Assessing the energy efficiency & embodied energy of insulation materials in the UK housing stock

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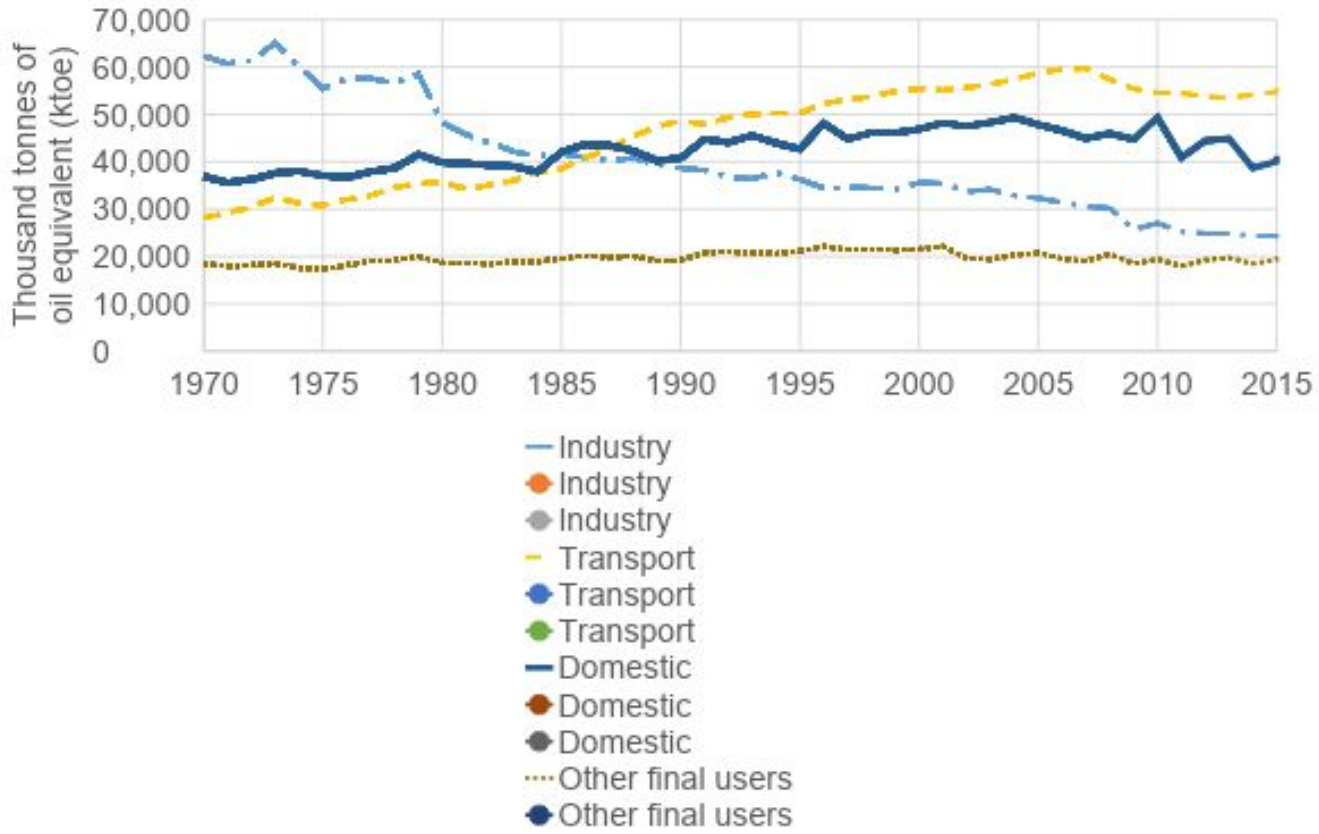
The UK housing energy usage



- Energy consumption by sector in the UK.
- Adapted from: (DBEIS, 2017)

The UK Dwelling stock: Age

- 80% of the current UK housing stock were built before 1980 (DBEIS, 2017).
- Thus, they have poor energy performance.

