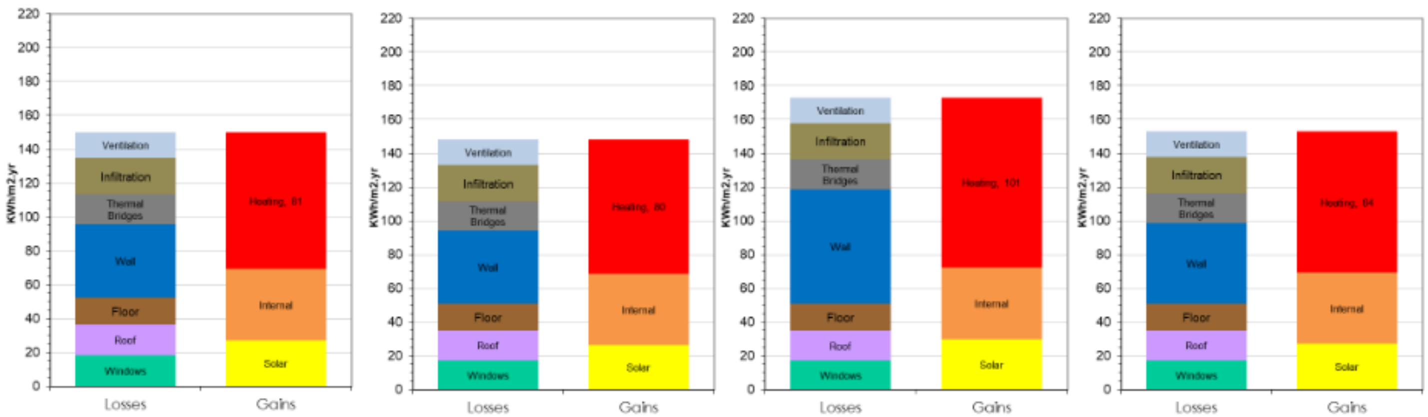
- Model calculates the predicted annual energy consumption of the building considering the climate in the surrounding area

- Breakdown of energy consumption associated with each element of the building

- Recommendations made on how we can optimise the building fabric to improve thermal comfort & energy consumption

Criteria	EnerPHit Component Method	C1 – Single Secondary Glazing	C2 – double secondary glazing	C3 – double secondary glazing and wet uninsulated west wall	C4 – double secondary glazing and wet insulated west wall
Opaque envelope U-value W/(m².K)	0.3	0.18	0.18	0.37	0.24
Opaque envelope U-value for IWI W/(m².K)	0.5	0.48	0.48	0.48	0.48
Window U-value W/(m².K)	1.05	1.37	1.26	1.26	1.26
Glazing g-value -	Ug - g*3.2 ≤ -0.6	0.64	0.56	0.56	0.56
Ventilation heat recovery %	75	81	81	81	81
Airtightness ACH at 50Pa	1.0	4.3	4.3	4.3	4.3
Space Heating Demand kWh/m².yr	-	81	80	101	84
Heating Load W/m²	-	35	35	41	36

