Embracing Uncertainty - a new approach to the retrofit of existing buildings – Triage, Learning and Holism

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NBT, UCL, STBA

Key Issues for Radical Retrofit

- Lack of knowledge (data, relevant research)
- Complexity of interactions
- Conflicting priorities and values
- Human factors

With

- An urgent need to get on and do something
- The forces of evil (ie existing paradigms that are causing the problem)

Two different approaches

- Single value, non-reciprocal, end driven
- Plural value, reciprocal, means driven

Sustainable Traditional Buildings Alliance

- English Heritage, Historic Scotland, Cadw, SPAB, National Trust, RICS, RIBA, CITB, CIOB, CIAT, FMB, IHBC, UCL, GCU et al
- Set up in November 2011 to link historic building thinking and practice to mainstream construction and government policy
- Project on Responsible Retrofit of Traditional Buildings awarded by DECC Feb 2012, completed start of April 2012.

Responsible Retrofit of Traditional Buildings Project

- Gap analysis of research and guidance about energy performance of traditional buildings both as existing and as retrofitted
- Guidance structure to collate the best practice research and guidance

Added during work:

- Implicit Guidance research
- Guidance tool ideas

Researchers and Writers

- Neil May (Lead – NBT, GHA, UCL)
- Russell Smith (Director – Parity Projectrs)
- Caroline Rye (Gap Analysis – Archimetrics)
- Bill Bordass and Isabel Carmona (Guidance Structure – W Bordass Associates)
- Sophie Pelsmaker (Researcher - UCL)
- Catherine Bull (Researcher – RICS/ SPAB)
- Tom Randall & Laura Morgan (Support - SDF)

Organisations active in review

- UCL
- SPAB
- English Heritage
- Historic Scotland
- Cadw
- Construction Skills
- RICS
- RIBA

Limitations

- Actual time input and process very short
- 9 authors, 12 organisations and 20 advisors
- However, drawing on much experience
- Brief peer review of parts of document prior to submission

- Report is not properly finished

Gap Analysis

- Traditional building performance as existing and retrofitted, in UK and beyond
- Methodology
  - Building on STBA Gap Analysis (research on UK traditional building performance)
  - UK Experts (8 from SPAB, UCL, GCU, WBA)
  - International Experts (14 lead profs from IEA Annex 55)
  - Extended literature search (Dr Caroline Rye and Sophie Pelsmaker)
  - Call for research (39 organisations – 49 responses)

Research papers

- UK experts – 104
- International – 52
- Further Academic search – 167
- Call for Research – 120 (incl books, technical reports, and other documents)
- Also 17 active unfinished research projects (including TSB, EST, LEAF, SUSREF, EH, HS, and UCL work).
- Total 460 documents found for analysis

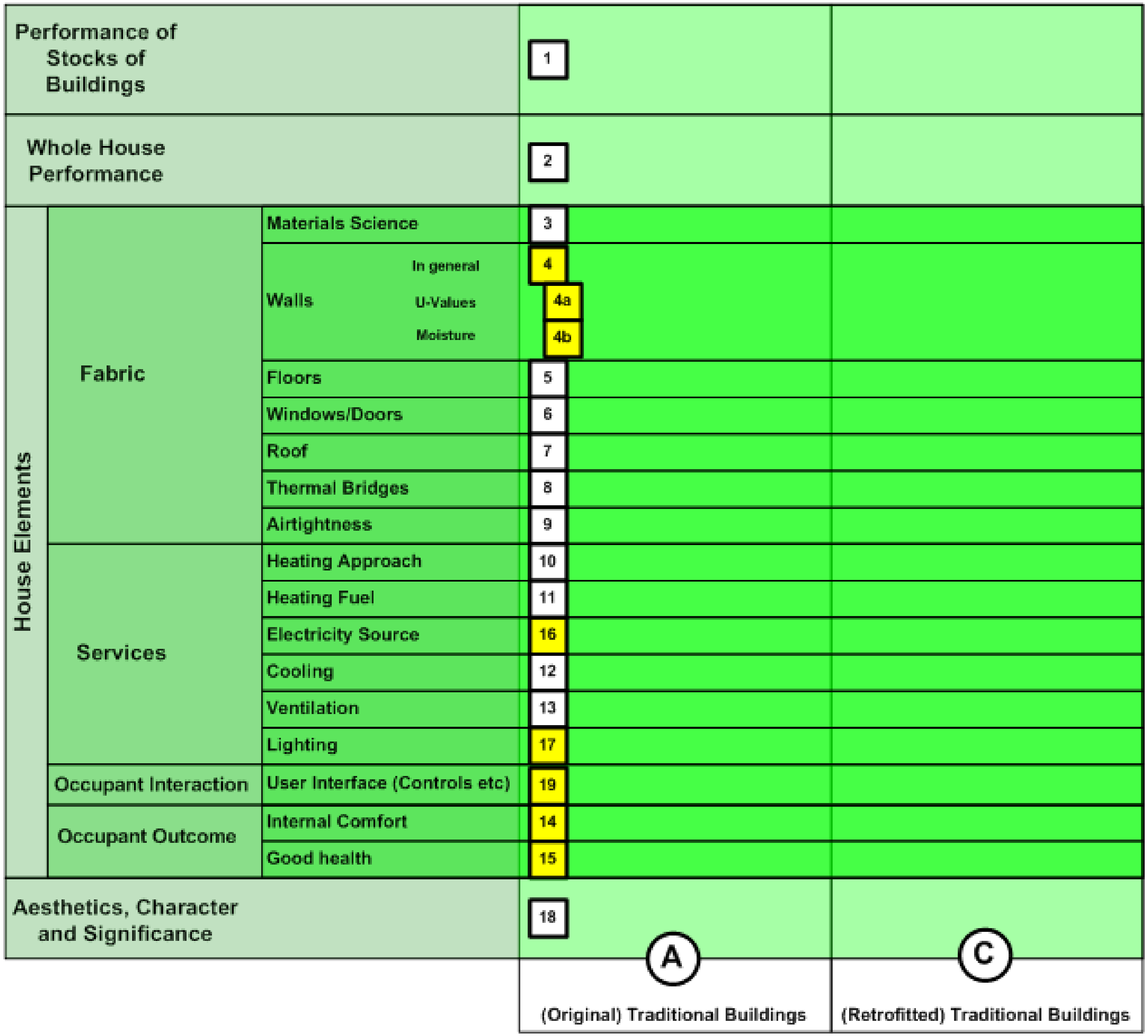
Guidance documents

- Search included in Research Gap Analysis method
- Additionally search from statutory bodies, councils, local energy trusts, other advisory bodies and on internet
- 102 documents were found worthy of analysis

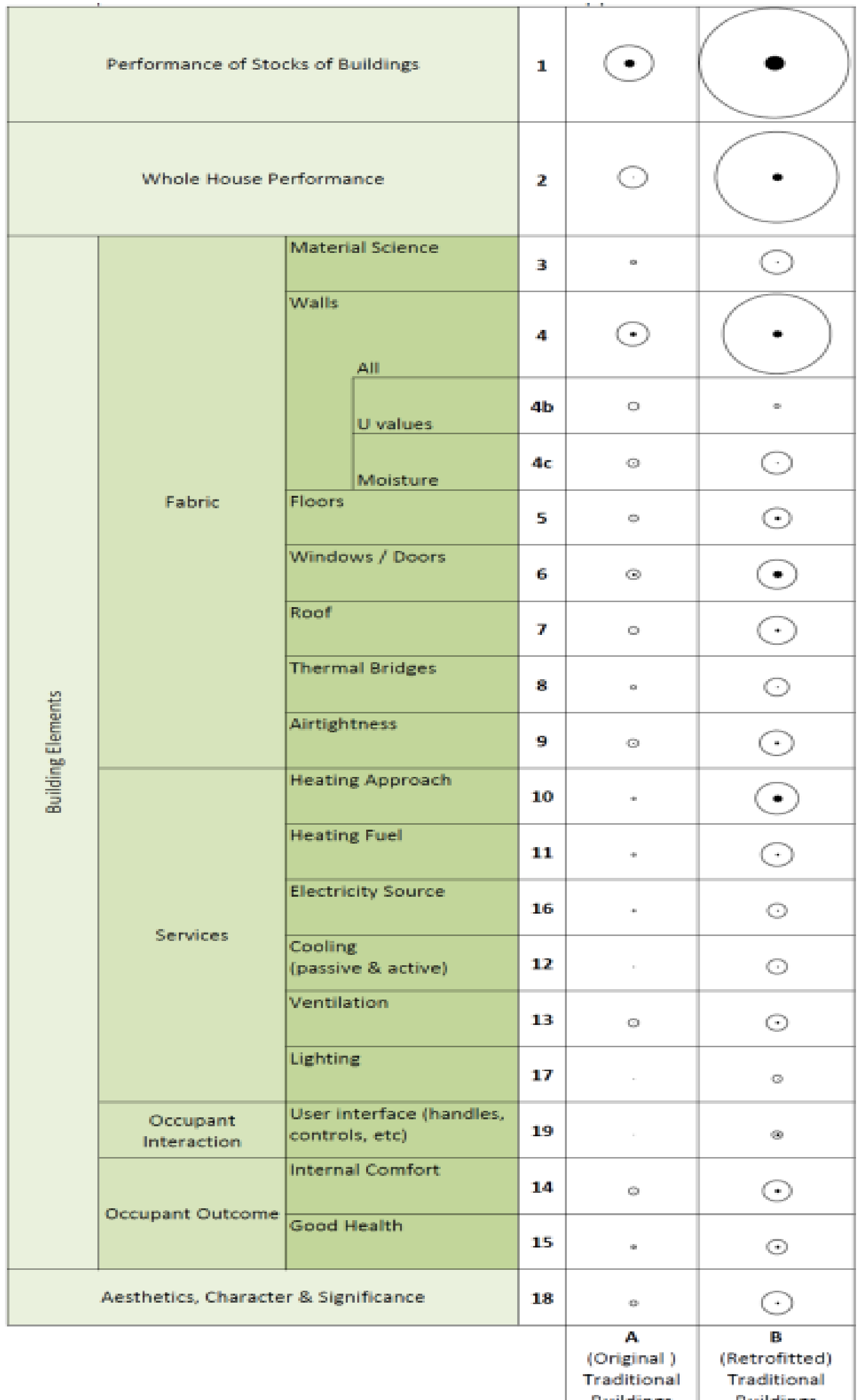
Judging the value of the documents - where are the gaps?

- Are all areas of retrofit decision making and installation processes covered by the available research? i.e. the intelligence must be mapped.
- Which of the research provided has genuine worth? i.e there must be a judgement process

By carrying out these two processes we see where retrofit is adequately covered by intelligence and how well that intelligence has dealt with it.


Performance of Stocks of Buildings
1
Whole House Performance
2
House Elements
Fabric
Materials Science
3
Walls
In general
4
U-Values
4a
Moisture
4b
Floors
5
Windows/Doors
6
Roof
7
Thermal Bridges
8
Airtightness
9
Services
Heating Approach
10
Heating Fuel
11
Electricity Source
16
Cooling
12
Ventilation
13
Lighting
17
Occupant Interaction
User Interface (Controls etc)
19
Occupant Outcome
Internal Comfort
14
Good health
15
Aesthetics, Character and Significance
18
A
(Original) Traditional Buildings
C
(Retrofitted) Traditional Buildings

Tier	In general	Qualities to Expect in Each Tier			
		Evidence Base	Independently Reviewed	Significance to a Defined Area on the Intelligence Map (may be more than one)*	Relevance
Tier 4	Poor quality but record that we know it exists	Little real evidence base to the research; guidance is selectively based on evidence or based on no evidence.	No independent review	N/A	Misleading, wrong or harmless?
Tier 3	The research is of value and makes some contribution to issues of retrofit of older properties and the in GD context	Evidence backs up the research	Some evidence of independent review.	It offers an insight to a particular area or areas on the Intelligence Map.	May have longer term relevance if not immediately relevant
Tier 2	The research is of value and makes some contribution to issues of retrofit of older properties esp in GD context	Research evidence is based on modelling and simulation; guidance is based on Tier 1 or 2 research.	The research has not undergone peer-review.	It offers the strongest information in its area on the Intelligence Map	Immediate relevance
Tier 1	Seminal research that identifies issues of greatest relevance to retrofit of older properties esp in GD context	Evidence backs up the research; guidance is based on Tier 1 research.	The research has been independently reviewed and verified as being derived from the evidence or is sufficiently critically reflective.	It offers the strongest information in its area on the Intelligence Map	Immediate relevance


Performance of Stocks of Buildings
1
Whole House Performance
2
Building Elements
Fabric
Material Science
3
Walls
4
All
4b
U values
4c
Moisture
Floors
5
Windows / Doors
6
Roof
7
Thermal Bridges
8
Airtightness
9
Services
Heating Approach
10
Heating Fuel
11
Electricity Source
16
Cooling
(passive & active)
12
Ventilation
13
Lighting
17
Occupant Interaction
User interface (handles, controls, etc)
19
Occupant Outcome
Internal Comfort
14
Good Health
15
Aesthetics, Character & Significance
18
A
(Original)
Traditional
Buildings
B
(Retrofitted)
Traditional
Buildings

Gap Analysis of Research and Guidance

- 512 documents with 1241 references mapped
- 79% are on retrofit only 21% on traditional building performance – big gap in base line data and traditional building understanding.
- 3 main areas of research are performance of stock, whole house performance and solid wall performance, all retrofitted
- Some areas of real significance have almost no research or guidance (ie floors, overheating, occupant interaction, user health, lighting)

In nearly every category there are major knowledge gaps

- Lack of basic research nearly everywhere
- Real lack of data in regard to traditional materials, construction, air permeability/ ventilation rates and systems, and weather. *Gaps in data.*
- Over-reliance on modelling which has been shown to be unreliable in many cases. *Gap between models and reality*.
- Current thermal (BR443 including RdSAP) and moisture conventions (BS5250) are not correct for traditional buildings in most cases. *Gap between conventions and reality.*
- Lack of understanding of moisture physics. *Knowledge gap*
- Windows knowledge and research is good! But the information is not getting into mainstream guidance (*gap!*).