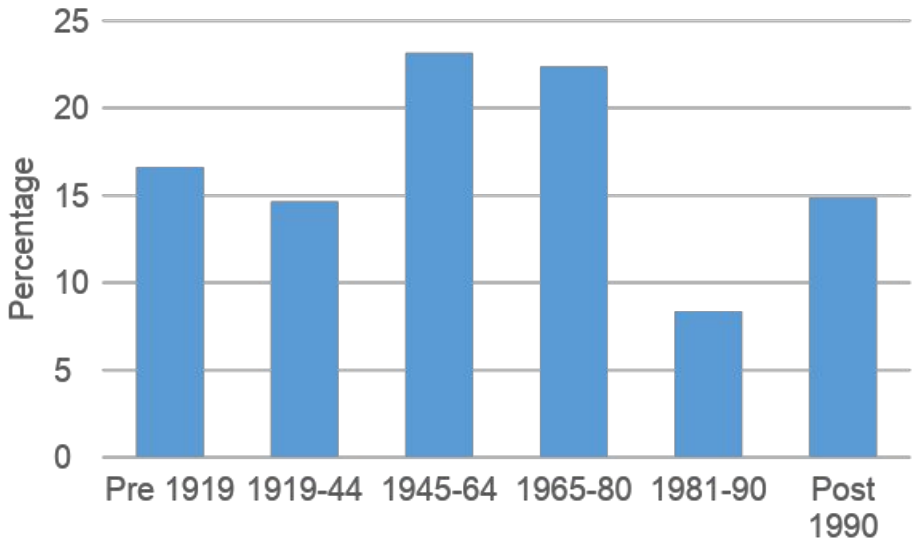
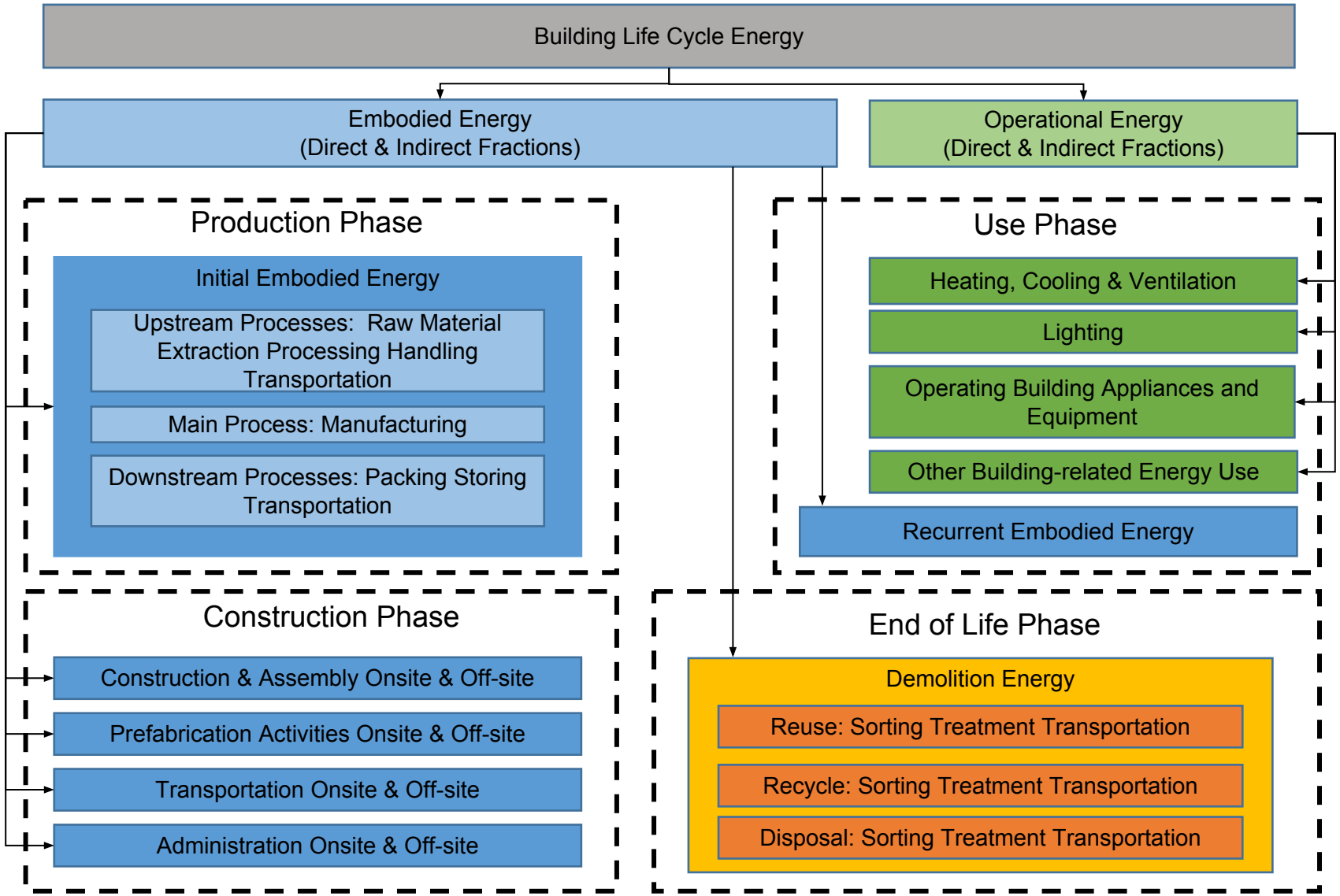


Figure: Date of construction of existing housing stock in UK
Adapted from: (DBEIS, 2017)

