Energy Efficiency Technology Scorecards

Please click links below to navigate to full detailed scorecards populated for each technology reviewed as part of this study:

				Application				
Ref#	**Class**	**Intervention**	**Technology**	**Community**	**Domestic**	**Public**	**Commercial**	**Industrial**
E_a01	Ground / Basement Floor Insulation	Solid Floor Insulation	**Ultra thin aerogel backed floor panels**	x	x	x	x	
E_a02	Ground / Basement Floor Insulation	Solid Floor Insulation	**Vacuum insulation panels**	x	x	x	x	
E_a03	Ground / Basement Floor Insulation	Perimeter Insultation	**Closed cell EWI perimeter insulation to footings**		x			
E_a04	Ground / Basement Floor Insulation	Suspended Floor Insulation	**PU Spray Foam Systems**	x	x			
E_a05	Ground / Basement Floor Insulation	Suspended Floor Insulation	**Foamed glass pumice under floor void**	x	x			
E_a06	Ground / Basement Floor Insulation	Suspended Floor Insulation	**Blown/loose fit suspended floor insulation**		x			
E_b01	Wall Insulation	Cavity Wall Insulation	**PU Spray Foam Systems**	x	x	x	x	x
E_b02	Wall Insulation	Cavity Wall Insulation	**Blown bonded EPS bead based systems**	x	x	x	x	x
E_b03	Wall Insulation	Cavity Wall Insulation	**Loose blown material blends**	x	x	x	x	
E_b04	Wall Insulation	External Wall Insulation	**Vapour open wet render systems**	x	x	x	x	
E_b05	Wall Insulation	External Wall Insulation	**Insulated rainscreen cladding systems**	x		x	x	
E_b06	Wall Insulation	External Wall Insulation	**Dynamic External Wall Insulation**	x	x	x	x	
E_b07	Wall Insulation	External Wall Insulation	**Off-site manufactured cassette systems**	x	x	x	x	
E_b08	Wall Insulation	External Wall Insulation	**External paints, plaster and renders**	x	x	x	x	x
E_b09	Wall Insulation	Internal Wall Insulation	**Offsite Manufactured (OM) Cut Panel Systems**	x	x	x	x	
E_b10	Wall Insulation	Internal Wall Insulation	**Vacuum wall panel insulation**	x	x	x	x	
E_b11	Wall Insulation	Internal Wall Insulation	**PU Spray Foam Systems**	x	x	x	x	x
E_b12	Wall Insulation	Internal Wall Insulation	**Internal insulation stud systems**	x	x	x	x	
E_b13	Wall Insulation	Internal Wall Insulation	**Internal paints, wall paper and plaster coatings**	x	x	x	x	x
E_b14	Wall Insulation	Internal Wall Insulation	**Phase Change Materials**	x	x	x	x	x
E_b15	Wall Insulation	Internal Wall Insulation	**Ultra thin insulation for hard-to-treat areas**		x	x		
E_c01	Roof Insulation	Cold Roofs	**Blown/loose fit cold roof insulation**	x	x	x	x	
E_c02	Roof Insulation	Temperate Roofs	**PCM Ceiling Tiles / Ceiling Void additions**			x	x	
E_c03	Roof Insulation	Warm Roofs	**Warm roof insulation systems**	x	x	x	x	
E_c04	Roof Insulation	Large Span Roofs	**ETFE Roofing**			x	x	x
E_c05	Roof Insulation	Flat Roofs	**Green Roofs**	x	x	x	x	x
E_c06	Roof Insulation	Flat Roofs	**Reduced albedo (paint / materials)**	x	x	x	x	x
E_c07	Roof Insulation	Flat Roofs	**Offsite Manufactured (OM) Cut Cassette Systems**	x	x	x	x	x
E_c08	Roof Insulation	Thermal labarynths	**Chilled Beam Ceilings**			x	x	x
E_c09	Roof Insulation	Pitched Roofs	**Glass PV roof tiles**	x	x	x		
E_d01	Glazing and Shading Systems	Windows	**Secondary glazing including plastic films**	x	x	x	x	
E_d02	Glazing and Shading Systems	Windows	**Thin profile vacuum glazing**	x	x	x	x	
E_d03	Glazing and Shading Systems	Windows	**Low E Double Glazing**	x	x	x	x	x
E_d04	Glazing and Shading Systems	Windows	**Low E Triple Glazing**	x	x	x	x	x
E_d05	Glazing and Shading Systems	Windows	**Window films**	x	x	x	x	x
E_d06	Glazing and Shading Systems	Windows	**Spectrally selective glazing**			x	x	
E_d07	Glazing and Shading Systems	Windows	**Water filled double glazing**	x	x	x	x	
E_d08	Glazing and Shading Systems	Windows	**Ventilated windows**	x	x	x	x	
E_d09	Glazing and Shading Systems	Windows	**PCM filled glazing**	x	x	x	x	
E_d10	Glazing and Shading Systems	Windows/Curtain walling	**BIPV glazing**	x		x	x	x
E_d11	Glazing and Shading Systems	Shading Systems / glare control	**Dynamically selective glazing (electro & photo sensitive glazing)**			x	x	
E_d12	Glazing and Shading Systems	Shading systems	**Insulating celluar blinds / shades**	x	x	x	x	
E_d13	Glazing and Shading Systems	Curtain Walling	**PV integrated facades, cladding, windows**			x	x	
E_d14	Glazing and Shading Systems	Curtain Walling	**Double skin facades**	x	x	x	x	x
E_d15	Glazing and Shading Systems	Doors	**High performance doors**	x	x	x	x	x
E_d16	Glazing and Shading Systems	Daylighting	**Light pipes, light shelves; diffraction glazing**	x	x	x	x	x
E_e01	Ventilation and airtightness	Airtightness	**Draught stripping - novel profiles, tapes and sealants**	x	x	x	x	
E_e02	Ventilation and airtightness	Ventilation	**Mechanical Ventilation Heat Recovery (MVHR)**	x	x			
E_e03	Ventilation and airtightness	Ventilation	**Single Room Heat Recovery (SRHR) Ventilation**	x	x	x	x	
E_e04	Ventilation and airtightness	Ventilation	**Automated trickle ventilation systems**	x	x	x	x	x
E_e05	Ventilation and airtightness	Ventilation	**Automated window opening / closure**	x		x	x	
E_e06	Ventilation and airtightness	Ventilation	**Mixed mode ventilation (using thermal mass)**	x		x	x	
E_e07	Ventilation and airtightness	Ventilation	**Hybrid Ventilation**	x		x	x	x
E_e08	Ventilation and airtightness	Ventilation	**Passive Stack Heat Recovery**	x	x	x	x	x
E_e09	Ventilation and airtightness	Ventilation	**Insulation with passive wall ventilation labrinth**		x			
55				45	44	50	47	21
100%				82%	80%	91%	85%	38%

Ultra thin aerogel backed floor panels

Thin aerogel based insulation product for overlaying existing uninsulated solid floors

Technical	Score	Comments
Technology readiness	9	Commercially availible
Efficiency (product / technology efficiency)	5	Very low thermal conductivity
Reliability	4	Inert and reliable provided installed correctly and continuous.
(level of) Compatability with existing systems	3	Requires flat stable ground floor substrate. Floor to wall interface remains a challenge.
complexity of systems/ their integration	4	Simple installation once room is empty of possessions and furniture
risk/severity of unintended consequences	4	Low risk. Possible increased risk of thermal bridging at floor to wall interface
	29	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Moderate and directly linked to total surface area and existing slab build-up
whole life environmental impact	5	Zero ODP, <5 GWP and 100% recyclable
	8	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Fabric improvement measure suited to a high proportion of the scottish building stock
compatability with current regulation	5	Directly compatible, though regulations don't mandate such high levels of performance
compatibility with current assessment methodologies	5	Improved floor U value able to be directly reflected in both rdSAP, full SAP and iSBEM
	15	

Monetary	Score	Comments
capital costs	2	Relatively high capital cost in comparison to other floor insulation options, though low if as an alternative to complete slab replacement
life cycle costs	5	Low whole life cost due to 60+ year lifespan
carbon cost effectiveness (£ per tCO2 saved)	3	Moderate and directly linked to total surface area and existing slab build-up.
(potential for) economy of scale (to drive down costs)	4	High potential for improved economy of scale. Presently a low volume manufactured solution with limited manufacturing capacity and suppliers/installers.
	14	

Capacity/ Supply Chain	Score	Comments
applicability	4	Good applicability, high number of uninsulated solid floors in Scottish stock
existing Scottish capacity/skills	3	Limited deployment of the product in Scotland with very few installers actively aware/offering the solution
Scottish content (materials, IP)	3	Raw material unknown but at least one large manufacturer Scotland based (Proctor Group, Blairgowrie)
potential for cross-sector involvement/benefit	3	Potential to integrate into floor coverings, DIY solutions, engage social housing providers in relation to void periods etc.
scottish economic impact potential	3	Opportunities for Scottish leadership - significance difficult to guage on this.
	16	

Consumer	Score	Comments
user friendliness / practicality	4	Inert requiring no user intervention once installed
disruption	2	High disruption, requiring rooms to be vacant of furniture and possessions
customer aceptance	3	Unappealing, inert technology that can't be seen or engaged with once installed
savings on bills	3	'Moderate and directly linked to total surface area and existing slab build-up.
maintenance requirements	5	None
health/wellbeing/comfort	4	No known off-gassing or product deterioration. Improved internal comfort and increased floor surface temperatures. Installation and cutting of the material possibly hazardous and correct PPE must be worn
existing consumer protection? (adequacy?)	3	Only existing infrastructure around SEEP and miselling, trading standards. Performance in use protection/warranties not known to exist at present
	24	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Survey to understand existing slab build-up and performance improvement potential - cost/benefit Quality of installation - joints between boards, overall continuity, risk of thermal by-pass behind boards
other relvant considerations/risks/opportunities		Floor to wall junction - continuity and thermal bridging, condensation risks
adaptability / future proofing		Thermal conductivity cannot presently be bettered for given thickness - 29mm board on uninsulated slab would achieve a u-value of approx 0.3 W/m2K. Disruptive to remove or repair/replace
	106	

Sources and further reading:

Vacuum insulation panels

Vacuum insulation - in this instance for floors, with wider product availability and applicability for many applications with a need for thin load bearing applications to reduce thermal bridging / heat loss.

Technical	Score	Comments
Technology readiness	9	Number of mainstream maufacturers - eg Kingspan. http://www.kingspaninsulation.co.uk/Products/Optim-R/Optim-R/Overview.aspx
Efficiency (product / technology efficiency)	3	Highly efficient as an insulator, although with potential for panels to lose effectiveness if vacuum is lost due to eg occupant action.
Reliability	3	Vacuum should be retained over time - and hence perfromance retained - although occupnt / contractor effects might compromise vacuum in practical use.
(level of) Compatability with existing systems	3	Good compatability, although nature of product does limit capacity to apply (ie have to use fixed panel sizes with some filler strips available.
complexity of systems/ their integration	3	Nature of produce limited flexibility.
risk/severity of unintended consequences	2	Severe risks to perfromance if vacuum is compromised - occupiers will need to be advised as to what they cannot do (eg drill holes in panel). Possible (low) risk of thermal bridging associated with practical installation. Modular approach limited impact of such actions.
	23	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Thinkness of vacuum insulation products make them a viable option for retrofit where space is a limiting factor.
whole life environmental impact	4	No ODP, 90% recyclable, 0 GWP, moderate emodied carbon
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Fabric improvement measure suited to a significant proportion of the scottish building stock where there are a limited pool of alternative (thin) products
compatability with current regulation	5	Directly compatible, though regulations don't mandate such high levels of performance
compatibility with current assessment methodologies	5	Improved fabric U value able to be directly reflected in both rdSAP, full SAP and iSBEM
	14	

Monetary	Score	Comments
capital costs	2	Relatively high capital cost in comparison to other floor insulation options, though low if as an alternative to complete slab replacement
life cycle costs	3	Low whole life cost due to 60+ year lifespan, although question as to whether this will be achieved in practice due to vacuum integrity vulnerability
carbon cost effectiveness (£ per tCO2 saved)	4	Moderate and directly linked to total surface area and existing slab build-up.
(potential for) economy of scale (to drive down costs)	4	High potential for improved economy of scale. Presently a low volume manufactured solution with limited manufacturing capacity and suppliers/installers.
	13	

Capacity/ Supply Chain	Score	Comments
applicability	4	Good applicability, high number of uninsulated solid floors in Scottish stock
existing Scottish capacity/skills	2	Limited deployment of the product in Scotland with very few installers actively aware/offering the solution
Scottish content (materials, IP)	1	TBC - Kingspan manufacture in Herefordshire
potential for cross-sector involvement/benefit	3	Potential to integrate into floor coverings, DIY solutions, engage social housing providers in relation to void periods etc.
scottish economic impact potential	3	The key issue is how to provide solutions which minimise energy and potential health impact - key here is appropriate selection, installation, and integration - opportunities for Scottish leadership in this area reflecting legislative and regulatory leadership.
	13	

Consumer	Score	Comments
user friendliness / practicality	2	Solutions are limited by nature of vacuum panels - although applications do exist, and the nature of the product makes it very well suited to a wide range of circumstances.
disruption	3	Low disruption associated with alternatives for most alternatives to insulating floors.
customer aceptance	3	Low customer awareness of the technology - out of sight. Occupiers need to be informed as to limitations when product is in use.
savings on bills	3	Proportionate to size of floor. Potential installation edge effects may result in continued (low)
maintenance requirements	4	No maintenance - unless panel is pierced, in which case there would be a requirement to replace panel if perfromance is to be mantained.
health/wellbeing/comfort	5	Off-gasing potential low. Thickness makes a positive contribution to amenity. Applications can limit cold bridging, and hence reduce fabric and health effects associated with condensation.
existing consumer protection? (adequacy?)	3	As with other products limited protection where installation is inappropriate, poorly done.
	23	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Thickness of slab, although small, may still limit practical implementation; perfromance in use may suffer if occupiers / trades people are not aware of its requirements; training / competence of installers; handover to occupier(s)
other relvant considerations/risks/opportunities		Will reduce the thermal mass of the building by isolating the floor slab - overheating risk slightly increased as a result. 'Potential to reduce condensation risk associated with thermal loss of existing uninsulated solid ground floors.
adaptability / future proofing		Vacuum panels are inherently limited in their ability to be adjusted once manufactured (eg cut to size). Excellent thermal perfromance 0.007w/mk
	93	

Sources and further reading:

Closed cell EWI perimeter insulation to footings

Use of an externally applied closed cell insulation material (e.g. XPS) taken from damp proof course level down to the foundations. This minimises downward diagonal heatloss from the floor to wall junction and helps to create a warm 'pocket' beneath the whole solid floor.

Technical	Score	Comments
Technology readiness	9	Existing insulation product applied in a novel manner
Efficiency (product / technology efficiency)	3	Indirect approach to reducing the heatloss from uninsulated solid floors
Reliability	5	Low tech, inert solution, low maintenance once applied
(level of) Compatibility with existing systems	5	Good compatibility with EWI systems but can also be applied on it's own with capping/plinth at DPC level
complexity of systems/ their integration	3	Relatively low complexity, though install entails digging down to footings around the heat loss perimeter with services, rain water goods, drains etc. often posing a challenge
risk/severity of unintended consequences	4	Relatively low risk of unintended consequences provided insulation is closed cell, preventing moisture ingress.
	29	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Solid floors generally a relatively low heat loss area in comparison with other heat loss elements - walls, roofs etc.
whole life environmental impact	2	Green Guide rating of E for XPS. Manufacture presents high stratospheric ozone depletion and ecotoxicity to land
	5	

Policy / Regulation	Score	Comments
compatibility with Scottish policy	5	Good link with policies to reduce energy use
compatibility with current regulation	5	Good link to existing regulations that encourage improved fabric performance. Section 6.
compatibility with current assessment methodologies	5	Improved u-values well catered for in SAP, iSBEM and similar.
	15	

Monetary	Score	Comments
capital costs	3	Moderate material costs but install involves high amount of labour.
life cycle costs	3	Moderate whole life costs with savings accruing over a long period
carbon cost effectiveness (£ per tCO2 saved)	3	Moderate but neccesary as part of a whole house retrofit, reducing thermal bridging
(potential for) economy of scale (to drive down costs)	3	XPS material supply chains reasonably well established. Opps to save with economies limited to to high amount of labour requried to dig to footings and install.
	12	

Capacity/ Supply Chain	Score	Comments
applicability	4	High number of poorly insulated solid floors within domestic and non-domestic buildings
existing Scottish capacity/skills	4	Relatively low skill installation
Scottish content (materials, IP)	4	No known manufacturer of XPS within Scotland, though widely produced throughout Europe
potential for cross-sector involvement/benefit	3	Limited cross-sector opportunities - potential to upskill existing EWI, IWI and floor insulation installers
Scottish economic impact potential	3	Volume of XPS required unlikley to lead to significant economic stimulation but installation based could grow
	18	

Consumer	Score	Comments
user friendliness / practicality	4	Requires no occupant interaction once installed
disruption	4	Low disruption relative to alternative approaches.
customer acceptance	4	Very limited market awareness of the opportunity but acceptance most likely as part of a wider EWI install.
savings on bills	3	Limited noticable savings but internal surface temperature of floor would increase (comfort).
maintenance requirements	5	Very low maintenance requirements once installed and proper drainage backfill provided.
health/wellbeing/comfort	3	Improved internal surface temperature of floor surface.
existing consumer protection? (adequacy?)	3	Only existing infrastructure around SEEP and misselling, trading standards. Performance in use protection/warranties for this solution not known to exist at present
	26	

Opportunities / risks	Score	Comments
Critical success factors/watch points		System solutions best deisgned based on proper thermal bridging calculations, essential that closed cell insulation is used to limit moisture penetration. Existing services around the foot of the building can be difficult to negotiate
other relvant considerations/risks/opportunities		Insulation continuity is critical in order to mitigate thermal bridging. Externally applied significantly reduces resident disruption whilst improving the overall performance of uninsulated solid floors
adaptability / future proofing		Digging a trench to install is a significant undertaking, therefore installing a good thickness of insulation will help future proof. Other benefits of closed cell include reduced flood risk damage
	105	

Sources and further reading:

https://www.bre.co.uk/greenguide/ggelement2.jsp?buildingType=Housing&category=15&parent=0&elementType=10032&eid=17706
https://retrofit.support/detail/20/
http://www.exiba.org/about-exiba/exiba-family-in-Europe

PU Spray Foam Systems

There are a range of products based around spray foams, with some novel means of application (e.g. robotics) being to be tested. Can be applied to new or existing buildings. Key benefit is the flexibility of the approach. Unclear how such approaches will perform in the long term - as the approach essentially hides materials, and hence potentially, defects.

Technical	Score	Comments
Technology readiness	9	Commercially available systems exist. Some means of applications (eg robotics) are TRL 6.
Efficiency (product / technology efficiency)	4	Relatively cheap and flexible product. Applied thickness of foam can be variable.
Reliability	3	Reliability depends on expertise of installer, and particular installation. Long term consequences to fabric are unclear.
(level of) Compatibility with existing systems	5	Comparable to many existing systems - the benefit of the approach that it is very flexible with a wide range of potential applications.
complexity of systems/ their integration	3	How the spray foam will influence building durability / future repair costs / procedures is unclear at present.
risk/severity of unintended consequences	2	Poor, or ill considered installation can risk increased fabric damage.
	26	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Good energy savings potential in a wide range of applications - if installed correctly.
whole life environmental impact	2	Limited existing potential for recycling / re-use. Offgasing. Zero ODP, >0 GWP.
	6	

Policy / Regulation	Score	Comments
compatibility with Scottish policy	5	Good link with policies to reduce energy use
compatibility with current regulation	5	Good link to existing regulations that encourage improved fabric performance. Section 6.
compatibility with current assessment methodologies	4	Improved u-values well catered for in SAP, iSBEM and similar.
	14	

Monetary	Score	Comments
capital costs	5	Relatively low costs for its area of applicability.
life cycle costs	3	Unclear consequences on long term fabric performance / life.
carbon cost effectiveness (£ per tCO2 saved)	4	Good potential for cost effective reduction in energy / carbon
(potential for) economy of scale (to drive down costs)	3	Nature of products relies on skills of operators, specifiers (and potentially the robots). Increased numbers of trained operators should reduce costs.
	15	

Capacity/ Supply Chain	Score	Comments
applicability	4	Wide applicability across several building sectors.
existing Scottish capacity/skills	4	Product already available and sold in Scotland.
Scottish content (materials, IP)	4	cottish specifiers / installers.
potential for cross-sector involvement/benefit	3	Unclear potential
Scottish economic impact potential	3	Cost effective energy reduction - good (refurbishment, some new homes), main R&D associated with robotics not based in Scotland.
	18	

Consumer	Score	Comments
user friendliness / practicality	3	Consumers may not be aware of potential quality risks / long terms ramifications.
disruption	4	Low disruption relative to alternative approaches.
customer acceptance	3	Already accepted by many. Availability and relative risks associated with alternatives not well understood by most consumers.
savings on bills	4	When applied correctly - good energy cost reductions are possible.
maintenance requirements	3	Potentially low - although repair / maintenance of building components could be affected in long term.
health/wellbeing/comfort	4	Improved heat retention provides afordable warmth. Some off gassing potential.
existing consumer protection? (adequacy?)	3	Installers and manufacturers waranties - although long term impacts unclear if poorly specified.
	24	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Appropriate selection, application, trained operators, long term impact on accessibility and maintenance of associated fabric elements.
other relvant considerations/risks/opportunities		Potential to limited future retrofit applications.
adaptability / future proofing		Flexibility of system allows a wide range of application. Unclear how it might limit future component selection / fitting, given the adhesive nature of the product. May prove less flexibl if future products emerge which need to integrate with PUV insulation layer.
	103	

Sources and further reading:

Foamed glass pumice under floor void

Highly pourous foamed glass pumice poured into the void beneath uninsulated timber suspended floors.