Linkages and opportunity gaps

- Ventilation to health of occupants
- Retrofit to thermal comfort
- Lifestyle to energy use and the possible rebound effects of retrofit
- Thermal mass to energy and comfort
- Energy conservation and building conservation (particularly repair and maintenance)
- Energy efficiency and heritage values
- Energy efficiency and community

Implicit Guidance

- Evident that most guidance is not from research or official guidance documents but from standards, certifications, and commercial technical and marketing literature
- This workstream was an attempt to understand whether Implicit Guidance is aligned with the best research and guidance (ie Tier 1 and 2) and what the main causes for concern might be.
- Very limited study

Examination of implicit guidance

- Building Regulations
- British Standards (BSI)
- Product Certification (BBA)
- CE Marking
- Trade Literature
- Warranties/ Guarantees

How are traditional buildings dealt with?
Answer - hardly at all.

Case Study on Solid Wall Insulation

- Examination of Building Regulations, BBA certification and trade technical and other literature for EWI and IWI (46 BBA EWI certificates and 12 IWI certificates)
- Examination particularly of thermal and moisture issues in relation to Tier 1 and 2 research and guidance

- Very large gaps and misalignment found

Gaps between Tier 1 and Implicit Guidance

- Without exception all certifications, technical literature and advertising use BR 443 (BS 6946) or the RDSAP default values for solid wall U values and cost savings. This is incorrect.
- Thermal bridging in both EWI and IWI not properly dealt with.
- All use BS5250 (EN13788) rather than EN15026 (except where BS5250 doesn't allow use!) for moisture analysis

Recommendations

- Policy issues
  - New conventions
  - New standards
  - New assessment and training
- Delivery issues
  - A new approach based on learning and systemic thinking
  - Training and skills
  - A guidance structure and knowledge centre
- Development issues
  - A wide ranging research programme
  - Action based research and feedback

Conclusion

- If these recommendations are taken up, then some of the main risks to traditional buildings of the Green Deal policy may be averted. Furthermore it is believed by the STBA that, if these recommendations are carried through, the Green Deal and other retrofit policies could be undertaken with more financial, energy and environmental benefit than previously envisaged, and be a driver for significant positive change in industry (both in terms of employment and skills), in user behaviour and in terms of public understanding and engagement.

The problem of false certainty

- The difficulty of multiple factor complexity
- The complexity of situations where people are involved
- The failure of single focus solutions to deal with multi-causal problems
- The pressures to deliver and meet unrealistic targets or milestones.
- Commercial pressure to sell, sell, sell!

The opportunity of uncertainty

- The acceptance of a situation where there are no easy answers or perhaps no answers at all is liberating
- Uncertainty requires care, open-mindedness, and humility
- Uncertainty can lead to a different kind of success, perhaps a better one than we could imagine

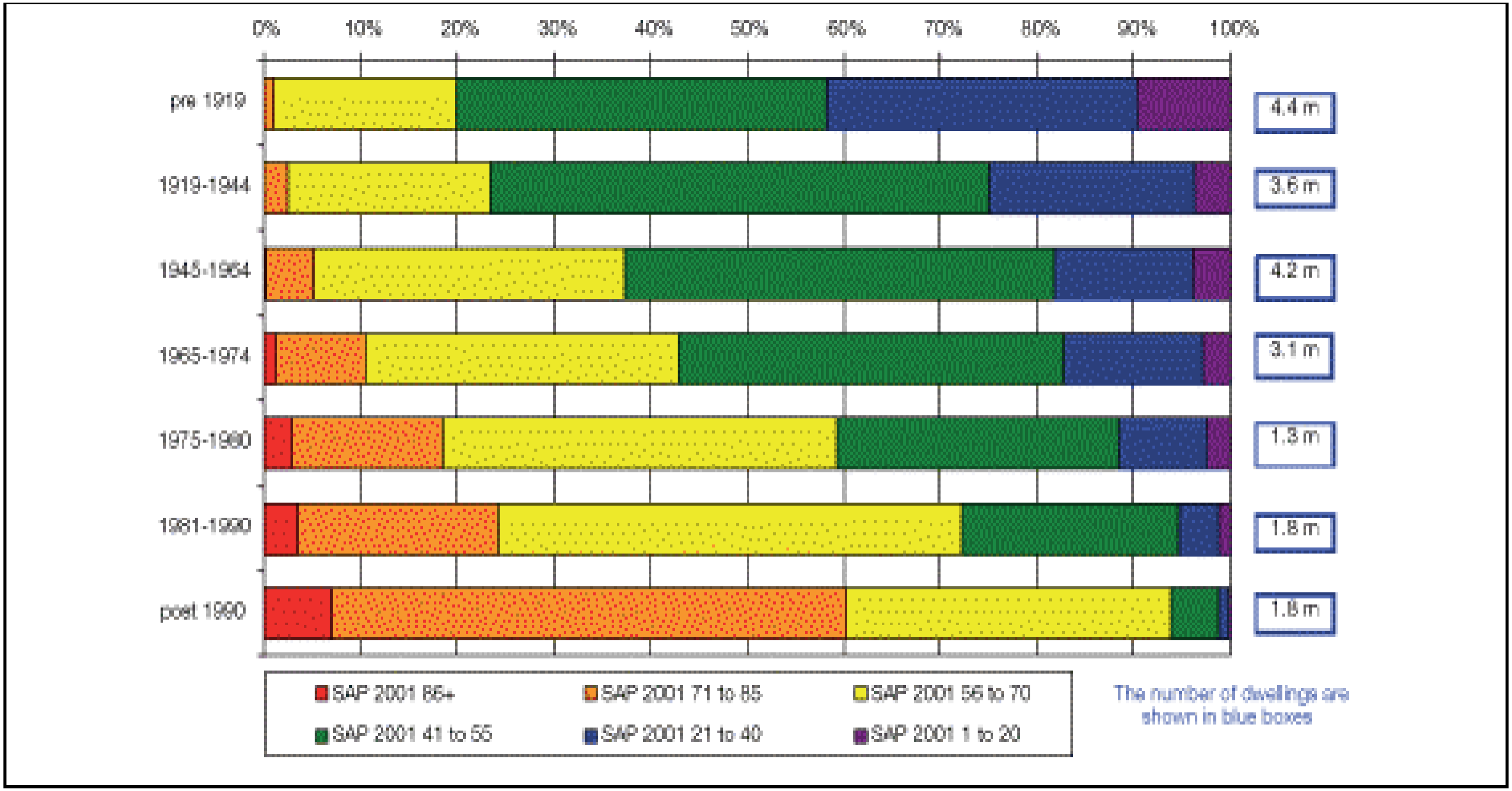
Solid walls

- Thermal and energy performance
- Moisture
- Health
- Community and culture?

Thermal and Energy Performance

- Background issue of U values of traditional walls and calculation methods
- Thermal Limits?
- Application in reality?
- User response

Old walls bad – new walls good

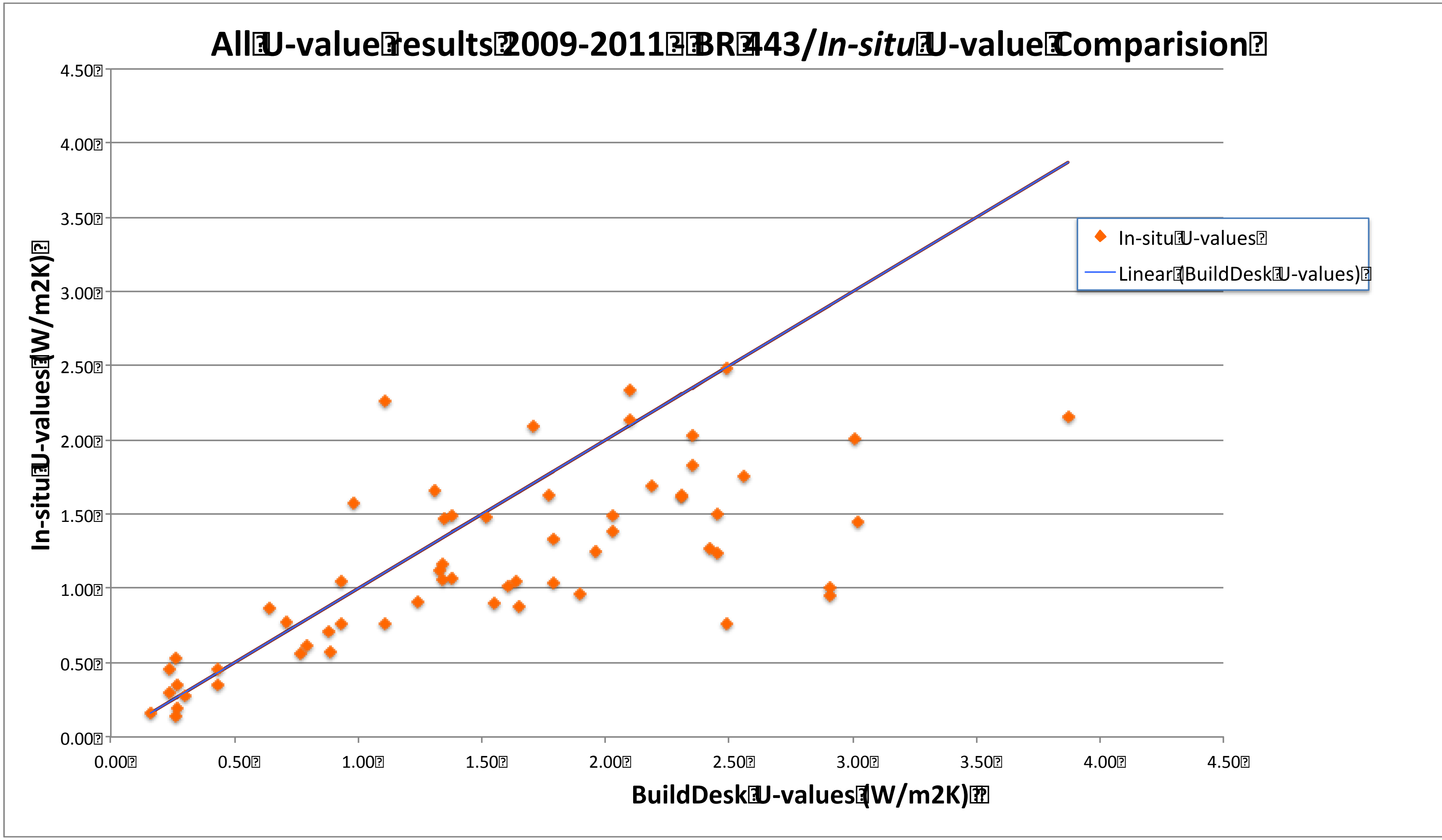


SAP energy assessment of dwellings based on age of stock.

Review of Sustainability of Existing Buildings, DCLG, 2006.

Thermal issues: Traditional walls

- Do not conform to type of wall suited to BR 443 (using BS 9496) – ie discreet layers of known materials
- Also no robust material data for traditional materials
- So are the Rd SAP values correct?