Building Life Cycle Energy



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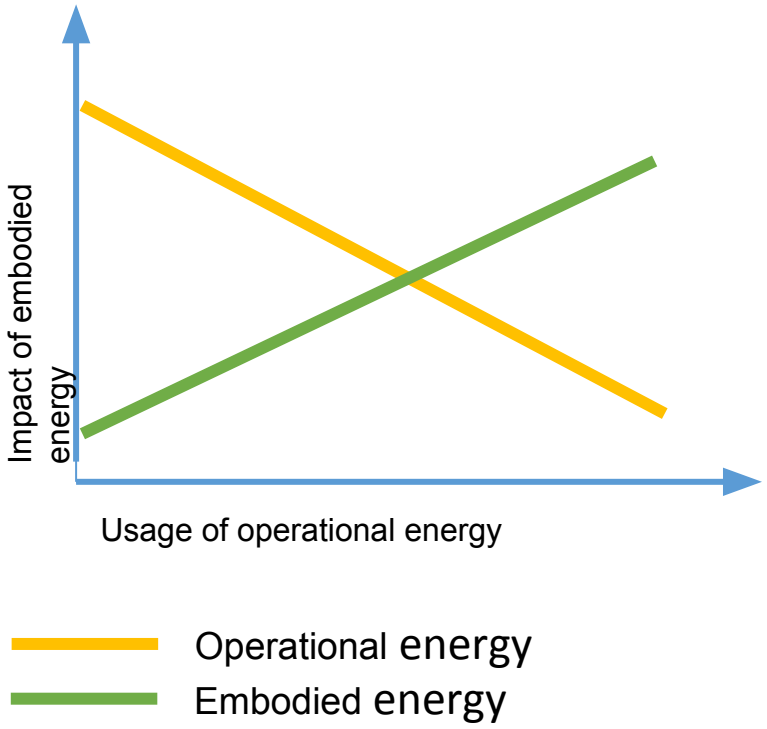
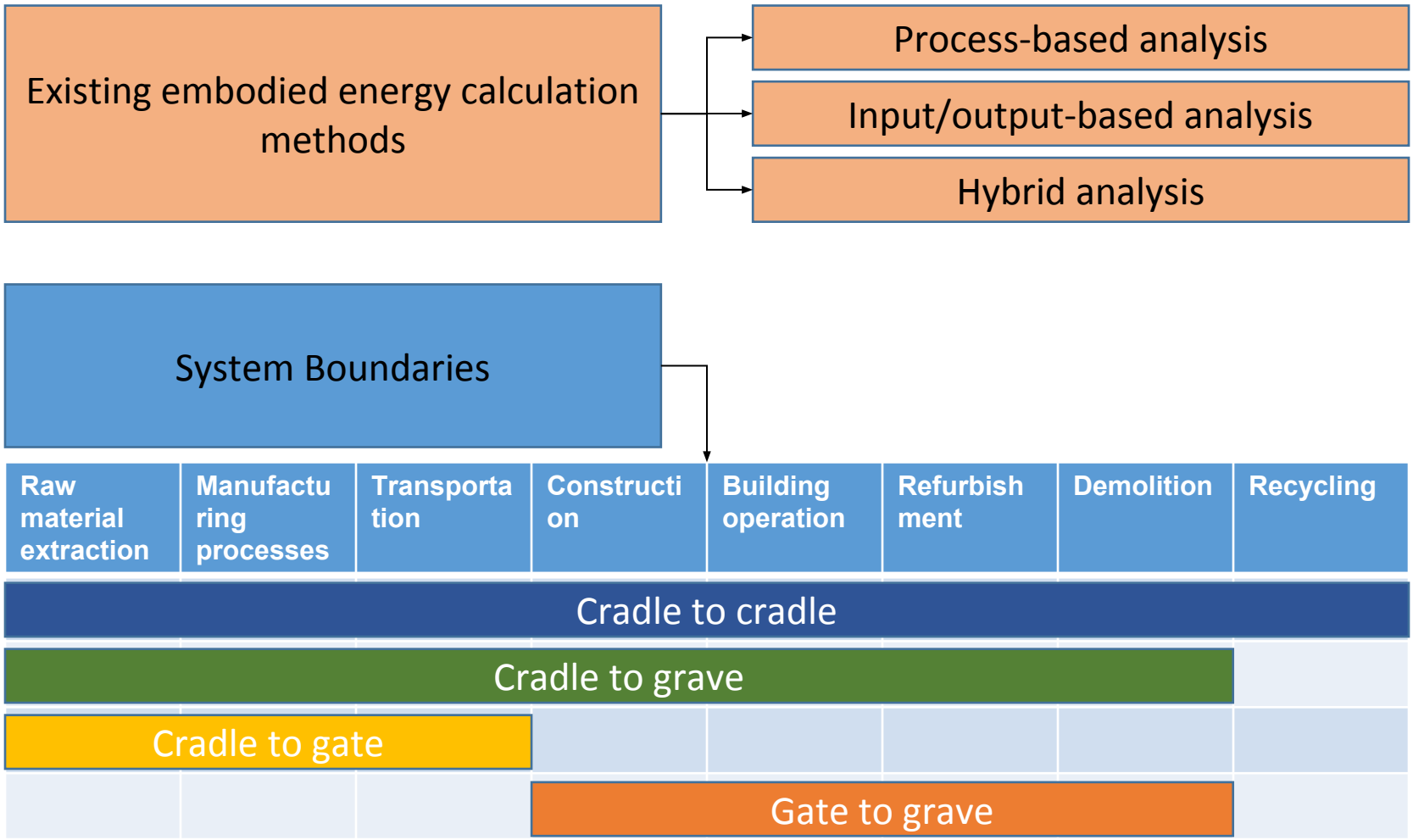
Importance of embodied energy

