Homes of today for tomorrow

Decarbonising Welsh Housing between 2020 and 2050

Stage 1: Scoping Review

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Homes of today for tomorrow

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Introduction

In March 2018, Cardiff University were commissioned by Welsh Government’s Homes and Places division to conduct Stage 1 of their Housing Decarbonisation programme, through the production of a scoping review. This piece of work was to identify ‘what works’ through a review of case studies (completed projects, mostly domestic retrofit but also new-build) and published literature (including industry publications, academic papers, advice for policy makers and other best practice). The context is as follows:

1 National and international legislation require that greenhouse gas emissions, specifically CO_2, produced across Wales be reduced by at least 80% of 1990 levels, by 2050. Decarbonisation at this scale is a huge national challenge, but also provides opportunities, particularly in the context of the Wellbeing of Future Generations Act. The housing sector has a part to play in achieving decarbonisation.

2 A particular requirement of the scoping review was that all findings be supported by evidence of ‘what works’, with clear links to sources / references. A further requirement was that actions to decarbonise housing with potential to impact on fuel poverty, affordable warmth or climate resilience be identified.

3 A series of best practice case studies was collated. Literature pertaining to the case studies and to the research topic more generally was reviewed, with further sources obtained via a questionnaire survey (159 respondents). A discussion was then developed around key recurring themes, with a quick-reference system highlighting key actions and challenges along with ‘timescale’ and ‘confidence’.

4 During Stage 1, interim findings were presented to the WG Housing Decarbonisation steering group, and to their Decarbonisation Advisory Group (DAG), composed of independent professional and academic advisers. Within these meetings, it was agreed that Stage1 would include an online survey to collect perspectives and opinion from a wide range of stakeholders.

5 This report presents and discusses information collected during Stage 1, and makes recommendations for future stages. The report has been structured to make this discussion as transparent as possible. Case studies are included as appendix 01 and literature reviews as appendix 02. Survey results are embedded in the discussion. ‘Headline’ observations are described over the following four pages: *Understanding the challenge*, *strategic approaches*, *retrofit: a discussion* and *next steps*.

Understanding the challenge

The UK government has committed to reduce emissions by at least 80% of 1990 levels by 2050, and contribute to limiting global temperature rise to as little as possible above 2°C. The Welsh Government has a legal duty in Part 2 of the Environment (Wales) Act 2016 to reduce carbon emissions in Wales by 80% by 2050, and Cabinet has agreed to set interim targets as follows: 27% reduction by 2020, 45% reduction by 2030, 67% reduction by 2040 (vs 1990 baseline levels). Key aspects of the challenge ahead include:

1 Decarbonising electricity generation is a clear achievement of the last decade. However, progress in the *power* sector masks a failure to decarbonise other sectors, including *housing*. The UK is not on course to meet the legally binding fourth and fifth UK carbon budgets, and will not do so unless risks to the delivery of existing policies are reduced significantly and new policies go beyond achievements to date.

2 Housing is responsible for 29% of UK carbon emissions. In Wales the figure is 21%, reflecting the high level of emissions from industry in Wales, and increasing the challenge of meeting carbon budgets.

3 The make-up of the Welsh housing stock has been very stable for the last two decades, with a significant increase only in the private rented sector. Low rates of new and replacement housing (around 50% of the demand for new homes) mean that the existing housing stock will be in use for many years to come. More than 90% of today's stock is predicted to remain in use by 2050.

4 The Welsh housing stock is particularly old. One third of homes were built before 1919. Just 6% were built in the last 30 years (as of 2016), increasing energy demand for heating and reducing comfort. Despite energy efficiency initiatives, almost a quarter of households currently experience fuel poverty.

5 Welsh housing consists of a range of different dwelling types, ages, physical forms and construction types, many of which have been modified over time to create a diverse stock of varying quality and condition. There is no single 'solution' for a housing stock that varies so significantly. However, a taxonomy of recurring dwelling *archetypes* should reveal appropriate pathways for improvement.

6 It is technically possible to reduce emissions by 80% from baseline levels through changes to the housing stock, but this requires maximum uptake of technically viable actions, including some that presently do not have a financial return on investment over their lifetime. Cleaner energy supply is therefore part of any likely road map.

Strategic approaches

Key strategic observations arising from the case studies and literature reviewed as a whole:

1 There is a need for a **defined strategic approach** (in stakeholder survey, 50% of respondents considered *strategic changes* to be the 'most important'). To achieve best value, it is necessary to plan and implement actions holistically, with an understanding of implications in real terms.

2 Strategies should **support simple, low-cost options** to reduce emissions. (Withdrawal of incentives has reduced the installation of insulation to 5% of 2012 levels.) A focus only on short term costs is short-sighted, as the total cost of meeting future targets will be higher without these actions in place.

3 A strategic pathway must be informed by **clear priorities for the decarbonisation programme**. The UK Fuel Poverty Monitor and Scottish Decarbonisation Route Map both advocate fuel poverty as a key reason for retrofit. However, other reasons to target dwellings include the cost, effectiveness and value of retrofit actions, potential scales of implementation, and potential to impact on housing quality.

4 Strategies should **commit to effective regulation and strict enforcement.** Tougher standards can further reduce emissions while driving consumer demand, innovation, and cost reduction. Providing long line of sight to new regulations also reduces the overall economic costs of compliance.

5 Strategies should **end the chopping and changing of policy**, where policy is evidence-based. Cancellation of key programmes has led to industry uncertainty and therefore cost. Consistent policy provides clear signals to consumers & industry, and gives businesses confidence to build supply chains.

6 Stakeholders should **act now to keep long-term options open**. An 80% reduction in emissions implies new national energy infrastructure. While the systems to be implemented for 2050 have not yet been determined, Government must demonstrate commitment by supporting key emerging technologies.

7 One 80% reduction scenario* assumed that 95% of easy to treat homes and 70% of hard to treat homes are retrofitted with insulation, draught proofing and glazing by 2050. This suggests a challenging **increase in the pace of retrofit**, particularly in hard to treat homes. *Low Carbon Routemap, GCB 2013

8 The **performance gap** between predicted and delivered efficiency must be addressed, to improve cost effectiveness, reduce risk and give greater stakeholder confidence. **Occupant engagement** must also be addressed, as this can have a significant positive or negative impact on operational performance.

Retrofit: a discussion

Much is already known about the implementation of individual retrofit actions, including technologies, but there is less clarity over the most effective combinations of actions. There is also conflicting evidence around the effectiveness of actions, which appears to be heavily influenced by occupant engagement, and a lack of confidence generally in the associated costs. The observations below were informed by the case studies:

1. Some case studies reduced carbon emissions by around 80% of benchmark levels (demonstrating technical feasibility), but capital costs for most were greater than £800/m^2. High costs are attributable to one-off / bespoke approaches, complex combinations of actions, and emerging technologies.
2. A sub group of more recent case studies reduced carbon emissions by between 50% and 80% of benchmark levels (1990), with capital costs between £300/m^2 and £400/m^2 . These lower costs are a consequence of more targeted actions and better understood techniques / technologies.
3. Most case studies are one-off / bespoke. There is scope to reduce costs by understanding key actions better and benefitting from economies of scale. Importantly, wider benefits (e.g. affordable warmth, health) increase the value of decarbonisation, and potentially offset costs when considered holistically.
4. Different sectors of the housing stock require different levers to make retrofit happen. Tenure is likely to have a particularly big influence. Smaller, lower value owner-occupied dwellings are among the 'hardest to reach'. Off-grid owner occupied dwellings are currently among the 'hardest to treat'.
5. Wrap-around retrofit includes technical, legal and financial advice, and after-care for occupants, and post occupancy evaluation for further learning. The importance of this is consistently emphasised.
6. There are clear issues around supply chain (skills, resources) which require a coordinated response.
7. The housing stock is complex and varied, with no single 'solution'. Pathways that deliver on quality as well as emissions reduction are likely to address both building fabric and energy/systems.
8. Decarbonisation of energy (principally electricity) at point of supply reduces the degree to which retrofit must be used to improve *fabric* efficiency as part of a decarbonisation strategy, but misses opportunities to improve dwelling quality and could increase fuel costs / fuel poverty. Future work should target an holistic understanding of the implications of actions that focus on *fabric*, *systems* and *energy*.

Next steps

1 Welsh Government should decide on the decarbonisation programme's priorities (e.g. exclusive focus on emissions versus combined focus on affordable warmth / fuel poverty / quality of homes). Further work delivering an holistic understanding of options should inform decision-making (see Retrofit, pt. 8).

2 A clear next step should be the application of Stage 1 knowledge to the specifics of the existing Welsh housing stock, beginning with the creation of a taxonomy that represents the existing housing stock. This taxonomy should break the housing stock down into recurrent dwelling *archetypes* using a big dataset (e.g. EPC dataset 2016, which was also used for IWA Re-energising Wales study).

3 Each dwelling *archetype* within the taxonomy should be interrogated and understood in detail, using a finer grain dataset e.g. the emerging Welsh House Condition Survey (2018).

4 A road map for decarbonisation can be developed when Stage1 knowledge is applied to this taxonomy.

5 The road map is likely to incorporate:

Goals – mapped from the Wellbeing of Future Generations (Wales) Act 2016.
Levers – to initiate decarbonisation.
Pathways – strategic combinations of actions designed to decarbonise.
Actions – individual measures designed to decarbonise.
Challenges – understanding barriers + limitations that reduce effectiveness of actions.
Targets – aspirations for the level of decarbonisation to be achieved.

6 Potential pathways should be identified for each dwelling archetype, giving due consideration to house condition and wider benefits (as reflected by the WFGAct). By identifying distinct pathways for different archetypes it is possible to reduce uncertainty and increase industry's capacity for delivering change.

7 Pathways are likely to be iterative and additive, with consecutive improvements between 2020 and 2050. The levers for delivering change will vary, and are likely to be heavily influenced by tenure.

8 Cost should be reported within future work. However, cost information must be forward thinking, not retrospective. It must consider future trends, economies of scale, supply needs and wider benefits.

9 To deliver best value in terms of decarbonisation and impact on dwelling quality, it may be necessary to vary the performance targets that are prescribed, based on dwelling location, type, tenure etc.

section 2. methodology

This report and the associated appendixes form the output for the First Stage Review of *Actions to Decarbonise the Welsh Housing Stock by 2050*, commissioned by Welsh Government's Homes and Places division in March 2018.

The key objective of the First Stage Review was to begin the process of mapping out pathways towards decarbonisation of the existing Welsh housing stock, by establishing a baseline for 'what works' – for actions that have an empirical basis for understanding their effectiveness, and for raising awareness of the challenges likely to reduce or resist effective implementation.

This baseline was to be constructed by producing a scoping review; in essence, a database of case studies of appropriate projects and literature reviews of relevant publications.

The outline programme for the First Stage review was as follows:

1 Commence scoping review (12 March 2018)
2 Preliminary report to identify scope of work (28 March 2018)
3 Workshop with WG to confirm suitability of the proposed scope (05 April 2018)
4 Production of literature reviews and case studies (April to July 2018)
5 Online questionnaire, sent to a wide range of stakeholders (June to July 2018)
6 Draft final report (August 2018)
7 Consultation / workshop with WG steering and advisory groups w.c. 30 July 2018
8 Delivery of final report including executive summary August 2018

At key milestones, work was presented back to key personnel in Welsh Government's Homes and Places division, and to the Advisory Group for the Decarbonisation of Homes in Wales, which was established by Ministers and is made up of external stakeholders. Both groups are focussed on decarbonisation of the existing housing stock, and these meetings provided a forum for testing the approach, emerging findings and format of the Scoping Review, through a series of presentations, updates and reviews.

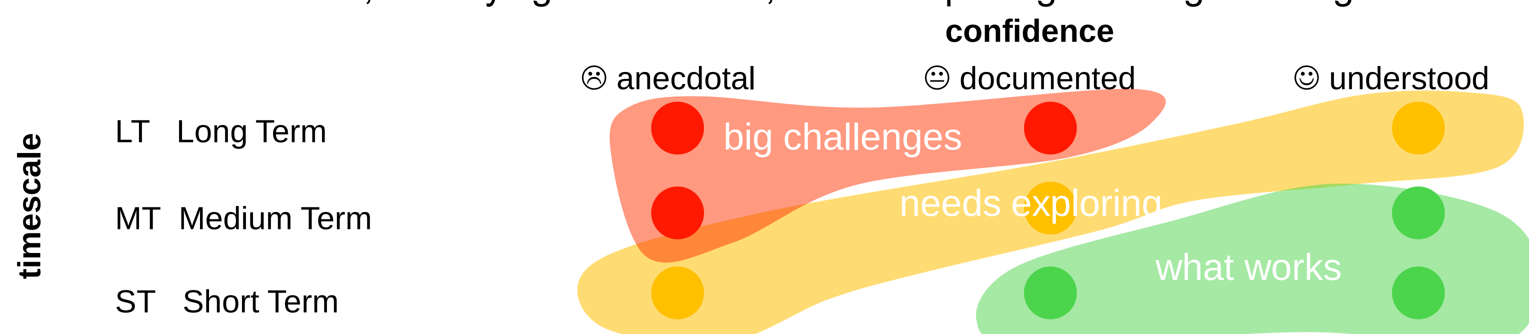
Key terminology for the First Stage scoping review was established as follows:

Goals review of WFGA identified short, medium and long term goals related to decarbonisation.
Levers to initiate decarbonisation.
Pathways strategic combinations of actions designed to decarbonise.
Actions a review of the case studies identified discrete actions under five recurring themes.
Challenges barriers + limitations that must be understood to be effective.
Targets aspirations for the level of decarbonisation to be achieved.

The review focussed on ‘what works’. Key steps included:

- Review of Welsh policy and key statistics to develop understanding of context.
- Creation of a series of best practice case studies.
- Review of literature pertaining to the case studies and to the research topic generally, incorporating European literature obtained through existing networks and further sources via questionnaire survey.
- The assembled literature was scrutinised to ensure relevance (to Wales) and replicability.
- Additional focussed searches were carried out when a gap was found in the literature.
- A discussion developed around key recurring themes within the literature. A quick reference system was incorporated, with flags for ‘timescale’ (short, medium, long term) and ‘confidence’ (anecdotal, documented and understood). See diagram below.

These flags were combined within a simple matrix summarising the key recurring themes drawn from case studies and literature reviewed, identifying ‘what works’, ‘needs exploring’ and ‘big challenges’:



Actions and challenges were mapped in detail, under five sub headings for each domain. Where possible sub headings were kept consistent across the two domains:

	actions		**challenges**
A1	strategic	C1	strategic
A2	fabric	C2	existing building
A3	renewables	C3	financial
A4	services	C4	supply chain
A5	people	C5	people

40 case studies were selected based on their relevance to the decarbonisation programme. The intention was to find at least one case study to represent each specific action and challenge identified. The focus of the project team was on finding case studies that provide empirical evidence of 'what works' wherever possible. Many of the case studies are located in Wales because this increases their relevance to the programme. Other case studies are located in the UK, while a small number are located overseas. A number of the case studies also capture the work of pre-existing retrofit programmes / funding streams, notably the Retrofit for the Future and WEFO funding programmes.

In order to develop appropriate strategies for decarbonisation over the next thirty years, pathways will need to be a combination of tried and tested actions ('what works') along with actions that are not currently fully understood. Literature was therefore reviewed from a wider range of sources, with the intention of capturing more speculative 'blue sky' thinking. **46 published pieces of literature were reviewed**, including academic papers, industry standards and best practice advice, stakeholder reports and guidance for policy-makers.

While the review cannot be considered comprehensive, it does capture the breadth of relevant ongoing work and exploration in the professional and academic domains. For this resource to be as useful as possible in the future, it should be updated with current and emerging best practice on a regular basis.

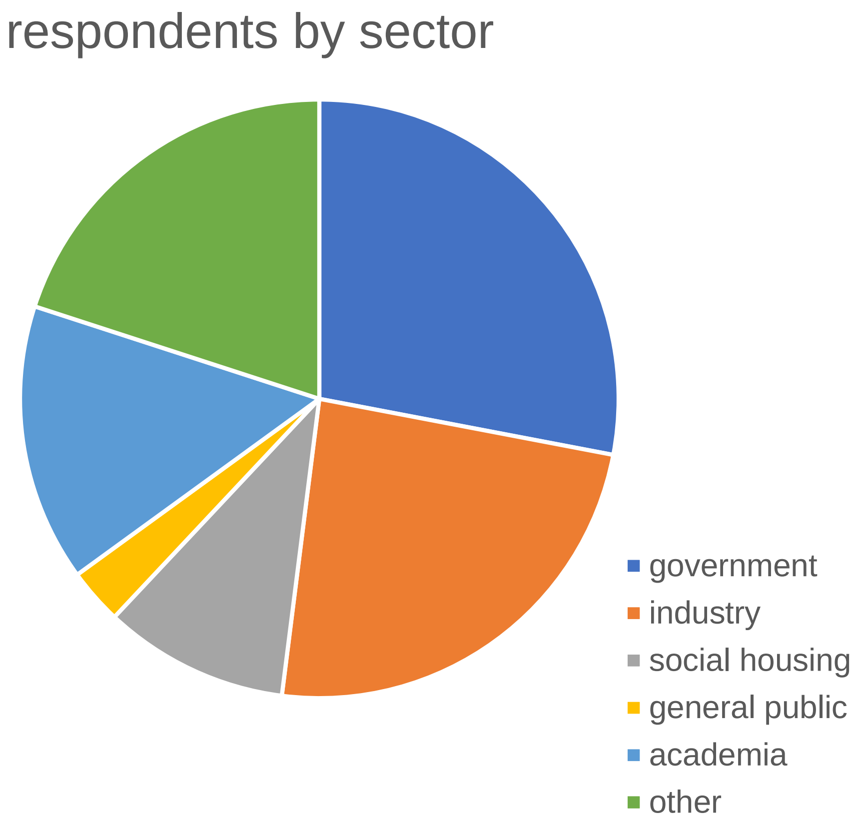
A questionnaire was also conducted as part of the scoping review, to test the breadth of the review (in terms of the case studies and literature reviewed), and canvas opinion.

A Survey Monkey tool was used to distribute the online questionnaire, between 11 June and 24 July, 2018. It was distributed via Cardiff University and Welsh Government contact lists to a broad range of stakeholders in the housing sector. This included property owners, developers, supply chain members, and individuals with relevant expertise in academia, industry and local and national government. Recipients were located in Wales, the UK and internationally.

In total, 159 responses were received (157 in English, 2 in Welsh language). There was a good representation from across different sectors (see chart adjacent).

The questions included in the questionnaire are listed overleaf.

Where pertinent, observations drawn from the questionnaire have been included in the discussion.



Q1 Please rank key ACTIONS in the order that you believe will help achieve a low carbon housing stock in Wales:
- strategic changes
- changes to fabric of building
- installation of renewables
- changes to services
- people

Q2 Rank key CHALLENGES that you believe may prevent large scale implementation of low carbon housing stock:
- strategic changes
- limitations of existing buildings
- financial
- supply chain
- people

Q3 Please provide any example/s of challenges that you have experienced in practice associated with reducing carbon emissions in housing. (Include examples where a project has not take place due to a barrier not being overcome)

Q4 Please provide information on any good practice case studies of retrofit or new build low carbon housing that you feel could help steer Wales to have a low carbon housing stock.

Q5 Please provide information on literature regarding retrofit or new build low carbon housing that you feel could steer Wales to have a low carbon housing stock.

Q6 What ONE change would you make to take low carbon housing forward, particularly thinking about retrofitting the existing Welsh stock?

Q7 Please rank how important you feel the following features are of a low carbon home?
- comfortable indoor environment
- low cost energy bills
- low maintenance of home
- low environmental impact
- cutting edge technologies installed

Q8 Please enter the type of organisation you work for

Q9 Please enter your role in your organisation (if appropriate)

Q10 What experience do you have with working with low carbon homes?

actions + challenges in more detail

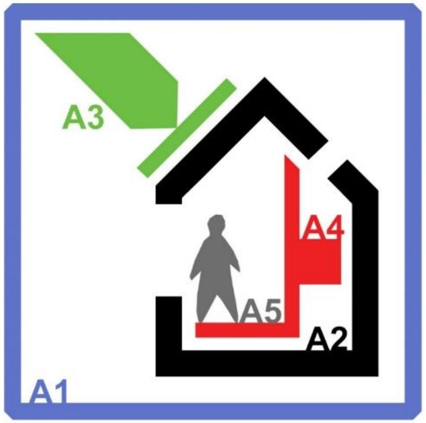
The focus of the Scoping Review was on the collection of data drawn from case studies and a review of key literature. As this work was undertaken, recurring themes emerged that enabled a more critical discussion of the changes available to decarbonise the housing stock, and the challenges that are presented. These themes were then used as the basis for evaluating both case studies and key literature.

It was agreed that changes to decarbonise would be described as a combination of actions and pathways:

Actions - individual measures to decarbonise.
Pathways - strategic combinations of actions to decarbonise.

The five key themes identified for *actions* were:

A1. **STRATEGIC**
A2. **FABRIC**
A3. **RENEWABLES**
A4. **SERVICES**
A5. **PEOPLE**

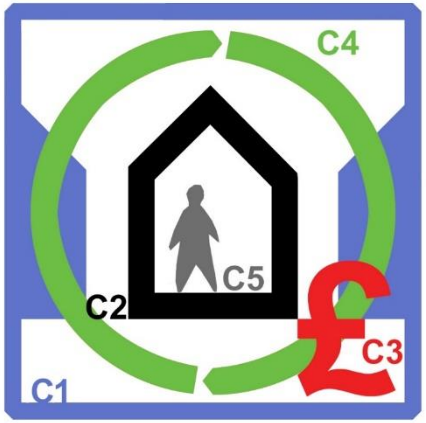


It was further agreed that challenges for decarbonisation include both barriers and limitations:

Barriers - preventing the uptake or effective implementation of actions.
Limitations - reducing the effectiveness of actions and pathways.

