appendix B. **literature reviews**

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LR 01	Retrofit for the Future: a guide to making retrofit work	2014	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	This guide examines 40 homes from the Retrofit for the Future programme, a £17m programme funded by TSB, which explored how existing homes can be improved to use less energy, cut carbon emissions and save costs.
LR 02	Retrofit for the Future: carbon emissions infographic	2014	Y										Summarises the work of the TSB Retrofit for the Future programme, as it impacts on carbon emissions. “By retrofitting homes, carbon emissions can be reduced dramatically…” A short summary is provided of overall delivered impact on carbon emissions of the Retrofit for the Future programme (24 case study projects)
LR 03	Energy Efficiency in Wales: A strategy for the next 10 years 2016–2026	2016	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	We want to ensure that Wales is in the best possible position to realise its full energy efficiency potential and become a major exporter of energy efficiency technology and know-how.
LR 04	NATIONAL ENERGY EFFICIENCY DATA-FRAMEWORK: Summary of analysis using the National Energy Efficiency Data Framework (NEED)	2017		Y	Y	Y							From stock analysis of 4 million homes that represent the stock of England and Wales gives: Loft insulation saves 4%; cavity wall saves 9.5%; solid wall saves 14%; new boiler saves 9%; PVs Save 10%
LR 05	The Future of Gas: How gas can support a low carbon future	2018	Y			Y							Currently 80% of the UK’s 26 million homes use gas for heat32, and this is responsible for over a quarter of current UK carbon emissions. 80% of current housing stock will still be in use in 205033. If decarbonisation of heat is to be successful, around 20,000 homes per week for the 25 years from 2025 to 2050 will need to move to a low carbon heat source. That will need considerable coordination and communication, commitment of resource, a reliable supply chain and willingness of the end consumer to change. National Energy Action recently highlighted that the decarbonisation of heat could put an additional 2.6m homes into fuel poverty. However, it will probably not be easy to persuade consumers to actively pursue a low carbon alternative to gas heating which is significantly more expensive, disruptive and potentially less effective.
LR 06	Sustainable technologies: The experience of housing associations	2015			Y	Y		Y		Y	Y	Y	The social housing sector, working generally to more stringent Code levels, has led the way in the use of sustainable technologies. Because of their ownership and management of significant portfolios of high-Code-level sustainable homes, they have been in a position to gain experience of the installation, performance and resident satisfaction with the various technologies
LR 07	NATIONAL ENERGY EFFICIENCY DATA-FRAMEWORK:	2017		Y		Y							Building regs standards since 1985

	Summary of Building Regulations											
LR 08	UK Fuel Poverty Monitor 2016 - 2017	2017	Y				Y					The fuel poverty monitor report is produced annually, to tack progress and activity to tackle fuel poverty, and to compare progress across the four nations over time. The report identifies the importance of a UK-wide strategy “to meet fuel poverty commitments across the UK and more generally improve our unhealthy and inefficient housing stock.” “This year’s report has a special focus on the impact living in cold, damp conditions has on the most vulnerable members of our society. We note the most at-risk groups continue to be typically older people, children and those with existing long-term illnesses. Whilst UK-wide statistics for fuel poverty are no longer produced5 by the UK Government, the last year that they were published in 2015 highlighted that there are over 3.5 million vulnerable households who are unable to heat and power their homes adequately across the UK; an increase of 500,000 compared to the previous year.”
LR 09	Technical options and strategies for Decarbonizing UK housing	2007	Y	Y	Y	Y						This paper explores the implications of some technical options for decarbonizing the UK domestic sector. "The main focus is on interactions between dwellings and the energy supply and conversion systems that support them, rather than on the detail of the dwelling stock. Synergies between the electricity supply system, intermediate energy-conversion systems and the dwelling envelope make it possible to achieve 60–70% reductions in CO2 emissions with plausible combinations of existing and/or emerging technologies.”
LR 10	Bryson Energy Retrofit Scheme – Whole House Solutions	2014	Y			Y	Y	Y			Y	This report presents the results of the impact assessment of the “whole house” retrofit scheme by Bryson Energy. The scheme involved 100 houses in west areas of Northern Ireland particularly afflicted by fuel poverty. The scheme was used to test the delivery of “whole house” solutions to properties which had already been partially retrofitted through Warm Homes scheme (with walls and loft insulation and solar panels). Additional solutions delivered by the Bryson Energy scheme comprised new boilers and heating controls. The impact assessment included three surveys and 6 case studies. The overall impact of the scheme was very positive, as it improved energy performance and occupant’s comfort while reducing energy expenses.

LR 11	Whole house solutions – transforming Northern Ireland's domestic energy efficiency landscape	2014	Y		Y			Y					This report outlines the case that can be made in Northern Ireland (NI) for adopting a new domestic energy efficiency ethos. This would be centred on whole house solutions, with retrofit completed as a single programme of works, and encompassing both state of the art technical innovations and wrap-around customer advice and support.
LR 12	Welsh Government Warm Homes Arbed EU, Final Report (Ricardo 2017, Arbed2)	2017	Y	Y				Y	Y		Y	Y	This report evaluates the Arbed2 retrofit scheme of Welsh Government by detailing the outcomes of three surveys conducted by Ricardo AEA (covering about 10% of retrofitted properties): • A survey to investigate householder satisfaction with the measures installed and their impacts on the household; • A technical survey to evaluate the quality and appropriateness of measures • A follow-up survey to evaluate the impact of the measure on the household over time.
LR 13	Designing an 'optimal' domestic retrofit programme.	2017	Y					Y					This paper describes the results of the qualitative assessment of the US Better Buildings Neighbourhood Program (BBNP), which was a large-scale programme to stimulate the private sector of the energy retrofit market in the US. The BBNP was initiated and funded by the Federal US Government but each State had significant flexibility with regards to its implementation and the direction of funding. The paper summarises the insights of the research into a strategy for a successful programme. Comparison between this strategy and the Green Deal programme allows drawing useful lessons for the UK context.
LR 14	Exploring the complexities of energy retrofit in mixed tenure social housing: a case study from England, UK	2018	Y					Y				Y	The paper describes a large energy retrofit project of five tower blocks by Oxford City Council, which houese both coucil tenats and private owners. The attempt of the council to recover a share of the cost of the retrofit works (involving EWI and other measures) from the building residents led to a legal dispute This case is used to discuss aspects of property law, allocation of project costs and benefits, and issues of communication, engagement and decision-making. The paper also presents qualitative data gathered from social housing associations to provide an indication of the extent to which these issues are affecting energy retrofits in England.
LR 15	Warmer and greener: a guide to the future	2016	Y										This report sets out a series of policy recommendations developed by the Westminster Sustainable Business

	of domestic energy efficiency policy											Forum. "The UK Government's fuel poverty strategy for England sets a target to bring as many fuel poor homes in England as is reasonably practicable up to a minimum Energy Performance Certificate (EPC) rating of C by 2030. However, this report argues that current policies will be insufficient to engage with this target and tackle fuel poverty. This report has also identified a clear shortfall between the Government's targets on greenhouse gas emissions and the current policy mix."
LR 16	Design for future climate - Opportunities for adaptation in the built environment	2010	Y	Y		Y						This report provides an overview of the opportunities for adaptation to climate change in the built environment of the UK. It includes background information on climate projections for the UK and outlines a series of challenges and solutions for three areas: • Comfort – heating and cooling; • Construction – structural stability and resistance to extreme weather events; • Water management – conservation, drainage and flooding.
LR 17	Countdown to Low Carbon Homes	2014	Y					Y		Y		"The Countdown to Low Carbon Homes project (2012-14) was set up to research, develop and communicate an integrated practical delivery approach to community scale retrofit of energy improvements to buildings, with a particular focus on homes and delivery by Small and Medium Enterprises (SMEs). (…) the project partners worked with households, installers and other key decision makers involved in domestic retrofit in their communities to gather evidence on the situation at a local level. This work informed the development of practical delivery models for the retrofit of buildings. Severn Wye Energy Agency developed and trialled a model that could be rolled out at a community scale, linking in with local businesses. As part of the delivery model Severn Wye aimed to develop and pilot a loan scheme offering households alternative sources of finance for their improvements."
LR 18	Building the Future: sector review of qualifications and the qualification system in Construction and the Built Environment	2018	Y					Y		Y		The construction and built environment sector is key to the economic development of Wales. Sector review of vocational qualifications across the construction and built environment (CBE) sector, consulting about a thousand people across Wales, and identifying short term actions that are being taken, and longer term actions that are being considered

LR 19	Lenders project	2017	Y				Y	Y		Y			The LENDERS project was set up to examine the link between property energy efficiency and fuel bills, and how this link could enable homes with better energy performance to demonstrate lower fuel costs in a way that can be passed on as a tangible benefit to homebuyers [to explore a possible lever for energy efficiency improvements in the private owner occupier sector].
LR 20	Zero Carbon Compendium	2011											Report provides an international perspective of how 15 different countries are demonstrating leadership in low carbon technology, culture change, policy development and change management. For each country, headline energy consumption and climatic data has been assembled to provide context. Lessons are learnt across 7 core thematic areas.
LR 21	Implications of the UK field trial of building mounted horizontal axis micro-windturbines	2010			Y								Wind turbines in urban areas do not produce the predicted amount of energy. The wind speeds around buildings are much lower than in rural areas.
LR 22	Energy Efficient Scotland	2018			Y								Route map to 2040, has a couple of really good case studies to provide evidence. Pretty much business as usual
LR 23	Evaluation of a regional retrofit programme to upgrade existing housing stock to reduce carbon emissions, fuel poverty and support the local supply chain	2016	Y	Y		Y		Y	Y	Y	Y		“This paper will present an evaluation of a £9.6 million regional scale retrofit programme funded under the Welsh Governments Arbed 1 Programme which aimed to reduce fuel poverty, reduce carbon emissions and support the energy efficiency and renewable supply chain and encourage recruitment and training in the sector. (...) The evaluation work presents the technical, environmental and economic impacts of the programme and demonstrates lessons learnt to help improve the implementation of the other regional retrofit projects providing evidence of the impacts of a large scale retrofit programme that are necessary for the deep carbon reductions required in the near future.”
LR 24	Energy advice and promotion supports to community groups (Ireland WG2 COST Smarter)	2016	Y					Y					This paper gives an overview of the activity of the Carlow Kilkenny Energy Agency (CKEA) with two examples: the RDF Leader Programme and the Better Energy

													Community programme. It shows the role that community engagement and independent expert support play in fostering renewable and energy efficiency projects.
LR 25	Freedom project	2018	Y			Y						Y	"The Freedom Project is seeking to understand the potential role of multi-vector solutions in the decarbonisation of domestic heating. Based in Bridgend, South Wales, the project is investigating the consumer, network and energy system implications of hybrid heating system deployments, where domestic heating systems have the option of operating using a standard gas boiler, an air source heat pump (ASHP), or both. The Freedom Project has completed 13 months of a 27-month project programme. The Project has installed 75 hybrid heating systems in a mix of private and social housing, with the focus now on the optimised controlling, monitoring and consumer feedback throughout the 2017-18 heating season. Once the heating season has concluded the collected data will be reviewed and analysed with final reporting due in January 2019."
LR 26	Energy Efficient Mortgages Pilot Scheme Implementations & Product Framework	2018	Y							Y			This report outlines the framework developed by the Energy Efficient Mortgage Initiative for energy efficient mortgage schemes to be adopted in lending institutions across EU countries. The framework is the result of consultation with financial stakeholders and will be tested in a pan-European pilot scheme. The framework provides three types of guidelines: • implementation principles for lending institutions, • building performance assessment criteria, • valuation guidance and energy efficiency checklist.
LR 27	Measuring and mitigating overheating risk in solid wall dwellings retrofit fi tted with internal wall insulation	2018	Y	Y					Y			Y	This paper describes a unique experiment set up to investigate the impact of IWI on overheating UK dwellings and possible mitigation strategies. Results of the experiment show that IWI increased the indoor temperature of 1-2 degrees in comparison to the uninsulated house. A mitigation strategy consisting of window blinds

												and night ventilation was also tested. This strategy minimised the increase in temperature in the insulated house, especially at night.
LR 28	Social and health outcomes following upgrades to a national housing standard: a multilevel analysis of a five-wave repeated cross-sectional survey.	2017	Y	Y		Y						This paper discusses the health benefits of house retrofits by presenting the results of a five-wave repeated cross-sectional survey. This was conducted from 2009 to 2016 to evaluate a retrofit programme designed to meet the Welsh social housing standard. The results of the survey indicate that most retrofit measures are associated with social and health improvements, and that the latter are proportionate to the number of measures installed and amount invested.
LR 29	Emergency hospital admissions associated with a non-randomised housing intervention meeting national housing quality standards: a longitudinal data linkage study Sarah E Rodgers,1,2 Rowena Bailey,2,3 Rhodri Johnson,2 Damon Berridge,2 Wouter Poortinga,4 Simon Lannon,4 Robert Smith,5 Ronan A Lyons2	2017	Y	Y		Y						This paper presents a longitudinal survey to assess the impact on tenant health care utilisation following a retrofit programme of over 8000 Welsh dwellings. The indicator studied were emergency hospital admissions for cardiorespiratory conditions and injuries for residents aged 60 years and over. The results show that residents of retrofitted dwellings were associated with up to 39% fewer admissions in comparison to residents of non-retrofitted dwellings
LR 30	Examining domestic retrofit systems and governance in Haringey, London. FINAL REPORT February 2016	2016	Y								Y	“This research has focussed on the approaches to retrofit emerging in the specific context of Haringey, London, with its own particular challenges and priorities. This report will outline the project brief, theoretical approach and methodology, then the national and local priorities surrounding retrofit. It will outline the key issues emerging from Haringey’s retrofit network and then assess the strengths and weaknesses of the responses that have emerged. Finally, the report will present a series of suggestions for Haringey’s next phase of retrofit, encompassing its own unique vision and priorities.”
LR 31	Self-build communities: the rationale and	2016	Y					Y		Y		“This paper presents an initial examination of the rationale, motivations and social experiences of group-build

	experiences of group-build (Baugruppen) housing development in Germany.												housing from Germany, where over half of all new homes are produced independently from volume-build developers. The paper aims, firstly, to test the hypothesis that group-build delivers general 'community' benefits; secondly, to contribute to an understanding of the processes leading to successful schemes; and lastly, to demonstrate that by making individual home-building dependent on the success of a larger group, collective interests can prevail over personal pursuit."
LR 32	Rhee-Duverne, S. and Baker, P. 2013. Research into the thermal performance of traditional brick walls. English Heritage Research Report	2013		Y				Y					This report discusses two studies conducted in 2010: • In-situ measurement of the U-value of solid brick walls in 18 houses in England in 2010; • Laboratory measurement of the thermal conductivity of three types of bricks (alike to those used in the monitored houses) at different levels of moisture content. The results of the studies show that conventional estimates of U-values for solid wall (such as those used by RdSAP) significantly underestimate the performance of solid walls in comparison to the measurements in-situ. However, the research also shows that if the physical properties of the solid wall materials are known in detail (following laboratory measurements), U-value calculations for the solid wall produce figures in accordance with the results of the in-situ measurements. Therefore, retrofit measures on solid wall properties could be based on more accurate figures for U-values. Rather than using 'typical' figures for solid walls, the types of materials in each wall should be identified to estimate more accurate U-values
LR 33	Minewater heating in Caerau	2017	Y										This report is part of the Working Package 17 of the FLEXIS project. Its presents information about the minewater heating scheme in Caerau and the results of a survey on the perspective of the local residents. "The scheme is part of the Energy Technology Institute 'Smart Systems and Heat' programme, which is being delivered by the Energy Systems Catapult (ESC). Bridgend County Borough Council (BCBC) put out a tender for groups with appropriate expertise to run the project in conjunction with them. A consortium, led by Cardiff University and including Swansea and Cardiff Metropolitan Universities, as well as private

												companies, was successful in winning the bid. Total cost £ 9.4 million.
LR 34	Each Home Counts	2018	Y							Y		Each Homes Counts has a total of 27 recommendations and sets out a new quality and standards framework for all those operating in the retrofit sector. This includes the setting up of: A quality mark against which all those engaged in design and installation of energy efficiency and renewable energy measures will be assessed and certified / A Consumer Charter to set out the positive experience that the consumer can expect under the quality mark including response times, financial protections and access to redress procedures when things go wrong / A Code of Conduct to set out clear requirements and guidance on how companies behave, operate and report in order to be awarded and hold the quality mark / Technical Codes of Practice and Standards for the installation of home renewable energy and energy efficiency measures so that the risk of poor-quality installation is minimised / development of an infomration Hub and Data Warehouse
LR 35	Residential Retrofit: 20 Case Studies	2013		Y	Y							This book illustrates 20 case studies of residential retrofit across England and Wales. 18 of these retrofits were funded under the Retrofit for the Future programme. Together, the 20 case studies allow drawing several considerations on the effectiveness of the various measures implemented in the retrofits and related problems
LR 36	A review on Building Renovation Passport: Potentialities and barriers on current initiatives	2018	Y					Y				“This paper contributes to the body of knowledge in three ways: (i) it provides an overview on Building Passport (BP) definition from first initiatives in EU and one in Australia; (ii) it presents an updated evaluation and comparison of some BRP experiences developed in some European Member states (Belgium, France and Germany, selected for their advanced phase of development; (iii) it pinpoints the main known barriers and the lesson learned within the review initiatives in order to provide suggestions for the standardization of BRP across EU. Although the paper comparison fo- cuses only on three countries, the overview of barriers and mo- tivators and the overall approach and

												conclusions can be used to identify gaps and opportunities in other countries policy schemes as well."
LR 37	Energy and Environmental Report: Castleland Renewal Area, Barry. Stage 2	2013	Y	Y		Y		Y	Y	Y		This report presents an analysis of the pre-1919 dwelling stock (1248 homes) in Castleland Renewal Area, Barry, and its potential for retrofit measures. The research is the result of the collaboration between Warm Wales, who provided the initial data, and the Welsh School of Architecture (WSA). The analysis was based on a GIS model of the stock (the Energy and Environmental Prediction model, developed by WSA) and the SAP methodology.
LR 38	NEA Technical Innovation Fund	2017	Y	Y		Y		Y			Y	This report presents the delivery of the Technical Innovation Fund (TIF) by NEA " Through TIF, NEA provided charitable grants to help install a range of innovative technologies. Up to£5.1 million was made available to meet the capital and installation cost of high cost (large) and low cost (small) in-home measures in fuel poor and vulnerable households across England and Wales, with the aim of reducing the cost of heating their homes and addressing the underlying causes and symptoms of fuel poverty. Where possible, there was a focus on rural and off-gas communities and EPC band D, E, F and G properties. TIF beneficiaries were predominantly living in social housing (82%). 522 (24%) were living off the mains gas network and reliant on more expensive heating fuels."
LR 39	SOLID WALL INSULATION Unlocking Demand and Driving Up Standards	2015	Y	Y				Y	Y		Y	This report presents an overview of the drivers and barriers affecting the insulation of domestic properties with solid wall construction. It provides specific recommendations for policy-makers.
LR 40	Responsible retrofit of traditional buildings	2012	Y	Y				Y	Y			"This report looks into key aspects of the responsible retrofit of traditional buildings on behalf of the Department of Energy and Climate Change (DECC). This work was undertaken by the Sustainable Traditional Buildings Alliance (STBA) which represents most of the main historic building groups in the UK as well as mainstream construction-related organisations. The work was carried out following concerns raised with regard to the application of certain retrofit measures, including those incorporated into the Green Deal, in respect of the UK's traditional building stock. A traditional building is defined as a property built