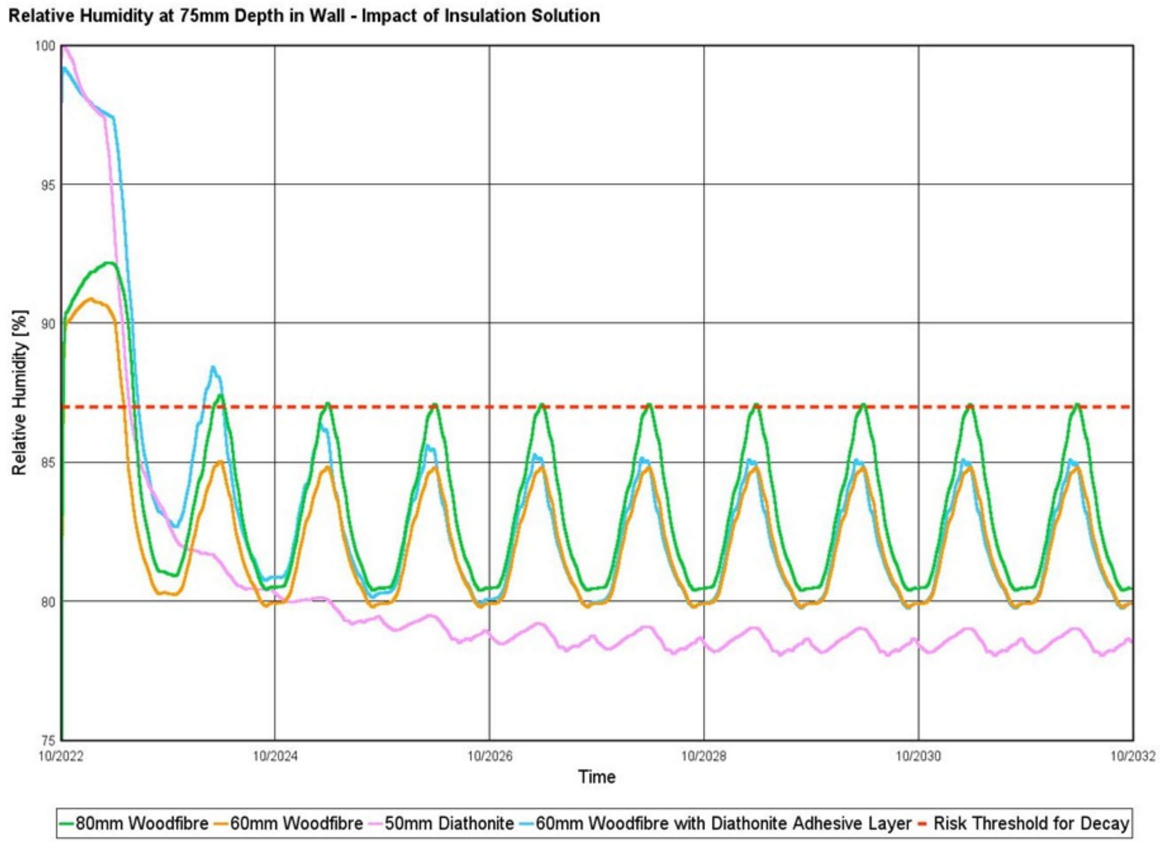
EnerPHit criteria and model results



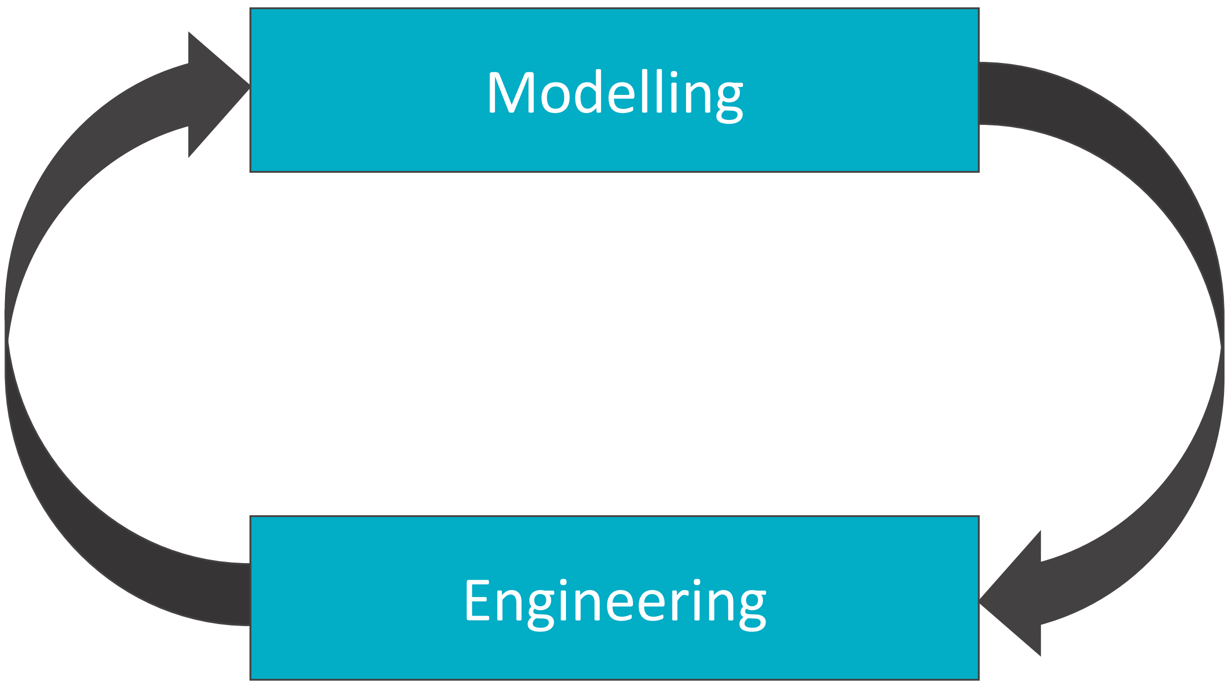
Heat Chart of heat gains and losses for the building diagram for C1 (left), C2 (mid-left), C3 (mid-right) and C4 (right)