The five key themes identified for *challenges* were:

C1. **STRATEGIC**
C2. **EXISTING BUILDING**
C3. **FINANCIAL**
C4. **SUPPLY CHAIN**
C5. **PEOPLE**



actions + challenges in more detail

The Questionnaire challenged respondents to *rank the five key ACTIONS in the order they believe they will help to achieve a low carbon housing stock in Wales. The results of the survey are expressed in the table:*

	Importance (1:most important, 5:least)				
ACTION:	1	2	3	4	5
Strategic changes	50%	21%	14%	5%	10%
Changes to **building fabric**	23%	27%	18%	19%	13%
Installation of **renewables**	11%	19%	17%	30%	23%
Changes to building **services**	5%	8%	27%	32%	28%
People	14%	23%	24%	14%	25%

KEY OBSERVATIONS:

- *Strategic changes* were considered most important by 50% of respondents (71% considered *strategic changes* to be either most or second-most important).
- *Changes to building fabric* considered to be second most important, with 50% of respondents identifying *building fabric* as either most or second-most important.
- Significant inconsistency around opinions on the importance of *people* in helping to achieve a low carbon housing stock.

actions + challenges in more detail

The Questionnaire challenged respondents to *rank the five CHALLENGES in the order they believe they will help to achieve a low carbon housing stock in Wales. The results of the survey are expressed in the table:*

	Importance (1:most important, 5:least)				
CHALLENGE:	1	2	3	4	5
Strategic implications	16%	15%	18%	26%	25%
Limitations of **building fabric**	23%	24%	20%	16%	16%
Financial challenges	39%	28%	16%	9%	8%
Supply chain	6%	20%	21%	29%	23%
People	18%	13%	25%	19%	26%

KEY OBSERVATIONS:

- *Financial challenges* are ranked most important by 39% of respondents (67% as most important or second-most important).
- *Limitations of building fabric* considered to be second most important (47% saying most or second-most important, corresponding with Q1).
- *Strategic implications, supply chain* and *people* are considered less challenging, but are also demonstrate a lack of consistency around importance / relevance).

section 3. understanding the challenge

“The UK contains more than 26 million homes...
Collectively, those homes emit more than a quarter of the UK’s emissions…
23 to 25million of the homes already standing will still be lived in half a century from now…” House of Commons report: Existing Housing and Climate Change (2008)

“Compared to the UK housing stock, Wales has higher proportions of solid-wall homes (29% as against 27% for the UK) and properties off the gas grid (21% as against 15% for the UK).” Building a low-carbon economy in Wales – Setting Welsh carbon targets (CCC, 2017)

Context 01: UK

Through the Climate Change Act, the UK government has committed to:

- reduce emissions by at least 80% of 1990 levels by 2050
- contribute to limiting global temperature rise to as little as possible above 2°C

Carbon budgets:
To meet these targets, the UK government has set five-yearly carbon budgets which currently run until 2032. They restrict the amount of greenhouse gas the UK can legally emit in a five year period. The UK is currently in the third carbon budget period:

Carbon budget:	time period:	Budget (reduction below 1990 levels)
1st carbon budget	(2008 to 2012)	25%
2nd carbon budget	(2013 to 2017)	31%
3rd carbon budget	(2018 to 2022)	37%
4th carbon budget	(2023 to 2027)	51%
5th carbon budget	(2028 to 2032)	57%

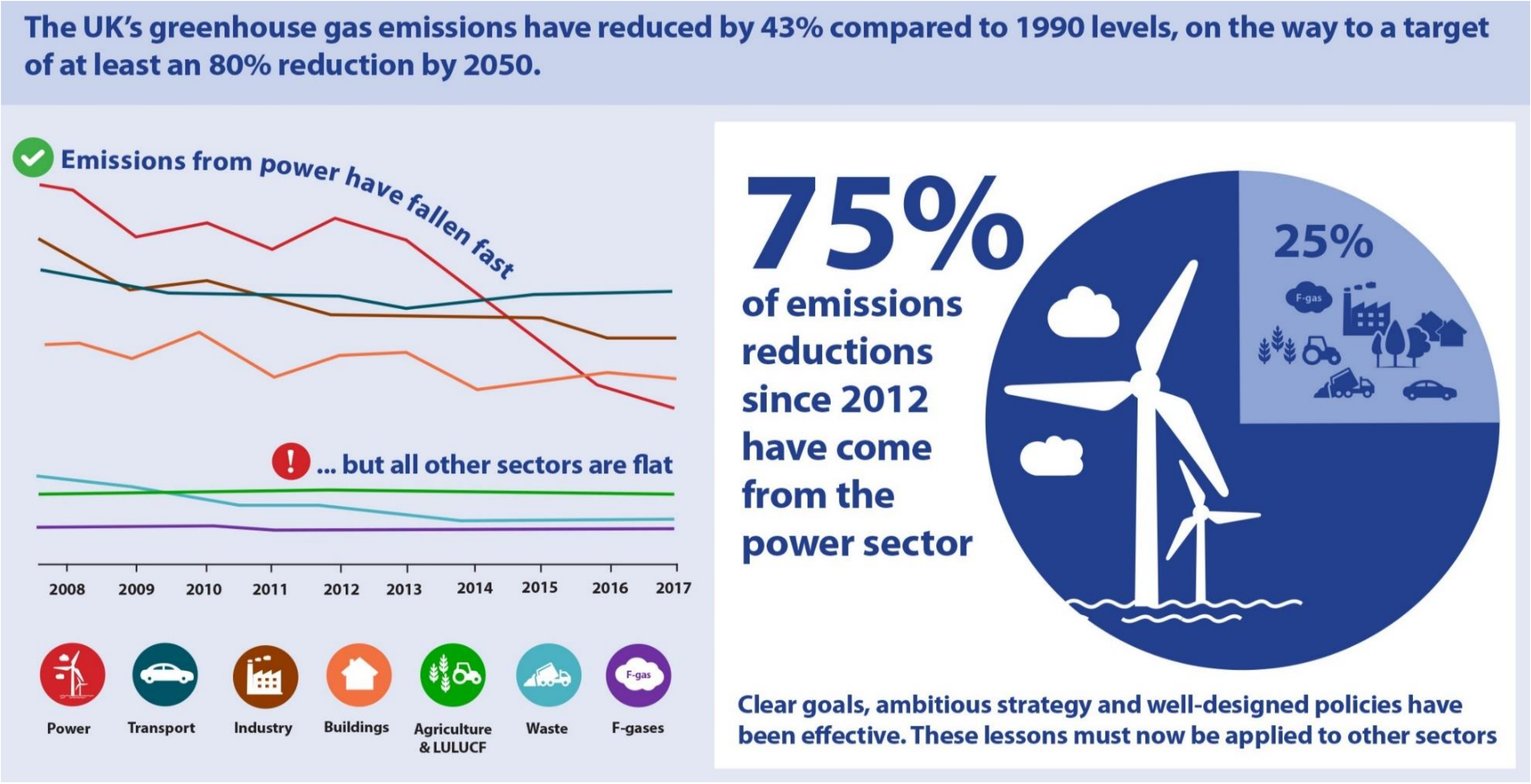
The Committee on Climate Change (CCC) report to Parliament and the Devolved Administrations annually. In 2016, UK emissions were 41% below 1990 levels. The first and second carbon budgets were met. However, the UK is not on track to meet the fourth (2023 to 2027). To meet future carbon budgets, the UK will need to apply more challenging measures, and reduce emissions by at least 3% a year from now on.

CCC: Independent advice to government on building a low-carbon economy and preparing for climate change
https://www.theccc.org.uk/tackling-climate-change/reducing-carbon-emissions/carbon-budgets-and-targets/

Context 01: UK

The Committee on Climate Change (CCC) report highlights excellent progress in reducing emissions from electricity generation, but that this success masks failure in other sectors.

Four key CCC messages for the future:
- Support the simple, low-cost options
- Commit to effective regulation + strict enforcement
- End the chopping and changing of policy
- Act now to keep long-term options open



Context 02: Wales

The Environment (Wales) Act 2016 puts in place the legislation needed to plan and manage Wales' natural resources in a more proactive, sustainable and joined-up way, and positions Wales as a low carbon, green economy, ready to adapt to the impacts of climate change.

"The [Welsh Government] Act sets our long-term ambition to reduce greenhouse gas emissions by at least 80% in 2050… Cabinet has agreed to set interim targets as follows:

- 2020: 27% reduction
- 2030: 45% reduction
- 2040: 67% reduction." (vs 1990 baseline)

Lesley Griffiths AM, Cabinet Secretary Energy, Planning and Rural Affairs (June 2018)

The Well-being of Future Generations (Wales) Act 2015 came into force in April 2016. The Act in an international first, and requires that all public bodies take a more joined up approach by thinking longer term, working better with people, communities and internally – helping to create a Wales that we all want to live in, now and in the future.

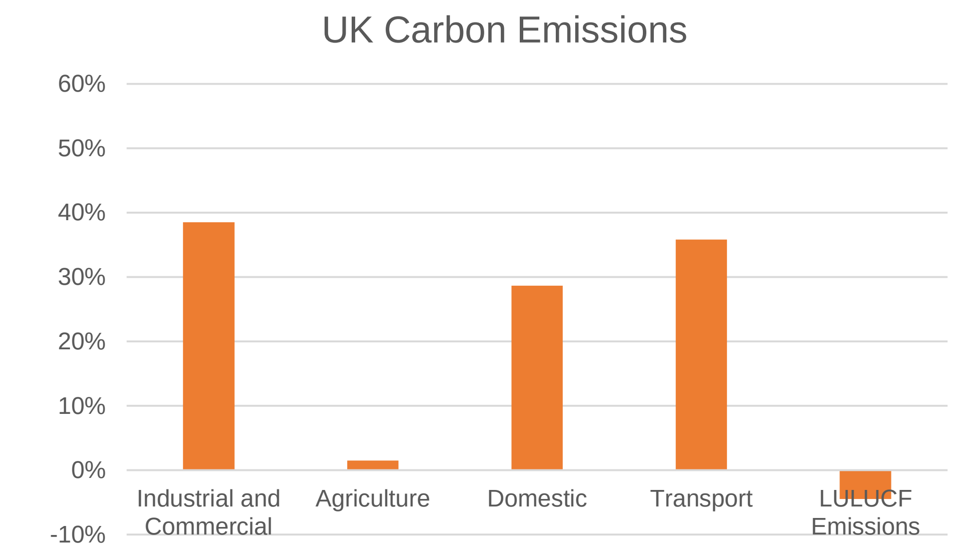
Taken together, the Well-being of Future Generations Act and the Environment Act are very ambitious. They demand a focus upon medium term gain rather than short term expedience, and create a context for Wales to lead the way with decarbonisation of the existing housing sector.

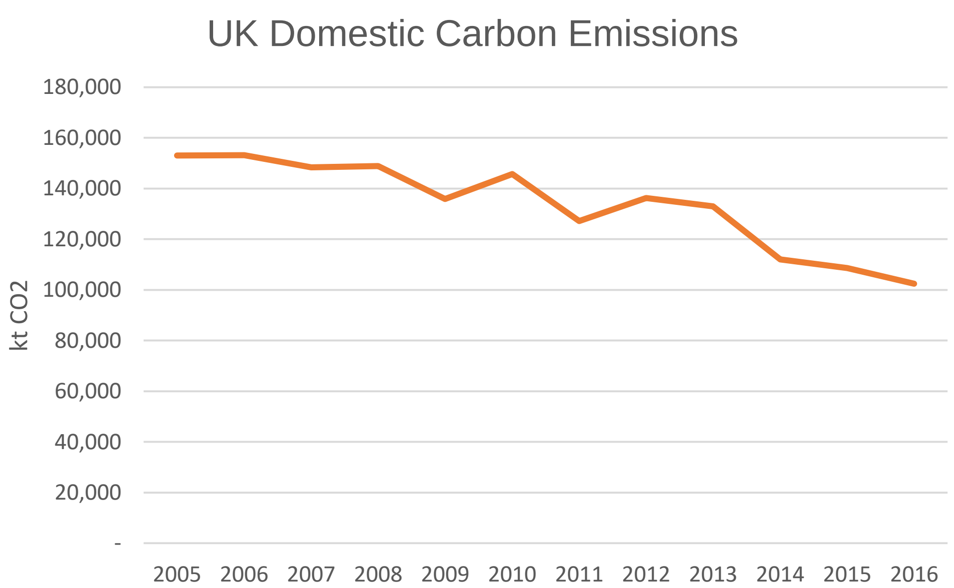
Environment (Wales) Act 2016:
https://gov.wales/topics/environmentcountryside/consmanagement/natural-resources-management/environment-act/?lang=en
Well-being of Future Generations (Wales) Act 2015:
https://gov.wales/topics/people-and-communities/people/future-generations-act/?lang=en

2.1
Housing is responsible for significant carbon emissions.

Understanding the challenge

carbon emissions: UK





The UK built environment was responsible for almost 210 MtCO2e of emissions in 1990, and just over 190 MtCO2e in 2010.

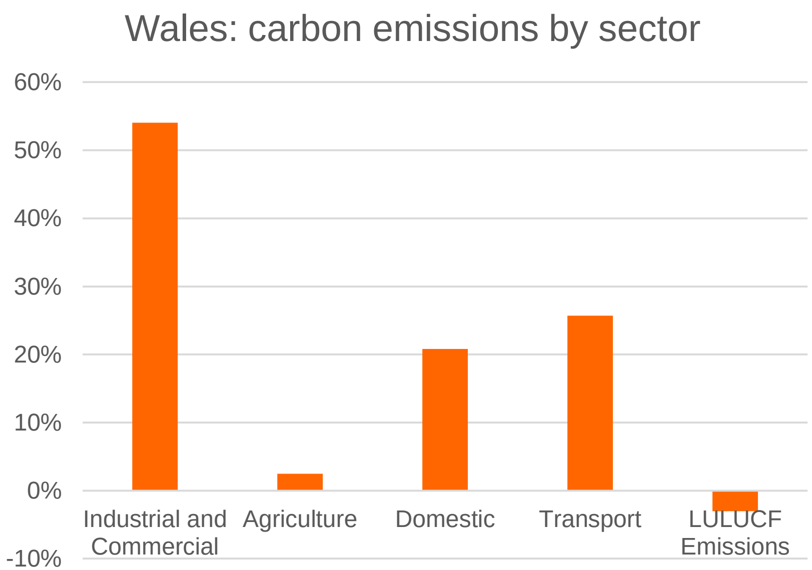
Carbon emissions from the UK domestic sector has shown a steady reduction of 33% over the last 11 years, and is now 29% of the overall emissions produced by the UK.

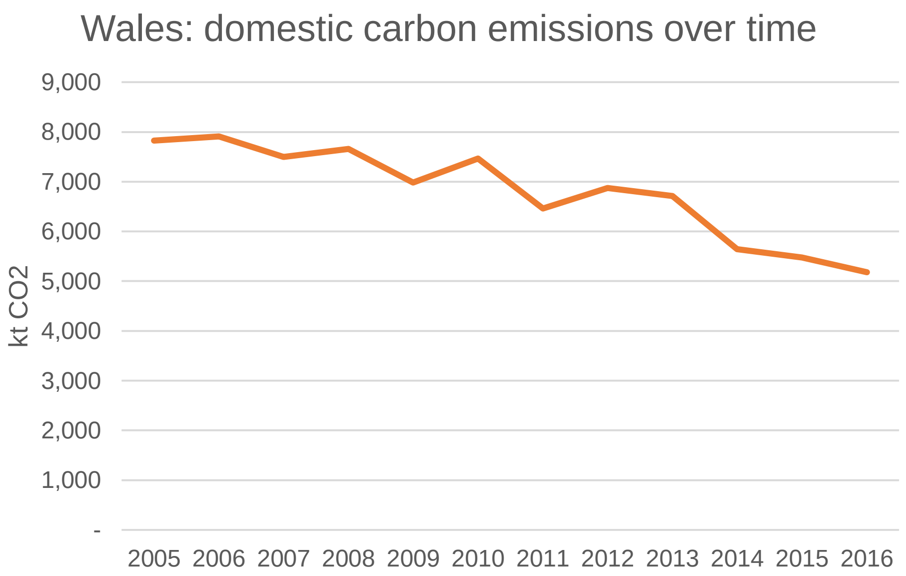
Source: UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2016

carbon emissions: Wales

In comparison, carbon emissions from the Welsh domestic sector now represents 21% of all carbon emissions. Over the past 11 years (to 2016), there has been a similar, steady reduction in carbon emissions across Wales, by 34% of 2005 levels.

This still leaves considerable room for emissions improvement within the housing sector. The scope for improvement is reflected in the average EPC for a dwelling in Wales.





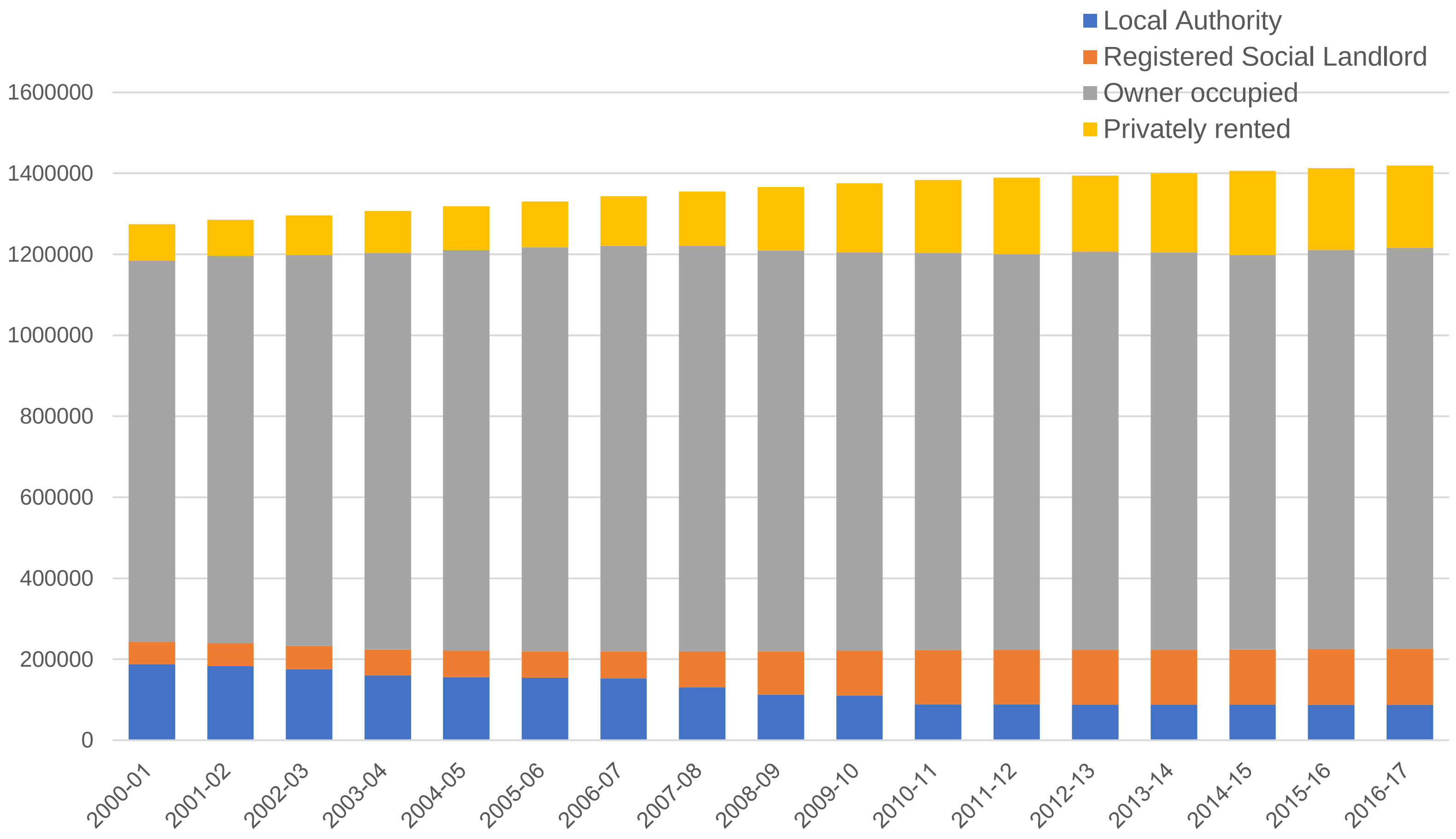
Source: BEIS UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2016

2.2
Existing Welsh houses will be with us for a long time to come.

Housing stock

The Welsh housing stock was estimated at 1.4 million dwellings at 31 March 2017…
an increase of 6% over the last 10 years.

The private sector has increased steadily (with an increase in privately rented dwellings) to 84% of stock. Owner occupied remains constant at 70%.



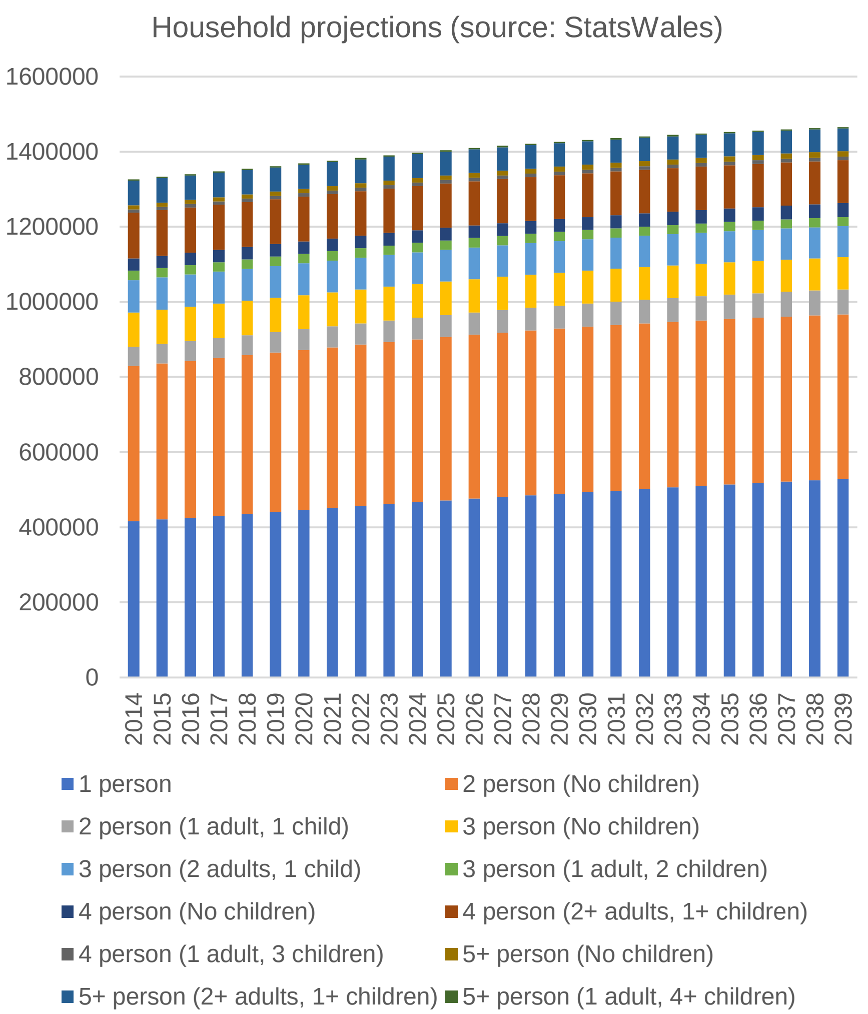
Dwelling stock by tenure (source: StatsWales)

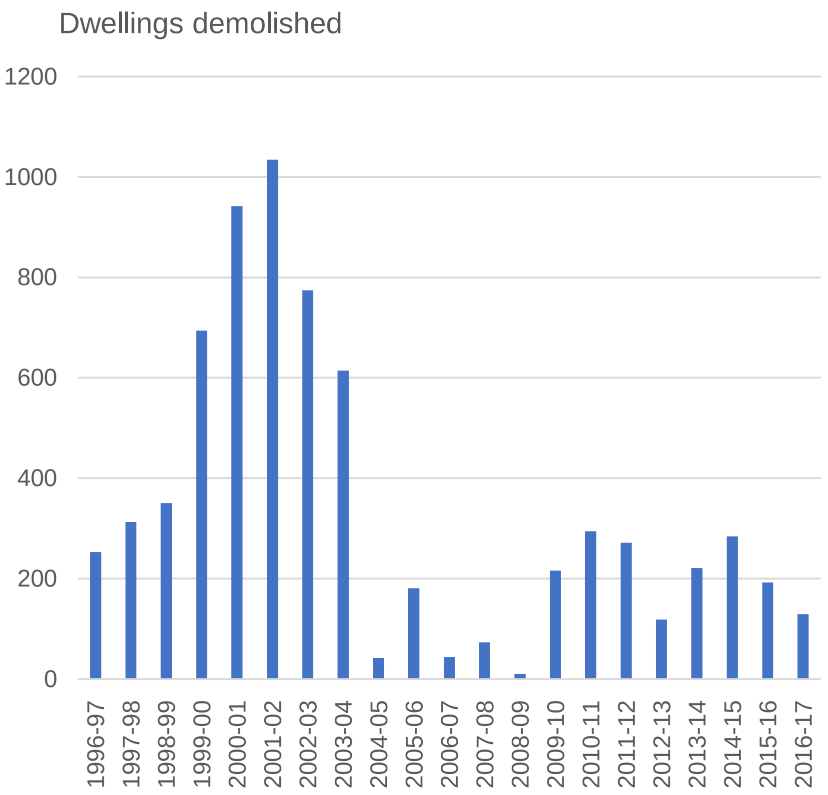
Understanding the challenge

Housing stock

Each year in Wales, less than half the new homes we need are constructed.
Very low levels of demolition keep the rate of replacement below 0.1% per year.