Thermal performance of traditional walls underestimated by BR 443 in 73% of cases (2009 – 2011, 59 samples)

S·P·A·B

ArchiMetrics

Average *in situ* U-value for stone & brick walls

Table S6 : Wall U-values – England and Wales

Age band	A	B	C	D	E	F	G	H	I	J	K
Wall type											
Stone: granite or whin (as built)	2.4	2.4	2.4	2.4	1.7	1.0	0.60	0.60	0.45	0.35	0.30
Stone: sandstone (as built)	2.1	2.1	2.1	2.1	1.7	1.0	0.60	0.60	0.45	0.35	0.30
Solid brick (as built)	2.1	2.1	2.1	2.1	1.7	1.0	0.60	0.60	0.45	0.35	0.30
Stone/solid brick (external insulation)	0.60	0.60	0.60	0.60	0.55	0.45*	0.35*	0.35*	0.30*	0.25*	0.21*
Stone/solid brick (internal insulation)	0.60	0.60	0.60	0.60	0.55	0.45*	0.35*	0.35*	0.30*	0.25*	0.21*
Cob (as built)	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.60	0.45	0.35	0.30
Cob (external insulation)	0.40	0.40	0.40	0.40	0.40	0.40	0.35*	0.35*	0.30*	0.25*	0.21*
Cob (internal insulation)	0.40	0.40	0.40	0.40	0.40	0.40	0.35*	0.35*	0.30*	0.25*	0.21*
Cavity (as built)	2.1	1.6	1.6	1.6	1.6	1.0	0.60	0.60	0.45	0.35	0.30
Filled cavity+	0.50	0.50	0.50	0.50	0.50	0.40	0.35	0.35	0.45†	0.35†	0.30†
Timber frame (as built)	2.5	1.9	1.9	1.0	0.80	0.45	0.40	0.40	0.40	0.35	0.30
Timber frame (internal insulation)	0.60	0.55	0.55	0.40	0.40	0.40	0.40†	0.40†	0.40†	0.35†	0.30†
System build (as built)	2.0	2.0	2.0	2.0	1.7	1.0	0.60	0.60	0.45	0.35	0.30
System build (external insulation)	0.60	0.60	0.60	0.60	0.55	0.45	0.35*	0.35*	0.30*	0.25*	0.21*
System build (internal insulation)	0.60	0.60	0.60	0.60	0.55	0.45	0.35*	0.35*	0.30*	0.25*	0.21*

* wall may have had internal or external insulation when originally built; this applies only if insulation is known to have been increased subsequently (otherwise "as built" applies)

+ cavity wall with internal or external insulation to be treated as filled cavity wall for the purposes of the SAP calculation.

† assumed as built

Appendix S SAP 2009 – Stone 2.1 & 2.4 W/m^{2}K, Brick 2.1 W/m2K

In situ U-value Stone & Brick = 1.48 W/m^{2}K (average)

S·P·A·B

ArchiMetrics

Trinity College results - monitoring

- Walls bone dry (extensive heating)
- Some very wet joists (one façade at ground level)
- Better thermal performance of the wall than modelled under modified BR443

	U-Value (W/m2K)
RdSAP 2009 default	2.1
Calculated (BuildDesk)	1.46
Measured (Heat Flux)	0.69 (average)

External lime render (20mm), natural stone (600mm), internal lime plaster (20mm)

Trinity College results -monitoring

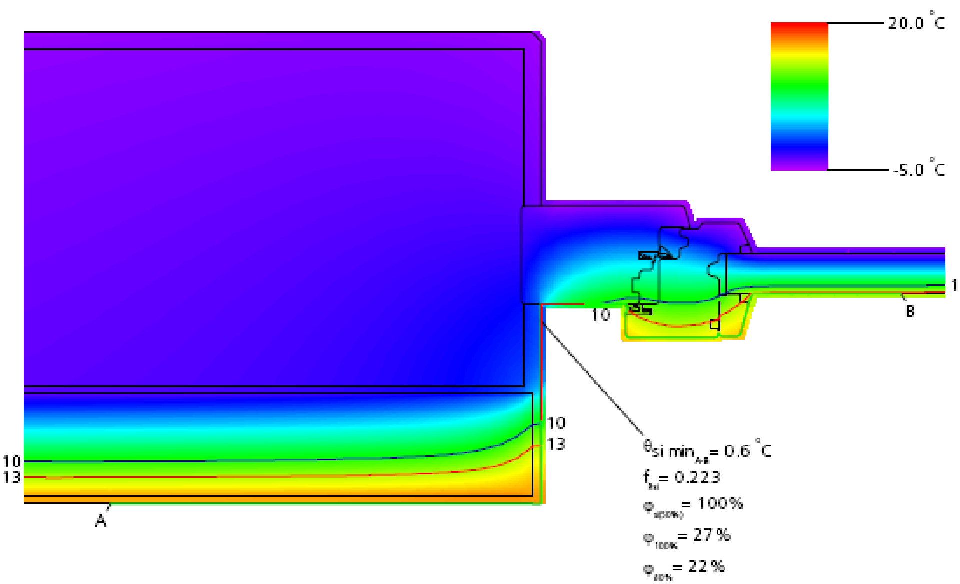
- Very different material properties between the two brick samples
- Initial monitoring of RH and Temperature fails
- Initial tests of in situ U values and air permeability completely different from second tests

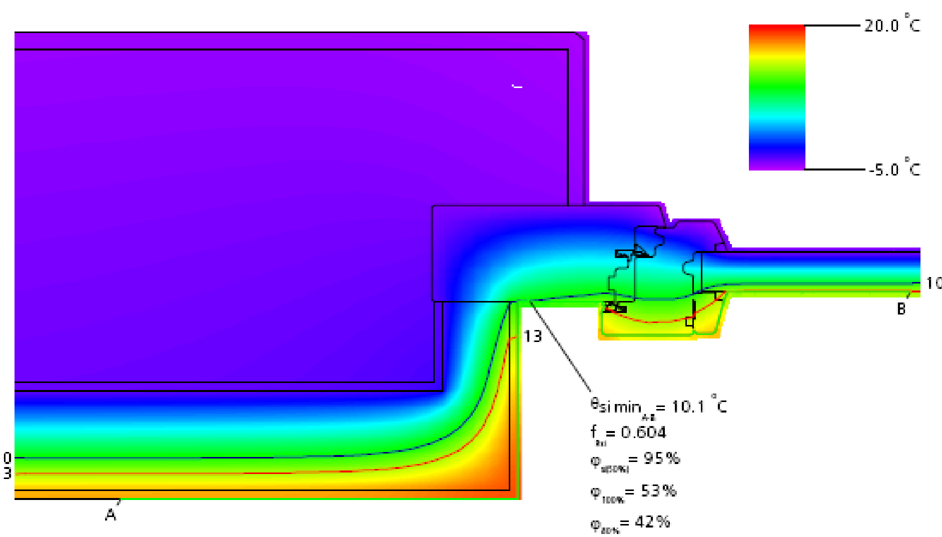
	Test 1	Test 2
In situ U values	1.4	0.7
Air Permeability	22m3/m2/hr	11m3/m2/hr

Consequences

- We need more research and better understanding of solid wall thermal performance
- We need to be careful of modelling and monitoring. These require a lot of skill
- We need to be aware that the forecast energy and financial payback will almost certainly not be as good as predicted when buildings are retrofitted

Practical limits: Thermal Bridges

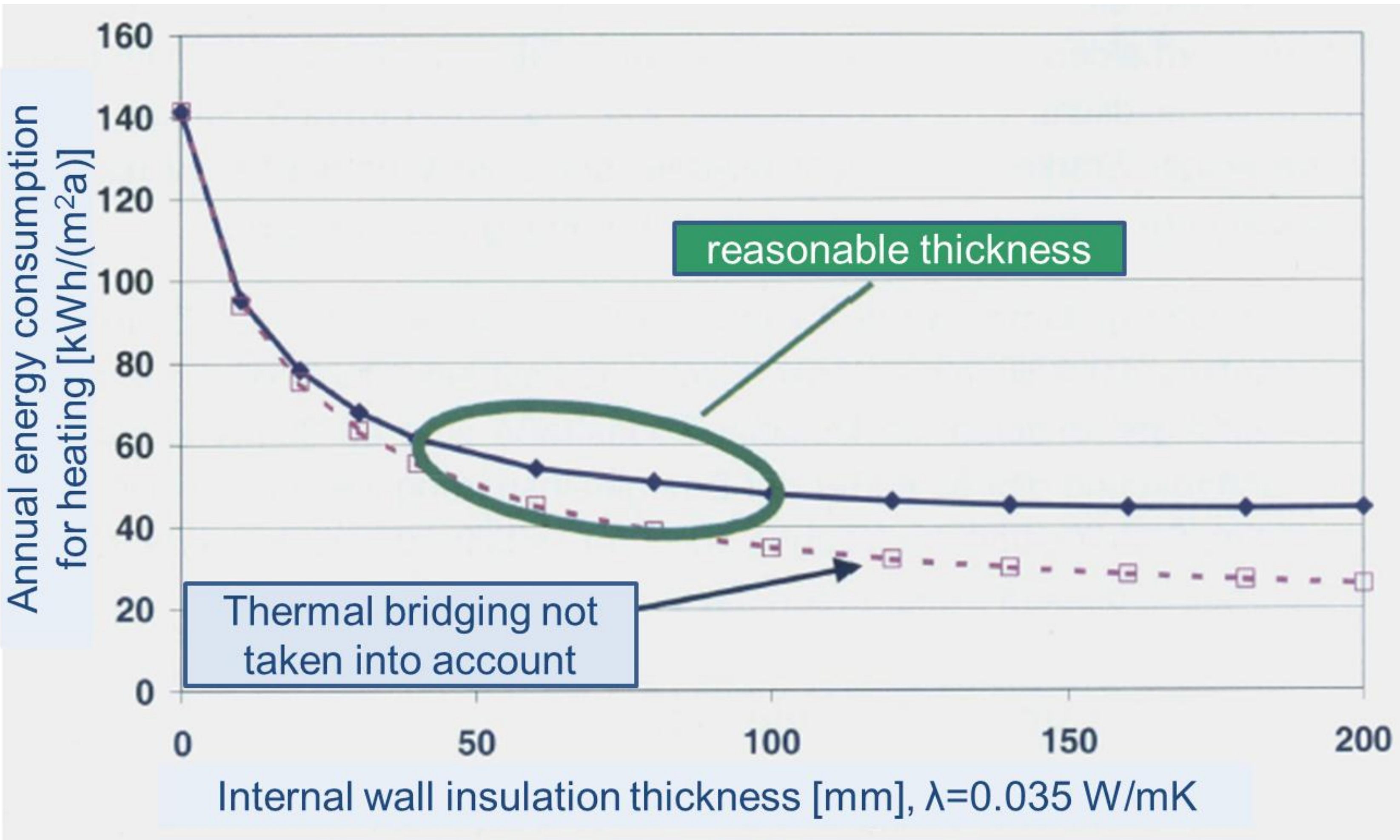




Refurbishment of a traditional stone wall with 60 mm insulation on the inside

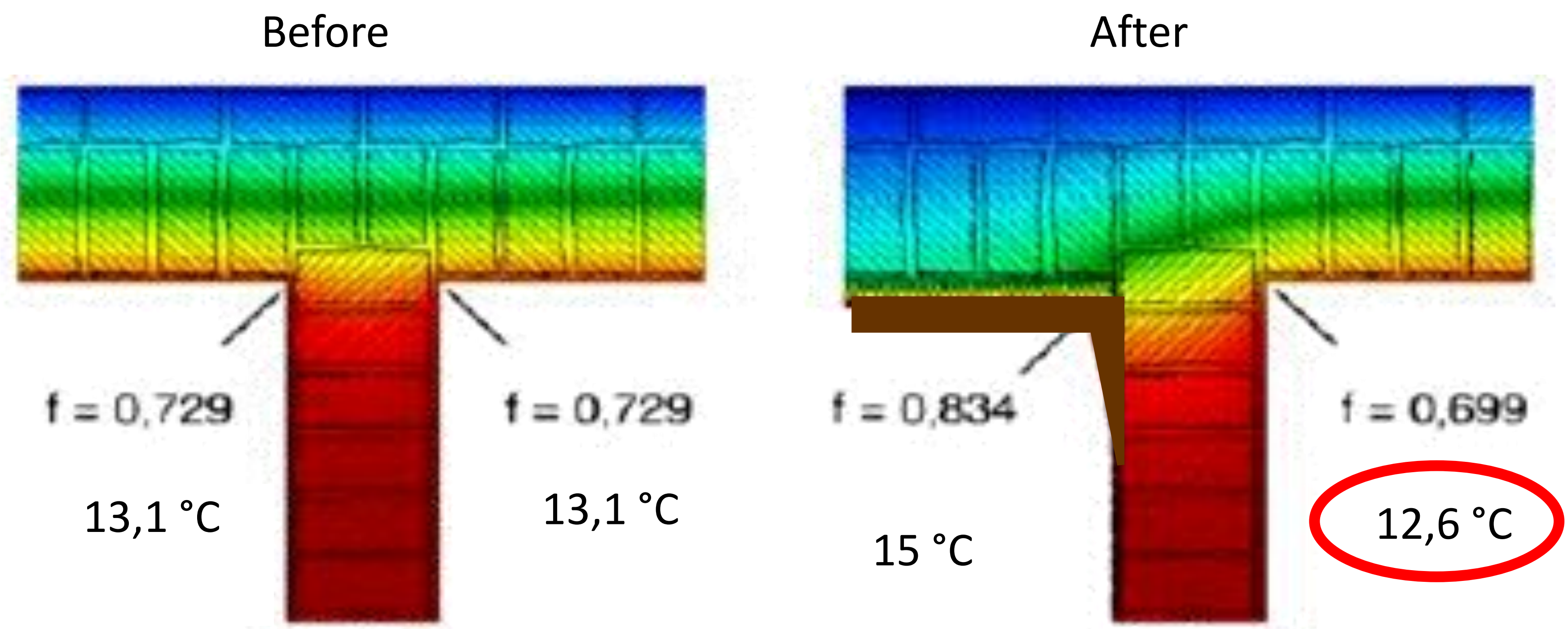
- Reveal not insulated
- Reveal now insulated with 40 mm insulation