Technical	Score	Comments
Technology readiness	**9**	Existing insulation product applied in a novel manner
Efficiency (product / technology efficiency)	3	Requires a fairly substantial thickness to deliver similar performance levels to mineral fibre and petrochemical based insulants
Reliability	5	Low tech, inert solution, zero maintenance once installed
(level of) Compatibility with existing systems	3	Bulky material. Some floor boards will need lifting to get access
complexity of systems/ their integration	4	
risk/severity of unintended consequences	5	Very low risk of unintended consequences. Good moisture management properties
	29	

Environmental	Score	Comments
(in-use) carbon saving potential	3	
whole life environmental impact	4	
	7	

Policy / Regulation	Score	Comments
compatibility with Scottish policy	5	Good link with policies to reduce energy use
compatibility with current regulation	5	Good link to existing regulations that encourage improved fabric performance. Section 6.
compatibility with current assessment methodologies	4	Improved u-values well catered for in SAP, iSBEM and similar.
	14	

Monetary	Score	Comments
capital costs	4	
life cycle costs	4	
carbon cost effectiveness (£ per tCO2 saved)	4	
(potential for) economy of scale (to drive down costs)	3	A bulky product often used in large volumes for roads, foundations etc. Fairly limited opps to optimise costs further
	15	

Capacity/ Supply Chain	Score	Comments
applicability	2	Moderate number of timber suspended floors - mostly domestic
existing Scottish capacity/skills	4	Relatively low skill installation
Scottish content (materials, IP)	3	Limited opportunities for production? Installer base could grow.
potential for cross-sector involvement/benefit	3	Limited
Scottish economic impact potential	3	Fairly limited, though numerous wider uses for the glass pumice product
	15	

Consumer	Score	Comments
user friendliness / practicality	3	Disruptive to install. Requires no occupant interaction once done.
disruption	3	Moderate disruption compared to alternatives. Bulky product will need to be carried into the house for install
customer acceptance	3	Very limited market awareness of the opportunity but acceptance may be effected by disruption
savings on bills	3	Likley limited noticable savings for occupant. Improved airtightness if new deck installed.
maintenance requirements	5	Zero maintenance requirements once installed
health/wellbeing/comfort	5	Known to significantly help to stablise internal RH
existing consumer protection? (adequacy?)	3	Only existing infrastructure around SEEP and miselling, trading standards. Performance in use protection/warranties for this solution not known to exist at present
	25	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Uniform fill required
other relvant considerations/risks/opportunities		Survey and address any wet or dry rot in existing timbers prior to installation
adaptability / future proofing		Future proof once installed. No performance decay over time. Product can be used elsewhere at end of use.
	105	

Sources and further reading:

http://red.coop/suspendedtimberfloors
http://www.ecomerchant.co.uk/in-ground/insulated-sub-floor/technopor-foamed-glass-sub-floor-insulation.html

Blown/loose fit suspended floor insulation

Loose insulation products, commonly produced from waste products, and blown or spread under suspended floor rafters. Examples include: Sheepswool with PET, Cellulose, mineral fibre, cotton waste

Technical	Score	Comments
Technology readiness	**9**	
Efficiency (product / technology efficiency)	4	Efficient insulation with lambda less than 0.04W/mK
Reliability	4	Strongly influenced by quality of installation and continuity.
(level of) Compatability with existing systems	3	Required access to floor void either from above or below.
complexity of systems/ their integration	3	Requires underfloor access
risk/severity of unintended consequences	4	
	27	

Environmental	Score	
(in-use) carbon saving potential	4	
whole life environmental impact	4	Insulation formed from recycled materials
	8	

Policy / Regulation	Score	
compatability with Scottish policy	5	Good link with policies to reduce energy use
compatability with current regulation	5	Good link to existing regulations that encourage improved fabric performance. Section 6. BBA certified products.
compatibility with current assessment methodologies	4	Improved u-values well catered for in SAP, iSBEM and similar.
	14	

Monetary	Score	
capital costs	4	Varies on the specific source, but relatively low cost in terms of an energy efficiency improvement
life cycle costs	5	
carbon cost effectiveness (£ per tCO2 saved)	5	
(potential for) economy of scale (to drive down costs)	3	
	17	

Capacity/ Supply Chain	Score	
applicability	2	Moderate number of timber suspended floors - mostly domestic
existing Scottish capacity/skills (people)	4	Relatively low skill installation
Scottish content (materials, IP)	3	Installers. Limited opps for material/product system production
potential for cross-sector involvement/benefit	4	Potential to utilise a wider variety of waste/recycled/repurposed materials
scottish economic impact potential	2	
	15	

Consumer	Score	
user friendliness / practicality	3	Simple material, but difficult to effectively install. No intervention once installed.
disruption	3	Required access to floor void either from above or below. Cutting/pumping of material on-site.
customer aceptance	3	Very limited market awareness of the opportunity but acceptance may be effected by disruption
savings on bills	3	Likley limited noticable savings for occupant. Improved airtightness if new deck installed.
maintenance requirements	5	Zero maintenance requirements once installed
health/wellbeing/comfort	4	
existing consumer protection? (adequacy?)	3	Only existing infrastructure around SEEP and misselling, trading standards. Performance in use protection/warranties for this solution not known to exist at present
	24	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Observe material performance over time.
other relvant considerations/risks/opportunities		Poor performance arises where floor voids have been poorly filled
adaptability / future proofing		Improves thermal envelope, making good use of the space
	105	

Sources and further reading:

http://red.coop/suspendedtimberfloors
http://www.ecomerchant.co.uk/in-ground/insulated-sub-floor/technopor-foamed-glass-sub-floor-insulation.html

PU Spray Foam Systems

There are a range of products based around spray foams, with some novel means of application (eg robotics) being to be tested. Can be applied to new or existing buildings. Key benefit is the flexibility of the approach. Unclear how such approaches will perform in the long term - as the approach essentially hides materials, and hence potentially, defects.

Technical	Score	Comments
Technology readiness	9	Commercially available systems exist. Some means of applications (eg robotics) are TRL 6.
Efficiency (product / technology efficiency)	4	Relatively cheap and flexible product.
Reliability	3	Reliability depends on expertise of installer, and particular installation. Long term consequences to fabric are unclear.
(level of) Compatibility with existing systems	5	Comparable to many existing systems - the benefit of the approach that it is very flexible with a wide range of potential applications.
complexity of systems/ their integration	3	How the spray foam will influence building durability / future repair costs / procedures is unclear at present.
risk/severity of unintended consequences	2	Poor, or ill considered installation can risk increased fabric damage.
	26	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Good energy savings potential in a wide range of applications - if installed correctly.
whole life environmental impact	2	Limited existing potential for recycling / re-use. Offgasing. Zero ODP, >0 GWP.
	6	

Policy / Regulation	Score	Comments
compatibility with Scottish policy	5	Good link with policies to reduce energy use.
compatibility with current regulation	3	Variations in application can be expected to result in differences in as built cf as designed u-values.
compatibility with current assessment methodologies	3	See above
	11	

Monetary	Score	Comments
capital costs	5	Relatively low costs for its area of applicability.
life cycle costs	3	Unclear consequences on long term fabric performance / life.
carbon cost effectiveness (£ per tCO2 saved)	4	Good potential for cost effective reduction in energy / carbon
(potential for) economy of scale (to drive down costs)	3	Nature of products relies on skills of operators, specifiers (and potentially the robots). Increased numbers of trained operators should reduce costs.
	15	

Capacity/ Supply Chain	Score	Comments
applicability	4	Wide applicability across several building sectors.
existing Scottish capacity/skills	4	Product already available and sold in Scotland.
Scottish content	4	cottish specifiers / installers.
potential for cross-sector involvement/benefit	3	Unclear potential
Scottish economic impact potential	2	Main R&D associated with robotics not yet based in Scotland. Scope for further innovation
	17	

Consumer	Score	Comments
user friendliness / practicality	3	Consumers may not be aware of potential quality risks / long terms ramifications.
disruption	4	Low disruption relative to alternative approaches.
customer acceptance	3	Already accepted by many. Availability and relative risks associated with alternatives not well understood by most consumers.
savings on bills	4	When applied correctly - good energy cost reductions are possible.
maintenance requirements	3	Potentially low - although repair / maintenance of building components could be affected in long term.
health/wellbeing/comfort	4	Improved heat retention provides afordable warmth. Some off gassing potential.
existing consumer protection? (adequacy?)	3	Installers and manufacturers waranties - although long term impacts unclear if poorly specified.
	24	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Appropriate selection, application, trained operators, long term impact on accessibility and maintenance of associated fabric elements.
other relvant considerations/risks/opportunities		Potential to limited future retrofit applications.
adaptability / future proofing		Flexibility of system allows a wide range of application. Unclear how it might limit future component selection / fitting, given the adhesive nature of the product. May prove less flexibl if future products emerge which need to integrate with PUV insulation layer.
	99	

Sources and further reading:

Blown bonded EPS bead based systems

CWI - using EPS beads. Widely used in the UK, whilst not innovative, is an effective technology.

Technical	Score	Comments
Technology readiness	9	Already commercially available and being installed - beyond 9
Efficiency (product / technology efficiency)	4	Reuses waste product for high quality, high value product. Improves efficiency of cavity walls.
Reliability	5	Highly reliable - 25 yr waranty
(level of) Compatability with existing systems	4	Requires an empty cavity wall, but applicable with any.
complexity of systems/ their integration	4	Blown during installation, remains fitted through gravity. Flexibly fits alongside adjacent walls.
risk/severity of unintended consequences	4	Allows for breathability between beads, therefore danger of damp, moisture gathering or decay is low
	30	

Environmental	Score	Comments
(in-use) carbon saving potential	4	up to 30% energy savings, as well as second life product, making use of recycled waste product
whole life environmental impact	4	Utilising a waste product, although ultimately unrecyclable at end of life.
	8	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Applications to reduce energy use.
compatability with current regulation	5	Aligns well with section 6 regulation ambition to minimise fabric heat loss
compatibility with current assessment methodologies	5	Can be accommodated by DSM or SAP. Lambda values documented.
	14	

Monetary	Score	Comments
capital costs	5	Low cost measure - made from recyclables, blown installation, uninvasive, some grants available for installation
life cycle costs	4	Second-life product, however end-life waste is not widely recycled
carbon cost effectiveness (£ per tCO2 saved)	5	Good cost effectiveness - up to 30% saving, for low cost
(potential for) economy of scale (to drive down costs)	3	Technology sufficiently mature
	17	

Capacity/ Supply Chain	Score	Comments
applicability	2	Requires cavity wall, of sufficient width and blockage free to enable free flow of insulation.
existing Scottish capacity/skills	4	Widely understood and applied
Scottish content	3	Existing EPS supply/manufacture in scotland unknown but opportunty to do this
potential for cross-sector involvement/benefit	3	EPS bead appliable as wall, floor and roof fill products + backfill, packaging etc.
scottish economic impact potential	2	Limited impact on productivity, and economic growth due to limited potential (based on maturity) and multiple competing systems. Some good niche areas of application.
	14	

Consumer	Score	Comments
user friendliness / practicality	4	Needs to be part of an integrated system whose operation and performance may not be clear to building occupants.
disruption	4	No different from most competing systems.
customer aceptance	4	Mature tech, with customer acceptance. Challenge from competing systems
savings on bills	4	Claims of 30% savings in heating bills
maintenance requirements	5	No anticipated maintenance requirements
health/wellbeing/comfort	4	Improved warmth, insulation with fabric breathability
existing consumer protection? (adequacy?)	5	25yr gurantee from CIGA
	30	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Availabilty of suitable buildings and surpassing incumbant CWI technologies
other relvant considerations/risks/opportunities		Comparatively mature technology
adaptability / future proofing		Once installed, little adaptability or future proofing. Would be messy to extend.
	113	

Sources and further reading:

Loose blown material blends

Loose insulation products, commonly produced from waste products, and blown into cavity. Examples include: Sheepswool with PET, Cellulose, mineral fibre, cotton waste

Technical	Score	Comments
Technology readiness	9	Products already exist.
Efficiency (product / technology efficiency)	4	Efficient insulation with lambda less than 0.04W/mK - some foam based products provide higher perfromancew
Reliability	4	Range of products so different physical characteristics, so some c are needed when selecting product.
(level of) Compatability with existing systems	4	Simple blown installation - differences in materials may mean some differences in installation practices.
complexity of systems/ their integration	4	Low complexity, and generally good compatability with existing buildings. Needs inspection to check cavity in good enough condition to allow installation. Potentioal issues with settlement of insulation, or incomplete fill.
risk/severity of unintended consequences	4	Poor inspection / installation practices can lead to damp issues. 'Materials generally inert, low off-gassing. Potential unintended consequences associated with moisture movement / rain penetration, and caqvity condition and poor installation can lead to thermal; bridged.
	29	

Environmental	Score	
(in-use) carbon saving potential	5	CWI is highly effective at saving thermal losses, and therefore making carbon savings
whole life environmental impact	5	Insulation formed from recycled materials
	10	

Policy / Regulation	Score	
compatability with Scottish policy	4	Consistent with regulations
compatability with current regulation	5	BBA certified products
compitibility with current assessment methodologies	4	Good compatability with assessment methodologies.
	13	

Monetary	Score	
capital costs	5	Varies on the specific source, but relatively low cost in terms of an energy efficiency improvement
life cycle costs	5	Should be install and forget - some potential for further action if fill settles, or is not installed correctly, or (certain products) is affected by water ingress.
carbon cost effectiveness (£ per tCO2 saved)	5	Very high - particularly where materials lock in carbon.
(potential for) economy of scale (to drive down costs)	3	Limited further cost reductions - costs can be reduced if applied as part of a development rather than individual homes.
	18	

Capacity/ Supply Chain	Score	
applicability	2	Requires cavity wall, of sufficient width and blockage free to enable free flow of insulation.
existing Scottish capacity/skills (people)	4	Widely understood and applied
Scottish content (materials, IP)	4	Installers, potential for certain materials to be based around using waste products from existing scottish industry - eg cellulose.
potential for cross-sector involvement/benefit	4	Potential to utilise a wider variety of waste/recycled/repurposed materials
scottish economic impact potential	3	Use of waste materials from existing industries has potential to benefit scottish economy as a whole as a result of improved efficiencies.
	17	

Consumer	Score	
user friendliness / practicality	4	Relatively easy to apply, generally low toxicityt.
disruption	4	Usually applies externally, so low disruption.
customer aceptance	4	High consumer acceptance of certain materials types, althgough some consumers may need to be assured re: low term biodegredation / fire consequences of certain materials selection.
savings on bills	4	Where cavities are of a sufficient size, potential savings can be large.
maintenance requirements	4	Low - unless materials / water ingress / poor cavity condition / poor installation.
health/wellbeing/comfort	4	Minimal off-gassing from most materials.
existing consumer protection? (adequacy?)	4	Existing testing of products likely to provide effective consummer protection, although consummers may need reassurance over: condition of cavity; completeness of installation fill; long term perfromance including in face of moisture ingress / condensation.
	28	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Observe material performance over time.
other relvant considerations/risks/opportunities		Poor performance arises where cavities have been poorly filled
adaptability / future proofing		Improves thermal envelope, making good use of the space, however would need to be disposed of when walls repurposed
	115	

Sources and further reading:

http://thermoflocinsulation.co.uk/cellulose-based-insulation/building-insulation-advantages.php
http://www.knaufinsulation.co.uk/products/blown-mineral-wool/supafil-carbonplus-cavity-wall-insulation
http://www.which.co.uk/reviews/insulation/article/cavity-wall-insulation/cavity-wall-insulation-damp-problems
http://www.energysavingtrust.org.uk/home-insulation/cavity-wall?gclid=EAIaIQobChMI9Kuqg6H-1AIVJbXtCh0CRQ6UEAAYAiAAEgLLffD_BwE

Vapour open wet render systems

Vapour open external wall insulation systems that help maintain the original hydroscopic properties of an existing wall structure. Particularly important for traditional and conservation buildings. Material examples include woodfibre, hemp and rock mineral wool.

Technical	Score	Comments
Technology readiness	9	Already commercially available and being installed - beyond 9
Efficiency (product / technology efficiency)	3	Significant savings potential, though often thermal performance is lower for same thickness of oil based insulants.
Reliability	4	Inert and good overall reliablility and moisture management properties once installed
(level of) Compatability with existing systems	4	Good compatability with most solid walls. Can accommodate uneven surfaces well. Some services, rain water goods etc can require rework.
complexity of systems/ their integration	4	Relative low complexity once specified. Details similar to other EWI solutions re. Eaves, verges etc.
risk/severity of unintended consequences	4	Low risk due to moisture management properties of insulation material
	28	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Significnalty reduced heat loss as well as typically a second life product, making use of recycled waste product
whole life environmental impact	5	Utilising a waste product and remains recyclable at end of life.
	9	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Applications to reduce energy use.
compatability with current regulation	5	Aligns well with section 6 regulation ambition to minimise fabric heat loss
compatibility with current assessment methodologies	5	Can be accommodated by DSM or SAP. Lambda values documented.
	14	

Monetary	Score	Comments
capital costs	3	Moderate costs due to relatively low volume production
life cycle costs	5	Second-life product and typically fully recyclable at end of life
carbon cost effectiveness (£ per tCO2 saved)	4	Good whole life carbon cost effectiveness
(potential for) economy of scale (to drive down costs)	4	High potential to drive down costs with increased volumes
	16	

Capacity/ Supply Chain	Score	Comments
applicability	4	Applicable to a good number of existing solid wall, timber frame and heritage buildings throughout scotland
existing Scottish capacity/skills	4	Aligns well with existing Scottish skills and capability. Similar to many other established EWI solutions
Scottish content	4	Could be readily produced in Scotland, particlarly wood fiber and a by-product of timber frame manufacturing.
potential for cross-sector involvement/benefit	3	Moderate potential - similar insulants may be used in floors, roofs + overlap with ventilation industry etc.
scottish economic impact potential	3	There could be a strong manufacture and install base for these products in Scotland.
	18	

Consumer	Score	Comments
user friendliness / practicality	4	Externally applied, no user intervention required
disruption	4	No different from most competing systems.
customer aceptance	4	Mature tech but general customer and wider supply chain awareness is low. Challenge from competing systems
savings on bills	4	
maintenance requirements	4	
health/wellbeing/comfort	4	Improved warmth, insulation with fabric breathability
existing consumer protection? (adequacy?)	5	most systems offer 25yr gurantee from SWIGA
	29	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Design and specification of the correct systems is essential
other relvant considerations/risks/opportunities		Comparatively mature technology with low uptake due to costs comparitively higher than more mass market oil based products. Competing against large manufacturers with much bigger marketing budgets
adaptability / future proofing		Would be difficult to adapt/modify once installed, thus requiring correct insulation thickness initially.
	114	

Sources and further reading:

Insulated rainscreen cladding systems

Though not precluding low-rise, rainscreen cladding is usually retro-fitted to buildings over two storeys as part of an overall refurbishment. Whilst the approach itself is not particulalry new or innovative, a typical rainscreen cladding system comprises of a series of layers through which numerous suppliers and manufacturers have introduced new materials and installation techniques. A typical rainscreen cladding system comprises of an outer skin or panel (the rainscreen), an air gap and a backing wall which typically comprises of an insulating layer and an air barrier. Innovations applicable to the Scottish stock include use of vapour open insulation within the system, use of low embodied energy rainscreen cladding panels and also framing and bracket solutions that reduce thermal bridging.

Technical	Score	Comments
Technology readiness	9	Commercially available systems exist. Continuous component parts/system level innovation.
Efficiency (product / technology efficiency)	4	Good scope to adjust insulation thickness for increased performance + introduce air barrier.
Reliability	3	Reliable and well tried and tested. Workmanship risks include the ability to use the cladding to cover up insulation jointing and continuity.
(level of) Compatability with existing systems	5	Standalone system, highly compatible with exisitng masonry, concrete and timber frame structures.
complexity of systems/ their integration	4	Low system complexity with rainscreen panels, ties/framework and the insulation itself all well understood
risk/severity of unintended consequences	3	Low risk of unintended consequences provided systems are specified and installed correctly.
	28	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Good energy savings potential in a wide range of applications - if installed correctly.
whole life environmental impact	3	Varies by system e.g. aluminium/plastic composite cladding panels and insulation used. Good protection to the existing structure, extending overall building life.
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Good link with policies to reduce energy use and fabric heat loss. Good visual uploft to blocks, also.
compatability with current regulation	5	Good link to existing regulations that encourage improved fabric performance. Section 6.
compitibility with current assessment methodologies	5	Improved u-values well catered for in SAP, iSBEM and similar.
	15	

Monetary	Score	Comments
capital costs	4	Relatively high capital costs, requiring whole block to be treated. Cost per unit (e.g. per flat) remains competitive.
life cycle costs	4	Significant whole life benefit in reduced fabric heat loss and also possibly reduced maintenance
carbon cost effectiveness (£ per tCO2 saved)	4	Good potential for cost effective reduction in energy / carbon
(potential for) economy of scale (to drive down costs)	3	Maginal gains to be made. Already a well established body of manufacurers, suppliers, installers with prelims (scaffolding, site arranagements) a significant cost.
	15	

Capacity/ Supply Chain	Score	Comments
applicability	5	Applicable to most medium to high rise buildings - residential and non-residential. Also scope for low rise applications.
existing Scottish capacity/skills	4	Product solutions already available, sold and installed in Scotland.
Scottish content	3	Limited though potential for framing, insulation and cladding panels to be Scottish manufactured.
potential for cross-sector involvement/benefit	3	Unclear potential other than reduced space heating loads supporting new low carbon heating solutions.
scottish economic impact potential	3	Moderate given wide applicability.
	18	

Consumer	Score	Comments
user friendliness / practicality	4	Cladding requires no occupant interaction once installed
disruption	4	Low disruption relative to alternative internal lining or external wet render approaches.
customer aceptance	4	Good given the visual uplift/modernisation combined with thermal performance improvement
savings on bills	3	Space heating savings and improved comfort but will vary based on extent of external wall area per flat.
maintenance requirements	4	Low maintenance requirements once installed. Good protection to the existing structure, extending building life.
health/wellbeing/comfort	4	Improved internal surface temperature of wall surface. More stable internal temperatures.
existing consumer protection? (adequacy?)	4	Most systems offer 25yr gurantee from SWIGA + existing infrastructure around SEEP and misselling, trading standards.
	27	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Pre-work survey, pull-out tests, detailed review of the existing structure. Overall system specification and build-up.
other relvant considerations/risks/opportunities		Surveying, system design, resident engagement, planning, skills, management and maintenance post install
adaptability / future proofing		Flexibility of system allows a wide range of application and is largely reversable/can be removed if required. Individual components e.g. rainscreen panels can be updated independently.
	110	

Sources and further reading:

http://www.greenspec.co.uk/building-design/rainscreen-cladding/
http://swissfacades.com/swiss-facades-provides-innovative-ways-to-reduce-thermal-bridging/
https://www.ancon.co.uk/whats-new/ancon-brings-low-energy-fixing-innovation-to-ecobuild-2013

Dynamic External Wall Insulation

Wall insulation which is an integral part of a ventilation system. Air is drawn through the insulation such that heat losses are minimised by extracting heat to air before it is introduced into the building. Has been used in aminal shelters in Scandinavia. Some trials in the UK.

