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Solid Wall Insulation: Best Practice and Innovation

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Outline

1. Objectives
2. Methods
3. Findings
    a. Internal
    b. External
4. Conclusions

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3. **Findings**
    a. **Internal**
    b. **External**
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Objectives

Specific research questions:

1. What is the state of the art?
2. What materials are available?
3. Are there under-exploited approaches?
4. What materials are ‘pre-commercial’ and ‘early stage’
5. What are pros and cons of new technologies?
6. What are the gaps and opportunities for innovation?
7. What can we learn from previous EWI projects?
8. What evidence gaps remain?

Methods

Telephone and face-to-face interviews with 29 organisations

Internet searching and literature review of 52 sources

Name	Company	External wall insulation	Internal wall insulation
Nick Egdell	ProCost Solutions	Y	N
Andrew Champ	SWIGA	Y	N
Two Anonymous interviewees	Celotex Ltd	N	Y
Suzanne Johnston	Smithers Rapra, collaborating in Foam-build	Y	N
Sofie Pelsmakers	Sheffield University	Y	N
Matthew Evens, Matthew Ball, Jonathon Ducker	Kingspan	Y	Y
Yangang Xing	Cardiff University	Y	Y
Tim Acheson	Green Hat Construction	Y	Y
Jim Ross	Caroe Architecture	Y	Y
Anne Cooper	AC Architects	Y	Y
Nigel Gervis	Ty Mawr Lime Ltd	Y	Y
James Alcock	The Greenage	N	Y
Anonymous	Architect, AECB CarbonLite Retrofit training, Energy Assessor	Y	N

Name	Company	External wall insulation	Internal wall insulation
Patrick McCool	Make My Home Green	N	Y
Andrei Tartza	Pioneer Wall Cladding and Building Insulation Ltd	Y	Y
Charlotte Knott	Rockwarm	Y	Y
Peter Dunsby	ECO Matters	Y	Y
Nick Lloyd	Urbane-eco	Y	Y
Nick Miles	EWI-Pro	Y	N
Terry Evans	InstaGroup	Y	Y
Matthew McKnight	Therm-eco EWI Ltd	Y	N
Nick Stevens	Retrofit UK	Y	N
Anonymous	Matilda's Blanket	N	Y
Gabby Mallet	NEF	N	Y

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Methods

Interview Questions

1. What kinds of work do you do?
2. How do materials and technologies perform?
3. What is the total cost of installing these technologies?
4. Do your methods go beyond normal practice? (How?)
5. What other factors affect cost, performance and quality?
6. Do you have innovative business processes? (What?)
7. What innovative methods do you plan to use in future?
8. How will these affect total installation costs?
9. Do you know of SWI innovations by other firms?

Table 1: Comparing costs and benefits of different insulation materials

Technology	Thermal conductivity (lambda, in W/mK)	Indicative cost per m² (materials only)	Indicative Cost for 3-bed semi-D (materials only)	Notes
Vacuum-insulated panels (VIPs)	0.007	£125	£14,375	VIPs cannot be cut on site and must be ordered to size. Gaps must be filled with other materials. Performance may suffer if they are pierced. They remain expensive because manufacture is expensive.
Aerogel	0.013	£100	£11,500	Aerogel is fragile and expensive to manufacture. It is favoured for small areas where thickness is important, like window reveals.
Phenolic foam	0.022	£17	£1,955	Rigid phenolic foam is used for internal and external insulation (e.g. in Kingspan boards). It offers better insulation than the same thickness of PUR or PIR, and good fire performance.
Polyurethane (PUR)	0.025	£16	£1,840	PUR can be sprayed or formed into boards. Untreated PUR is highly combustible, but most PUR is treated with fire retardant. How effective this is is contested.
Poly-isocyanurate (PIR)	0.025	£16	£1,840	PIR has better fire performance and lower combustibility than PUR. It is commonly used for IWI, including by Celotex, with a foil facing.
Expanded polystyrene (EPS)	0.03	£4	£460	EPS is commonly used in external wall insulation. Different specifications/thermal conductivities are available. EPS is flammable, although fire-retardant and encapsulation reduces fire hazard.
Glass wool	0.033	£5	£575	Glass wool is breathable/vapour permeable. It is less commonly used for retrofit wall insulation. It offers acoustic insulation as well as thermal. (Knauf use glass wool in their products.)
Wood fibre	0.039	£4	£460	Breathable (vapour-permeable), but needs a lime plaster and permeable paint on top to breath. (A lime plaster needs three coats, and takes longer to dry than modern plaster, so this may increase installation costs.)


Internal Wall Insulation

What is ‘best practice?’ Internal Wall Insulation

Best practice is important because poor IWI can lead to damp, mould, poor air-quality and ultimately the illness of occupants.