The impact of embodied energy depends on the usage of operational energy. As in recent time, the operational energy has been reduced in dwellings the relative impact of embodied energy has increased.



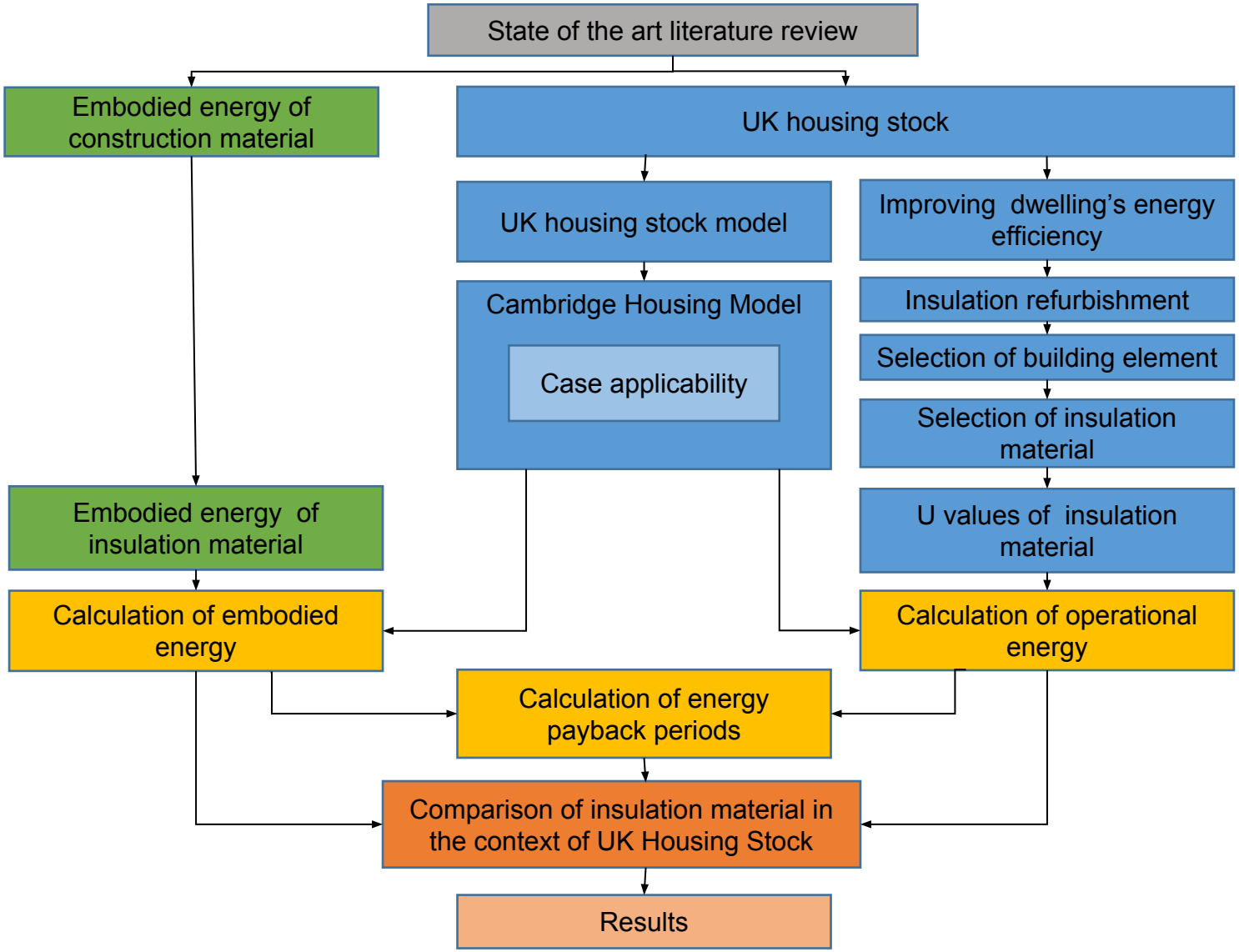
Existing calculation methods of embodied energy



Aim of the research

The aim of this research is to evaluate insulation refurbishment options in terms of operational and embodied energy to provide a comprehensive understanding of the energy efficiency in the context of the UK housing stock.