Thermal Limits (Internal Insulation)



Quelle W. Feist: Faktor 4 auch bei sensiblen Altbauten, Passivhauskomponenten + Innendämmung

Thermal Bridges: Party Wall Issues



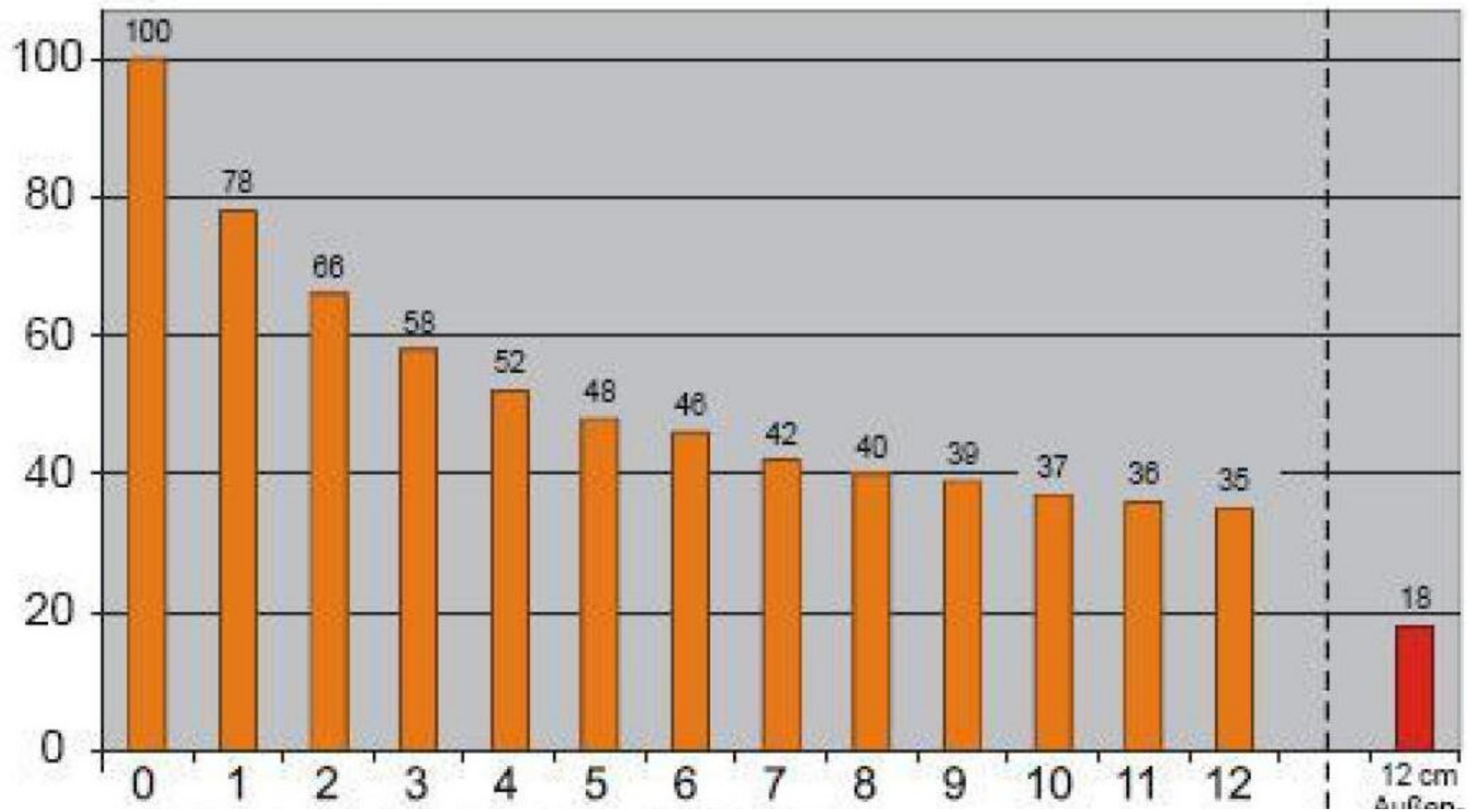
Partial fixed internal wall insulation:

- Displacement of isotherms, surface temperature sinks on the non-insulated side of the wall

    ↳Risk of mould / mildew

External Insulation versus Internal?

Energy loss through external wall in %



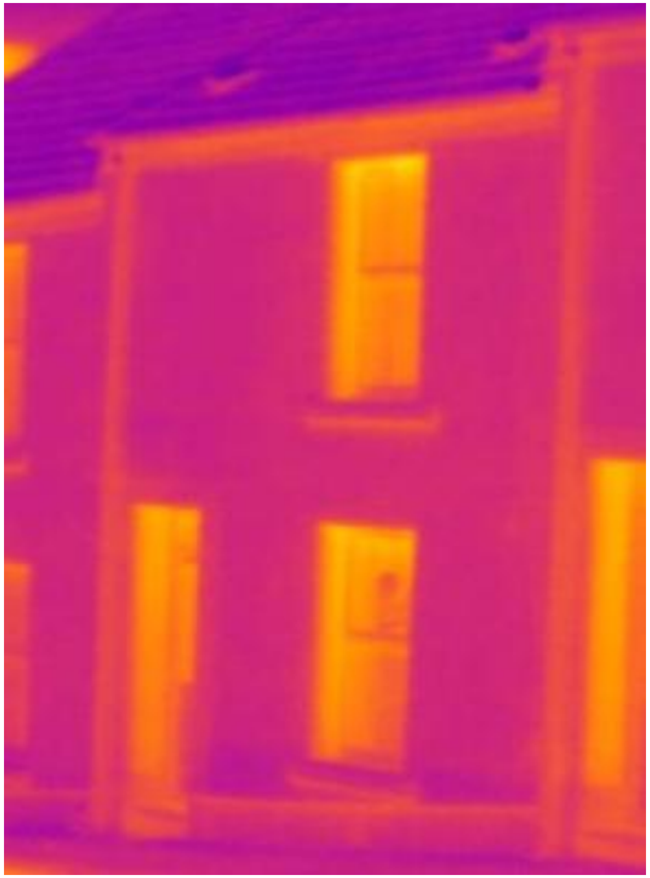
Thickness of internal insulation in cm

External insulation


GLOBE INN
THE GLOBE
HOWARD STREET
ENDS

Reality

Assessing the execution of retrofitted external wall insulation for pre-1919 dwellings in Swansea (UK); Joanne Hopper et al 2011



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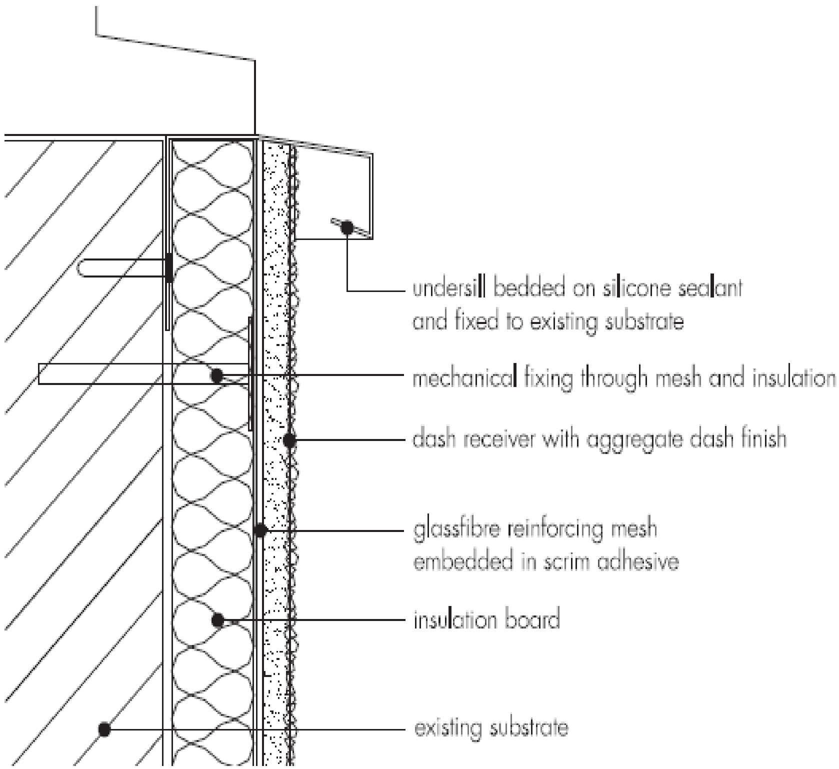
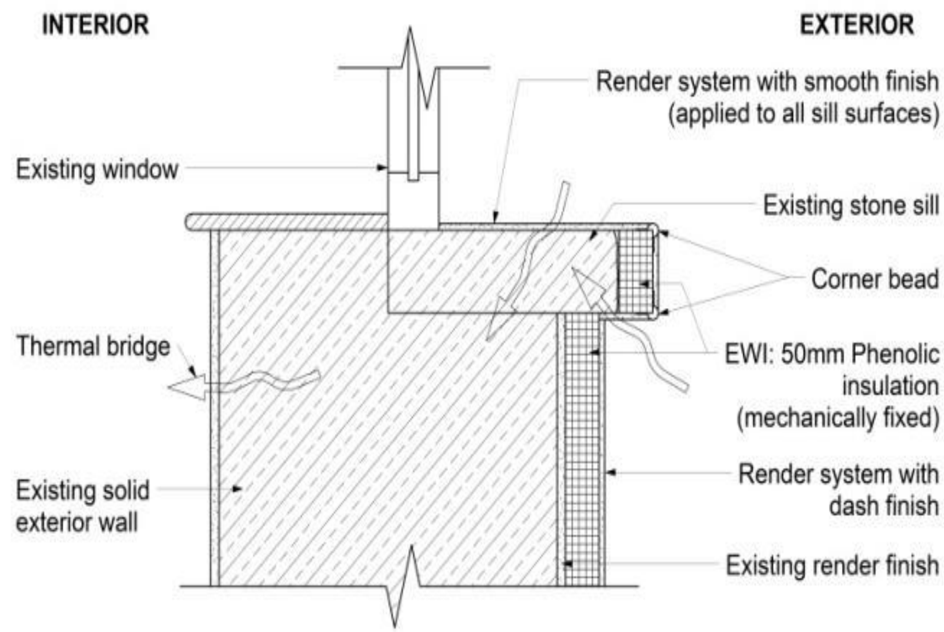


Detail in BBA Certificate



As applied on site

Assessing the execution of retrofitted external wall insulation for pre-1919 dwellings in Swansea (UK); Joanne Hopper et al 2011

