Homes of today for tomorrow

Decarbonising Welsh Housing between 2020 and 2050

Housing Information Group

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CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Decarbonising Welsh Housing between 2020 and 2050

STAGE 1

April 2018 to September 2018

A scoping review combining retrofit best practice and relevant publications to understand ‘what works’ and begin to establish decarbonisation pathways.

STAGE 2

November 2018 to July 2019

A modelling exercise to understand the size and shape of the Welsh housing stock, and its potential to be decarbonised - based on the existing knowledge base.

STAGE 1 - understanding the challenge

Legislation requires at least 80% reduction in carbon emissions by 2050 (vs 1990 levels).

CCC has stated that Wales should target >95% reduction in carbon emissions by 2050.

Housing is responsible for 21% of Welsh carbon emissions.

90% of existing Welsh homes are likely to remain in use in 2050.

Wales has one of the oldest housing stocks in Europe.

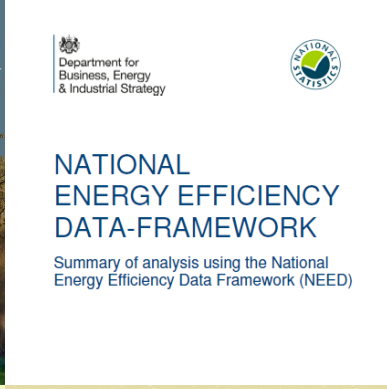
The stock is diverse, in terms of type and condition.

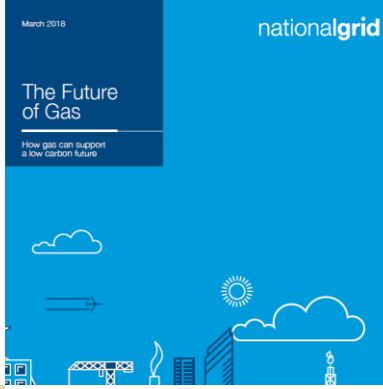
A decarbonisation pathway must deliver holistically against WFGA.


RETROFIT
FOR THE FUTURE
Technology Strategy Board


On completion, 24 properties achieved carbon emissions less than half of the national average.
3 houses achieved 80% - 90%
less carbon emissions than the national average
10 houses achieved 70% - 80%
less carbon emissions than the national average
11 houses achieved 50% - 70%
less carbon emissions than the national average

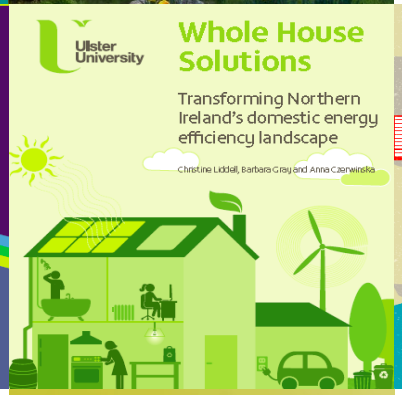

Llywodraeth Cymru
Welsh Government
www.gov.wales


Department for
Business, Energy
& Industrial Strategy
NATIONAL
ENERGY EFFICIENCY
DATA-FRAMEWORK
Summary of analysis using the National
Energy Efficiency Data Framework (NEED)


March 2018
nationalgrid
The Future
of Gas
How gas can support
a low carbon future

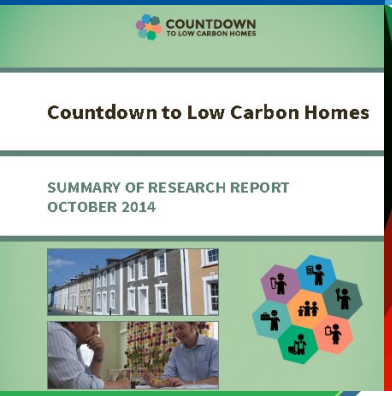

Sustainable technologies
The experience of housing associations

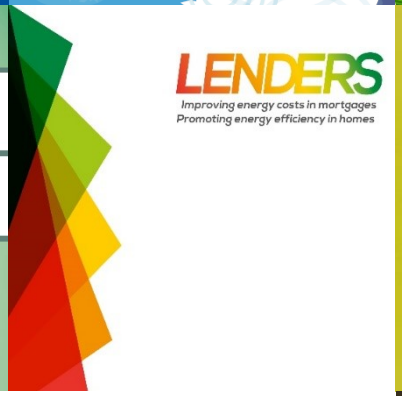

UK Fuel Poverty Monitor
2016 - 2017
A review of progress
across the nations

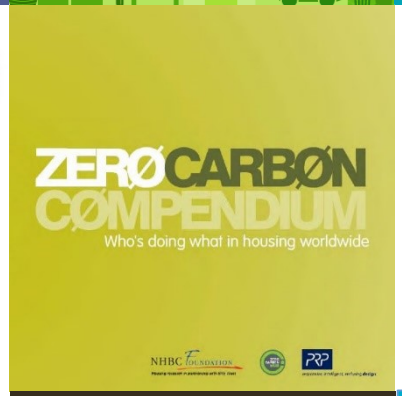

Ulster University
Whole House
Solutions
Transforming Northern
Ireland's domestic energy
efficiency landscape
Christine Liddell, Barbara Gray and Anna Czerwinska


WARMER & GREENER:
A GUIDE TO THE FUTURE
OF DOMESTIC ENERGY
EFFICIENCY POLICY


Technology Strategy Board
Driving Innovation
Design for future climate
Opportunities for adaptation in the built environment