Method


State of the art literature review
Embodied energy of construction material
UK housing stock
UK housing stock model
Improving dwelling's energy efficiency
Cambridge Housing Model
Case applicability
Insulation refurbishment
Selection of building element
Selection of insulation material
Embodied energy of insulation material
U values of insulation material
Calculation of embodied energy
Calculation of operational energy
Calculation of energy payback periods
Comparison of insulation material in the context of UK Housing Stock
Results

Selected Insulation materials

Building element	Insulation materials			
External walls	Cellular glass			
Internal walls	Cellular glass			
Cavity walls	EPS	Mineralwool	Rockwool	
Cold pitched roofs	Cellulose	Sheepwool	Mineralwool	Rockwool
Warm pitched roofs	EPS	Rigid Polyurethane	Cellular glass	
Flat roofs	Cellular glass			

Properties:	Rigidity	Water Permeable	Combustable	Vermin Proof
Insulation Types				
Mineralwool	Yes, with resin	Yes	No, Treated	Yes, Treated
Rockwool	Yes, with resin	Yes	No, Treated	Yes, Treated
EPS	Yes	No	No	Yes
Rigid Polyurethane	Yes	No	No	Yes
Cellular Glass	Yes	No	No	Yes
Cellulose	Yes	No, Treated	Yes, Treated	
Sheepwool	No	Yes	No, Treated	Yes, Treated

Calculation steps: Embodied energy

Selection of applicable cases from CH|M model

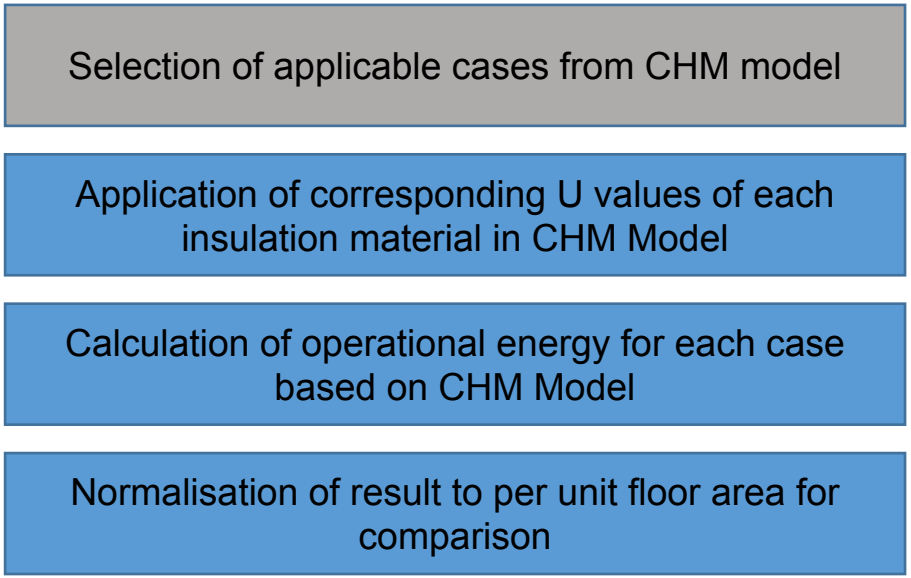
Calculation of required mass of each insulation material for each case

Calculation of embodied energy and CO2 emission for each case by using property data from the table below