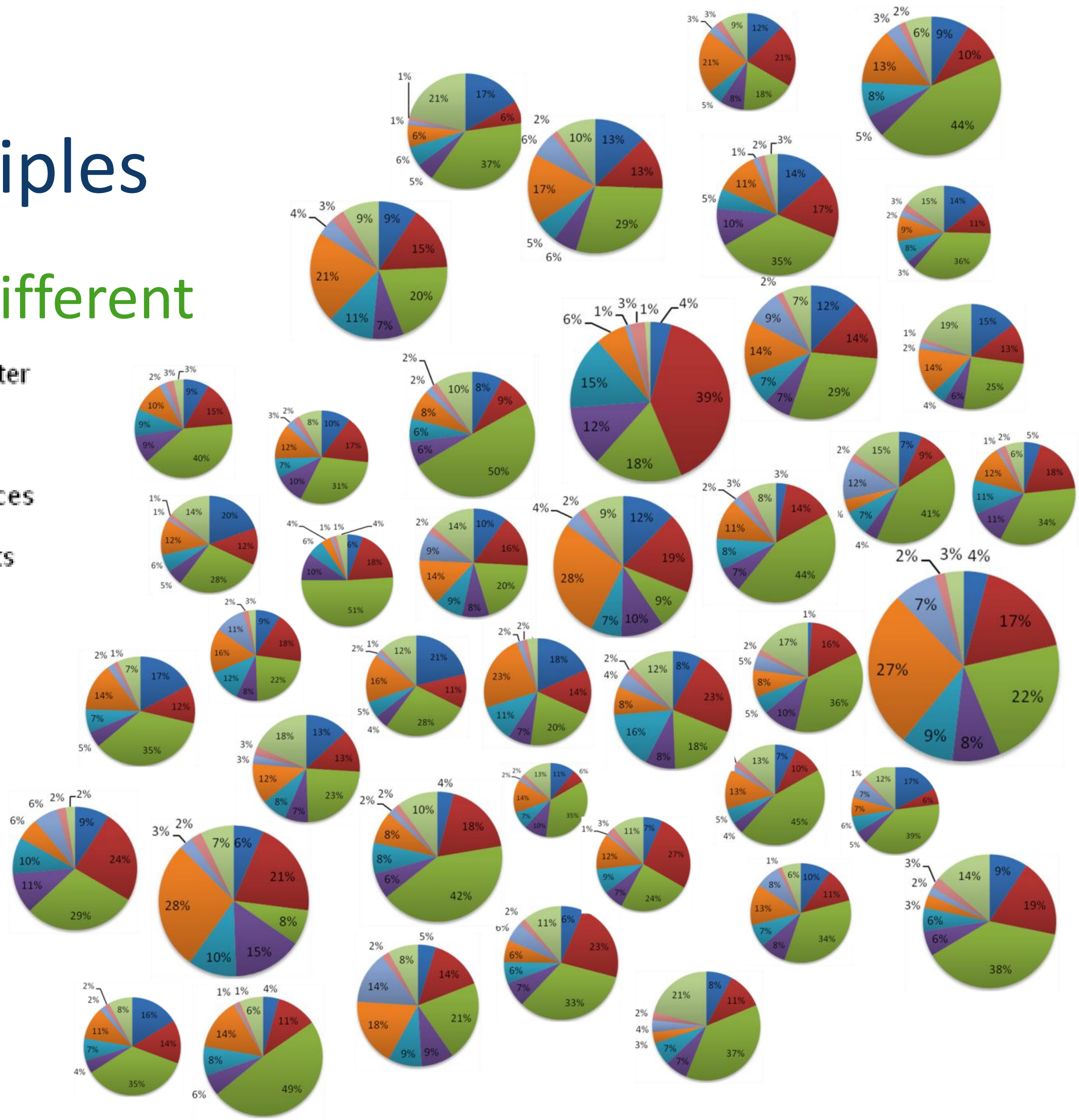
Energy/Carbon – the human factor

- Warm Front
- BedZed
- Traditional buildings?

Energy principles

Every home is different

- Windows/Doors
- Heating inefficiency
- Roof
- Floor
- Lights
- Hot Water
- Walls
- Appliances
- Draughts



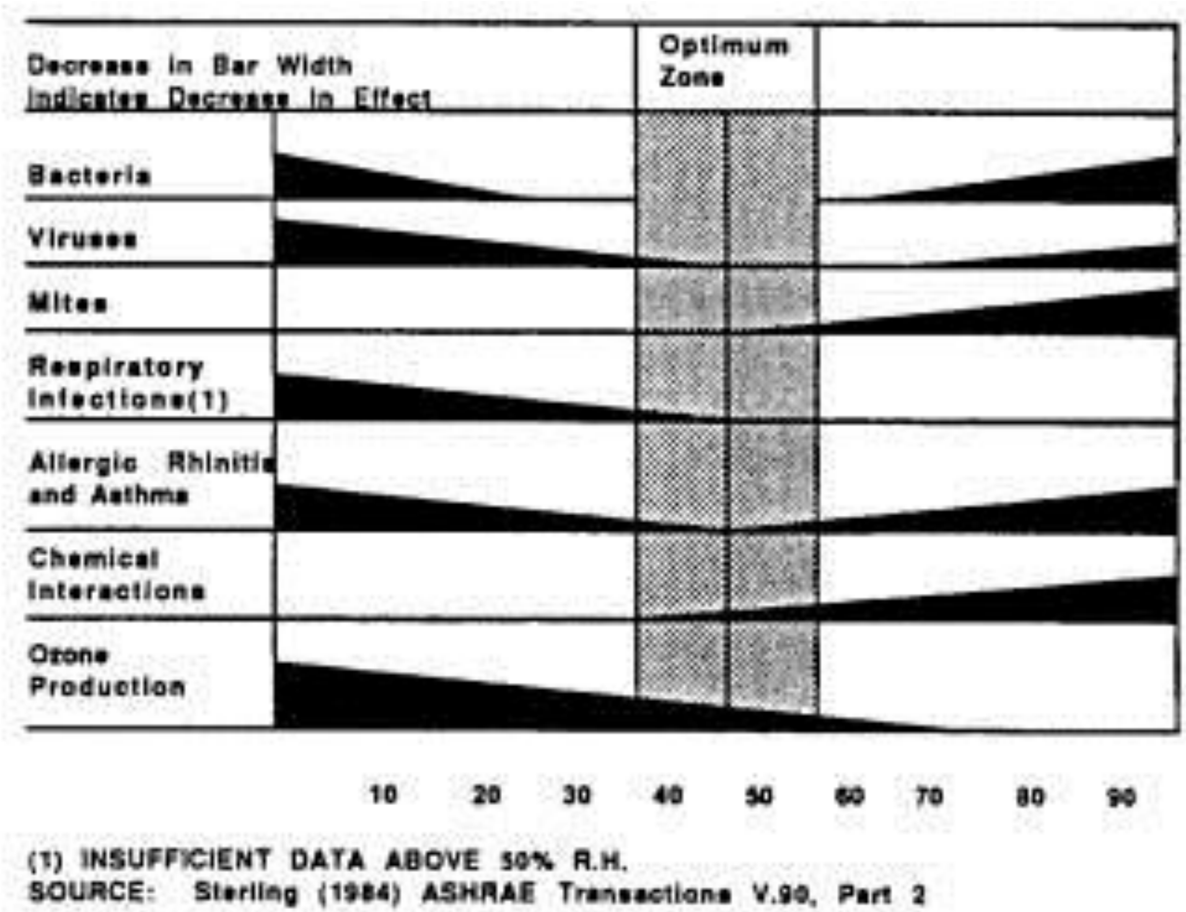
Parity Projects analysis of 40 homes in London, built within 5 years of each other around 1900, within one mile of each other, unusual houses removed

Moisture: more unknowns

- Material data
- Weather data
- Moisture physics
- Durability of fabric over time
- Construction fault modelling

What we do know is that moisture is the main cause of building decay and one of the main causes of human health problems in buildings

Building Health & Human Health



Conflicting understanding of mould risk?

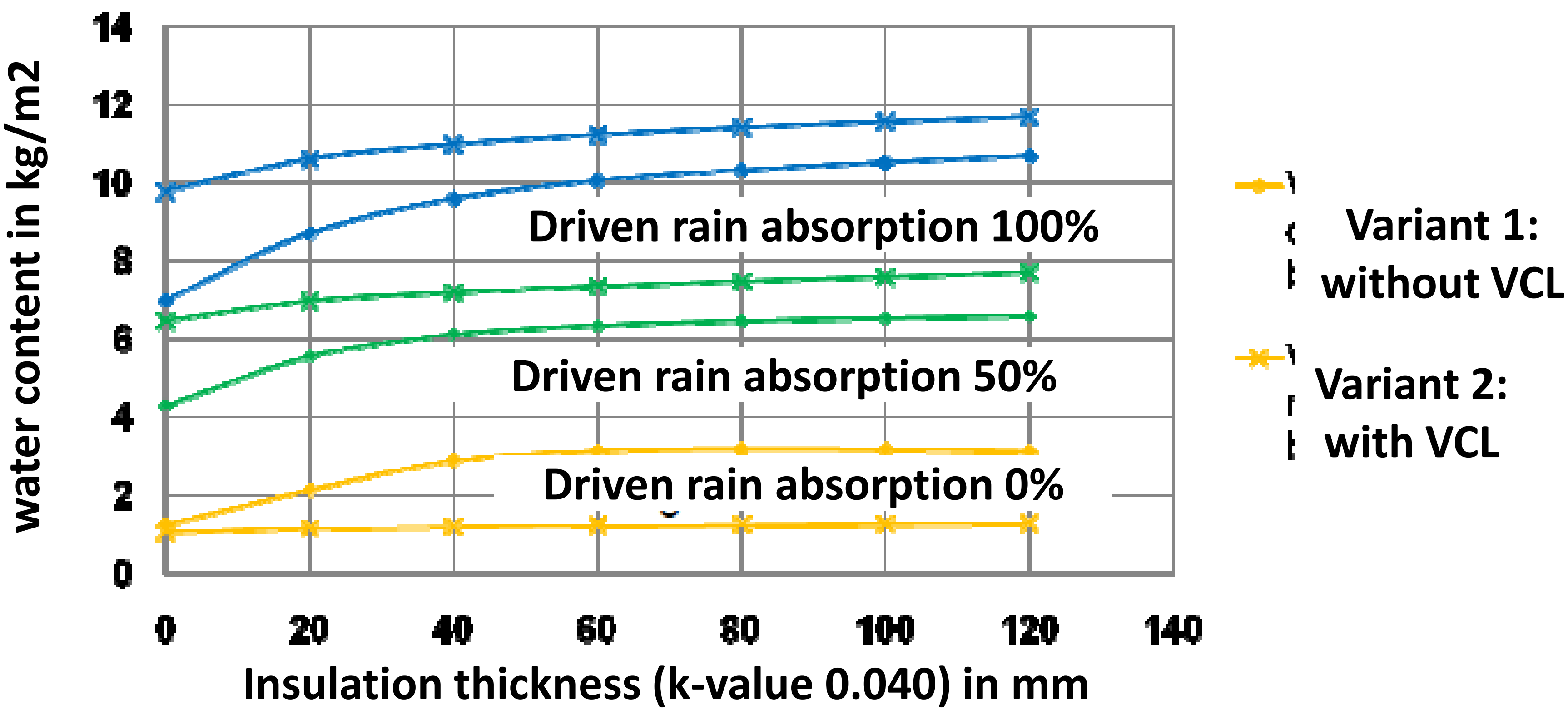
- Driven rain is not so important in Germany as UK
- IBP sees presence of oxygen as critical
- RH limits in IBP
  - Max RH with air = 85%
  - Max RH without air = 95%
- Part F limits
  - 1 day 85%
  - 1 week 75%
  - 1 month 65%

