RICKABY THOMPSON ASSOCIATES
ARCHITECTS + ENERGY CONSULTANTS

Low Carbon Retrofit: Getting the Specification Right

Peter Rickaby

www.rickabythompson.com
Supporting Sustainable Design and Construction

Low carbon retrofit

Low carbon retrofit

- What is an appropriate standard?
- What package of measures will meet it?
- How much is it likely to cost?

Key specification issues

- Solid wall insulation
- Ground floors
- Air-tightness and ventilation

Low Carbon Retrofit

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Constraints

- National objective
  - 80% reduction in CO_2 emissions by 2050
    - Social housing expected to lead the way
- *Retrofit for the Future* suggests
  - £85,000 for one-off 80% CO_2 emissions reduction
    - At *current* emissions factors
  - Possibly reduce to £50,000 by economies of scale?
- Financial modelling suggests
  - Maximum < £20,000 per dwelling
    - Combining Green Deal (PAYS) and ECO, plus FiT and RHI
    - At most favourable interest rates
    - Assuming 'Golden Rule' (retrofit financed by 100% of savings)

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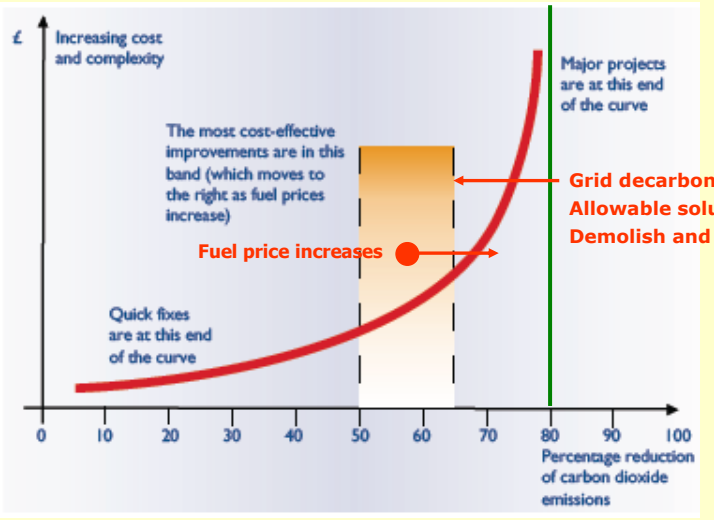
Cost and Complexity v Emissions



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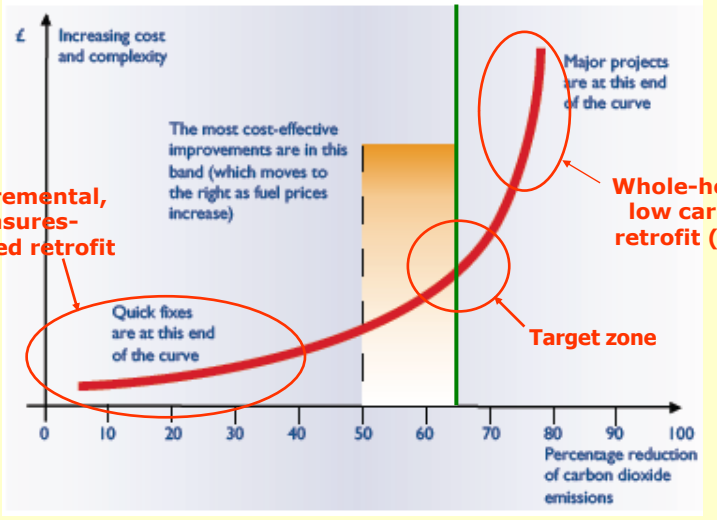
Cost and Complexity v Emissions



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What's not in the target zone?

- Unaffordable and unnecessary
  - *RFF* (PassivHaus) standard, e.g.
    - Wall and floor U values ≤ 0.15 W/m²K
    - Air permeability < 1 m³/m²h @ 50 Pa
    - Aerogel insulation board
    - Vacuum insulation
    - Exhaust air heat pumps
- Not good enough
  - Uncoordinated incremental measures, e.g.
    - Cavity fill (on its own)
    - Uninsulated solid walls
    - Inadequate ventilation
    - Over-reliance on fossil fuels

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What is in the target zone?