Normalisation of result to per unit floor area for comparison

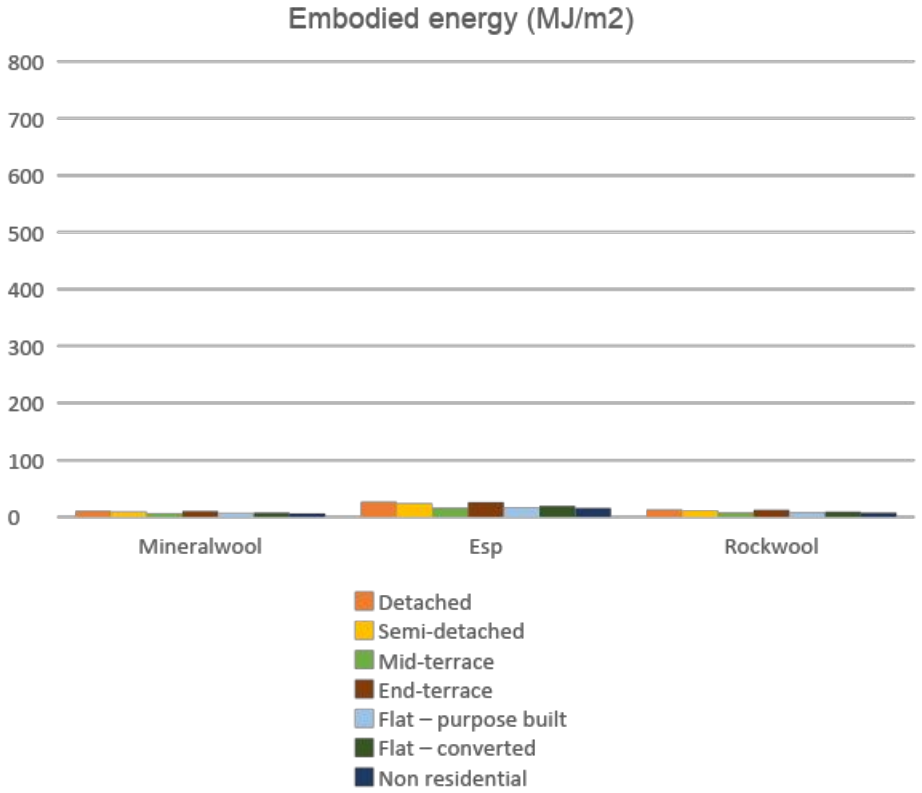
Properties:	Density	Embodied Energy	Embodied Carbon	Thermal Conductivity
Insulation Types				
Mineralwool	25	16.6	1.28	0.034
Rockwool	30	16.8	1.12	0.039
EPS	12	88.6	3.29	0.039
Rigid Polyurethane	24	101.5	4.26	0.023
Cellular Glass	120	27		0.043
Cellulose	40	3.3		0.04
Sheepwool	22	2.45		0.039