Modelling Protocols

- BS EN 13788 (BS 5250) versus EN 15026

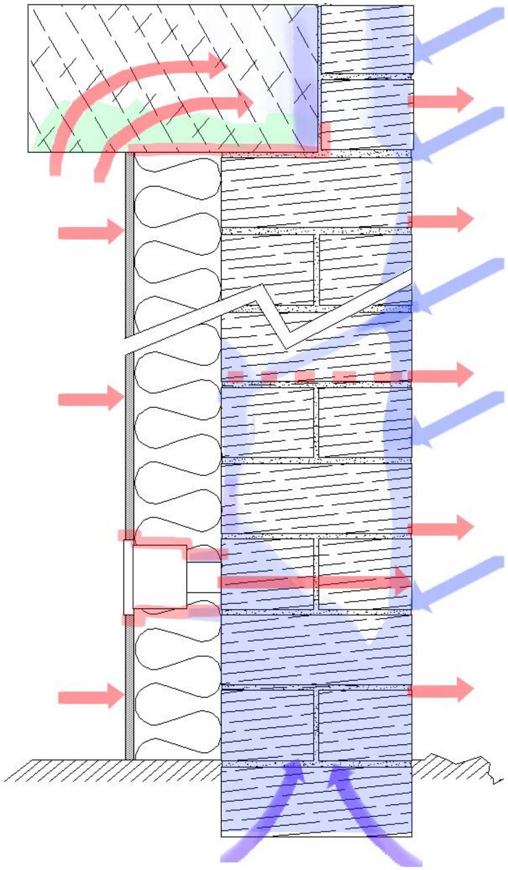
EN 13788	EN 15026
Steady state	Dynamic
Monthly (averaged)	Hourly
Limited materials criteria	Full materials criteria
No driven rain	Driven rain
No orientation	Orientation

Driven rain and internal VCLs: Average water content of an external (German) wall

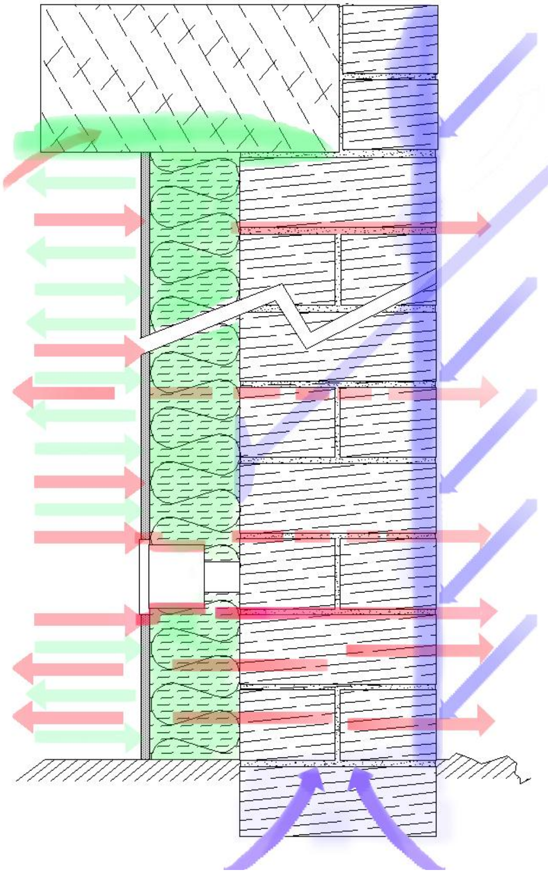


Source: Dr. A. Worch: Innendämmung: Bauphysikalische Aspekte, Probleme und Grenzen und Lösungswege für die Praxis (engl: Dr. A. Worch: Internal insulation: structural-physical aspects, problems and limits and solutions for the practice)