Technical	Score	Comments
Technology readiness	**8**	Some trails (new build and refurbishment in the UK). A longer track record in Scandinavia in animal shelters.
Efficiency (product / technology efficiency)	2	Potentially a way to provide fresh air at low cost, practical field trials in the UK have provided mixed results - eg recent results from BRE / Leeds Beckett of a refurbished home showed it to be less energy efficient than a conventionally EWI property. The work also identified the potential for condensation risk.
Reliability	2	See above - success depends on application.
(level of) Compatability with existing systems	3	Needs to be part of an integrated approach to building refurbishment and control.
complexity of systems/ their integration	3	At one level DWI can be very simple - particularly for single spaces such as animal shelters. Its inclusion in more complex situations introduces potential for a significant performance gap.
risk/severity of unintended consequences	3	Inappropriate specification, installation, and operation can result in poor performance.
	21	

Environmental	Score	Comments
(in-use) carbon saving potential	2	In practice the results appear mixed, and there are multiple alternatives.
whole life environmental impact	3	Not appreciably worse than most other alternatives.
	5	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Potential applications to reduce energy use.
compatability with current regulation	3	Has implications for energy and ventilation control, although in practice there may be a significant performance gap.
compatibility with current assessment methodologies	3	Can be accommodated by DSM. Some limitations with SAP.
	10	

Monetary	Score	Comments
capital costs	3	Some cost penalties to competitor materials, although need to compare like for like (eg cost of ventilation components displaced by dynamic insulation.
life cycle costs	3	Practical experience is mixed as to whether energy savings and air quality benefits accrue.
carbon cost effectiveness (£ per tCO2 saved)	3	Good cost effectiveness for certain applications where the approach is successful.
(potential for) economy of scale (to drive down costs)	3	In most buildings need care to ensure good overall design.
	12	

Capacity/ Supply Chain	Score	Comments
applicability	3	Potential for new build and existing buildings (homes), although evidence of a field trial in the latter found poor practical performance.
existing Scottish capacity/skills	3	Design and modelling capability in Scotland.
Scottish content	3	See above
potential for cross-sector involvement/benefit	2	Limited potential.
scottish economic impact potential	2	Limited impact on productivity, and economic growth due to limited potential (based on experience) and multiple competing systems. Some good niche areas of application.
	13	

Consumer	Score	Comments
user friendliness / practicality	3	Needs to be part of an integrated system whose operation and performance may not be clear to building occupants.
disruption	4	No different from most competing systems.
customer aceptance	3	Customer may not be aware of the performance and operating requirements of the overall system.
savings on bills	3	Likely to be relatively small overall - depends on application.
maintenance requirements	3	Apart from very simple buildings, there is a need to maintain and operate ventilation system.
health/wellbeing/comfort	3	Potential for improved air quality - particularly for certain building types.
existing consumer protection? (adequacy?)	3	Whereas product warranties exist, the main issue is whether system performance guarantees can be provided.
	22	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Specification, alternatives, overall system performance.
other relvant considerations/risks/opportunities		Potential fabric condensation risk for some applications.
adaptability / future proofing		Limitations as to how the characteristics of the fabric can be changed.
	83	

Sources and further reading:

Off-site manufactured cassette systems

Off-site manufactured cassette systems/panels craned into position on site, improving quality control and reducing installation time for residents. Suited to low to medium rise buildings.

Technical	Score	Comments
Technology readiness	9	Commercially availible with fast growing market interest
Efficiency (product / technology efficiency)	5	Good quality control regimes and system improves ability to ensure continuity and good junction detailing
Reliability	4	Good quality control in manufacture with façade system life of 30+ years
(level of) Compatability with existing systems	3	Typically requires full wall and cassette roof system inclusive of windows and doors
complexity of systems/ their integration	3	Moderately simple once working at volumes. High initial set-up costs and steep learning curve for industry
risk/severity of unintended consequences	3	Moderate performance risks in terms of thermal by-pass and insulation continuity
	27	

Environmental	Score	Comments
(in-use) carbon saving potential	5	Significant thanks to whole fabric upgrade - walls and roof
whole life environmental impact	4	Low due to systems typically being based upon timber and common recycleable building components, façade systems
	9	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Fabric improvement measure suited to a high proportion of the scottish building stock
compatability with current regulation	5	Directly compatible, though regulations don't mandate such high levels of performance
compatibility with current assessment methodologies	4	Improved fabric U values and airtightness able to be directly reflected in both rdSAP, full SAP and iSBEM
	14	

Monetary	Score	Comments
capital costs	3	Relatively high capital cost but which tend to be offset against other planned works such as replacement glazing, façade repairs or re-roofing. Volume deployment required in order to be cost effective
life cycle costs	4	Low whole life cost due to 60+ year lifespan
carbon cost effectiveness (£ per tCO2 saved)	4	Good due to extent of whole life savings (space heating, cooling and comfort, health benefits)
(potential for) economy of scale (to drive down costs)	4	High potential for improved economy of scale. Presently a low volume manufactured solutions with limited manufacturing capacity and suppliers/installers.
	15	

Capacity/ Supply Chain	Score	Comments
applicability	4	Good applicability, high number of well suited non-traditional low and medium rise stock
existing Scottish capacity/skills	3	Limited deployment of the product in Scotland with very few installers actively aware/offering the solution
Scottish content	4	Good potential with panels based on timber and potentially able to come from existing scottish timber frame manufacturing facilities
potential for cross-sector involvement/benefit	4	High potential to involve others and for the fabric solutions to inform serving and renewable strategies e.g. Energiesprong
scottish economic impact potential	4	High potential for Scottish leadership in this area
	19	

Consumer	Score	Comments
user friendliness / practicality	4	No user intervention once installed
disruption	4	Only moderate disruption during installation. Majority of works is external, though access for cranes required
customer aceptance	4	Potential for high consumer engagement due to aesthetic appeal of the full fabric solution (link to regeneration)
savings on bills	5	Very high lifetime saving on bills due to full fabric solution
maintenance requirements	4	Limited beyond what would typically be required of a more conventional fabric solution.
health/wellbeing/comfort	4	Good. Improved internal comfort and increased floor surface temperatures.
existing consumer protection? (adequacy?)	3	Only existing infrastructure around SEEP and miselling, trading standards. Performance in use protection/warranties are part of Energiesprong but would need looking at for alternative but similar approaches.
	28	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Ensuring complete system design and integration with existing systems/services
other relvant considerations/risks/opportunities		Surveying, system design, resident engagement, planning, skills, management and maintenance post install
adaptability / future proofing		Significant future proofing opportunity provided the specification is high enough.
	112	

Sources and further reading:

External paints, plaster and renders

A number of solutions exist, however are largely limited in effectiveness of insulation based on the thickness of the material. E.g. Cork embedded renders

Technical	Score	Comments
Technology readiness	9	A range of produicts already exist - these tend to be based on either ways of reducing heat loss thopugh embedding insulating materials in the render; or increasing the albedo of external building elements to reduce solar gain (and hence overheating in summer). Some low e-paints for internal use available, although limited independent testing, and much scepticism.
Efficiency (product / technology efficiency)	2	Most products have limited independent testing, and hence energy efficiency measures are hard to assess on the basis of cost effectivbeness.
Reliability	3	Limited test data / long term resilience.
(level of) Compatability with existing systems	5	Potentially high compatability.
complexity of systems/ their integration	4	
risk/severity of unintended consequences	2	Lack of independent test data on many products mean that energy savuings likely not to be achieved. Amenity may be affected. Poducts applied to building may change moisture movement through building.
	25	

Environmental	Score	
(in-use) carbon saving potential	2	Limited by thickness. Increased albedo - clear impact, although limited benefits in Scotland.
whole life environmental impact	2	
	4	

Policy / Regulation	Score	
compatability with Scottish policy	2	Lack of test data, and multiple concerns over consumer protection, means limited applicability to Scottish policy.
compatability with current regulation	2	As above - lack of independent test data raises questions over their compatibility.
compatibility with current assessment methodologies	4	Should be amenable to current assessment methodologies.
	8	

Monetary	Score	
capital costs	4	Low cost measure - although questionable performance for many products in this space.
life cycle costs	2	Uncertainty over savings imples potentially high liffe cycle costs.
carbon cost effectiveness (£ per tCO2 saved)	2	At best unclear for most paint products
(potential for) economy of scale (to drive down costs)	3	Although already influenced by economies of scale
	11	

Capacity/ Supply Chain	Score	
applicability	3	For externally rendered buildings
existing Scottish capacity/skills (people)	3	Applicability of thin render systems will require care to avoid thermal bridghe effects.
Scottish content (materials, IP)	3	Installer skills
potential for cross-sector involvement/benefit	4	
scottish economic impact potential	1	Low potential for savings.
	14	

Consumer	Score	
user friendliness / practicality	4	Although potentially easily applied, performance questions remain.
disruption	4	Low disruption.
customer acceptance	3	Lack of test data, visual impact may adversely affect consumer acceptance.
savings on bills	1	Likely to be low or nil for some products, and at best limited due to thickness of render.
maintenance requirements	3	Unclear at this stage.
health/wellbeing/comfort	3	Unlikely to have a significant negative impact.
existing consumer protection? (adequacy?)	2	Lack of independent test data (paints), and long term impact assessment of thin external renders and their longevity.
	20	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Received good marketing and some products effective
other relvant considerations/risks/opportunities		Requires extenally rendered building, not as beneficial as externally mounted EWI panels
adaptability / future proofing		Applicable to externally rendered buildings
	82	

Sources and further reading:

https://www.diasen.com/sp/en/p/diathonite-evolution.3sp
https://www.scientificamerican.com/article/benefits-of-insulating-paint/

Offsite Manufactured (OM) Cut Panel Systems

A couple of proprietry OM technologies are available currently under licence, providing bespoke designed IWI, laser cut for ease of install.

Technical	Score	Comments
Technology readiness	9	Patents filed, installers lined up, initial systems installed
Efficiency (product / technology efficiency)	4	*Improvement on building energy efficiency
Reliability	4	No reason to assume degredation in performance or requirement to regularly service
(level of) Compatability with existing systems	4	Compatible with most walls due to laser scanning and precision cutting
complexity of systems/ their integration	3	Complex installation due to fitting to walls, although no electrical or moving parts
risk/severity of unintended consequences	4	
	28	

Environmental	Score	Comments
(in-use) carbon saving potential	4	NEF report identified major potential for energy savings
whole life environmental impact	3	Little applicability for recycling or reuse
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Energy savings potential, health and comfort benefits
compatability with current regulation	5	Building Regulations requirements.
compatibility with current assessment methodologies	5	SAP includes IWI
	15	

Monetary	Score	Comments
capital costs	4	Higher than CWI, but cheaper than most advanced insulation materials
life cycle costs	3	Due to bespoke product, no abilty to reuse
carbon cost effectiveness (£ per tCO2 saved)	5	Significant potential to reduce carbon, if properly specified, in solid wall homes where other solutions are unviable
(potential for) economy of scale (to drive down costs)	4	Scale up would improve system efficiency
	16	

Capacity/ Supply Chain	Score	Comments
applicability	2	Widely applicable, although limited attractiveness due to losing internal floor space. Good for solid wall properties.
existing Scottish capacity/skills (people)	1	Installers available, although minimal number currently
Scottish content (materials, IP)	2	Minimal, although Scottish specification, design and fitting valuable
	3	Cross building sectors - yes.
scottish economic impact potential	3	Rate of uptake of units is limited by market - potential for sizable market in solid wall buildings
	11	

Consumer	Score	Comments
user friendliness / practicality	4	Ease of installation on site, one day disruption. Passive system once installed therefore no training required for operation, some training about impacts on heating demand would be beneficial.
disruption	4	One day disruption
customer aceptance	3	Moderate due to space reduction issues
savings on bills	4	Good potential saving on heating bills
maintenance requirements	4	Minimal
health/wellbeing/comfort	4	Improved comfort
existing consumer protection? (adequacy?)	3	Varies by product and solution but SWIGA, BBA etc as per other solutions. Limited in-use performance protection.
	26	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Uptake dependent on consumer willingness to
other relvant considerations/risks/opportunities		Changes in buildings use / neighbouring developments may mean that the particular units selected on day one are no longer optimal.
adaptability / future proofing		Limited flexibility due to reduction in internal floor space, could be removed or added to
	103	

Sources and further reading:

Vacuum wall panel insulation

Vacuum insulation - in this instance for floors, with wider product availability and applicability for many applications with a need for thin load bearing applications to reduce thermal bridging / heat loss.

Technical	Score	Comments
Technology readiness	9	Number of mainstream maufacturers - eg Kingspan. http://www.kingspaninsulation.co.uk/Products/Optim-R/Optim-R/Overview.aspx
Efficiency (product / technology efficiency)	3	Highly efficient as an insulator, although with potential for panels to lose effectiveness if vacuum is lost due to eg occupant action.
Reliability	3	Vacuum should be retained over time - and hence perfromance retained - although occupnt / contractor effects might compromise vacuum in practical use.
(level of) Compatability with existing systems	3	Good compatability, although nature of product does limit capacity to apply (ie have to use fixed panel sizes with some filler strips available.
complexity of systems/ their integration	3	Nature of produce limited flexibility.
risk/severity of unintended consequences	2	Severe risks to perfromance if vacuum is compromised - occupiers will need to be advised as to what they cannot do (eg drill holes in panel). Possible (low) risk of thermal bridging associated with practical installation. Modular approach limited impact of such actions.
	23	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Thinkness of vacuum insulation products make them a viable option for retrofit where space is a limiting factor.
whole life environmental impact	4	No ODP, 90% recyclable, 0 GWP, moderate emodied carbon
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Fabric improvement measure suited to a significant proportion of the scottish building stock where there are a limited pool of alternative (thin) products
compatability with current regulation	5	Directly compatible, though regulations don't mandate such high levels of performance
compatibility with current assessment methodologies	5	Improved fabric U value able to be directly reflected in both rdSAP, full SAP and iSBEM
	14	

Monetary	Score	Comments
capital costs	2	Relatively high capital cost in comparison to other floor insulation options, though low if as an alternative to complete slab replacement
life cycle costs	3	Low whole life cost due to 60+ year lifespan, although question as to whether this will be achieved in practice due to vacuum integrity vulnerability
carbon cost effectiveness (£ per tCO2 saved)	4	Moderate and directly linked to total surface area and existing slab build-up.
(potential for) economy of scale (to drive down costs)	4	High potential for improved economy of scale. Presently a low volume manufactured solution with limited manufacturing capacity and suppliers/installers.
	13	

Capacity/ Supply Chain	Score	Comments
applicability	4	Good applicability, high number of uninsulated solid floors in Scottish stock
existing Scottish capacity/skills	2	Limited deployment of the product in Scotland with very few installers actively aware/offering the solution
Scottish content	1	TBC - Kingspan manufacture in Herefordshire
potential for cross-sector involvement/benefit	3	Potential to integrate into floor coverings, DIY solutions, engage social housing providers in relation to void periods etc.
scottish economic impact potential	3	The key issue is how to provide solutions which minimise energy and potential health impact - key here is appropriate selection, installation, and integration - opportunities for Scottish leadership in this area reflecting legislative and regulatory leadership.
	13	

Consumer	Score	Comments
user friendliness / practicality	2	Solutions are limited by nature of vacuum panels - although applications do exist, and the nature of the product makes it very well suited to a wide range of circumstances.
disruption	3	Low disruption associated with alternatives for most alternatives to insulating floors.
customer aceptance	3	Low customer awareness of the technology - out of sight. Occupiers need to be informed as to limitations when product is in use.
savings on bills	3	Proportionate to size of floor. Potential installation edge effects may result in continued (low)
maintenance requirements	4	No maintenance - unless panel is pierced, in which case there would be a requirement to replace panel if perfromance is to be mantained.
health/wellbeing/comfort	5	Off-gasing potential low. Thickness makes a positive contribution to amenity. Applications can limit cold bridging, and hence reduce fabric and health effects associated with condensation.
existing consumer protection? (adequacy?)	3	As with other products limited protection where installation is inappropriate, poorly done.
	23	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Thickness of slab, although small, may still limit practical implementation; perfromance in use may suffer if occupiers / trades people are not aware of its requirements; training / competence of installers; handover to occupier(s)
other relvant considerations/risks/opportunities		Will reduce the thermal mass of the building by isolating the floor slab - overheating risk slightly increased as a result. 'Potential to reduce condensation risk associated with thermal loss of existing uninsulated solid ground floors.
adaptability / future proofing		Vacuum panels are inherently limited in their ability to be adjusted once manufactured (eg cut to size). Excellent thermal perfromance 0.007w/mk
	93	

Sources and further reading:

PU Spray Foam Systems

There are a range of products based around spray foams, with some novel means of application (eg robotics) being to be tested. Can be applied to new or existing buildings. Key benefit is the flexibility of the approach. Unclear how such approaches will perform in the long term - as the approach essentially hides materials, and hence potentially, defects.

Technical	Score	Comments
Technology readiness	9	Commercially available systems exist. Some means of applications (eg robotics) are TRL 6.
Efficiency (product / technology efficiency)	4	Relatively cheap and flexible product.
Reliability	3	Reliability depends on expertise of installer, and particular installation. Long term consequences to fabric are unclear.
(level of) Compatibility with existing systems	5	Comparable to many existing systems - the benefit of the approach that it is very flexible with a wide range of potential applications.
complexity of systems/ their integration	3	How the spray foam will influence building durability / future repair costs / procedures is unclear at present.
risk/severity of unintended consequences	2	Poor, or ill considered installation can risk increased fabric damage.
	26	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Good energy savings potential in a wide range of applications - if installed correctly.
whole life environmental impact	2	Limited existing potential for recycling / re-use. Offgasing. Zero ODP, >0 GWP.
	6	

Policy / Regulation	Score	Comments
compatibility with Scottish policy	5	Good link with policies to reduce energy use.
compatibility with current regulation	3	Variations in application can be expected to result in differences in as built cf as designed u-values.
compatibility with current assessment methodologies	3	See above
	11	

Monetary	Score	Comments
capital costs	5	Relatively low costs for its area of applicability.
life cycle costs	3	Unclear consequences on long term fabric performance / life.
carbon cost effectiveness (£ per tCO2 saved)	4	Good potential for cost effective reduction in energy / carbon
(potential for) economy of scale (to drive down costs)	3	Nature of products relies on skills of operators, specifiers (and potentially the robots). Increased numbers of trained operators should reduce costs.
	15	

Capacity/ Supply Chain	Score	Comments
applicability	4	Wide applicability across several building sectors.
existing Scottish capacity/skills	4	Product already available and sold in Scotland.
Scottish content	4	cottish specifiers / installers.
potential for cross-sector involvement/benefit	3	Unclear potential
Scottish economic impact potential	3	Cost effective energy reduction - good (refurbishment, some new homes), main R&D associated with robotics not based in Scotland.
	18	

Consumer	Score	Comments
user friendliness / practicality	3	Consumers may not be aware of potential quality risks / long terms ramifications.
disruption	4	Low disruption relative to alternative approaches.
customer acceptance	3	Already accepted by many. Availability and relative risks associated with alternatives not well understood by most consumers.
savings on bills	4	When applied correctly - good energy cost reductions are possible.
maintenance requirements	3	Potentially low - although repair / maintenance of building components could be affected in long term.
health/wellbeing/comfort	4	Improved heat retention provides afordable warmth. Some off gassing potential.
existing consumer protection? (adequacy?)	3	Installers and manufacturers waranties - although long term impacts unclear if poorly specified.
	24	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Appropriate selection, application, trained operators, long term impact on accessibility and maintenance of associated fabric elements.
other relvant considerations/risks/opportunities		Potential to limited future retrofit applications.
adaptability / future proofing		Flexibility of system allows a wide range of application. Unclear how it might limit future component selection / fitting, given the adhesive nature of the product. May prove less flexibl if future products emerge which need to integrate with PUV insulation layer.
	100	

Sources and further reading:

Internal insulation stud systems

Insulation applied internally to external heat loss walls - stud systems allowing for an optimum build up of insulation without changing the external appearance of the building. Innovation includes the type of insulation used and also the framing/batenning system e.g. light guage steel framing, insulation backed studs and use of insulants such as cellulose, sheepwool, mineral fibre batts and woodfirbre board.

Technical	Score	Comments
Technology readiness	9	Commercially available systems exist but with innovations and enhancements coming on stream
Efficiency (product / technology efficiency)	3	Fleible in terms of thickness of build-up but overall thickness limited by availible internal space
Reliability	3	Reliability depends on qualty of installation and specification of system used. Long term risks are known to exisit in relation to moisture management, for example.
(level of) Compatibility with existing systems	3	Internal linings can require services to be removed, remounted and/or extended e.g rads, plug sockets. Compatibility with existing wall structure and moisture management properties is also key
complexity of systems/ their integration	4	Stud systems relatively low complexity and similar to approaches used by trades for internal walling and partitions.
risk/severity of unintended consequences	3	Poor inappropriate specification can lead to significant moisture management issues. Risk reduced with good design.
	25	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Good energy saving potential in a wide range of applications if specified and installed correctly.
whole life environmental impact	4	Will depend on exact product and insulant used but generally a lightweight system based on a relatively low embodied energy insulant e.g. mineral fibre, wood fibre, sheeps wool, cellulose
	8	

Policy / Regulation	Score	Comments
compatibility with Scottish policy	5	Good link with policies to reduce energy use and fabric heat loss. Good visual uploft to blocks, also.
compatibility with current regulation	5	Good link to existing regulations that encourage improved fabric performance. Section 6.
compatibility with current assessment methodologies	5	Improved u-values well catered for in SAP, iSBEM and similar.
	15	

Monetary	Score	Comments
capital costs	5	Moderate capital costs - comparible to alternatives such as other IWI and EWI solutions
life cycle costs	4	Significant whole life benefit in reduced fabric heat loss. Inert, fit and forget.
carbon cost effectiveness (£ per tCO2 saved)	4	Good potential for cost effective reduction in energy / carbon, reducing heat loss through walls for their lifetime.
(potential for) economy of scale (to drive down costs)	4	Although there are a number of systems already on the market, good opportunties to drive down costs through volume production, remain.
	17	

Capacity/ Supply Chain	Score	Comments
applicability	4	Wide applicability across several building sectors. - residential and non-residential
existing Scottish capacity/skills	4	Simplicity of IWI systems make good use of existing skills. Biggest gap is in design and specification. Buyer awareness of importantace to get things right.
Scottish content	3	Scottish specifiers / installers. Limited existing scottish made product.
potential for cross-sector involvement/benefit	4	Strong potential to align IWI programmes with home improvement/fit outs etc. Stud systems can also cover up services - plumbing and electrics etc.
Scottish economic impact potential	3	IWI a popular solution for conservation buildings. Moderate economic impact potential depending on exent of the system that could be produced in Scotland and shofting from specialist installation to mainstream.
	18	

Consumer	Score	Comments
user friendliness / practicality	4	Inert once installed with no user interaction required
disruption	2	High disruption given possible need to move furniture and relocate services from internal heat loss walls.
customer acceptance	3	Moderate due to space reduction issues. Benefit = redecoration and cover up of uneven, crumbly plaster walls.
savings on bills	4	When applied correctly - good energy cost reductions are possible.
maintenance requirements	4	Minimal
health/wellbeing/comfort	4	Improved heat retention provides afordable warmth. Some off gassing potential depending on insulants used
existing consumer protection? (adequacy?)	4	Installers and manufacturers waranties - although long term impacts unclear if poorly specified. Most systems offer 25yr gurantee from SWIGA + existing infrastructure around SEEP and misselling, trading standards.
	25	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Appropriate specification and deisgn, application, use of trained installers is key. Long term impact on moisture management properties and thermal behaviours at key junctions etc. remain a concern for some products in some cases, hence importance of correct design and specification.
other relvant considerations/risks/opportunities		Surveying, system design, resident engagement, planning, skills, management and maintenance post install
adaptability / future proofing		Flexible and adaptable in the sense that the IWI may be readily removed. Good opportunities to affix plasterboards horizontally in flood zones.
	108	

Sources and further reading:

http://www.greenspec.co.uk/building-design/internal-insulation/

Internal paints, wall paper and plaster coatings

A number of solutions exist many of which are based around claims that the paints have a low emissivity. Any impact as a more traditional insulating product is limited in effectiveness odue to the thickness of the material.