Future Need and Demand for Housing in Wales, PPIW (updated 2015)





Wales has one of the oldest housing stocks in Europe.

The stock is diverse, in terms of type and condition.

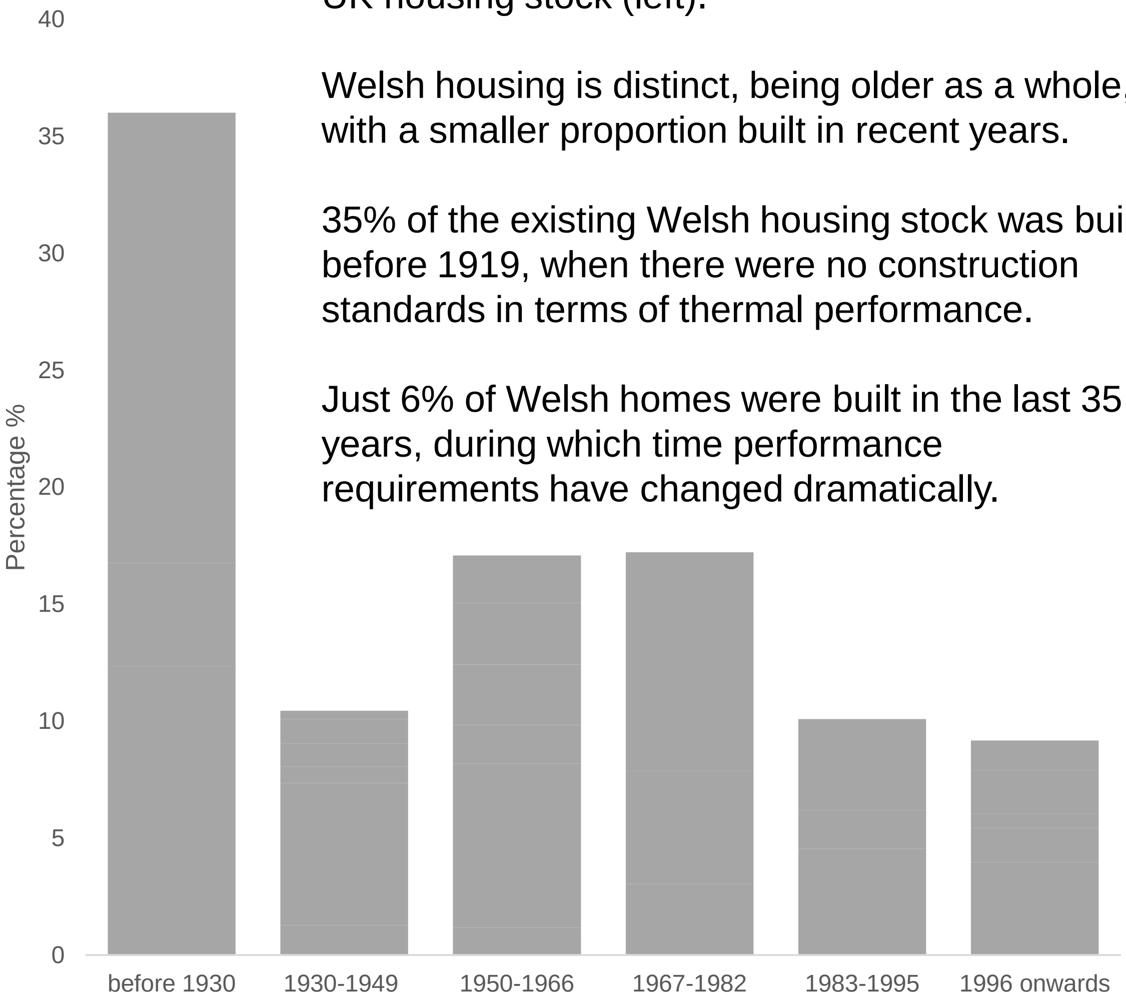
Dwelling age

The two diagrams below illustrate key differences between the Welsh housing stock (right) and the UK housing stock (left).

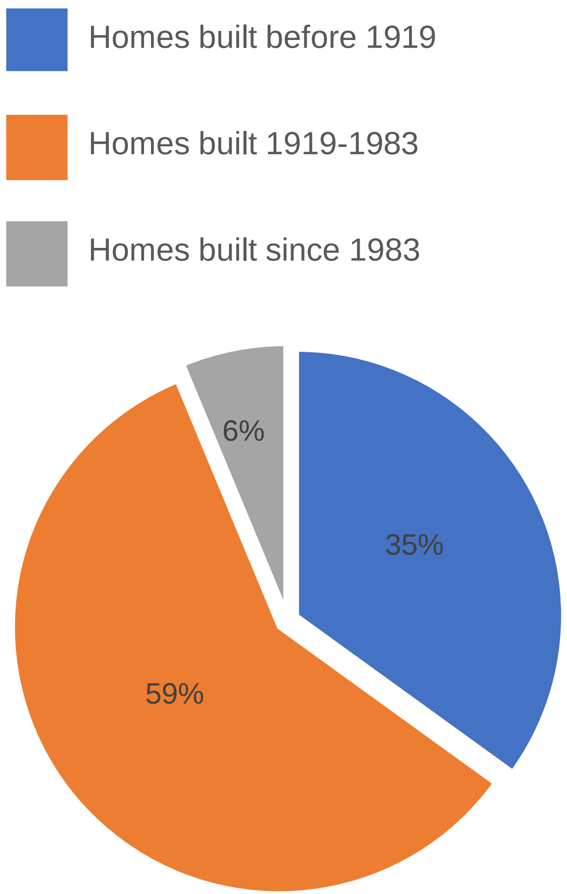
Welsh housing is distinct, being older as a whole, with a smaller proportion built in recent years.

35% of the existing Welsh housing stock was built before 1919, when there were no construction standards in terms of thermal performance.

Just 6% of Welsh homes were built in the last 35 years, during which time performance requirements have changed dramatically.



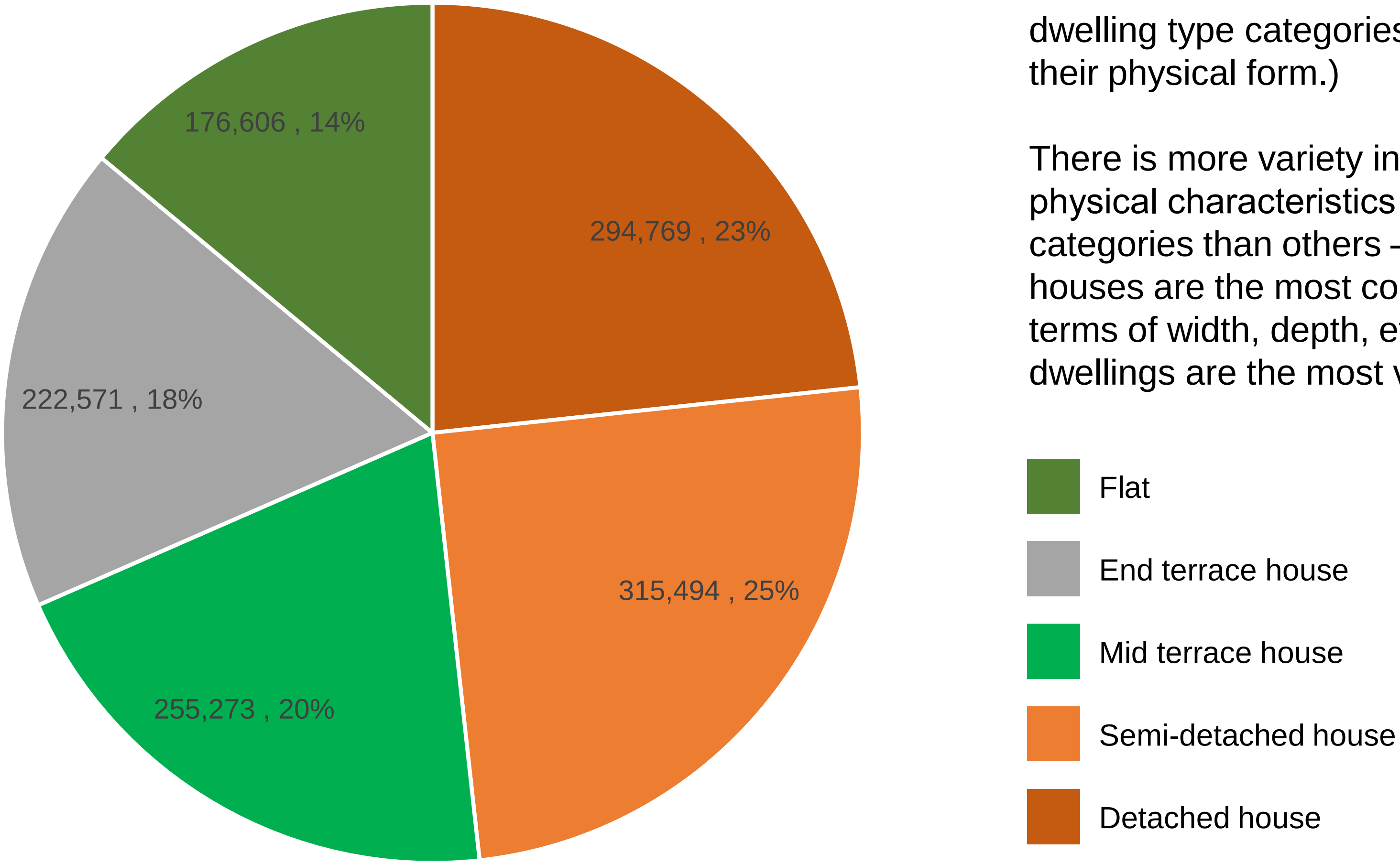
UK: dwellings by age
(source: NEED 2014)



Wales: dwellings by age
(source: Re-energising Wales)

Dwelling type

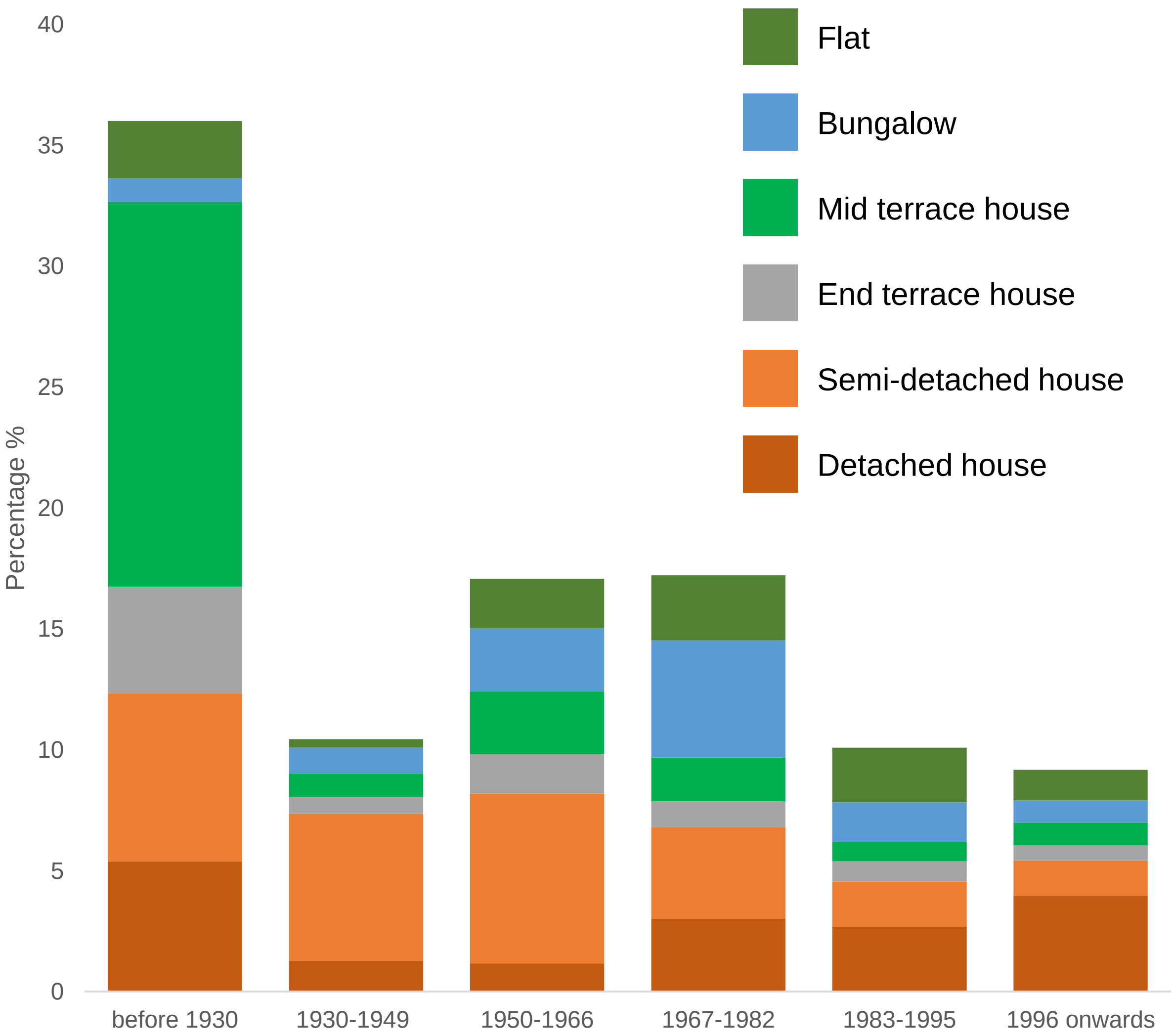
Numbers and Types of Welsh Domestic Properties (source: Re-energising Wales WP1)



There is a relatively even distribution of dwelling types across the Welsh housing stock. (Within these statistics, bungalows are included within ‘detached’ and ‘semi-detached’ dwelling type categories, depending on their physical form.)

There is more variety in terms of physical characteristics in some ‘type’ categories than others – terraced houses are the most consistent (in terms of width, depth, etc). Detached dwellings are the most varied.

Dwelling type and age



UK dwellings by age and type (source: NEED 2014)

Dwelling type varies considerably across all ages.

All dwelling types are evident in all age categories, but the proportion of each dwelling type changes with age category.

Within each time period, there were prevalent designs for ‘typical’ houses, resulting in recurrent dwelling archetypes. Some of these archetypes are relatively consistent (for example the typical Victorian terraced house) while others exhibit more variety.

Dwelling type and age

UK dwellings by age and type (source: NEED 2014)

On closer inspection, some of these recurring dwelling ‘archetypes’ capture a significant percentage of the existing housing stock.

Through **cluster analysis,** physical characteristics can be used to statistically break the housing stock down into a full taxonomy of recurrent dwelling ‘archetypes’.

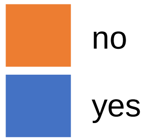
The three groups identified here correspond with three recurring dwelling ‘archetypes’ with relatively consistent physical characteristics – the pre-war (mostly Victorian) mid-terrace house, the (smaller) inter-war semi-detached house, and the (somewhat larger, more suburban) post-war semi-detached house. Together, these three archetypes may represent as much as 35% of the total housing stock, or 400,000 homes.

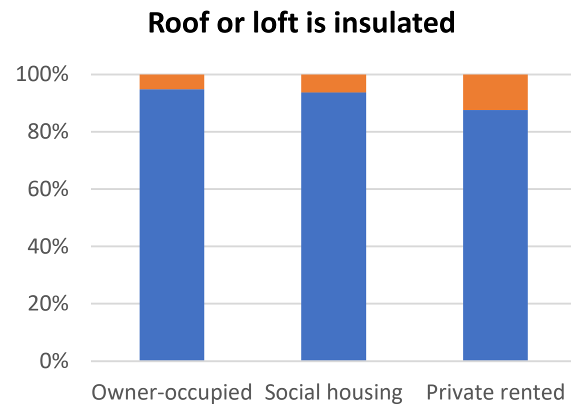
2.5
Despite energy efficiency initiatives, almost a quarter of households are in fuel poverty

UK Fuel Poverty monitor 2016 2017, NEA

Understanding the challenge

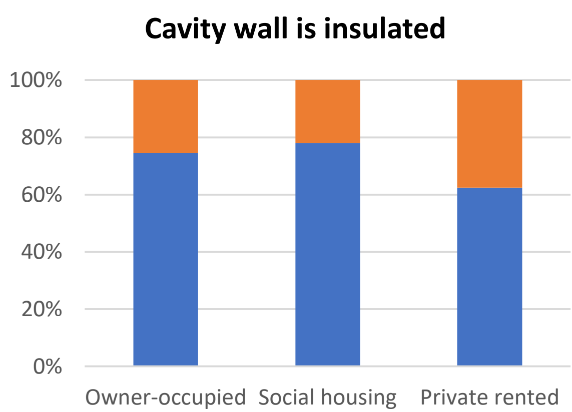
Condition

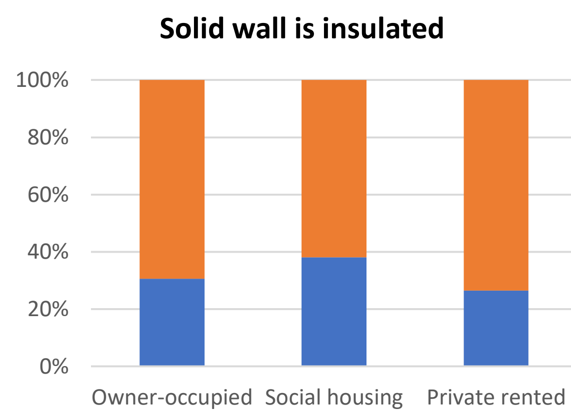




Dwelling condition can vary considerably, even among very consistent house ‘types’ on a single street or estate. As a consequence, thermal performance also varies. Any proposals that incorporate retrofit actions need to take into account this variety of condition.

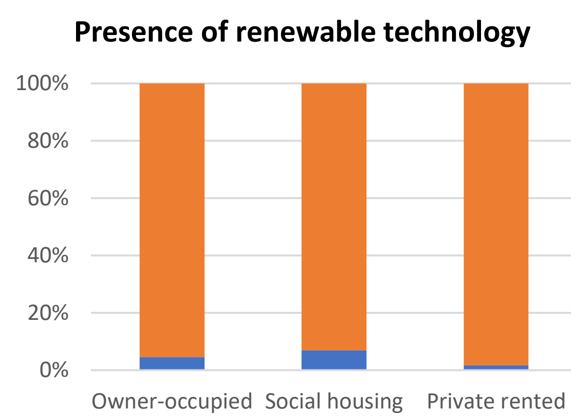
Roof insulation is present in >90% of dwellings, but to very varying degrees. There is an assumption that roof insulation has been ‘done’ but at least 15% of dwellings have less than 150mm of insulation present in the roof.





Wall insulation is present in two thirds of cavity wall construction, but many retrofits are now removing cavity fill for health and performance reasons.
Less than a third of solid-wall dwellings have wall insulation, presenting a retrofit opportunity.

While variety of condition is expected in the owner occupied sector, it is also evidenced in the social housing sector, and records do not always reflect the current ‘state’ of a property. It can affect cost-effectiveness and the impact on performance of key retrofit actions.



Renewables have been installed in only a tiny fraction of the housing stock. Social housing leads the way with renewables uptake, with the smallest presence in the private rented sector.

Source: National Survey for Wales 2015

Fuel poverty

Year	% households in fuel poverty
2012	29
2013	28
2014	30
2015	24
2016	23

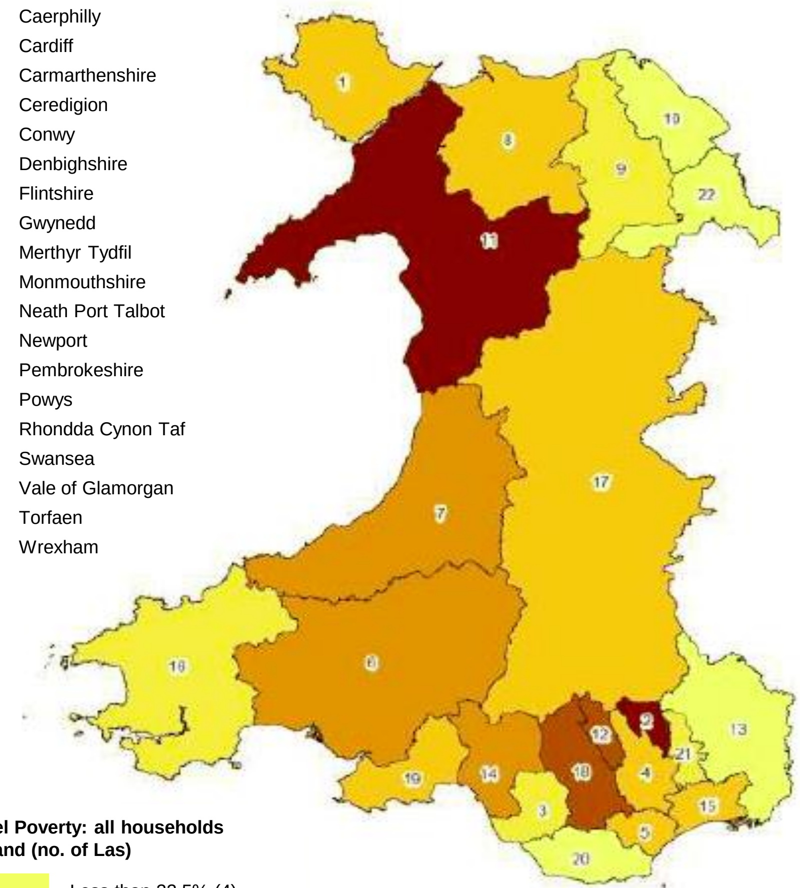
Households in fuel poverty are spread throughout Wales, although somewhat more focussed in west and north-west Wales.