													prior to 1919 with solid walls constructed of moisture-permeable materials.2 It is estimated that traditional buildings number over 6 million, almost one quarter of the UK domestic housing stock. The concerns around retrofitting this class of buildings include possible failures of financial and energy payback, fabric and human health issues, and potential damage to heritage, as well as missed opportunities for the radical improvement of traditional building performance."
LR 41	Planning responsible retrofit of traditional buildings	2015	Y	Y									"There is increasing evidence that the retrofit of traditional buildings (and indeed all buildings) over the past few years has not led to the expected reductions in energy use, and has harmed the building fabric, heritage or health of building occupants. This is for three primary reasons: • Incorrect standards and assessment of traditional buildings; • Single or narrow focus approach to both risks and retrofit measures; • Disjointed and poor quality building process. This guide makes clear where existing standards and information are wrong. It shows the need to consider three broad areas of risk: Energy and Environment; Building Health (health of both fabric and people); and Heritage and Community. Sometimes compromises must be made between these values to get the best overall outcome, and this guide demonstrates a practical approach to this problem. "
LR 42	An investigation into retrofitting the pre-1919 owner-occupied UK housing stock to reduce carbon emissions	2018	Y							Y	Y	Y	This paper presents the results of a survey conducted to explore the drivers and barriers affecting the retrofit of privately-owned pre-1919 houses in the UK. The survey consisted in a questionnaire to owners of pre-1919 houses (43 respondents) ad a series of semi-structured interviews with homeowners and retrofit experts. The results suggest that the main barriers to a wider uptake of pre-1919 retrofits are financial (lack of funding and long payback time), technical (lack of trusted sources of information) and social (limited interest in retrofit).
LR 43	Calor introduces BioLPG to the UK market and sets path to be fully renewable by 2040	2018	Y			Y		Y					BioLPG is now being imported at the moment there is no UK based production. It is a direct replacement for LPG and is being sourced from Neste Biofuels production facility in Rotterdam.
LR 44	Retrofit for the Future – Analysis of cost data	2014		Y	Y	Y				Y			This report presents the analysis conducted by the SWEETT Group on the cost of retrofit components based on data from the Retrofit for the Future

												programme. The components (i.e. measures and technologies) included in the analysis are: IWI, EWI, loft insulation, floor insulation, windows, MVHR, air-source and ground-source heat pumps, biomass boilers, PV and solar thermal panels. Costs include materials and installation. The report includes recommendations on how to limit additional costs in successive retrofits.
LR 45	Raising the bar - A post-Grenfell agenda for quality and professionalism in construction	2018	Y									This short document outlines three step recommended by the FMB to improve the quality of the UK construction industry. “The UK’s home owners continue to fall prey to significant numbers of incompetent builders, who lack the necessary training and technical knowledge and who are a risk to themselves and their customers. Although the standard of new buildings in the UK is generally very high, concerns continue to reach the media about the quality of some new builds and inadequate routes to consumer redress. The Independent Review of Building Regulations and Fire Safety, set up in the wake of the Grenfell Tower tragedy, has raised serious questions about standards, regulation and compliance within the built environment.”
LR 46	Do homes with better energy efficiency ratings have higher house prices?	2016	Y							Y		This report illustrates the results of a study by Copenhagen Economics on the relationship between house prices and improvements in energy ratings. “In this analysis, we examine to what extent an improved energy rating will give rise to a higher house price. From the outset, neither a theoretical nor a practical perspective provides a clear answer to that complex question. We have made a variety of analyses to isolate the actual effect of energy ratings on selling prices. Compared to previous analyses of by other authors, our approach ensures that the resulting price effect comes solely from the energy rating and not from any other (correlated) characteristics such as location of the house and general condition of the house.”

Literature review: LR 01

Publication title:	RETROFIT FOR THE FUTURE A guide to making retrofit work
Reference / source	https://www.gov.uk/government/publications/retrofit-for-the-future-a-guide-to-making-retrofit-work
Author(s)	Technology Strategy Board
Publication type	report
Publisher	Technology Strategy Board
Date of publication	2014
Target audience	Industry / advisory for designers, clients, energy consultants, contractors

Key words: **Retrofit case study programme**

Summary: The Retrofit for the Future programme explored how existing homes can be improved to use less energy, cut carbon emissions and save costs. The £17m programme, funded by TSB, explored new opportunities in the growing retrofit market. This guide examines 40 homes from the Retrofit for the Future programme. It describes innovative energy saving systems and explains how they were used in the context of lived-in homes. Measured CO2 reductions across case studies were up to a maximum of 80%.

Related literature: LR02, LR35

Related case studies: Report draws from 40 of the 80+ TSB funded projects, but references 4 key case studies in detail: CS10 house#1, CS11 house#8, CS12 house#35, CS13 house#109

reference	action theme*	details	evidence
action 01	Strategic: importance of 'retrofit planning'	Prioritising insulation and airtightness ('fabric first') was the most commonly taken approach. Performance targets that are "clear, well-communicated, ambitious and achievable can help unite the project team around a vision." The most energy efficient home used 75% less energy than the national average, with 80% less carbon emissions	80+ delivered case studies, including extensive reporting, plus predicted and actual energy use
action 02	fabric	Almost all projects significantly reduced heat loss by insulating the fabric. The most comprehensive approaches considered all fabric elements with particular attention to insulation continuity. This helped reduce the predicted annual space heating demand by as much as 95%.	as above. Maximum benefit, CS13 house #109
action 03	services	35 of 40 dwellings were fitted with MVHR. In polluted environments there can be health benefits.	as above, eg CS13 house #109
action 04	strategic: performance gap	In one home, [House#19], actual energy use was 50% less than forecast. In four houses, [#51,#72, #90, #28], the difference was marginal, less than 5%. In the majority of houses, actual energy use was at least 50% more than the forecast; in one home by 240% more.	Predicated and actual energy use, 40 case study projects

action 05	people	In addition to fuel bill savings, there was a significant shift from reporting poor or very poor conditions before the retrofit to reporting good and excellent conditions after the retrofit. Overheating in homes may become more of a problem if heatwaves increase. Homes with effective ventilation and shade-over glazing are less likely to overheat.	Qualitative interviews, 40 case study projects

*action themes: strategic / fabric / renewables / services / people

reference	**challenge theme****	**details:**	**relating to:**
challenge 01	People – meeting needs / aspirations	The retrofit plan should be explained to the residents as early as possible. Some projects created an energy system based around people's needs.	action 01
challenge 02	Financial – unanticipated costs	Older homes can be unpredictable and contingency should be provided for additional works.	all actions
challenge 03	People - behaviour	Poorly integrated MVHR can lead to stuffy indoor air or mechanical noise, so people may leave windows open (leading to higher heating + carbon emissions) or switch off the system altogether.	action 03

** challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 02

Publication title:	Retrofit for the Future: carbon emissions infographic
Reference / source	https://retrofit.innovateuk.org/documents/1524978/2138994/Retrofit%20-%20Carbon%20Emissions%20Infographic
Author(s)	Technology Strategy Board
Publication type	Online infographic
Publisher	Technology Strategy Board
Date of publication	2014
Target audience	Industry / advisory for designers, clients, energy consultants, contractors

Key words: **Retrofit case study programme**

Summary: The publication summarises the work of the TSB Retrofit for the Future programme, as it impacts on carbon emissions. “By retrofitting homes, carbon emissions can be reduced dramatically…” A short summary is provided of overall delivered impact on carbon emissions of the *Retrofit for the Future* programme (24 case study projects).

Related literature: LR01, LR35. See also source documents: LR02B Carbon emissions infographic and LR02C comfort infographic

Related case studies: Report draws from the 80+ TSB funded projects – see also LR35

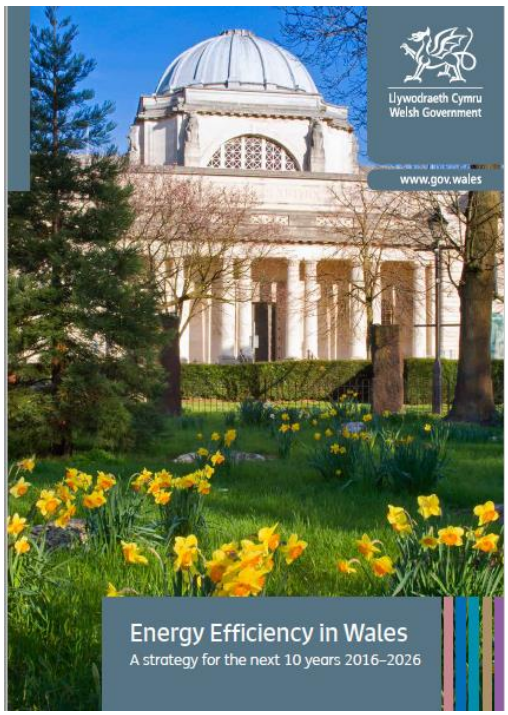
reference	action theme*	details	evidence
action 01	Strategic: importance of ‘retrofit planning’	Advocating a ‘whole-house’ retrofit planning approach considering six key themes: retrofit planning, building fabric, indoor air quality, services, working on site, engaging residents.	High level summary providing overall % reductions in carbon emissions, but linked to in depth case study data.

*action themes: strategic / fabric / renewables / services / people

reference	challenge theme**	details:	relating to:
challenge 01	Supply chain - knowledge	Lack of knowledge – a holistic approach requiring careful planning	action 01
challenge 02	Financial – capital costs	Capital cost – an holistic approach requires up front expenditure	action 01
challenge 03	People – resident decant	Invasive approach – most projects required resident decant while actions took place	action 01

** challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 03



Publication title:	Energy Efficiency in Wales: A strategy for the next 10 years 2016–2026
Reference / source	https://gov.wales/topics/environmentcountryside/energy/efficiency/energy-efficiency-strategy-for-wales/?lang=en
Author(s)	Welsh Government
Publication type	Policy strategy
Publisher	Welsh Government
Date of publication	2016
Target audience	Policy-makers

Key words: **Strategic policy statement**

Summary: We want to ensure that Wales is in the best possible position to realise its full energy efficiency potential and become a major exporter of energy efficiency technology and know-how.

Related literature

Related case studies

reference	action theme*	details	evidence
action 01	strategic	Presents aspirations and policies in place to help the uptake of energy efficiency.	

*action themes: strategic / fabric / renewables / services / people

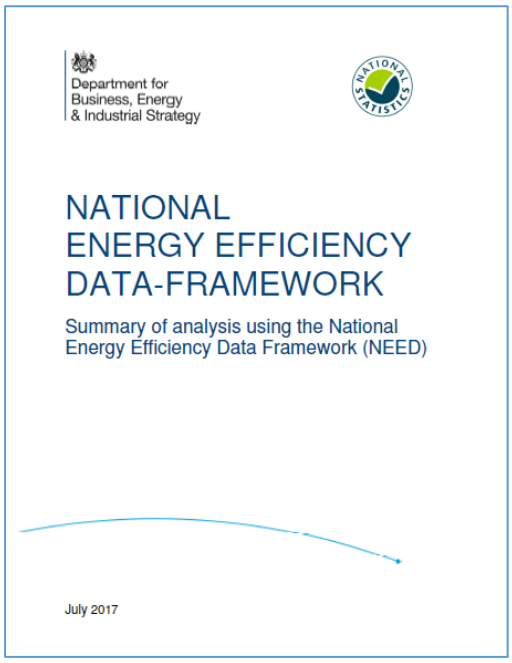
reference	barrier theme**	details:	relating to:
barrier 01	Strategic	Information is critical: "Achieving energy efficiency refurbishments at scale will be impossible without buy-in from all households. Whether they are fuel poor, have low incomes or are relatively well-off, people need to understand, in clear and simple terms, the benefits to them of taking action. The evidence that we received showed that there remains a lack of knowledge and understanding about the benefits of energy efficiency. Respondents to the call for evidence also identified complexity, lack of trust and insufficient financial incentives as key barriers."	
barrier 02	supply chain	Supply chain development	

		“The call for evidence responses identified concern from the supply chain regarding continuity of funding and demand for energy efficiency. With the exception of fuel poor households, we need to encourage more market-driven demand; that will be a sustainable solution, which will give the energy efficiency supply chain the confidence to invest in and develop their businesses.”	

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 04

Publication title:	NATIONAL ENERGY EFFICIENCY DATA-FRAMEWORK Summary of analysis using the National Energy Efficiency Data Framework (NEED)
Reference / source	https://www.gov.uk/government/collections/national-energy-efficiency-data-need-framework
Author(s)	UK Government
Publication type	Report
Publisher	UK Government
Date of publication	2017
Target audience	Policy-makers



Key words: **Retrofit impact assessment**

Summary: From stock analysis of 4 million homes that represent the stock of England and Wales gives: Loft insulation saves 4%; cavity wall saves 9.5%; solid wall saves 14%; new boiler saves 9%; PVs Save 10%

Related literature

Related case studies LR07

reference	action theme*	details	evidence
action 01	fabric	Cavity wall insulation	43,240 installations show median reduction of 9.5% 1,300 kwh/annum
action 02	fabric	Loft insulation	21,510 installations show median reduction 4.0% 500 kwh/annum
action 03	System	Condensing boiler	185,150 installations show median reduction 9.0% 1,300 kwh/annum
action 04	renewables	Solar PV	6,130 installations show median reduction 10.2% 500 kwh/annum

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 05

Publication title:	The Future of Gas: How gas can support a low carbon future
Reference / source	http://futureofgas.uk/news/future-of-gas-how-gas-can-support-a-low-carbon-future/
Author(s)	National Grid
Publication type	Policy strategy
Publisher	National Grid
Date of publication	2018
Target audience	Policy-makers

Key words: **Decarbonising gas**

Summary: Currently 80% of the UK's 26 million homes use gas for heat32, and this is responsible for over a quarter of current UK carbon emissions. 80% of current housing stock will still be in use in 2050. If decarbonisation of heat is to be successful, around 20,000 homes per week for the 25 years from 2025 to 2050 will need to move to a low carbon heat source. That will need considerable coordination and communication, commitment of resource, a reliable supply chain and willingness of the end consumer to change. National Energy Action recently highlighted that the decarbonisation of heat could put an additional 2.6m homes into fuel poverty. However, it will probably not be easy to persuade consumers to actively pursue a low carbon alternative to gas heating which is significantly more expensive, disruptive and potentially less effective.

reference	action theme*	details	evidence
action 01	strategic	Contains excellent road mapping and scenarios for decarbonising heat.	
action 02	services	Discusses the potential for hybrid systems using gas and electric for heating	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 06

Publication title:	Sustainable technologies The experience of housing associations
Reference / source	https://www.nhbcfoundation.org/publication/sustainable-technologies-the-experience-of-housing-associations/
Author(s)	Lychgate Projects Ltd
Publication type	Report
Publisher	NHBC Foundation
Date of publication	2015
Target audience	Practitioners

Key words: **Retrofit impact assessment**

Summary: The social housing sector, working generally to more stringent Code levels, has led the way in the use of sustainable technologies. Because of their ownership and management of significant portfolios of high-Code-level sustainable homes, they have been in a position to gain experience of the installation, performance and resident satisfaction with the various technologies.

Data gather from 3 focus groups, and 200 in-depth telephone interviews with housing associations

reference	action theme*	details	evidence
action 01	renewables	**The broad use of photovoltaics is likely to continue** The housing associations surveyed had installed photovoltaics on more than 16,500 new homes since 2006, with 82% indicating that this was the main technology that they used. General satisfaction scores are high, with over two-thirds rating them as good or excellent, which combined with a high score for ease of installation, and perceptions of low user involvement with controls, appears to confirm a preference for this technology. Almost 80% expect this to be the technology	
action 02	services	**Heat pumps are delivering poor levels of satisfaction** The three types of heat pumps surveyed (air source, ground source and exhaust air) all attracted low general satisfaction levels. 60% of those questioned scored air source heat pumps as poor or fair, with	

		63% scoring ground source heat pumps and 93% scoring exhaust air heat pumps in the same way. Interestingly, despite these low satisfaction scores, 45% said they would use air source heat pumps again and it was the most identified technology which was considered to be sound but not yet delivering against expectation.	

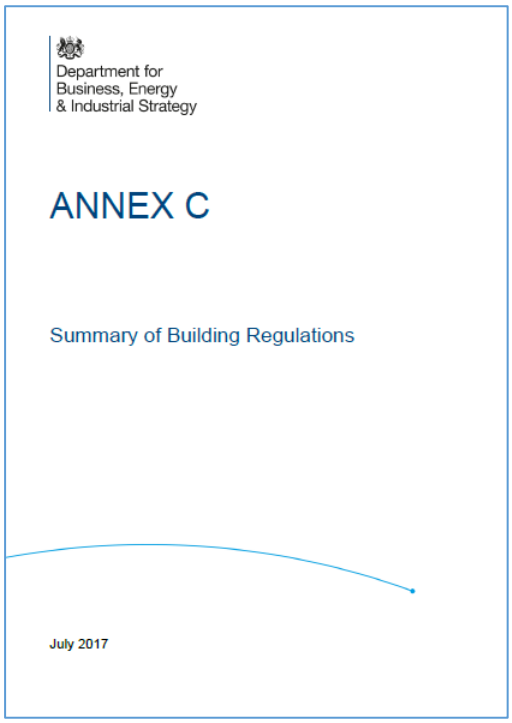
*action themes: strategic / fabric / renewables / services / people

reference	barrier theme**	details:	relating to:
01	strategic	All those questioned in the focus groups and by telephone indicated that planning, funding requirements, and meeting the Code for Sustainable Homes requirements were the main drivers to using and installing technologies. Only 5% saw the installation of technologies as a revenue opportunity.	
02	financial	**Cost of the technology influences its installation**. Two-thirds stated that the main reason for choosing which specific technology to install into homes is the upfront capital cost.	
03	supply chain	**Inadequate installation skills is an issue** Despite the ease of installation only being mentioned by 10% of respondents as a main driver for technology choice, almost two-thirds experienced problems during installation due to a lack of skilled or experienced trades. Quality installation also influences how successful a project is, with 23% agreeing that good quality installers who understand the product can make a difference.	
04	people	**Residents could benefit further with better understanding** In both the focus groups and telephone survey, respondents commented that providing residents with a good understanding of technologies is fundamental to success, with 86% stating that resident instruction and knowledge could positively affect the successful use of sustainable technologies. 72% thought that the best way to help their residents understand the technologies was through a personal demonstration, with 50% offering printed information. 87% agreed that the most effective approach was to ensure that user controls were simple and easy to use.	

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 07

Publication title:	NATIONAL ENERGY EFFICIENCY DATA-FRAMEWORK Summary of Building Regulations
Reference / source	https://www.gov.uk/government/collections/national-energy-efficiency-data-need-framework
Author(s)	UK Government
Publication type	Report
Publisher	UK Government
Date of publication	2017
Target audience	Policy-makers



Key words: **Building Regulations**

Summary: Building regulations standards since 1985

Related case studies: LR04

reference	action theme*	details	evidence
action 01	fabric	Gives the specific U values for Roof Loft insulation thickness and Wall u-value	
action 02	services	Boiler and Heating controls	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 08

Publication title:	UK Fuel Poverty Monitor 2016 - 2017 A review of progress across the nations
Reference / source	https://www.nea.org.uk/wp-content/uploads/2017/06/FPM_2017.pdf
Author(s)	National Energy Action (NEA) and Energy Action Scotland (EAS)
Publication type	Report
Publisher	NEA
Date of publication	2017
Target audience	Policy-makers

Key words: **Fuel poverty | energy efficiency**

Summary:

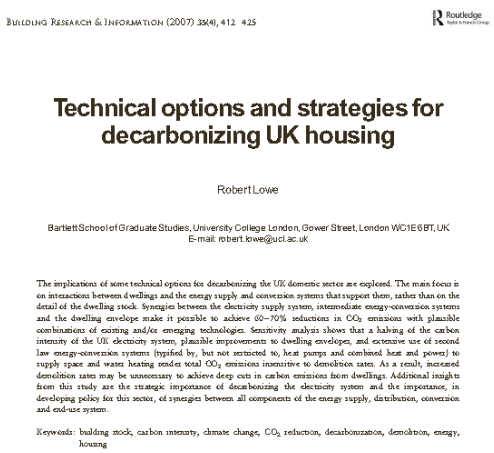
The fuel poverty monitor report is produced annually, to tack progress and activity to tackle fuel poverty, and to compare progress across the four nations over time. The report identifies the importance of a UK-wide strategy “to meet fuel poverty commitments across the UK and more generally improve our unhealthy and inefficient housing stock.”