COUNTDOWN
TO LOW CARBON HOMES
Countdown to Low Carbon Homes
SUMMARY OF RESEARCH REPORT
OCTOBER 2014

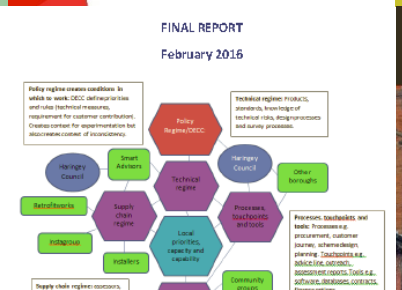

LENDERS
Improving energy costs in mortgages
Promoting energy efficiency in homes


ZERO CARBON
COMPENDIUM
Who's doing what in housing worldwide
NHBC FOUNDATION

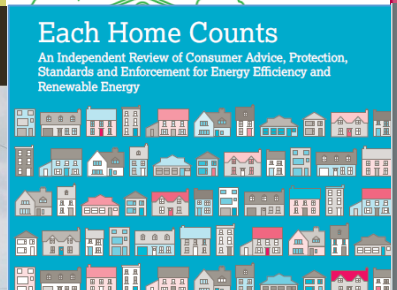

Energy Efficient Scotland


Freedom Project
Freedom
Project
Interim Report

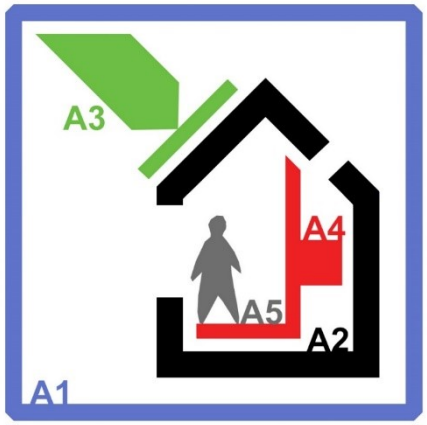

Energy Efficient Mortgages
Pilot Scheme
Implementation &
Product Framework


FINAL REPORT
February 2016


RESEARCH INTO THE THERMAL PERFORMANCE
OF TRADITIONAL BRICK WALLS

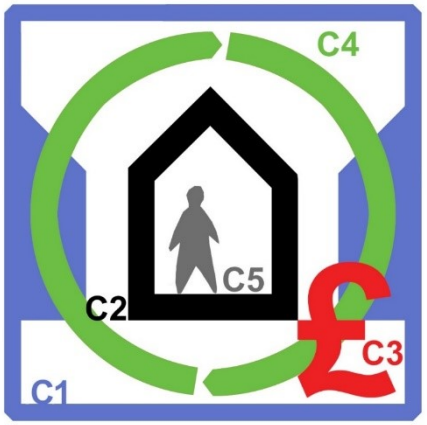

Each Home Counts
An Independent Review of Consumer Advice, Protection,
Standards and Enforcement for Energy Efficiency and
Renewable Energy


marion baeli
residential
retro
fit



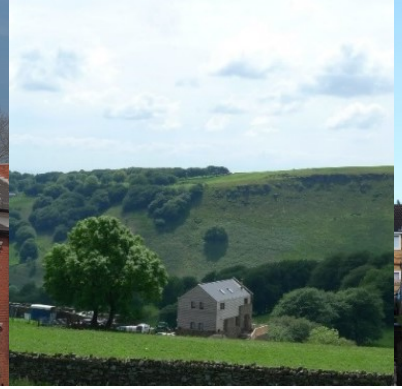
Five categories for retrofit *actions*:

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



Five categories for *challenges* to retrofit:

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


timescale

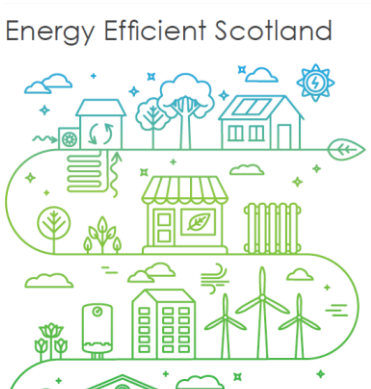
LT Long Term

MT Medium Term

ST Short Term

confidence

☹ anecdotal ☐ documented ☺ understood



1		STRATEGIC actions and challenges	time	conf	RAG
1.2	**Energy sources** Relevant CS: 9,10	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**	☹	
1.4	**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 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

STAGE 1 - findings

There is considerable scope to develop appropriate retrofit strategies utilising actions that are understood, and skills and products that are widely available.

Retrofit actions affecting dwelling fabric are best understood. Renewables and systems-based actions involve more emerging technologies. People represent the least understood aspect of retrofit, and introduce the most uncertainty around effectiveness, making future work around lifestyle and behaviour change particularly important.

The physical size and shape of a dwelling are not necessarily factors that change the approach taken to retrofit, apart from purpose built flats which are prone to overheating. However, these characteristics have considerable impact on capital cost and energy costs.

The selection of retrofit actions is more likely to be informed by the current condition and location of the dwelling, by which retrofit actions have previously been undertaken, and in some cases by the personal choice of the occupant / owner.