Fuel poverty statistics do not capture households in un-metered off-grid or rural locations. In such locations, fuel options are typically limited, and are often increasingly expensive (and carbon intensive).

As a result, particularly in more rural areas, true fuel poverty levels may be higher than the reported statistics.

Source:
The production of estimated fuel poverty levels in Wales 2012-2016

1 Anglesey
2 Blaenau Gwent
3 Bridgend
4 Caerphilly
5 Cardiff
6 Carmarthenshire
7 Ceredigion
8 Conwy
9 Denbighshire
10 Flintshire
11 Gwynedd
12 Merthyr Tydfil
13 Monmouthshire
14 Neath Port Talbot
15 Newport
16 Pembrokeshire
17 Powys
18 Rhondda Cynon Taf
19 Swansea
20 Vale of Glamorgan
21 Torfaen
22 Wrexham



Fuel Poverty: all households % and (no. of Las)

- Less than 22.5% (4)
- 22.5%-23.5% (4)
- 23.5%-24.5% (7)
- 24.5%-25.5% (3)
- 25.5%-26.5% (2)
- More than 26.5% (2)

Proportion of households in fuel poverty (10% definition) by Local Authority

section 4. strategic approaches

DRAWING STRATEGIC APPROACHES FROM CASE STUDIES AND LITERATURE

Consideration of the 40 case studies and 46 pieces of literature reviewed resulted in guidance that should inform the development of **strategic approaches**. This guidance is summarised over the next twelve pages:

THE CASE STUDIES

Overleaf, the forty case studies are listed by name, along with their location.

The table on the subsequent page summarises all forty case studies, in terms of the actions that were undertaken for each project. Each key theme (STRATEGIC, FABRIC, RENEWABLES, SERVICES, PEOPLE) is subdivided into the specific (often recurring) actions that were identified by the study. Where possible, these specific actions are grouped into a relevant sub-theme (eg ‘ventilation’, ‘heating’ or ‘boilers’ for SERVICES).

This breakdown means that the table identifies actions that are commonplace, for example re-provision of roof insulation or installation of MVHR (mechanical ventilation and heat recovery). It also identifies actions that are infrequently used, for example oil as a fuel source or underfloor heating (no relevant case studies for either action).

The table also provides headline data for each case study (at the top of the table) on carbon savings, energy savings and cost, where data were available.

The table should be used as an index to identify appropriate case studies for further research, where a particular action or combination of actions is being considered.

Strategic approaches

case studies 1 of 4

The scoping review collated information describing the following case studies:

01	Zero Carbon House	Birmingham
02	Maes yr Onn Farmhouse	Caerphilly
03	TSB Shorhouse	Newport
04	SOLCER - Galltcwm Terr	Port Talbot
05	SOLCER - Cricklewood	Bridgend
06	SOLCER - Tyn y Waun	Bettws
07	SOLCER - King Street	Gelli
08	SOLCER - Poppy Close	Sandfields
09	SOLCER house	Pyle
10	Pentre Solar	Pembrokeshire
11	Milford Way Passivhaus	Swansea
12	LCBE retrofit - Taff Street	Gelli
13	Energy Efficient Scotland	Stirling, various
14	BRE park victorian terr.	Watford
15	Retrofit for the Future #1	North Belfast
16	Retrofit for the Future #8	London
17	Retrofit for the Future#35	Norfolk
18	Retrofit for the Future#109	West London
19	Grove Cottage	Hereford
20	TSB#57 Highfields	Leicester
21	TSB#57 Hawthorn Rd	North London
22	TSB#51 Shaftesbury pk	Wandsworth
23	TSB#98 Easton Road	Bristol
24	CarbonLight Homes	Northampton
25	Reno2020 - Rue Molinay	Liege
26	Retrofit for the Future hse	Cambridge
27	Retrofit and Replicate	South London
28	Low Carbon Adapt. Home	Dublin
29	Salford Energy House	Salford
30	BEAMA Heating Controls	Salford
31	Heathcott Road, Leicester	Leicester
32	Greyligwell district heating	Chichester
33	West Bridge Mill CHP	Kirkcaldy
34	Edinburgh social housing	Edinburgh
35	Flat retrofit in Serbia	Belgrade
36	CTE ARBED 1 scheme	North Wales
37	Retrofit for the Future hse	Oxford
38	CTE 'hard to heat' homes	South Gwynedd
39	Trem y Môr Terrace	Treforest

A number of other projects were considered for the Scoping Review, but were found to have limited relevance, or insufficient data to warrant their inclusion.

case studies 2 of 4

		Case study:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Summary	key metrics	Newbuild or retrofit (N/R)	N+R	N	R	R	R	R	R	R	N	N	N	R *4		R	R	R	R	R	R	R	R	R	R	N	R	R	R	N	R	R	N	N+R	R	N	R	R	R	R	R	R
		% Primary energy reduced	100		80						100	100					85	?	93P		58	76	70	76	56	0	62	?	84	?	n/a	n/a					28					
		% CO_2 emissions reduced	100		75	64	49	54	74	61	100	100				80	83	?	93P		82	80	72	70	61	100	?	?	83	?	n/a	n/a							85	51	56	
		Cost *1 (£/sqm)	1700		923	454	391	352	322	381	1200	1200		380 *2			?	?			500 *2	800	825	1295	641	?	890	?	?	?	n/a	n/a					22					
		ACTIONS																																								
A1 strategic		Part of a funded programme			●	●	●	●	●	●	●	●		●				●	●	●	●	●	●	●	●		●	●		●								●	●	●		●
		Solution restricted by funder																								●	●		●		●	●										
		change in primary energy supply	●	●		●	●	●	●	●	●	●	●	●		●			●					●						●										●	●	●
		Fabric first approach	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●		●		●		●				●		●		●	
		Explicitly address overheating	●																											●												
		Higher standard than B.regs	●										●			●					●					●		●	●	●			●	●								
		Upskilling supply chain			●																																					
		Void reduction				●																																				
A2 fabric	insulation	Roof	●		●	●	●	●	●	●	●	●		●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●								●		●	
		Wall internal	●		●				●		●	●		●		●	●	●	●			●	●	●	●				●										●		●	
		Wall cavity					●																						●													
		Wall external	●			●	●		●	●	●			●		●				●	●		●	●	●	●	●	●		●	●						●		●	●	●	●
		floor	●		●				●		●	●				●	●	●	●	●	●			●		●	●	●	●	●	●								●			
	windows	new	●	●	●	●					●	●	●			●	●	●		●	●	●	●	●	●		●	●	●	●							●		●		●	
		Secondary																	●						●																	
		shading	●																							●																
		Airtightness	●			●					●	●				●	●	●	●	●	●		●	●	●	●		●	●	●	●											
A3 renewables	lower carbon sources	Heat recovery	●		●	●	●							●			●	●	●	●	●	●	●		●	●		●	●	●												
		CHP																																●	●	●						
		PV	●	●	●	●		●	●	●	●	●		●		●	●	●	●									●	●					●					●			●
		Electric battery		●																																						
		Wind																																●								
		Solar thermal			●											●		●	●	●		●	●	●	●	●		●	●	●									●		●	●
		Transpired solar C.									●			●																												
A4 services	boilers	Gas		●	●	●	●	●								●	●	●		●	●	●	●		●		●	●	●		●	●										
		Oil																																								
		biomass	●	●																																						
		heat pumps			●						●					●			●					●		●				●										●	●	●
	heating	Radiant	●	●	●						●					●	●	●	●	●	●	●	●	●	●	●		●	●		●	●								●	●	●
		Underfloor																																								
		Storage									●	●														●																
		Warm air									●																			●												
		Hot water		●	●													●	●	●	●	●	●	●	●	●			●	●												
	vent.	Natural	●	●							●	●												●		●				●										●	●	●
		MVHR	●		●	●	●				●		●	●		●	●	●	●	●	●	●	●		●	●			●	●			●						●			
A5 People		Occupant participation	●	●	●							●					●	●		●		●	●	●	●												●					
		Remain in situ			●													●		●				●				●				●								●		
		Simple controls	●														●	●				●	●		●							●										
		Smart meters and homes		●																								●														
		Influencing lifestyle change	●	●								●													●			●														
		Intention to improve occ. health																																								

*notes:

P Indicates predicted not measured data

*1 Cost data for new-build is total build cost. Cost data for retrofit includes energy efficiency measures only.

*2 Cost per square metre is approximated from other data.

*3 Project not yet complete.

case studies 3 of 4

Key strategic observations arising from the case studies as a whole:

1 Much is already known about individual retrofit actions, including technologies. There is less clarity over the most effective pathways (combinations of actions). There is also conflicting evidence around the effectiveness of retrofit, which appears to be particularly influenced by the level of occupant engagement. Where occupants are kept outside the retrofit process there appears to be a significant performance gap (with limits to effectiveness and potential for abortive work), compared with retrofit where occupants are active participants.

2 Some case studies (notably associated with the Retrofit for the Future programme) reduced carbon emissions by 80% or more of benchmark levels (demonstrating technical feasibility of achieving this level of impact), but capital costs were generally >£800/m^2. High capital costs can be attributed to one-off / bespoke approaches that focus on the greatest possible impact on emissions, using complex combinations of actions, emerging techniques and technologies.

3 A sub group of more recent case studies (predominantly in-Wales, WEFO funded projects) targeted similar impact, but at lower cost. They typically reduced carbon emissions by between 50% and 80% of benchmark levels, with capital costs between £300/m^2 and £400/m^2 . Lesser costs are a consequence of more targeted actions and better understood techniques / technologies (these projects tend also to be more recently completed).

4 Most of the case studies evaluated are one-off / bespoke. There is scope to further reduce costs in the future, through greater understanding of key actions and economies of scale. Importantly, wider benefits (eg affordable warmth, health) increase the value of decarbonisation, and potentially offset costs when considered holistically.

5 The housing stock is complex and varied, with no single ‘solution’. Pathways that deliver improvements in housing quality as well as emissions reduction are likely to address both building fabric and energy/systems.

case studies 4 of 4

Key strategic observations arising from the case studies as a whole (continued from previous page):

6 Decarbonisation of energy (principally electricity) at point of supply reduces the degree to which retrofit must be used to improve *fabric* efficiency as part of a decarbonisation strategy, but misses opportunities to improve dwelling quality and could increase fuel costs / fuel poverty. Future work should target an holistic understanding of the implications of actions that focus on *fabric*, *systems* and *energy*.

7 Different sectors of the housing stock require different levers to make retrofit happen. Tenure is likely to have a particularly big influence on the most appropriate choice of lever. Smaller, lower value owner-occupied dwellings are among the ‘hardest to reach’. Smaller Off-grid owner occupied dwellings are currently among the ‘hardest to treat’, while dwellings located in conservation areas also present specific challenges. However, these considerations may change in the future with changes in retrofit techniques and technologies.

8 The importance of wrap-around retrofit is consistently emphasised. This includes technical, legal and financial advice, and after-care for occupants, and post occupancy evaluation for further learning. The importance of a holistic service is exemplified by the performance gap between occupant as participant and occupant as bystander (see previous page).

9 Case studies were not particularly forthcoming with findings relating to ‘supply chain’ or ‘people’ – the questionnaire was more helpful in discussing these themes. However, there are clear ongoing issues around supply chain (shortage of appropriate, up-to-date, affordable, locally available skills and resources) which require a coordinated response form the industry and governance as a whole, if the challenge of decarbonisation is to be properly addressed. There are also significant opportunities for economic benefit, if supply chain is addressed in a forward-thinking way, in line with the Wellbeing of Future Generations (Wales) Act 2015.

literature

The scoping review also collated information describing the following key pieces of literature:

01	Retrofit for the Future: a guide to making retrofit work	2014
1A	Retrofit for the Future: carbon emissions infographic	2014
02	Residential Retrofit: 20 Case Studies	2013
03	Energy Efficiency in Wales: A strategy for the next 10 years	2016
04	NEED: Summary of analysis using the NEED framework	2017
05	The Future of Gas: How gas can support a low carbon…	2018
06	Sustainable technologies: The experience of housing assoc	2015
07	NEED framework: Summary of Building Regulations	2017
08	UK Fuel Poverty Monitor 2016 – 2017	2017
09	Technical options and strategies for Decarbonizing UK…	2007
10	Bryson Energy Retrofit Scheme – Whole House Solutions	2014
11	Whole house solutions: transforming NI's domestic energy..	2014
12	Welsh Government Warm Homes Arbed EU, Final Report	2017
13	Designing an 'optimal' domestic retrofit programme.	2017
14	Exploring the complexities of energy retrofit in mixed tenure	2018
15	Warmer and greener: a guide to the future of domestic…	2016
16	Design for future climate - Opportunities for adaptation in…	2010
17	Countdown to Low Carbon Homes	2014
18	Building the Future: sector review of qualifications and…	2018
19	Lenders project	2017
20	Zero Carbon Compendium	2011
21	UK field trial of building mounted… micro-wind turbines	2010
22	Energy Efficient Scotland	2018

23	Evaluation of a regional retrofit programme to…	2016
24	Energy advice and promotion supports to community..	2016
25	Freedom project	2018
26	Energy Efficient Mortgages Pilot Scheme	2018
27	Measuring and mitigating overheating risk in solid wall	2018
28	Social and health outcomes… national housing std:	2017
29	Emergency hospital admissions associated with a..	2017
30	Examining domestic retrofit systems and governance	2016
31	Self-build communities: the rationale and experiences	2016
32	Thermal performance of traditional brick walls.	2013
33	Minewater heating in Caerau	2017
34	Each Home Counts, Peter Bonfield	2018
35	Health impact, and economic value, of meeting HQS	2018
36	A review on Building Renovation Passport:	2018
37	Energy and Environmental Report: Castleland Stage2	2013
38	NEA Technical Innovation Fund	2017
39	SOLID WALL INSULATION Unlocking Demand…	2015
40	Responsible retrofit of traditional buildings	2012
41	Planning responsible retrofit of traditional buildings	2015
42	Solid-wall U-values: heat flux measurements…	2014
43	Calor introduces BioLPG to the UK market and sets path…	2018
44	Retrofit for the Future – Analysis of cost data	2014
45	Raising the bar - A post-Grenfell agenda for quality and…	2018

literature

Certain publications provide immediate strategic direction that could directly inform the strategic approach adopted for a decarbonisation programme. The publications listed below are considered key references, and are summarised over subsequent pages:

1 Committee on Climate Change report: Reducing UK emissions – 2018
A recent Progress Report to Parliament (2018) captures high level CCC guidance for policy makers, with a focus on looking forwards.

2 Low Carbon Routemap for the UK Built Environment
Produced by the Green Construction Board in 2013, this route map includes a summary of challenges and opportunities arising from an understanding of the existing housing stock (UK).

3 Energy Efficient Scotland: a route map
Released by the Scottish Government in 2018, it provides an example of a legible high level strategy designed to deliver decarbonisation of the Scottish housing stock by 2050.

4 Building Renovation Passports:
Developed in 2016, a systemic approach for the production of customised roadmaps towards deep renovation and better homes focussed on dwelling performance (EPC).

5 Each Home Counts
An independent Review (2016) of Consumer Advice, Protection, Standards and Enforcement for retrofit in the UK (domestic energy efficiency and renewable energy measures).

6 The Wellbeing of Future Generations (WALES) Act 2015
The Act, enforced in 2016, enables us to define holistic goals for decarbonisation of the existing housing stock, that are relevant in the short, medium and long term.

Committee on Climate Change report: Reducing UK emissions – 2018 Progress Report to Parliament (2018)

The recent Progress Report to Parliament (2018) from the Committee on Climate Change captures high level guidance for policy makers, with a focus on looking forwards, and includes a Wales-specific sub document. Key observations from the Committee on Climate Change report include:

Decarbonising electricity generation is a clear achievement of the last decade. However, progress in the power sector masks a **failure to decarbonise other sectors**. The UK is not on course to meet the legally binding fourth and fifth UK carbon budgets, and will not do so unless risks to existing policy delivery are reduced significantly and new policies go beyond achievements to date on electricity generation and waste.

Support the simple, low-cost options to reduce emissions that are not being supported. Withdrawal of incentives has cut home insulation installations to 5% of their 2012 level. Worries over short term costs are misleading, as the whole-economy cost of meeting the legally binding targets will be higher without cost-effective measures in place.

Commit to effective regulation and strict enforcement. Tougher long-term standards for construction can cut emissions while also driving demand, innovation, and cost reduction. Providing long lead in to new regulation also reduces the economic costs of compliance.

End the chopping and changing of policy, where policy is evidence-based. A number of important programmes have been cancelled in recent years, including Zero Carbon Homes. This has led to uncertainty, which adds cost. A consistent policy environment provides clear signals to the consumer and industry, and gives businesses the confidence to build UK-based supply chains.

Act now to keep long-term options open. An 80% reduction in emissions has always implied the need for new national infrastructure. While the systems for carbon capture or electrification of heat in 2050 have not yet been determined, the Government must demonstrate it is serious about their future use. Development of key technologies should be encouraged to reduce costs and support the growth of the low-carbon sector.

Low Carbon Routemap for the UK Built Environment
Green Construction Board, 2013

The Low Carbon Routemap for the UK Built Environment (Green Construction Board, 2013) includes a summary of challenges and opportunities arising from an understanding of the existing housing stock (UK):

It is technically possible to deliver the government's target of an 80% reduction in carbon emissions in the built environment, however, this would require maximum uptake of technically viable solutions in all sectors, including technologies that at present do not have a financial return on investment over their lifetime.

The most significant source of carbon emissions in the built environment is domestic emissions from space heating. Improvements can be made through building fabric and controls, but ultimately a change in fuel source is also required to achieve an overall 80% emissions reduction, and reduction of emissions from the buildings sector is dependent on the pace of grid decarbonisation and associated technologies. However, building fabric will also play a key role – if energy demand is reduced, the proportion which must be met from renewable sources becomes more manageable.

The Low Carbon Routemap's 80% reduction scenario assumed that 95% of easy to treat homes and 70% of hard to treat homes will be retrofitted with insulation, draught proofing and superglazing by 2050. This would require a substantial increase in the pace of retrofit, particularly in hard to treat homes.

Taking responsibility for carbon reduction at an industry level is essential to driving uptake and delivering results as quickly as possible. There are many sectors where no industry body "owns" the carbon and no plans have been developed to manage carbon reduction. Market failures need to be addressed as there is not a strong enough business case or incentive for the private sector to implement even the measures which could have a return on investment over their lifetime.

The performance gap is a major issue, which could improve the efficiency of (and returns from) retrofit initiatives, reduce risk and give greater confidence to investors / owners. Occupant behaviour will also need to be addressed as this can have a significant positive or negative impact on performance and emissions.

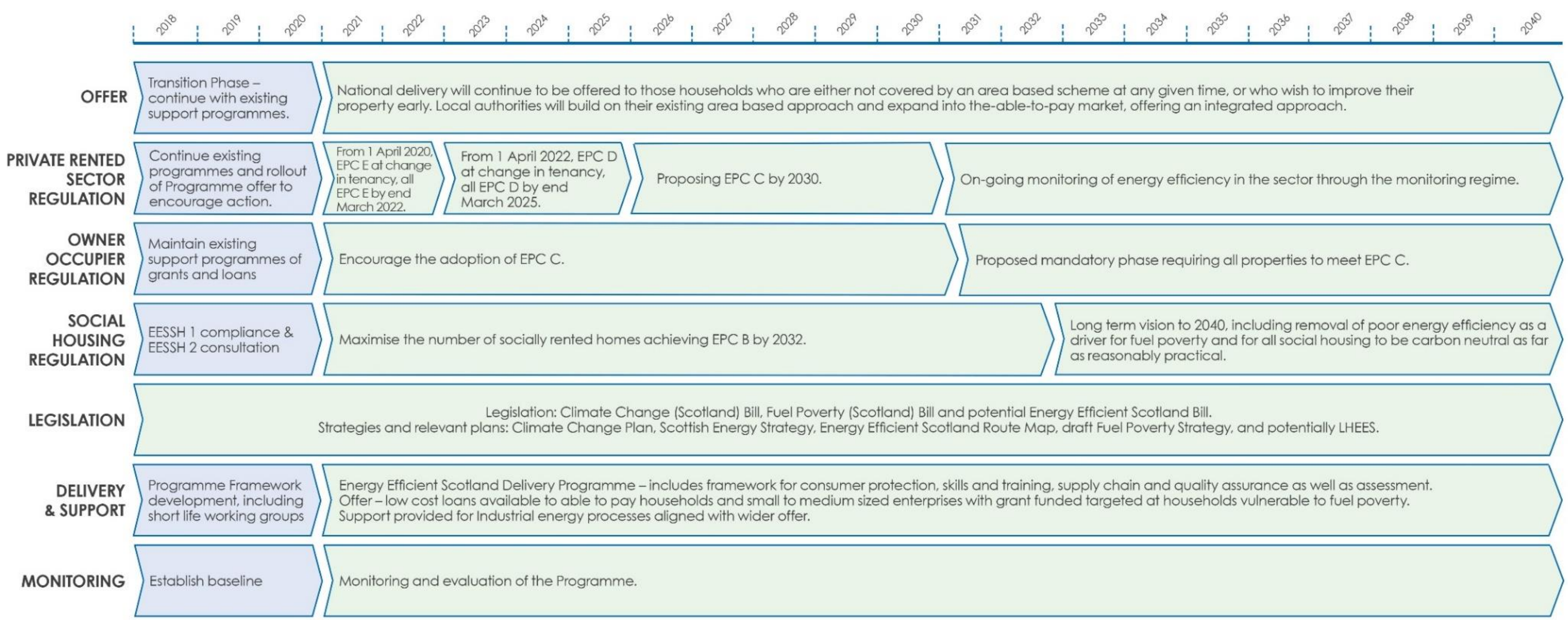
Lighting represented about 25% of energy use in 2010. There are significant opportunities to reduce emissions from lighting, particularly as much of the technology already exists and payback can be quick.