“This year’s report has a special focus on the impact living in cold, damp conditions has on the most vulnerable members of our society. We note the most at-risk groups continue to be typically older people, children and those with existing long-term illnesses. Whilst UK-wide statistics for fuel poverty are no longer produced5 by the UK Government, the last year that they were published in 2015 highlighted that there are over 3.5 million vulnerable households who are unable to heat and power their homes adequately across the UK; an increase of 500,000 compared to the previous year.”

reference	action theme*	details	evidence
action 01	strategic	The report advocated a joint ministerial summit with representatives from across all four nations' governments by winter 2017/18 to formally recognise the importance of cold homes as a key determinant of ill health and establish an ongoing UK-wide taskforce. In Wales there has been a small decrease in fuel poverty in 2016 (291,000 households) compared to 2015 (305,000 households). The Welsh Government estimates that fuel poverty has fallen by 6 percentage points from 29% in 2012 to 23% in 2016 following rising incomes, energy efficiency improvements and reductions in energy prices. In March 2016, 93% of social housing dwellings were compliant with the WHQS requirement for properties to have a minimum SAP rating of 65 and 98.1% were compliant with the central heating requirement. However, 27% of social housing tenants in Wales were estimated to be in fuel poverty in 2016. The Welsh Government's Warm Homes Programme, has around £26m funding per year committed until 2021. Up to 25,000 homes are expected to receive efficiency measures over the next four years. Despite this activity under the Warm Homes Programme, NEA Cymru remains concerned that the Welsh Government's policy direction appears to have shifted from a focus on eradicating fuel poverty to the reduction of fuel poverty. A new long-term strategy for addressing fuel poverty is required.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 09


Building Research & Information (2007) 35(4), 412–425

Technical options and strategies for decarbonizing UK housing

Robert Lowe

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The implications of some technical options for decarbonizing the UK domestic sector are explored. The main focus is on interactions between dwellings and the energy supply and conversion systems that support them, rather than on the detail of the dwelling stock. Synergies between the electricity supply system, intermediate energy-conversion systems and the dwelling envelope make it possible to achieve 60–70% reductions in CO_2 emissions with plausible combinations of existing and/or emerging technologies. Sensitivity analysis shows that a halving of the carbon intensity of the UK electricity system, plausible improvements to dwelling envelopes, and extensive use of second law energy-conversion systems (typified by, but not restricted to, heat pumps and combined heat and power) to supply space and water heating render total CO_2 emissions insensitive to demolition rates. As a result, increased demolition rates may be unnecessary to achieve deep cuts in carbon emissions from dwellings. Additional insights from this study are the strategic importance of decarbonizing the electricity system and the importance, in developing policy for this sector, of synergies between all components of the energy supply, distribution, conversion and end-use system.

Keywords: building stock, carbon intensity, climate change, CO_2 reduction, decarbonization, demolition, energy, housing

Publication title:	Technical options and strategies for Decarbonizing UK housing
Reference / source	Lowe, R. 2007. Building Research & Information 35(4), 412–425
Author(s)	Robert Lowe
Publication type	Academic paper
Publisher	Taylor & Francis
Date of publication	2007
Target audience	Researchers, policy-makers

Key words: **Fuel supply | fabric | energy efficiency**

Summary: This paper explores the implications of some technical options for decarbonizing the UK domestic sector. "The main focus is on interactions between dwellings and the energy supply and conversion systems that support them, rather than on the detail of the dwelling stock. Synergies between the electricity supply system, intermediate energy-conversion systems and the dwelling envelope make it possible to achieve 60–70% reductions in CO_2 emissions with plausible combinations of existing and/or emerging technologies. Sensitivity analysis shows that a halving of the carbon intensity of the UK electricity system, plausible improvements to dwelling envelopes, and extensive use of second law energy-conversion systems (typified by, but not restricted to, heat pumps and combined heat and power) to supply space and water heating render total CO_2 emissions insensitive to demolition rates. As a result, increased demolition rates may be unnecessary to achieve deep cuts in carbon emissions from dwellings. Additional insights from this study are the strategic importance of decarbonizing the electricity system and the importance, in developing policy for this sector, of synergies between all components of the energy supply, distribution, conversion and end-use system."

reference	action theme*	details	evidence
action 01	fabric	The study is based on a basic model of the dwelling stock and supply system. Houses built before the year 2000 are assumed to be progressively retrofitted with three main measures: gas boiler replacement (from 70% efficiency to 86%); windows replacement from average U-value of 4 W/m^{2}K to 1 W/m^{2}K); external wall insulation (U-value 0.25 W/m^{2}K).	
Action 02	services	Future decrease in the carbon intensity of the electricity supply were modelled to explore the carbon reductions achievable with heat pumps and combined heat and power units (CHP). With regards to CHP, it is noted that maximization of savings requires large generators and district heating, and that the long-term viability of CHP will be affected by future technological developments in electricity generation.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 10

Bryson Energy Retrofit Scheme – Whole House Solutions

Publication title:	Bryson Energy Retrofit Scheme – Whole House Solutions
Reference / source	http://www.brysonenergy.org/downloads/publications/THE-BRYSON-ENERGY-MODEL-2014_final.pdf
Author(s)	Barbara Gray, Anna Czerwinska & Christine Liddell
Publication type	report
Publisher	Bryson Energy / Ulster University
Date of publication	2014
Target audience	Policy-makers

Key words: **Retrofit policy impact assessment**

Summary: This report presents the results of the impact assessment of the "whole house" retrofit scheme by Bryson Energy. The scheme involved 100 houses in west areas of Northern Ireland particularly afflicted by fuel poverty. The scheme was used to test the delivery of "whole house" solutions to properties which had already been partially retrofitted through Warm Homes scheme (with walls and loft insulation and solar panels). Additional solutions delivered by the Bryson Energy scheme comprised new boilers and heating controls. The impact assessment included three surveys and 6 case studies. The overall impact of the scheme was very positive, as it improved energy performance and occupant's comfort while reducing energy expenses. The strategic approach to "whole house" solutions is discussed in companion report Transforming Northern Ireland domestic energy efficiency landscape (LR11).

Related literature LR11

reference	action theme*	details	evidence
action 01	Strategic: whole house approach	The positive impact of the scheme shows the benefits of providing holistic solutions to improve energy efficiency, fuel poverty and comfort (in comparison to single-measure approach focusing on one aspect). Insights from the case studies highlight the importance of providing one-stop services (public and private) for whole house solutions, i.e. agencies capable to deliver a number of services, such as survey, advice, EPC, installation, post installation support etc.	solutions delivered to 100 properties
action 02	services	New oil-based boilers, heating controls, and radiators were installed in 100 properties. Improved energy performance and comfort levels, lowered energy expenses.	average increase of 17 points in SAP rating (across 75 properties), lower levels of mould, less frequent use of additional heating,

			average 20% bill savings
action 03	people	Over 90% of households involved were satisfied with the delivery of the scheme. Many comments showed the appreciation (and the importance) of professional and friendly installers together with direct support with legal papers.	Qualitative interviews, 6 case studies

*action themes: strategic / fabric / renewables / services / people

reference	**barrier theme****	**details:**	**relating to:**
barrier 01	Strategic	Need of providing whole house solutions through one-shop services to maximise impact of policy and facilitate uptake by industry and citizens.	All actions
barrier 02	People	Need of professional supply chains and expert advisers/consultants.	Action 03

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 11

Publication title:	Whole house solutions – Transforming northern Ireland's domestic energy efficiency landscape
Reference / source	http://www.brysonenergy.org/downloads/publications/UU-WHS-report-final-pdf.pdf
Author(s)	Christine Liddell, Barbara Gray and Anna Czerwinska
Publication type	report
Publisher	Ulster University
Date of publication	2014
Target audience	Policy-makers

Key words: **retrofit**

Summary: "This report outlines the case that can be made in Northern Ireland (NI) for adopting a new domestic energy efficiency ethos. This would be centred on whole house solutions, with retrofit completed as a single programme of works, and encompassing both state of the art technical innovations and wrap-around customer advice and support.
This report details why this new ethos seems particularly apposite in NI and goes on to explicate what such a transformation of ethos would require in terms of multi-level stakeholder engagement, Commensurate with a whole house approach, it also argues that a single agency is likely to provide the most optimal business solution for delivering such a complex and coordinated retrofit strategy, with an initial requirement for work in 130,000 homes."
The companion report (LR10) presents the results of the impact assessment of the "whole house" retrofit scheme by Bryson Energy.

Related literature LR10

reference	action theme*	details	evidence
action 01	Strategic	It is argued that the piece-meal interventions on the NI housing stock have resulted mostly in shallow retrofits and failed to realise the full potential of addressing the house in its entirety from a system - thinking perspective. Both deep and shallow types of retrofit can achieve greater energy- and cost-effectiveness through a whole house approach.	

action 02	Supply chain	The report argues that the establishment of a single agency providing whole house solutions is the optimal strategy for large-scale retrofit schemes. The single agency would be capable to cover all aspects of energy retrofits and create a local network of trusted professionals. Ensuring a high quality on the execution of work is very important for the success of a retrofit scheme as well as for the public acceptance of the scheme.
		The typical business profile of a single agency for whole house solutions would include
		• Business planning
		  ○ Strategic planning
		  ○ Training
		  ○ Procurement
		  ○ Sub-contracts
		• Marketing and communications
		• Building assessment
		  ○ Customer interaction
		  ○ Whole house assessment
		• Sales
		• Contract administration	

*action themes: strategic / fabric / renewables / services / people

reference	barrier theme**	details:	relating to:
barrier 01	Strategic	Whole house solutions require the occupants to be away from house during the execution of works, this creates problems with acceptance as well as additional costs.	Action 01
	Financial	There is insufficient evidence the reliability of the payback time of energy retrofits. Piece-meal approach makes the later installation of more expensive measures less cost-effective.	

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 12

Publication title:	Welsh Government Warm Homes Arbed EU, Final Report (Arbed 2)
Reference / source	https://gov.wales/docs/desh/publications/171106-welsh-government-warm-homes-arbed-eu-project-final-report-en.pdf
Author(s)	Kathryn Warren and Nigel Griffiths (Ricardo AEA)
Publication type	report
Publisher	Welsh Government
Date of publication	2017
Target audience	Policy-makers, public, research

Key words: **retrofit | wall insulation**

Summary: (source: LR12) This report evaluates the Arbed2 retrofit scheme of Welsh Government by detailing the outcomes of three surveys conducted by Ricardo AEA (covering about 10% of retrofitted properties):

- A survey to investigate householder satisfaction with the measures installed and their impacts on the household;
- A technical survey to evaluate the quality and appropriateness of measures
- A follow-up survey to evaluate the impact of the measure on the household over time.

The overall householder satisfaction with the scheme was positive. “Issues reported by householders were mainly concerned with reinstatement of services (after EWI was installed), clean-up, communications with site managers or misunderstanding of what measures they would receive, or disappointment that they had not received the same measures as other households.” Householders particularly appreciated the improved visual appearance after the installation of External Wall Insulation.

“Scheme managers were required to encourage the participation of Welsh SME’s when procuring site contractors and other suppliers. This approach resulted in the creation of over 498 jobs and in many cases local people were employed to work on local schemes. The schemes delivered training including 2842 apprenticeship weeks and further training opportunities through graduate placements and work experience. The Arbed2 scheme was the first programme to achieve a Welsh Local Multiplier of £2.”

reference	action theme*	details	evidence
action 01	Strategic	The objectives of the project were to: • Improve energy efficiency in at least 4,800 existing homes in Wales by the end of 2015. • Save at least 3.17ktc of annual GHG emissions by the end of 2015. • Create 283 gross jobs. • Reduce fuel poverty. Arbed2 started in 2012 and installations were completed in 2016. Various measures were installed on a total of 6,535 dwellings. Total value of the project was £45million. The sections of the dwelling stock targeted by the scheme were in the lowest 10-30% most deprived areas in Wales and contained a high proportion of 'hard-to-treat' houses. Main strategic recommendations future energy retrofit schemes: • continue focusing on social, economic, and environmental cross-cutting themes; • maintain the whole house approach; • continue focusing on areas of multiple deprivation; • a different procurement route may be needed to give greater weight to the stimulation of local economies in future schemes.	
action 02	Fabric	There have been instances of poor quality installation of EWI in the scheme. The report recommends that all specifiers and installers of EWI should be trained on courses recognised by key industry, heritage and sustainability bodies. The scheme should be followed by periodical surveys on a selection of properties treated with EWI to monitor issues related to thermal bridging, moisture levels and indoor air quality.	

*action themes: strategic / fabric / renewables / services / people

reference	barrier theme**	details:	relating to:
barrier 01	Strategic	The lack of data on the energy consumption of the targeted properties did not allow an appropriate assessment of the impact of the scheme in terms of energy efficiency, GHG emissions and fuel poverty reduction.	action 01
	Supply chain	It is acknowledged that EWI is complex to install due to risk of poor detailing when adapting the additional fabric around the existing building elements (roof, window sills, pipes, etc.). This requires bespoke specification for each building. In many cases it appears that decisions about detailing are made on site by personnel who is not adequately trained. Budgetary constraints and the time pressure of fixed price contracts obstacle the uptake of additional works to ensure the best detail for EWI. Instances of poorly detailed and executed works have been noted in properties where EWI was installed. So far there have been no reports of increased damp or other issues related to EWI, but these will take time to become noticeable.	action 02
	People	The installation of new boilers and heating controls encountered no technical obstacle, while the main issue was the lack of understanding in some households on how to control the new equipment. This was a particular problem for elderly and vulnerable people who are not familiar with electronic controls.	

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 13

Building Research & Information

ISSN: 0961-3218 (Print) 1466-4321 (Online) Journal homepage: http://www.tandfonline.com/loi/rbri20

Designing an 'optimal' domestic retrofit programme

Aaron Gillich, Minna Sunikka-Blank & Andy Ford

To cite this article: Aaron Gillich, Minna Sunikka-Blank & Andy Ford (2017): Designing an 'optimal' domestic retrofit programme, Building Research & Information, DOI: 10.1080/09613218.2017.1368235

To link to this article: https://doi.org/10.1080/09613218.2017.1368235

Publication title:	Designing an 'optimal' domestic retrofit programme
Reference / source	Aaron Gillich, Minna Sunikka-Blank & Andy Ford (2017) Designing an 'optimal' domestic retrofit programme, Building Research & Information, DOI: 10.1080/09613218.2017.1368235
Author(s)	Aaron Gillich, Minna Sunikka-Blank & Andy Ford
Publication type	paper
Publisher	Taylor & Francis
Date of publication	2017
Target audience	Policy-makers, researchers

Key words: **retrofit | strategic**

Summary: This paper describes the results of the qualitative assessment of the US Better Buildings Neighbourhood Program (BBNP), which was a large-scale programme to stimulate the private sector of the energy retrofit market in the US. The BBNP was initiated and funded by the Federal US Government but each State had significant flexibility with regards to its implementation and the direction of funding.
The paper summarises the insights of the research into a strategy for a successful programme. Comparison between this strategy and the Green Deal programme allows drawing useful lessons for the UK context.

reference	action theme*	details	evidence
action 01	Strategic	The strategy for a successful retrofit programme comprises 5 main steps: Programme design • assess the retrofit market to determine its status from the point of view of both the homeowner and the workforce • choose a policy niche by considering how the programme interacts with existing policies • establish a network of partnerships for financing, marketing, staffing and infrastructure • establish a management structure and ground network Marketing and outreach • design a suitable market and outreach strategy including both traditional media and personal engagement Workforce engagement	The BBNP achieved 5 out of 7 stated objectives: • over 100,000 retrofits • over 10,000 jobs created, • average energy cost savings of 15% • nearly US$1.4 billion in private investments leveraged

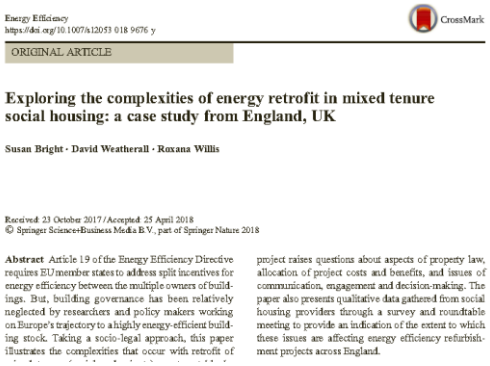
		• design a suitable strategy to engage the workforce by identifying the strengths and weaknesses of the contractor market • establish an ongoing communication strategy with contractors to update them on programme benefits and changes Financial incentives • reduce the upfront cost barrier through rebates, loans or a combination of the two Data and evaluation • monitor the progress of the programme throughout its delivery • carry out interim evaluations to measure programme progress • adjust outreach strategies, workforce-engagement strategies and levels of incentives in response to interim evaluations • design a strategy to ensure the programme could continue either via a new funding stream or through the incorporation of its components into other existing programmes	• 84% of grantees continued programme elements after its end

*action themes: strategic / fabric / renewables / services / people

reference	barrier theme**	details:	relating to:
	strategic	Learning from the success of the BBNP, the UK Green Deal programme could have benefitted from: • a more flexible and granular approach to better respond to the local conditions of the market • the inclusion of community-based social marketing strategies • stronger workforce engagement, helped by the presence of energy advisors to support administrative tasks • a more strategic use of incentives (to sustain and rise demand predictably over time)	action 01

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 14



Energy Efficiency
https://doi.org/10.1007/s12053-018-9676-y

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ORIGINAL ARTICLE

Exploring the complexities of energy retrofit in mixed tenure social housing: a case study from England, UK

Susan Bright · David Weatherall · Roxana Willis

Received: 23 October 2017 / Accepted: 25 April 2018

Abstract Article 19 of the Energy Efficiency Directive requires EU member states to address split incentives for energy efficiency between the multiple owners of buildings. But, building governance has been relatively neglected by researchers and policy makers working on Europe's trajectory to a highly energy-efficient building stock. Taking a socio-legal approach, this paper illustrates the complexities that occur with retrofit of project raises questions about aspects of property law, allocation of project costs and benefits, and issues of communication, engagement and decision-making. The paper also presents qualitative data gathered from social housing providers through a survey and roundtable meeting to provide an indication of the extent to which these issues are affecting energy efficiency refurbishment projects across England.

Publication title:	Exploring the complexities of energy retrofit in mixed tenure social housing: a case study from England, UK
Reference / source	Susan Bright, David Weatherall & Roxana Willis 2018. Exploring the complexities of energy retrofit in mixed tenure social housing: a case study from England, UK. Energy Efficiency. DOI: https://doi.org/10.1007/s12053-018-9676-y
Author(s)	Susan Bright, David Weatherall & Roxana Willis
Publication type	paper
Publisher	Springer
Date of publication	2018
Target audience	Policy-makers, researchers

Key words: **retrofit | strategic | financial**

Summary: (source: LR14)

"The paper focuses on a detailed study of a large refurbishment project of five tower blocks by Oxford City Council, involving external wall insulation and other energy efficiency measures. In addition to the Council's social tenants, these blocks house significant numbers of private owners who have challenged the Council's attempt to recover from them a share of the refurbishment costs. The experience of the Oxford project raises questions about aspects of property law, allocation of project costs and benefits, and issues of communication, engagement and decision-making. The paper also presents qualitative data gathered from social housing providers through a survey and roundtable meeting to provide an indication of the extent to which these issues are affecting energy efficiency refurbishment projects across England."

reference	action theme*	details	evidence
action 01	Strategic	The paper draws insights into the social and legal challenges encountered in retrofit works on mixed tenure buildings by describing the case of 5 mixed tenure residential towers owned by Oxford City Council, The works consisted in visual and thermal improvements of the façade and a few additional measures such as the installation of extracting fans. During the works, a legal dispute arose between the Council and the flat owners who had been recharged between £50,000 and £70,000 for the cost of the works. The issue was exacerbated by the unclarity of the property law with regards to rechargeable costs and by the lack of communications between the Council and the flat owners, who were not adequately informed on the type of works, their costs and benefits.	