Three criteria for choosing improvement packages

Capital cost

Capital cost band	Symbol
Up to £100	£
£100 - £1000	££
£1000 - £5000	£££
£5000 - £10,000	££££
Over £10,000	£££££

Net cost (£)
(capital minus fuel saving)
divided by
Whole-life carbon dioxide emissions reduction (tonne)

Disruption

Disruption	Band	Examples
Minimal	🛠	Low energy lamps, energy efficient appliances
Low	🛠🛠	Heating controls, cavity wall insulation, draught-stripping, loft insulation
Moderate	🛠🛠🛠	Replacement boiler, solar water heating
High	🛠🛠🛠🛠	Replacement windows, whole house ventilation, external wall insulation
Significant	🛠🛠🛠🛠🛠	Ground floor insulation, internal wall insulation, new heating system

Carbon cost effectiveness

Carbon cost effectiveness	Symbol
Pays for itself	☺☺☺☺☺
0 – 10 £/tonne CO_2	☺☺☺☺
10 – 100 £/tonne CO_2	☺☺☺
100 – 500 £/tonne CO_2	☺☺
> 500 £/tonne CO_2	☺

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What is in the target zone?

UK average house

Capital cost, disruption and carbon cost effectiveness

Measure	Capital cost	Carbon cost effectiveness	Disruption
Floors			
Floor insulation	££	☺☺☺☺☺	✕✕✕✕✕
Walls			
Internal wall insulation	£££££	☺☺☺☺☺	✕✕✕✕✕
Cavity wall insulation	££	☺☺☺☺☺	✕✕
External wall insulation	£££/£	☺☺☺☺☺	✕✕✕
Roofs			
Loft insulation	££	☺☺☺☺☺	✕✕
Rafter insulation (only when reroofing)	£££	☺☺	✕✕✕
Windows and doors			
Replacement windows and doors (U value 1.8)	£££	☺☺	✕✕✕
Replacement windows and doors (U value 0.8)	£££££	☺☺	✕✕✕
Air tightness and ventilation			
Draught-stripping	£	☺☺☺☺☺	✕✕✕
Major air-tightness measures	££	☺☺☺☺☺	✕✕✕
Air-tightness measures with MVHR	£££	☺☺	✕✕✕✕
Lighting and appliances			
Low energy lights	£	☺☺☺☺☺	✕
Low energy appliances (marginal cost of replacement)	£££	☺☺	✕
Heating			
Replacement gas boiler	£££	☺☺	✕✕✕
Upgrading heating controls	££	☺☺☺	✕✕
Micro CHP	££££	☺	✕✕✕
Ground source heat pump	£££££	☺	✕✕✕✕
Air source heat pump	££££	☺	✕✕✕✕
Wood pellet boiler	££££	☺☺	✕✕✕✕
Renewable energy systems			
Solar hot water heating	£££	☺	✕✕
1 kW solar photovoltaic panels	££££	☺	✕✕
Micro wind turbine	£££	☺	✕✕

What is in the target zone?

- A medium-term plan for every dwelling type
  - Derived from SAP assessment, PassivHaus strategy
  - Implemented over 10-20 years
- Cost effective specification?
  - U values ≤ Approved Document L1B (2010)
  - Solid wall insulation and ground floor insulation
  - Reduced thermal bridging
  - Air permeability ≤ 5 m^3/m^2h @ 50 Pa
  - Whole-house ventilation (to recover internal gains)
  - Solar water heating (HW now biggest thermal load)
  - PV to offset lights and appliances (self-funded via FiT)

Summary - standards

- 80% emissions reduction is not appropriate
  - At *current* emissions factors
- ~ 60% emissions reduction is more appropriate
  - Assuming decarbonisation of the grid, etc
  - But watch for double-counting of PV on roofs!
- *RFF* measures are probably unaffordable
  - The funding gap is too big
- Select improvement packages on the basis of
  - Capital cost, disruption and carbon cost effectiveness
  - Specifications will vary by dwelling type
  - SWI, GFI, SWH and PV will be essential components

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Key Specification Issues

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Key specification issues

Essential improvements

- Solid wall insulation
  - Internal (IWI)
  - External (EWI)
- Ground floor insulation
- Air tightness and ventilation

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Solid wall insulation

Internal wall insulation (IWI)

- Must take account of thermal bridging
  - At partitions, party walls and around openings
- Involves condensation risk
  - On cold walls behind the insulation – must be sealed
- Involves risk of rot
  - Joists penetrating insulation and built into cold walls
- Involves risk of mould growth
  - On cold, wet walls in exposed orientations
- Usually involves decanting residents