Technical	Score	Comments
Technology readiness	9	Products that purport to be insulating paints already exist. Limited independent testing to date, and multiple claims of consumer deception.
Efficiency (product / technology efficiency)	1	Limited independent test data as to their effectiveness. Multiple claims as to questionable performance.
Reliability	3	Limited long term performance data.
(level of) Compatability with existing systems	5	It's a paint - so cant be used with decorative tiles etc.
complexity of systems/ their integration	3	Integration iussues associated with lack of perfromance data.
risk/severity of unintended consequences	2	Limited lindependent long term perfromance data and manufacturer claims which it is claimed mislead the consumer make this a risk area.
	23	

Environmental	Score	
(in-use) carbon saving potential	1	Limited independent savings data which can be used to assess product.
whole life environmental impact	1	As above.
	2	

Policy / Regulation	Score	
compatability with Scottish policy	2	Lack of independent test data, and media report of consumers being misled imply poor compability with policy.
compatability with current regulation	2	As above.
compatibility with current assessment methodologies	3	Limited independent test data. Some question as to whether existing assessment methodologies for wall insulation assessment are wholly applicable given that the low e nature of the product.
	7	

Monetary	Score	
capital costs	4	Low cost product.
life cycle costs	1	Unproven benefits, hence potential low payback.
carbon cost effectiveness (£ per tCO2 saved)	1	As above.
(potential for) economy of scale (to drive down costs)	2	As a paint - limited potential top further reduce costs.
	8	

Capacity/ Supply Chain	Score	
applicability	5	High applicability (it's a paint).
existing Scottish capacity/skills (people)	3	High skills level in terms opf applicability. Low in terms of whether it should be used.
Scottish content (materials, IP)	2	Low involvement.
potential for cross-sector involvement/benefit	3	Some potential - limited by a lack of independent test data.
scottish economic impact potential	1	Based on lackl of independent test data - low impact.
	14	

Consumer	Score	
user friendliness / practicality	4	Easy to apply.
disruption	4	Internal paint - so some disruption.
customer aceptance	2	Lack of independent long term performance evaluation.
savings on bills	1	Likely to be small.
maintenance requirements	4	Unclear - but in theory - low.
health/wellbeing/comfort	3	Range of p[aint products, no clear link to off-gassing based on low e materials typically used.
existing consumer protection? (adequacy?)	1	Lack of independent long term testing, and potential costs and benefits to the consumer.
	19	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Received good marketing, but overall low impact technology despite being adaptable
other relvant considerations/risks/opportunities		Low performing and numerous works to identify benefits have come up short of firm conculsions
adaptability / future proofing		Broadly adaptable
	73	

Sources and further reading:

https://en.wikipedia.org/wiki/Insulative_paint

Phase Change Materials

Series of products available which embed phase change materials in the building fabric as a means of increasing thermal mass. When combined with night purge these systems can reduce, or at the margins eliminate, the need for air conditioning.

Technical	Score	Comments
Technology readiness	9	Series of products already available - eg thermacool range
Efficiency (product / technology efficiency)	3	Has applicability particularly at the margins when a/c is only just necessary, or alternatively where high thermal mass is required for stable temperature control.
Reliability	4	Early systems degraded over time - current generation come with 15 or 20 year warranties.
(level of) Compatability with existing systems	4	Can be used as a part of a design solution which focuses on the avoidance of a/c, or alternatively is looking to ensure stable temperature control. The main challenge is overall system design.
complexity of systems/ their integration	3	Main complexity is overall system design and operation to ensure the phase change material works as part of a system.
risk/severity of unintended consequences	4	Some potential - early materials had a fire risk (largely now overcome); the lag introduced into the system may negate the need for rapid control response if that becomes an issue. If the overall system's approach doesn't function as designed then in theory overheating issues can under extreme conditions be exacerbated.
	27	

Environmental	Score	Comments
(in-use) carbon saving potential	2	Good savings potential where used to avoid air conditioning, however the potential range of buildings where this is applicable is limited. Some applications involve incorporating phase change material in ceiling void of non-dom buildings - although limited uptake although technology available for > 10 years.
whole life environmental impact	3	Limited consideration to re-use / recycling in practice. Old materials had fire risk - new ones much safer. Most PCM have low toxicity. Zero ODP, zero GWP.
	5	

Policy / Regulation	Score	Comments
compatability with Scottish policy	3	Can contribute to reduced energy use, particularly at the margins (eg where a/c being considered.
compatability with current regulation	3	No specific requirement for high thermal mass.
compatibility with current assessment methodologies	3	Can be included in DSM models. SAP more limited.
	9	

Monetary	Score	Comments
capital costs	4	Relatively low cost - particularly if compared to a/c costs.
life cycle costs	4	Low maintenance / implications in use of well designed products.
carbon cost effectiveness (£ per tCO2 saved)	3	Reasonably good savings - if part of an avoidance of a/c strategy.
(potential for) economy of scale (to drive down costs)	3	Limited use at present - some cost reduction potential if produced at greater scale.
	14	

Capacity/ Supply Chain	Score	Comments
applicability	2	Main benefit is at the margins, and as part of an integrated approach to eg avoidance or minimisation of a/c system.
existing Scottish capacity/skills	4	Main capability is in the design of integrated systems, which include PCM.
Scottish content	3	See above.
potential for cross-sector involvement/benefit	2	Limited - generic approach may have some applications in other industries
scottish economic impact potential	2	Relatively small impact due to limited number of applications where the technology will be particularly relevant.
	13	

Consumer	Score	Comments
user friendliness / practicality	4	Fairly low tech approach - needs to be integrated with other systems - which may not always be understood by occupants.
disruption	3	Limited - so long as used as part of a major refurb / new build.
customer aceptance	4	Limited consumer feedback.
savings on bills	2	Significant where a/c avoided - less so in other applications.
maintenance requirements	3	Modern PCR should require no maintenance - although usually used as part of a system which needs to be properly specified, operated and maintained.
health/wellbeing/comfort	3	Where applied potential benefit from avoidance of temperature extremes. Some work suggests occupants are best served by a temperature variation across day / year, and PCM run a little counter to this.
existing consumer protection? (adequacy?)	3	Product liability / warranties from reputable manufacturers ok. Key limitation is whether the PCM is part of a functioning services strategy which works.
	22	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Integrated as part of services strategy - which is specified, commissioned, maintained and operated correctly.
other relvant considerations/risks/opportunities		Wide range of PCM used, some original products had poor long term operating characteristics, provided a fire risk, and had the potential for some limited toxicity - specifiers need to check PCM material and impacts.
adaptability / future proofing		Usually a limited potential to upgrade (add new plasterboard / ceiling tiles).
	90	

Sources and further reading:

Ultra-thin insulation for hard to treat areas

Refers to ultra-thin insulation products, purposely designed to insulate hard to treat areas such as window reveals

Technical	Score	Comments
Technology readiness	9	Range of products already exist.
Efficiency (product / technology efficiency)	4	These products are partly designed to reduce condensation risk as well as save energy.
Reliability	4	Depends on product - mainstream manufacturers should produce products which are reliable, the key question is whether these products can be fitted in line with manufacturers requirements. Hard to treat tends to equate with hard to install. Some products eg vacuum panels - can have their perfromance compromised by faulty practice or operating practices.
(level of) Compatability with existing systems	4	Good compatabability with most systems - need to be designed / manuafcatured to address key hard to treat applications.
complexity of systems/ their integration	4	Design and installation practices need to be addressed.
risk/severity of unintended consequences	4	Some potential for poor design, install, and operating practices to adversely affect performance in use.
	29	

Environmental	Score	
(in-use) carbon saving potential	4	Limited by thickness and external area. Need approach as part of a wider strategy so as to avoid condensation.
whole life environmental impact	4	As above.
	8	

Policy / Regulation	Score	
compatability with Scottish policy	4	Consistent with Scottish policies - energy efficiency, health, and wellbeing.
compatability with current regulation	4	Most productrs are compatable.
compatibility with current assessment methodologies	4	Compatable. Ae key issue is field realised perfromance rather than off-site tests.
	12	

Monetary	Score	
capital costs	3	Varies on the technology, however some are aerogel based, therefore increase price.
life cycle costs	3	Depends on technology - and resilience in use.
carbon cost effectiveness (£ per tCO2 saved)	3	Avoidance of condensation facilitates carbon savings more generally.
(potential for) economy of scale (to drive down costs)	4	Wider adoption / familiarisation should reduce need for bespoke solutions and skills training.
	13	

Capacity/ Supply Chain	Score	
applicability	5	Any building with a window reveal
existing Scottish capacity/skills (people)	4	Many approaches require no additional skills.
Scottish content (materials, IP)	3	Installers
potential for cross-sector involvement/benefit	3	Likely to be installed as part of a wider package of measures.
scottish economic impact potential	4	Required to manage condensation risk - and so facilitate refurbishment performance in use.
	19	

Consumer	Score	
user friendliness / practicality	4	Designed for hard to treat areas - although actuial installation may still be problematic.
disruption	4	Site dependant.
customer acceptance	4	Should be high - although cost issues may lead to low cost solutions reduce the size of the market.
savings on bills	3	Savings likely to be small in themselves - although an important element of whole house refurbishment.
maintenance requirements	4	Depends on technology. Many are fit and forget, some are impacted by potential operational issues.
health/wellbeing/comfort	4	Should be beneficial - reduced condensation risk, and hence improved health / wellbeing.
existing consumer protection? (adequacy?)	4	Constraint is less the performance of the product, more the performance of the system as a whole.
	27	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Requires increased market awareness of the need for reveal insulation to encourage market take up
other relvant considerations/risks/opportunities		Potential to be a large market supporting other IWI installations. Push for marketing needed.
adaptability / future proofing		Improves thermal envelope, making buildng more suitable for colder climates.
	108	

Sources and further reading:

http://www.proctorgroup.com/images/downloads/Thermal-Insulation/Spacetherm/Proctors%20-%20Spacetherm%20WRB%20-%20datasheet.pdf
https://irp-cdn.multiscreensite.com/001c71f9/files/uploaded/THERMASHIELD-PDF.pdf
http://www.knaufinsulation.co.uk/products/blown-mineral-wool/supafil-carbonplus-cavity-wall-insulation

Blown/loose fit cold roof insulation

Loose insulation products, commonly produced from waste products, and blown or spread in ceiling/roof voids. Examples include: Sheepswool with PET, Cellulose, mineral fibre, cotton waste.

Technical	Score	Comments
Technology readiness	9	Products already exist
Efficiency (product / technology efficiency)	4	Efficient insulation with lambda less than 0.04W/mK
Reliability	4	Most products have excellent long term reliability
(level of) Compatability with existing systems	5	Simple blown or spread installation
complexity of systems/ their integration	5	Assuming loft access
risk/severity of unintended consequences	3	Risks if incorrect PPE used; risks if installation practices are poor - condensation and associated fabric damage.
	30	

Environmental	Score	
(in-use) carbon saving potential	4	Will depend on level of roof heat loss area to be insulated but generally very good savings potential.
whole life environmental impact	5	Insulation formed from recycled materials
	9	

Policy / Regulation	Score	
compatability with Scottish policy	4	Reduction in energy use.
compatability with current regulation	5	Aligns well with section 6 regulation ambition to minimise fabric heat loss. BBA certified solutions.
compatibility with current assessment methodologies	4	Can be accommodated by DSM or SAP. Lambda values documented.
	13	

Monetary	Score	
capital costs	5	Varies on the specific source, but relatively low cost in terms of an energy efficiency improvement
life cycle costs	5	Generally very good - mostly fit and forget. Ability to remediate disruptive activities in loft are very high.
carbon cost effectiveness (£ per tCO2 saved)	5	Low cost, potentiall high savings.
(potential for) economy of scale (to drive down costs)	3	Already applied, limited potential for additional savings - unless roilled out at a development cf an individual building level.
	18	

Capacity/ Supply Chain	Score	
applicability	2	Requires loft or ceiling void, or pocket created in rafter void. Most voids already filled.
existing Scottish capacity/skills (people)	5	Readily applied by existing operatives.
Scottish content (materials, IP)	4	Installers, some products arise as a biproduct of Scottish industry
potential for cross-sector involvement/benefit	3	Potential to utilise a wider variety of waste/recycled/repurposed materials
scottish economic impact potential	3	Potential to increase use of waste material
	17	

Consumer	Score	
user friendliness / practicality	4	Simple material, easy to install.
disruption	4	Relatively low disruption - so long as loft space is not used as a store. Need to take care with power cables.
customer aceptance	3	Should be high - although may need to reassure customer that the material is not a fire hazard, and of its long term perfromance and absence as a foodstuff for little beasties.
savings on bills	4	Potentially high - although most lofts already filled.
maintenance requirements	4	Usually low.
health/wellbeing/comfort	4	Most products have no negative consequences.
existing consumer protection? (adequacy?)	4	Installation and selection practices and quality control remain issues where further protection might be desirable.
	27	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Observe material performance over time.
other relvant considerations/risks/opportunities		Poor performance arises where ceiling voids have been poorly filled
adaptability / future proofing		Can be removed or readily added to, depending on requirements
	114	

Sources and further Reading:

http://thermoflocinsulation.co.uk/cellulose-based-insulation/loose-fill-insulation.php

Temperate Roofs

Encompasses a range of technologies which increase the internal thermal mass of a building envelope by embedding Phase Change Material (PCM) into the ceiling construction, e.g. ceiling tiles or TubeICE

Technical	Score	Comments
Technology readiness	9	Technologies / approach already exists.
Efficiency (product / technology efficiency)	3	Benefits when applied in temporary occupied buildings, will reduce AC demand
Reliability	4	No moving parts therefore reliable, however some are liable to separation and performance may diminish overtime
(level of) Compatability with existing systems	4	Passive technology, therefore simple application, however requires complementary HVAC design to fully achieve benefits
complexity of systems/ their integration	4	Relatively simple installation
risk/severity of unintended consequences	3	Depends on the technology used. Most unintended risks designed out. Poor HVAC design could undermine performance
	27	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Effective savings possible, with complementary AC strategy
whole life environmental impact	4	Depends on PCM chosen, some pertroleum based, some plant oil based
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Addresses energy efficiency
compatability with current regulation	4	Compatible with regulation
compatibility with current assessment methodologies	2	Can only be modelled using certain modelling packages
	11	

Monetary	Score	Comments
capital costs	3	Relatively expensive, although costs coming down
life cycle costs	3	Moderate
carbon cost effectiveness (£ per tCO2 saved)	2	Effective savings achievable with complementatry HVAC strategy, however could be cost prohibitive
(potential for) economy of scale (to drive down costs)	4	Would benefit from economies of scale
	12	

Capacity/ Supply Chain	Score	Comments
applicability	3	Effective in subsection of non-domestic building stock
existing Scottish capacity/skills	4	For installation, capability exists, manufacturing is UK or Intl based
Scottish content	3	Installation, maintenance - local.
potential for cross-sector involvement/benefit	2	May benefit from manufacturing techniques and chemical synthesis, however largely a simple product requiring little interaction
scottish economic impact potential	1	Low relative to other methods.
	13	

Consumer	Score	Comments
user friendliness / practicality	4	High, so long as the accompanying HVAC strategy is appropriate. No need for behaviour change - although impractical if building use changes drastically
disruption	3	Would require ceiling work, therefore best done out of hours. Little disruption if this can be accomodated
customer aceptance	3	Some acceptance, however due to HVAC strategy requirements can be some resistance
savings on bills	3	Will save for low thermal mass buildings with a highly variable heating and cooling load situation during year. Limited subsection of applicable buildings
maintenance requirements	5	No maintenance required. May require replacing after 10+ years
health/wellbeing/comfort	5	Improves comfort without any running costs
existing consumer protection? (adequacy?)	3	Limited.
	26	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Requires effective accompanying of HVAC strategy
other relvant considerations/risks/opportunities		Potential benefits for manufacturing, however limited applicable building segment therefore risk that economies of scale might not be realised
adaptability / future proofing		Technologies can be retrofited simply should use of space vary.
	96	

Sources and further Reading:

Warm roof insulation systems

The practice of installing insulation betweeen and/or above rafters within pitched roofs and above existing joists on flat roofs is well established, with warm pitched roofs being converted into rooms or used to house building services and flat roofs often needing to be insulated from above so as not to cause disruption to the rooms below. Innovations in this area include responding to improved understanding of vapour control, use of off-site manufacturing and also imporved, better engineered whole system build-ups.

Technical	Score	Comments
Technology readiness	9	
Efficiency (product / technology efficiency)	4	Range of insulants can be used to varying thicknesses.
Reliability	4	Comparable to cold roof with wall plate junctions able to be more robust but added reliability issues with joints and workmanship risks.
(level of) Compatability with existing systems	4	Compatable with most roofs although full build-up must be appropriately specified
complexity of systems/ their integration	3	More complex than cold roof alternatives, with systems taking longer to install.
risk/severity of unintended consequences	3	Some risks in relation to moisture management and vapour control (timber joists at risk of wet or dry rot if systems are not properly specified or if ventilation needs are not met.
	27	

Environmental	Score	
(in-use) carbon saving potential	4	Will depend on level of roof heat loss area to be insulated but generally very good savings potential.
whole life environmental impact	4	Will depend on exact type of insulant/system but roof system likley to be designed to last 50+ years, extending overall building life.
	8	

Policy / Regulation	Score	
compatability with Scottish policy	4	Reduction in energy use, though other options include cold roofs which are lower cost for similar benefit.
compatability with current regulation	5	Aligns well with section 6 regulation ambition to minimise fabric heat loss. BBA certified solutions.
compitibility with current assessment methodologies	4	Can be accommodated by DSM or SAP. Lambda values documented.
	13	

Monetary	Score	
capital costs	3	Moderate capital costs in comparison with cold roof solutions, though marginal added cost if integrated as part of a re-roofing programme or room in the roof conversion works.
life cycle costs	5	Will depend on exact type of insulant/system but roof system likley to be designed to last 50+ years, extending overall building life.
carbon cost effectiveness (£ per tCO2 saved)	4	
(potential for) economy of scale (to drive down costs)	3	Limited given established nature of the existing market, though more mainstream off-site roof cassettes etc shows promise
	15	

Capacity/ Supply Chain	Score	
applicability	4	Largely applicable to most pitched and flat roofs - domestic and wide range of non-domestic
existing Scottish capacity/skills (people)	5	Well established practice, though qualityt and performance standards must continually improve
Scottish content (materials, IP)	4	Existing scottish installation teams and builders very familiar with warm roofs concepts. Scope for Scottish manufacturing of insulants, off-site manufactured cassettes, membranes, airtightness barriers, ventilation solutions.
potential for cross-sector involvement/benefit	4	Potential to utilise a wider variety of waste/recycled/repurposed materials
scottish economic impact potential	3	Moderate
	20	

Consumer	Score	
user friendliness / practicality	4	Often a better solution for the building owner, making picthed roofs more versatile e.g. rooms, storage. Downside being that the building has a greater total volume to heat.
disruption	3	Moderate to high disruption depending on approach e.g. scaffolding and removal of tiles for access from above through to insulation and materials in through the house and via loft hatch (moderate). Low disruption for flat roofs.
customer aceptance	4	Good awareness and commonly accepted in the form of room in roof conversions/modular roof extentions
savings on bills	4	Moderate, offering good thermal continuity though leaves building occupant with a greater volume to heat.
maintenance requirements	4	
health/wellbeing/comfort	4	
existing consumer protection? (adequacy?)	4	BBA certification usually covers the system, assurance of installation workmanship and quality less established.
	27	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Appropriate system deisgn and specification is critical, with vapour control properties key. Risks to thermal continuity if poorly installed in hard to reach areas etc.
other relvant considerations/risks/opportunities		Budget for proper survey and solution design, with the building owner long term needs of the roof space needing to be well understood.
adaptability / future proofing		Good futureproofing overall - allows roofs to be converted into rooms and/or for high thicknesses of insulation to be specified.
	110	

Sources and further Reading:

http://thermoflocinsulation.co.uk/cellulose-based-insulation/loose-fill-insulation.php

ETFE Roof

Ethylene tetrafluoroethylene (ETFE) refers to roofs that utilise the robust clear plastic material

Technical	Score	Comments
Technology readiness	9	Established technology, however provides novel applications
Efficiency (product / technology efficiency)	4	Provides green house effect leading to as much as 30% energy savings
Reliability	4	25 year life span
(level of) Compatability with existing systems	1	Requires purpose built fittings. Only suitable for large-scale building repurposing
complexity of systems/ their integration	3	Flexible material, capable of achieving complex roofing designs
risk/severity of unintended consequences	4	Inert materials
	25	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Savings through slight fabric U-value savings, and more significantly through heat retention
whole life environmental impact	4	It is a plastic, therefore poor end of life applications, however, the durability will minimise waste generated
	8	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Addresses energy efficiency
compatability with current regulation	5	Compatible with regulation
compatibility with current assessment methodologies	3	Can be modelled, although will require specialist modelling
	13	

Monetary	Score	Comments
capital costs	3	Moderate alternative to traditional methods
life cycle costs	3	Moderate
carbon cost effectiveness (£ per tCO2 saved)	4	Effective savings achievable due to solar gains and heat retention
(potential for) economy of scale (to drive down costs)	4	Likely would improve the installation knowledge, which would improve the installation process
	14	

Capacity/ Supply Chain	Score	Comments
applicability	1	Highly effective for buildings requiring atrium redevelopment, however these are few in the building stock
existing Scottish capacity/skills	2	
Scottish content	2	
potential for cross-sector involvement/benefit	4	Potential benefit, increasing trend in buildings with ETFE roofs, however minimal market
scottish economic impact potential	2	Potential benefit, however minimal impact due to narrow market
	11	

Consumer	Score	Comments
user friendliness / practicality	1	Solves a difficult problem, but requires extensive work to implement
disruption	2	Only viable as part of a large scale redevelopment
customer aceptance	4	Popular building trend for suitable buildings
savings on bills	5	Retrofitting an atrium space would benefit significantly
maintenance requirements	5	Self-cleaning
health/wellbeing/comfort	5	Improves warmth, provides light
existing consumer protection? (adequacy?)	3	
	25	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Narrow market, therefore only applicapable in small section of buildings
other relvant considerations/risks/opportunities		Benefits where applicable and a trend of buildings using the technology
adaptability / future proofing		Provides opportunities for buildings to be adapted, however, as a technology, once installed, is fixed.
	96	

Sources and further Reading:

Green Roofs

Covers the range of innovative technologies involved in making green roofs viable. For the most part these include drainage and structural loading systems

Technical	Score	Comments
Technology readiness	9	Technologies / approach already exists.
Efficiency (product / technology efficiency)	5	Thermal benefits through insulation/thermal mass addition
Reliability	4	Only risk is of flooding/drainage system failure
(level of) Compatability with existing systems	2	Require structural loading, laying of turf and maintenance
complexity of systems/ their integration	3	Require some design calcs, although likely easily applicable for many
risk/severity of unintended consequences	3	Depends on technology and maintenance arrangements
	26	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Savings through CO2 seqresation and thermal mass addition
whole life environmental impact	5	biological material therefore low impact
	8	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Addresses energy efficiency
compatability with current regulation	4	Compatible with regulation
compatibility with current assessment methodologies	3	Assessment procedures available
	12	

Monetary	Score	Comments
capital costs	3	Relatively expensive, although costs coming down
life cycle costs	4	low life cycle costs,
carbon cost effectiveness (£ per tCO2 saved)	4	Costs offset by carbon absorption
(potential for) economy of scale (to drive down costs)	4	Would benefit from further economies of scale
	15	

Capacity/ Supply Chain	Score	Comments
applicability	3	
existing Scottish capacity/skills	3	
Scottish content	4	
potential for cross-sector involvement/benefit	3	
scottish economic impact potential	2	
	15	

Consumer	Score	Comments
user friendliness / practicality	4	
disruption	2	
customer aceptance	4	Strong acceptance where occurred
savings on bills	3	
maintenance requirements	1	Requires maintenance to keep neat
health/wellbeing/comfort	4	Positive benefits
existing consumer protection? (adequacy?)	3	
	21	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Need for structural assessments and modification to accommodate
other relvant considerations/risks/opportunities		Growing number of buildings, although unlikely to become highly widespread until costs come down further
adaptability / future proofing		Can be removed or adapted, however would largely be disposed of
	97	

Sources and further Reading:

Cool Roof

Encompasses a range of technologies which reduce solar gain through a building roof (or in some instances wall). Technologies include green roofs (and facades), and paints / finishes with high albedo.