*action themes: strategic / fabric / renewables / services / people

reference	barrier theme**	details:	relating to:
	strategic	Property law of mixed tenure residential buildings can obstacle energy retrofits if the type of works is restricted by the lease contract.	action 01
	financial	Recharging the costs of energy retrofits is challenging because: • property law can be unclear, usually tenants/flat owners can be recharged the costs of “maintenance” and “repairs”, but not “improvements”, which makes most energy retrofit measures not eligible; • recharging costs sustained by tenants/flat owners can be very high and difficult to repay.	action 01
	people	A lack of communication between the building owner and the tenants/flat owners and a lack of consultation and engagement on the retrofit works can lead to legal disputes as well as social distress and negative public opinion. Energy retrofits in large mixed tenure buildings face the additional challenge of bringing together a large number of flat owners with different interests and attitudes.	action 01

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 15

Publication title:	Warmer and greener: a guide to the future of domestic energy efficiency policy
Reference / source	http://www.policyconnect.org.uk/wsbf/sites/site_wsbf/files/report/761/fieldreportdownload/warmergreenerreport.pdf
Author(s)	Westminster Sustainable Business Forum
Publication type	report
Publisher	Westminster Sustainable Business Forum
Date of publication	2016
Target audience	Policy-makers, researchers

Key words: **retrofit | strategic | financial**

Summary: (source: LR15) This report sets out a series of policy recommendations developed by the Westminster Sustainable Business Forum.
"The UK Government's fuel poverty strategy for England sets a target to bring as many fuel poor homes in England as is reasonably practicable up to a minimum Energy Performance Certificate (EPC) rating of C by 2030. However, this report argues that current policies will be insufficient to engage with this target and tackle fuel poverty. This report has also identified a clear shortfall between the Government's targets on greenhouse gas emissions and the current policy mix."

reference	action theme*	details	evidence
action 01	Strategic	Recommendations for updating regulations: • reinstate a long-term mandatory zero carbon standard for newly built homes; • strengthen the minimum energy efficiency standards to ensure that they have a meaningful impact; • address the problems associated with houses in multiple occupation and landlords' lack of awareness of the regulations; • increase the minimum energy efficiency standards for private rented properties beyond EPC E rating; • advertising of private rented accommodation should include a figure for monthly expected energy costs calculated from the EPC for that property; • introduce minimum energy efficiency standards for the sale of properties. . Recommendations on financial mechanisms:	

		• base future grant schemes on a sustainable funding model. Tax incentive schemes can provide a long term, structural source of demand that the market can deliver against; • base the next phase of ECO on a system of deemed scores and supported it with a tax-payer funded fuel poverty scheme administered by local actors; • introduce a stamp duty incentive to encourage the uptake of energy efficiency measures in the domestic sector; • mortgage lenders should include more accurate calculations of energy costs in their mortgage affordability assessments and provide mortgage extensions to finance energy efficiency measures. Recommendations on advice and Information: • provide "whole house" roadmaps for energy • efficiency improvements in every house; • campaigns should emphasise all the benefits of energy efficiency beside bill savings; • local authorities should seek partnerships to showcase retrofitted homes; • helping the end user to understand energy efficiency measures installed should be part of the quality assurance of installers' work. Recommendations for developing the energy efficiency industry: • provide a much greater degree of policy certainty and consistency to the industry; • engage with Energiesprong UK to reduce barriers to its development and provide initial funding.	
	People		

*action themes: strategic / fabric / renewables / services / people

reference	barrier theme**	details:	relating to:
	strategic	Houses in multiple occupation let on a room-by room basis are practically exempted from minimum energy efficiency standards. There is a high level of non-compliance with requirements to issue EPCs at the point of letting. Most landlords are unaware of the new minimum energy efficiency standards. Current and past supplier obligation schemes have prioritised measures at the lowest possible cost. Thus, schemes have limited impact on households which are more expensive to treat but are often most in need, such as rural properties.	Action 1
	financial	The Government should learn from the failure of the Green Deal and follow the model of 'soft loans'. Short-term grant schemes like the Green Deal Home Improvement Fund tend to create a cycle of boom and bust.	Ac

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 16

Technology Strategy Board
Driving Innovation

Publication title:	Design for future climate - Opportunities for adaptation in the built environment
Reference / source	https://www.arcc-network.org.uk/wp-content/D4FC/01_Design-for-Future-Climate-Bill-Gething-report.pdf
Author(s)	Bill Gething
Publication type	report
Publisher	Technology Strategy Board
Date of publication	2010
Target audience	Policy-makers, researchers

Key words: **retrofit | strategic | overheating**

Summary: This report provides an overview of the opportunities for adaptation to climate change in the built environment of the UK. It includes background information on climate projections for the UK and outlines a series of challenges and solutions for three areas:

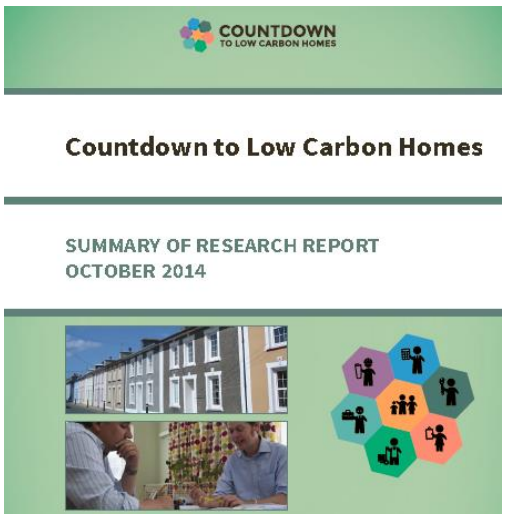
- Comfort – heating and cooling;
- Construction – structural stability and resistance to extreme weather events;
- Water management – conservation, drainage and flooding.

reference	action theme*	details	evidence
action 01	Strategic	The UK climate is shifting towards warmer summers and winters. This will reduce the heating demand but increase the need for cooling. In summer time, air temperature and relative humidity are above comfort levels in large part the UK building stock. Designers should integrate passive architectural solutions to address overheating and limit the need for active cooling, which would increase carbon emissions from buildings. Overheating can be addressed by: • Using construction materials with high thermal mass; • Limiting solar gains from the building envelope; • High levels of thermal insulation; • Controlled ventilation and high levels of airtightness. It is likely that the integration of these solutions in some of the existing buildings will not be cost-effective and therefore demolition and re-construction should be considered. Overheating should also be addressed at the urban level with the use of green and blue spaces to reduce the urban heat island effect.	
Action 02	Fabric	Designers should integrate flexible shading devices to protect from solar gains in summer.	

		Designing an adequate building envelope for a warmer climate requires high levels of thermal mass and insulation and limited glazed surface, unless it can be extensively shaded in summer. Thus, lightweight and over-glazed designs should be avoided.	
Action 03	Services	MVHR might become less cost-effective as the intensity and duration of the heating season will reduce. Even with passive solutions in place, active cooling will likely be needed in most UK buildings by the end of the century if temperature continue to rise (i.e. if carbon emissions are not drastically reduced).	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 17



Publication title:	Countdown to Low Carbon Homes
Reference / source	http://www.severnwye.org.uk/fileadmin/Resources/SevernWye/Publications/countdown_to_low_carbon_homes_-_EXECUTIVE_SUMMARY.pdf
Author(s)	Severn Wye Energy Agency
Publication type	report
Publisher	Severn Wye Energy Agency
Date of publication	2014
Target audience	Policy-makers, researchers

Key words: **retrofit | strategic | financial**

Summary: "The Countdown to Low Carbon Homes project (2012-14) was set up to research, develop and communicate an integrated practical delivery approach to community scale retrofit of energy improvements to buildings, with a particular focus on homes and delivery by Small and Medium Enterprises (SMEs). (…) the project partners worked with households, installers and other key decision makers involved in domestic retrofit in their communities to gather evidence on the situation at a local level. This work informed the development of practical delivery models for the retrofit of buildings. Severn Wye Energy Agency developed and trialled a model that could be rolled out at a community scale, linking in with local businesses. As part of the delivery model Severn Wye aimed to develop and pilot a loan scheme offering households alternative sources of finance for their improvements."

reference	action theme*	details	evidence
action 01	Strategic	The project identified several 'triggers' affecting the decision of homeowners to undertake energy retrofit: • rising fuel costs, although detailed advice on running costs and potential savings from improvement measures is required; • works for repairs and general maintenance; • major life events; • perceptions of payback time; • improved visual impact; • access to trusted installers and tradespeople, possibly locally-based. Besides the adequate installation of technologies, two main factors affect the success of the energy retrofit: • a comprehensive understanding of the retrofit measures and the impact they will have on the property, in terms of benefits and costs as well as of disruption during works;	

		• effective communication between homeowners and tradespeople/ installers during works; • adequate post installation support, especially when the retrofit involves new technologies that require behavioural changes.	

*action themes: strategic / fabric / renewables / services / people

reference	barrier theme**	details:	relating to:
	Strategic	Energy retrofit schemes and markets tend to focus on the selective delivery of measures with the quickest financial and carbon paybacks. A 'whole house' approach and more attention to older and hard-to-treat buildings is required to achieve carbon and fuel poverty targets.	
	Strategic	The complicated eligibility criteria and application processes associated with energy retrofits poses a challenge to both industry and homeowners.	
	Strategic	Energy retrofit grants and incentives have boosted demand but that they have also helped to create a 'payback' culture that overshadows the other benefits of energy retrofits.	
	Financial	Short-term and uncertain programmes for energy retrofit create a 'boom and bust' cycles for the retrofit industry and do not provide the stability necessary for growth and innovation uptake.	
	Supply chain	The lack of impartial advisers as opposed to an installer, tradesperson or supplier can obstacle the uptake of energy retrofit from homeowners.	

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 18

Publication title:	BUILDING THE FUTURE: Sector review of qualifications and the qualification system in CBE
Reference / source	http://www.qualificationswales.org/media/3176/building-the-future.pdf
Author(s)	Qualifications Wales
Publication type	Report, from study
Publisher	Qualifications Wales
Date of publication	2018
Target audience	Policy makers, academic institutions and industrial partners

Key words: **qualifications apprenticeship construction**

Summary:

The construction and built environment sector is key to the economic development of Wales. Sector review of vocational qualifications across the construction and built environment (CBE) sector, consulting about a thousand people across Wales, and identifying short term actions that are being taken, and longer term actions that are being considered.
The study identified flaws in the overall qualification system, including gaps, unclear progression routes, repetition in key training pathways, outdated training content, and concerns that training is biased with a one size fits all approach tailored to larger employers. The study also identified that there are challenges in attracting enough learners, at the right ability level, into the industry.

"The majority of employers we interviewed placed greatest value on core, interpersonal, problem-solving skills and the ability to take on a wider range of tasks than those prescribed in qualifications"

The study proposed that in the short term, the findings of the study be considered and addressed. Longer term, the study advocates new, broadbased qualifications (full-time programmes) in further education and on apprenticeships. At the heart of the proposals is the suggestion that further education and apprenticeships should form a clear and coherent end-to-end progression route which starts with broad-based learning and ends with the employer sign-off and final assessments.

The study proposes new Foundation, Progression and Apprenticeship qualifications that take a project-based approach to assessment combined with professional discussions and specialist tests.

Related literature n/a

Related case studies n/a

The progression routes from B2 to C2 (that is, typically, from age 16) are exemplified in the diagram below:

reference	action theme*	details	evidence
action 01	Strategic: new models for apprenticeship	Positive findings included that apprentices did benefit from off-site learning programmes unlike in some other sectors;	Study, 1000+ contributors
action 02	Strategic: new models for apprenticeship	models of Shared Apprenticeships were also a positive initiative, enabling apprentices to work more widely across several organisations.	Study, 1000+ contributors

*action themes: strategic / fabric / renewables / services / people

reference	challenge theme**	details:	relating to:
challenge 01	Supply chain – lack of skilled workforce	In relation to apprenticeship programmes: NVQs were unreliably and inconsistently assessed, and the amount of observation required was beyond the resourcing capability of most learning providers. Some qualifications require skills that few employers use (or need). Many employers believe that apprenticeships are too short – and are generally shorter than in comparator nations.	general

** challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 19

Publication title:	LENDERS core report
Reference / source	http://www.epcmortgage.org.uk/report
Author(s)	The LENDERS project: Arup, BRE, Constructing Excellence Wales, Energy Saving Trust, Nationwide Building Society, Principality Building Society, UCL, Energy Institute and the UK Green Building Council.
Publication type	Core report
Publisher	See above
Date of publication	July 2017
Target audience	Public, legislators, industry

LENDERS
Improving energy costs in mortgages
Promoting energy efficiency in homes

Key words: **Mortgages energy efficiency EPC borrowing**

Summary:

"The LENDERS project was set up to analytically examine the link between property energy efficiency and fuel bills, and ways in which this link could enable homes with better energy performance to be able to demonstrate lower fuel costs in a way that can be passed on as a tangible benefit to homebuyers [to explore a possible lever for energy efficiency improvements in the private owner occupier sector].

Through use of comparatively large data sets, the project has been able to map the relationship between property energy performance and household fuel bills. It has created a working calculator through which homebuyers can access, with the provision of limited property and household information, estimates of their likely bills before they have purchased the home. Based on larger data sets than those underpinning the existing calculators, the project has demonstrated it is possible for mortgage lenders to utilise better energy performance estimation to demonstrate within their lending decisions that funds not committed to fuel costs in low energy homes can support higher maximum mortgage lending amounts."

The project found that the fuel bill savings in a higher rated home (two EPC bands), could equate to around £4,000 in additional mortgage finance.

The project acknowledges any process to incorporate these changes is not straight-forward: There is not a one size fits all solution (due to the range and complexity of lenders' systems). The project also recognises only a minority of homebuyers borrow to near their maximum affordability.

However, the project has believes that the benefit of inclusion at the right point in the mortgage process may have a behavioural impact beyond the direct financial benefit, influencing homebuyers' perception of value.

Related literature: Lenders tool (fuel bill cost prediction tool): http://www.epcmortgage.org.uk/

reference	action theme*	details	evidence
action 01	People: influencing lifestyle change	The project found no regulatory barriers to the adoption of the more sophisticated consideration of fuel costs in affordability calculations.	Study, broad stakeholders
action 02	People: influencing lifestyle change	The project found homebuyers on balance to be supportive of including energy performance in mortgages	Study, broad stakeholders
action 03	Strategic: addressing overheating	risk of overheating could be addressed as a specific item to be reported in mortgage survey reports.	
action 04	People: influencing lifestyle change	As guidance to homebuyers, the calculator developed by this project could be an effective guidance tool, which could become a supporting tool for the mortgage process. Whilst it is recognised that homebuyers are already presented with a range of complex financial information which can be hard to understand, particularly for inexperienced purchasers, and that it is crucial that any additional information be presented in the right manner, the provision of guidance to homebuyers may represent a route to early adoption that could precede any changes to financial systems.	
Action 05	Strategic	Mortgage lenders can access more accurate energy performance estimations. This allows highlighting potential savings on utility bills and demonstrating that funds not committed to fuel costs in energy-efficient homes can support higher mortgage lending amounts. Monthly savings from lower bills in an energy-efficient home could be taken into account to provide around £4,000 of additional mortgage finance. Providing more accurate energy performance estimations at the early stage of the homebuying process also increases the chance fort this information to affect the decision of homebuyers.	Calculations based on larger data sets than those underpinning the existing affordability calculators for mortgages

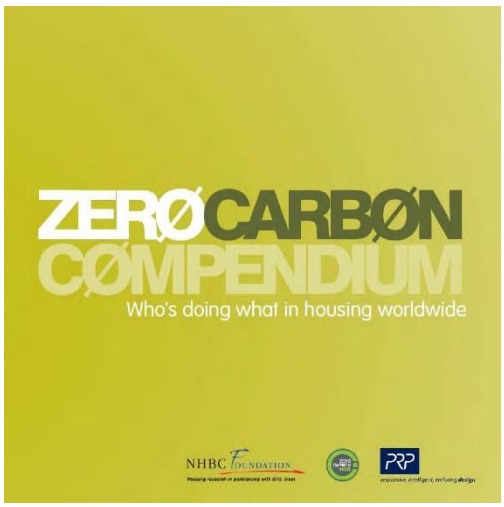
*action themes: strategic / fabric / renewables / services / people

reference	challenge theme**	details:	relating to:
challenge 01	Strategic	Concerns about the quality of assessments undertaken to produce EPCs could lead to questions about how EPCs can be usefully applied to the mortgage lending process	all
challenge 02	Financial	Formal adoption of the projections and corresponding impact on available lending within the mortgage journey is extremely complex, particularly given the multiplicity of systems and sales processes across the sector. Individually, lenders will need to consider how and when it is appropriate to consider home efficiency as part of their lending decision. Adjustments to existing	

		processes at this scale can be extremely costly, and lenders will need to consider these changes alongside the emergence of new innovations and technologies. These represent significant barriers and mean adoption of any changes will require further work and is unlikely to occur quickly under normal conditions.	
	strategic	The mortgage industry should improve the current methods used by affordability calculations to estimate household fuel expenditure to take into account property occupancy and energy efficiency.	

** challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 20



Publication title:	ZERO CARBON COMPENDIUM: Who's doing what in housing worldwide
Reference / source	http://www.epcmortgage.org.uk/report
Author(s)	Zero Carbon Hub and PRP Architects on behalf of the NHBC Foundation
Publication type	Compendium of national studies
Publisher	NHBC Foundation
Date of publication	2009 (updated 2010)
Target audience	Policy makers and legislators, commissioners of housing, public

Key words: **zero carbon, housing, international**

Summary: (from preface)

"…the first synthesis of international activity in this field, providing a unique snapshot of how 15 different countries are demonstrating leadership in low carbon technology, culture change, policy development and change management. For each country, headline energy consumption and climatic data has been assembled to provide context.

This is accompanied by an analysis of progress against national aspirations and policy targets for emissions reductions. The information has been organised to facilitate easy comparisons between countries, providing clarity for those wishing to learn from international experience and those seeking to build international links and collaboration…

The Compendium urges us not to reinvent the wheel or ignore critical insights which have been gained over time."