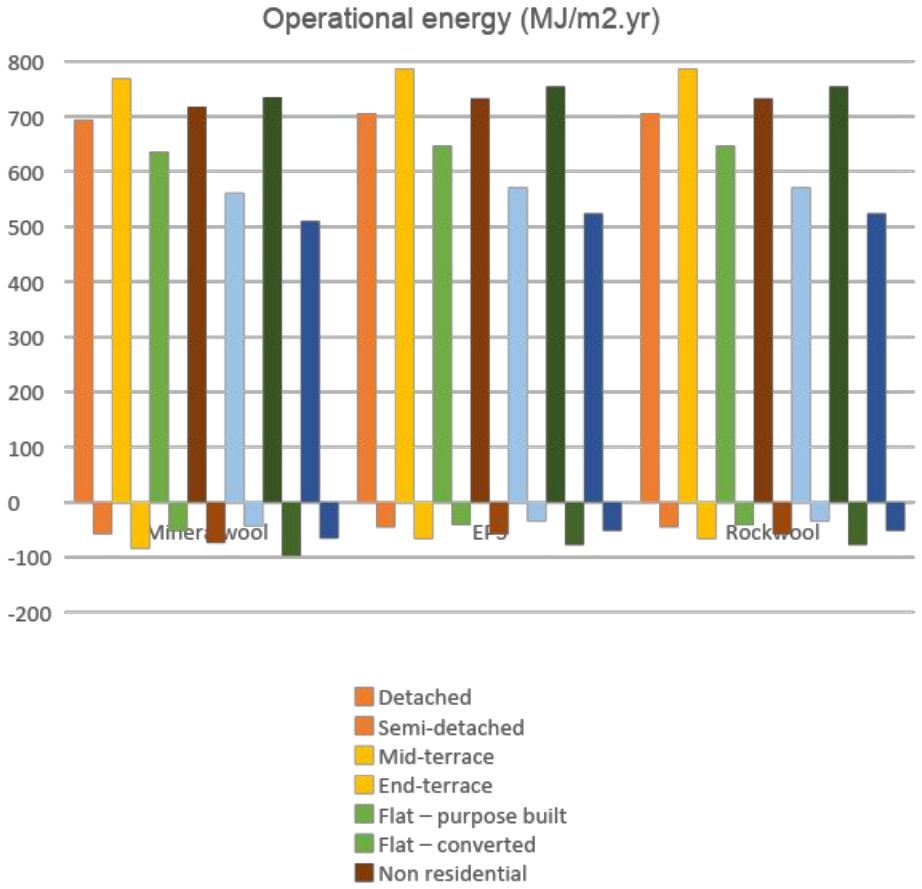
Calculation steps: Operational energy



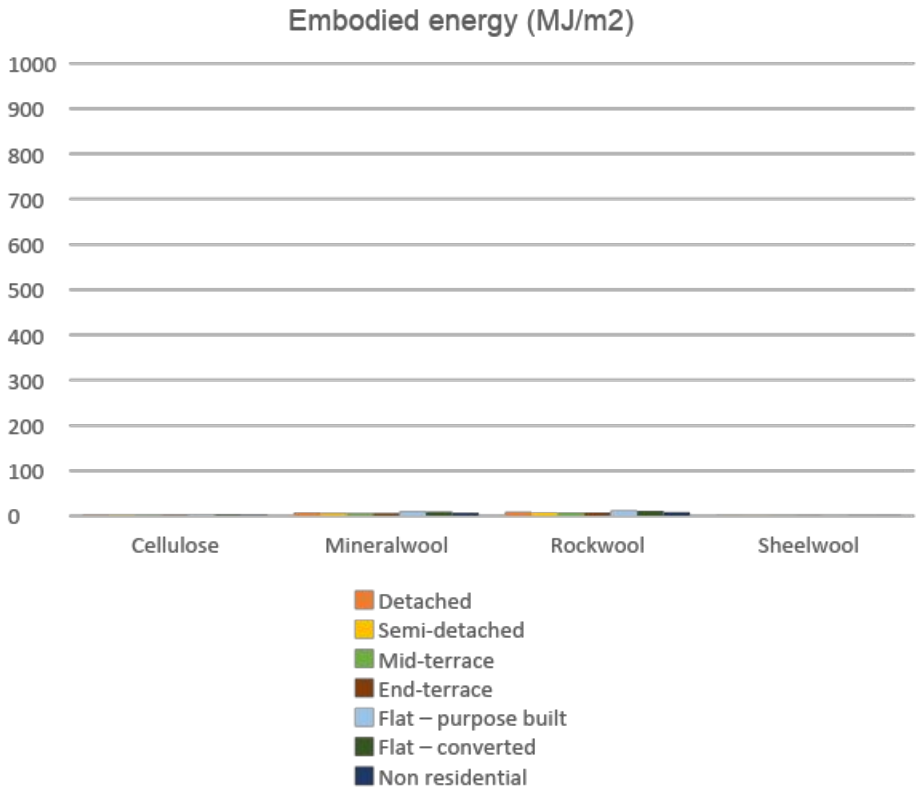
- For the cavity wall refurbishments the U Values in Standard Assessment Procedure (SAP) table S6 were used.
- For internal and external wall refurbishments the U Values in SAP table S3 were used.
- For cold, pitched roof refurbishments the U Values in SAP tables S9 S10 were used.
- For warm, pitched roof refurbishments the U Values in SAP tables S9 and S10 were used.
- For flat roof refurbishments the U Values in SAP table S10 were used.