Energy Efficient Scotland: a route map
Scottish Government, 2018

Released by Scottish Government in 2018, the Energy Efficient Scotland route map provides an example of a legible high level strategy designed to deliver decarbonisation of the Scottish housing stock by 2050:

The Scottish route map (see flowchart diagram below) provides an example of a high level strategy designed to deliver decarbonisation of the Scottish housing stock by 2050. It utilises EPC targets, and is based on pre-existing mechanisms for performance measurement and ‘understood’ actions / pathways.

The route map recognises the importance of tenure, subdividing targets and levers into ‘private rented’, ‘owner occupied’ and ‘social housing’, with an additional focus on affordable warmth for all. However because of this low level of specificity, there is limited detail to the route map, and many of the more challenging aspects remain at consultation stage.



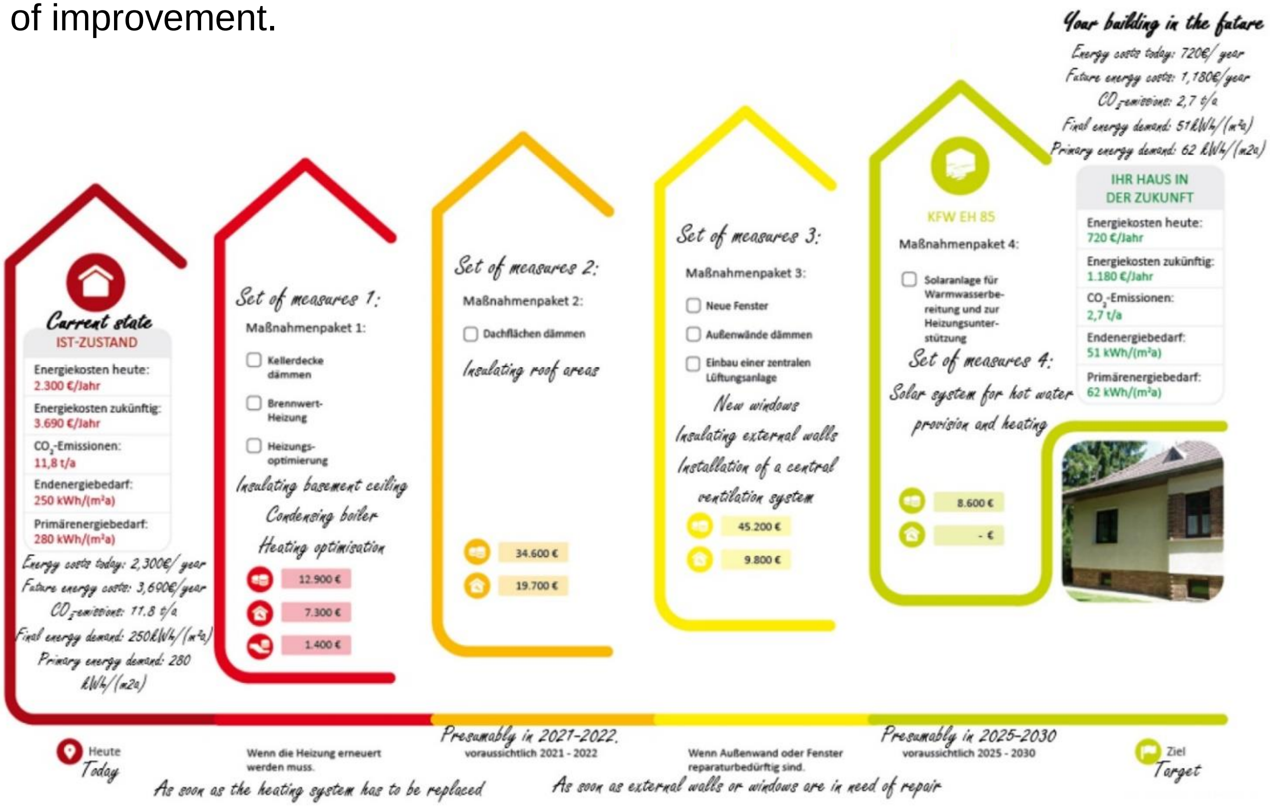
Source: LR22 or link: http://www.gov.scot/Publications/2018/05/1462

Strategic approaches 4 of 6

Building Renovation Passports
Buildings Performance Institute Europe, 2016

Developed in 2016 by the BPIE, Building Renovation Passports provide a systemic approach for the production of customised (building specific) roadmaps towards deep renovation and better homes, focussed on dwelling performance (EPC).

The approach has been trialled in several European countries (LR32) and provides a model for a phased approach. Iterative improvements are made in an augmented EPC model, providing a series of clear phased improvements to an individual dwelling or dwelling type. Each phase is explained in terms of impact on energy and carbon and associated financial cost. Together the cumulative phased improvements deliver a roadmap for the target level of improvement.



Source: LR32 **Building Renovation Passports:** customised roadmaps towards deep renovation and better homes. Buildings Performance Institute Europe (BPIE. Authors Fabbrie, De Groote and Rapf, 2016)

Each Home Counts
Peter Bonfield et al. 2016

In 2015, Dr Peter Bonfield (Chief Executive, BRE) was commissioned to chair an independent review of Consumer Advice, Protection, Standards and Enforcement for UK home energy efficiency and renewable energy measures:

The **Each Homes Counts** report identified that “despite long-term energy price rises, increasing publicity and awareness of energy efficiency and renewable energy options, considerable investment by the private sector, and a number of government enabling policies, we have not seen a large scale increase in the level of public demand for [energy efficiency] measures.”

The 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.”

It set out a new quality and standards framework for the retrofit sector, which would include:

- 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

Source: LR34 or link: http://www.eachhomecounts.com/

Strategic approaches 6 of 6

The Wellbeing of Future Generations (WALES) Act
Welsh Government (2016)

The Wellbeing of Future Generations (WALES) Act 2015 is a piece of legislation insisting that all public bodies in Wales consider long term implications over short term expedience.

WFGA provides a framework for defining holistic goals for decarbonisation of the existing housing stock. In the table below (with reference to work previously conducted around new-build housing - see More | Better, 2016), we have explored goals in terms of benefits that are relevant in the short, medium and long term:

WFGA goal:	short term benefit:	medium term benefit:	long term benefit:	focus:
>80% carbon reduction	low embodied CO_2 locking in carbon	reduced carbon footprint potential for carbon negative	decarbonising communities meeting international targets	CO_2
Local / Wales supply chain	addressing cost and value local resource use	more affordable housing supporting Welsh suppy chain	affordability, local economy skills and community building	capital
greater climate resilience	robust, low maintenance changeable by the community	resilient to climate change acessible construction	adaptability and resilience reskilling and empowering	change
reduce burden on healthcare	natural resource use breathable construction	healthy internal environment reduced impact on environment	positive health benefits reduced strain on public services	health
affordable warmth for all	low embodied energy reduced heating bills	energy generation offsetting rental costs	affordable warmth for all energy positive homes	energy
community-led action	flexibility in layout constructable by end user	long life loose fit 'other' procurement pathways	meeting specific housing need flexible, high quality homes	space
improved placemaking	variety in form and materials suitability to different contexts	building strong neighbourhoods creating places with character	supporting people, communities and distinctive places	place

section 5. Retrofit: a discussion

discussion structure

The five subheadings for Actions and Challenges, and the key headlines that arose within the scoping review, have been combined into the following discussion structure:

5.1 Thinking strategically

5.2 Building fabric

5.3 Renewables

5.4 Services

5.5 Financial

5.6 Supply chain

5.7 People

Each of these themes is used to pull together the key discussion and findings that were drawn from both case studies and literature.

The traffic light system (see section 3: *methodology*) is used to identify implications for each discussion subheading, in terms of the timescale for applicability (short term / medium term / long term) and the confidence with which observations are made (anecdotal / documented / understood). This assessment flags whether each subheading / area of discussion falls into the category of ‘what works’, ‘needs exploring’ or ‘big challenge’.

The discussion itself provides a high level summary of key headlines, cross referenced against relevant case studies and literature, to enable the reader to locate resources from within the database.

A summary of the traffic light assessment for each discussion subheading is provided overleaf.

Retrofit: a discussion

discussion summary

1 thinking strategically

1.1 taking advantage of funding
1.2 energy sources
1.3 change in primary energy supply
1.4 fabric first approach
1.5 development constraints
1.6 addressing overheating
1.7 standards beyond Building Regulations
1.8 void reductions

2 building fabric

2.1 spatial constraints
2.2 construction or condition not as expected
2.3 roof upgrade
2.4 wall upgrade
2.5 floor upgrade
2.6 windows
2.7 shading
2.8 air tightness

3 renewables

3.1 Heat recovery
3.2 Combined Heat and Power (CHP)
3.3 Photovoltaics (PV)
3.4 Electric battery
3.5 Wind
3.6 Solar Thermal
3.7 Transpired solar collectors

4 services

4.1 gas
4.2 oil
4.3 biomass
4.4 heat pumps
4.5 radiant heat
4.6 underfloor
4.7 storage
4.8 ventilation
4.9 district heat networks

5 financial

5.1 availability of finance
5.2 high cost of actions
5.3 unexpected costs
5.4 payback periods
5.5 maintenance costs
5.6 locked-in investment

6 supply c.

6.1 Knowledge - good advice / emerging tech.
6.2 Materials and products- perf. and availability
6.3 skills- workforce and capacity
6.4 skills – training and apprenticeship

7 people

7.1 occupant engagement
7.2 occupants stay put
7.3 simple controls
7.4 smart meters and homes
7.5 entrenched behaviour
7.6 health issues
7.7 influencing lifestyle

discussion #1: **thinking strategically**

1	STRATEGIC		time	conf	RAG
1.1	**Taking advantage of funding** TSB funding: CS15-CS23 WEFO funding: CS04-CS08	Many case study projects would not have happened without financial support, which enabled a more holistic package of actions. In some cases, funding sources impact on the actions undertaken, e.g. Scottish PV programme (CS13) which installed PV on 42% of the Stirling Council housing stock, with significant variations in orientation, aspect and effectiveness. Conversion and newbuild workstreams should also inform the retrofit programme. While distinct from retrofit, they provide opportunities to fundamentally change the effectiveness of key actions and the means by which dwellings are selected and incentivised for retrofit.	**ST**	☺	
1.2	**Energy sources**	80% of UK homes use mains gas for heat. For successful decarbonisation, around 20,000 homes per week must move to a low carbon heat source from 2025 to 2050 .This will require considerable coordination and communication, resources, and a reliable supply chain. (LR09,10,11,22) In the long term, decarbonisation of electricity at point of generation should mean that where mains electricity is available, dwellings will move to all-electric supply (and generation) via the national grid. (CS09, CS10) However, decarbonisation of the grid could increase energy costs, putting additional homes into fuel poverty. It may not be easy to persuade consumers to move to low carbon alternatives which are more expensive, potentially less effective. (NEA, LR05) There is also the possibility of a less carbon-intensive gas supply (LR29).	**LT**	☹	
1.3	**Change in primary energy supply** Relevant CS: 1,2,4,5,6,7,8,9,10, 11,12,14,17,22,28 ,38,39,40	Where available, mains gas supply is currently popular due to cost effectiveness and reliability (see ARBED case studies, LR23). Short term, LPG and Oil systems could be switched to gas (for fuel economy – see LR05) or to mains electricity / air source heat pumps, where the change can be combined with a package of works that reduces energy demand sufficiently (CS38, CS39, CS40). Case studies that switch from mains supply (e.g. gas) to a combination of PV and energy storage (typically via battery) have demonstrated that there are low / zero carbon options for off grid homes, however this is an expensive solution requiring full fabric first and extensive PV (see CS10). BioLPG offers a substitute for fossil LPG, produced from sustainable biomass feedstocks such as wastes, residues and energy crops. Work in Japan, verified through experimental work in the UK, has developed a cost effective route for production of BioLPG through the catalytic dehydration of methanol. By 2030 BioLPG produced from waste may be able to heat off-grid homes for a similar cost to fossil LPG but with 90% lower GHG emissions. Heating a typical off-grid home using BioLPG will be 30% less expensive than using a heat pump. Overall, BioLPG is seen as the lowest cost solution for low-carbon off-grid heating.	**ST**	😐	

1	STRATEGIC	page 2 of 3	time	conf	RAG
1.4	**Fabric first approach** Relevant CS: 1,2,3,4,5,6,7,8,9,10,11,12,14,15,16,17,18,22,23,24,25,27,29,31,35,37,39	Fabric First is a well documented priority action. (CS29: heating demand reduced by 63% through fabric insulation alone, CS37: improved fabric and infiltration saves 66% of CO_2). All but four case studies adopted a fabric first approach. (CS33, CS34,and CS35 focus explicitly on CHP, while CS13 is a PV-only programme.) While fabric first actions are not the most economic options, and do not necessarily have the shortest payback periods, they consistently and reliably deliver benefits in terms of reduced fuel bills and fuel poverty. They consistently reduce energy use and carbon emissions (LR09), and generate measurable social and health benefits (LR28 and LR29). Because changes to fabric tend not to result in changes to the way the dwelling is used, there are not typically issues around underperformance (compared with, for example, systems retrofit). However, quality of workmanship is particularly important for fabric interventions, as poorly executed work can significantly limit effectiveness. This requires a skilled workforce (LR12 and LR23).	ST	😐	
1.5	**Development constraints** Relevant CS: 1,2,3,7,14,15,16,17,20,21,22,23,24,28,39	There are 2 types of development constraints: Neighbourhood constraints tend to be implied rather than explicit (i.e. more subjective), and relate to a combination of form, materiality and character. Typically enforced by planning or conservation officers, and may or may not be categoric. Dwelling constraints can be more subjective – e.g. form, materiality, style and character (again the remit of planning / conservation officers (CS 07, 15, 17, 22, 23) OR more explicit, e.g. construction type, room size, dwelling condition, etc. Explicit constraints will be the remit of building control officers, as well as warrantee providers and potentially lenders. These constraints can affect the range of suitable actions and their effectiveness. They need to be taken into account but should not be seen as insurmountable challenges (e.g. CS21 and CS27 had extensive constraints, but significant CO2 savings were achieved).	ST	☹	
1.6	**Addressing overheating** Relevant CS: 1,28 only, but other dwellings are prone to overheating	The probability of overheating and associated health risks is increasing. The perception that increased thermal performance, air tightness and MVHR increase the risk of overheating is not necessarily true, although LR27 identified increased indoor temperatures from IWI. LR27 also provides mitigation measures. Most modelling tools predict overheating; some (e.g. Passivhaus) quite comprehensively. Thermal mass can reduce the risk of overheating, and purge cooling can be a part of a window/door retrofit. Only a small number of case studies actively considered overheating, while more either reinforced or replaced an existing ventilation strategy. Few incorporated solar shading into their retrofit, an additional option. It has been suggested that in the future, overheating could be explicitly reported in mortgage surveys.	MT	😐	

			time	conf	RAG
1.7	**Standards beyond Building Regs** Relevant CS: 1,11,14,19,24,26, 27,28,31,32	Only ten of the case studies (listed as relevant) pursued a specific performance standard beyond Building Regs compliance. Passivhaus was the most used, and there were further case studies that employed the thermal performance targets (and modelling) without seeking accreditation (mostly due to the costs associated with accredited products). Other standards sought include CfSH level 5, CfSH level 6 and zero carbon (as defined by the Zero Carbon Hub).	**ST**	😐	
1.8	**Void reduction** Relevant CS: 4	Only one case study was explicitly concerned with void reduction. The empty dwelling was in a poor area and in poor condition. A retrofit above WHQS meant that it could be rented at mid rather than base rent. Currently about 2000 social housing units owned by Welsh LA are not compliant with WHQS. (Source: StatsWales) One possible explanation for the low level of reporting is that the housing shortage has made voids less commonplace, and more problematic / resistant to treatment by retrofit where they do exist. However, in 2016-17 there were about 4000 vacant social housing units in Wales and about 2100 were 'not available for letting' (10% of total social housing lettings 2016-17, Source: StatsWales).	**ST**	☹	

discussion #2: **building fabric**

2 BUILDING FABRIC page 1 of 2

			time	conf	RAG
2.1	**Spatial constraints** Relevant to CS: 3,17,20,21,22,23, 27 and an influencing factor in all smaller homes	In Wales, space standards for social housing tend to be seen as a maximum, and recently built homes for sale are often built even smaller. 8% of dwellings are below 50m^2 floor area (mostly flats) and 46% of dwellings are between 50m^2 and 100m^2 (mostly semi-detached and terraced houses: NEED 2014). Because UK house prices are driven by number of rooms rather than floor area, there is a tendency towards more, smaller rooms. As a result, a high proportion of smaller homes are functionally compromised (to differing degrees) by actions that reduce available floor area. This includes internal wall insulation, ground floor insulation, and the provision of space-consuming services (including ducting for MVHR).	**ST**	☹	
2.2	**Construction or condition not as expected** Relevant to CS: 15,16,20	On two case studies (CS15 and CS16) unexpected structural and safety concerns added considerable unforeseen time and cost. More generally, there were relatively few surprises in terms of overall construction, but condition was notably worse than anticipated in 10% of projects. Contingencies are an important part of any retrofit budget, and older stock means greater likelihood of cost increases through unanticipated work (see LR12). Conversely, generic u-values tend to underpredict performance for older construction, notably for solid brick and stone exterior walls (see LR30, LR39 and LR41).	**ST**	😐	
2.3	**Roof upgrade** Action for CS: 1,3,4,5,6,7,8,9,10, 12,14,15,16,17,18 ,19,20,21,22,23, 24,25,26,27,28,29 ,37,39	The widest range of differing strategies were employed for actions around roof performance. These ranged from modest upgrade of pre-existing loft insulation (present at some level in >90% of homes) to full roof replacement using prefabricated volumetric whole-roof systems incorporating new loft spaces and renewables. Some homeowners and landlords presume that roof insulation has been 'done', but in many cases there is scope for considerable top-up of existing insulation levels, and quality of existing installations is very varied (in 2014, 14% of dwellings still had less than 15cm of loft insulation. NEED2014).	**ST**	☺	
2.4	**Wall upgrade** Action for CS: 1,3,4,5,7,8,9,10, 12,14,15,16,17,18 ,19,20,21,22,23, 24,25,26,27,28,29 ,35,37,38,39,40	One of the more expensive actions, but also one of the more effective (see LR34 FutureFit), and a fundamental part of any fabric first strategy. External wall insulation (EWI) is considered to be slightly more expensive but also slightly more effective than internal wall insulation (IWI), by eliminating cold bridges and improving air tightness (LR35). The question of EWI versus IWI is project specific (see constraints 1.5 and 2.1). More projects had the 'option' of IWI than EWI, but more (55%) chose EWI. Reasons were mainly to do with performance, but most social housing is delivered to tight spatial constraints (see 2.1), and loss of floor area through IWI can have implications for usability (e.g. CS22). Both options are necessarily part of any pathway, and monitoring of quality is essential. Cavity wall insulation (only 2% of CS) is no longer considered an appropriate action by many experts. In addition to limited effectiveness and the potential for performance breakdown over time, there are measurable negative impacts on health (see LR33).	**ST**	😐	

2 BUILDING FABRIC

			time	conf	RAG
2.5	**Floor upgrade** Action for CS: 1,3,7,9,10,14,15, 16,17,18,19,21,24 ,25,26,27,28,29, 37	Floor insulation is the most problematic fabric action, in terms of technical challenges and programming (it typically requires occupier decant). WHCS identifies % of dwellings with solid floor construction, limiting the potential for insulation within the floor. Even in cases where in-floor insulation is possible, performance is limited by the perimeter detail, which generally requires very invasive work to address (e.g. CS18 and CS19). Dwellings on sloping topography with access to suspended floors tend to present opportunities for (albeit often partial) improvement of floor performance. Where insulation must be applied on top of existing solid floor construction, there are often implications (adjustment of door heights, etc) and smaller dwellings tend also to have lower floor-to-ceiling heights, heightening the impact of raised floors (e.g. CS15, CS16, CS17).	ST	😐	🟢
2.6	**Windows** Action for CS: 1,2,3,4,9,10,11,14 ,15,16,17,18,19,2 0,21,22,23,24,25, 26,27,28,29,35,37 ,38,39,40	Replacement of windows is problematic in some locations, albeit to less of a degree than EWI (26% of case studies, compared to 45% of case studies where EWI was problematic). Where period-style glazing is required, high performance glazing is significantly more expensive. Where existing glazing must be kept in place, there are limits to the effectiveness of secondary glazing. Casement windows perform better than sash windows, because the frame typically achieves better airtightness. However, sash windows may be required in conservation areas / Listed facades. There are examples of triple-glazed sash windows, but they are visually heavy (LR35). Triple glazing has depressed payback periods that constrain its viability. Where thermal standards of the building fabric are not high, triple glazing tends not to be recommended. However, it is an important part of any fabric first strategy looking to achieve higher performance standards (e.g.Passivhaus).	ST	🙂	🟢
2.7	**Shading** Action for CS: 1,24 only, but other dwellings are prone to overheating	Typically, external shading devices are not incorporated into UK retrofit projects. LR16 also considers night ventilation and internal shading as overheating mitigation measures. As issues around overheating increase, external shading could be introduced at relatively low cost. This should be considered case by case (ideally window by window), as the installation of air conditioning units would significantly increase electricity demand.	MT	☹️	🔴
2.8	**Airtightness** Action for CS: 1,4,9,10,14,15,16, 17,18,19,21,22,23 ,24,26,27,28,29	A number of projects identified explicit limits to airtightness imposed by the existing dwelling. This in turn compromised the effectiveness of certain actions such as MVHR. Delivering airtightness requires attention to detail, a well-trained well managed workforce, toolbox talks etc. In several cases projects did not achieve the targeted airtightness levels (although they achieved higher levels that standard for new built). Particular difficulties arise when several materials are combined and when there are complex geometrical details. The workforce is particularly unskilled with regard to airtightness measures (LR35 and LR42).	ST	😐	🟢