Lessons are learnt across 15 countries and 7 themes – see overleaf:

Related literature: Zero Carbon Compendium (2009)

reference	action theme*	details	evidence
action 01	Strategic: energy supply	Reducing distribution losses plays a significant role in lowering overall carbon emissions (up to 20-25% savings in CO2). A number of countries (Denmark, Sweden) have made it mandatory where possible to connect to district systems. Others, such as Switzerland, have financial incentives for energy producers to encourage decentralised energy production. in countries where significant improvements in energy performance have been achieved, information, infrastructure and financial incentives have gone hand in hand with new policy, paving the way for policy success and market acceptance.	
action 03		From 1990-2006, household energy efficiency in Austria improved by 23%, mainly due to the increasing number of homes with good insulation. In 1999, the government began a Haus der Zukunft, or 'Building of Tomorrow' programme to support trend-setting research and development projects and the implementation of exemplary pilot projects. This initially ran from 2000-2005 and raised huge market awareness, technological innovation and cost surety.	
action 04		1. Driven by Change: Strong political leadership is essential in order to provide solid ground for ambitious targets and national aspirations.	
action 05		2. Aspirations: Solid aspirations, strong government policy and implementation and widespread acceptance and commitment by the private sector are needed to achieve UK aspirations for zero carbon housing, which requires a comprehensive multi-sectoral solution.	
action 06		3. Energy supply: A dialogue between the energy and housing sectors is necessary, to understand the issues surrounding supply and delivery.	
action 07		4. Acceptance and diffusion: Other countries in the study (eg. Australia, Austria) have shown a high degree of success with regards to public and private acceptance of low energy (newbuild) housing standards.	
action 08		5. Clear Strategies: Simple, focused strategies for dealing with energy and climate change can help consolidate efforts and engage the public. Frameworks for achieving zero-carbon can easily become too onerous and complex, and the key is to simplify, using clear-cut strategies and visions that have a robust technical base.	
action 09		6. Technology : Any strategy must be flexible enough to accommodate new technologies, and support their development. The role of innovation and research cannot be stressed enough as it forms an integral part of decarbonising the national grid, developing controls for appliances and energy use, and delivering alternative carbon-free transport. Any upcoming standards or certification schemes must be able to embrace these new technologies.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 21

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Implications of the UK field trial of building mounted horizontal axis micro-wind turbines

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ABSTRACT

Building mounted micro-wind turbines and photovoltaics have the potential to provide widely applicable carbon free electricity generation at the building level. Photovoltaic systems are well understood and it is easy to predict performance using software tools or widely accepted yield estimates. Micro-wind, however, is far more complex and in comparison poorly understood. This paper presents the key findings of the building mounted (<2 kWp) turbine component of the UK micro-wind trial undertaken by the Energy Saving Trust in 2008/09. The monitored performance of 39 horizontal axis turbines in urban, suburban and rural locations is discussed alongside the accuracy of predictive wind speed tools for the sites. The performance of urban and suburban micro-wind sites in the trial was poor with annual generation of less than 75 kWh/m² swept area, the majority of which were less than 25 kWh/m². Good rural sites had an annual generation of between 100 and 280 kWh/m², far less than the nominal 360 kWh/m² (10% load factor for a typical turbine) that is often assumed. In the light of these findings, the potential impact of the UK's latest policy instrument, the 2010 micro-generation tariffs, is considered for both micro-wind and photovoltaics.

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1. Introduction

Micro-generation is seen as an important technology to help deliver low carbon dwellings. In addition to technical benefits such as (i) electricity generation at the point of use, (ii) low cost mounting using the building as the fixing point and (iii) positive contribution to the carbon rating of a building (Watson et al., 2006), micro-generation can promote energy usage reduction through behaviour change. There are a range of possible deployment scenarios for micro-generation including owner-occupied, lease purchase and utility/energy service company ownership (Watson et al., 2006; Watson et al., 2008), across all of which social acceptance is a key issue (Watson and Sauter, 2007). All options are being driven by the continual tightening of housing energy performance legislation to reduce CO_2 emissions (Part L, 2006). For example, by 2016, all new homes must be zero carbon in operation which should provide a spur to micro-generation (Code for Sustainable Homes, 2006). An important issue is to understand the true yield that micro-generation technologies deliver, this paper details a UK field trial for micro-wind.

Micro-wind turbines are classified in terms of their swept areas (<25 m²) and therefore, have rated powers of up to 6 kW. Small micro-wind turbines (<0.5 kWp) have historically been used in the UK for off-grid battery charging applications, most notably on sailing boats. Over the last five years there has been an increasing interest in the application of micro-wind turbines for use on buildings. These turbines are either evolutions of off-grid products or specially designed for the built environment market. Some manufacturers claim improved performance for their devices at lower wind speeds, more representative of the urban environment and often rate the power of their turbines at wind speeds less than the 15 m/s associated with full scale MW devices.

There is, however, a paucity of real site in-situ performance data for building mounted micro-wind turbines, both across the UK and internationally. In the UK to date, load factors of 10% for a 'suitably installed building mounted turbine' have often been assumed by the industry and policymakers (BWEA, 2008; SAP, 2005). Recent published work has suggested load factors of between 4% and 6.4% for appropriate "urban house" sites in the UK and USA (Mithraratne, 2009).

A study by Strathclyde University in 2007 (Peacock et al., 2008) considered two sites with different measured wind speed profiles (2.0 and 4.9 m/s average wind speed for 'low' and 'high' wind site) and applied the published power curves of 4 turbines, three of which are discussed in this paper (manufacturers Eclectic, Ampair, Swift and Proven (2.5 kW pole mounted)) to predict

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doi:10.1016/j.enpol.2010.05.070

Key words: **Wind turbine case studies**

Summary: Building mounted micro-wind turbines and photovoltaics have the potential to provide widely applicable carbon free electricity generation at the building level. Photovoltaic systems are well understood and it is easy to predict performance using software tools or widely accepted yield estimates. Micro-wind, however, is far more complex and in comparison poorly understood. This paper presents the key findings of the building mounted (<2 kWp) turbine component of the UK micro-wind trial undertaken by the Energy Saving Trust in 2008/09. The monitored performance of 39 horizontal axis turbines in urban, suburban and rural locations is discussed alongside the accuracy of predictive wind speed tools for the sites. The performance of urban and suburban micro-wind sites in the trial was poor with annual generation of less than 75 kWh/m2 swept area, the majority of which were less than 25 kWh/m2. Good rural sites had an annual generation of between 100 and 280 kWh/m2, far less than the nominal 360 kWh/m2 (10% load factor for a typical turbine) that is often assumed. In the light of these findings, the potential impact of the UK's latest policy instrument, the 2010 micro-generation tariffs, is considered for both micro-wind and photovoltaics.

reference	action theme*	details	evidence
action 01	renewables	Wind turbines in urban areas do not produce the predicted amount of energy. The wind speeds around buildings are much lower than in rural areas.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR22

Publication title:	Energy Efficient Scotland
Reference / source	http://www.gov.scot/Publications/2018/05/1462
Author(s)	Scottish Government
Publication type	Route Map
Publisher	Scottish Government
Date of publication	2018
Target audience	Policymakers

Key words: **Energy efficiency Route Map fuel poverty 2050**

Summary: (edited, from executive summary)

Scottish Government (SG) ambition: **"to eradicate fuel poverty, mitigate climate change, and grow the Scottish economy in an inclusive way…"**

Establishes a 20 year programme of clear, long term energy efficiency standards by 2040, including both voluntary and compulsory measures, with a focus on eradicating fuel poverty, as well as measures that are cost effective and technically feasible.

Overarching aim of making Scotland's existing building stock near zero carbon by 2050. Two main objectives:

- Removing poor energy efficiency as a driver for fuel poverty.
- Reducing greenhouse gas emissions through more energy efficient buildings and decarbonised heat supply. Targets propose residential emissions reductions of 23% on 2015 levels by 2032, and a 15% reduction in domestic heat demand by 2032.

It is proposed that progress of the programme be reviewed every four years.

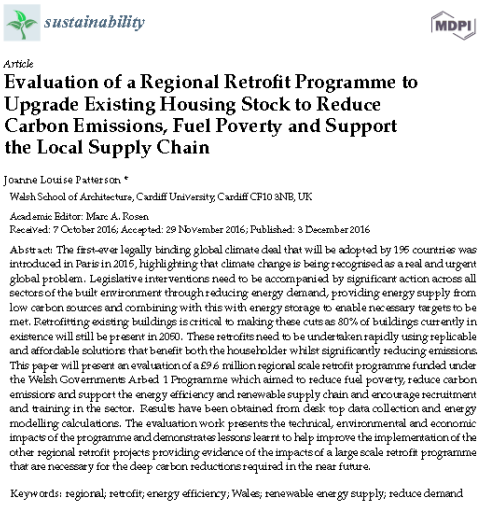
SG has chosen to use EPC's to set future standards for energy efficiency across both domestic and non-domestic sectors. They are commissioning research to explore how EPC's can be improved

Related case studies: CS13

reference	action theme*	Details	evidence
action 01	Strategic: a long term domestic standard	By 2040, all Scottish homes achieve an EPC C rating, where technically feasible and cost effective.	
action 03	Strategic: social rented sector	Social rented sector is the most energy efficient in Scotland, with 90% already achieving an EPC of D or above. To consolidate this, the consultation proposes to maximise the number of social rented homes that achieve an EPC B or above by 2032, and to include air quality and environmental impact requirements. Also proposes that social housing with an EPC less than D should not be let, from a date to be determined.	
action 04	Strategic: private rented sector	Private rented sector includes some of the least energy efficient homes. A gradual increase in standards is proposed: EPC E by 2022, to EPC D by 2025, and to EPC C by 2030 (where feasible and cost effective). To be linked to changes in tenancy.	
action 05	Strategic: owner occupied	34% of Scottish owner occupied homes are already EPC C or above. The pathway requires that all owner occupied homes reach EPC C by 2040 (where feasible and cost effective) and are considering the requirement to reach this standard by 2030.	
action 06	Strategic: households in fuel poverty	SG are proposing their most ambitious target for households in fuel poverty, in line with their intent to eradicate fuel poverty. There were 650,000 homes in fuel poverty in Scotland in 2016. SG are proposing that all fuel poor households reach EPC C by 2030 and EPC B by 2040.	
action 07	Strategic: decarbonising heat	Overarching strategy: emissions from all buildings in Scotland to be near zero by 2050. Trajectory requires that by 2032, 35% of domestic heat is supplied via low carbon technologies With a consequent reduction in domestic heat demand of 15% in the same period (due to building fabric improvements).	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 23



sustainability

MDPI

Article

Evaluation of a Regional Retrofit Programme to Upgrade Existing Housing Stock to Reduce Carbon Emissions, Fuel Poverty and Support the Local Supply Chain

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Academic Editor: Marc A. Rosen

Received: 7 October 2016; Accepted: 29 November 2016; Published: 3 December 2016

Abstract: The first-ever legally binding global climate deal that will be adopted by 195 countries was introduced in Paris in 2015, highlighting that climate change is being recognised as a real and urgent global problem. Legislative interventions need to be accompanied by significant action across all sectors of the built environment through reducing energy demand, providing energy supply from low carbon sources and combining with this with energy storage to enable necessary targets to be met. Retrofitting existing buildings is critical to making these cuts as 80% of buildings currently in existence will still be present in 2050. These retrofits need to be undertaken rapidly using replicable and affordable solutions that benefit both the householder whilst significantly reducing emissions. This paper will present an evaluation of a £9.6 million regional scale retrofit programme funded under the Welsh Governments Arbed 1 Programme which aimed to reduce fuel poverty, reduce carbon emissions and support the energy efficiency and renewable supply chain and encourage recruitment and training in the sector. Results have been obtained from desk top data collection and energy modelling calculations. The evaluation work presents the technical, environmental and economic impacts of the programme and demonstrates lessons learnt to help improve the implementation of the other regional retrofit projects providing evidence of the impacts of a large scale retrofit programme that are necessary for the deep carbon reductions required in the near future.

Keywords: regional; retrofit; energy efficiency; Wales; renewable energy supply; reduce demand

Publication title:	Evaluation of a Regional Retrofit Programme to Upgrade Existing Housing Stock to Reduce Carbon Emissions, Fuel Poverty and Support the Local Supply Chain
Reference / source	http://www.mdpi.com/2071-1050/8/12/1261
Author(s)	Jo Patterson
Publication type	paper
Publisher	MDPI
Date of publication	2016
Target audience	Policy-makers, researchers

Key words: **retrofit | strategic | supply chain**

Summary: (source: LR23)

"This paper will present an evaluation of a £9.6 million regional scale retrofit programme funded under the Welsh Governments Arbed 1 Programme which aimed to reduce fuel poverty, reduce carbon emissions and support the energy efficiency and renewable supply chain and encourage recruitment and training in the sector. (...) The evaluation work presents the technical, environmental and economic impacts of the programme and demonstrates lessons learnt to help improve the implementation of the other regional retrofit projects providing evidence of the impacts of a large scale retrofit programme that are necessary for the deep carbon reductions required in the near future."

reference	action theme*	details	evidence
action 01	Strategic	The Arbed 1 'Warm Wales' programme set out to deliver energy retrofit measures with a 'whole house' approach. 1391 measures were delivered in total on 1147 properties, with a total cost of about £6,370,000. The majority of properties received one type of measure. The most cost-effective measure in term of carbon reduction was the installation of gas boilers, because the carbon intensity of gas is much lower than other energy sources in the UK.	Average SAP rating before works was 60, ranging from 43 to 66. Average SAP rating after works was 69, ranging from 58 to 82. The combined potential for financial savings as a result of the Warm Wales programme is £285,000 per year.
action 02	Fabric	648 properties received EWI, for an average cost of £7,730.	
action 03	Renewables	414 properties received PV panels (average cost £4,988) and 46 properties received solar thermal	

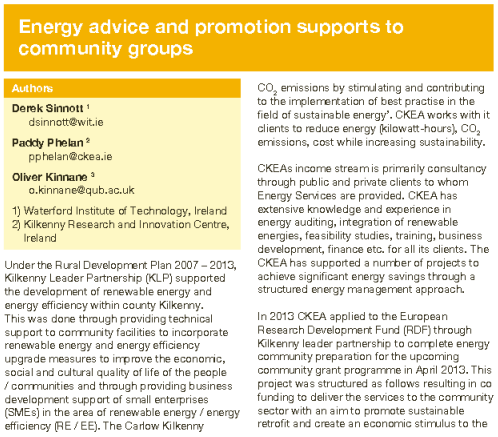
		panels for DHW (average cost £4,393). About 40 properties received air-source heat pumps.	
action 04	Services	241 properties switched to gas as the main heating fuel for an average cost of £3,126.	

*action themes: strategic / fabric / renewables / services / people

reference	barrier theme**	details:	relating to:
	Strategic	The quick turnaround time required by Arbed did not allow sufficient time for appropriate planning and selection of measures. As a result, the distribution and type of measures installed reflect a 'blanket' approach rather the intended 'whole house' approach. More time should be allowed for the planning stage to conduct a survey of the properties and select the appropriate combination of measures.	Action 01
	Existing buildings	Short times, small variations in properties and the lack of attention to details in EWI applications leads to poor execution, which reduces the effectiveness of the insulation. Providing a range of detailing solutions developed by manufacturers and installer would help addressing this problem.	Action 02
	Financial	Capital costs and long-term operational costs should be more carefully planned and managed by project administrator and management team.	
	Supply chain	Lack of experience and training among local installers led to poor executed works, especially with regards to EWI. Future programmes should evaluate the capacity of the local supply chain and provide training opportunities. Local Manufacturers should be engaged to develop appropriate technical solutions and provide product warrantees. Main contractors should underwrite compliance with product specifications.	

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 24



Energy advice and promotion supports to community groups

Authors

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Under the Rural Development Plan 2007 – 2013, Kilkenny Leader Partnership (KLP) supported the development of renewable energy and energy efficiency within county Kilkenny. This was done through providing technical support to community facilities to incorporate renewable energy and energy efficiency upgrade measures to improve the economic, social and cultural quality of life of the people / communities and through providing business development support of small enterprises (SMEs) in the area of renewable energy / energy efficiency (RE / EE). The Carlow Kilkenny

CO_2 emissions by stimulating and contributing to the implementation of best practise in the field of sustainable energy'. CKEA works with it clients to reduce energy (kilowatt-hours), CO_2 emissions, cost while increasing sustainability.

CKEAs income stream is primarily consultancy through public and private clients to whom Energy Services are provided. CKEA has extensive knowledge and experience in energy auditing, integration of renewable energies, feasibility studies, training, business development, finance etc. for all its clients. The CKEA has supported a number of projects to achieve significant energy savings through a structured energy management approach.

In 2013 CKEA applied to the European Research Development Fund (RDF) through Kilkenny leader partnership to complete energy community preparation for the upcoming community grant programme in April 2013. This project was structured as follows resulting in co funding to deliver the services to the community sector with an aim to promote sustainable retrofit and create an economic stimulus to the

Publication title:	Energy advice and promotion supports to community groups, in Smart Energy Regions – Skills, knowledge, training and supply chains.
Reference / source	
Author(s)	Derek Sinnott, Paddy Phelan, Oliver Kinnane
Publication type	Book chapter
Publisher	Cardiff University
Date of publication	2016
Target audience	Policy-makers, researchers

Key words: **strategic | people**

Summary:

This paper gives an overview of the activity of the Carlow Kilkenny Energy Agency (CKEA) with two examples: the RDF Leader Programme and the Better Energy Community programme. It shows the role that community engagement and independent expert support play in fostering renewable and energy efficiency projects.
The RDF Leader Programme delivered knowledge and training support to local communities and firms with the aim to promote energy retrofits and renewable energy projects. The programme also allowed the successful delivery of subsequent funded programmes by mentored rural businesses and providing independent technical support to local communities.
The Better Energy Community programme brought together several partners with the aim to achieve specific energy and carbon emissions through energy retrofits. Retrofitted buildings included hotels, the City Hall, two community centres, 140 houses owned by local authorities and 38 privately-owned homes.

reference	action theme*	details	evidence
action 01	Strategic	Both programmes leverage existing links within the local community to promote energy efficiency awareness and provide technical support. The RDF Leader Programme also performed energy audits for community buildings, which went on to be retrofitted in a successive grant scheme.	The RDF Leader Programme is considered a key driver in the achievement of 8Gwh of energy savings through two subsequent energy retrofit schemes in the county of Kilkenny.

*action themes: strategic / fabric / renewables / services / people

reference	barrier theme**	details:	relating to:
	Strategic	The RDF Leader Programme addressed the need for independent technical support on energy efficiency and renewable technologies, which had been identified as a barrier.	Action 01

**barrier themes: strategic / existing building / financial / supply chain / people

Literature review: LR 25

Publication title:	Freedom Project – Interim Report
Reference / source	https://www.westernpower.co.uk/docs/Innovation/Current-projects/FREEDOM/Freedom-Project-Interim-Report-Online.aspx
Author(s)	Freedom Project
Publication type	Report
Publisher	Freedom Project
Date of publication	January 2018
Target audience	Policy-makers, researchers

Key words: **strategic | services**

Summary:

(source: LR25)

"The Freedom Project is seeking to understand the potential role of multi-vector solutions in the decarbonisation of domestic heating. Based in Bridgend, South Wales, the project is investigating the consumer, network and energy system implications of hybrid heating system deployments, where domestic heating systems have the option of operating using a standard gas boiler, an air source heat pump (ASHP), or both. The Freedom Project has completed 13 months of a 27-month project programme. The Project has installed 75 hybrid heating systems in a mix of private and social housing, with the focus now on the optimised controlling, monitoring and consumer feedback throughout the 2017-18 heating season. Once the heating season has concluded the collected data will be reviewed and analysed with final reporting due in January 2019."

Project partners: Wales & West Utilities, Imperial College London, Western Power Distribution, PassivSystems, City University London, Delta.

reference	action theme*	details	evidence
action 01	Strategic	Burning gas in domestic boilers at 93% efficiency is less carbon intensive than burning fossil fuel in coal and gas plants (efficiency between 28% and 48%) and incurring in 6% transmission losses of the electricity network.	Modelling by the Imperial College of London
	services	The project shows that it is possible to install hybrid heating systems across a range of typical Welsh housing units. Installing these hybrid systems is less disrupting than other technologies as they use the existing domestic radiators.	Installation in 35 private homes and 40 social housing units in Bridgend.
	services	The recommended control strategy for a hybrid	Field testing

		heating system is to warm the house through the gas boiler, while using the heat pump to maintain temperature and a ‘base load’ when a fully warm house is not required.	

*action themes: strategic / fabric / renewables / services / people

reference	**challenge theme****	**details:**	**relating to:**
	people	A survey of stakeholders indicates that there is a low awareness of hybrid heating systems and heat pumps.	

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 26

Publication title:	Energy Efficient Mortgages Pilot Scheme Implementations & Product Framework
Reference / source	http://eemap.energyefficientmortgages.eu/wp-content/uploads/2018/06/EEM-Pilot-Scheme-Implementation-Product-Framework-1.pdf
Author(s)	Energy Efficient Mortgage Initiative
Publication type	Report
Publisher	Energy Efficient Mortgage Initiative
Date of publication	2018
Target audience	Policy-makers, researchers

Key words: **strategic | financial**

Summary:

(source: LR26)

This report outlines the framework developed by the Energy Efficient Mortgage Initiative for energy efficient mortgage schemes to be adopted in lending institutions across EU countries. The framework is the result of consultation with financial stakeholders and will be tested in a pan-European pilot scheme. The framework provides three types of guidelines:

- implementation principles for lending institutions,
- building performance assessment criteria,
- valuation guidance and energy efficiency checklist.