Design Process - Risks

- Retrofit is complex
- Changing the buildings internal conditions has impacts on moisture
- We can complete a risk assessment model – Hygrothermal Risk Assessment
- We decided to model the various wall constructions
- Allows for risk optimisation



Design Process



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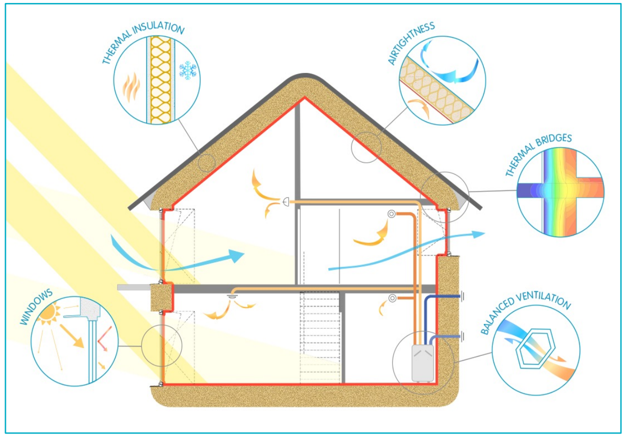
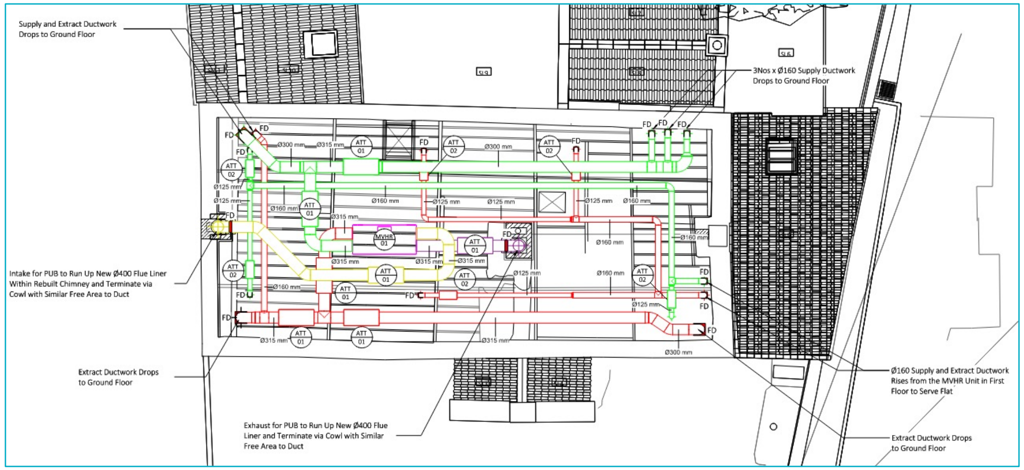
Design Considerations

Meeting with the client/architect to assess the project

- High Occupancy
- High Energy Density
- Domestic Space Upstairs
- Commercial Kitchen
- 2 Buildings in one with different needs
- 2 Different sets of equipment
- Metering
- Identify Critical Elements