discussion #3:
renewables

3 RENEWABLES page 1 of 2

			time	conf	RAG
3.1	**Heat recovery** Action for CS: 1,3,4,5,12,15,16, 17,18,19,20,21,23 ,24,26,27,28	Used extensively, especially in higher performing projects e.g. Passivhaus, as an essential part of Mechanical Ventilation and Heat Recovery (MVHR), and adopted widely for Retrofit for the Future projects (see LR35). It can be very expensive to install due to the unexpected need for additional and remedial works (LR44). Requires a good level of airtightness to be efficient, and sufficient space for plant and ducting (see CS22 and LR35). MVHR can include a summer bypass mode to help mitigate overheating (CS28). In CS17 the summer bypass was not installed which led to uncomfortable temperatures in summer. CS4 identifies the importance of after care and occupant understanding. There is very limited awareness of MVHR technologies among homeowners (LR42).	**ST**	😐	
3.2	**Combined heat and power (CHP)** Action for CS: 33,33,34	Limited information is available on CHP use in retrofit, however this is a readily-available technology. Typically includes provision of hot water, with a saving of around 20% carbon emissions compared to mains supply. Does not necessarily have to be large district scheme, for example, single buildings containing a number of apartments (see CS32, CS33 and CS34). It does not appear to be suitable for single dwelling applications.	**MT**	😐	
3.3	**Photovoltaics (PV)** Action for CS: 1,2,3,4,6,7,8,9,10, 12,14,15,16,17,26 ,27,32,37,40	Cost of PV has stabilised over recent years but performance continues to increase. Across 2,400 PV installations (42% of Stirling council housing stock, CS13) the average size of system installed was 3.0kWp at an average cost of £4,200 (ex VAT) generating on average 2,330kWh per annum per property. To maximise the “self-consumption” benefit to tenants, solar diverters were provided for “off-gas” stock with battery storage (see below). Energy efficiency rating was increased between 10 and 20 RdSAP (2012) points, depending on size and orientation of array, PV is now considered viable across east-west facing roofs as well as on southerly orientations. Integrated PV is 10% more expensive than bolt on, and can be combined with roof replacement. However, lack of cool air behind integrated PV affects performance.	**ST**	☺	
3.4	**Electric battery** Action for CS: 2	Across more than 100 installations (CS13) systems range from internally mounted 2kWh batteries to externally mounted 13.5kWh systems, which provide the householder with 25% of consumed energy during winter months, rising to over 90% during summer months. The cost of a 13.5kWh battery storage system is currently around £5,600 (ex VAT) but costs continue to fall with growth in the UK market. Battery storage opens up other opportunities including sharing microgeneration power over connected homes and the ability to import Economy 7 power in to the battery. Storage on site is particularly relevant for off-grid areas, but dependant on costs and holistic fabric first retrofit. With a transition away from petroleum-based cars, electric cars will increasingly be integrated into the home, and provide additional battery storage. Charging points are incorporated into best practice newbuild schemes, and will be needed in retrofit also.	**MT**	😐	

			time	conf	RAG
3.5	**Wind** Action for CS: 32	The only case study featuring wind power (CS32) has one large turbine for community use. They tend not to be standalone on dwellings. It is not clear whether this is due to technical or planning constraints. Questions exist over their reliability and possible noise pollution, as well as the potential for long term vibration (of rotors) to cause damage to buildings. Wind turbines in urban areas do not typically produce the predicted amount of energy, because wind speeds around urban / suburban buildings are much lower than in rural areas. (LR21)	MT	😐	🟡
3.6	**Solar thermal** Action for CS: 3,14,16,17,18,20, 21,22,23,24,26,27 ,28,37,39,40	Solar thermal panels are prevalent in older retrofit projects, including some of the TSB-funded case studies (e.g. LR35), but not in more recent case studies. Solar thermal appears to have been superseded by PV systems. This is likely to relate to improvements in efficiency and cost of PV that make it increasingly viable, and the concern that solar thermal only works as part of a complex (hot water) system, making it difficult to use in standalone / off grid situations and more prone to maintenance issues. In some cases, planning officers have voiced concerns over the visual impact of combined PV and solar thermal installations (e.g. CS02).	ST	☺	🟢
3.7	**Transpired solar collectors** Action for CS: 9,12	TSC are highly efficient and can collect around 50% of the solar energy falling on the incident surface. For a well insulated dwelling, the heat collected by the TSC can contribute up to 50% of heating demand (e.g. CS09 Solcer House, further reference: https://www.tatasteelconstruction.com/en_GB/sustainability/sustainable-building-envelope-centre-sbec/sbec-technologies/transpired-solar-collectors/Transpired-solar-collectors-%28TSCs%29). TSC are currently very expensive, despite being manufactured locally. However, at scale and with a production line, costs could be reduced significantly.	MT	😐	🟡

discussion #4: **services**

4	SERVICES	page 1 of 2	time	conf	RAG
4.1	**Gas** Action for CS: 2,3,4,5,6,14,15, 16,18,19,20,21, 23,25,26,27,29, 30	For carbon-intensive / inefficient heating systems (e.g. oil and coal), switching to an efficient mains gas boiler is a suitable first step to reduce emissions at relatively low cost and limited disturbance of occupants, where supply exists. Using efficient domestic gas boilers is presently less carbon-intensive than using electric energy from coal and gas plants, due to the low efficiency of electricity at point of generation and transmission losses (LR25). However, as electricity supply becomes increasingly low carbon, the current benefits of mains gas will continue to dwindle. However, there is not likely to be a significant move away from mains gas in the short term, so long as fuel poverty and fuel cost are primary factors.	ST	☺	
4.2	**Oil** no relevant case studies	Oil is expensive, but is a known entity for owner occupiers living in off-grid situations. As a fuel, it will only get more expensive. Electric supply (grid plus PV) provides an alternative to oil and LPG in locations where mains gas is not available, but for less energy efficient dwellings, large PV arrays and big batteries would currently be required to deliver efficiency. Innovative solutions including heat pumps are also a possibility (CS36, CS37, CS39, LR38).	ST	☹	
4.3	**Biomass** Action for CS: 1,2	The main barriers to biomass uptake are the space required for fuel storage, and the need for ongoing maintenance. Systems are relatively affordable to purchase, but are only affordable to run in locations where fuel is available nearby. As a fuel, biomass fuel is dirty, and less convenient at a domestic scale (CS02). Current regulations consider wood pellets to be carbon neutral so long as the wood is FSC sourced. However, it is arguable that there is a net increase in carbon emissions in the short term, and fuel sources are sometimes questionable (see report: *Stealing the Last Forest*, link).	ST	☹	
4.4	**Heat pumps** Action for CS: 3,9,14,17,22,24, 28,38,39,40	Heat pumps are typically only used by projects where achieving higher standards is a priorty, e.g. Passivhaus. The FREEDOM project is an ongoing, locally based study looking at effectiveness of heat pumps combined with mains gas (LR25). CS27 argues against use of heat pumps *at present*, because the carbon intensity of electric energy in the UK is more than twice that of mains gas, thus a COP > 2.5 would be required to make a heat pump more advantageous than an efficient condensing gas boiler. However, heat pumps are suitable solutions for off-grid properties using solid fuel (CS36, CS37, CS39, LR38).	ST	😐	
4.5	**Radiant heat** Action for CS: 1,2,3,9,14,15,16, 17,18,19,20,21,2 2,23,24,26,27,29 ,30,38,39,40	The reuse of pre-existing wet central heating systems is quite commonplace, as it minimises disruption and cost, and can be combined effectively with MVHR. Because systems are pre-existing, users understand how they work (see LR35, and CS15 to CS24). The CAERAU project (LR33) is seeking to combine pre-existing domestic radiant systems with heat recovered from locally sourced mine water (includes a survey of local residents), but it is not yet clear whether existing radiators and pipework can be used for such low grade heat.	ST	😐	

4 SERVICES page 2 of 2

			time	conf	RAG
4.6	**Underfloor** no relevant case studies	No case studies were found for the use of underfloor heating in a retrofit context. As an action, it is generally considered too disruptive for retrofit, although in certain circumstances (e.g. steeply sloping sites where sub-floor is accessible) it could be combined with thermal upgrade of ground floor construction.	**ST**		
4.7	**Storage** Action for CS: 9,10,24	The approach to storage adopted by the Pentre solar projects (CS10) is to store energy obtained from PV in economy7 or 10 electric storage heaters. This is a conventional piece of technology (the electric storage heater) which becomes advantageous in combination with the daytime generation of PV panels. See also *Renewables: battery storage* (discussion 3.4).	**MT**		
4.8	**Ventilation** Action for CS: 1,2,3,4,5,9,10,11,12,14,15,16,17,18,19,20,21,22,23,24,27,28,31,37,38,39,40	More than half of the case studies (53%) installed MVHR systems (mechanical ventilation with heat recovery). Most of the remainder reinforced existing natural ventilation strategies. A number of these projects only avoided MVHR due to concerns around limits to airtightness, that would have compromised effectiveness. MVHR is now a commonplace action, combining heat delivery with guaranteed background ventilation rates and air quality - see *Renewables: Heat Recovery* (discussion section 3.1). There is a perception that MVHR prevents occupants from opening windows, as well as concerns around indoor air quality and overheating. Typically these concerns are unfounded, but issues often arise as a result of occupants not understanding either operation or maintenance. Drawbacks to MVHR are the space needed for equipment and ductwork, and possible background noise, which has been reported by occupants as a reason for turning off systems (perceptions of wasted energy) and is typically a result of poorly installed ductwork. A less onerous solution for smaller dwellings or dwellings with leaky fabric is the continuously running extractors, usually in bathrooms and kitchens (e.g. CS26).	**ST**		
4.9	**District heat networks** Described within LR 25,33. ref. also CS36	District heating systems are more easily applied to new developments, due to the infrastructure that is needed. However, the Caerau minewater project (LR33) provides an examples of a project seeking to establish a district heating network for existing dwellings. Smaller distribution losses are typically experienced in European installations, where expertise is greater. In CS36 (not yet built), Eneteq have devised a financial model to fund a CHP district heating network, and coordinated with a legal team to cover all related aspects such as customer supply agreements, maintenance contracts, metering and billing contracts, and warranties.	**MT**		

discussion #5: **financial**

5	FINANCIAL	page 1 of 2	time	conf	RAG
5.1	**Availability of finance**	Availability of finance does not feature as a recurrent challenge in case studies that were delivered, but is clearly one of the factors preventing or obstructing the delivery of projects, particularly holistic retrofits with a focus on quality, where capital costs will be higher – note 'high cost of actions' below. From the questionnaire: "funding is not timed well and is too short – prevents long term projects being planned efficiently and carried out properly", which can lead to boom and bust (LR17). Research in Denmark (LR46) links post-retrofit improvements in EPC ratings directly with an increase in sale value (all property types). For a typical 100sqm house, value increases by 5,400€ to 7.400€ per increment in the energy rating scale. Variations in impact on sales price are affected mostly by energy prices at the time of the sale, and by the information made available to prospective buyers about energy ratings and impact on running costs. The LENDERS project (LR 19) proposes that mortgage lenders be given more accurate energy performance estimations. This would quantify potential savings on utility bills, which could be taken into account when agreeing lending limits. The project team suggest this could provide, on average, around £4,000 of additional finance. It also increases the chance for this information to affect the decision of homebuyers. Similar approaches could be used to increase finance for active retrofit across the existing housing stock. Guidance on how mortgage companies can develop products is available (LR26).	**ST**	☹	
5.2	**High cost of actions**	Funded holistic retrofit programmes typically acknowledged a high cost to the actions undertaken. The TSB-funded RFTF programme delivered identified particularly high costs (circa £800/sqm+). However these retrofits were undertaken more than a decade ago (in some cases nearly 20 years prior), and many deliberately utilised a range of technologies still in development or techniques that were not fully understood. They were also comprehensive, rather than selective in their use of actions (CS20 to CS23, CS26). In contrast, the more recent WEFO funded projects typically utilised fewer, better known techniques and consequently the impact on carbon is somewhat reduced but the impact on cost is dramatic (typically £300-£400/sqm) (CS04 to CS07). The cost of retrofit actions for the RFTF programme were monitored and analysed (LR44). Higher than average costs were found to be linked to a lack of coordination between the various suppliers and installers, which led to delays (due to remedial works) and avoidable expenses (e.g. double scaffolding). The over-specification of products / systems, and sourcing products from abroad (e.g. for Passivhaus certification) also increased cost. Costs can be reduced by taking actions from niche (in development) to mainstream (market-ready), through improved economies of scale (e.g. retrofitting several units at the same time or rolling out improvement programmes), by contracting builders with direct experience of the products/systems being utilised, and by appropriate coordination of works.	**ST**	☹	

			time	conf	RAG
5.3	**Unexpected costs**	Contingency sums have always been an important aspect of budget in retrofit. While only 10% of case studies actively identified unexpected costs as a challenge, more case studies reported unanticipated issues around either construction or condition. If quality is to be a focus and unexpected eventualities are to be accommodated, contingencies will continue to be an important element of the retrofit budget. (CS15, CS16, CS19, CS20, LR23) Poor design and lack of coordination between project team members can lead to unexpected costs (LR44). Innovative technologies such as MVHR are particularly vulnerable to unexpected costs, due to the limited experience of contractors and the need for bespoke design (e.g. ductwork). Further unexpected costs are generated when lack of occupant understanding generates remedial work post-completion. This can be avoided with occupant support and after-care.	ST	☹	
5.4	**Payback periods**	Long payback periods are one of the main barriers to the widespread uptake of retrofit in the private sector (LR42). Payback periods will reduce with capital costs, typically through economies of scale, more local delivery of actions, or more widespread uptake of developing techniques or technologies. When making choices about the type of renovation actions to undertake, payback periods can inform the decision making process (e.g. CS25), but longer payback periods do not necessarily mean that actions should be discounted (see discussion: 1.4 fabric first, 2.4 wall insulation and 2.6 window replacement).	ST	☹	
5.5	**Maintenance costs**	The incorporation of technologies and techniques that are not widely used can increase maintenance costs significantly. Housing providers and even small scale landlords have maintenance teams who will be familiar with particular 'tried and tested' systems and products. Their lack of experience with alternatives will often increase time and cost associated with the delivery of maintenance and repairs, through mistakes and delays ordering parts, the need to learn new skills, and workmanship issues in use (e.g. CS02). Some actions also have hidden maintenance costs if the project team are not familiar with them (e.g. regular replacement of MVHR filters, CS03 and CS12)	ST	☹	
5.6	**Locked-in investment**	Care should be taken to avoid short term improvements that preclude future retrofit actions. For example, housing providers have reported difficulty convincing occupants to upgrade windows if dwellings are already double glazed, or upgrading boilers if they are already 'A' rated (CS05 to CS08, CS12). Thought should be given to establishing pathways that build iteratively towards known goals through a series of related actions, and to providing a legible means of explaining these staged improvements in terms of cost, impact and the relationship between them (see LR32 Building Renovation Passports: customised roadmaps towards deep renovation and better homes).	ST	☹	

discussion #6: **supply chain**

6 SUPPLY CHAIN page 1 of 2

time | conf | RAG

There are recurring issues around the availability of experienced consultants, suppliers and installers. This is a particular issue in more remote locations. The lack of impartial, reliable advice around both technical and financial issues is one of the main barriers to uptake of improvements in the private sector (LR17, LR38, LR42).
This can result in inconsistent advice, which causes confusion and difficulties in the decision-making process, and reduces trust in retrofit actions (CS02 to CS07, CS26).
Understandably, a lack of full understanding of emerging technologies by all members of the supply chain can instil lack of confidence, inflated risk levels and unanticipated cost.

6.1 **Knowledge -** good advice / emerging technologies

time: ST | conf: ☹

There is currently limited breadth in the experience and knowledge embedded in the UK supply chain, which could develop with more widespread retrofit. One third of questionnaire respondents referred to supply chain, highlighting:

- *A lack of knowledge and understanding throughout the whole supply chain.*
- *Technical gaps in knowledge between design and construction – technologies are selected, but there is a lack of understanding of how they fit together.*
- *Additional costs associated with installation of low carbon technologies can result in them being dropped from a retrofit.*
- *Differences of opinion between stakeholders engaged in 'design', 'planning' and 'technology' – agendas can be different, leading to contradictory advice. Some need motivation to change or update knowledge, others need to work more flexibly.*
- *Commissioning has to take place at the right time and be done well.*
- *Appropriate solutions have to be found – not one size fits all.*
- *Lack of planning of retrofit causes problems: there is a role for retrofit manager*.

6.2 **Materials and products –** performance and availability

time: ST | conf: ☹

In the survey, supply chain was not considered as challenging as financial constraints in preventing large scale decarbonisation. However, supply chain generated a large amount of discussion and feedback in the open-ended questions.
Some adopted standards, e.g. Passivhaus, encourage project teams to specify certified products outside the UK. This adds costs and leads to issues around maintenance. A more diverse local supply chain could address this. Some materials and technologies, e.g. external wall insulation, can already be sourced entirely within Wales.
Within the questionnaire, case studies and lit review, numerous issues were highlighted around underperformance, misuse, inappropriate specification, and products that are at risk of improper / incorrect use. Improper installation of insulation was identified as an example of a recurrent problem, typically due to poor workmanship, and difficult to correct retrospectively (see CS02). Consistency of funding would allow supply chain and associated skills to develop, together with appropriate training.

6	**SUPPLY CHAIN page 2 of 2**		**time**	**conf**	**RAG**
6.3	**Skills –** workforce and capacity	The Building Performance Evaluation Programme (InnovateUK, 2016) observed that “…there is no way to meet the Government’s 80% carbon reduction target by 2050 without a revolution in the way we construct and run buildings.” This, in turn, demands major changes of the industry’s supply chain. "Each home counts" (LR34) stressed the need for Government and key stakeholders to establish a code of conduct for retrofit good practice and a quality mark for contractors, manufacturers and installers. Companies wishing to gain the mark would need to embed 'core retrofit knowledge’ (good practice relating to building physics, installation techniques, customer care) in their training and operations (LR30). There are recurring issues around project management of retrofit projects / programmes, and the delivery of comprehensive projects that include after-care / wrap-around services. These issues suggest scope for skills and services that do not currently exist or are not fit for purpose (CS02, LR06, LR12, LR23, LR39, LR42). Without a construction or retrofit manager in place, there is potential for a lack of overall responsibility to be held by any one party if problems arise, and for blame to be passed from one installer to another. In the wake of the Grenfell disaster, the Federation of Master Builders (FMB) called for a mandatory licensing scheme for all builders and contractors in the UK (LR45). This would increase professionalism in the industry, and discourage rogue / incompetent builders, although it is also likely to increase the cost of retrofit short term.	**ST**	😐	
6.4	**Skills –** training and apprenticeship	The construction and built environment sector is key to future economic development in Wales, but lack of skilled / trained workforce has prevented retrofit schemes from taking place in the past and such experiences reduce willingness to take risk in future projects. A review of qualifications across the construction and built environment sector advocates new full-time programmes, recommending that further education and apprenticeships form a clear and coherent end-to-end progression route which starts with broad-based learning and ends with assessment and employer sign-off (LR18). There is a lack of long term training in the building sector. Where training is taking place, 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). Apprenticeships are generally shorter than in comparable nations, and many employers believe that they are too short. Once workers are qualified, there is typically no follow-on required or expected by the industry, and any additional training is personally motivated. Additional training in local / natural / healthy materials, techniques and technologies should be encouraged to stimulate the Welsh economy. Collaboration between supply chain and education sectors could encourage this (e.g. retrofit coordinator training, run by the Retrofit Academy).	**ST**	☹	

discussion #7:
people

7 PEOPLE page 1 of 2

			time	conf	RAG
7.1	**Occupant engagement** Relevant CS: 01,02,03,04,05, 06,07,10,12,15, 16,18,20,21,22, 23,35	A lack of occupant engagement can lead to underperformance in terms of delivered energy or carbon savings, as well as reduced comfort, distress, further improvement work, and legal disputes (e.g. LR14). There is a need for expert retrofit advisers, and for a more consistent level of understanding among consultants generally (LR10). Public awareness of innovative products and actions is generally low (LR25). Providing residents with a good understanding of technologies is fundamental to success (86% of HA's installing PV stated that resident knowledge could assist in 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. LR06). Occupant engagement needs to be embedded in the retrofit process from project inception and planning through to delivery and finally operation, to ensure that occupants feel they are part of the process and fully understand implications and long term operational issues (CS03, CS04-07 and CS12). When motivated by external factors (for example impact on fuel bills or quality of the home) occupants will engage with the low carbon agenda (CS02).	**ST**	☺	
7.2	**Occupants stay put** Relevant CS: 03, 07, 12, 16, 18, 22, 26, 30, 38	Finding ways to reduce the need of decanting the occupants avoids additional costs (LR44). Decantation can also impact on quality of life and well being by householders being away from community and daily activities (CS03, CS04-07 and CS12). Whole house retrofits are difficult to carry out without decanting, particularly where internal modifications such as IWI and floor insulation are needed. However it is possible to achieve this aim, by working on one room at a time, when occupants are engaged in the process (CS03, CS07 and CS12).	**ST**	😐	
7.3	**Simple controls** Relevant CS: 01, 15, 16, 20, 21, 23, 30.	87% of Housing Associations installing renewables agreed that the most effective approach was to ensure that user controls were simple and easy to use.(LR06). Complex or unfamiliar controls and systems are a particular problem for elderly and vulnerable people, may of whom are not familiar with electronic controls (LR12). Controls tend to be considered late in the programme. This can lead to inappropriate decisions around the design and installation of controls, which are often made without occupant involvement.	**ST**	😐	
7.4	**Smart meters and homes** Relevant CS: 02 26	While there is considerable publicity around smart technology in the home, much of the focus of key suppliers (e.g. Loxone, no case study data available) is on relatively upmarket integrated, centralised systems and controls, with an emphasis on systems and solutions that impact mostly on lifestyle and entertainment.	**MT**	☹	

7 PEOPLE page 2 of 2

			time	conf	RAG
7.5	**Entrenched behaviour** Relevant CS: 03 04 26 38 39 40	Recurring problems across many of the retrofit case studies are caused by occupants not understanding how to operate or maintain new systems (LR27). See also discussion: 7.1 Occupant engagement and 7.3 Simple controls. Problems associated with entrenched behaviour are particularly prevalent when occupants are not invested in the retrofit process (either intellectually or financially, see 7.1). This issue highlights the need for wraparound retrofit – including training in the use and maintenance of new systems, along with post-retrofit monitoring and support	**ST**	😐	
7.6	**Health issues** Relevant CS: 07	There is significant evidence linking fuel poverty with both physical and mental health issues (LR08). There is also evidence linking retrofit improvements with health benefits (LR28, LR29). 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. However fuel poverty is still reported as being more prevalent in Wales than elsewhere in the UK (LR08). Actual fuel poverty levels may be higher than reported figures, where fuel poor households are hidden by un-metered properties, in rural or off-grid locations.	**MT**	😐	
7.7	**Influencing lifestyle** Relevant CS: 01, 02,10,23,26	Respondents to the questionnaire reflected that 'people' were seen as the least significant challenge associated with preventing the large scale implementation of low carbon housing in Wales. However, elsewhere the scoping review has reported the strong links between engaged/informed occupants and the impact of retrofit on energy consumption and emissions production. One of the key factors in this connection is the degree to which occupants change their behaviour / lifestyle in conjunction with the retrofit. The survey also highlighted that "*the average owner occupier has no concept of why they should spend money on reducing carbon emissions.*" Responses indicated that: • *People, particularly older people, are reluctant to change (heating system, behaviour etc.)* • *People do not know how to use new technologies and are either not provided with clear instructions or are not interested in learning.* • *People don't understand energy in their homes, how their houses work with regards to energy use or carbon emissions.* • *People do not understand why they have to change –they cannot see the value in it.* However, evidence from case studies demonstrates that with appropriate incentives (which may differ widely from household to household) occupants *can* change their lifestyle to maximise the benefits of the system, and to deliver wider long term benefits (e.g. CS02).	**MT**	☹	

section 6. next steps

Looking ahead: stage 2

This final section of the report draws out key recommendations and suggestions from the Stage 1 work that have potential to bear directly on the shape that further work takes.