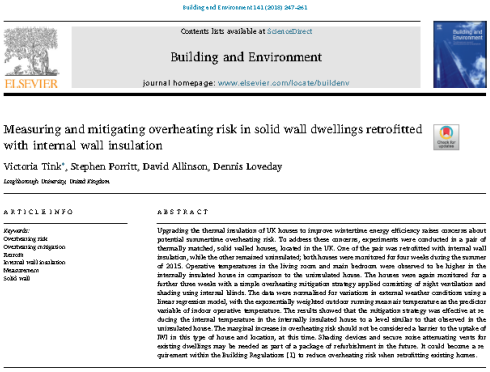
Related literature LR19

reference	action theme*	details	evidence
action 01	Strategic	The principles for the implementation of Energy Efficient Mortgage (EEM) schemes have been developed to be flexible enough to be adapted in different countries and lending institutions, for both new constructions and retrofit projects. These principles include: • The EEM should allow the borrower access to favourable financing conditions provided that a set of building performance assessment criteria are met; • The EEM should link access to favourable conditions to gradual improvement of the property in time. • Lending institutions should require proof that certified energy experts and installers have been involved in the design and construction works. • Energy efficiency features should be included in the aspects considered by the property valuing process. • Lending institutions should take every opportunity to integrate EEM into their financial services and systems.	

		Eligibility criteria for an EEM are based on three aspects: • The energy performance of the building/project should be either compliant with the national definition of nearly zero energy buildings (NZEBs), or b. 20% better than building regulations, or improved at least by 30% (in the case of retrofit). • The borrower should provide a revised Energy Performance Certificate (EPC) after the works, and for both new-builds and retrofits should report the measured energy consumption at least once per year. • Works impacting on the energy performance of the building should be developed by certified experts and implemented by certified contractors, and all documentation should be retained by the borrower.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 27


Building and Environment 141 (2018) 247–261

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Measuring and mitigating overheating risk in solid wall dwellings retrofitted with internal wall insulation

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ARTICLE INFO

Keywords:
Overheating risk
Overheating mitigation
Retrofit
Internal wall insulation
Measurement
Solid wall

ABSTRACT

Upgrading the thermal insulation of UK houses to improve wintertime energy efficiency raises concerns about potential summertime overheating risk. To address these concerns, experiments were conducted in a pair of thermally matched, solid walled houses, located in the UK. One of the pair was retrofitted with internal wall insulation, while the other remained uninsulated; both houses were monitored for four weeks during the summer of 2015. Operative temperatures in the living room and main bedroom were observed to be higher in the internally insulated house in comparison to the uninsulated house. The houses were again monitored for a further three weeks with a simple overheating mitigation strategy applied consisting of night ventilation and shading using internal blinds. The data were normalised for variations in external weather conditions using a linear regression model, with the exponentially weighted outdoor running mean air temperature as the predictor variable of indoor operative temperature. The results showed that the mitigation strategy was effective at reducing the internal temperature in the internally insulated house to a level similar to that observed in the uninsulated house. The marginal increase in overheating risk should not be considered a barrier to the uptake of IWI in this type of house and location, at this time. Shading devices and secure noise attenuating vents for existing dwellings may be needed as part of a package of refurbishment in the future. It could become a requirement within the Building Regulations [1] to reduce overheating risk when retrofitting existing homes.

Publication title:	Measuring and mitigating overheating risk in solid wall dwellings retrofitted with internal wall insulation
Reference / source	Tink, V., Porritt, S., Allinson, D., and Loveday, D. 2018. Measuring and mitigating overheating risk in solid wall dwellings retrofitted with internal wall insulation. Building and Environment 141, pp.247-261
Author(s)	Tink, V., Porritt, S., Allinson, D., and Loveday, D.
Publication type	Paper
Publisher	Elsevier
Date of publication	2018
Target audience	Policy-makers, researchers

Key words: **Retrofit | overheating**

Summary:

(source: LR27)

This paper describes a unique experiment set up to investigate the impact of IWI on overheating UK dwellings and possible mitigation strategies. The research team studies two adjacent semi-detached houses: one house was insulated internally (to simulate the measures adopted in a typical retrofit), while no interventions were made on the other house. Since the houses were unoccupied, the research team was able to artificially replicate typical internal gains (due to occupants and appliances) in equal conditions for both houses. Outdoor and indoor temperature of the houses were monitored for four weeks in summer 2015. Temperatures had also been monitored before the experiment in order to determine the inherent difference between the two houses due to different orientation. Results of the experiment show that IWI increased the indoor temperature of 1-2 degrees in comparison to the uninsulated house. A mitigation strategy consisting of window blinds and night ventilation was also tested. This strategy minimised the increase in temperature in the insulated house, especially at night.

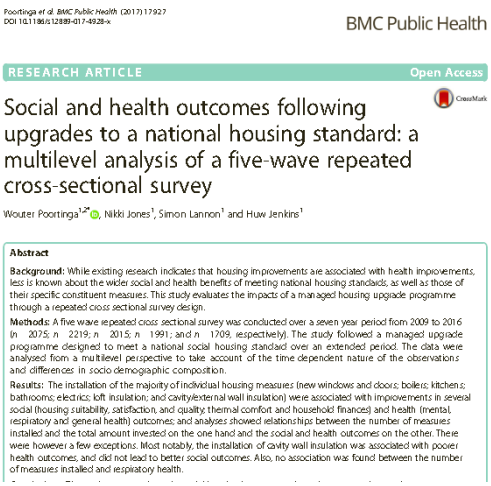
reference	action theme*	details	evidence
action 01	fabric	Walls insulated internally with 5 cm of phenolic foam bound to 1.25 cm of plasterboard	

*action themes: strategic / fabric / renewables / services / people

reference	challenge theme**	details:	relating to:
Challenge 01	people	The occupants might not be willing to adopt the mitigation strategies: may not want to keep blinds down during the day and may not want to ventilate at night due to noise/insects/security issues	

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 28



Publication title:	Social and health outcomes following upgrades to a national housing standard: a multilevel analysis of a five-wave repeated cross-sectional survey.
Reference / source	https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-017-4928-x
Author(s)	Wouter Poortinga, Nikki Jones, Simon Lannon and Huw Jenkins
Publication type	Academic paper
Publisher	BMC Public Health
Date of publication	2017
Target audience	Policy-makers, researchers

Key words: **Housing standards | quality | fuel poverty | health**

Summary: (source: LR28)

This paper discusses the health benefits of house retrofits by presenting the results of a five-wave repeated cross-sectional survey. This was conducted from 2009 to 2016 to evaluate a retrofit programme designed to meet the Welsh social housing standard.

"The installation of the majority of individual housing measures …were associated with improvements in several social (housing suitability, satisfaction, and quality; thermal comfort and household finances) and health (mental, respiratory and general health) outcomes; and analyses showed relationships between the number of measures installed and the total amount invested on the one hand and the social and health outcomes on the other. There were however a few exceptions. Most notably, the installation of cavity wall insulation was associated with poorer health outcomes, and did not lead to better social outcomes.
The study suggests that substantial housing investments through a managed upgrade programme may result in better social and health outcomes, and that the size of the improvements are proportionate to the number of measures installed and amount invested. However, there may be risks associated with specific measures; and more attention is needed for mechanical ventilation when upgrading energy efficiency of houses through fabric work."

Related literature LR29

reference	action theme*	details	evidence
action 01	strategic	The retrofit programme involved more than 9000 social housing units in Carmarthenshire.	
action 02	Fabric	External walls – Units were installed with external or cavity wall insulation (depending on the property) to achieve a SAP rating of 65. Roof – some properties were given loft insulation Windows and doors – new double-glazed windows and insulated doors	
action 03	services	Units equipped with external walls insulation were also given MVHR. The retrofit programme also included the upgrade of kitchen and bathroom elements.	

*action themes: strategic / fabric / renewables / services / people

reference	challenge theme**	details:	relating to:
Challenge 01	strategic	Cavity wall insulation was found to be associated with negative health outcomes, which may have been affected by the choice of not combining cavity insulation with MVHR. This is in line with recent research indicating that, in certain conditions, fabric improvements can lead to respiratory risks.	Action 02

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 29

Publication title:	Emergency hospital admissions associated with a non-randomised housing intervention meeting national housing quality standards: a longitudinal data linkage study
Reference / source	https://jech.bmj.com/content/early/2018/06/20/jech-2017-210370
Author(s)	Sarah E Rodgers,Rowena Bailey, Rhodri Johnson, Damon Berridge, Wouter Poortinga,Simon Lannon, Robert Smith, Ronan A Lyons
Publication type	Academic paper
Publisher	BMJ Journals
Date of publication	2017
Target audience	Policy-makers, researchers

Key words: **health**

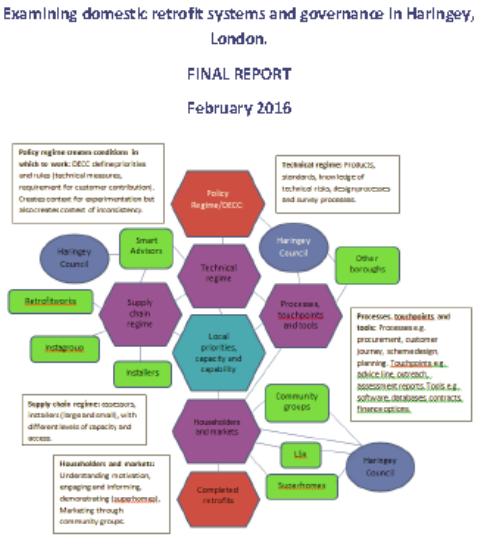
Summary: This paper presents a longitudinal survey to assess the impact on tenant health care utilisation following a retrofit programme of over 8000 Welsh dwellings. The indicator studied were emergency hospital admissions for cardiorespiratory conditions and injuries for residents aged 60 years and over.
The results show that residents of retrofitted dwellings were associated with up to 39% fewer admissions in comparison to residents of non-retrofitted dwellings.

Related literature LR28

reference	action theme*	details	evidence
action 01		The retrofit programme included several measures: • Installing new windows and doors, • Improving kitchen and bathroom elements; • Improving heating systems, • Installing wall and loft insulation, • Upgrading electrical systems • Improving garden paths. The highest levels of reduced admissions were associated with interventions on electrical systems, windows and doors, wall insulation, and garden paths. Reduced admissions were also associated with windows and doors, wall insulation and gardens and estates. There were no associations of change in emergency admissions with Upgrades to heating services, loft insulation, kitchens and bathrooms were not found to be associated with changes in emergency admissions.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 30



Publication title:	Examining domestic retrofit systems and governance in Haringey, London. Final report
Reference / source	
Author(s)	Rebecca Ince
Publication type	Report
Publisher	Durham University
Date of publication	2016
Target audience	Policy-makers, researchers

Key words: **Retrofit | policy**

Summary:

(source: LR30)

"This research has focussed on the approaches to retrofit emerging in the specific context of Haringey, London, with its own particular challenges and priorities. This report will outline the project brief, theoretical approach and methodology, then the national and local priorities surrounding retrofit. It will outline the key issues emerging from Haringey's retrofit network and then assess the strengths and weaknesses of the responses that have emerged. Finally, the report will present a series of suggestions for Haringey's next phase of retrofit, encompassing its own unique vision and priorities."

reference	action theme*	details	evidence
action 01		The research to produce the report was approached as a quasi-ethnography of a single case study using mixed qualitative methods. The detailed findings are specific to Haringey but the general outcomes are relevant for the whole UK. The researcher adopted the socio-technical 'systems' theoretical approach to analyse and interpret the context and practice of house retrofitting in Haringey. The research focused particularly on the delivery of the Smart Homes scheme. This scheme offered a grant of 75% (up to a maximum of £6000) per household for solid wall insulation or hard to treat cavity walls, or a secondary time limited offer of up to £3000 for boiler and windows replacement. To be eligible, householders had to make a contribution to the cost of the works, and living in a solid wall property.	

*action themes: strategic / fabric / renewables / services / people

reference	challenge theme**	details:	relating to:

Challenge 01	Strategic	The research concluded that regulatory initiative and coordination are the most significant elements missing from the 'Haringey retrofit system'. Challenges identified by the research: • The complexity of the Smart Homes scheme process and lack of trust in contractors discouraged applications; • Too many intermediaries in the operational structure of the scheme; • Difficulties in leveraging the local communities to promote the scheme. • The role of an independent advisor (called 'Smart Advisor') was essential to quality of works and residents' satisfaction. The Smart Advisors were able to: 1) advise householders and installers of technical risks and extra works not covered by the Smart Homes grant, 2) check that installers' quotations offered value for money, 3) set a standard approach to be followed by installers for more complex elements of installations, and 4) conduct post-installation audits to identify and remedy installation defects. • Lack of common methods and tools for building performance assessment; • Inconsistency in retrofit policy created significant issues for the industry and householders.	
Challenge 02	Supply chain	• The structure of training and accreditation does not lead to job creation, because the PAS2030 is a quality management reporting system, and not a technical standard or training.	

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 31

Publication title:	Self-build communities: the rationale and experiences of group-build (Baugruppen) housing development in Germany.
Reference / source	Housing Studies, 31(4) https://www.tandfonline.com/doi/abs/10.1080/02673037.2015.1091920?journalCode=chos20
Author(s)	Iqbal Hamiduddin and Nick Gallent
Publication type	Academic paper
Publisher	Taylor & Francis
Date of publication	2016
Target audience	Policy-makers, researchers

Key words: **Strategic | policy**

Summary:

(source: LR31)

"Group-build housing developments can bring together the cost and customisation benefits regularly attributed to self-build housing with a communitarian ethos associated with 'intentional' communities. This paper presents an initial examination of the rationale, motivations and social experiences of group-build housing from Germany, where over half of all new homes are produced independently from volume-build developers. The paper aims, firstly, to test the hypothesis that group-build delivers general 'community' benefits; secondly, to contribute to an understanding of the processes leading to successful schemes; and lastly, to demonstrate that by making individual home-building dependent on the success of a larger group, collective interests can prevail over personal pursuit."

reference	action theme*	details	evidence
action 01	strategic	The German housing market presents low shares of private ownership in comparison to most European countries. Group-build (Baugruppen) types of development are a niche section of this market, but their popularity is increasing, especially in cities such as Berlin, Freiburg and Hamburg. In Freiburg, over 1,100 homes were delivered through group-build developments between 1993 and 2013. Each group-build development is different, however they are generally initiated by a group of like-minded people based on existing relationships or by an individual with relevant profession skills (e.g. an architect) gathering prospective participants. In Germany, municipalities identify suitable land for group-build developments and sell it at a fixed price. The urban and architectural design of the development is the result of a collaborative process between the members of the grou-build. The group-build model presents three benefits in comparison to conventional large developments:	

		• Lower delivery cost, since there is no profit for the developers; • Custom housing units; • Community creation and empowerment.	

*action themes: strategic / fabric / renewables / services / people

reference	**challenge theme****	**details:**	**relating to:**
Challenge 01	financial	Land dedicated to group-build models of development needs to be made available by local authorities at a fixed price on the basis of design-led competition, as is common practice in German cities where the group-build model has been most successful. This enables group-build developers to access the land without competing with large developers.	Action 01
Challenge 02	strategic	There is a risk for group-build developments to be limited to a narrow socio-economic section of the population, typically young couples who cannot afford a house from a large developer but with sufficient means for a self-build construction. Thus, the group-build model is not sufficient to address the housing shortage in its entirety.	Action 01

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 32

Publication title:	Research into the thermal performance of traditional brick walls
Reference / source	English Heritage report 70/2013 https://research.historicengland.org.uk/Report.aspx?i=15741
Author(s)	Rhee-Duverne, Soki Baker, Paul
Publication type	Report
Publisher	English Heritage
Date of publication	2013
Target audience	Policy-makers, researchers

Key words: **Solid wall**

Summary:

This report discusses two studies conducted in 2010:

- In-situ measurement of the U-value of solid brick walls in 18 houses in England in 2010;
- Laboratory measurement of the thermal conductivity of three types of bricks (alike to those used in the monitored houses) at different levels of moisture content.

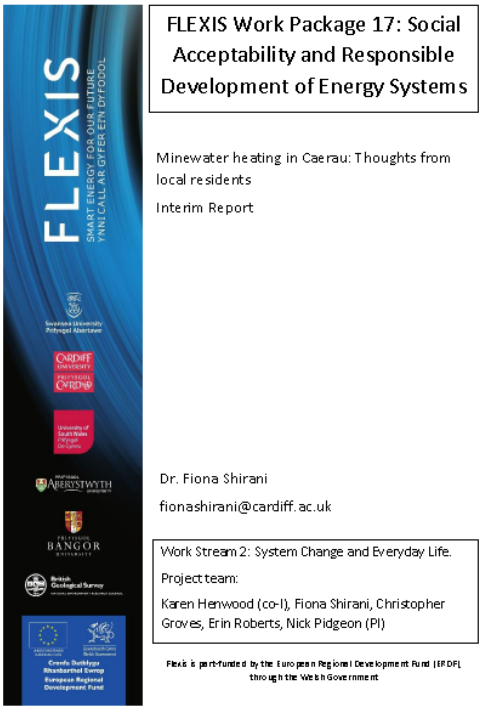
The results of the studies show that conventional estimates of U-values for solid wall (such as those used by RdSAP) significantly underestimate the performance of solid walls in comparison to the measurements in-situ. However, the research also shows that if the physical properties of the solid wall materials are known in detail (following laboratory measurements), U-value calculations for the solid wall produce figures in accordance with the results of the in-situ measurements. Therefore, retrofit measures on solid wall properties could be based on more accurate figures for U-values. Rather than using 'typical' figures for solid walls, the types of materials in each wall should be identified to estimate more accurate U-values.

reference	action theme*	details	evidence
action 01	fabric	The average U-value of solid walls measured in-situ at the eighteen houses was 1.4 W/m2K, compared to the 'typical' U-value of 2.1 W/m2 K for a solid (9-inch) brick wall used in energy-performance assessments.	In-situ heat flux measurements

*action themes: strategic / fabric / renewables / services / people

Literature review: LR

Publication title:	Minewater heating in Caerau: Thoughts from local residents. Interim Report
Reference / source	https://www.energybiographies.org/wp-content/.../09/Minewater-heating-report-web-version.pdf
Author(s)	Dr Fiona Sharani
Publication type	Report
Publisher	FLEXIS project
Date of publication	2017
Target audience	Policy-makers, researchers



Key words: **District heating | heat pump**

Summary: (source: LR33)

This report is part of the Working Package 17 of the FLEXIS project. Its presents information about the minewater heating scheme in Caerau and the results of a survey on the perspective of the local residents.
"The scheme is part of the Energy Technology Institute 'Smart Systems and Heat' programme, which is being delivered by the Energy Systems Catapult (ESC). Bridgend County Borough Council (BCBC) put out a tender for groups with appropriate expertise to run the project in conjunction with them. A consortium, led by Cardiff University and including Swansea and Cardiff Metropolitan Universities, as well as private companies, was successful in winning the bid. Total cost £ 9.4 million.
The Llynfi Valley scheme (in Caerau) is one of two proposed district heating (hereafter DH) schemes being investigated by BCBC, the other focussing on Bridgend town centre. Water in the disused mine workings represents a potential geothermal energy source as it has an average temperature of 10 to 14 degrees Celsius. Heat will be extracted from the minewater and transported to residents' properties using a network of pipes and their existing radiator system. It is still to be decided whether the scheme would use a central heat pump or whether individual properties would have their own heat pump. As the heat would be 'low grade', alterations to the existing housing stock in order to improve heat retention are likely to be required."