Technical	Score	Comments
Technology readiness	9	Technologies / approach already exists.
Efficiency (product / technology efficiency)	2	Relatively low absolute effects (high albedo paint), or effect relative to cost (green roofs)
Reliability	3	Green facades need regular maintenance, green roofs can also need uptake (depending on planting regime). High albedo finishes may need mintenance from time to time - location dependant.
(level of) Compatability with existing systems	4	Green roofs limit flexibility as to where to position services. High albedo paint / finishes only works if it can reflect the sun (ie nothing on top).
complexity of systems/ their integration	2	Relatively uncomplex.
risk/severity of unintended consequences	4	Maintenance requirements (watering / replanting) of green roofs / facades not always recognised.
	24	

Environmental	Score	Comments
(in-use) carbon saving potential	1	Carbon savings potential relatively low.
whole life environmental impact	5	Wider environmental impact - very positive for green roofs
	6	

Policy / Regulation	Score	Comments
compatability with Scottish policy	3	Some energy savings, biodiversity, reduced heat island effect in cities.
compatability with current regulation	2	Some elements addressed indirectly.
compatibility with current assessment methodologies	1	Urban heat island cooling effects not addressed.
	6	

Monetary	Score	Comments
capital costs	3	Low albedo coatings - very low; green roofs / facades - significant.
life cycle costs	3	As above.
carbon cost effectiveness (£ per tCO2 saved)	2	Reatively low.- benefit to urban climate of green roof not fully accounted, and limited issue in Scotland.
(potential for) economy of scale (to drive down costs)	2	Limited - high albedo finishes. Green roofs - scale may provide more capacity and hence competitions from providers.
	10	

Capacity/ Supply Chain	Score	Comments
applicability	3	Limited usefulness in Scotland.
existing Scottish capacity/skills	4	Capability exists.
Scottish content	4	Installation, maintenance - local.
potential for cross-sector involvement/benefit	3	Benefits accrue to the wider urban environment.
scottish economic impact potential	1	Low relative to other methods.
	15	

Consumer	Score	Comments
user friendliness / practicality	3	High albedo finishes - high; green roofs / facades need maintenance.
disruption	2	Limited disruption new build - significant if part of refrb (green roofs).
customer aceptance	5	Generally acceptable - green roofs add amenity.
savings on bills	1	Low
maintenance requirements	3	Low - high albedo finishes; potentially significant green roofs / facades
health/wellbeing/comfort	3	Good - wider sustainability, urban effects.
existing consumer protection? (adequacy?)	2	Limited need (high albedo).
	19	

Opportunities / risks	Score	Comments
Critical success factors/watch points		maintainability of green roofs / facades.
other relvant considerations/risks/opportunities		benefit to diversity, urban heat island effect.
adaptability / future proofing		Green roofs tend to be very well insulated, plants provide cooling effect. Extreme climate events can affect longevity.
	80	

Sources and further Reading:

Offsite Manufactured (OM) Cut Cassette Systems

Off-site manufactured cassette roofing systems/panels craned into position on site, improving quality control and reducing installation time. Suited to low to medium rise buildings.

Technical	Score	Comments
Technology readiness	9	Multiple systems available on market
Efficiency (product / technology efficiency)	4	Improvement on building energy efficiency
Reliability	4	No reason to assume degredation in performance or requirement to regularly service
(level of) Compatability with existing systems	4	Compatible with most ceiling types due to laser scanning and precision cutting
complexity of systems/ their integration	3	Complex installation due to fitting new ceiling/roof
risk/severity of unintended consequences	4	
	28	

Environmental	Score	Comments
(in-use) carbon saving potential	5	major potential for energy savings
whole life environmental impact	3	Little applicability for recycling or reuse
	8	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Energy savings potential, health and comfort benefits
compatability with current regulation	5	Building Regulations requirements.
compatibility with current assessment methodologies	4	eaves insulation readily modelled
	14	

Monetary	Score	Comments
capital costs	3	Higher than loft insulation, comparable with new roof
life cycle costs	3	Due to bespoke product, no abilty to reuse
carbon cost effectiveness (£ per tCO2 saved)	5	Significant potential to reduce carbon, if properly specified, in loft converted homes where other solutions are unviable
(potential for) economy of scale (to drive down costs)	4	Scale up would improve system efficiency
	15	

Capacity/ Supply Chain	Score	Comments
applicability	4	Widely applicable, good for loft converted/inhabited buildings.
existing Scottish capacity/skills (people)	2	Installers available, although minimal number currently
Scottish content (materials, IP)	2	Minimal, although Scottish specification, design and fitting valuable
potential for cross-sector involvement/benefit	3	Cross building sectors - yes.
scottish economic impact potential	3	Rate of uptake of units is limited by market - potential for sizable market
	14	

Consumer	Score	Comments
user friendliness / practicality	4	Ease of installation on site, one day disruption. Passive system once installed therefore no training required for operation, some training about impacts on heating demand would be beneficial.
disruption	4	One day disruption
customer aceptance	4	Moderate due to daily disruption
savings on bills	4	Good potential saving on heating bills
maintenance requirements	4	Minimal
health/wellbeing/comfort	4	Improved comfort
existing consumer protection? (adequacy?)	3	Limited due to emerging tech, however roof insulation well regulated
	27	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Uptake dependent on consumer willingness to
other relvant considerations/risks/opportunities		Changes in buildings use / neighbouring developments may mean that the particular units selected on day one are no longer optimal.
adaptability / future proofing		Creates further flexibility through insulated loft space
	106	

Sources and further Reading:

Chilled Beam Ceilings

Includes either active or passive air, water or induction technologies. Typically they involve panels fitted to the ceiling, commonly around the perimeter of a conditioned space

Technical	Score	Comments
Technology readiness	9	Technologies / approach already exists.
Efficiency (product / technology efficiency)	3	Application dependent, although some alternatives can be more efficient at providing cooling, and are more flexible when being applied to a retrofit solution..
Reliability	4	Relatively reliant, occational maintenance of gaskets and/or valves (and chilled water system)
(level of) Compatability with existing systems	2	Passive variations are relatively simple to install, however both active and passive require monitoring and control, and cooling adds a degree of complexity to any refurbishment.
complexity of systems/ their integration	2	Integration with other system is relatively complex
risk/severity of unintended consequences	3	Design or operational errors can lead to cold spots and mold growth if below dew point
	23	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Avoidance of cooling is generally more energy efficient. Compared to some alternatives (including DX units), chilled beam systems are more complex. Running costs cf alternatives are application specific.
whole life environmental impact	3	There are a wide range of colling systems available to buildings, some are better, others less good, from an environmental perspective.
	6	

Policy / Regulation	Score	
compatability with Scottish policy	4	Consistent with Scottish policy - although inclusion of cooling systems will increase energy use.
compatability with current regulation	4	Regulations for housing not well suited to accommodate the refurbishment of cooling systems.
compatibility with current assessment methodologies	4	Good - although complexity is the overall performance of the building / system as a whole.
	12	

Monetary	Score	
capital costs	3	Depends on what it is being compared to.
life cycle costs	3	As above.
carbon cost effectiveness (£ per tCO2 saved)	3	As above.
(potential for) economy of scale (to drive down costs)	3	Wide application likely to result in better design and installation practices.
	12	

Capacity/ Supply Chain	Score	
applicability	2	Limited market with refurbishment.
existing Scottish capacity/skills	4	Skills exist in commercial sector.
Scottish content	3	Design, installation, and operation capability.
potential for cross-sector involvement/benefit	3	
scottish economic impact potential	3	Need to balance economic and energy / carbon cost with potential for improved wellbeing / productivity.
	15	

Consumer	Score	
user friendliness / practicality	4	
disruption	2	Retrofit will be disruptive.
customer aceptance	3	Likely to be high.
savings on bills	3	Depends on basis of comparison.
maintenance requirements	3	Depends on details of overall system, and what its being compared to.
health/wellbeing/comfort	4	Should improve comfort if operated correctly.
existing consumer protection? (adequacy?)	3	System selection, and performance in use not adequately addressed.
	22	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Requires suitable accompanying BEMS and suitable for perimeter spaces to complement HVAC system
other relvant considerations/risks/opportunities		Mature technology, used in certain places, some innovative applications but rare
adaptability / future proofing		Technologies can be retrofited simply should use of space vary.
	90	

Sources and further Reading:

Glass PV roof tiles

Glass roof tiles that have inbuilt solar PV cells, capable of generating electricity without unduly changing the aesthetic of the property

Technical	Score	Comments
Technology readiness	**8**	Demo houses launched in US Spring 2017. First shipping Summer 2017. Outside US in 2018
Efficiency (product / technology efficiency)	5	Highly energy efficient in contrast to typical roof tiles
Reliability	4	highly robust material, reliability of PV generation untested
(level of) Compatability with existing systems	4	Compatible as roof tile, unproven in UK electrical installation
complexity of systems/ their integration	3	Simple as tile, complexity in electrical connection
risk/severity of unintended consequences	4	Minimal, possible reflectivity issues or over heating
	28	

Environmental	Score	Comments
(in-use) carbon saving potential	5	Very high compared to traditional roof tiles
whole life environmental impact	4	High amount of carbon savings offset any manufacturing impact
	9	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Addresses energy efficiency well
compatability with current regulation	2	Likely hurdles to overcome on planning and grid connectivity fronts
compatibility with current assessment methodologies	3	Limited modelling, DSM possible
	10	

Monetary	Score	Comments
capital costs	3	Cheap compared to solar panels
life cycle costs	3	Moderate
carbon cost effectiveness (£ per tCO2 saved)	5	High level of energy saving offsetting costs
(potential for) economy of scale (to drive down costs)	5	Would benefit from economies of scale
	16	

Capacity/ Supply Chain	Score	Comments
applicability	4	Applicable to most pitched roofs, prevalent across Scotland
existing Scottish capacity/skills	3	Expertise of fitting roofs and solar panels, but not in the combined approach
Scottish content	2	Installation, maintenance - local. Manufacture would be outside Scotland
potential for cross-sector involvement/benefit	5	Power generation has wider benefits to home
scottish economic impact potential	5	Potential to greatly benefit economy through dispersed power generation
	19	

Consumer	Score	Comments
user friendliness / practicality	5	Once installed, attractive and practical
disruption	3	Would require a roof replacement
customer aceptance	4	Untested, but early notes are positive
savings on bills	5	May mitigate electrical bill
maintenance requirements	5	No maintenance required. May require replacing after 25+ years
health/wellbeing/comfort	3	Improves wellbeing through less carbon emissions from power stations, little impact either way
existing consumer protection? (adequacy?)	3	Minimal, save for provider service arrangements
	28	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Requires importing and trialing in a UK context
other relvant considerations/risks/opportunities		requires review with UK electrical network to explore options, and review of solar generation potential for Scottish homes
adaptability / future proofing		Readily replaced or upgraded with new products.
	110	

Sources and further Reading:

Secondary glazing including plastic films

Not innovative as a concept, however there are innovations in the field through low profile, or low invasive, high performing films to provide low impact secondary glazing.

Technical	Score	Comments
Technology readiness	9	Wide range of products already available. Performance characteristics of gl;ass and plastic films continues to evolve.
Efficiency (product / technology efficiency)	3	Depends on product employed - low e plastic films are low cost, secondary glazing units are more expensive, but cheaper than replacement double glazing units.
Reliability	4	Depends on product - plastic films can be affected by operational issues, as can the durability of secondary glazing.
(level of) Compatability with existing systems	4	Fairly simple improvement.
complexity of systems/ their integration	4	Low complexity - although some skills required in selecting the characteristics of the glass / film given the range of products available.
risk/severity of unintended consequences	3	Daylight as well as heating can be affected. Potential for condensation on fabric as glazing is warmed. Potential for secondary glazing / film selection characteristics to contribute to overheating risk. Low hanging fruit approach (low cost, limited energy efficiency) may detract from a more comprehensive energy efficiency refurbishment.
	27	

Environmental	Score	
(in-use) carbon saving potential	3	Modest savings potential.
whole life environmental impact	3	Lower potential benefit, and impact than replacement glazing systems - can be used to prolong
	6	

Policy / Regulation	Score	
compatability with Scottish policy	4	Potential for energy efficiency is aligned with scottish policy, although may hold back more effective products.
compatability with current regulation	4	Regulations don't fully accommodate the range of transmission, emissivity, characteristics which can be changed through the use of different glass / film types.
compitibility with current assessment methodologies	4	Broadly comparable with existing assessment methodologies.
	12	

Monetary	Score	
capital costs	4	Relatively low cost. Can help improve comfort as well as reduce energy use.
life cycle costs	4	Lowest cost solutions (plastic films) generally have the shorter lifetimes.
carbon cost effectiveness (£ per tCO2 saved)	3	May negate more efficient solutions by their low cost nature.
(potential for) economy of scale (to drive down costs)	3	More effective selection of glass and glazing could significantly reduce overall life cycle costs.
	14	

Capacity/ Supply Chain	Score	
applicability	3	Double glazing has achieved a significant penetration of the scottish housing sector. There is opportunity to upgrade old glazing units with plastic films (or new glazing units), although potential is aless than with single glazing.
existing Scottish capacity/skills	3	Selection of glazing characteristics not well covered in housing sector, better in non-domestic.
Scottish content	4	Installation. Some manufacture.
potential for cross-sector involvement/benefit	3	Optimisation of glazing characteristics could benefits from cross sector involvement.
scottish economic impact potential	2	Relatively limited potential - most glazing already double glazed.
	15	

Consumer	Score	
user friendliness / practicality	4	Easy to implement (apart from transmission, emissivity properties selection)
disruption	3	Low disruption - although needs access to inside of building.
customer aceptance	3	Low cost cf new units. Some visual amenity issues.
savings on bills	3	Reasonable savings potential.
maintenance requirements	3	Likely to be less durable than comprehensive glazing unit replacement.
health/wellbeing/comfort	4	Can improve comfort.
existing consumer protection? (adequacy?)	4	Glazing characteristics and their selection not addressed fully.
	24	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Watch for longevity of thin film of secondary glazing
other relvant considerations/risks/opportunities		Mature technology, therefore little opportunity
adaptability / future proofing		Highly adaptable, readily removed or adjusted.
	98	

Sources and further Reading:

Thin profile vacuum glazing

Modern developments of vacuum glazing is enabling thin profile solutions for heritage windows, suppliers include Pilkington

Technical	Score	Comments
Technology readiness	8	Units exist, with breadth of exemplar properties with installations
Efficiency (product / technology efficiency)	4	Optimum set of values depends on specifics of the installation. Improved U and g values against double glazing.
Reliability	3	10 year warranty and greater life expectancy. Resilience of double glazed units, and retention of low emissivity gases (if used) continues to improve.
(level of) Compatability with existing systems	5	Thin glazing units suitable for retrofiting into heritage windows
complexity of systems/ their integration	2	Requires experts to install. Retrofitting requires reconditioning of frames, however all parts are static once installed.
risk/severity of unintended consequences	2	Dependent on skill level of installer.
	24	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Considerable improvement against single glazed windows which are typically incumbent in heritage windows
whole life environmental impact	3	Moderate - increased energy used in manufacture compared to standard glazing
	7	

Policy / Regulation	Score	
compatability with Scottish policy	5	No issue
compatability with current regulation	5	No issue
compatibility with current assessment methodologies	4	Compatible with SAP and DSM through input of U and g values
	14	

Monetary	Score	
capital costs	2	Expensive compared to alternatives, expensive compared to low-cost fabric insulation
life cycle costs	2	
carbon cost effectiveness (£ per tCO2 saved)	3	Good carbon saving vs single glazed windows, however expensive installation
(potential for) economy of scale (to drive down costs)	3	Potential to drive down costs through improved manufacturing, however limitations through bespoke installation
	10	

Capacity/ Supply Chain	Score	
applicability	5	Broadly applicable, and particularly beneficial in buildings where double glazing is not typically applicable
existing Scottish capacity/skills	2	No speciality identified
Scottish content	2	None identified
potential for cross-sector involvement/benefit	3	Potential with Scottish heritage trusts to develop tailored solution ranges
scottish economic impact potential	3	Potential but no clear case
	15	

Consumer	Score	
user friendliness / practicality	5	No change to the way users previously used windows
disruption	2	Requires window frames to be removed, refurbished and reinstalled
customer aceptance	3	Case studies of uptake, but little evidence of overwhelming evidence
savings on bills	4	Improves a poor performing element of building fabric
maintenance requirements	3	None needed for daily operation, however longevity is unproven
health/wellbeing/comfort	4	Improves warmth whilst maintaining light and external views
existing consumer protection? (adequacy?)	4	10yr guarntee
	25	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Development of low disruption processes for installation, reduction in cost to make accessible
other relvant considerations/risks/opportunities		Improves glazing element, however doesn't upgrade drafty window frames, should be upgraded alongside window frame upgrades.
adaptability / future proofing		Technology enables the future proofing of heritage windows, however due to vacuum and glass, little flexibility once installed
	95	

Sources and further Reading:

Low E Double Glazing

Wide range of triple galzed units providing different combnations of U and g values (thermal resistance and solar transmittance) with frames, glazing and hardware each serving as areas of innovation in their own right.

Technical	Score	Comments
Technology readiness	9	Wide range of units exist.
Efficiency (product / technology efficiency)	3	Wide range of U and g values exist. Optimum set of values depends on specifics of the installation.
Reliability	4	Resilience of double glazed units, and retention of low emissivity gases (if used) continues to improve.
(level of) Compatability with existing systems	3	Not compatible with most existing frames or glazing systems - ie often need to replace frame as well.
complexity of systems/ their integration	3	Selecting the optimal double glazing to the particular application requires dsm - existing tools are relatively simple. Sub-optimal selection can lead in extremis to overheating, excess lighting use, greater heating or cooling energy use.
risk/severity of unintended consequences	3	See above.
	25	

Environmental	Score	Comments
(in-use) carbon saving potential	4	NEF report identified major potential for energy savings if optimal glazing units selected, and thermal bridge effects negated by appropriate frame installation.
whole life environmental impact	3	Re-use / recycling schemes in place, but no-where near universal in practice. High embodied energy content. Range of frame types with a wide range of life cycle impacts and characteristics.
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Energy savings potential, health and comfort benefits
compatability with current regulation	5	Building Regulations requirements.
compitibility with current assessment methodologies	3	SAP / WERS don't provide a means of optimal selection of glazing. Both can mislead the consumer / specifier.
	13	

Monetary	Score	Comments
capital costs	3	High cost building element.
life cycle costs	3	High - due to initial costs.
carbon cost effectiveness (£ per tCO2 saved)	3	Moderate potential to reduce carbon, if properly specified, although can be high capital cost for good units.
(potential for) economy of scale (to drive down costs)	4	Rate of uptake of units is limited by market, though just as with scandinavian countries, opportunity to enter market of high end air tight, thermally effient, durable, storm proof glazing. Timber composite frames etc.
	13	

Capacity/ Supply Chain	Score	Comments
applicability	4	Widely applicable, although most buildings now have double glazing, o rate of replacement is limited.
existing Scottish capacity/skills	4	Installation skills widespread - although two major shortcomings: avoidance of thermal bridging; specification of optimal glazing package.
Scottish content	4	No glass manufacture - although key is the specification and installation of units.
potential for cross-sector involvement/benefit	3	Cross building sectors - yes.
scottish economic impact potential	3	Rate of uptake of units is limited by market
	18	

Consumer	Score	Comments
user friendliness / practicality	3	Unit - high. Limitations: understanding of optimal units; understanding of consumer as to impact of glazing on visual amenity, comfort etc; installation to minimise thermal bridging & how consumers can assess quality.
disruption	4	Usually relatively low.
customer aceptance	5	High
savings on bills	2	Relatively small contribution for the high capital cost.
maintenance requirements	3	Cleaning and general maintenance
health/wellbeing/comfort	4	Good glazing can contribute to significant health and wellbeing.
existing consumer protection? (adequacy?)	4	Significant consumer protection, although most will not understand the need to optimise the characteristics of the glazing unit to meet their needs / optimise energy use / minimise overheating risk.
	25	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Product selection, installation, consumer awareness
other relvant considerations/risks/opportunities		Changes in buildings use / neighbouring developments may mean that the particular units selected on day one are no longer optimal.
adaptability / future proofing		Limited flexibility - can apply window films, external or internal blinds, replace the glazing unit.
	101	

Sources and further Reading:

Low E Triple Glazing

Wide range of triple galzed units providing different combnations of U and g values (thermal resistance and solar transmittance) with frames, glazing and hardware each serving as areas of innovation in their own right.