STAGE 2 :
modelling decarbonisation of the Welsh housing stock

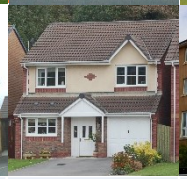
What it included:

- 14 dwelling models to represent the Welsh housing stock.
- 4 retrofit narratives to explore domestic retrofit options.
- 3 energy supply scenarios to investigate the impact of cleaner energy.
- Assumptions made to model the housing stock as a whole.
- Recommendations that informed Independent Advisory group report: *Better Homes, Better Wales, Better World.*

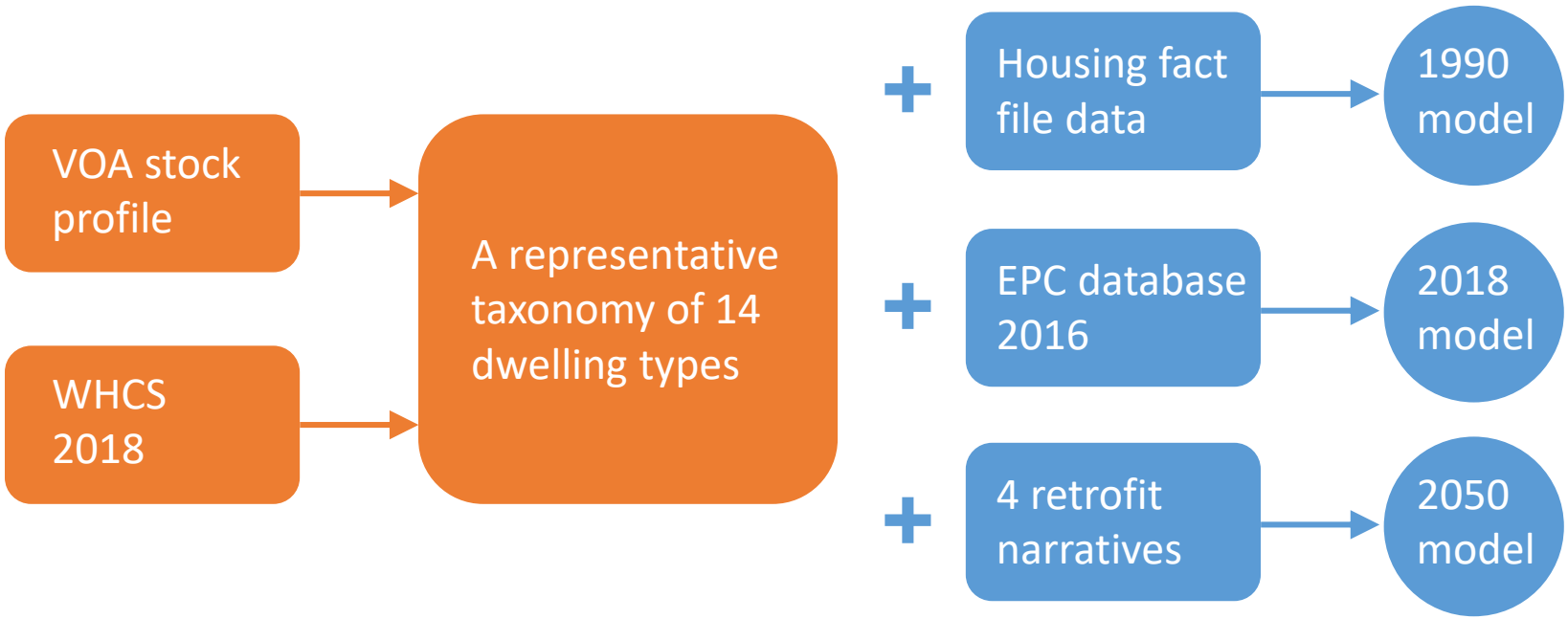
STAGE 2 : A representative taxonomy of 14 dwelling types

	HOUSE End terrace	HOUSE Mid terrace	HOUSE Semi-detached	HOUSE Detached	FLAT (Purpose built)	Total
pre 1919	3%	9%	4%	7%		23%
1919-1944			5%			5%
1945-1964			10%			10%
1965 - 1990	4%	6%	10%	9%	4%	33%
post 1990			5%	7%	1%	13%
Total	7%	15%	33%	23%	6%	84%

STAGE 2 : A representative taxonomy of 14 dwelling types

	HOUSE End terrace	HOUSE Mid terrace	HOUSE Semi-detached	HOUSE Detached	FLAT (Purpose built)	Total
pre 1919						23%
1919-1944						5%
1945-1964						10%
1965 - 1990						33%
post 1990						13%
Total	7%	15%	33%	23%	6%	**84%**

Modelling the housing stock at three points in time



Four retrofit narratives for the 2050 simulation:

good practice

Actions are driven by best value – in terms of affordability, cost effectiveness, and availability of skills and resources in the current marketplace.
Equivalent to current Building Regulations.
Primary energy is mains gas.

best practice

Assumes an aspirational client or owner occupier, likely to be more concerned with long term quality than cost. Environmental impact is a priority.
Exceeds current Building regulations.
Primary energy is electricity.

heritage

Actions are constrained, e.g. as a result of listed building status or within a conservation area. Impact on exterior appearance is assumed to be challenging.
Does not meet current Building Regulations.
Primary energy is mains gas.

rural

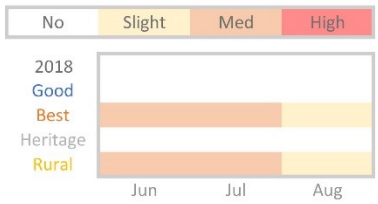
Location or context dictates off grid energy solutions. As a result the focus is on energy conservation and use of locally viable renewables.
Exceeds current Building regulations.
Primary energy is electricity.