Related literature: Web article https://www.bridgend.gov.uk/news/65m-awarded-for-uk-s-first-large-scale-mine-water-energy-project/

Literature review: LR34

Publication title:	Each Home Counts: Review of Consumer Advice, Protection, Standards and Enforcement for Energy Efficiency and Renewable Energy
Reference / source	http://www.eachhomecounts.com/
Author(s)	Dr Peter Bonfield BRE
Publication type	Independent review
Publisher	DBEIS / DCLG
Date of publication	2016
Target audience	Industry, policymakers

Key words: **Home energy efficiency | renewable energy | quality standards**

Summary: (edited, from executive summary from website http://www.eachhomecounts.com/next-steps/)

In October 2015 the Secretaries of State for DECC and DCLG, Amber Rudd and Greg Clark commissioned Dr Peter Bonfield (Chief Executive of independent building science centre BRE) to chair an Independent Review of Consumer Advice, Protection, Standards and Enforcement for UK home energy efficiency and renewable energy measures.

"Each Homes Counts has a total of 27 recommendations and sets out a new quality and standards framework for all those operating in the retrofit sector. This includes the setting up of:

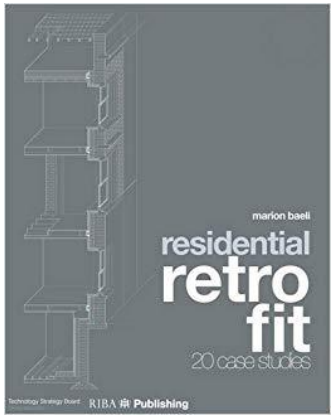
- A quality mark against which all those engaged in design and installation of energy efficiency and renewable energy measures will be assessed and certified
- A Consumer Charter to set out the positive experience that the consumer can expect under the quality mark including response times, financial protections and access to redress procedures when things go wrong
- A Code of Conduct to set out clear requirements and guidance on how companies behave, operate and report in order to be awarded and hold the quality mark
- Technical Codes of Practice and Standards for the installation of home renewable energy and energy efficiency measures so that the risk of poor-quality installation is minimised
- Development of an Information Hub and Data Warehouse."

Companies willing to work within this framework and to use the quality marks will need to display (1) technical competence, (2) quality performance and (3) customer-interfacing skills.

reference	action theme*	Details	evidence
action 01	Strategic: a new approach from the market	Report recommends a new approach to the provision of energy efficiency measures for the domestic sector: “underpinned by strong standards and enforcement, to bring clarity and confidence to consumers, whilst providing a simplified and certain route to market for those companies, large and small, wishing to operate and do business in the energy efficiency and renewable energy sector in the United Kingdom.”	Developed cross sector – see section: ‘the view from the industry’
action 03	Strategic: consumer protection	Consumer protection should be at the core of the new approach. A Code of Conduct should be developed as requirement for the quality mark. The Code should be followed by a Consumer Charter stating clearly what the consumer can expect form companies displaying the quality mark.	
action 04	Strategic: advice and guidance	New ways should be developed to engage the consumer and raise awareness on energy retrofit. An Information Hub and a Data Warehouse should be set up to gather information on retrofit measures and provide impartial information to consumers.	
action 05	Strategic: skills	The industry should start embedding core knowledge on retrofit measures (building physics, design, consumer interaction) in all relevant qualifications, training courses and apprenticeships.	
action 06	Strategic: enforcement and compliance	The new quality mark should be managed and regulated by an independent organisation.	
action 07	Strategic: building fabric	All retrofit project should include a holistic assessment of the building (context, climate, materials, occupants) to identify suitable retrofit measures, with particular attention to fabric interventions.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 35



Publication title:	Residential retrofit: 20 case studies
Reference / source	Baeli, M. 2013. Residential retrofit: 20 case studies. London: RIBA Publishing
Author(s)	Marion Baeli
Publication type	Book
Publisher	RIBA Publishing
Date of publication	2013
Target audience	architects, researchers

Key words: **Fabric | services | retrofit**

Summary: This book illustrates 20 case studies of residential retrofit across England and Wales. 18 of these retrofits were funded under the Retrofit for the Future programme. Together, the 20 case studies allow drawing several considerations on the effectiveness of the various measures implemented in the retrofits and related problems.

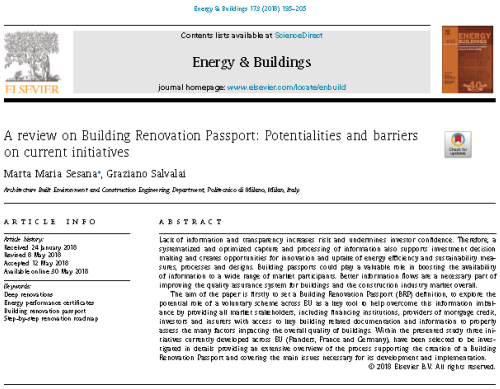
Related case studies: CS15-23, CS26, CS37

reference	action theme*	details	evidence
action 01	Fabric	Wall insulation: EWI presents the advantage of a continuous insulation layer and the possibility of installation without significant disturbance to the occupiers. However, in several retrofits there was a need for extra insulation (applied internally) to limit the thermal bridges at the borders of the EWI (i.e. the junctions between wall and roof, wall and ground floor, wall and wall of the adjacent property, if uninsulated). IWI is usually adopted when it is necessary to maintain the traditional aspect of the existing façade. If properly designed, it allows a continuous layer of insulation between walls, ceiling and floor. However, IWI creates a loss of internal space, which is generally already limited in historical properties. There have also been instances where IWI led to increases in interstitial condensation in walls. 'Breathable' IWI can be installed using hygroscopic materials such as sheep wool insulation, however these require a thicker layer to achieve the same U-value of non-hygroscopic materials (such as plastic foams). Very thin layers of highly performing materials (such as aerogels) can be used for IWI, however they have a much higher cost than other types of insulation. Windows: new casement windows are considered the best option to reduce heat loss from windows. The frame structure of casement windows can easily	20 case studies

		accommodate triple glazing panes and ensure good airtightness. New sash windows are more problematic, as triple glazed units are thick and heavy to operate, and airtightness is more difficult to ensure. A possible solution for historical facades featuring sash windows is the installation of a secondary window with good performance, however this requires sufficient space in the wall thickness. Airtightness: most of the projects did not achieve the targeted airtightness level (around 1 m^3/m^2d@50Pa). However, all project achieved higher airtightness than the building regulation standard for new dwellings. Lack of skills and knowledge among installers was considered the main cause for this underachievement. It was found that simple and robust construction such as taped OSB helped achieve good airtightness level, while most problems were encountered when multiple materials were combined.	
Action 02	Services	14 of the 20 case studies included the installation of MVHR to limit heat losses from ventilation while ensuring air changes. It was found that these systems work well, although they require special attention in the design phase, due to space requirements for ductworks.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 36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journal homepage: www.elsevier.com/locate/enbuild

A review on Building Renovation Passport: Potentialities and barriers on current initiatives

Marta Maria Sesana*, Graziano Salvalai

ARTICLE INFO

ABSTRACT

Publication title:	A review on Building Renovation Passport: Potentialities and barriers on current initiatives
Reference / source	Energy & Buildings 173 https://www.sciencedirect.com/science/article/pii/S0378778818302937
Author(s)	Sesana, M.M and Salvalai, G.
Publication type	Academic paper
Publisher	Elsevier
Date of publication	2018
Target audience	Policy-makers, researchers

Key words: **Building passport**

Summary: (source: LR36)

"This paper contributes to the body of knowledge in three ways: (i) it provides an overview on Building Passport (BP) definition from first initiatives in EU and one in Australia; (ii) it presents an updated evaluation and comparison of some BRP experiences developed in some European Member states (Belgium, France and Germany, selected for their advanced phase of development; (iii) it pinpoints the main known barriers and the lesson learned within the review initiatives in order to provide suggestions for the standardization of BRP across EU. Although the paper comparison fo- cuses only on three countries, the overview of barriers and mo- tivators and the overall approach and conclusions can be used to identify gaps and opportunities in other countries policy schemes as well."

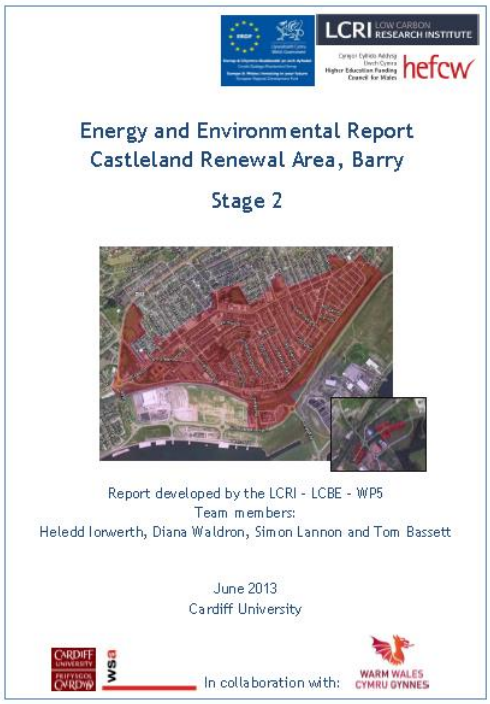
reference	action theme*	details	evidence
action 01	strategic	Various forms of 'building passport' have been developed and tested since the late 1990's. With regards to existing buildings the Building Performance Institute Europe defines the Building Renovation Passport (BRP) as "a document – in electronic or paper format – outlining a long-term (up to 15 or 20 years) step-by-step renovation roadmap for a specific building, resulting from an on-site energy audit fulfilling specific quality criteria and indicators established during the design phase and in dialogue with building owners". Thus the BRP collates information on building state, materials, services, and works undertaken, and provides guidelines for building operation and the potential for future improvements. The BRP has been introduced in EU policy with the amendment of the EPBD in April 2018. The BRP represents the next step beyond EPC by addressing the lack of knowledge among building owners of what types of measures can be undertaken, and in what order. It also aims to provide a source of information for real estate and insurance services.	

*action themes: strategic / fabric / renewables / services / people

reference	challenge theme**	details:	relating to:
Challenge 01	strategic	The paper concludes by outlining the challenges for an effective implementation of BRP across EU countries: • The need for a long-term perspective • The need to engage with building owner and consider the appropriate measures for the individual context • The need for an attractive and motivating BRP scheme, learning from the limitations of the EPC • The need for an automated and dynamic tool, preferably digital	

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 37



Publication title:	Energy and environmental report. Castleland Renewal Area, Barry. Stage 2
Reference / source	Iorwerth, Heledd, Waldron, Diana, Lannon, Simon Charles and Bassett, Thomas 2013. Energy and environmental report. Castleland Renewal Area, Barry. Cardiff: Welsh School of Architecture. http://orca.cf.ac.uk/51253/
Author(s)	Iorwerth, Heledd, Waldron, Diana, Lannon, Simon Charles and Bassett, Thomas
Publication type	Report
Publisher	Cardiff: Welsh School of Architecture.
Date of publication	2013
Target audience	Policy-makers, researchers

Key words: **Fabric | services**

Summary: This report presents an analysis of the pre-1919 dwelling stock (1248 homes) in Castleland Renewal Area, Barry, and its potential for retrofit measures. The research is the result of the collaboration between Warm Wales, who provided the initial data, and the Welsh School of Architecture (WSA). The analysis was based on a GIS model of the stock (the Energy and Environmental Prediction model, developed by WSA) and the SAP methodology.

reference	action theme*	details	evidence
action 01		Most of the Castleland stock was assessed to be in the D and E bands of the SAP rating, in line with national averages. The project team investigated two targets for the retrofit: • Achieving the 'Housing Health and Safety Rating System' (HHSRS) in all dwellings (equivalent to SAP rating 62.5); • Achieving 80% reductions of GHG emissions in all dwellings by 2050 (equivalent to SAP rating 92). Two possible retrofit approaches were modelled: • Fabric first (e.g. wall insulation); • Services first (e.g. boiler replacement). The results show that each of the two approaches can achieve the fist target (SAP 62.5). However, to achieve the second target (SAP 92), the two approaches need to be combined and supplemented with renewable energy technologies (e.g. PV panels).	

*action themes: strategic / fabric / renewables / services / people

reference	challenge theme**	details:	relating to:
Challenge 01	Financial	The research team estimated a total cost of £5,178,218 to achieve the first target with the fabric first approach (average per dwelling = £4,150), and £1,337,100 with the services first approach (average per dwelling = £1,072). The annual carbon savings were estimated at 1,634,224 kgCO_2 with the fabric first approach and 1,140,791 kgCO_2 with the services first approach. This results in total annual savings per pound invested of 0.31 kgCO_2/£ for the fabric first approach and 0.85 kgCO_2/£ for the services first approach. The cost of achieving the second target was estimated in £26,551,071, with annual carbon saving of 4,832,729 kgCO_2.	

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 38

Publication title:	Technical Innovation Fund – Interim Report 2017
Reference / source	https://www.nea.org.uk/wp-content/uploads/2017/09/TIF_Report_2017-FINAL-FOR-PRINT.pdf
Author(s)	NEA
Publication type	Report
Publisher	NEA
Date of publication	2017
Target audience	Policy-makers, researchers

Key words: **Innovation | heat pumps | storage**

Summary: (source: LR38)

This report presents the delivery of the Technical Innovation Fund (TIF) by NEA "NEA believes that there is huge potential for new technologies to provide solutions for some of the 4 million UK households currently living in fuel poverty, particularly those residing in properties which have traditionally been considered too difficult or expensive to include in mandated fuel poverty and energy efficiency schemes. There has been a lack of the robust monitoring and evaluation needed to understand the application of these technologies and assess their suitability for inclusion in programmes such as the Energy Company Obligation (ECO) and other publicly funded programmes across the UK. Through TIF, NEA provided charitable grants to help install a range of innovative technologies. Up to £5.1 million was made available to meet the capital and installation cost of high cost (large) and low cost (small) in-home measures in fuel poor and vulnerable households across England and Wales, with the aim of reducing the cost of heating their homes and addressing the underlying causes and symptoms of fuel poverty. Where possible, there was a focus on rural and off-gas communities and EPC band D, E, F and G properties. TIF beneficiaries were predominantly living in social housing (82%). 522 (24%) were living off the mains gas network and reliant on more expensive heating fuels."

reference	action theme*	details	evidence
action 01	strategic	Through the TIF, several innovative technologies were installed: • Fabric: non-conventional external and cavity wall insulation, park home insulation; • Services: heat pumps, domestic multi-fuel stoves, micro CHP, electric storage heating; electric heating, thermal storage; • Controls: smart controls and TRV	Data from the delivered programme

		• Complementary measures such as flue gas heat recovery, heating enhancement devices, ventilation. Multiple benefits have resulted from the installation of these technologies: • increased thermal comfort in 78.2% of the households; • 35.5% of households reporting major savings in energy bills, and 37.5% reporting minor savings. • 85.5% of households were satisfied or very satisfied with the support received during the works. Key insights and recommendations: • incentives are needed for social and private housing to support the adoption of innovative technologies; • local authorities and social landlords are discouraged from investing in innovation when technologies are not included in the SAP methodology; • the installation of innovative technologies can present additional risks and delay, plans and alternatives must be envisioned beforehand; • the resident must always be kept at the core of the programme by guaranteeing the high quality of installation and ensuring support after the works.	

*action themes: strategic / fabric / renewables / services / people

reference	**challenge theme****	**details:**	**relating to:**
Challenge 01	Supply chain	The delivery of the TIF programme presented an opportunity to improve the understanding of fuel poverty and energy efficiency among frontline workers via dedicated training sessions. With regards to manufacturers of innovative technologies, the delivery of the TIF programme highlights that there is need for more direct support from manufacturers to social landlords and their contractors when technologies are installed.	

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 39

Publication title:	Solid wall insulation: unlocking demand and driving up standards
Reference / source	http://www.superhomes.org.uk/wp-content/uploads/2017/02/BIS-15-562-solid-wall-insulation-report.pdf
Author(s)	Peter Hansford
Publication type	report
Publisher	HM Government
Date of publication	2015
Target audience	Policy-makers

Key words: **Solid wall**

Summary: This report presents an overview of the drivers and barriers affecting the insulation of domestic properties with solid wall construction. It provides specific recommendations for policy-makers.
Solid Wall Insulation (SWI) presents multiple benefits:

- carbon savings
- financial savings;
- improved comfort, health and wellbeing;
- increased fuel security (through reduction of energy demand);
- reduced fuel poverty;
- building improvement and reduced maintenance costs;
- aesthetic improvement;
- contribution to GDP and tax revenues.

Growth in the demand for SWI is hampered by policy and technical issues, while cases of poor executed SWI have contributed to discourage further uptake.

reference	action theme*	details	evidence
action 01	strategic	Government policy affecting SWI should be clear and consistent, avoiding 'stop-start' funding streams to encourage industry investment in this sector. Several regulations and standards require review to increase their detail with regards to SWI: • BS 5250; • PAS 2030 and other quality control, verification and accountability requirements; • Assessment standards; • Building Regulations; • Statutory Planning requirements; • Enforcement arrangements.	Review of policy and practice

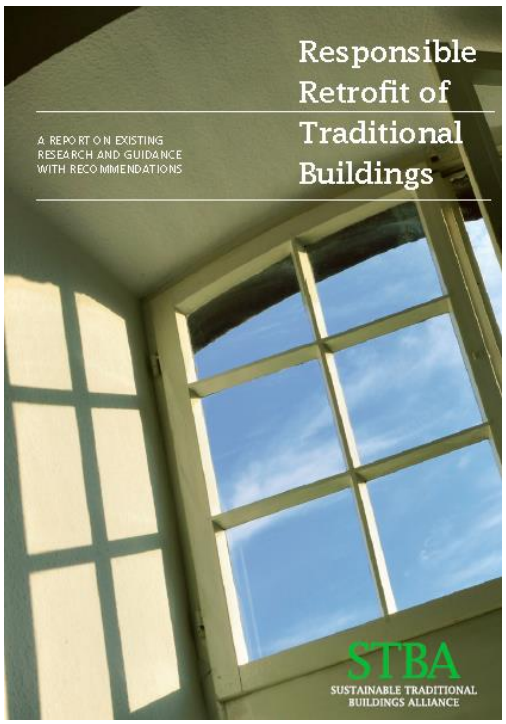
		The standards and incentives for building assessment need to be addressed to improve the quality of output. Quality control arrangements should also be reviewed, including the introduction of regulation and sanctions. Generally, the industry adopts quality standards rapidly when these are a necessary condition to access grants and contracts.	
	fabric	There is no single SWI solution that can be applied to all buildings. In addition, the exact physical properties of the materials are often unknown, and there are still gaps in the understanding of moisture dynamics in traditional solid walls. This has led to many cases where incorrect SWI has been applied causing damp and poor indoor air quality. There is need for further research on these aspects. More generally, the solid wall stock needs to be analysed and categorised into archetypes, to develop a 'catalogue' of appropriate solutions and focus the research efforts on the more problematic archetypes. The recurring issue of poor design of SWI detailing should be addressed by establishing a 'Retrofit Co-ordinator' as responsible for ensuring that works are correctly designed and executed. There is a general lack of performance data from properties installed with SWI. This data is essential to	

*action themes: strategic / fabric / renewables / services / people

reference	**challenge theme****	**details:**	**relating to:**
Challenge 01	Supply chain	A higher level of expertise is needed in to address the technical issues associated with SWI works and their execution. There is a general lack of knowledge and skills in installers and contractors. This is soluble through flexible training courses and apprenticeships. There is also need to train site management and professional skills in the domestic retrofit sector. The role of the 'Retrofit co-ordinator' should be appointed for all works involving SWI, with clearly defined responsibilities. With regards to the manufacturing sector, a significant constraint in output capacity is not likely. Given sufficient confidence in consistent demand for SWI, manufacturers are willing to invest in their output capacity.	