Internal Insulation Approaches

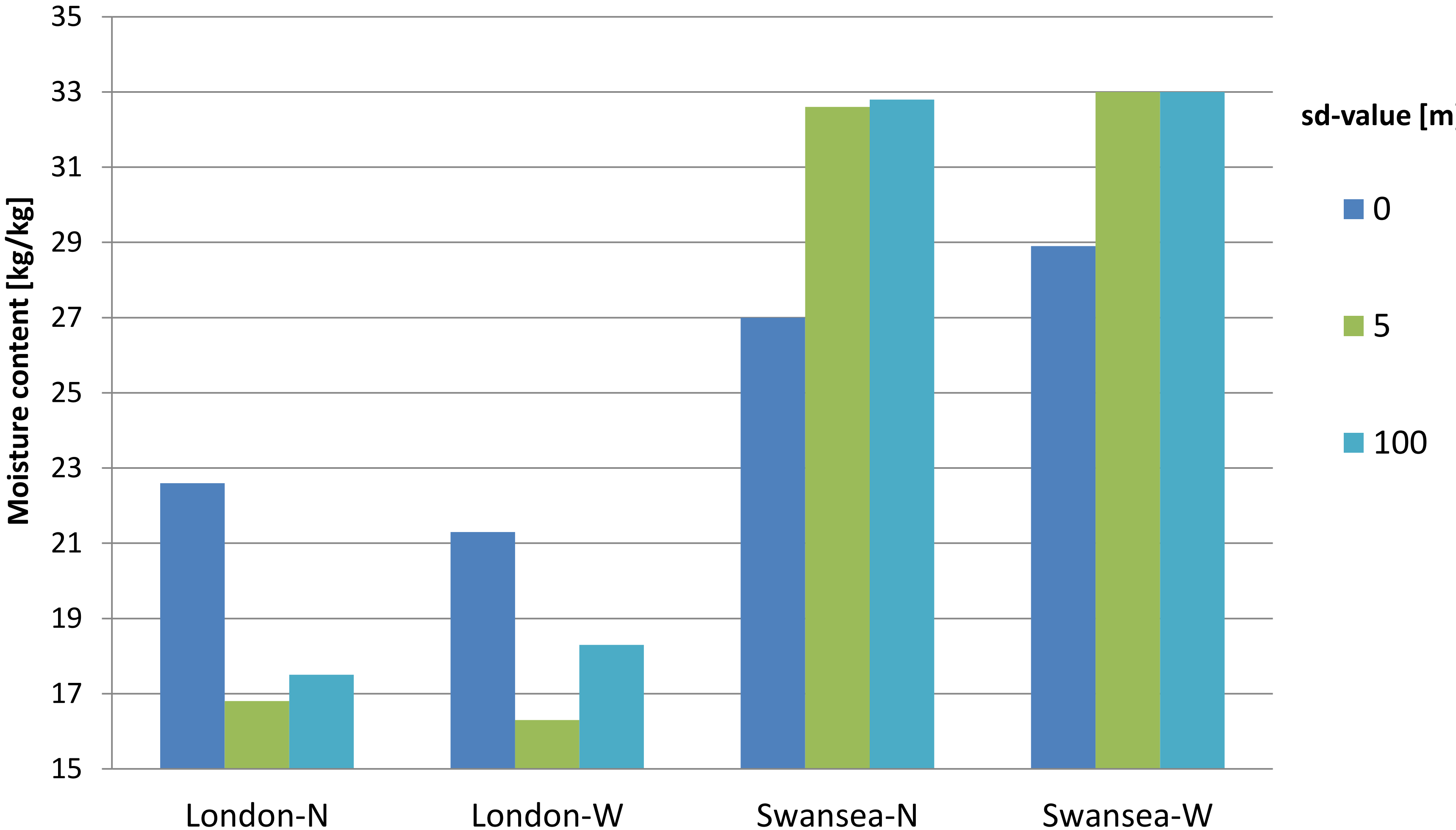


Non breathable

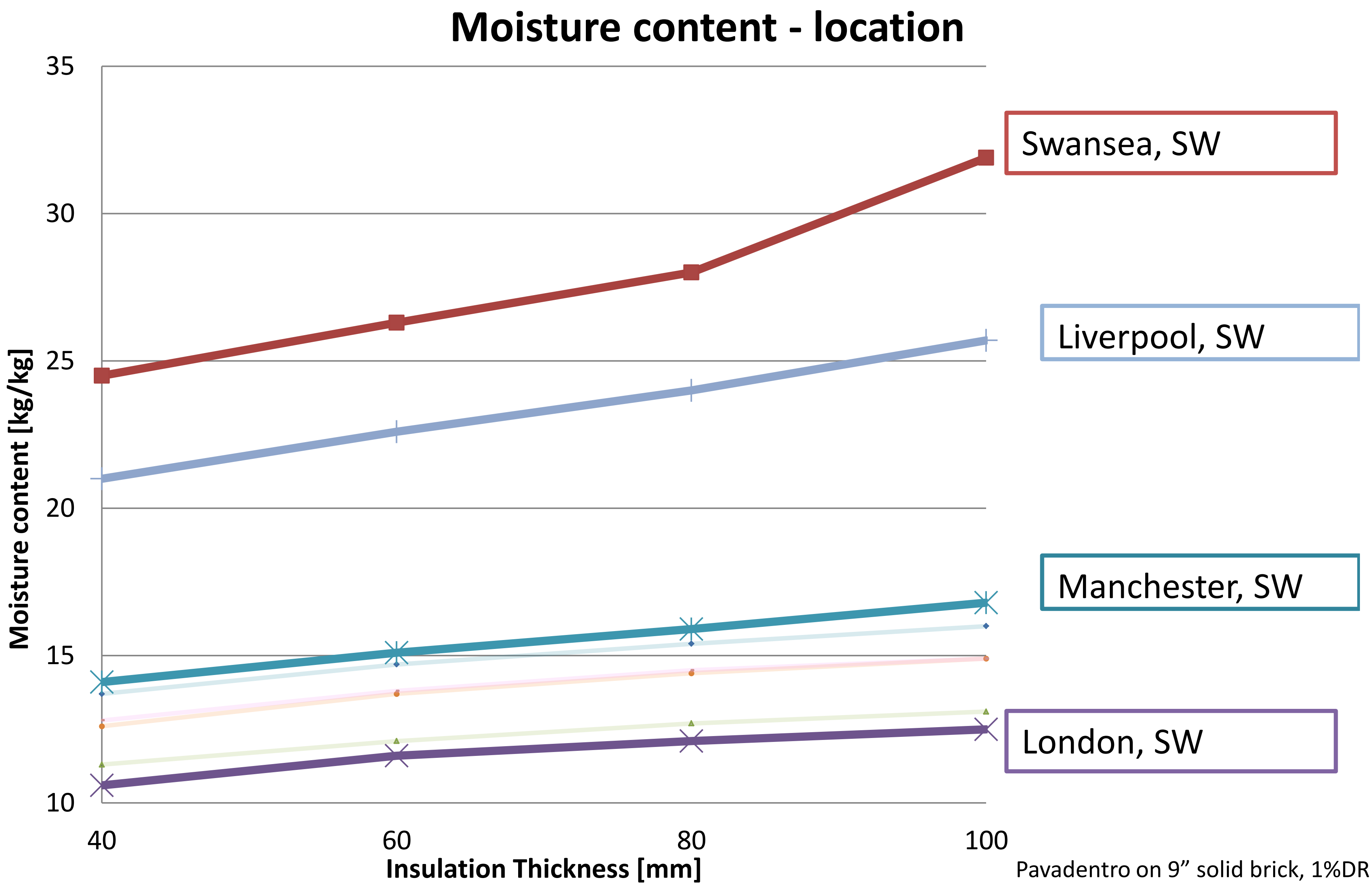


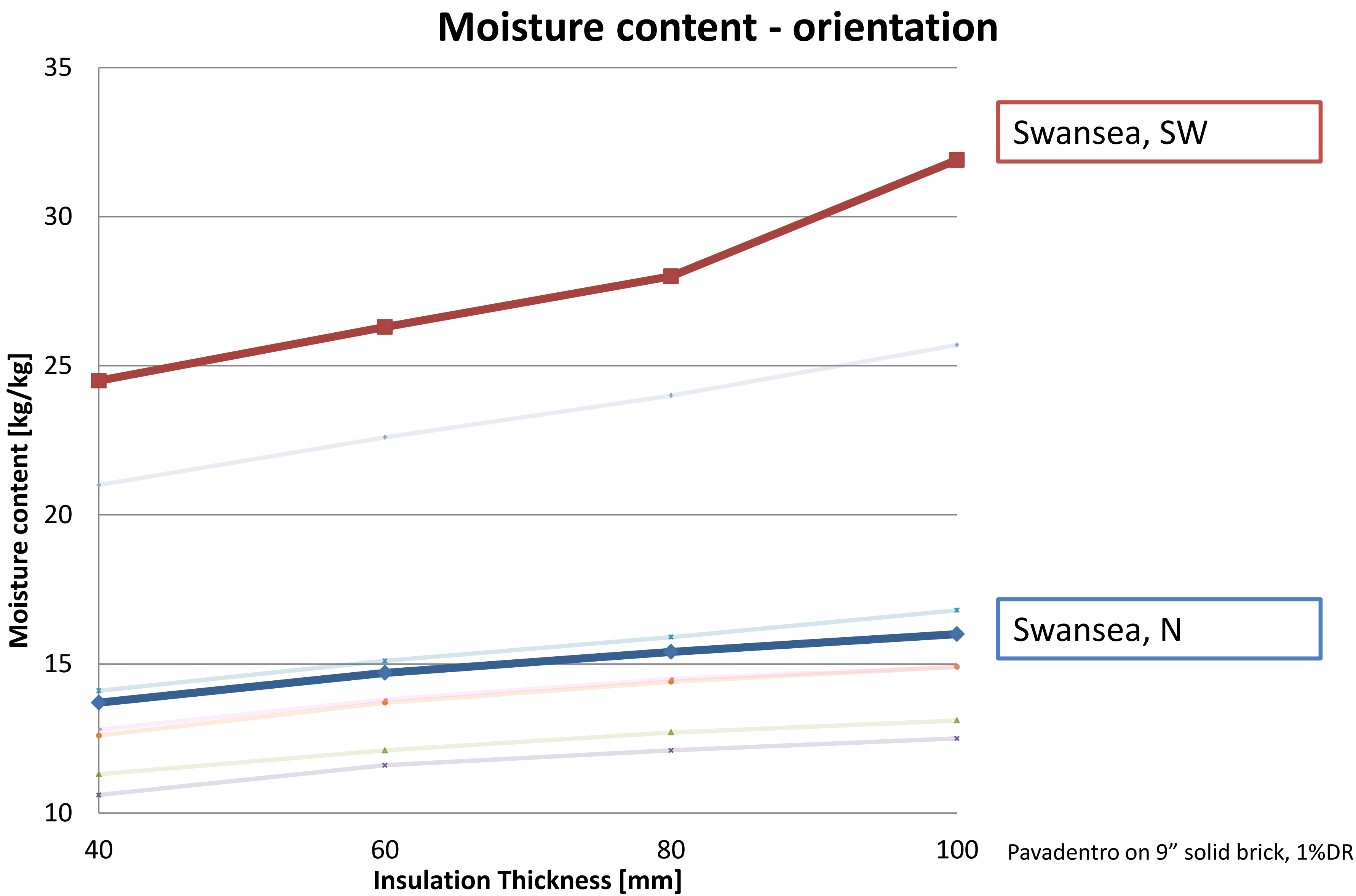
Breathable

Moisture content – different membranes



100mm Pavaflex on 9"solid brick, 0 DR


Moisture content - location
35
30
25
20
15
10
Moisture content [kg/kg]
40
60
80
100
Insulation Thickness [mm]
Swansea, SW
Liverpool, SW
Manchester, SW
London, SW
Pavadentro on 9” solid brick, 1%DR

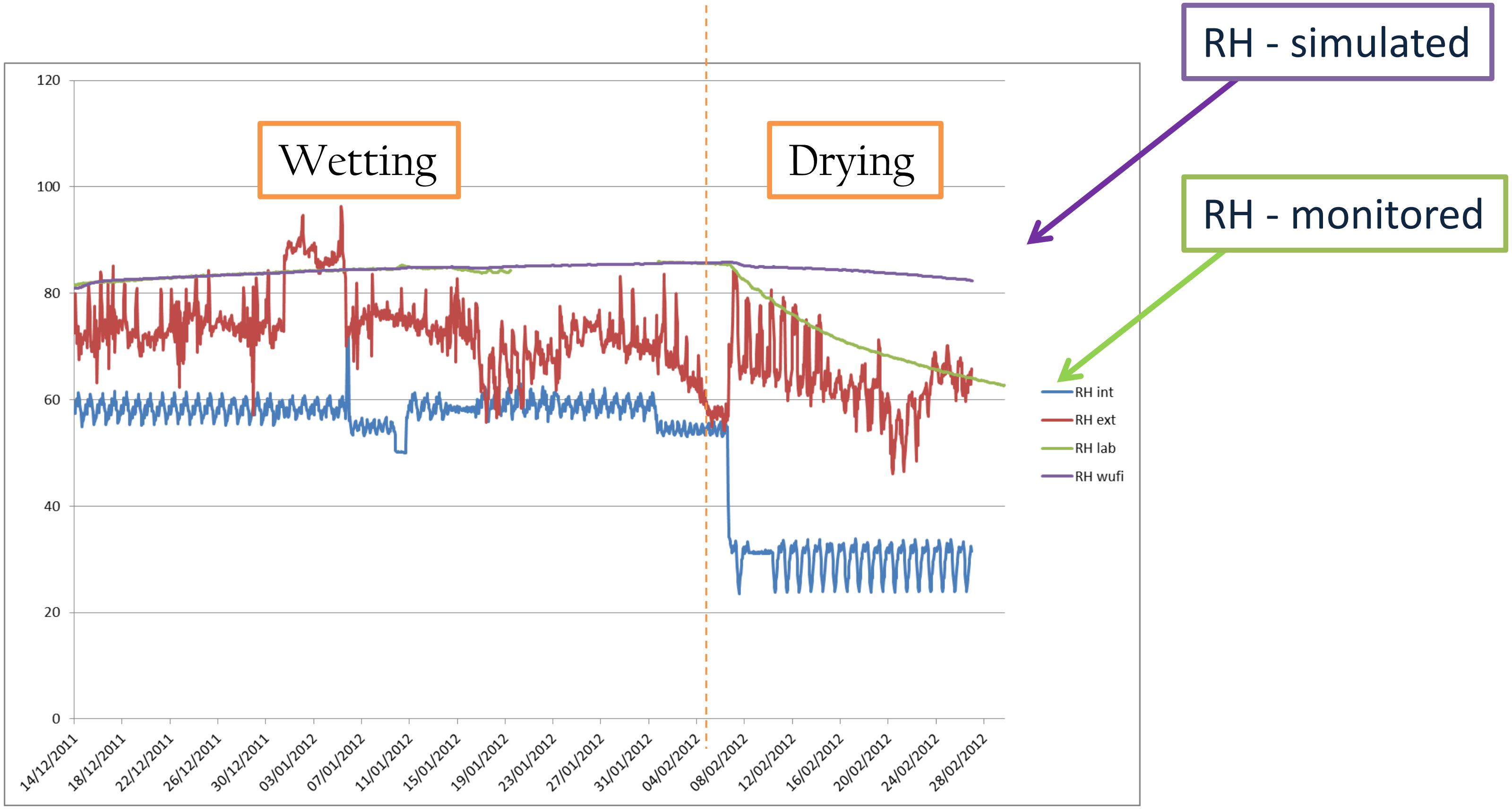

Moisture content - orientation
35
30
25
20
15
10
Moisture content [kg/kg]
40
60
80
100
Insulation Thickness [mm]
Swansea, SW
Swansea, N
Pavadentro on 9” solid brick, 1%DR

Problems with Modelling

- Human error
- Manipulation
- Data errors/ unknowns (ie OSB μ = 30/175)
  - Material data
  - Weather data
- Simplification of complex structures
- Problems at junctions/ bits you can't model
- Issue of how to model bad application
- False certainty

Problems with WUFI models

Climate chamber – Pavadentro (sec.1)



What is the reality?

- How do things happen in reality?
- What happens when things are not done right?
- What about users? Old, young, disabled?

Health Performance?

IGT on Low Carbon Construction

Recommendation 8.3:

“that, to avoid the risk of a new generation of sick buildings, the promotion of the health and well-being of occupiers should be placed on an equal footing with the current emphasis on carbon reduction.”

Is anyone listening?

Health – VERY complex

- Interaction insulation, airtightness and ventilation with fabric moisture, living conditions and human health… Umm
- Research work sees known risks with dust mites, overheating, and even obesity of thermally better housing.
- What about unknowns?

Real Dangers of Bad Energy Efficient Building Envelopes

- Increased Cardio-Respiratory illness (Lancet)
- UCL research found an increase in dust mites in beds of 2500 x base case house when air permeability 10m/hr was decreased to 3m/hr.
- Decrease by 60% at 20m/hr
- Also 350 x increase over base case when one type of MVHR was installed
- Minor increases when U values improved

Modern ventilation?

- Work by AECOM for Part F 2010
- Airtightness in new buildings was better than predicted (on completion – no long term analysis).
- Ventilation of all type fails to provide sufficient air changes in majority of cases.
- Out of 22 dwellings assessed with natural ventilation 70% fail to have sufficient air changes. 4 exceed safe mould levels and 11 exceed safe VOC levels.
- Out of 9 houses with mechanical ventilation 8 fail to have sufficient air changes, one by 63%.
- BSRIA report 95% failure rate in MVHR system air quality

Big UNKNOWNS

- Effect on community
- Effect on culture
- Effect on relationship with the natural environment

Radical retrofit requires rethinking

- Is fabric the best place to start?
- How do buildings relate to lifestyle and community?
- How do we encourage learning and engagement?
- Do we start with buildings or with food, or childcare, or something else? Or do we several things together?
- What is sustainability for?
- What are humans for?

STBA proposal

We need to accept our current lack of knowledge and the possibly unresolvable complexity of this situation and turn it to good.

This led to a specific proposal for

- Learning based approach, based on a guidance structure: iterative, open, contextual, systemic, holistic, with feedback mechanisms
- Linked to public knowledge centre to guide research, training, and to log, analyse and integrate feedback

Upgrade Analysis

Measure type (Fabric/Services/Behaviour)														
							Associated measures required							
Upgrade	GD eligible	Context Dependence (H/M/L)	Energy Benefit or Risk	Technical Benefit or Risk	Heritage Benefit or Risk	Right opportunity?	BEFORE Pre-implementation checks	DURING Quality Control	AFTER Maintenance Requirement	Monitoring / Feedback	User Issues	Guidance	Research	Case Studies
Measure subtype (e.g. wall, roof, heat generation, people interaction)														
Upgrade type														

External Wall Insulation

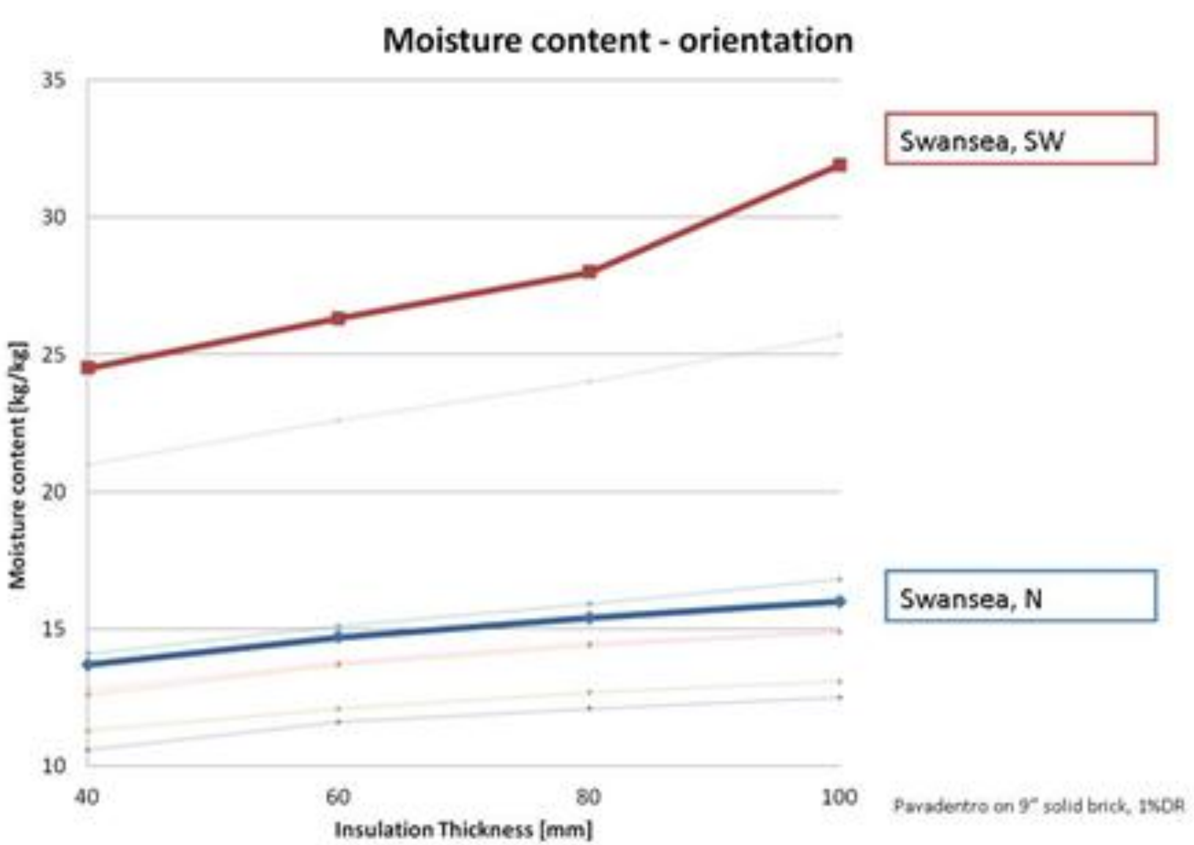
FABRIC															
							Associated measures required								
Upgrade	GD eligible	Context Dependence (H/M/L)	Energy Benefit or Risk	Technical Benefit or Risk	Heritage Benefit or Risk	Right opportunity?	BEFORE Pre-implementation checks	DURING Quality Control	AFTER Maintenance Requirement	Monitoring / Feedback	User Issues	Guidance	Research	Case Studies
Wall(s)														
External wall insulation	Y	H = High. Fabric quality and make up. Exposure. Heritage value	Likely reduction of heat loss but Less reduction loss than expected? Check U-value	Risk of trapped moisture? Check fabric quality	Damages character? Unlike measure if Listed Building	Easier to implement as whole block/terrace measure.	Check U-value of original fabric and compare with modelled values -see research ID14 & 15	Careful detailing to keep character and minimise thermal bridges	Check integrity of drains and gutters and that external wall is kept dry, in good condition. Ensure ground levels are kept low.	Check U-value of insulated fabric	Comfort "Take back" effect means less energy savings?	[See docs List] 2No Tier 1 Guidance Refs	[See docs List] 12No Tier 1 Research Refs	[See docs List] 6No Tier 1 Case Study Refs
						At change of tenancy or ownership	Check hygrothermal properties of wall and exposure. Thickness of insulation and risk? - see guidance and research ID 39	Carry out Condensation/ Moisture Risk for proposed solution and detail. [Various Research] Check Installation needs and carry out as per detail - see research ID 50	Moisture monitoring at risk locations at thermal bridges	Feedback any Moisture/mould problems?	Sufficient dwelling ventilation when draughtiness improved? Research ID 1,15			
						When it can improve heritage character	Check external detailing - survey to identify what needs moving (pipes etc), existing thermal bridges (research ID 53)	Installation quality checks - continuity of insulation - thermal imaging?						