Best practice hard to generalise but usually includes:

1. Moving pipework, skirting boards or electric sockets from the internal face of the wall.
2. Attaching insulation boards securely so they touch tightly.
3. Insulating window reveals, along with a 150mm return along any internal walls, to stop thermal bridging.
4. Placing plasterboard on top of the insulation boards (sometimes integrated), with a thin coating of ‘skim’ plaster on top.

FINDINGS – IWI - Technology Innovations

Technology	Advantages	Disadvantages	Future prospects
Vacuum insulated panels	Thinner insulation	Cannot be cut to size – available in a range of sizes Expensive (but can save money for enabling works)	Could be wide uptake, but cost is a barrier
WHISCERS [prefabricated panels allowing fast install]	Fast installation, cut to fit offsite so low mess	Requires board cutter	Mobile board cutter would make 1-day installation possible
Matilda's Blanket [prefabricated panels and tracking allowing fast install]	Fast installation: 1 day per room	Higher materials cost	Company has wound down
Aerogel	Thinner insulation, good for small areas such as window reveals	Expensive, fragile	Could be wide uptake, but cost is a barrier
AeroTherm	Very thin (1mm), straightforward installation	Unlikely to achieve 0.3 W/m^2K	Could be wide uptake
Multifoil	Fast installation with low mess. Inexpensive.	Hard to go beyond 0.3 W/m^2K	Could be wide uptake
Calcium silicate insulation	Lightweight, and antibacterial properties	More thickness needed for the same performance	Could be wide uptake
Blown PUR (polyurethane) foam	Good for uneven walls	Specialist contractor needed	New propellant with low GWP needs BBA approval

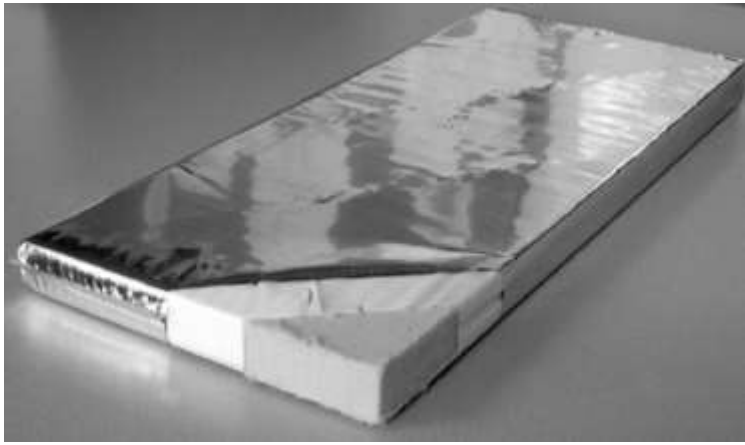
Barriers to take up

Interviewees emphasised:

1. Rigid funding mechanisms, like the Green Deal and ECO
2. Impediments to area-wide marketing and funding
3. Concerns about quality
4. Concerns about lost floor space
5. The capital cost of IWI.

Two Significant Materials

- **Vacuum-Insulated Panels**
- **Kingspan's OPTIM-R now available and BDA certified in early 2016**
- **More commonly used in roofs**
- **Expected to last "as long as the building".**
- **Aluminium-polymer protection could be punctured and cannot be cut on site.**
- **Different thicknesses available to meet U-value targets, but limited set of dimensions is available.**
- **Other insulation materials also required as "flex"**



Aerogel

- **Aerogels give better performance than conventional insulants – as low as 0.13 W/mK**
- **The are translucent, so may ultimately be used to bring in daylight**
- **They are fragile, so may be damaged during installation**

Two Significant Installation Methods

WHISCERS (Whole-House In-Situ Carbon and Energy Reduction Solution)

- **Laser scanning to measure rooms and cut insulation boards to size off site. (Different boards may be used.)**
- **Faster and cleaner on site, with less waste (and easier recycling) than conventional IWI.**
- **Only one installer needed.**
- **Costs vary "hugely" between sites: typical costs from £90 to £140 per m2 installed.**

Matilda's Blanket

- **Alternative large-scale method, using PIR boards with Rigidur H plasterboard and Gyproc back board, mounted on metal tracking.**
- **Air gap behind the boards, with overall thickness typically 88mm.**
- **No wet trades needed, and one room can be installed in one day.**


External Wall Insulation

What is ‘best practice?’ External Wall Insulation

Experts differ, and different situations call for different solutions, but in many cases best practice includes:

1. Expanded polystyrene boards attached to the outer face of all external walls with adhesive and mechanical fixings
2. Acrylic or silicate render or brick slips applied over the top of the polystyrene, on suitable scrim (reinforcement material) and basecoat layers
3. High performance insulation materials on window/door reveals
4. Continuous insulation, with all exposed edges of the insulation protected
5. Where eaves do not cover the thickness of the insulation they are extended to protect the top of the EWI
6. Appropriate strengthened fixings for satellite dishes, TV aerials, washing lines or other services that need to be attached to the wall

Some experts hold that only vapour permeable materials should be used: permeable insulation made from wood fibre or mineral wool, with permeable adhesives and finishes, including lime render.