3 energy supply scenarios to investigate the impact of cleaner energy:

Scenario 1 **minor improvement**	Modest improvement on the existing energy supply infrastructure, currently 34% cleaner than in 1990 (BEIS 2017)	**40%**
Scenario 2 **significant improvement**	Significant continued improvement of the national grid, with 60% of all energy generated without carbon emissions.	**60%**
Scenario 3 **transformational change**	This scenario represents transformation of the national grid to a low carbon energy supply infrastructure.	**80%**

Dwelling type 2: Mid terrace pre 1919
Scenario 1

Overheating Risk



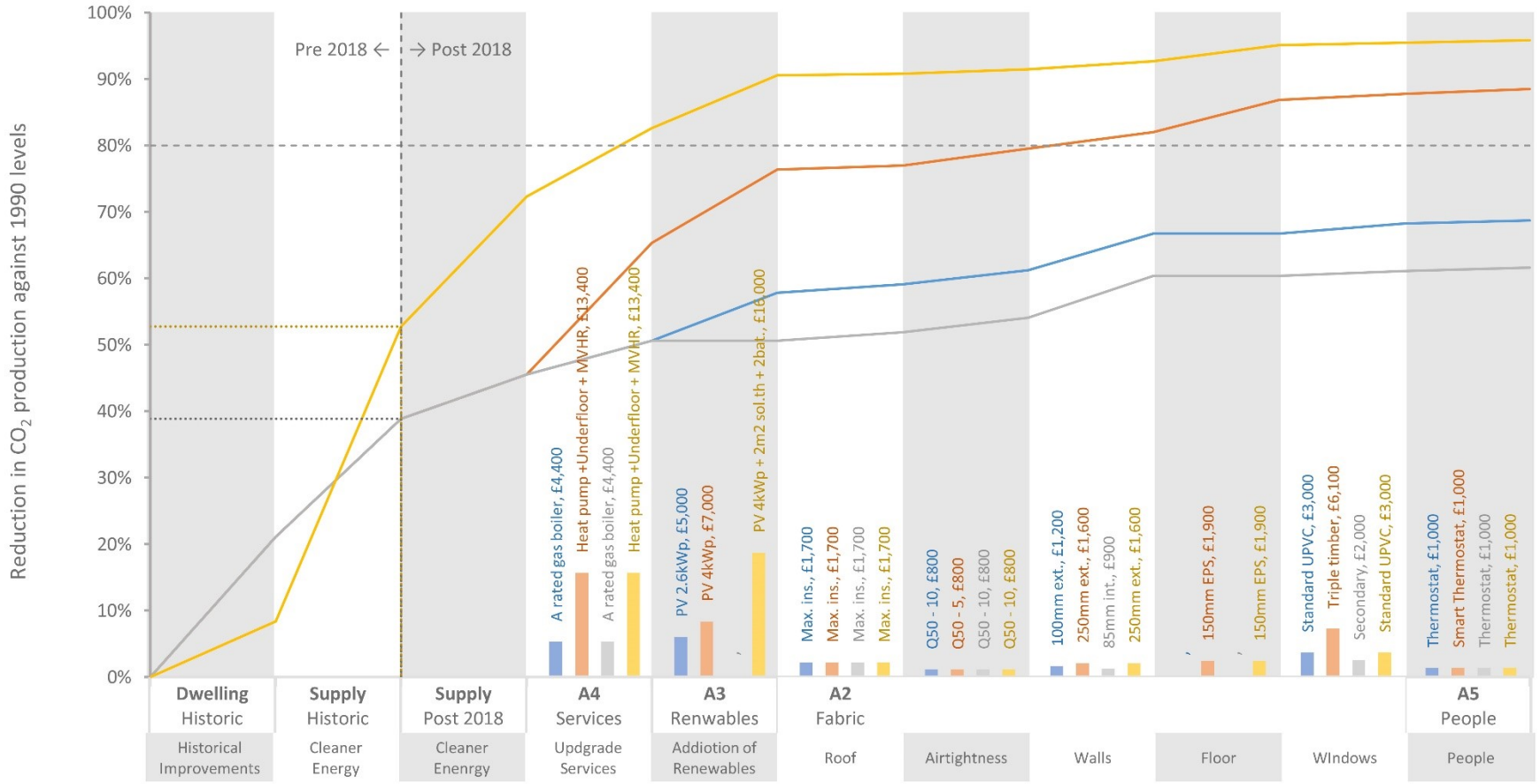
Good Practice

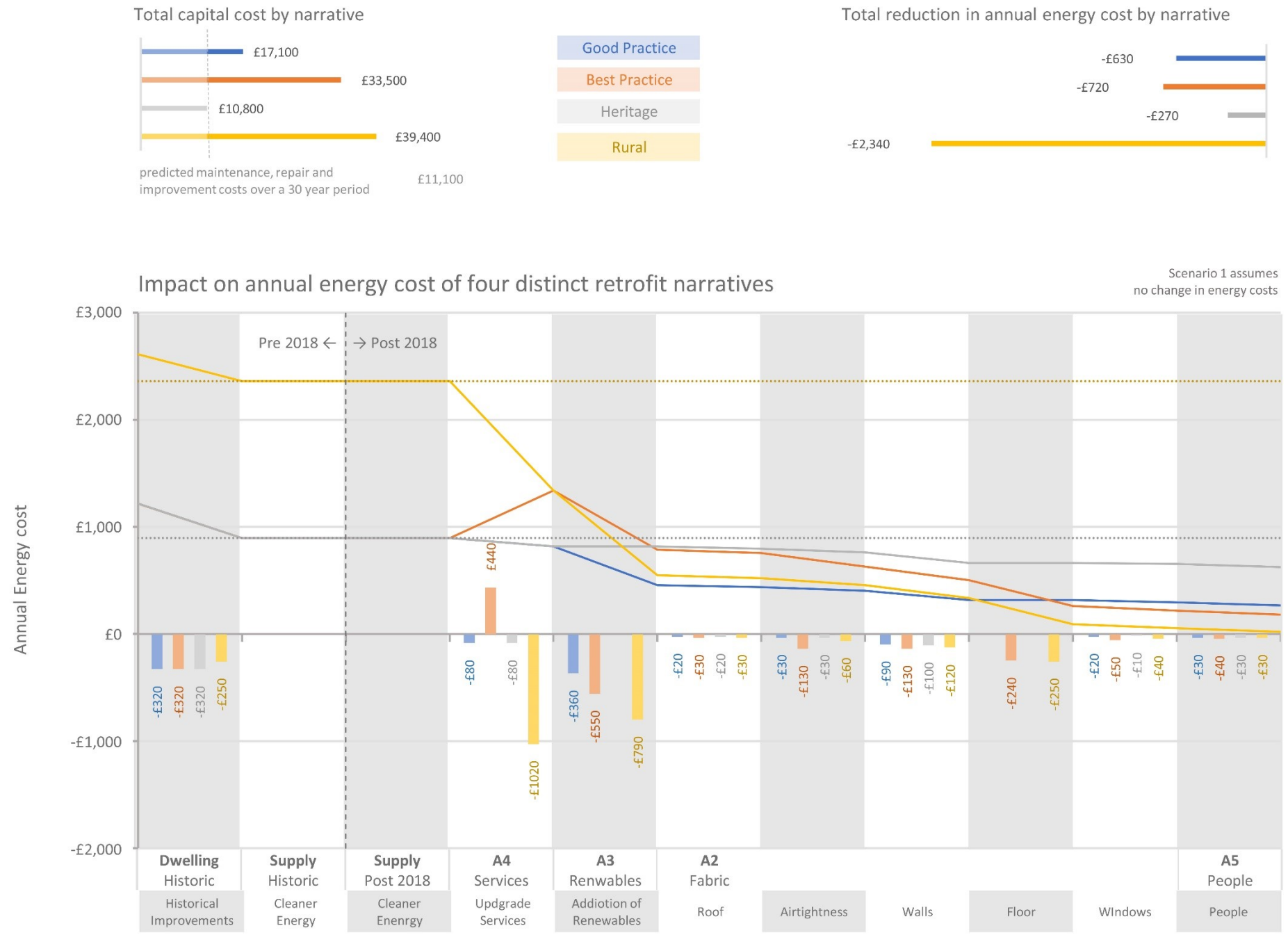
Best Practice

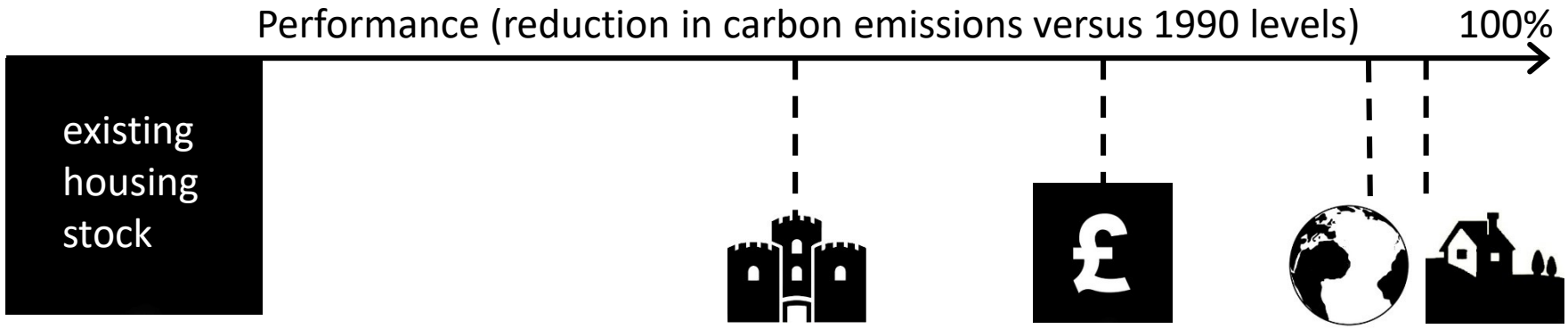
Heritage

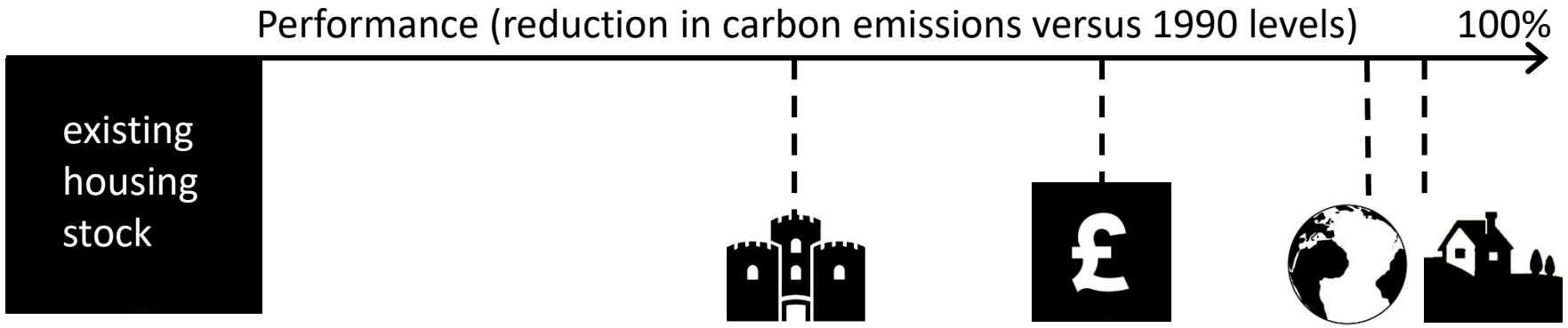
Rural

Impact on carbon emissions of four distinct retrofit narratives, each with costed actions