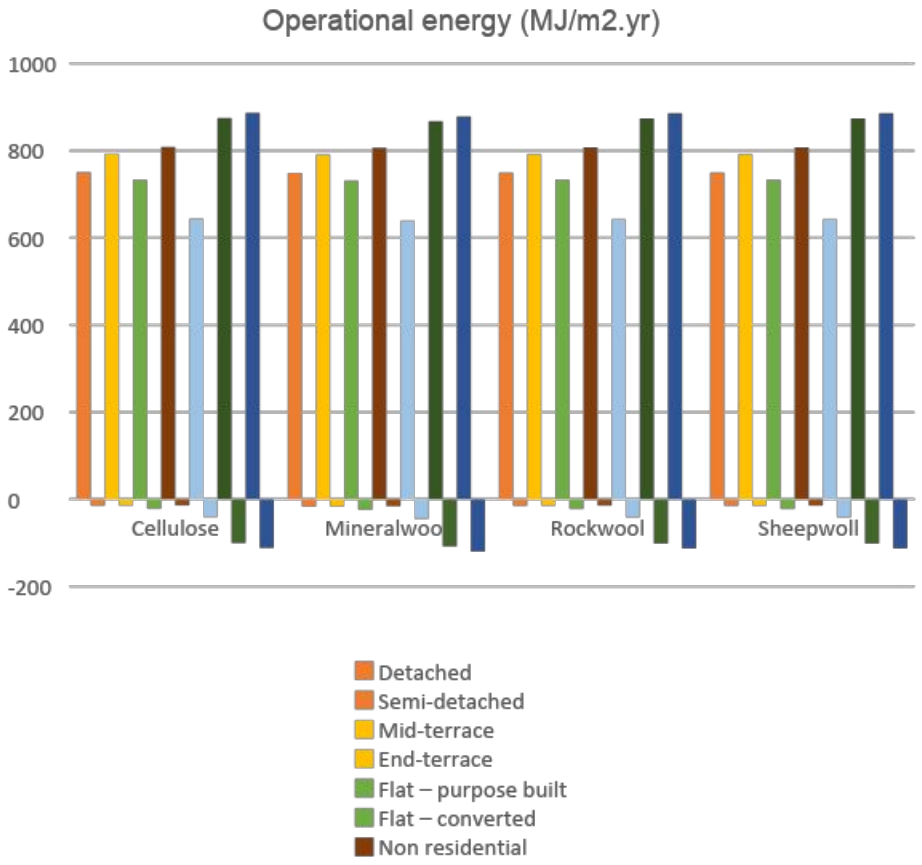
Results: Cavity wall insulants



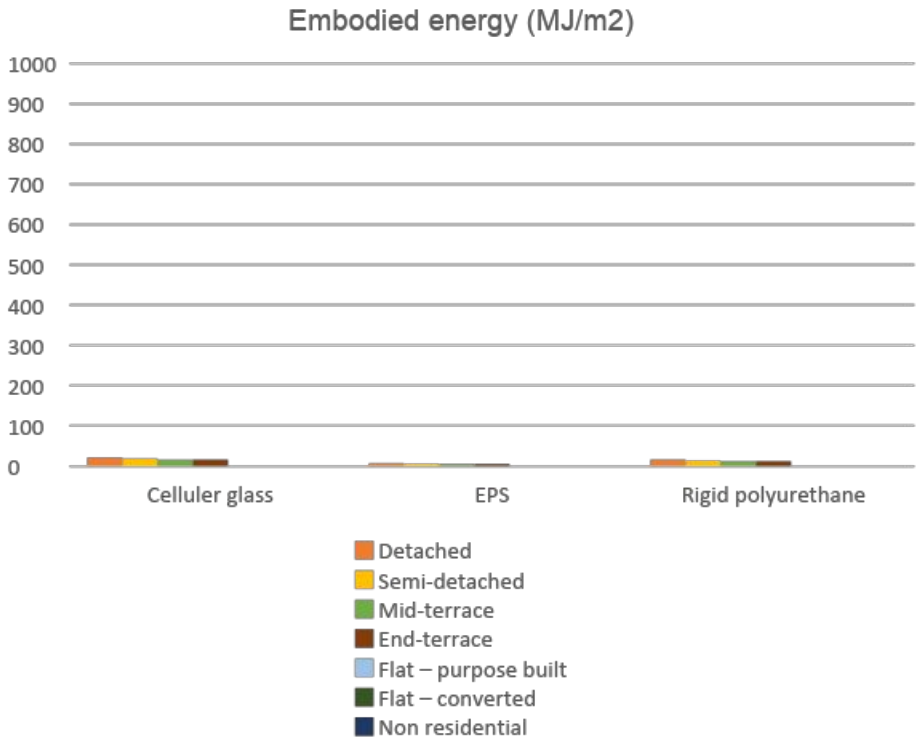


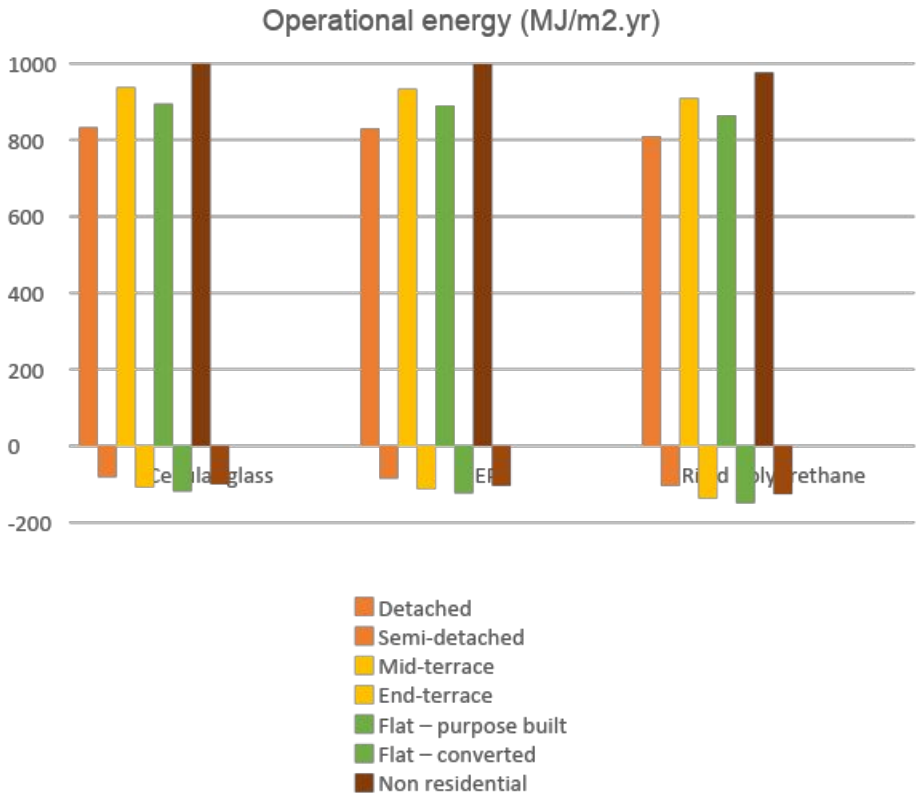
Results: Cold pitched roof insulants





Results: Warm pitched roof insulants





Thank You