All whilst retaining historic character of the building

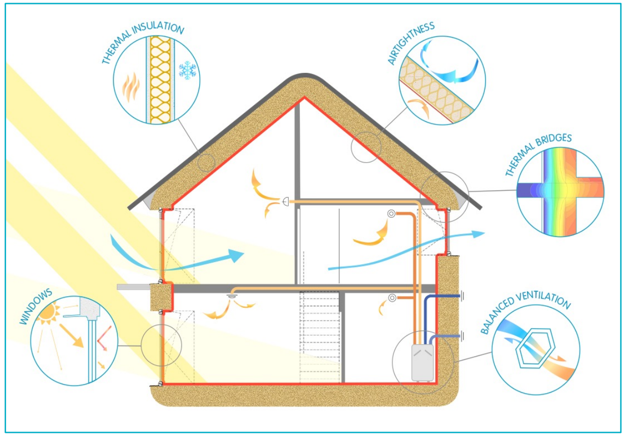
Ventilation

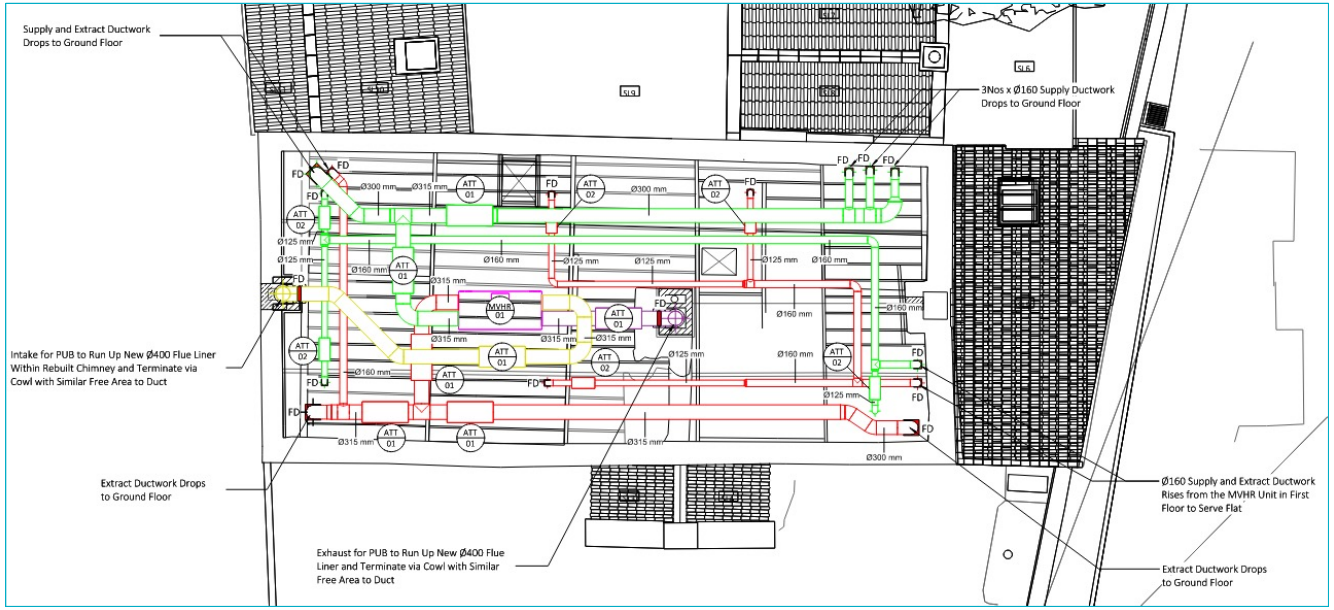
- Hygrothermal Risk Analysis is based on managing the internal environment