The work encapsulated by the Stage 1 scoping review has taken place at very particular scales. These distinct scales of operation are articulated diagrammatically on pages 78-81.

Pages 82 to 86 explore the levers that might be employed to drive or encourage the uptake of decarbonisation. A wide range of levers are available, and can be implemented at a range of different scales (see also pp.78-80). A key observation of this section is that different housing tenures are likely to demand different levers.

Pages 87 to 89 discuss the importance of an iterative approach that builds sequentially over a period of time, enabling phased targets to be established and met, and encouraging the development of a coordinated strategic approach.

Pages 90 to 92 explore the level of complexity required of a future route map, by discussing the benefits of a simple or complex approach.

Pages 93 and 94 outline a possible way forwards for future work around decarbonisation of the existing Welsh housing stock.

working at scale

The work encapsulated by the Stage 1 scoping review has taken place at very particular scales. These distinct scales of operation are articulated diagrammatically on pp.79-81, and can be explained as follows:

Most of the case studies concerned individual houses, or a small number of dwellings. In some cases, these activities were standalone actions or improvements to reduce energy consumption and lower carbon emissions (bottom of the diagrams overleaf).

At the next scale of operation, holistic strategies were employed on many case studies, notably those with clear funding sources. These holistic retrofit strategies tended to require a coordinated project team and an integrated approach.

Some of the case study projects were part of a wider retrofit programme, which delivered the added benefit of being able to draw comparisons across projects, to identify transferrable approaches.

There are a small number of databases in existence that already attempt to draw data from across various retrofit programmes and explore strategic decarbonisation. To do so, they tend to pool resources from numerous individual case studies, and offer resources that are potentially applicable to a broader range of situations. The work undertaken within Stage 1 achieves this, providing a cross-cutting database of relevant case studies and literature, indexed and tabulated for easy access.

The *next steps* (see p.81 and pp.93-94) are to build a bridge to connect this resource (Stage 1) directly to the Welsh housing stock. To do so, it is necessary to understand the challenge posed by the existing housing stock, through an analysis of the constraints (top two sections of the diagram overleaf). One way to obtain this understanding is by developing a taxonomy of house archetypes that describes in relative terms the makeup and condition of the existing housing stock…

UNDERSTANDING THE CHALLENGE:
the housing stock as a whole

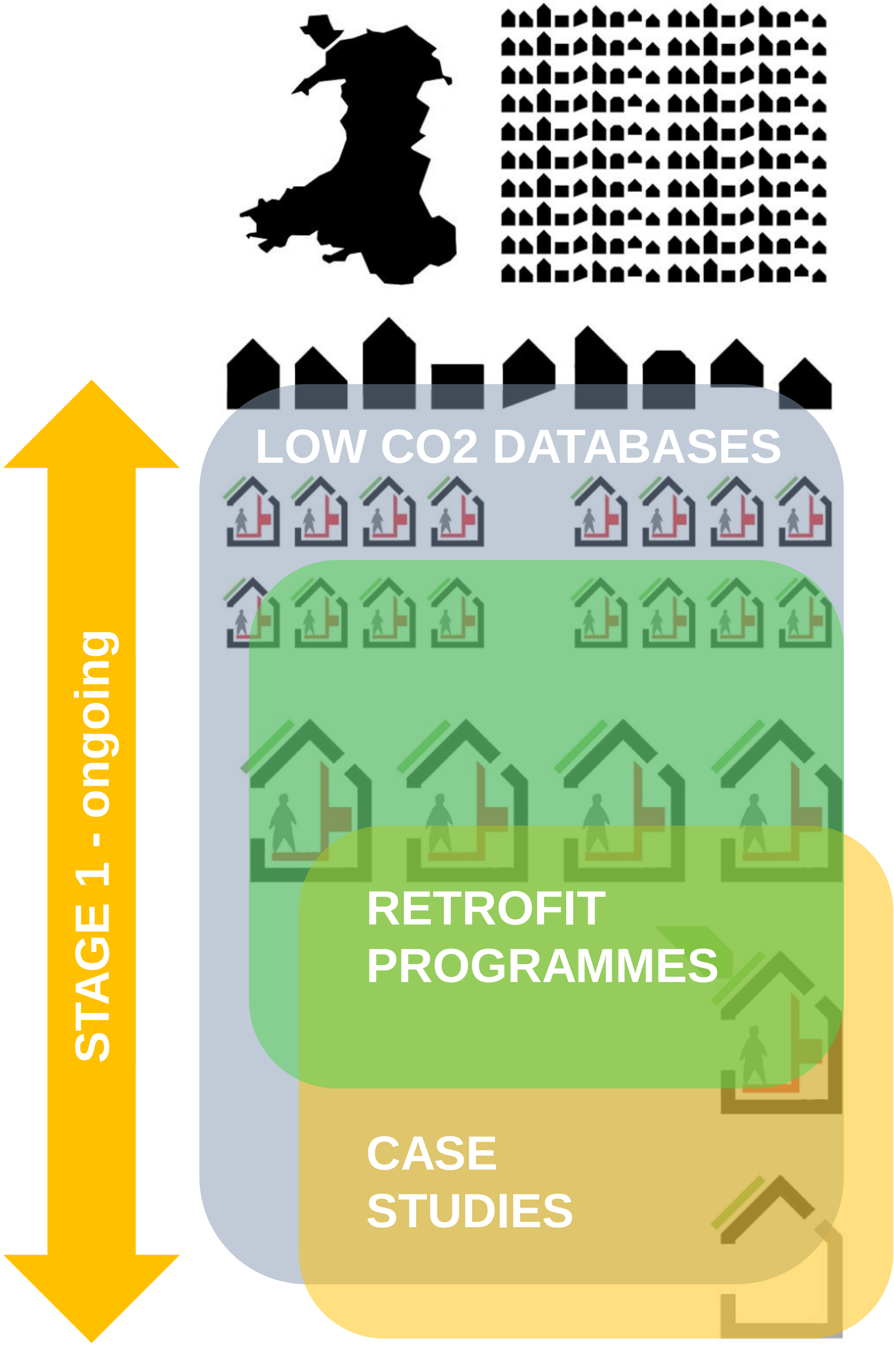
ANALYSING THE CONSTRAINTS:
a taxonomy of dwelling types

STRATEGIC DECARBONISAITION:
Integrated approaches, multiple locations

TRANSFERABLE APPROACHES:
Multiple dwellings – group, street, estate…

HOLISTIC STRATEGY:
Multiple actions, single dwelling

QUICK WINS?
Standalone actions for lower carbon



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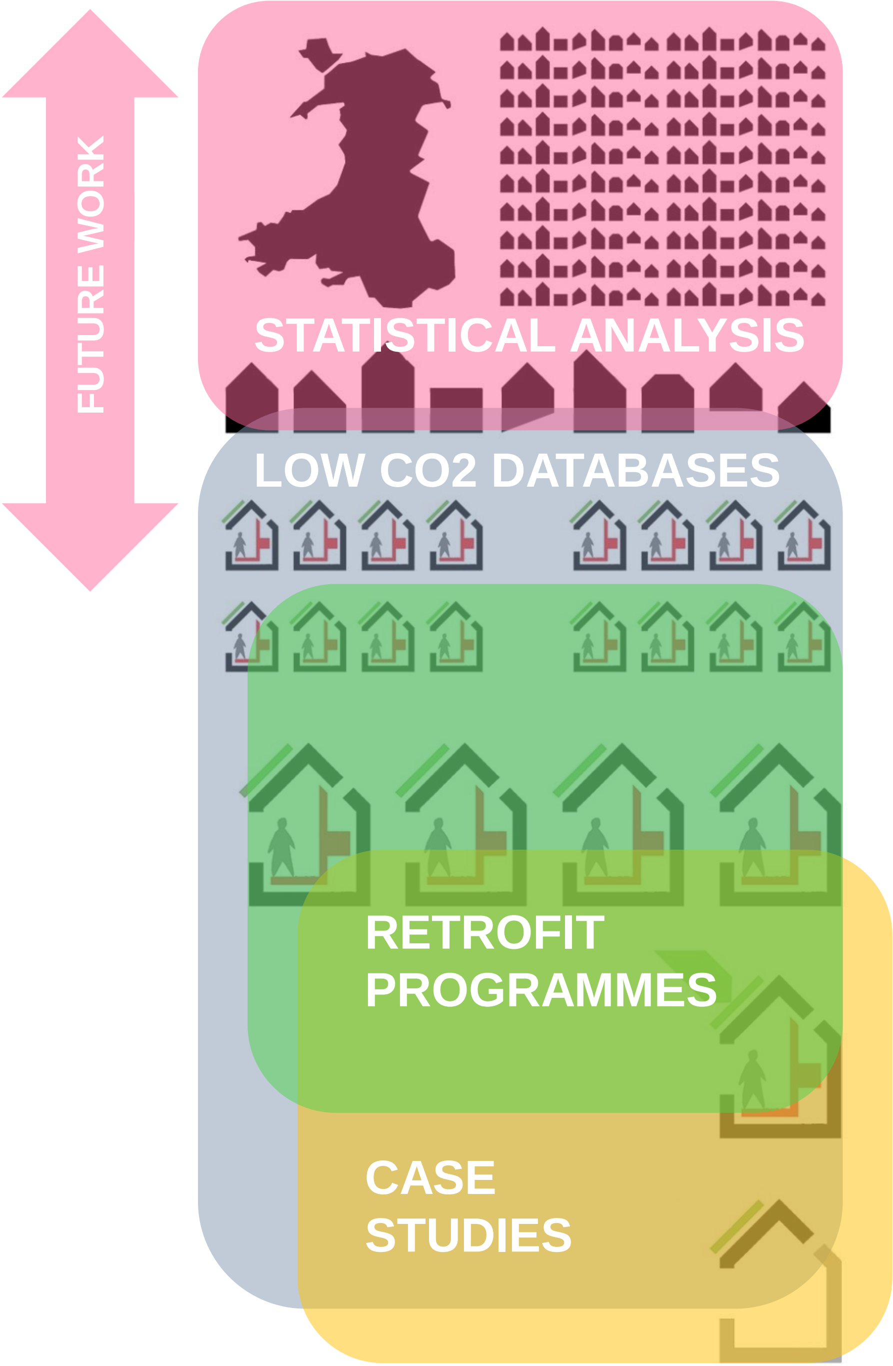

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Multiple dwellings – group, street, estate…

HOLISTIC STRATEGY:
Multiple actions, single dwelling

QUICK WINS?
Standalone actions for lower carbon

Next steps

Levers

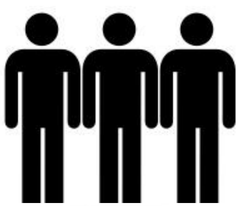
A wide range of levers have potential to assist in encouraging or enforcing decarbonisation of the existing housing stock. The FIRST STAGE REPORT has identified the following levers for improvements (actions and pathways) associated with decarbonisation of the existing housing stock:

Performance standards:

- Building regulations
- Housing standards
- NDF, planning and development orders

Financial incentives:

- Loans
- Procurement
- Funding / retrofit programmes
- Tax incentives
- Good deals (cost subsidy / economy of scale)
- Reduced running costs
- reduced maintenance costs



Advisory support:

- Quality assurance
- Technical advice
- Community advice

Personal agenda:

- Moral obligation / improving behaviour
- Changes in expectations
- Increased comfort
- Improved health

Next steps

Levers

These levers can be implemented at a range of different scales. Some could be administered at a national scale, whether that be UK, or via Welsh Government:

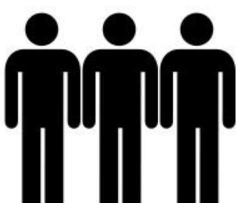
NATIONAL?

Performance standards:

- Building regulations
- Housing standards
- NDF, planning and development orders

Financial incentives:

- Loans
- Procurement
- Funding / retrofit programmes
- Tax incentives
- Good deals (cost subsidy / economy of scale)
- Reduced running costs
- reduced maintenance costs



Advisory support:

- Quality assurance
- Technical advice
- Community advice

Personal agenda:

- Moral obligation / improving behaviour
- Changes in expectations
- Increased comfort
- Improved health

Levers

Some of these levers could be administered at a local level, through local authorities, housing associations or via community groups:

NATIONAL?

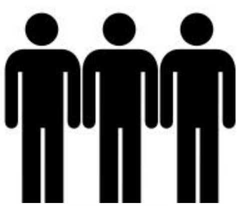
LOCAL?

Performance standards:

- Building regulations
- Housing standards
- NDF, planning and development orders

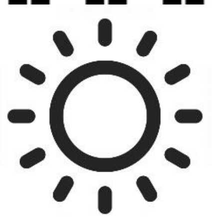
Financial incentives:

- Loans
- Procurement
- Funding / retrofit programmes
- Tax incentives
- Good deals (cost subsidy / economy of scale)
- Reduced running costs
- reduced maintenance costs



Advisory support:

- Quality assurance
- Technical advice
- Community advice



Personal agenda:

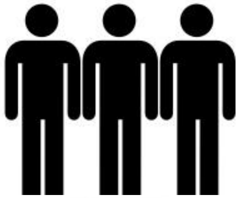
- Moral obligation / improving behaviour
- Changes in expectations
- Increased comfort
- Improved health

Levers

Some of the levers have a project-specific component, either in terms of the nature of the project, the aspirations of the occupant, or the moral intentions of the project team:

Performance standards:

Financial incentives:



Advisory support:

Personal agenda:

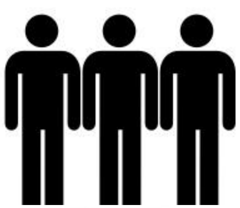
Next steps

Levers

It is anticipated that TENURE of housing stock will have a significant impact on which levers are most appropriate or effective. The Energy Efficient Scotland route map, for example, stratifies their Decarbonisation strategy specifically by tenure:

Performance standards:

Financial incentives:



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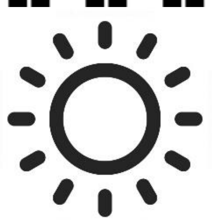
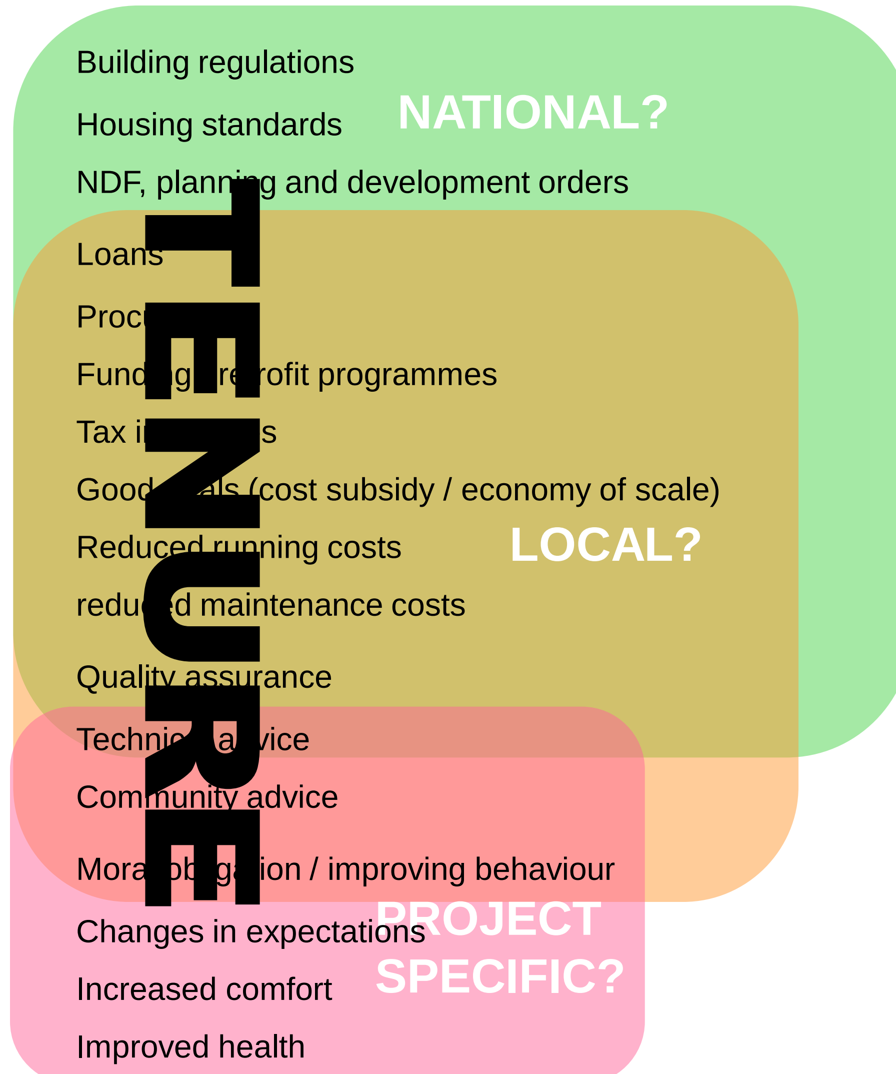


Personal agenda:



Goals

Welsh Government will need to establish the priorities of the decarbonisation programme and these priorities will, in turn, establish more concrete goals for the programme.

As previously identified, the Wellbeing of Future Generations Act (2015) provides a valid framework for establishing a broad, holistic range of goals, but these priorities go beyond those demanded by a focus purely on decarbonisation, and will result in different actions and pathways.

For example, an exclusive focus on emissions could engender a very ‘systems’ heavy approach, whereas an aspiration to address affordable warmth / fuel poverty / quality of homes will necessitate a broader range of actions including a clear focus on building fabric. While decarbonisation of energy (principally electricity) at point of supply reduces the degree to which retrofit must be used to improve *fabric* efficiency as part of a decarbonisation strategy, it misses opportunities to improve dwelling quality and could increase fuel costs / fuel poverty.

Future work should target an holistic understanding of the implications of actions that focus on *fabric*, *systems* and *energy,* to facilitate more informed decision-making around programme priorities and goals.

Next steps

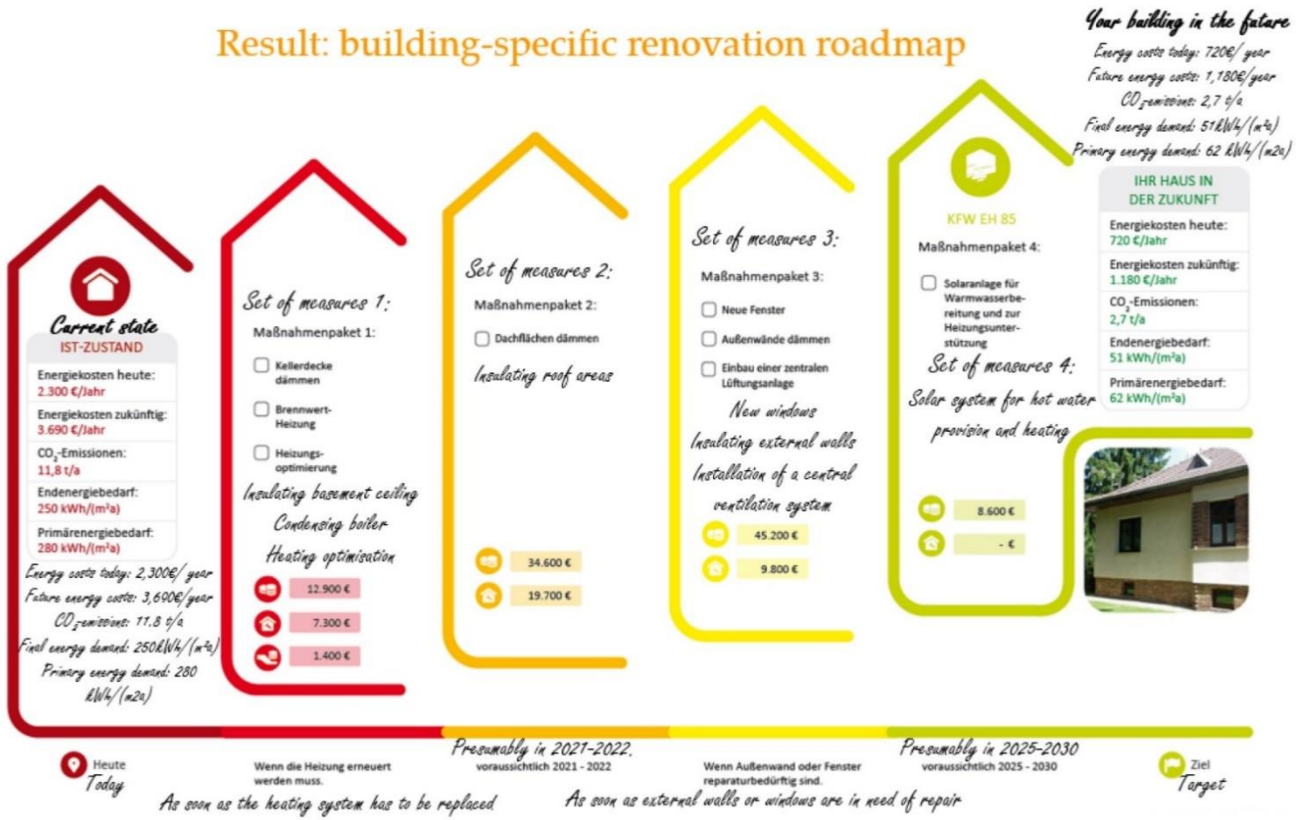
an iterative approach

The Building Renovation Passports approach trialled in several European countries (LR32) provides a model for an iterative approach. Improvements are made in an augmented EPC model, providing a series of clear phased improvements to an individual dwelling or dwelling type. Each phase is explained in terms of impact on energy and carbon and associated financial cost. Together the cumulative phased improvements deliver a roadmap for the target level of improvement.

This approach allows actions to be placed in order of priority, whether this be based on cost, feasibility, impact etc.

It allows actions to be delivered in packages, potentially at volume, for economies of scale and in tandem with skills and supply chain-building.

It enables performance-based targets to be aligned with carbon budgets.