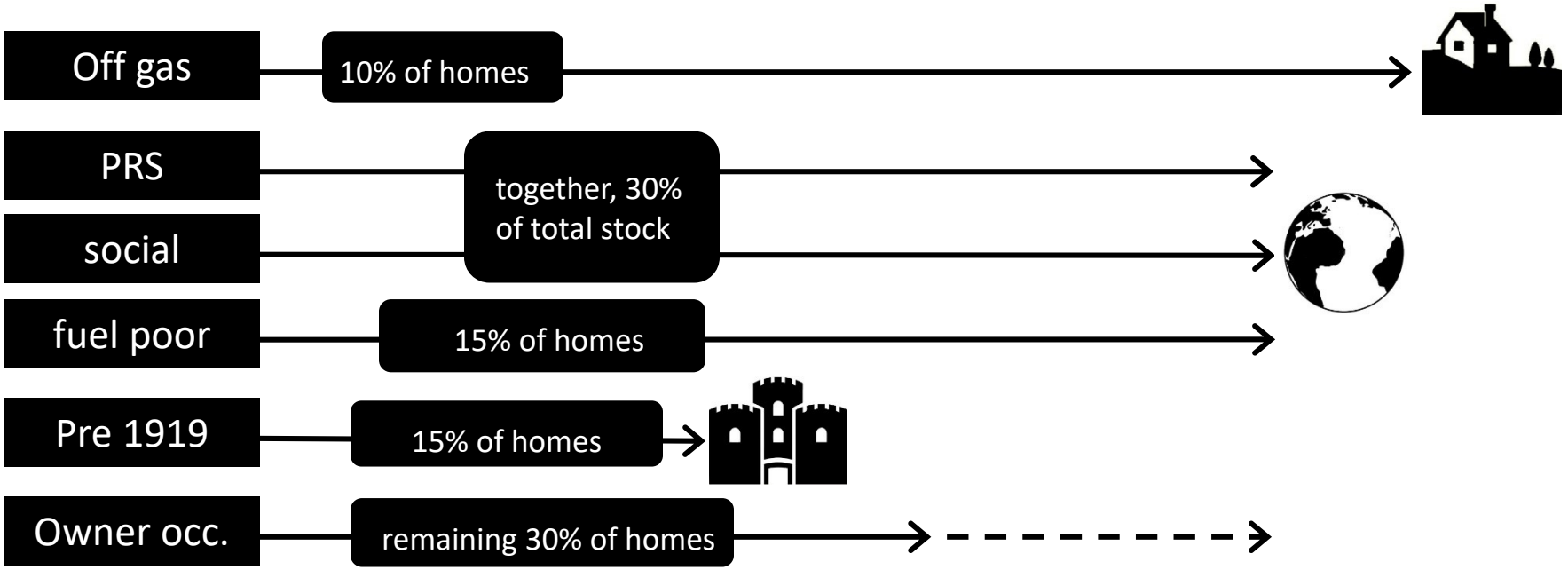


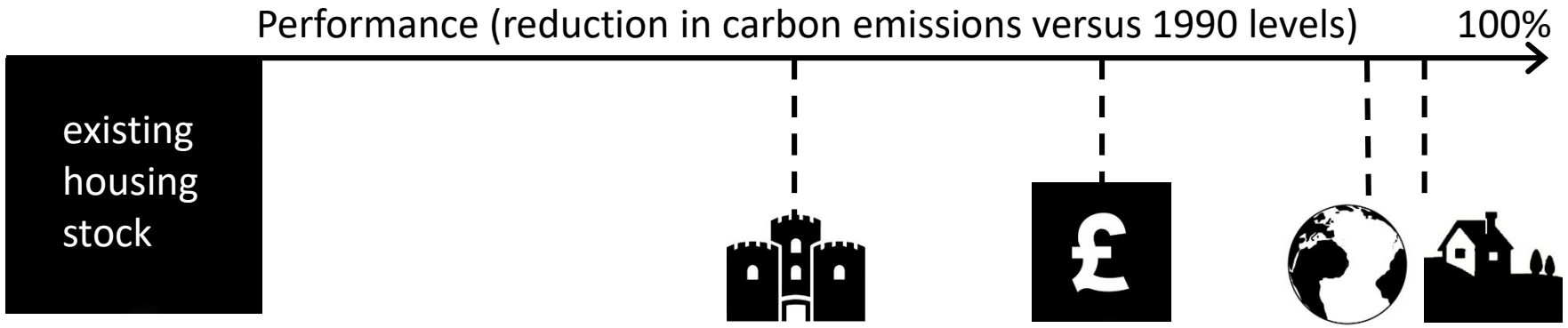

Total capital cost by narrative
£17,100
£33,500
£10,800
£39,400
predicted maintenance, repair and improvement costs over a 30 year period
£11,100
Good Practice
Best Practice
Heritage
Rural
Total reduction in annual energy cost by narrative
-£630
-£720
-£270
-£2,340
Impact on annual energy cost of four distinct retrofit narratives
Scenario 1 assumes no change in energy costs
Annual Energy cost
£3,000
£2,000
£1,000
£0
-£1,000
-£2,000
Pre 2018 ←
→ Post 2018
-£320
-£320
-£320
-£250
-£80
£440
-£80
-£1020
-£360
-£550
-£790
-£20
-£30
-£20
-£30
-£30
-£130
-£30
-£60
-£90
-£130
-£100
-£120
-£240
-£250
-£20
-£50
-£10
-£40
-£30