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 40



Publication title:	Responsible retrofit of traditional buildings
Reference / source	http://www.sdfoundation.org.uk/downloads/RESPONSIBLE-RETROFIT_FINAL_20_SEPT_2012.pdf
Author(s)	Neil May and Caroline Rye
Publication type	Report
Publisher	Sustainable Traditional Building Alliance (STBA)
Date of publication	2012
Target audience	Policy-makers, researchers

Key words: **Solid wall | moisture**

Summary: (source: LR40)

"This report looks into key aspects of the responsible retrofit of traditional buildings on behalf of the Department of Energy and Climate Change (DECC). This work was undertaken by the Sustainable Traditional Buildings Alliance (STBA) which represents most of the main historic building groups in the UK as well as mainstream construction-related organisations.
The work was carried out following concerns raised with regard to the application of certain retrofit measures, including those incorporated into the Green Deal, in respect of the UK's traditional building stock. A traditional building is defined as a property built prior to 1919 with solid walls constructed of moisture-permeable materials.2 It is estimated that traditional buildings number over 6 million, almost one quarter of the UK domestic housing stock. The concerns around retrofitting this class of buildings include possible failures of financial and energy payback, fabric and human health issues, and potential damage to heritage, as well as missed opportunities for the radical improvement of traditional building performance."

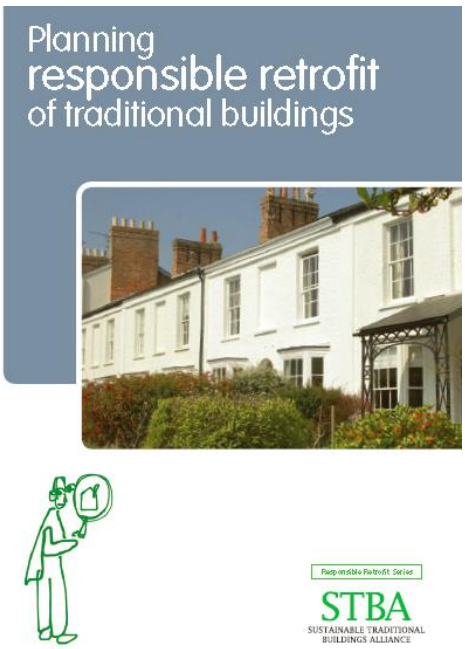
Related literature LR41

reference	action theme*	details	evidence
action 01	strategic	A different set of assessment procedures is required for traditional buildings. A national strategy should eb developed to incorporate evidence, methodologies and tools from best research into regulations standards and certification methods. Requirements for U-value improvements of solid walls should set appropriate targets for these masonry types, taking into account the limits of realistic heat loss due to thermal bridging, and the risks of condensation.	

	fabric	The convention document BR 443 Conventions for U-value Calculations is required for U-value estimates by Part L of the Approved Documents, and it also underpins SAP and RdSAP calculations. This convention and its accompanying standard BS EN ISO 6946:1997 are based upon a modern conception of wall construction where the material properties are known with high certainty. Specific conventions to assess heat loss in solid walls need to be established as soon as possible. BR 443, RdSAP and commercial U-value calculators should not be used for solid walls without an understanding of their limitation. Empirical evidence shows that traditional solid walls often have lower U-values than those estimated on basis of conventions. RdSAP default U-values can be larger by 30% or more in comparison with in situ measurements of many traditional solid walls. BS 5250:2011 is generally used as the test of moisture performance of buildings and building components, however the standard itself states (in relation to the calculation methodology of BS EN ISO 13788: 2002) that “it does not provide an accurate prediction of moisture conditions within the structure under service conditions“. BS EN 15026:2007 should be used for traditional buildings, particularly internal wall insulation, but also for other fabric-related measures. Internal Wall Insulation (IWI) presents limits in energy- and cost-effectiveness due to the thermal bridging left by partitioning walls and floors. U-values lower than 0.3 W.m2K are difficult to achieve. Empirical evidence indicates that secondary glazed historic windows and other measures such as shutters can represent a viable alternative to double-glazed new windows for reducing heat loss.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 41



Publication title:	Planning responsible retrofit of traditional buildings
Reference / source	http://www.sdfoundation.org.uk/downloads/Guide-1-Planning-Responsible-Retrofit-2015-08.pdf
Author(s)	Neil May and Nigel Griffiths
Publication type	Guidance report
Publisher	Sustainable Traditional Building Alliance (STBA)
Date of publication	2015
Target audience	Building owners, designer, project managers, contractors

Key words: **Solid wall | risk**

Summary: "There is increasing evidence that the retrofit of traditional buildings (and indeed all buildings) over the past few years has not led to the expected reductions in energy use, and has harmed the building fabric, heritage or health of building occupants. This is for three primary reasons:

- Incorrect standards and assessment of traditional buildings;
- Single or narrow focus approach to both risks and retrofit measures;
- Disjointed and poor quality building process.

This guide makes clear where existing standards and information are wrong. It shows the need to consider three broad areas of risk: Energy and Environment; Building Health (health of both fabric and people); and Heritage and Community. Sometimes compromises must be made between these values to get the best overall outcome, and this guide demonstrates a practical approach to this problem. It identifies and promotes a Whole Building Approach which integrates Fabric, Services (such as heating and ventilation) and Human Behaviour with the Context of the building. We show how this balanced approach is essential to long term performance. Finally, it demonstrates the importance of a Joined-up Process, linking up assessment, design, construction and use with proper training, quality assurance and feedback."

Related literature LR40

reference	action theme*	details	evidence
action 01	fabric	Inappropriate retrofit measures in traditional buildings can lead to unintended consequences, such as condensation and mould growth or more serious fabric decay. This happens when moisture is prevented from drying out or channelled into cold areas through poor design or execution of works. Thermal bridging can also lead to condensation. High levels of relative humidity can also lead to	

		in mould spores and dust mites. Fabric retrofit measures generally reduce the air permeability of the envelop, which may lead to poor indoor air quality if sufficient ventilation is not ensured. The UK has one of the highest rates of asthma among Western countries, which can be attributed in part to poor indoor air quality. Summertime overheating, and the associated health risks, can be the unintended consequence of fabric improvement works. Reducing thermal mass, increasing thermal insulation and reducing ventilation rates can all lead to overheating. Retrofit works on building fabric and services can affect the internal and external appearance and heritage value of a building. Although retrofit works are generally associated with improved aesthetics, a lack of attention in design and execution can damage or erase heritage features. This is particularly relevant in the case of external wall insulation and of new services requiring extensive ductwork.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 42

Publication title:	An investigation into retrofitting the pre-1919 owner-occupied UK housing stock to reduce carbon emissions
Reference / source	Kaveh, B., Mazhar, M.U., Simmonite, B., Sarshar, M. and Sertyesilisik, B. 2018. An investigation into retrofitting the pre-1919 owner-occupied UK housing stock to reduce carbon emissions. Energy and Buildings (in press)
Author(s)	Kaveh, B., Mazhar, M.U., Simmonite, B., Sarshar, M. and Sertyesilisik, B.
Publication type	Academic paper
Publisher	Elsevier
Date of publication	2018
Target audience	Researchers, policy-makers

Key words: **Retrofit | drivers | barriers | cost**

Summary: This paper presents the results of a survey conducted to explore the drivers and barriers affecting the retrofit of privately-owned pre-1919 houses in the UK. The survey consisted in a questionnaire to owners of pre-1919 houses (43 respondents) ad a series of semi-structured interviews with homeowners and retrofit experts. The results suggest that the main barriers to a wider uptake of pre-1919 retrofits are financial (lack of funding and long payback time), technical (lack of trusted sources of information) and social (limited interest in retrofit).

reference	action theme*	details	evidence
action 01	Strategic	The most important drivers for the retrofit of pre-1919 are: • improving comfort conditions; • lowering utility bills • tax reductions • added property value • aesthetic improvement of the property.	Questionnaire and interviews

*action themes: strategic / fabric / renewables / services / people

reference	challenge theme**	details:	relating to:
Challenge 01	financial	Lack of consistent government funding, and the long payback period associated with the most expensive measures (such as EWI) are the most relevant financial barriers.	
	Supply chain	The lack of skilled designers and installers of retrofit measures continues to be a significant barrier. Knowledge of airtightness measures is particularly poor.	

	people	The survey reveals that most homeowners are not driven by reducing carbon emissions from their properties. Questionnaire respondents show a fairly high awareness of retrofit measures such as: • Roof and loft insulation; • Boiler replacement; • Efficient lighting; • Draught proofing; • Cavity wall insulation; • Double and triple glazing. However, other measures were less known: • Smart meters; • Solid wall insulation; • MVHR (the measure with the lowest awareness response). Disruption of home life due to retrofit works and difficulties in finding a trustable source of technical advice were found to be significant barriers.	

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 43

Publication title:	Calor introduces BioLPG to the UK market and sets path to be fully renewable by 2040
Reference / source	https://www.calor.co.uk/news/calor-introduces-biolpg-to-the-uk-market-and-sets-path-to-be-fully-renewable-by-2040/
Author(s)	Calor
Publication type	Webpage
Publisher	Calor
Date of publication	2018
Target audience	Researchers, policy-makers

Key words: **Retrofit | drivers | barriers | cost**

Summary: BioLPG is now being imported at the moment there is no UK based production. It is a direct replacement for LPG and is being sourced from Neste Biofuels production facility in Rotterdam.

Related literature

Related case studies

reference	action theme*	details	evidence
action 01	Strategic	Modelling shows huge potential for uptake	modelled
Action 02	services	Can decarbonise existing LPG supplies	modelled

*action themes: strategic / fabric / renewables / services / people

reference	challenge theme**	details:	relating to:
Challenge 01	strategic	Lack of UK based system and doesn't deal with the amount required for mass replacements	

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 44

Publication title:	Retrofit for the Future – Analysis of cost data
Reference / source	https://retrofit.innovateuk.org/documents/1524978/1866952/Retrofit%20for%20the%20Future%20-%20analysis%20of%20cost%20data%20report%202014
Author(s)	SWEETT Group
Publication type	Report
Publisher	SWEETT Group
Date of publication	2014
Target audience	Policy-makers, retrofit programmes

Key words: **Cost | fabric | services | retrofit**

Summary: This report presents the analysis conducted by the SWEETT Group on the cost of retrofit components based on data from the Retrofit for the Future programme. The components (i.e. measures and technologies) included in the analysis are: IWI, EWI, loft insulation, floor insulation, windows, MVHR, air-source and ground-source heat pumps, biomass boilers, PV and solar thermal panels. Costs include materials and installation. The report includes recommendations on how to limit additional costs in successive retrofits.

Related literature	LR35
Related case studies	CS03, CS15-18, CS20-23, CS26, CS37

reference	action theme*	details	evidence
action 01	Fabric	IWI – The cost of IWI is strongly affected by the choice of material. The average cost for rigid foam insulation is £123/m^2, ranging from £56/ m^2 to £177/ m^2. High-tech (aerogels and vacuum panels) and natural insulation (sheep wool and wood fibre) materials are at least two times more expensive. In the majority of cases, IWI was installed while the occupants remained in situ. Temporary relocation of the occupants adds between £3,000 and £5,000. Cost variations are also determined by the quantity of wall socket, skirting and wall furniture to be removed and reinstalled. Costs can be reduced by coordinating the works with periods when the property is empty, and by having a single organisation carrying out both IWI and remedial works. EWI – The large majority of EWI measures installed rigid foam insulation, for an average cost of £161/m^2, ranging from £63/m^2 to £288/m^2. The large majority of retrofits used rigid foam insulation. Cost variations are determined by the type of finishes chosen. Costs	Cost analysis of over 100 retrofits

		can be reduced by choosing a contractor already familiar with the specified insulation and cladding. Loft insulation – Loft insulation resulted to be cheaper with soft materials (sheep wool and mineral wool, average £30/m^2) than for rigid foams (average £82/m^2). Costs are increased by the need to work around complex shapes. Floor insulation – The cost of floor insulation is affected by the material specified. Rigid foam insulation is cheaper (average £65/m^2) than natural and high-tech materials (average £94/m^2 and £130/m^2, respectively). The cost is also significantly affected by the floor structure, with suspended timber floors being cheaper (and easier) to insulate than solid concrete floors. Floor insulation works are highly disruptive, but insulating one room at a time can avoid the need to decant the occupants. Windows – Triple-glazed windows (average £567/m^2) are about two times more expensive than double-glazed ones (average £257/m^2). In both cases, higher costs are associated with imported products and non-standard dimensions of windows.	
Action 02	Services	MVHR – The average cost of MVHR unit (supply + installation) is £6,117, however, the single costs ranged from £1,326 to £11,836. High costs were associated with Passivhaus-certified units, but mostly with additional works required to fit the MVHR unit and ductworks. Lack of coordination between traders also caused additional cost due to the need for redesign/remedial works. Heat pumps – the average cost of an air-source heat pump unit was £1,310/kW. Only one ground-source heat pump unit was installed for a cost of £2,893/kW. Biomass – the two biomass boilers installed costed on average £1,742/kW.	Cost analysis of over 100 retrofits
Action 03	Renewables	PV panels costed on average £5,567/kWp, however typical costs have decreased dramatically already by 2013 (about £1,700/kWp). Solar thermal panels costed on average £1,739/m^2. For both technologies there are opportunities to limit costs by coordinating with other works (such as EWI), thus avoiding the need to erect the scaffolding a second time.	Cost analysis of over 100 retrofits

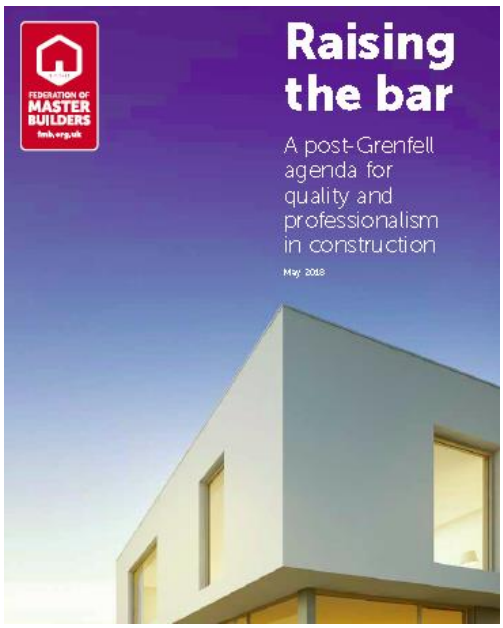
*action themes: strategic / fabric / renewables / services / people

reference	**challenge theme****	**details:**	**relating to:**

Challenge 01	Financial	Generally, higher-than-average costs are associated with: • Using non-standard products, and the need to train the workforce; • Products procured abroad; • Over-specification (choosing top-of-the-range products); • Poor design and/or execution, which creates the thee for remedial works. To ensure a cost-effective retrofit, the following points should be considered: • There must be good communication among traders and suppliers involved; • Products/systems should not be over-specified, neither should be the cheapest option; • Innovative products/systems might be difficult to procure (especially in small orders), and are likely to require additional time during installation; • End-user requirements shod not be ignored, to avoid the need for successive remedial works.	

**challenge themes: strategic / existing building / financial / supply chain / people

Literature review: LR 45



Publication title:	Raising the bar - A post-Grenfell agenda for quality and professionalism in construction
Reference / source	https://www.fmb.org.uk/media/39817/raising-the-bar.pdf?utm-campaign=raisingthebar
Author(s)	UK Federation of Master Builders (FMB)
Publication type	Manifesto
Publisher	FMB
Date of publication	2018
Target audience	Policy-makers, general builders

Key words: **Safety | construction**

Summary:

This short document outlines three steps recommended by the FMB to improve the quality of the UK construction industry.

(source: LR45)

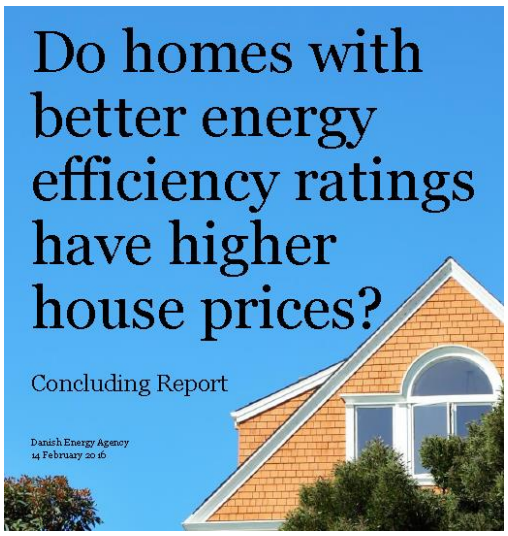
"The UK's home owners continue to fall prey to significant numbers of incompetent builders, who lack the necessary training and technical knowledge and who are a risk to themselves and their customers. Although the standard of new buildings in the UK is generally very high, concerns continue to reach the media about the quality of some new builds and inadequate routes to consumer redress. The Independent Review of Building Regulations and Fire Safety, set up in the wake of the Grenfell Tower tragedy, has raised serious questions about standards, regulation and compliance within the built environment."

reference	action theme*	details	evidence
action 01	strategic	The Government should introduce a licensing scheme for all builders and contractors in the UK, setting up a minimum level of quality standard. Currently only optional schemes exist. Introducing this scheme would: • Eliminate incompetent builders from the industry; • Provide a much higher level of consumer • protection; • drive up quality and professionalisation; • Help improve health and safety compliance among • smaller firms; • Improve the public image of the industry.	The recommendations are based upon agreement among FMB members
Action 02	strategic	The Government should introduce mandatory warranties for any work requiring Building Regulations approval. This would further reduce the	

		space for rogue and incompetent traders and introduce an additional level of consumer protection.	
Action 03	strategic	The construction industry should introduce a voluntary 'general builder' qualification, setting standards above the mandatory licensing scheme (action 01). This new 'general builder' qualification would set a benchmark for the highest levels of professionalism, and further improve the public image of the industry.	

*action themes: strategic / fabric / renewables / services / people

Literature review: LR 46



Publication title:	Do homes with better energy efficiency ratings have higher house prices?
Reference / source	https://ens.dk/sites/ens.dk/files/Energibesparelser/bilag_-_do_homes_with_better_energy_efficiency_ratings_have_higher_house_prices_oekonometrisk_tilgang.pdf
Author(s)	Sigurd Næss-Schmidt, Martin Bo Hansen, Christian Heebøll, Jossi Steen-Knudsen, Niels Christian Fredslund, Sabine Wilke
Publication type	Report
Publisher	Danish Energy Agency
Date of publication	2015
Target audience	architects, policy-makers, researchers

Key words: **Cost | energy efficiency**

Summary:

(source: LR46)

This report illustrates the results of a study by Copenhagen Economics on the relationship between house prices and improvements in energy ratings.

“In this analysis, we examine to what extent an improved energy rating will give rise to a higher house price. From the outset, neither a theoretical nor a practical perspective provides a clear answer to that complex question. We have made a variety of analyses to isolate the actual effect of energy ratings on selling prices. Compared to previous analyses of by other authors, our approach ensures that the resulting price effect comes solely from the energy rating and not from any other (correlated) characteristics such as location of the house and general condition of the house.”

reference	action theme*	details	evidence
action 01		Houses with a higher energy rating systematically have a higher selling price independently from other characteristics. The price increases by 5,400 € - 7.400 € per step up in the energy rating scale, for an average house of 100 sqm. Variations in the impact of the energy rating on sales price are affected by a number of factors. The energy label’s impact on the house price is strongly affected by energy prices at the time of the sale. The higher the price of energy, the more buyers are willing to pay for a good energy rating. Prices are also affected by the information available to prospective buyers about the energy rating and the impact that a good energy rating has on the household running costs.	Econometric analyses on 365,000 sales of single-family houses in Denmark from 2006 to 2014, with detailed information on energy rating, construction, general condition, location, sales situation and buyer/seller characteristics.

		The strongest correlation between price and improved energy rating is found in houses built in the period between 1931 and 1960. This may be because the houses built before this period have a higher potential for energy renovation. Finally, the effect of the energy rating is also affected by the buyer's income, the selling price of the house and location.	Controlled experiments on both potential buyers and real estate agents to derive the isolated effect of the energy rating on the house price.

*action themes: strategic / fabric / renewables / services / people