Clear consensus that extra ventilation is needed after EWI has been installed, to reduce moisture risks.

Innovations for EWI

We identified seven emerging technologies for EWI:

1. **Dry installation with pre-fabricated boards (Mauer UK)**
2. **Breathable, wood-based insulation materials**
3. **Insulating below ground, and always moving the gutter beyond the edge of the wall insulation**
4. **SuperQuilt multi-foil EWI, which is faster to install than conventional approaches**
5. **Calcium silicate insulation, which has higher thermal conductivity than EPS (i.e. a poorer insulator), but which has anti-bacterial properties, deterring mould growth**
6. **Render-brick, render that looks like bricks**
7. **Aluminium verge trims.**

Innovations for EWI

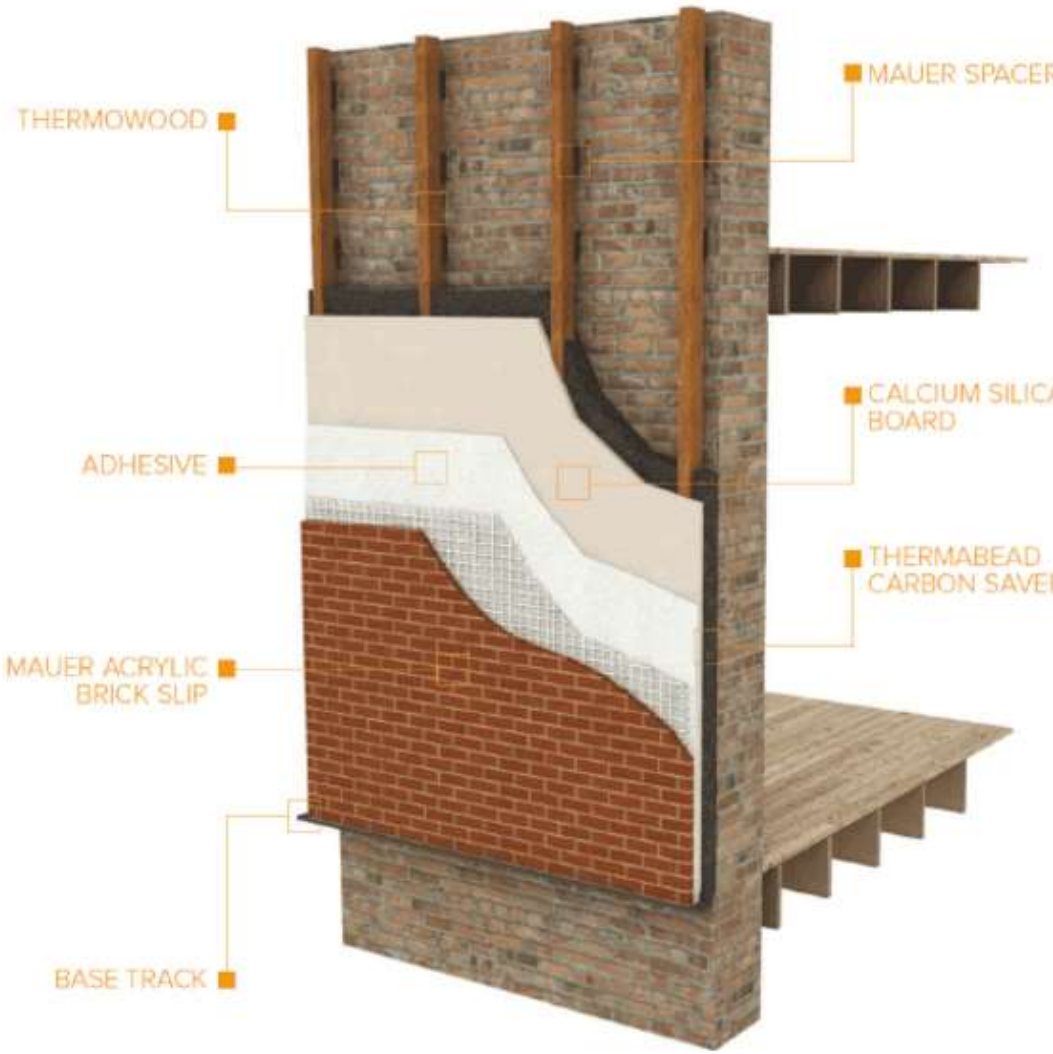
Mauer UK's dry-install EWI

Laser scanning to measure dimensions & cut boards

Tracks at top & bottom of wall

Use timber battens & patented spacers to fix 'façade boards' and brick slips, with a cavity