Technical	Score	Comments
Technology readiness	9	Wide range of units exist.
Efficiency (product / technology efficiency)	4	Wide range of U and g values exist. Optimum set of values depends on specifics of the installation.
Reliability	4	Resilience of triple glazed units, and retention of low emissivity gases (if used) continues to improve. Other areas of ever improving efficiency include unit airtightness and overall performance of frames.
(level of) Compatability with existing systems	3	Not compatible with most existing frames or glazing systems - ie often need to replace frame as well.
complexity of systems/ their integration	3	Selecting the optimal triple glazing to the particular application requires dsm - existing tools are relatively simple. Sub-optimal selection can lead in extremis to overheating, excess lighting use, greater heating or cooling energy use.
risk/severity of unintended consequences	3	See above.
	26	

Environmental	Score	Comments
(in-use) carbon saving potential	4	NEF report identified major potential for energy savings if optimal glazing units selected, and thermal bridge effects negated by appropriate frame installation.
whole life environmental impact	3	Re-use / recycling schemes in place, but no-where near universal in practice. High embodied energy content. Range of frame types with a wide range of life cycle impacts and characteristics.
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Energy savings potential, health and comfort benefits
compatability with current regulation	5	Building Regulations/Section 6 requirements.
compatibility with current assessment methodologies	3	SAP / WERS don't provide a means of optimal selection of glazing. Both can mislead the consumer / specifier.
	13	

Monetary	Score	Comments
capital costs	3	High cost building element.
life cycle costs	3	High - due to initial costs and moderate energy savings delivered, especially when upgrading from double to triple.
carbon cost effectiveness (£ per tCO2 saved)	3	Moderate potential to reduce carbon, if properly specified, although high capital cost.
(potential for) economy of scale (to drive down costs)	3	Limited potential for industry to grow further - approaching point where most installations are replacing existing double glazing. Significant potential for better specification tools.
	12	

Capacity/ Supply Chain	Score	Comments
applicability	4	Widely applicable, although most buildings now have double glazing, so rate of replacement is limited.
existing Scottish capacity/skills	4	Installation skills widespread - although two major shortcomings: avoidance of thermal bridging; specification of optimal glazing package.
Scottish content	4	No flat glass manufacture known - although key is the specification and installation of units.
potential for cross-sector involvement/benefit	4	Cross building sectors - yes.
scottish economic impact potential	4	Rate of uptake of units is limited by market, though just as with scandinavian countries, opportunity to enter market of high end air tight, thermally effient, durable, storm proof glazing. Timber composite frames etc.
	20	

Consumer	Score	Comments
user friendliness / practicality	3	Unit - high. Limitations: understanding of optimal units; understanding of consumer as to impact of glazing on visual amenity, comfort etc; installation to minimise thermal bridging & how consumers can assess quality.
disruption	4	Usually relatively low.
customer aceptance	5	High given added aesthetic benefits, security, acoustics etc.
savings on bills	2	Relatively small contribution for the high capital cost.
maintenance requirements	3	Cleaning and general maintenance.
health/wellbeing/comfort	4	Good glazing can contribute to significant health and wellbeing - daylighting, thermal performance, ventilation
existing consumer protection? (adequacy?)	4	Significant consumer protection, although most will not understand the need to optimise the characteristics of the glazing unit to meet their needs / optimise energy use / minimise overheating risk.
	25	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Product selection, installation, consumer awareness
other relvant considerations/risks/opportunities		Changes in buildings use / neighbouring developments may mean that the particular units selected on day one are no longer optimal. Rate of innovation is fast paced.
adaptability / future proofing		Limited flexibility - can apply window films, external or internal blinds, replace the glazing unit.
	103	

Sources and further Reading:

Window films

Although not innovative, there are innovations in the sector that are providing energy efficient benefits

Technical	Score	Comments
Technology readiness	**9**	Mature technology
Efficiency (product / technology efficiency)	2	Reduces excess solar gain, and can offer secondary glazing properties
Reliability	4	Good reliability
(level of) Compatability with existing systems	5	Film suitable for application to all window types. Only limited by planning or listed status
complexity of systems/ their integration	5	Low complexity, adheres to external surfaces
risk/severity of unintended consequences	3	Film will reduce solar gain, which may cause increased need for heating if applied to unsuitable buildings
	28	

Environmental	Score	Comments
(in-use) carbon saving potential	2	Insulating films likely to save some carbon
whole life environmental impact	2	Oil based product, but readily mass produced, however limited recycling options
	4	

Policy / Regulation	Score	
compatability with Scottish policy	5	No issue
compatability with current regulation	5	No issue
compatibility with current assessment methodologies	4	Compatible with SAP and DSM through input of U and g values. Thin layer may cause problems on some DSM packages
	14	

Monetary	Score	
capital costs	5	Low cost
life cycle costs	4	Low cost, however oil based and limited recycling options
carbon cost effectiveness (£ per tCO2 saved)	4	Good carbon saving vs single glazed windows, however expensive installation
(potential for) economy of scale (to drive down costs)	1	Already a mass produced, low value product, unless further innovation can be identified
	14	

Capacity/ Supply Chain	Score	
applicability	5	Broadly applicable
existing Scottish capacity/skills	2	No speciality identified
Scottish content	2	None identified
potential for cross-sector involvement/benefit	2	Potential
scottish economic impact potential	1	Mature tech thereforeno clear case
	12	

Consumer	Score	
user friendliness / practicality	5	No change to the way users previously used windows
disruption	4	Minimally disruptive, requires application of film
customer aceptance	4	Relatively wide uptake, especially in non-domestic buildings
savings on bills	3	Provides savings, predominantly in improving shading and reducing AC bills for non-domestic
maintenance requirements	4	None needed for daily operation, however replacement over time potentially required
health/wellbeing/comfort	4	Reduces glare with low impace
existing consumer protection? (adequacy?)	4	Mature market, however low value product, so little need for guarntees
	28	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Is this product widely needed in Scotland, little development need
other relvant considerations/risks/opportunities		Mature and low value product, therefore limited opportunities
adaptability / future proofing		Easily removed, although may leave small marks that need cleaning/repainting
	100	

Sources and further Reading:

Spectrally selective glazing

Spectrally selective glazing is window glass that permits some portions of the solar spectrum to enter a building while blocking others

Technical	Score	Comments
Technology readiness	8	Range of spectrums which the glazing can be tuned to continues to develop.
Efficiency (product / technology efficiency)	4	Costs associated with the spectral element of glazing continue to fall, and the extenty to which light and heat can be accepted or rejected is continually being improved.
Reliability	5	Perfromance does not fall off if windows are cleaned.
(level of) Compatability with existing systems	3	Requires glazing replacement
complexity of systems/ their integration	4	Passive system - however calculation of best glazing characteristics is not well done.
risk/severity of unintended consequences	4	System good at mitigating overheating. Needs to be selected in the context of the overall building and occupancy needs. In practice occupancy may change, and overall integration of building systems not done well.
	28	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Savings potential from glazing is significant, although tends to be more expensive than other energy saving features.
whole life environmental impact	3	Potential to recycle or reuse glazing and associated frames has yet to be fully realised.
	6	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Consistent with policies to reduce energy use.
compatability with current regulation	3	Regulations could be more effective at catering for the wide range of glazing characteristics which are now available. Initial selection is important, and is not done well.
compatibility with current assessment methodologies	3	In line with major methodologies.. Key element is operformance of the building as a whole.
	10	

Monetary	Score	Comments
capital costs	3	Relatively high cost measure.
life cycle costs	3	Savings are low relative to capital costs.
carbon cost effectiveness (£ per tCO2 saved)	3	See above. High carnbon intensity in the manufacturing process.
(potential for) economy of scale (to drive down costs)	3	Key element is the correct selection of glazing characteristics.
	12	

Capacity/ Supply Chain	Score	Comments
applicability	4	Widespread potential.
existing Scottish capacity/skills	3	Instalation. Secection / optimisation of glazing typoe not well done at present.
Scottish content	3	Installation, specification, maintenance.
potential for cross-sector involvement/benefit	3	Optimisation of glazing characteristics.
scottish economic impact potential	3	Significant energy nd potentially productivity, benefits.
	16	

Consumer	Score	Comments
user friendliness / practicality	4	Select, fit and forget.
disruption	3	Requires occupied space intervention.
customer aceptance	3	Consumers have very low awareness of the costs and benefits of spectrally selective glazing, and the construction supply chain is not much better.
savings on bills	3	Potentially significant if properly selected.
maintenance requirements	4	No special maintenance requirements.
health/wellbeing/comfort	4	Can reduce overheating use, provide good levels of daylight.
existing consumer protection? (adequacy?)	3	Limited information as to whether the glazing system selected is right for the building and occupier.
	24	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Main benefit to reduce overheating whilst allowing in daylighting. Useful where overheating occurs.
other relvant considerations/risks/opportunities		Watch for Scottish installations, as overheating less problematic the further north.
adaptability / future proofing		Limits functionality of internal space, should additional solar gain be desirable
	96	

Sources and further Reading:

http://www.glazingsupplychaingroup.org.uk/publications/

Water filled glazing

Water filled double reflective glazing system - with flow through glazing to reduce cooling loads and harness useful heat - alike a building integrated solar thermal, or green algae system for shading,

Technical	Score	Comments
Technology readiness	8	A couple of one off solutions installed and active
Efficiency (product / technology efficiency)	4	Provides efficient thermal shading and/or warm building envelope
Reliability	2	Unproven, but given experiences of buildings, likely to be problematic.
(level of) Compatability with existing systems	1	Applicability for retrofit, however would require extensive retrofit design to become compatible, including HVAC redesign.
complexity of systems/ their integration	1	Highly complex
risk/severity of unintended consequences	1	Risk of leakage, or of mis-operation between skin design and internal HVAC design. Complexity implies high potential for unintended consequences.
	17	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Relatively modest savings - depending on alternative cooling strategies which are being adopted.
whole life environmental impact	3	Will depend on overall system performance in use.
	6	

Policy / Regulation	Score	Comments
compatability with Scottish policy	3	Addresses energy efficiency.
compatability with current regulation	2	Not addressed by SAP
compatibility with current assessment methodologies	1	Requires advanced modelling
	6	

Monetary	Score	Comments
capital costs	1	Expensive
life cycle costs	1	Complexity is likely to result in high on-going costs.
carbon cost effectiveness (£ per tCO2 saved)	2	More effective solutions are available.
(potential for) economy of scale (to drive down costs)	3	Would need to be adopted at scale if is to be applied effectively.
	7	

Capacity/ Supply Chain	Score	Comments
applicability	2	Some potential, limited by overall system needs, and applicability of alternative solutions.
existing Scottish capacity/skills	1	Not applied yet.
Scottish content	2	Installation, maintenance.
potential for cross-sector involvement/benefit	2	Better solutions which limit complexity.
scottish economic impact potential	3	Limited impact.
	10	

Consumer	Score	Comments
user friendliness / practicality	2	Once installed, operates without building occupant interaction, although building occupants will struggle to conrol
disruption	2	Significant disruption - more so than conventional replacement windows.
customer aceptance	2	Consumers may question practicality, and sense given other solutions.
savings on bills	3	Savings need to be compared to a wide range of alternatives.
maintenance requirements	1	Likely to be much higher than existing glazing systems.
health/wellbeing/comfort	3	Benefits depend on which system it is compared to, and how well each can be expected to work in practice.
existing consumer protection? (adequacy?)	2	Lack of standards
	15	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Increasing number of demonstrators with long-term success cases required to increase uptake
other relvant considerations/risks/opportunities		Lots of moving parts, therefore risk of leakage and incompatability with existing HVAC solutions
adaptability / future proofing		Adaptability possible through adjustments in flow rates, but broadly limited due to complexity
	61	

Sources and further Reading:

Ventilated glazing

ventilated (airflow) glazing enabling 'heat recovery windows', such as 'Climawin'

Technical	Score	Comments
Technology readiness	7	EU trials completed, no evidence of mass manufacturing yet
Efficiency (product / technology efficiency)	4	Claims of 20% overall energy savings
Reliability	1	Unproven
(level of) Compatability with existing systems	4	Contained unit, therefore retrofittable into window openings. Options to integrate with BMS if present
complexity of systems/ their integration	3	Highly complex systems, however self-contained, therefore simple
risk/severity of unintended consequences	2	Smart system with moving parts, therefore opportunities for more to go wrong, and more difficult to fix
	21	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Strong energy and carbon saving potential, although those realised may not be as significant due to system complexity issues.
whole life environmental impact	4	Strong energy and carbon saving potential - but see above.
	9	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Offers strong benefits to policy objectives
compatability with current regulation	3	Novel, therefore untested against regulation. Passed EU testing
compatibility with current assessment methodologies	1	Would require advanced modelling due to complex heat transfer and ventilation strategies
	8	

Monetary	Score	Comments
capital costs	2	Likely to be substantially higher than alternatives.
life cycle costs	2	See above.
carbon cost effectiveness (£ per tCO2 saved)	3	Unproven in-use savings, and many simpler ways of achieving savings.
(potential for) economy of scale (to drive down costs)	3	Savings potentioal likely to be limited by potential use.
	14	

Capacity/ Supply Chain	Score	Comments
applicability	3	Practical implementation in refurbishment is limited.
existing Scottish capacity/skills	1	None known of.
Scottish content	3	Scottish installers, maintainers.
potential for cross-sector involvement/benefit	3	Limited potential due to bespoke nature of solutions. Some manufacturing savings possible.
scottish economic impact potential	2	Limited because of lack of potential. Complexity may negate benefits.
	16	

Consumer	Score	Comments
user friendliness / practicality	3	Consumer understanding limited.
disruption	2	More disruptive than traditional window replacement.
customer aceptance	1	Unproven
savings on bills	3	20% from one piece of technology is very signifiant - but in use savings are unproven, and likely to be less due to issues around complexity.
maintenance requirements	2	Unknown, however expected high, due to number of moving parts and filters
health/wellbeing/comfort	3	Improvements in thermal comfort in summer and ventilation/IAQ year round, balanced by potential downsides of poor perfromance associated with complexity and likely in-use performance
existing consumer protection? (adequacy?)	1	EU testing, but no existing standards as to what consumers should expect. Previous similar tech went bust leaving customers unsupported
	22	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Proven longevity of the product
other relvant considerations/risks/opportunities		Proven performance across the board
adaptability / future proofing		Limited due to need for window replacement to make changes
	90	

Sources and further Reading:

http://www.engineersjournal.ie/2014/04/10/intelligent-ventilation-windows-cuts-building-energy-usage-by-20/
http://climawin.eu/the-system/
http://climawin.ie/wp-content/uploads/2014/06/CLIMAWIN-Brochure-English-Final17March2014.pdf

PCM filled glazing

Quadrouple layered glazing with PCM material contained between panes, suitable for frosted glazing or thermal shading, or against an opaque wall, e.g. glass x, reduces HVAC requirement for highly glazed buildings

Technical	Score	Comments
Technology readiness	9	Buildings
Efficiency (product / technology efficiency)	4	Significant savings claimed - in practice in-use savings likely to reflect overall design of building and its use.
Reliability	3	Relatively complex product - so some question as to reliable long term operation in face of possible changes in occupant needs.
(level of) Compatability with existing systems	2	Stand alone installations for opaque walls into existing glazed walls/curtain walling
complexity of systems/ their integration	3	Practically similar to conventional window replacement. Significant design consideration.
risk/severity of unintended consequences	3	Adding thermal mass to building skin will require careful design/redesign of associated HVAC system
	24	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Strong energy and carbon saving potential
whole life environmental impact	4	Made from glass and salt solution
	8	

Policy / Regulation	Score	Comments
compatability with Scottish policy	3	Offers benefit re energy efficiency policy, however applicable to few Scottish buildings. Potential amenity risk.
compatability with current regulation	3	Not easily included in simple design tools.
compatibility with current assessment methodologies	2	Would require advanced modelling due to complex heat transfer and connected HVAC strategies
	8	

Monetary	Score	Comments
capital costs	2	Significantly more expensive than some alternative approaches.
life cycle costs	2	Perfromance in use will depend on how well the glazing is tuned as part of the overall operation of the building.
carbon cost effectiveness (£ per tCO2 saved)	3	Depends on what comparator is used.
(potential for) economy of scale (to drive down costs)	4	Manufacturing potential cost savings.
	11	

Capacity/ Supply Chain	Score	Comments
applicability	2	Applicable to glass fronted or curtain wall buildings
existing Scottish capacity/skills	3	For fitting, but German product
Scottish content	3	Scottish installers
potential for cross-sector involvement/benefit	4	Manufacturing at scale potential.
scottish economic impact potential	3	Low potential, low benefits.
	15	

Consumer	Score	Comments
user friendliness / practicality	3	In the right context, no need for behaviour change
disruption	3	As disruptive as replacing windows
customer aceptance	3	Some flagship building take up, but not widespread
savings on bills	3	30-50% claimed HVAC savings, actual savings will depend on what it is compared to, and site specific issues.
maintenance requirements	4	PCM core is 100yrs guaranteed, maintenance free. Occupant requirements may change.
health/wellbeing/comfort	4	Improvements in thermal comfort in summer and winter, increase in natural dispersed light
existing consumer protection? (adequacy?)	3	Perfromance in use requires an assessment of overall building perfromance.
	23	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Identification of sufficient suitable buildings
other relvant considerations/risks/opportunities		Care to model and design appropriate HVAC strategies in conjunction make it challenging for retrofit
adaptability / future proofing		Limited due to need for window replacement to make changes
	89	

Sources and further Reading:

http://glassx.ch/fileadmin/_migrated/content_uploads/GLASSX_AG__products_e.pdf

BIPV Glazing

Glass that produces electricity for use as glazing, facades and curtain walling

Technical	Score	Comments
Technology readiness	8	Technology exists, and case studies available.
Efficiency (product / technology efficiency)	4	Improvement potential exists re efficiency of sun conversion to electricity
Reliability	4	Most building integrated PV systems have proved to be reliable in practice, this can generally be expected to remain the case for BIPV glazing. There are some exceptions, where such systems require moving parts. Inverter life expectancy now expected to last > 10 years.
(level of) Compatability with existing systems	4	Fits onto existing building structures
complexity of systems/ their integration	4	Requires some wiring
risk/severity of unintended consequences	3	Potential overshading. Some limitations will apply as to potential to extent to which light can be selectively filtered by the glazing. Different glazing types within a building may impact amenity.
	27	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Significant savings potential, limited by (i) economics, (ii) building orientation and shading factors which are significant constraints for existing buildings.
whole life environmental impact	3	Relatively high cost measure. Glazing will need usual cleaning regimes.
	6	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Compatable with policy on renewables, and buildings.
compatability with current regulation	4	Consistent with regulations.
compatibility with current assessment methodologies	3	Overall consideration of potential for a particular building retrofit not done well at present.
	11	

Monetary	Score	Comments
capital costs	2	Relatively high costs.
life cycle costs	3	O&M costs are fairly low.
carbon cost effectiveness (£ per tCO2 saved)	3	May displace other (passive) approaches to solar optimisation.
(potential for) economy of scale (to drive down costs)	3	Manufacturing cost reductions, although bespoke solutions required.
	11	

Capacity/ Supply Chain	Score	Comments
applicability	3	Potential to apply in existing buildings limited in practyice by overshading / façade design.
existing Scottish capacity/skills	1	Design, install - limited experience.
Scottish content	2	Design, install, maintain.
potential for cross-sector involvement/benefit	3	Benefit from experiences of PV generally.
scottish economic impact potential	2	Potential limited by likely limitations on applicability.
	11	

Consumer	Score	Comments
user friendliness / practicality	3	Selection in fdace of site constraints is a limiting factor
disruption	3	Requires glazing to be replaced.
customer acceptance	3	Likely to be acceptable
savings on bills	2	Potential is relatively low cf roof or façade mounted PV units
maintenance requirements	3	Fairly low - although this should be considered in the context of the relatively low contribution such systems will make.
health/wellbeing/comfort	3	May detract from alternative solar utilisation strategies.
existing consumer protection? (adequacy?)	2	Consumers need to be satisfied that the selection of BIPV has fully considered site cnstraints, and other ways of utilising solar gain.
	19	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Watch for mass take up beyond the existing case studies
other relvant considerations/risks/opportunities		Developed in UK, opportunity for manufacturing in Scotland, further R&D and scale up
adaptability / future proofing		Useful future benefits from electricity generation, costly adaptability due to need to replace windows
	85	

Sources and further Reading:

Electro-Chromic Glazing - (variable g value electrically controlable)

There are a range of "smart glazing" concepts currently under development which adust the transmission characteristics of glass. The technology considered most appropriate for energy control in buildings is electrochromic glazing where the transmission characteristics of the glazing can be adjusted electrically. In theory this approach can be used to control solar gain, glare, and gneral ambience. The technology has been demonstrated in the lab over many years, although to date its costs are considered far higher than tradition forms of solar control.

Technical	Score	Comments
Technology readiness	7	Issues remain about the economics of the approach cf alternative forms of solar control.
Efficiency (product / technology efficiency)	2	High costs imply significant embedded energy.
Reliability	3	Yet to be demonstrated at scale - electrochromic offers the potential of reliable control cf some other smart glasses which eg involve pumping liquids between two sheets of glass.
(level of) Compatability with existing systems	5	Potential high compatibility, although traditionally control of most things in buildings is usually problematic in practice - resulting in a large performance gap.
complexity of systems/ their integration	3	A complex product, although once produce at scale relatively straight forward to integrate.
risk/severity of unintended consequences	4	Failure of units may result in significant risks. Occupant / automatic control issues likely in practice.
	24	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Significant potential to reduce cooling load from solar gain in non-domestic (and in future high end residential) buildings. Potential constrained by cost.
whole life environmental impact	3	Recycling associated with potentially complex smart glass / film approach not fully resolved, and recovery likely entails the low cost element of the product.
	6	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	In line with policies associated with energy efficiency, reduced carbon, and potentially wellbeing / productivity
compatability with current regulation	3	Ability to provide a building element with variable transmission properties is not fully addressed by regulations.
compatibility with current assessment methodologies	2	o known protocols currently available for applying "in use" factors to smart glass in iSBEM, SAP - these could be developed.
	9	

Monetary	Score	Comments
capital costs	1	Currently high cost - not available commercially for energy control.
life cycle costs	2	Potential benefits (if specified, used appropriately) to reduce air conditioning load.
carbon cost effectiveness (£ per tCO2 saved)	1	High capital cost.
(potential for) economy of scale (to drive down costs)	4	Developments may significantly reduce costs - although the technology has been "In development" for >30 years, there is space for significant technological developments over next 10-20 years
	8	

Capacity/ Supply Chain	Score	Comments
applicability	1	Products not available for energy control at this date
existing Scottish capacity/skills	2	No recognised R&D capability into development of smart glazing in Scotland, although good capability for modelling required to specify and control glazing.
Scottish content	3	No manufacturing. Potential for high Scottish content in terms of integration.
potential for cross-sector involvement/benefit	3	Once available, good potential for multiple uses / benefits across sectors.
scottish economic impact potential	2	Limited R&D capability, first applications likely in prestige, high rise accommodation. Potential to exploit Scottish design / integration skills.
	11	

Consumer	Score	Comments
user friendliness / practicality	4	Potentially high, although past experience suggests that control will be problematic.
disruption	4	Potentially low, although unit failure will be expensive, and will cause disruption.
customer aceptance	3	Some smart glasses (privacy glasses) have quickly gained acceptance - unclear how more sophisticated energy controlling systems will be accepted.
savings on bills	3	Potential for energy savings where solar gain through windows is an issue - although will nee to compete with other technologies which are currently very much cheaper.
maintenance requirements	3	Unclear what the lifetime in use will be - products remain in development phase.
health/wellbeing/comfort	4	Potential for occupant control, and the allow selective admittance of particular wavelengths has the potential to improve productivity and wellbeing.
existing consumer protection? (adequacy?)	3	Normal consumer protection measures apply - the complexity of the product in terms of what can be achieved means that consumers may not be aware what they are buying, and what can be done.
	24	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Development of technology; appropriate specification; effective control; long term product reliability; unintended consequences.
other relvant considerations/risks/opportunities		Alternative products / approaches.
adaptability / future proofing		The development of electrochromic glazing is linked to a number of smart glass approaches, which include the application or incorporation of "smart" films - rapidly changing areas.
	82	

Sources and further Reading:

Insulating cellular blinds/shades

Blinds with high performance shading / insulating properties, such as Honeycomb style Duette® blinds, as more insulating alternatives to standard blinds.