Source: LR32 **Building Renovation Passports:** customised roadmaps towards deep renovation and better homes. Buildings Performance Institute Europe (BPIE. Authors Fabbrie, De Groote and Rapf, 2016)

Next steps

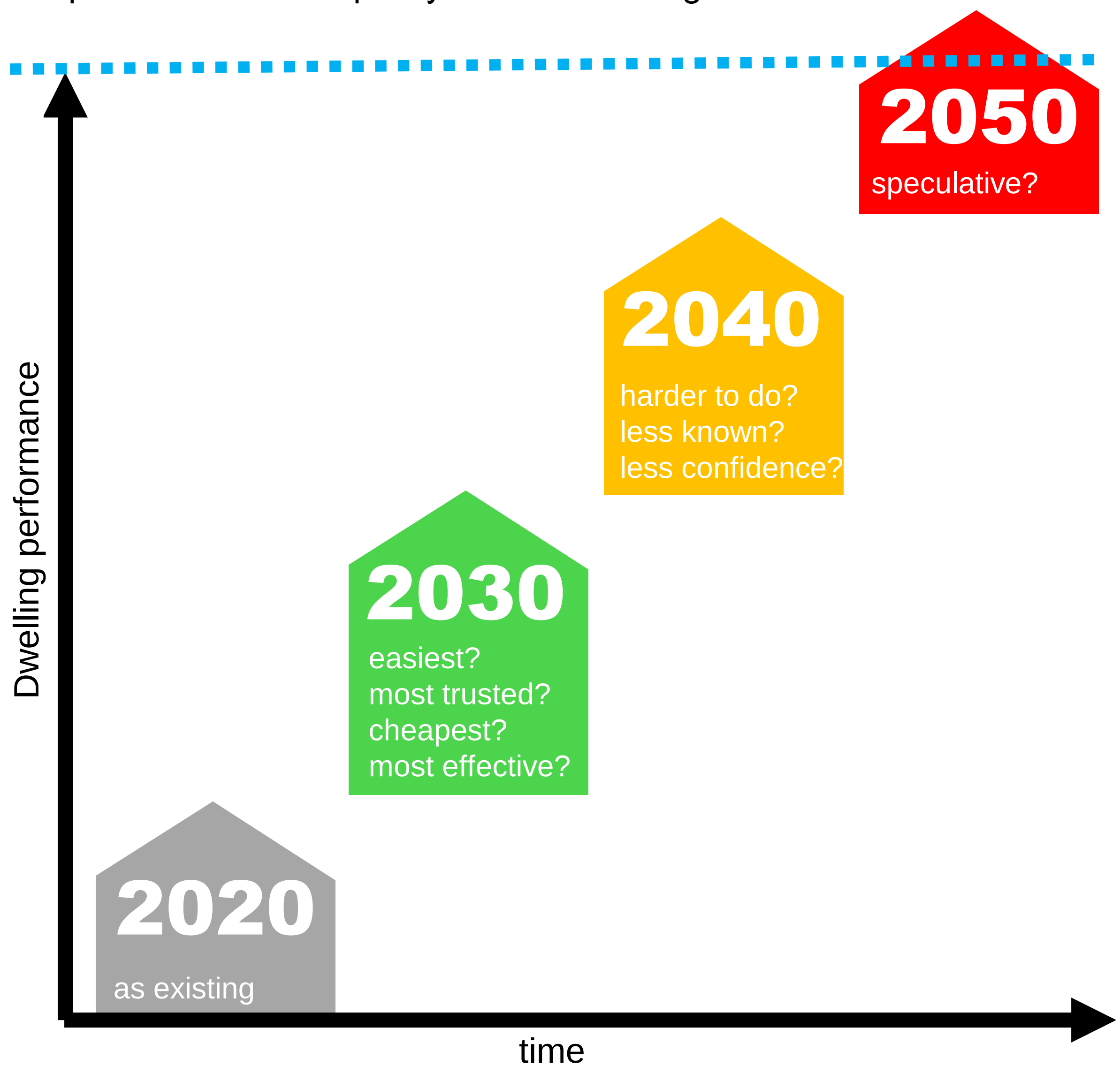
an iterative approach

Each dwelling **type** may follow an iterative approach - a pathway made up of sequential packages of actions, designed to improve performance and quality while controlling cost…

GOALS

- >80% carbon reduction
- Local / Wales supply chain
- greater climate resilience
- reduce burden on healthcare
- affordable warmth for all
- community-led action
- improved placemaking

LEVERS



Next steps

an iterative approach

GOALS

>80% carbon reduction

Local / Wales supply chain

greater climate resilience

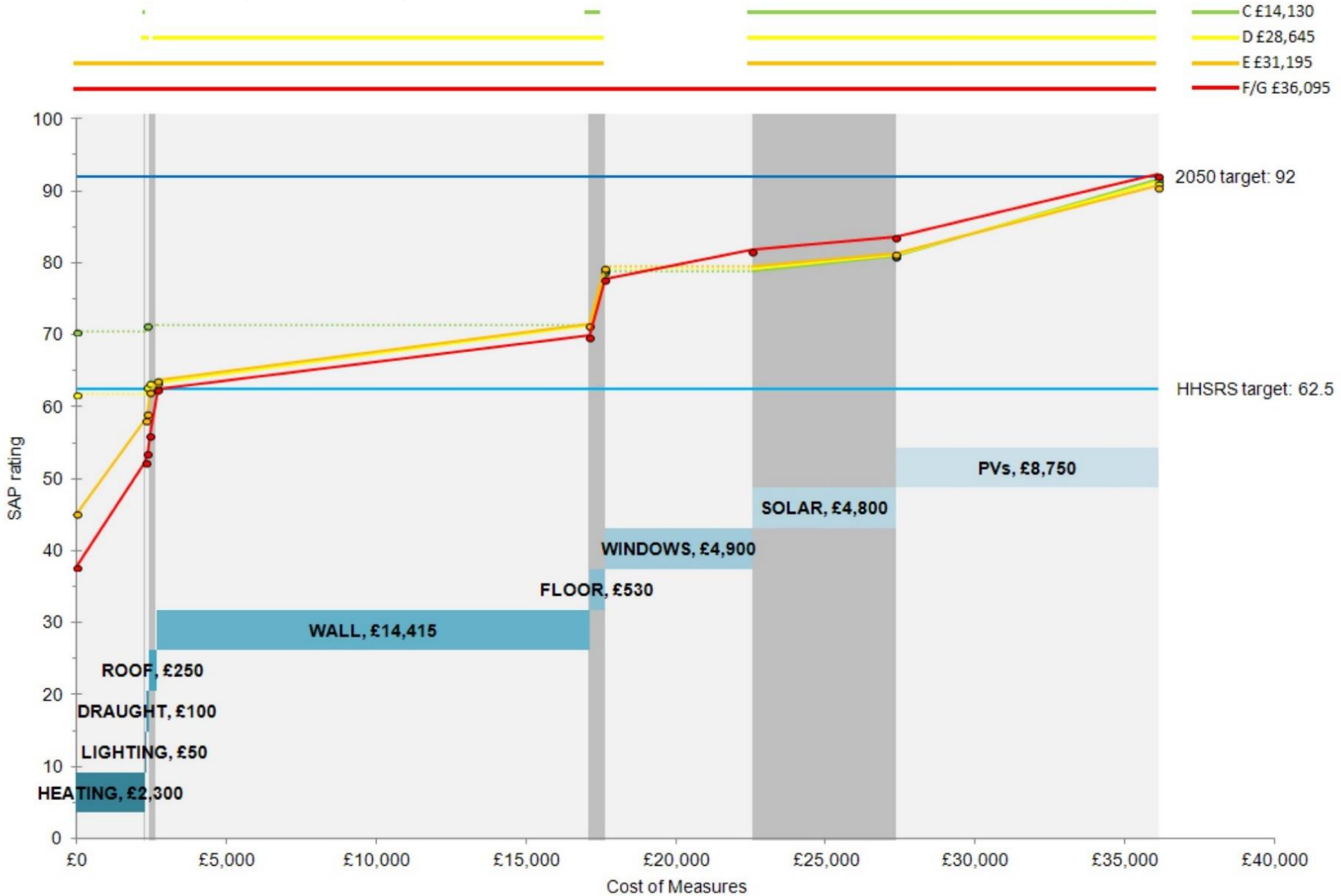
reduce burden on healthcare

affordable warmth for all

community-led action

improved placemaking

This example is for a pre-1919 end terrace or semi-detached dwelling, taking a staged 'systems first' approach to delivering a target SAP of 92, equivalent to an EPC A-rating. (Ref. LR37: Energy and Environmental Report: Castleland Stage2.)
Impact on SAP rating is shown vertically, and cost of measures on the horizontal axis. Above the graph, total capital costs are shown for different baseline starting points.

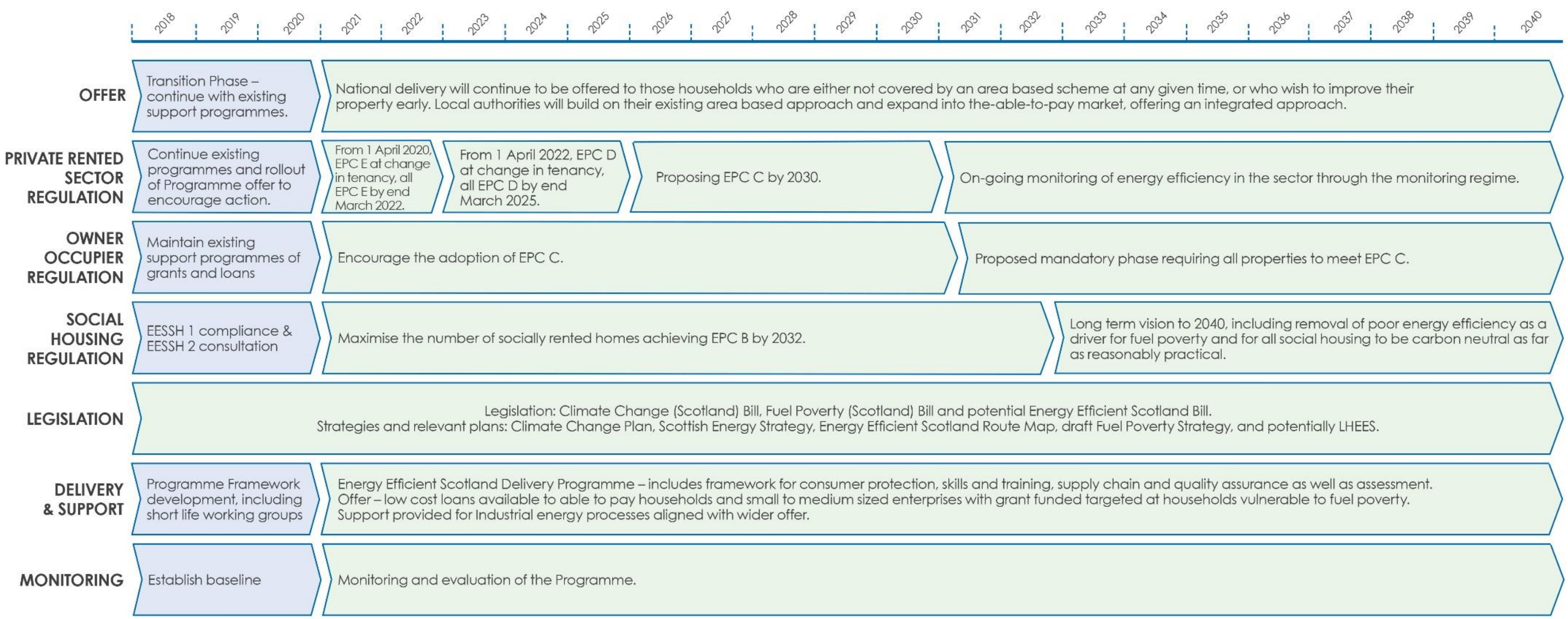


Next steps

complexity

The Scottish route map (see flowchart diagram below) sets performance targets using EPC figures. It recognises the importance of tenure, subdividing targets and levers into ‘private rented’, ‘owner occupied’ and ‘social housing’. There is an additional focus on affordable warmth for all.

However because of this low level of specificity, there is limited detail to the route map, and many of the more challenging aspects of the strategy remain at consultation stage. In order to make more explicit recommendations, a more complex breakdown of the existing housing stock is needed.



Source: LR22 **Energy Efficient Scotland: a route map**. Scottish Government 2018 http://www.gov.scot/Publications/2018/05/1462

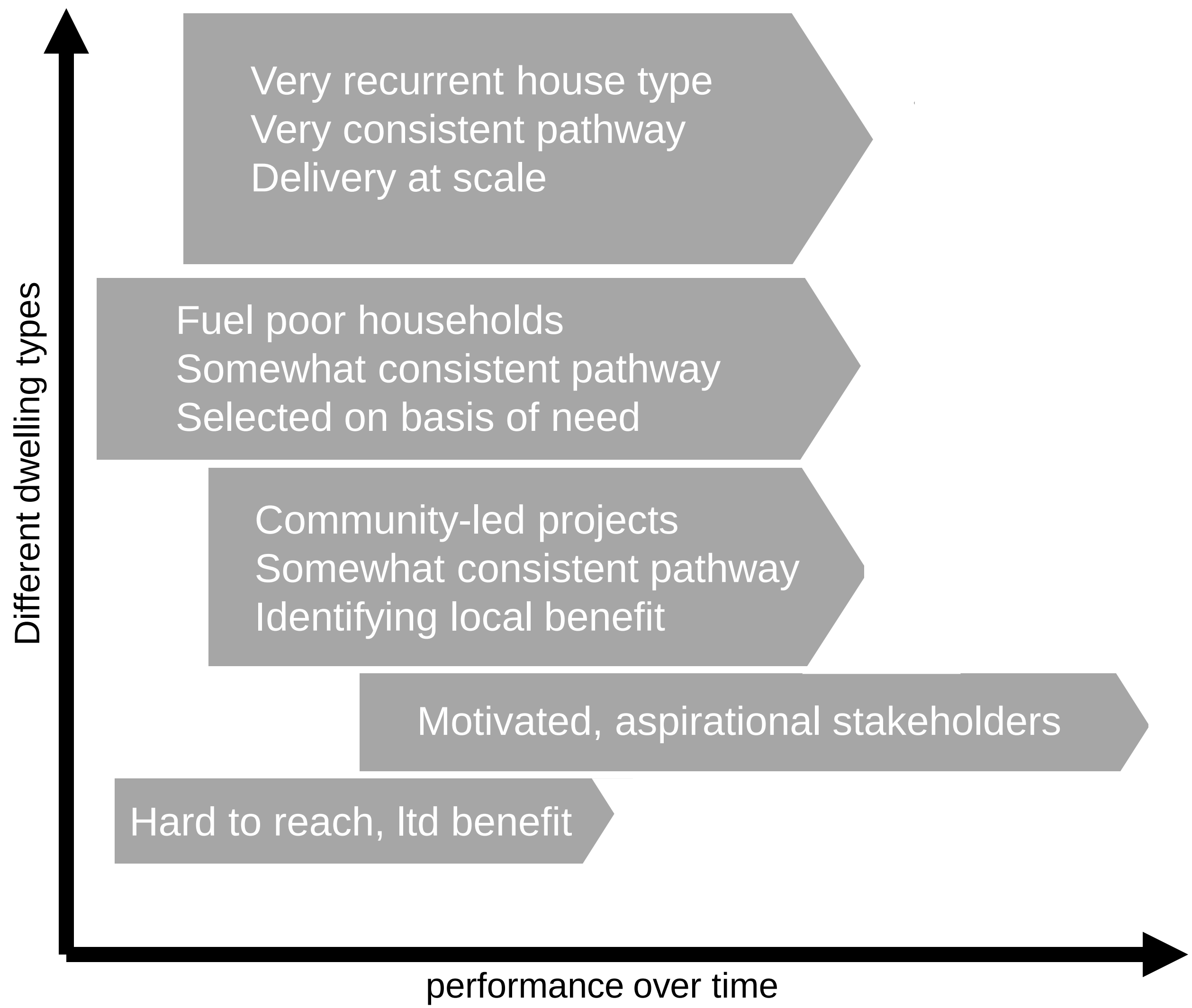
Next steps

GOALS
>80% carbon reduction
Local / Wales supply chain
greater climate resilience
reduce burden on healthcare
affordable warmth for all
community-led action
improved placemaking

LEVERS

complexity

A more sophisticated understanding of the existing stock allows distinct, iterative pathways to be developed for different dwelling types (in terms of physical form, occupant, location etc…)



Next steps

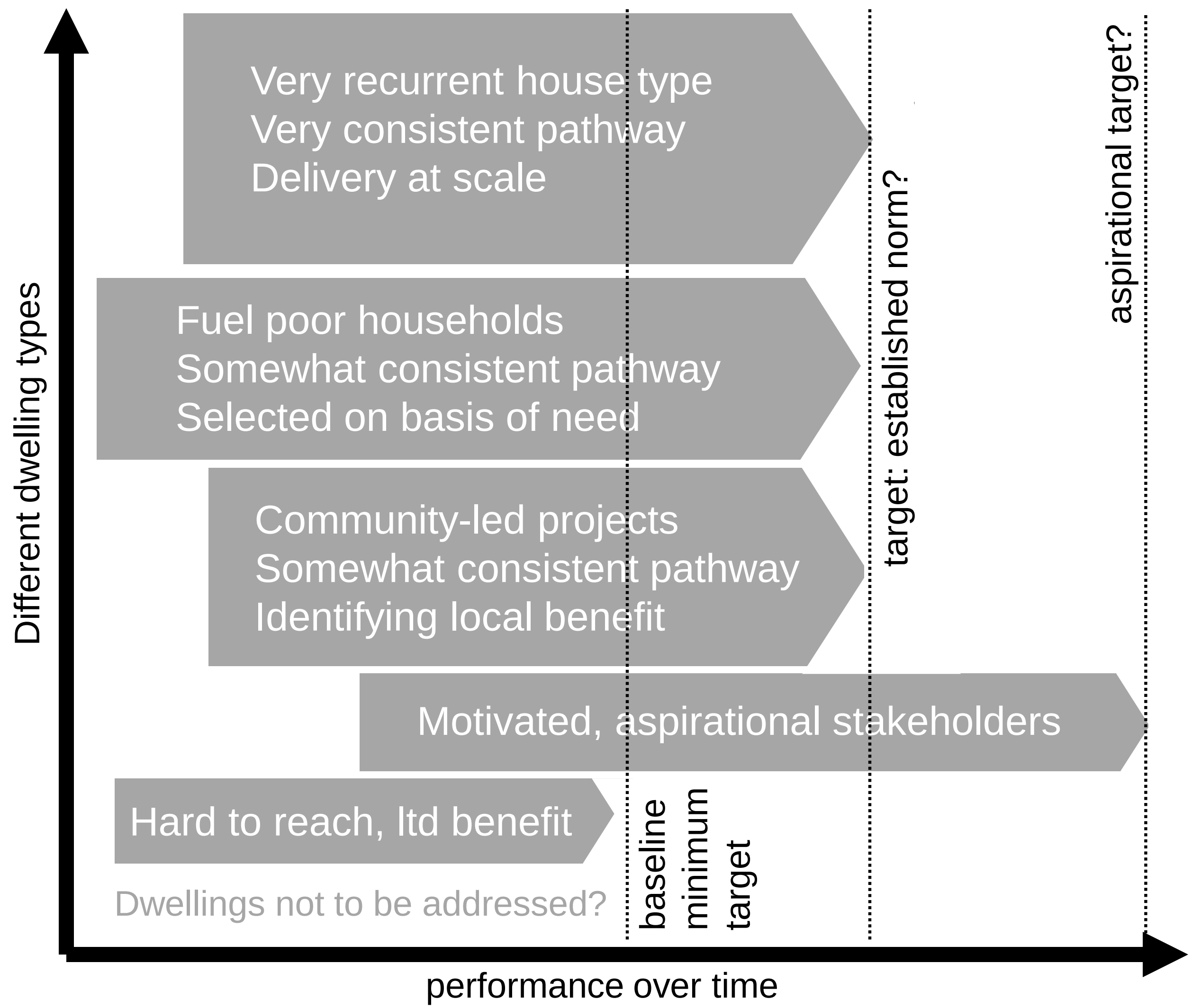
complexity

Different dwelling tenures, types and pathways will necessitate different levers, and there may be benefits in establishing different performance-based targets...

GOALS

- >80% carbon reduction
- Local / Wales supply chain
- greater climate resilience
- reduce burden on healthcare
- affordable warmth for all
- community-led action
- improved placemaking

LEVERS



Next steps

a three stage programme?

The Stage 1 scoping review takes a first step towards understanding the options available to Welsh Government in the development of a national decarbonisation strategy for housing, by building an evidence base.

What might further stages of the programme look like?

Decarbonising Welsh Housing between 2020 and 2050:

Stage 1

SCOPING REVIEW: WHAT WORKS & WHAT MIGHT WORK

- Building an evidence base for 'what works' from relevant case studies.
- Exploring ongoing innovation through relevant literature.
- Collating strategic guidance from key sources.

Stage 2

SYNTHESISING SOLUTIONS: UNDERSTANDING THE OPTIONS

- Synthesis - mapping lessons learnt from Stage 1 onto the Welsh housing stock.
- Understanding retrofit options in terms of carbon, cost and quality, and in terms of the housing stock as a whole.

Stage 3

MAKING DECISIONS: TOWARDS A ROUTE MAP

- Identifying priorities for the housing decarbonisation programme
- Designing a route map using Stage 2 understanding that can meets international targets and delivers on programme priorities.

Next steps

next steps in more detail

Further work should synthesise the understanding gained in stage 1, by applying it to the specifics of the existing Welsh housing stock. This should inform a discussion of decarbonisation pathways that gives consideration to *condition, cost* and *quality*:

Step:	**2.1**	**2.2**	**2.3**	**2.4**
Method:	Data from the current (2016) EPC data set is used to produce a taxonomy of the existing Welsh housing stock based on established dwelling 'archetypes'.	The dwellings grouped under each 'archetype' are analysed, to discuss variation within each group in terms of age, type, etc. WHCS data inform a discussion of condition and quality.	A 'best fit' pathway is established for each notional dwelling archetype, and then modelled (using SAP, EPC) for impact on emissions, cost and quality.	The individual archetype models are re-combined to allow a discussion of pathways and options for creating a route map for the housing stock as a whole.
Outputs:	Taxonomy of (around twenty) notional dwelling 'archetypes'. The parameters for each archetype are based on physical characteristics.	Detailed understanding of each archetype. In addition to condition and quality (from WHCS 2018), dwelling archetypes will be cross checked for consistency against age, type, tenure etc.	Predicted impact of proposed pathway for each archetype, in terms of emissions reduction, cost and impact on quality. Revised EPC's, to inform discussion of future performance standards.	Results gained in 2.3 are mapped back up to national scale, to provide an indication of how actions and pathways selected for notional dwelling archetypes impact one the housing stock as a whole.