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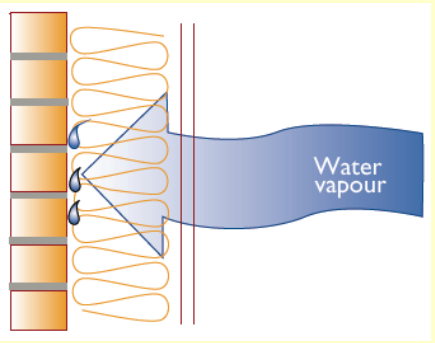
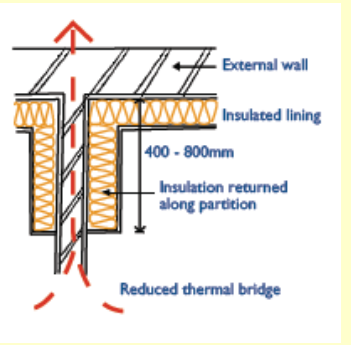
Solid wall insulation

Internal wall insulation



Condensation risk



Dealing with
thermal bridging

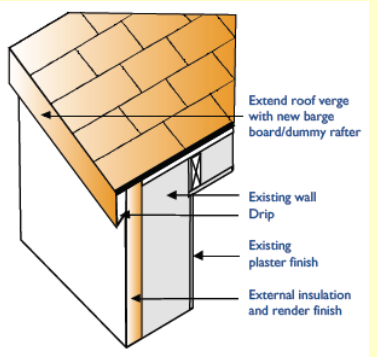
Solid wall insulation

External wall insulation (EWI)

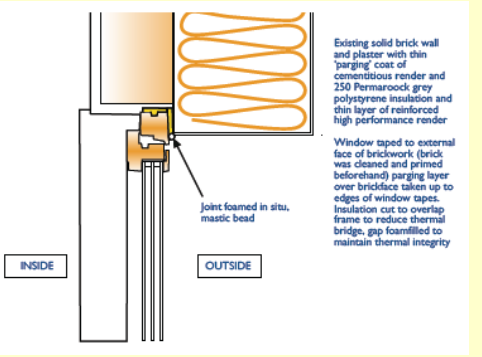
- Less risky, but often unacceptable
  - For planning or architectural reasons
- Provides thermal mass inside the insulation
  - Eliminates thermal bridging
- Must take account of
  - Architectural features (eaves, lintels, cills, etc)
  - Difficulties with openings at internal corners
  - Modification of eaves and verges, drainage, etc
  - Re-fixing of cables, satellite dishes, etc
- Does not involve decanting residents

Solid wall insulation

External wall insulation



Extending the verge



Detail at window head

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Solid wall insulation

Conclusions

- Technically EWI is superior to IWI
  - EWI provides better performance with less risk
  - EWI is compatible with re-roofing and new windows
- IWI and EWI costs are comparable
  - When thermal bridging, air tightness, decanting, etc, are considered and dealt with properly
  - Typical costs ~ £120/m^2 (~ £10,000 per dwelling)
- When specifying:
  - Start with EWI, move to IWI only if you have to

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Ground floor insulation

- Low carbon retrofit must include floor insulation
  - Significant proportion of heat loss envelope
    - Especially in terraced dwellings and ground-floor flats
- Difficult to achieve without decanting residents
  - Unless there is access beneath a suspended floor
- Important to connect GFI with SWI
  - Thermal bridge at floor-wall junction is often difficult

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Ground floor insulation

Solid floors

- Insulation goes on top (usually)
  - Involves modifying doors, stairs, etc.
  - Easy to connect with IWI and maintain air-tightness
  - Difficult to connect with EWI without thermal bridge

Suspended floors

- Insulation can be on top or underneath
  - Difficult to maintain air-tightness if underneath
  - Can fill the whole floor void with insulation (beads)
    - Method being tested in Peabody *RFF* project

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Air-tightness and ventilation

Air-tightness

- Difficult to achieve < 5 m^3/m^2h
- Half the original permeability is a good standard
- Requires meticulous attention to detail!
  - Effective sealing involves significant time and cost

Ventilation

- Whole-house ventilation essential for air quality
- Heat recovery essential to reduce heat demand
  - Options: HRRVs, MVHR

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Air-tightness and ventilation

A note of caution

- "Beware of things that whirr"
  - They often don't work and usually don't tell you that they are not working
  - Insist on readouts to prove that equipment is working as intended

(John Doggart, Sustainable Energy Academy)

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Summary - specifications

- Low carbon retrofit is difficult and costly!
  - The main technical problems are
    - Minimising thermal bridging
    - Achieving air-tightness
    - Minimising the risks of condensation and rot
- Successful projects involve
  - Detailed specification of the whole package
    - Measures must be integrated and coordinated
  - Time and attention to detail on site
- Does it matter?
  - Yes, a poor installation may result in twice the heat loss (and emissions) associated with a good one

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