Technical	Score	Comments
Technology readiness	9	Widely available and well researched technology. Some improvements in perfromance may be possible.
Efficiency (product / technology efficiency)	4	13.7% savings identified in controlled trial against alternative vinyl blinds. Can reduce need for cooling as well as improve heat retention.
Reliability	3	5yr manufacturer guarantees. Ability to deliver benefits requires occupant use
(level of) Compatability with existing systems	3	Suitable for installation to replace internal shading systems. Some issues around blind selection and sizing to meet all functionailty requirements.
complexity of systems/ their integration	4	As complex as curtain / blind replacement
risk/severity of unintended consequences	4	A common use of manual control with blinds is that they are left down so increasing power use for lighting.
	27	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Good energy and carbon saving potential - and one which reflects the practical situation on the ground =- often a retrofit measure than included in the design.
whole life environmental impact	4	Typically low environmental impacts - although range of materials can be used, so can be product supplier/case specific.
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Offers benefit, broadly applicable to Scottish buildings. Use ideally suited to retrofit, as this is the market they naturally occupy.
compatability with current regulation	4	Models, and regulations, include consideration of blinds, although often not an outcome of a design process focused around compliance.
compitibility with current assessment methodologies	4	Occupancy behaviour means that actual performance may well differ from that modelled.
	12	

Monetary	Score	Comments
capital costs	4	Relatively low capital costs.
life cycle costs	4	See above.
carbon cost effectiveness (£ per tCO2 saved)	3	Depends what is installed, how it is used, and what it is compared with.
(potential for) economy of scale (to drive down costs)	3	Bespoke nature of solutions mitigates against major cost break throughs.
	14	

Capacity/ Supply Chain	Score	Comments
applicability	4	Broadly applicable in retrofit, consummer preference will dictate market size.
existing Scottish capacity/skills	4	Manufacture, install, maintain
Scottish content	3	Scottish installers
potential for cross-sector involvement/benefit	3	Some potential for manufacturing improvements.
scottish economic impact potential	3	Some benefits, although consumer preference will dictate uptake and hence benefit.
	17	

Consumer	Score	Comments
user friendliness / practicality	4	Largely easy to use. Robustness in operation is a trade off with initial cost.
disruption	3	As disruptive as replacing curtains
customer aceptance	4	Wide distribution and developed marketing materials
savings on bills	4	up to 25% energy bill saving claimed, although this is unlikely to be the norm.
maintenance requirements	3	low capital cost drivers means that robustness sometimes needs to be improved.
health/wellbeing/comfort	4	Improved thermal comfort, softer lighting and better shading
existing consumer protection? (adequacy?)	4	BBSA provides guidance.
	26	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Mature product, therefore broadly suitable, look for a strong Scottish opportunity
other relvant considerations/risks/opportunities		Opportunities to combine with automated BMS for optimum savings
adaptability / future proofing		Highly adaptable and easily upgraded / replaced
	103	

Sources and further Reading:

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24857Rev1.pdf

http://labhomes.pnnl.gov/documents/PNNL-SA-119839.pdf

http://valeblinds.com/duette-honeycomb-blinds/luxaflex/

PV integrated facades, cladding, windows

PV systems can be integrated into externally facing elements of buildings. There are a wide range of products, although significant variation in cost effectiveness / perfromance / development. PV integration into glass cladding and glazing systems can be incororated as part of a range of coatings / films sometimes referred to as smart glas.

Technical	Score	Comments
Technology readiness	9	Range of products on market, some others in pilot stage - so range of TRL.
Efficiency (product / technology efficiency)	3	Generally PV efficiency and costs and improving - practical efficiencies and power generation are influenced by location (solar intensity), orientation, over-shadowing at component and building level.
Reliability	4	PV systems are generally reliable, although on early systems inverter reliability was questionable - these are now greatly improved.
(level of) Compatability with existing systems	4	PV systems are largely stand alone. BIPV glazing has implications for transmission characteristics. Power generation, and hence economics, of glazing integrated BIPV are generally lower than those associated with optimally mounted roof installations.
complexity of systems/ their integration	4	BIPV systems generally are stand alone. Some systems combine power and heat generation (hot water) - although these are more efficient at collecting solar gain, they require integration with services. In the BPE programme most solar hot water systems were found to be either not monitored (because of the low value of the heat they produce), or functioning poorly.
risk/severity of unintended consequences	4	Potential for poor location, overshadowing, failure to detect inverter failure.
	28	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Good carbon savings from displacing electricity use. Relatively high cost of savings cf other investment choices.
whole life environmental impact	4	Energy production costs continue to fall, although are still significant.
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Good compatability, although relatively low solar radiation intensity in Scotland reduces cost effectiveness compared to other locations.
compatability with current regulation	5	Ties in with building regulations
compitibility with current assessment methodologies	5	Consistent with iSBEM and SAP calculations.
	14	

Monetary	Score	Comments
capital costs	3	Still high costs relative to other measures. Falling PV costs mean that economics of power generation now closer to grid costs.
life cycle costs	3	As above. Need to ensure system performance is checked, faulty components (eg inverter) replaced.
carbon cost effectiveness (£ per tCO2 saved)	3	Still higher than many other carbon reduction technologies.
(potential for) economy of scale (to drive down costs)	4	Very significant cost reductions now achieved - limited by physical mass of units. Efficiencies of units likely to be improved. Limited potential for installation cost reductions.
	13	

Capacity/ Supply Chain	Score	Comments
applicability	3	Less relevant in Scotland, can be used on many buildings.
existing Scottish capacity/skills	4	Systems already installed, designer capability. No manufacturing. Limited R&D.
Scottish content	3	See above
potential for cross-sector involvement/benefit	1	Limited potential
scottish economic impact potential	2	Power generation.
	13	

Consumer	Score	Comments
user friendliness / practicality	4	Largely accepted, and low consumer requirements to maintain and operate.
disruption	4	Low disruption. Some potential for things to go wrong.
customer aceptance	5	Generally high.
savings on bills	3	Tangible returns on power generation, although still low compared to capital cost.
maintenance requirements	4	Fairly low in practice.
health/wellbeing/comfort	1	Limited impact - some BIPV provide shading / solar control so potential to reduce overheating, although many other ways to control this.
existing consumer protection? (adequacy?)	4	Generally good.
	25	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Good location, detailed design.
other relvant considerations/risks/opportunities		Size of FiT and its applicability. Structural integrity. Potential for 3rd party damage.
adaptability / future proofing		Potential for retrofit with higher efficiency panels at a future point.
	100	

Sources and further Reading:

Double skin facades

Curtain walling innovations that offer fabric energy efficiency improvements, typically offering vertical glazing solutions (e.g. MX SSG), including glazed trombe walls

Technical	Score	Comments
Technology readiness	9	Curtain walling is not new. Novel developments exist as one-off case studies
Efficiency (product / technology efficiency)	3	If efficient glazing used, it can be energy efficient. Typically used as design feature rather than energy feature
Reliability	3	Proven longevity of façade - overall system may not be.
(level of) Compatability with existing systems	3	For applicable buildings, provides a versatile building fabric to create glazed spaces
complexity of systems/ their integration	1	Higher complexity than alternative solutions.
risk/severity of unintended consequences	3	Poor perfromance associated with complexity
	22	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Savings depend on what its compared to.
whole life environmental impact	3	Depends how well the system operates - complexity may mean not well.
	6	

Policy / Regulation	Score	Comments
compatability with Scottish policy	3	Generally aligns with energy efficiency policies.
compatability with current regulation	3	Complexity of system may mean that the performance in use is an issue - not dealt with by regulations.
compatibility with current assessment methodologies	3	Key is the overall system operation, not the component.
	9	

Monetary	Score	Comments
capital costs	2	Relatively expensive - particularly for refurbishment.
life cycle costs	3	Main cost is capital. Cleaning needs to be considered.
carbon cost effectiveness (£ per tCO2 saved)	3	Relatively expensive - may be undertaken for other reasons.
(potential for) economy of scale (to drive down costs)	3	Limited potential for retrofit. If adopted widely costs of design etc will fall.
	11	

Capacity/ Supply Chain	Score	Comments
applicability	2	Limited potential for refurbishment.
existing Scottish capacity/skills	3	Design, install.
Scottish content	3	Design, install - no manufacture.
potential for cross-sector involvement/benefit	3	Limited potential - applications are bespoke.
scottish economic impact potential	2	Low due to overall number of installations, and wide range of alternative approaches.
	13	

Consumer	Score	Comments
user friendliness / practicality	3	Complexity of systems may negate user preference.
disruption	2	High disruption.
customer aceptance	3	Customer perception of system may reflect shortcomings associated with complexity.
savings on bills	3	Potential for savings depends on alternatives compared to.
maintenance requirements	3	Potential for savings depends on alternatives.
health/wellbeing/comfort	3	Overall benefits depends on which alternative is considered.
existing consumer protection? (adequacy?)	3	The key limitation is that the main element will be how well the system as a whole performs, rather than how one element does.
	20	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Design led drivers, therefore opportunities for energy efficient technologies to be called for
other relvant considerations/risks/opportunities		Technically challenging
adaptability / future proofing		Additional technology could be incorporated, however adaptations likely costly
	81	

Sources and further Reading:

High performance doors

High performing doors cover innovations in PassivHaus door performance, through minimisation of thermal bridges and incorporation of advanced materials

Technical	Score	Comments
Technology readiness	**9**	Already exist - although at a significant price premium to other products.
Efficiency (product / technology efficiency)	4	Significant perfromance improvement over traditional doors - makes most sense when buildings are refurbished to the Passivhaus standard overall.
Reliability	4	Performance should remain reasonably constant over time.
(level of) Compatability with existing systems	4	Best installed as part of a package of energy efficiency measures.
complexity of systems/ their integration	4	Simple measure.
risk/severity of unintended consequences	4	Should be implemented as part of an integrated low energy approach. Other requirements (eg crime) also need to be considered.
	29	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Overall savings are small, but significant.
whole life environmental impact	4	Most costs are associated with manufacturing.
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Contributes towards
compatability with current regulation	4	Fits easily within current regulations.
compatibility with current assessment methodologies	5	Compatable.
	13	

Monetary	Score	Comments
capital costs	2	Relatively expensive.
life cycle costs	2	Main costs are capital - energy savings provide some payback.
carbon cost effectiveness (£ per tCO2 saved)	3	Sensible measure where Passivhaus standard (or similar) is implemented.
(potential for) economy of scale (to drive down costs)	3	Costs could be reduced if manuifactured at scale in line with, eg regulatory requirements.
	10	

Capacity/ Supply Chain	Score	Comments
applicability	4	Applicable partiocularly where there is a commitment to very high energy efficiency standards.
existing Scottish capacity/skills	3	Installation
Scottish content	3	Installation
potential for cross-sector involvement/benefit	3	Manufacturing savings.
scottish economic impact potential	3	Relatively low carbon saving.
	16	

Consumer	Score	Comments
user friendliness / practicality	4	May not have all features (eg security) required by the consumer.
disruption	3	Door replacement.
customer aceptance	4	Consumer experience depends on need.
savings on bills	4	Relatively modest improvement, although significant for Passivhaus.
maintenance requirements	4	Rnot many - seals may need replacement.
health/wellbeing/comfort	4	Part of an energy efficiency approach which should improve comfort.
existing consumer protection? (adequacy?)	5	
	28	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Whether the cost outlay for a passivhaus door is prohibitive versus a typical double glazed door
other relvant considerations/risks/opportunities		Assured security and longevity of fittings
adaptability / future proofing		Future proofed due to strong thermal barrier between internal space and ambient conditions
	103	

Sources and further Reading:

Sun pipes / defraction glazing

Reflective light tubes, suitable for providing daylight to the centre of buildings via a sun difuser and reflective pipe.

Technical	Score	Comments
Technology readiness	9	Growing number of cases where installed
Efficiency (product / technology efficiency)	4	Reduces need for electrical lighting in central spaces during daylight periods
Reliability	4	Proven longevity. Need for some maintenance.
(level of) Compatability with existing systems	4	Only applicable where access to external light is easily accessible, i.e. on top floors
complexity of systems/ their integration	3	Requires some moderate re-roofing. For commercial applications will require lighting to be reprogrammed
risk/severity of unintended consequences	3	Potential issues at seals where light pipe breaks fabric - needs good detailing. Value of contribution depends on occupant perspective. Potential contribution to overheating risk if not addressed at design stage.
	27	

Environmental	Score	Comments
(in-use) carbon saving potential	4	If displaced LED lighting, savings are relatively low.
whole life environmental impact	4	Low impact - some potential for energy loss through light pipe if detailing / materials / maintenance not properly undertaken.
	8	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Aligns well energy efficiency, also well being.
compatability with current regulation	3	Practical implementation requires assessment of savings which, based on occupancy needs and patterns, are not done well.
compatibility with current assessment methodologies	3	Methodology to estimate savings could be improved.
	10	

Monetary	Score	Comments
capital costs	4	Relatively low.
life cycle costs	3	Relatively low savings, modest cost passive measure.
carbon cost effectiveness (£ per tCO2 saved)	3	Small saving.
(potential for) economy of scale (to drive down costs)	3	Bespoke solutions in refurbishment limit cost reductions.
	13	

Capacity/ Supply Chain	Score	Comments
applicability	3	Applications are site specific and customer dependant (space, quiality of light etc)
existing Scottish capacity/skills	3	Design skills exist, but arte not widespread.
Scottish content	4	Design, install, maintain.
potential for cross-sector involvement/benefit	3	Bespoke solutions, so limited.
scottish economic impact potential	3	Relatively small. Benefits of daylighting include wellbeing.
	16	

Consumer	Score	Comments
user friendliness / practicality	4	Depends on application / occupants needs.
disruption	3	Requires external envelope to be broken.
customer aceptance	4	High acceptance when installed.
savings on bills	3	Savings are low.
maintenance requirements	3	Seals where the light pipe breaks the fabric need to be maintained. Cleaning required.
health/wellbeing/comfort	4	Wellbeing can benefit from ioncreased availability of light / daylight.
existing consumer protection? (adequacy?)	3	Bespoke nature means that in-use performance is unclear.
	24	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Watch for market trends of uptake
other relvant considerations/risks/opportunities		Opportunities for installers/architects to upskill
adaptability / future proofing		Limited adaptability as fixture in ceiling/roof/wall
	98	

Sources and further Reading:

Draught stripping - novel profiles, tapes and sealants

Draught stripping has long been recognised as a means of reducing draughts around windows, doors and operable ventilation vents. Traditionally a DIY market, innovations for application in both new build and refurbishment markets have led to the topic of draught stripping having become quite specialist in order to derive maximum benefits.

Technical	Score	Comments
Technology readiness	9	Broadly established but innovations continue to make more robust, durable improvements possible
Efficiency (product / technology efficiency)	4	Installation quality is key to achieved performance enhancement
Reliability	3	Requires airtightness/PUSLE testing to determine installed effectiveness
(level of) Compatability with existing systems	4	Variety of existing technical options cover most existing situations/products, new solutions in developed in response to challenges all the time
complexity of systems/ their integration	4	Low complexity in terms of basic principles, installation can be a different matter with quality of install key
risk/severity of unintended consequences	4	Build tight, ventilate right. Making existing structures more airtight can be very high risk without also considering the wider ventilation strategy of the building.
	28	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Will depend on starting level of air leakage but unintended losses can account for more than a third of space heating needs, thus presenting significant carbon reduction potential
whole life environmental impact	4	Low material quantities generally required, with significant savings benefits delivered. Biggest risk is product performance deterioation over time, with many sealants, tapes and rubber profiles likely to need replacing at least every 10 years.
	8	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Reduction in energy use, fuel poverty and delivers improved comfort
compatability with current regulation	5	Aligns well with section 6 regulation ambition to minimise fabric heat loss. Typically BBA certified solutions.
compitibility with current assessment methodologies	3	Airtightness generally picked up by DSM and SAP models, though rdSAP (existing property EPCs) lacking in this area.
	13	

Monetary	Score	Comments
capital costs	5	Very low capital cost considering benefits on offer
life cycle costs	4	Low upfront cost and good medium term benefits. Will require re-installation/maintenance to ensure integrity over time
carbon cost effectiveness (£ per tCO2 saved)	5	
(potential for) economy of scale (to drive down costs)	4	Already delivered at reasonable scale through past grant programmes but innovation is increasingly making better results possible. Potential to improve what is achieved through such measures through a proper programme.
	18	

Capacity/ Supply Chain	Score	Comments
applicability	5	Applicable to most of the Scottish Building stock to varying degrees. Particularly older buildings where conservation constraints limit repacement of older components such as windows and doors.
existing Scottish capacity/skills	4	Strong exisitng installation capability and new build industry that recognises significance of building airtightness.
Scottish content	3	Generally unknown given the bredth of products availible - sealants and grommets through to membranes, tapes and draught strips.
potential for cross-sector involvement/benefit	5	Storng potential to overlay this field with wider insulation and fabric airtightness industry as well as ventilation industry.
scottish economic impact potential	3	As per Scottish content - no doubt scope to bring some some manufacturing into Scotland + generally to develop specialist capabilties in this field within Scotland.
	20	

Consumer	Score	Comments
user friendliness / practicality	4	No impact on building user. Inert requiring no user interaction once installed.
disruption	4	Relatively disruption depending on level of airtighness being sought e.g. sealing behind plug sockets through to simple sealing around windows and doors.
customer aceptance	5	General public understanding of the principals, recognition of the opportunity to improve comfort.
savings on bills	3	Savings to bills may be noticable, depending on extent and quality of works
maintenance requirements	4	Likley to require some sealing to be revisited approx every 5-10 years to check integrity. Making airtightness testing of existing buildings more commonplace could support this.
health/wellbeing/comfort	4	Reduced unintended airleakage can have significant impact on reduced draughts and improved comfort
existing consumer protection? (adequacy?)	3	Moderate with BBA on products etc. though very little regulation of wider impacts i.e. build tight, ventilate right
	27	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Installation quality and completeness of workmanship. See UoN 'Improving the airtightness in an existing UK dwelling' paper.
other relvant considerations/risks/opportunities		Appropriate specification of solutions in line with determining ventilation needs is key
adaptability / future proofing		Simple measure to future proof, due to DIY nature is widely adaptable
	114	

Sources and further Reading:

University of Nottingham - Improving the airtightness in an existing UK dwelling: the challenges, the measures and their effectiveness

Mechanical Ventilation Heat Recovery (MVHR)

Appropriate for use where air leakage rate has achieved < 3 m3/m2.h @ 50 Pa or lower, mechanical ventilation with heat recovery (MVHR) systems provide the optimum form of ventilation control. Tried and tested, particularly in Germany where insulation and airtightness standards have been traditionally been higher, MVHR systems are becoming increasingly common in the UK market. An MVHR system extracts warm moist air from the 'wet' rooms via ducting, but before passing to the outside, the air passes through a heat exchanger where the heat is passed to the incoming fresh air that is ducted through to the 'dry rooms'. Retrofitting such systems are a challenge and can be highly disruptive in terms of routing ductwork and positioning inlets/outlets in optimum positions but innovation is this field is continuous.

Technical	Score	Comments
Technology readiness	9	Broadly established but innovations continue to make MVHR better suited to retrofit applications
Efficiency (product / technology efficiency)	3	Good heat exchange efficiency (e.g. 90-95%) but overall system efficiency impacted by building airtightness and the nature and extent of duct work. Both of these a challenge in retrofit.
Reliability	3	MVHR plant itself highly reliable. Requires good building airtightness and well routed ductwork for whole system reliability.
(level of) Compatability with existing systems	3	Variety of existing technical options cover most existing situations with new solutions in developed in response to challenges all the time. As above, main compatability issue is with the building itself - ducts and airtightness.
complexity of systems/ their integration	2	As has been proven with R4F and BPE programmes, system deisgn and comissioning is key due to high complexity.
risk/severity of unintended consequences	3	Build tight, ventilate right. An underperforming MVHR system could lead to inadequate ventilation and higher bills.
	23	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Potentially significant if part of wider retrofit works - heat recovery reducing space heating bills and ventilation highly controllable with minimal uncontrolled losses. Key is unlocking the full potential, made difficult due to complexity.
whole life environmental impact	3	A relatively complex and extensive array of components and materials - ductwork, main plant, pipework. Rigid plastic or aluminimum ducts, plastic/aluminium enclosue and fans etc. Parts should have long lifespan - 15+ years.
	6	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Reduction in energy use and would deliver improved comfort and occupant control. Issue is the costs involved in encouraging/supporting required holistic whole building retrofits that would justify MVHR.
compatability with current regulation	4	Aligns well with section 6 ambition with products generally well established e.g. BBA, SAP PCDB
compitibility with current assessment methodologies	5	Ventilation generally picked up by DSM and SAP models, though rdSAP (existing property EPCs) lacking in this area. MVHR products inlcuded within SAP PCDB.
	13	

Monetary	Score	Comments
capital costs	3	Moderate capital cost for equipment, high labour costs for installation and comissioning.
life cycle costs	3	Moderate energy saving potential if comissioned correctly but unlikley to outweigh capital costs, maintenance and end of life
carbon cost effectiveness (£ per tCO2 saved)	3	Primary purpose is not as an energy saving technology but for ventilation - building and occupant health
(potential for) economy of scale (to drive down costs)	4	Already common place in new build where design and install is more straight forward. Significant opportunity to refine and develop solutions for retrofit and grow this market, drive down costs, improve install efficiencies.
	13	

Capacity/ Supply Chain	Score	Comments
applicability	3	Applicable across new build and retrofit of domestic and non-domestic buildings. Issue is getting buildings air tight enough to justify MVHR as the right ventilation strategy.
existing Scottish capacity/skills	4	Strong exisitng installation capability and new build industry that recognises significance of building airtightness and ventilation.
Scottish content	3	Generally unknown given the bredth of products and components availible - ducts, inlets/outlets, plant, heat exchangers, pipe work.
potential for cross-sector involvement/benefit	4	Storng potential to overlay this field with wider insulation and fabric airtightness industry. Also links to skills of existing plumbing and electrical contractors.
scottish economic impact potential	3	As per Scottish content - no doubt scope to bring some some manufacturing into Scotland + generally to develop specialist capabilties in this field within Scotland.
	17	

Consumer	Score	Comments
user friendliness / practicality	3	User guidance + a degree of behaviour change required. MVHR requires an air tight envelope with windows closed, for example. User control, fan boost, timer settings etc require good user understanding.
disruption	2	Perhaps the biggest shortcoming of MVHR is the disruption necessary to install the plant, route condensate outlet and install ductwork to wet rooms and main living areas, bedrooms etc. Easier in flats and bungalows.
customer aceptance	4	Generally good acceptance given health, indoor air quality and controllability benefits.
savings on bills	3	Primary purpose is not as an energy saving technology but for ventilation - building and occupant health
maintenance requirements	3	Annual cleaning/replacement of filters neccesary to maintain system effectiveness. System itself likley to require re-comissioning/re-balancing approx every 5-10 years.
health/wellbeing/comfort	5	Primary benefit - improved ventilation control, improved IAQ and comfort.
existing consumer protection? (adequacy?)	3	Moderate with BBA on products etc. though very little regulation of wider impacts i.e. build tight, ventilate right
	23	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Appropriate specification from the outset is key, closely followed by detailed system design and proper comissioning. User handover is also key - how to use the system and the working principals.
other relvant considerations/risks/opportunities		Opportunities for innovation in matching plant to rigid ductwork suited for retrofit. Build tight, ventilate right.
adaptability / future proofing		Adaptable through reconfiguration of system
	95	

Sources and further reading:

http://www.greenspec.co.uk/building-design/whole-house-ventilation/
https://website-encraftlive.rhcloud.com/wp-content/uploads/2012/08/Viewpoint-August-2012-MVHR-Designing-and-implementing-a-robust-and-effective-ventilation-system3.pdf
http://www.lowenergybuildings.org.uk/
https://retrofit.innovateuk.org/documents/1524978/2138994/Retrofit%20for%20the%20future%20-%20A%20guide%20to%20making%20retrofit%20work%20-%202014
http://www.greenwood.co.uk/content/1/139/mvhr-technical-tips.html

Single Room Heat Recovery (SRHR) Ventilation

With whole building based MVHR systems being difficult and disruptive to retrofit, one alternative is to use SRHR units within individual rooms. Based on the simple through-the-wall extractor fan, a SRHR unit simply incorporates a heat exchanger in a bid to help minimise the amount of heat lost through the process of extracting stale and/or water laden air. The heat exchangers used are typically less efficient than the larger heat exchangers used within MVHR plant and as with conventional extract fans, visual appearance, back draughts and operating noise are the main consumer concerns that are continuously being addressed through innovation by suppliers and manufacturers.