Developing the analysis into a tool: Context specific IWI

FABRIC											
							Associated measures required				
Upgrade	GD eligible	Context Dependence (H/M/L)	Energy Benefit or Risk	Technical Benefit or Risk	Heritage Benefit or Risk	Right opportunity?	BEFORE Pre-implementation checks	DURING Quality Control	AFTER Maintenance Requirement	Monitoring / Feedback	User Issues
Wall(s)											
Internal wall insulation	Y	H = High. Fabric quality= good and make up = solid wall brick, estate of repair= normal. **Exposure= High Swansea North Wall .** Heritage value = conservation area but no internal features	Likely reduction of heat loss but Less reduction loss than expected? Check U-value	Risk of trapped moisture HIGH Check fabric quality	Acceptable - possible to make reversible?	When decorating room with external wall	Check U-value of original fabric and compare with modelled values -see research	Careful detailing to keep character and minimise thermal bridges	Check integrity of drains and gutters and that external wall is kept dry, in good condition. Ensure ground levels are kept low.	Check U-value of insulated fabric	Floor space reduction. See Case Study ID28. Restrictions on use (picture hanging possible?)
						At change of tenancy or ownership	Check hygrothermal properties of wall and exposure. _MEDIUM Swansea N wall Thickness of insulation and risk? MEDIUM keep insulation thickness below 60mm?- see guidance and research ID 39 and attached slides. Carry out Condensation/ Mositure Risk for proposed solution and detail to standard EN15026	Check wall fabric qualities against hygrothermal models. If different re-model with correct data. CHECK Suitability of INSULATION SYSTEM. Understand installation detail.	Keep an eye for mould /surface condensation or damp	Feedback any Moisture/mould problems? Moisture monitoring at risk locations (eg. Joist ends , Thermal bridges)	Restrictions on furniture location? - see research ID50 - increased mould growth risk. Restriction on finishes - breathability retained where appropriate
						When carrying out repairs	Investigate internal fabric - check there is no hidden heritage features - see guidance	Installation quality checks - continuity of insulation - thermal imaging?	Maintain air barriers on insulation wall interface - don't' make holes!		Sufficient dwelling ventilation when draughtiness improved? Research ID 1,15

FABRIC											
							Associated measures required				
Upgrade	GD eligible	Context Dependence (H/M/L)	Energy Benefit or Risk	Technical Benefit or Risk	Heritage Benefit or Risk	Right opportunity?	BEFORE Pre-implementation checks	DURING Quality Control	AFTER Maintenance Requirement	Monitoring / Feedback	User Issues
Wall(s)											
Internal wall insulation	Y	H = High. Fabric quality= good and make up = solid wall brick, estate of repair= normal. **Exposure= High Swansea South West wall** . Heritage value = conservation area but no internal features	Likely reduction of heat loss but Less reduction loss than expected? Check U-value	Risk of trapped moisture HIGH Check fabric quality	Acceptable - possible to make reversible?	When decorating room with external wall	Check U-value of original fabric and compare with modelled values -see research	Careful detailing to keep character and minimise thermal bridges	Check integrity of drains and gutters and that external wall is kept dry, in good condition. Ensure ground levels are kept low.	Check U-value of insulated fabric	Floor space reduction. See Case Study ID28. Restrictions on use (picture hanging possible?)
						At change of tenancy or ownership	Check hygrothermal properties of wall and exposure. _HIGH Swansea SW Wall. Thickness of insulation and risk? HIGH even at low insulation thickness- see guidance and research ID 39 and attached slides. Carry out Condensation /Moisture Risk for proposed solution and detail to Standard EN15026	Check wall fabric qualities against hygrothermal models. If different re-model with correct data. CHECK Suitability of INSULATION SYSTEM. Understand installation detail.	Keep an eye for mould /surface condensation or damp	Feedback any Moisture/mould problems? Moisture monitoring at risk locations (eg. Joist ends , Thermal bridges)	Restrictions on furniture location? - see research ID50 - increased mould growth risk. Restriction on finishes - breathability retained where appropriate
						When carrying out repairs	Investigate internal fabric - check there is no hidden heritage features - see guidance	Installation quality checks - continuity of insulation and air barrier - thermal imaging?	Maintain air barriers on insulation wall interface - don't' make holes!		Sufficient dwelling ventilation when draughtiness improved? Research ID 1,15

Based on current best research



Another example – heritage context

FABRIC											
							Associated measures required				
Upgrade	GD eligible	Context Dependence (H/M/L)	Energy Benefit or Risk	Technical Benefit or Risk	Heritage Benefit or Risk	Right opportunity?	BEFORE Pre-implementation checks	DURING Quality Control	AFTER Maintenance Requirement	Monitoring / Feedback	User Issues
Wall(s)											
Internal wall insulation	Y	H = High. Fabric quality=good and make up = solid wall brick, estate of repair= normal. Exposure= Low LONDON **Heritage value = conservation area but no internal features**	Likely reduction of heat loss but Less reduction loss than expected? Check U-value	Risk of trapped moisture MEDIUM Check fabric quality	Acceptable - possible to make reversible?	When decorating room with external wall	Check U-value of original fabric and compare with modelled values -see research	Careful detailing to keep character and minimise thermal bridges	Check integrity of drains and gutters and that external wall is kept dry, in good condition. Ensure ground levels are kept low.	Check U-value of insulated fabric	Floor space reduction. See Case Study ID28. Restrictions on use (picture hanging possible?)
						At change of tenancy or ownership	Check hygrothermal properties of wall and exposure. _ LOW LONDON Thickness of insulation and risk? LOW insulation thickness up to100mm - see guidance and research ID 39 and attached slides. Check moisture/ condensation risk to EN 15026	Check wall fabric qualities against hygrothermal models. If significantly different re-model with correct data. CHECK Suitability of INSULATION system . Understand installation detail.	Keep an eye for mould /surface condensation or damp	Feedback any Moisture/mould problems? Moisture monitoring at risk locations (eg. Joist ends , Thermal bridges)	Restrictions on furniture location? - see research ID50 - increased mould growth risk. Restriction on finishes - breathability retained where appropriate
						When carrying out repairs	Investigate internal fabric - check there is no hidden heritage features - see guidance	Installation quality checks - continuity of insulation - thermal imaging?	Maintain air barriers on insulation wall interface - don't' make holes!		Sufficient dwelling ventilation when draughtiness improved? Research ID 1,15

Same but with listed features

Upgrade	GD eligible	Context Dependence (H/M/L)	Energy Benefit or Risk	Technical Benefit or Risk	Heritage Benefit or Risk	Right opportunity?	BEFORE Pre-implementation checks	DURING Quality Control	AFTER Maintenance Requirement	Monitoring / Feedback	User Issues	C
Wall(s)												
Internal wall insulation	Y	H = High. Fabric quality= good and make up = solid wall brick, estate of repair= normal. Exposure= Low LONDON Heritage value = Listed - Good Internal features	Likely reduction of heat loss but Less reduction loss than expected? Check U-value	Risk of trapped moisture MEDIUM Check fabric quality	Not Acceptable - Intricate internal features would be lost	When decorating room with external wall	Check U-value of original fabric and compare with modelled values -see research	Careful detailing to keep character and minimise thermal bridges	Check integrity of drains and gutters and that external wall is kept dry, in good condition. Ensure ground levels are kept low.	Check U-value of insulated fabric	Floor space reduction. See Case Study ID28. Restrictions on use (picture hanging possible?)	
						At change of tenancy or ownership	Check hygrothermal properties of wall and exposure. _ LOW LONDON Thickness of insulation and risk? LOW insulation thickness up to100mm- see guidance and research ID 39 and attached slides. Check moisture/ condensation risk to EN 15026	Check wall fabric qualities against hygrothermal models. If significantly different re-model with correct data. CHECK Suitability of INSULATION system . Understand installation detail.	Keep an eye for mould /surface condensation or damp	Feedback any Moisture/mould problems? Moisture monitoring at risk locations (eg. Joist ends , Thermal bridges)	Restrictions on furniture location? - see research ID50 - increased mould growth risk. Restriction on finishes - breathability retained where appropriate	
						When carrying out repairs	Investigate internal fabric - check there is no hidden heritage features - see guidance.Internal features valuable and in good state of repair	Installation quality checks - continuity of insulation - thermal imaging?	Maintain air barriers on insulation wall interface - don't' make holes!		Sufficient dwelling ventilation when draughtiness improved? Research ID 1,15	

Can use for services also

SERVICES														
							Associated measures required							
	GD eligible	Context Dependence (H/M/L)	Energy Benefit or Risk	Technical Benefit or Risk	Heritage Benefit or Risk	Right opportunity?	BEFORE Pre-implementation checks	DURING Quality Control	AFTER Maintenance Requirement	Monitoring / Feedback	User Issues	Guidance	Research	Cas
ration	1													
iency g	Y	M = Medium Gas Availability. Suitable route for flue. User Energy consumption profile (h/m/l)	Likely Improved efficiency. Less CO2? - but see research ID32	Increase air permeability? Moisture of condensing plume may dampen fabric?	Same as before if same heating mode	On appliance breakdown	Check potential routes for pipework and flue do not clash with original features. Also aesthetics of radiators if newly	Quality Control in positioning boiler flue and routing pipework.	Yearly service	Energy savings realised? - Comfort "take back"		[See docs List] 1No Tier 1 Guidance Refs	[See docs List] 5No Tier 1 Research Refs	[S 2N
						In conjuction with fabric measures	Are there suitable insulation measures to combine with boiler change? See Guidance ID46	Careful installation to avoid increasing fabric permeability - see research ID 20						
							Check usability of controls - see guidance/research ID 56	Choice of controls? - user involvement?		Usability of controls? User difficulties?	Need advice on controls and operation	BSRIA publication: Controls for End Users: A guide for good design and implementation		

An open, iterative, learning tool

- Updatable on the basis of new research and monitoring feedback both from academics and from Green Deal process.
- Can be used to estimate and quantify risk and to put in measures to deal with this
- Although focused on energy it incorporates non energy and incommensurable values in an open discursive structure
- Can be used by all parts of supply and user chain, GD and communities
- Requires intelligence and learning, but not too much!

For solid wall buildings only?

- Different in some details from all other buildings, but principles and the necessary approach are the same

Value pluralism in practice

- Accepting no single pre-destined answer
- Accepting different, often conflicting and sometimes incommensurable values (with different metrics)
- Accepting different levels of knowledge and interest
- Accepting uncertainty of data and outcomes
- Validating reciprocity and compromise
- But not relativist or nihilist – in fact the opposite!

Furthermore

- A way to get on now
- A defence against the dominant paradigm

- An opportunity for a holistic and fully human programme of learning, work and enjoyment

Thank you for listening

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