Inject 'thermabeads' behind the boards



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Innovations for EWI

Mauer UK's dry-install EWI

CLAIMED faster and all-weather installation

CLAIMED 50% saving compared to conventional rendered EWI

Uncertain performance & durability

Does not extend below damp-proof course

Innovations for EWI

NBT's breathable insulation boards

Made from wood fibre, fixed with no cavity

Lime render with vapour-permeable waterproof coating

Claimed to avoid risk of condensation & mould

BUT costs £1,500 to £2,000 more for typical semi-detached home

AND need to use breathable materials is contested

Innovations for EWI

SuperQuilt Multifoil

19 layers of wadding, aluminium foil and plastics foil. 40mm thick, plus air gap.

Achieves 0.3 W/m^{2}K.

Air and vapour-tight.

CLAIMED easier to seal, using tape, with quicker and easier installation.

Easier to take right into junctions than insulation boards, and cleaner, with less waste than boards.

Likely to be water-tight faster than conventional approaches

Materials cost £6 per m^2, compared to £12-£20 per m^2 for blown polymer boards

Innovations for EWI

Niche products and techniques

Insulating below ground, and always moving the gutter beyond the edge of the wall insulation

Calcium silicate insulation, which has higher thermal conductivity than EPS (i.e. a poorer insulator), but which has anti-bacterial properties, deterring mould growth

Render-brick, render that looks like bricks c17% cheaper than brick slips, but only suitable where brick finish is required

Bespoke aluminium verge trims, avoiding mastic sealant.

Foam-build: nano-particles in mortar, with conductivity of 0.02 W/mK (similar to Celotex)

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Overall Impact on Take-Up

Most Product Innovations Improve Quality

- **Reducing risk of condensation & mould**
- **Faster/less disruptive/more flexible installation**
- **Mauer UK's solution MAY reduce install costs, but brick finish is small proportion of all EWI work**
- **OVERALL: Existing and near-term innovations will have limited impact on take-up**
- **AND: Incentives for further innovation are muted because of low demand**

What Innovations Might Make a Difference?

- More economical ways to manufacture Aerogels
- More economical production of nano-insulated plaster (like AeroTherm)
- More economical ways to manufacture VIPs
- Simple, cheap ways to attach kitchen and bathroom equipment to external walls with thermal breaks.

Possible Impact on Take-up

	Cost now per home	Future Cost (low take-up)	Change in take-up*	Future Cost (high take-up)	Change in take-up*
Conventional IWI	£5,000-£10,400	-	-	-	-
Off-site manufacture	£5,000-£10,400	£4,500-£9,360	+16%	£2,500-£5,200	+80%
Economical Aerogel	£14,500-£20,000	£13,550-£19,050	+11%	£9,750-£15,250	+38%
Nano-insulating plaster (like AeroTherm)**	£4,750	£4,435	+11%	£3,175	+53%
Vacuum-Insulated Panels	£17,400-£22,800	£16,160-£21,560	+11%	£11,200-£16,600	+57%

**Assuming average price elasticity of demand of -1.6* ***Uncertain performance and durability.*

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Economic effects

	Cost now per home	Cost saving/ increase	Other benefits	Drawbacks
Conventional IWI	£5,000-£10,400	-	-	-
Off-site manufacture	£5,000-£10,400	(no change)	Faster installation; closer fitting boards, so better performance; less waste; cleaner	-
Economical Aerogel	£14,500-£20,000	+190%	Less sacrifice of space, potentially reduced thermal bridging	Fragile, so questionable longevity
Nano-insulating plaster (like AeroTherm)**	£4,750	-40%	Faster to install	Harder to find contractors with experience of using Aerotherm, uncertain long-term performance
Vacuum-Insulated Panels	£17,400-£22,800	+250%	Less sacrifice of space	Harder to find contractors with experience of using VIPs

Costs and Performance - IWI

Technology	Thermal conductivity (lambda, in W/mK)	U-value with 40mm thickness (W/m^2K)	Cost per m^2 (materials only)	Cost for 3-bed semi-D (materials only)	Thickness
Vacuum-insulated panels	0.007	0.16	£100-£150	£14,375	Variable
Aerogel	0.013	0.28	c.£100	£11,500	Variable
Phenolic foam	0.018-0.02	0.39	c.£17	£1,955	Variable
PIR/PUR (poly-isocyanurate/ polyurethane)	0.021-0.028	0.48	£12-£20	£1,840	Variable
Multifoil (SuperQuilt)	n/a (achieves 0.3 W/m^2 K)	0.3 (with air gap)	£6	£690	40mm