- Ventilation and managing humidity is critical to this

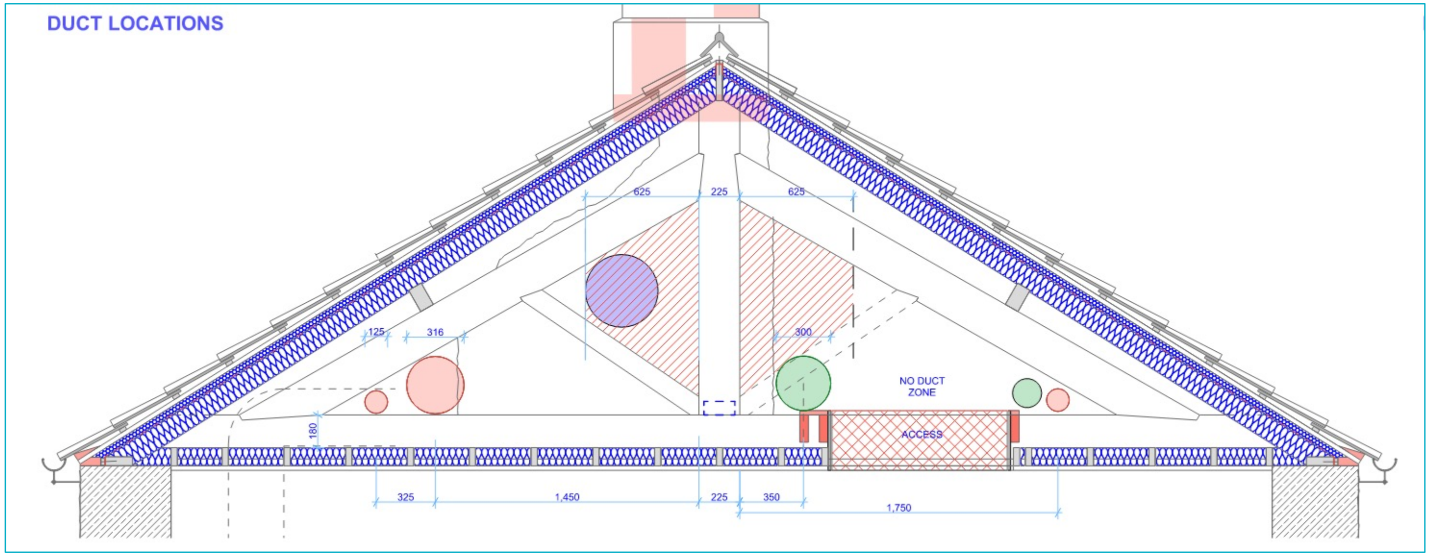
- Ventilation with heat recovery ensures good fresh air and balanced supply and extract

- Energy Savings are a bonus





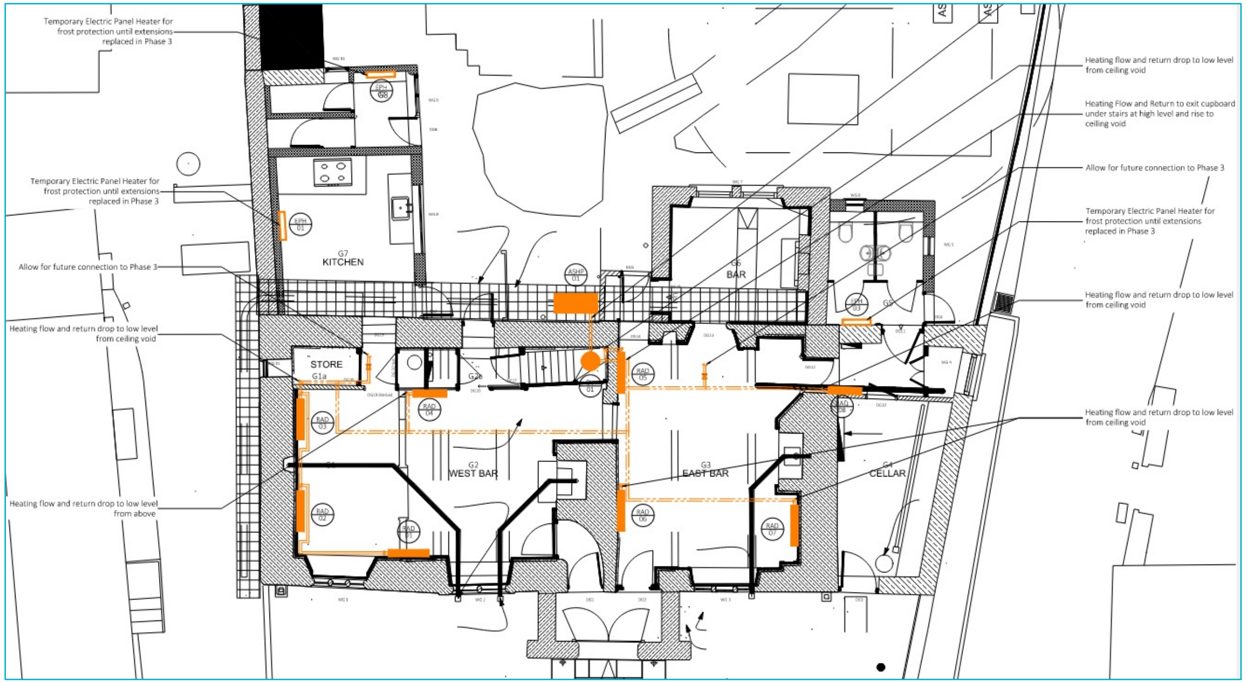
Ventilation



Heating

Considerations:

- Routing
- Cost
- Historical Significance
- Aesthetics
- Load Sizing
- Noise
- Design Temperature



Heat Pumps - Mythbusting

Myth 1 – You can’t heat old buildings with heat pumps

Myth 2 – Heat Pumps don’t work in Winter

Myth 3 – You need to upgrade all your radiators and pipework to get a Heat Pump to work

Myth 4 – Heat Pumps can’t provide Hot Water

Myth 5 – Heat Pumps are noisy

Heat pumps or insulation?

Supply Decarbonisation

"The fastest and cheapest way to cut carbon emissions to find clean means of heating"

Demand reduction

"We should dramatically reduce our energy demand, so the impact of heating is less, and it is easy to swap for low carbon sources."

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Valid challenges to the Fabric First approach

- Heat pump improving faster than fabric
- High profile fabric failures
- Flexible/intelligent tariffs
- Low-cost measurement techniques
- The challenges in Heritage buildings
    - Preservation of historic features
    - Thermal bridging
    - Moisture risk

But ...

- What about services?

- What about thermal comfort,

- What about health

- What about fuel poverty/ running costs?

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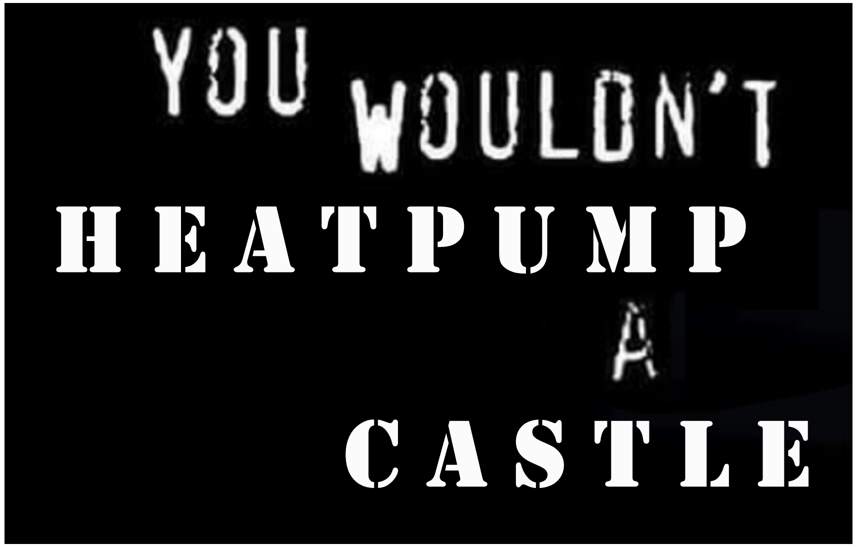
Myths and Realities

- If it's electrified, it's more or less decarbonised – but that doesn't mean it will be cheap
- Don't forget the impact of infrastructure
- Heat Pumps can work efficiently in heritage buildings, if they can run at low supply temperatures
- That means large emitters… which could be a detriment
- Is it OK to run cold?



Accommodating competing values

What is “Optimal”?

Intangibles

- Heritage
- Comfort
- Resilience
- Biodiversity
- Health

What can professionals in heritage do?

- Understand baseline performance
- What are the implications of doing nothing?
- Bold but Appropriate intervention
    - Fabric
    - Technology
- Control risk

Case Study 1: Fabric First

An ‘urban barn’ to Enerphit Youth Hostel (2015)

170mm of IWI (woodfibre)

Gas fired water heater; small space heat demand taken from large DHW cylinder

~75% demand reduction compared to an uninsulated scenario

Case Study 2: Heat pumps in a heritage asset

Large Tudor House

Client preference and heritage constraints on fabric improvements

Existing system monitored to accurately quantify output

Lower temperature experiment

Targeted upgrades to heat emitters, minimal disruption to historic fabric

GSHP's installed

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Case study 3: An integrated approach

Demonstrated that careful fabric measures can meaningfully reduce demand without endangering heritage fabric

Allowed the design of efficient, modest AHSP within UNESCO world heritage site

Recognised by BANES and Bath Preservation trust as best practise