Technical	Score	Comments
Technology readiness	9	Broadly established but innovations continue to make HRRV more acceptable to occupants.
Efficiency (product / technology efficiency)	3	Approx 70-80% efficient heat recovery, worse than MVHR but lower performance risks with no ducting or comissioning issues
Reliability	4	Good reliability with the need to simply clean filters over time
(level of) Compatability with existing systems	4	Makes good use of existing 110mm holes drilled for conventional fan extract systems. Well understood.
complexity of systems/ their integration	4	Low complexity alternative to MVHR with lower performance risks.
risk/severity of unintended consequences	3	Build tight, ventilate right. An underperforming SRHR system could lead to inadequate ventilation and higher bills.
	27	

Environmental	Score	Comments
(in-use) carbon saving potential	2	Limited carbon saving overall but primary purpose is to provide controlled ventilation as efficiently as possible. Less carbon savign than MVHR would deliver but a good advancement on conventional through-the-wall extract
whole life environmental impact	3	Comparable to through-the-wall units which offer no environmental benefits.
	5	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Small reduction in energy use and would deliver improved comfort and occupant control.
compatability with current regulation	4	Aligns well with section 6 ambition with products generally well established e.g. BBA, SAP PCDB
compitibility with current assessment methodologies	3	Ventilation generally picked up by DSM and SAP models, though rdSAP (existing property EPCs) lacking in this area. Unlike MCHR and MEV, SRHR products are not yet included within SAP PCDB.
	11	

Monetary	Score	Comments
capital costs	4	Reasonably low capital cost for equipment and easy quick installation.
life cycle costs	3	Small energy saving potential but if properly maintained, unit should last 10+ years, providing better building and occupant health.
carbon cost effectiveness (£ per tCO2 saved)	3	Primary purpose is not as an energy saving technology but for ventilation - building and occupant health
(potential for) economy of scale (to drive down costs)	4	Significant opportunity to refine and better promote SRHR solutions for retrofit, growing this market, driving down costs and improve system efficiencies.
	14	

Capacity/ Supply Chain	Score	Comments
applicability	4	Applicable across new build and retrofit of domestic and non-domestic buildings.
existing Scottish capacity/skills	4	Strong exisitng installation capability across new build and home improvement industry that recognises significance of building airtightness and ventilation. SRHV the natural replacement for conventional extract fans.
Scottish content	3	Unknown. SRHR comprises a moulded plastic + electronic control element
potential for cross-sector involvement/benefit	4	Strong potential to overlay this field with wider insulation and fabric airtightness industry. Also links to skills of existing plumbing and electrical contractors.
scottish economic impact potential	3	No doubt scope to bring some some manufacturing into Scotland + generally to develop specialist capabilties in the field of ventilation within Scotland.
	18	

Consumer	Score	Comments
user friendliness / practicality	4	Limited impact on building occupants/users. Background constant extract with heat recovery controlled automatically with timers and humidistats.
disruption	4	Low disruption to install, especially when in place of an existing extract fan.
customer aceptance	4	Generally good acceptance given health, indoor air quality and controllability benefits.
savings on bills	3	Primary purpose is not as an energy saving technology but for ventilation - building and occupant health
maintenance requirements	4	Annual cleaning/replacement of filters neccesary to maintain system effectiveness. Products/fans themselves should last 10+ years
health/wellbeing/comfort	4	Primary benefit - improved ventilation control, improved IAQ and comfort.
existing consumer protection? (adequacy?)	3	Moderate with BBA on products etc. though very little regulation of wider impacts i.e. build tight, ventilate right
	26	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Appropriate specification from the outset is key, build tight, ventilate right. User understanding is also key - how to use the system and the working principals.
other relvant considerations/risks/opportunities		Any ventilation strategy/product solution must be linked to, and designed in accordance with, the fabric airtightness of the building
adaptability / future proofing		Easy to remove, update as innovation in this area continues. Fully reversable.
	101	

Sources and further reading:

https://www.thegreenage.co.uk/get-single-room-heat-recovery-unit/
http://www.lowenergybuildings.org.uk/
https://retrofit.innovateuk.org/documents/1524978/2138994/Retrofit%20for%20the%20future%20-%20A%20guide%20to%20making%20retrofit%20work%20-%202014

Automated trickle vent systems

Humidity controlled ventilation fans (passive or active)

Technical	Score	Comments
Technology readiness	9	Widely produced and sold, with a wide range of potential solutions to address IAQ issues, and so optimise energy use for a given level of, eg, IAQ.
Efficiency (product / technology efficiency)	3	Systems are controlled on the basis of the actuator sensor - eg humidity control.
Reliability	3	Proven longevity for some systems. Occupant effects, and sensor longevity are issues for consideration.
(level of) Compatability with existing systems	4	Compatability depends on overall design. Many systems are stand alone - so potential for systems to fight each other.
complexity of systems/ their integration	4	Depends on solution. Some are very simple, others less so.
risk/severity of unintended consequences	4	IAQ is a major issue with new buildings, and this may also become the case wiuth major refurbishments. Trickle vents are part of the window unit.
	27	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Depends on the comparison base case.
whole life environmental impact	4	Potentially better than mechanical ventilation systems for a given level of performance, although in-use performance driven by practiucality and occupant effects.
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Aligns well with provision of ventilation.
compatability with current regulation	4	Uptake would be accelerated if regulatiuons required ventilation based on need.
compatibility with current assessment methodologies	3	Practical performance of trikle ventilators often limited by occupanty effects.
	11	

Monetary	Score	Comments
capital costs	3	Higher than manual trickle ventilators.
life cycle costs	4	More likely to provide good long term air quality than manual trickle ventilators.
carbon cost effectiveness (£ per tCO2 saved)	3	More a provider of good IAQ than energy efficiency.
(potential for) economy of scale (to drive down costs)	4	Potential for manufacturing to reduce costs, and for uptake to be increased through regulations.
	14	

Capacity/ Supply Chain	Score	Comments
applicability	5	Widespread applicability in housing, and simple non-domestic buildings.
existing Scottish capacity/skills	4	Installers.
Scottish content	3	Installers, designers.
potential for cross-sector involvement/benefit	3	Manufacturing improvement.
scottish economic impact potential	3	Improved IAQ should improve productivity whilst mionimising energy penalty.
	18	

Consumer	Score	Comments
user friendliness / practicality	4	Occupant behaviour is often to close or "tape off" trickle vents.
disruption	3	No more so than replacing window frames.
customer aceptance	4	Generally accepted.
savings on bills	3	May be an increase in some instances.
maintenance requirements	3	Preference for the market to go for low cost units may result in high failure rates.
health/wellbeing/comfort	5	Potential beneficial impact on ensuring IAQ requirements are satisfied for a minimum energy penalty.
existing consumer protection? (adequacy?)	3	Awareness of IAQ needed.
	25	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Whether the fan is on more or less of the time, compared to a typical fan.
other relvant considerations/risks/opportunities		Use of passive ventilation with humidty controlled luvres would improve energy efficiency
adaptability / future proofing		adaptable with reprogramming of humidity thresholds dependent on comfort preferences
	102	

Sources and further Reading:

Automated window opening systems

Systems that integrate with building management systems, offering natural ventilation when required -

Technical	Score	Comments
Technology readiness	9	well established but uncommon technology
Efficiency (product / technology efficiency)	4	Potentially a way of providing passive ventilatioon, so reducing the needs of mechanical ventilation.
Reliability	2	Building Perfromance Evaluation studies have shown a huge gap between design pand in-use perfromance of such systems, with a major failing being with control systems.
(level of) Compatability with existing systems	3	Simplifies operation, but requires an automated control system either installed or configured
complexity of systems/ their integration	2	Relatively complex.
risk/severity of unintended consequences	2	Security requirements, occupant interactions, unintended control interactions.
	22	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Should be better than mechanical ventiulation systems, although in-use effects can reduce these benefits.
whole life environmental impact	4	Relatively benign from an operating perspective.
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Addressed energy efficiency and IAQ policies.
compatability with current regulation	3	Where control is taken away from occupants, may have a negative impact on well-being
compatibility with current assessment methodologies	3	Lack of realistic performance in use assessments.
	10	

Monetary	Score	Comments
capital costs	3	More expensive than traditional window design.
life cycle costs	3	Maintenance costs more than traditional design./ Depends what base case is.
carbon cost effectiveness (£ per tCO2 saved)	4	Where fully functioning can provide good IAQ and energy efficiency.
(potential for) economy of scale (to drive down costs)	4	Manufacturing, and appropriate specification, design, installation, operation with increased use.
	14	

Capacity/ Supply Chain	Score	Comments
applicability	4	Applicable to a wide range of simple non-domestic properties.
existing Scottish capacity/skills	4	Design, install
Scottish content	3	Design, install, maintain
potential for cross-sector involvement/benefit	3	Manufacturing, and long term operation.
scottish economic impact potential	2	Limited by potential and "in-use" effects.
	16	

Consumer	Score	Comments
user friendliness / practicality	3	Mixed - some systems disliked as they take control away from occupants.
disruption	3	As per more typical systemes, plus some additional commissioning, maintenance.
customer aceptance	3	Mixed - depending on expectations.
savings on bills	3	Depends on in-use effects.
maintenance requirements	3	Higher than traditional windows, will save on mechanical ventilation costs.
health/wellbeing/comfort	4	Depends in part on occupier perception. Should be able to improve IAQ.
existing consumer protection? (adequacy?)	4	In use performance and warranties could be strengthened.
	23	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Whether the building has compatible windows and/or BEMS
other relvant considerations/risks/opportunities		Requires security assessment to ensure building access ways are covered by insurance
adaptability / future proofing		Adaptable through reprogramming of automated opening thresholds
	92	

Sources and further Reading:

Mixed mode ventilation (using thermal mass)

Innovative ventilation strategies that utilise both active and passive ventilation modes. In particular, technologies that utilise elements of thermal mass as part of their ventilation strategy, such as Monodraught's cool-phase

Technical	Score	Comments
Technology readiness	9	Established commercial technology, with ongoing innovation and revisions
Efficiency (product / technology efficiency)	4	Typically used as replacement to traditional AC systems. Depends on base case as to improvement in efficiency. Functionality, IAQ as well as energy need consideration.
Reliability	4	In use performance will depend on occupancy needs - which can change over time, and the ability to operate the building effectively.
(level of) Compatability with existing systems	3	Replaces existing ventilation/AC systems. With refurbishment more likely to be an upgrade from previously naturally ventilated building.
complexity of systems/ their integration	2	Needs appropriate design and operation.
risk/severity of unintended consequences	4	Minor risk of overheating during peak periods.
	26	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Saving depends on base case. For refurbioshment may be an upgrade from traditionally naturally ventilated building. Fan power only energy used, significantly lower than AC heat pump
whole life environmental impact	4	Thermal mass/filters may need replacing intermittently
	8	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Relates to energy policy. May impact on productivity if inappropriately selected / operated.
compatability with current regulation	4	Consistent with building regulations.
compatibility with current assessment methodologies	4	Practical in-use performance dictated by in-use and specification issues.
	12	

Monetary	Score	Comments
capital costs	3	Depends on base case.
life cycle costs	4	Better than wholly mechanically ventilated or air conditioned solutions.
carbon cost effectiveness (£ per tCO2 saved)	4	Depends on base case.
(potential for) economy of scale (to drive down costs)	3	Limited - bespoke solutions usually.
	14	

Capacity/ Supply Chain	Score	Comments
applicability	3	Building functionality affects potential - so limited set of buildings for which this is the best solution.
existing Scottish capacity/skills	4	Design
Scottish content	4	Capabilities in modelling
potential for cross-sector involvement/benefit	3	Limited.
scottish economic impact potential	3	Some positive benefits so long as appriately specified, designed, and operated.
	17	

Consumer	Score	Comments
user friendliness / practicality	4	Depends on base case. Range oif solutions. Needs to be intuitive to occupants.
disruption	3	Less so than many other services options
customer aceptance	3	Depends on occupant needs.
savings on bills	4	Better than a/c solutions, although has functionality implications.
maintenance requirements	4	Better than a/c systems.
health/wellbeing/comfort	3	Depends on occupant perception of control, and ability of design to deliver good environmental conditions given the particular occupant needs.
existing consumer protection? (adequacy?)	4	Performance in-use awareness.
	25	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Review HVAC strategy and occupancy profiles to deliver effective solutions
other relvant considerations/risks/opportunities		Sufficient capacity in thermal mass, consider annual needs,
adaptability / future proofing		Dependent on specific technology installed, whether upgrades or reprogramming possible, may limit adaptability
	102	

Sources and further Reading:

Hybrid ventilation - heat recovery and air quality control

Innovative hybrid ventilation systems mix recirculation air with building extract and inlet air, depending on the internal temperature needs and external temperature resources. Example systems are offered by Breathing Buildings, Monodraught, Ventive and others.

Technical	Score	Comments
Technology readiness	**8**	Systems built and installed, data validation underway. Serioes of ventilation approaches based around heat recovery through cross plate heat exchanges, heat wheels, variable speed control, and mixing.
Efficiency (product / technology efficiency)	3	Depends on baseline. Multiple systems which target a combination of: low cost; energy reductions, air quality, controlability..
Reliability	3	Low cost systems can equate to high maintenance or poor perfromance.
(level of) Compatability with existing systems	2	Can be retrofit into window opening space. Usually challenging.
complexity of systems/ their integration	2	Needs bespoke design / installation
risk/severity of unintended consequences	3	Poor design, installation, or operation can result in poor energy efficiency, IAQ, or functionality.
	21	

Environmental	Score	Comments
(in-use) carbon saving potential	4	Fan power only energy used, significantly lower than AC heat pump, however more than standard windows
whole life environmental impact	4	Depends on base case.
	8	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Addresses (depending on approach): energy efficiency, IAQ (health / wellbeing / productivity).
compatability with current regulation	4	Broiadly compatable, although in-use perfromance can be siugnificantly different than regulatory compliance would suggest.
compatibility with current assessment methodologies	3	Questionable perfromance in use.
	11	

Monetary	Score	Comments
capital costs	3	Depends on base case and system selected.
life cycle costs	3	See above.
carbon cost effectiveness (£ per tCO2 saved)	3	Effective mechanical ventilation should be better than many other alternatives. In use experience suggests that the efficiency of heat recovery systems is often below expectations due to poorly balanced systems.
(potential for) economy of scale (to drive down costs)	3	Solutions are often bespoke.
	12	

Capacity/ Supply Chain	Score	Comments
applicability	3	Wide spread constraints. There are a plethopra of competing systems / approaches.
existing Scottish capacity/skills	3	Appropriate specification, design, instalation, and operation.
Scottish content	3	Capabilities in modelling
potential for cross-sector involvement/benefit	3	Some manufacturing potential.
scottish economic impact potential	3	Depends on base case.
	15	

Consumer	Score	Comments
user friendliness / practicality	4	Not all systems perfrom well in practice, or are understood by occupants.
disruption	3	Significant for refurbishment.
customer acceptance	4	Generally accepted, al;though needs handover.
savings on bills	3	Depends on previous incumbent - natural vent or AC system
maintenance requirements	3	bi-annual service
health/wellbeing/comfort	4	Potential to affect quality of air (temperature and CO2 levels can be improved)
existing consumer protection? (adequacy?)	3	Limited in-use targets or experience.
	24	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Technology emerging, with rapid uptake from schools in particular
other relvant considerations/risks/opportunities		Provides an energy efficient solution to over populated buildings that are suffering from sick building syndrome
adaptability / future proofing		Dependent on specific technology installed, whether upgrades or reprogramming possible, may limit adaptability
	91	

Sources and further Reading:

Passive Stack Heat Recovery

High levels of insulation and air tightness require specifiers to consider controllable means of providing building ventilation with the lowest possible energy penalty. This energy penalty may be in the form of energy required to drive electric fans and/or energy losses in the form of conditioned air being lost to the outside. Passive stack ventilation (PSV) is a well-established means of providing natural ventilation strategy driven by a combination of cross ventilation, buoyancy (warm air rising) and the venturi (wind passing over the terminals causing suction) effect. With the inclusion of heat exchangers, it is now also possible to recover heat from the stack driven out-going air and use this to pre-warm incoming air. This scorecard refers to novel technologies which make use of the natural stack effect to provide ventilation whilst also passing exhaust, heated air, through a heat exchanger.

Technical	Score	Comments
Technology readiness	8	Broadly established but not mainstream or well understood
Efficiency (product / technology efficiency)	4	Moderate when passive driven (no electric fans) and with heat recovery element
Reliability	3	Passive and therefore reliable with limited moving parts. Performance reliability greatest concern, with stack effects driven by wind and temperature out of the control of building users.
(level of) Compatability with existing systems	3	Typically a standalone solution, often able to make use of chimneys, service duct runs etc.
complexity of systems/ their integration	4	Low complexity from a operation and working principles perspective. Can be more complex to install well.
risk/severity of unintended consequences	3	Build tight, ventilate right. Passive stack dependent on wind and temperature.
	25	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Moderate, though primary purpose is to provide controlled ventilation.
whole life environmental impact	4	Once installed, there are no running costs, thus delivering storng benefits over the long term.
	7	

Policy / Regulation	Score	Comments
compatability with Scottish policy	4	Small reduction in energy use and would deliver improved comfort and occupant control.
compatability with current regulation	4	Aligns well with section 6 ambition with products generally well established e.g. BBA, SAP PCDB
compatibility with current assessment methodologies	3	Ventilation generally picked up by DSM and SAP models, though rdSAP (existing property EPCs) lacking in this area. Unlike MCHR and MEV, Passive Stack products are not yet included within SAP PCDB.
	11	

Monetary	Score	Comments
capital costs	3	Moderate, with installation sometimes quite complicated in terms of duct runs and roof access.
life cycle costs	3	Small energy saving potential but if properly maintained, devices will last 10+ years, providing better building and occupant health.
carbon cost effectiveness (£ per tCO2 saved)	3	Primary purpose is not as an energy saving technology but for ventilation - building and occupant health
(potential for) economy of scale (to drive down costs)	4	Significant opportunity to refine and better promote passive ventilation solutions for retrofit, growing this market, driving down costs and improve system efficiencies.
	13	

Capacity/ Supply Chain	Score	Comments
applicability	4	Applicable across new build and retrofit of domestic and non-domestic buildings.
existing Scottish capacity/skills	4	Strong exisitng installation capability across new build and home improvement industry that recognises significance of building airtightness and ventilation.
Scottish content	3	Unknown. Likley to be limited given specialist nature of passive stack products and how few suppliers there are.
potential for cross-sector involvement/benefit	4	Strong potential to overlay this field with wider insulation and fabric airtightness industry. Also links to skills of existing plumbing and electrical contractors.
scottish economic impact potential	3	No doubt scope to bring some some manufacturing into Scotland + generally to develop specialist capabilties in the field of ventilation within Scotland.
	18	

Consumer	Score	Comments
user friendliness / practicality	4	Limited impact on building occupants/users. Constant background air changes typically with manually controlled dampers
disruption	3	Typically moderate disruption to install but level of disruption case specific. Typically easier in non-domestic settings.
customer acceptance	4	Generally good acceptance given health, indoor air quality and controllability benefits.
savings on bills	3	Primary purpose is not as an energy saving technology but for ventilation - building and occupant health
maintenance requirements	4	Possible need to clean/replace in order to maintain system effectiveness. Low number of moving parts and typically no mechanical or electrical elements
health/wellbeing/comfort	4	Primary benefit - improved ventilation control, improved IAQ and comfort.
existing consumer protection? (adequacy?)	3	Moderate with BBA on products etc. though very little regulation of wider impacts i.e. build tight, ventilate right
	25	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Appropriate specification from the outset is key, build tight, ventilate right. With passive stack, the site context, wind directions etc is also key to good system effectiveness. User understanding is also key - how to use the system and the working principals.
other relvant considerations/risks/opportunities		Any ventilation strategy/product solution must be linked to, and designed in accordance with, the fabric airtightness of the building
adaptability / future proofing		Worth considering likely future climate as part of system design. Once system installed, easier to update either end of the duct work for better wind capture or inlet control as technologies develop.
	99	

Sources and further reading:

http://www.ventive.co.uk/benefits-passive-ventilation-with-recovery-and-how-it-works/

Insulation with passive wall ventilation labrinth

Traditionally, fabric retrofit improvements have focused on reducing the thermal transmittance (how quickly heat moves in or out) of the building skin. Despite this, a proportion of heat is still lost through the building fabric. Some innovations are increasingly focusing on recovering this heat by passing inlet ventilation air through a labrinth in the building cavity, before then allowing it to enter the building. The technology is typically installed as external wall insulation. Active systems can be connected to bespoke MVHR systems though passive systems also exist with simplified integration requirements. Careful design and installation is required with significant performance risks if the solution doesn't perform as intended.

Technical	Score	Comments
Technology readiness	7	Solution evidenced
Efficiency (product / technology efficiency)	3	Limited evidence
Reliability	3	Limited evidence
(level of) Compatability with existing systems	2	Requires integration with specifc wall types
complexity of systems/ their integration	3	High complexity, with potential to lead to in correct installations
risk/severity of unintended consequences	2	Moderate to high risk due to complexity and risk of inproper installation
	20	

Environmental	Score	Comments
(in-use) carbon saving potential	3	Strong claims made by manufacturers, however in practice results dependent on existing levels of insulation
whole life environmental impact	3	Moderate, insulating element based on EPS graphit with GWP and ODP of zero.
	6	

Policy / Regulation	Score	Comments
compatability with Scottish policy	5	Applications to reduce energy use.
compatability with current regulation	5	Aligns well with section 6 regulation ambition to minimise fabric heat loss
compatibility with current assessment methodologies	4	Would be difficult to properly model full system benefits with DSM or SAP. Lambda values documented, so main benefit could be captured.
	14	

Monetary	Score	Comments
capital costs	3	More costly than insulation alone
life cycle costs	4	Additional benefits offset additional costs
carbon cost effectiveness (£ per tCO2 saved)	4	Additional benefits offset additional costs
(potential for) economy of scale (to drive down costs)	4	Very early stage technology, therefore costs may come down
	15	

Capacity/ Supply Chain	Score	Comments
applicability	2	Suitable for both domestic, however specific installation likely to limit applicability
existing Scottish capacity/skills	3	Limited existing experience
Scottish content	4	Minimal, save for some installers
potential for cross-sector involvement/benefit	4	Potential for benefits to improve cross-sectors
scottish economic impact potential	3	Impact limited by likely uptake
	16	

Consumer	Score	Comments
user friendliness / practicality	3	Once installed and configured, there is limited reconfiguration or control required
disruption	2	Requires re-skinning or rebuilding façade
customer aceptance	3	limited evidence
savings on bills	3	limited evidence
maintenance requirements	3	limited evidence
health/wellbeing/comfort	4	Expected benefits through improved ventilation in highly insulated buildings
existing consumer protection? (adequacy?)	3	
	21	

Opportunities / risks	Score	Comments
Critical success factors/watch points		Requires specific, careful design and installation to deliver performance
other relvant considerations/risks/opportunities		Requires integration into wider ventilation and sustainability strategy of building
adaptability / future proofing		Dependent on specific technology installed, whether upgrades or reprogramming possible, may limit adaptability
	92	

Sources and further reading:

http://debidentity.wix.com/lomond-breathing-wall#!how-it-works