-£40
-£30
-£30
Dwelling Historic
Supply Historic
Supply Post 2018
A4 Services
A3 Renwables
A2 Fabric
A5 People
Historical Improvements
Cleaner Energy
Cleaner Enenrgy
Updgrade Services
Addiotion of Renewables
Roof
Airtightness
Walls
Floor
WIndows
People


Performance (reduction in carbon emissions versus 1990 levels)
100%
existing housing stock



The Welsh housing stock as modelled, to explore limits to decarbonisation:





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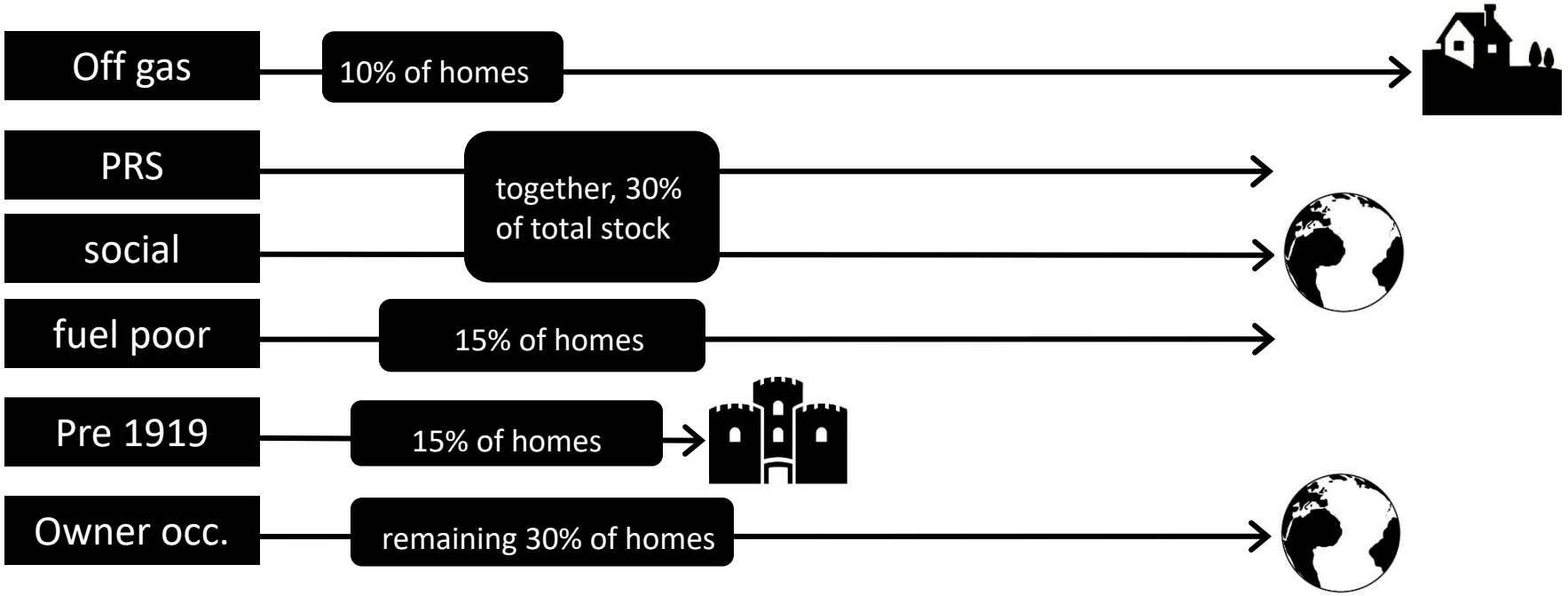


Findings – energy supply

The three distinct scenarios led us to believe that the impact of changes to energy supply on decarbonisation of the housing stock cannot be underestimated:

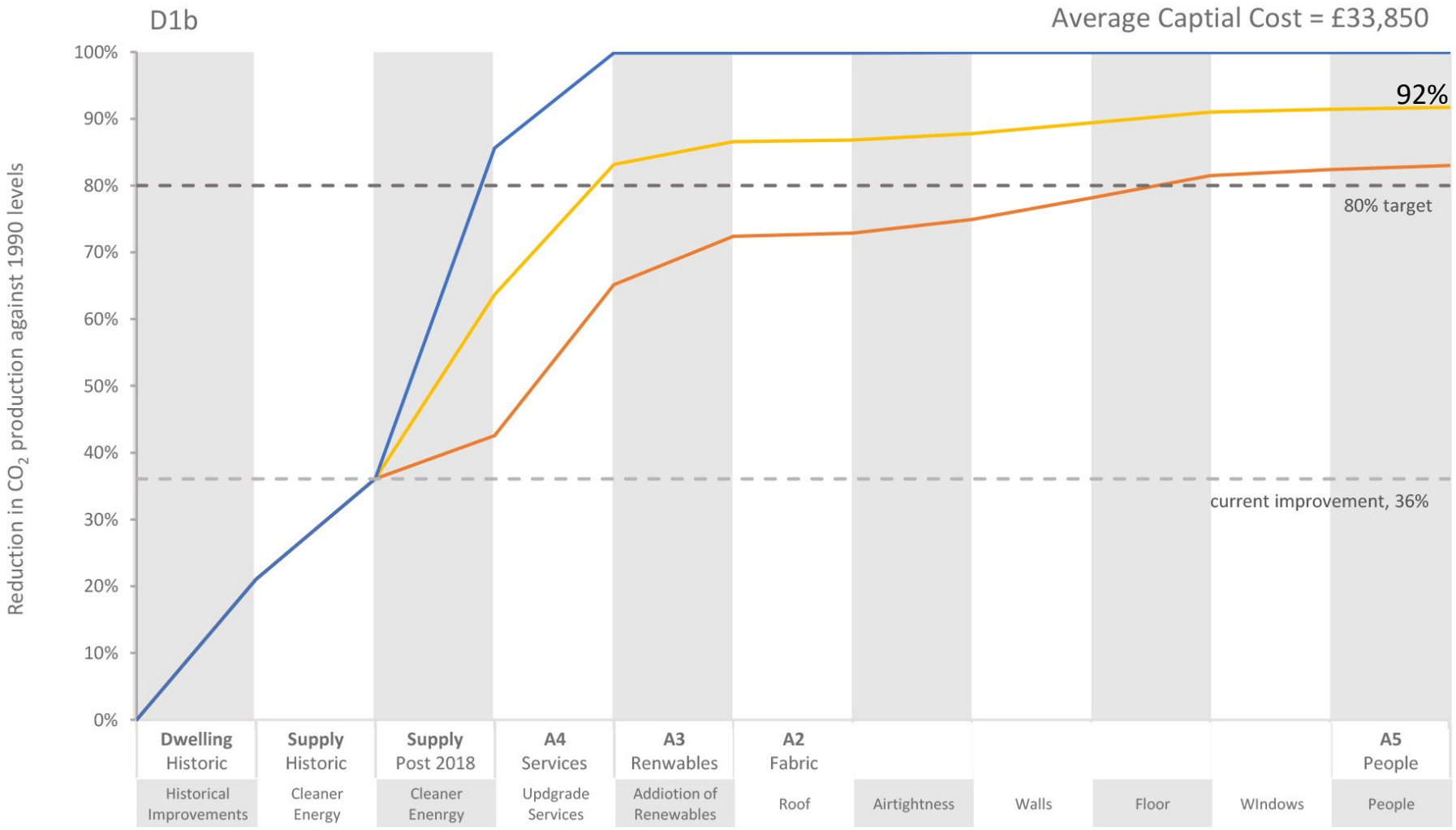
	Carbon reduction (as a range) by energy supply scenario:		
	1: 40% clean	2: 60% clean	3: 80% clean
 heritage	58-66%	78-83%	100%+
 good practice	64-76%	81-87%	100%+
 best practice	83-89%	92-95%	100%+
 rural	86-96%	93-98%	100%+

Predicting decarbonisation resulting from retrofit of the Welsh housing stock

Blue scenario – transformative improvement (80% clean energy)

Yellow scenario – significant improvement in clean energy supply (60%)

Red scenario – minor improvement in clean energy supply (40%)



Three energy supply scenarios for the 2050 simulation:

Scenario 1 **minor improvement**	It is not tenable to deliver 90%+ decarbonisation with established retrofit methods.	**40%**
Scenario 2 **significant improvement**	90%+ decarbonisation is tenable, but requires a high standard of retrofit throughout the stock.	**60%**
Scenario 3 **transformational change**	Focus shifts from decarbonisation to demand reduction, to limit increases in energy costs and fuel poverty.	**80%**

Findings – capital costs

Baseline capital costs are predictable for the four retrofit narratives, described by the ranges below. (Low costs are consistently for smaller mid terraced properties and high costs are for older, larger detached dwellings.)

Heritage narrative	£10.8k to £25.5k
Good practice narrative	£17k to £32k
Best practice narrative	£33.5k to £63.3k
Rural narrative	£39.4k to £66.8k

The specification of retrofit actions can impact considerably on cost – in particular the use of materials or products that are ethically sourced, environmentally sustainable or have related health benefits.

Anticipated maintenance and repairs across 30 years fall in the range £11.1k to £19.8k.

Capital costs assume retrofits are coordinated by the homeowner. Involvement of a contractor is likely to add circa 15%. However, by delivering retrofit in packages of around 50 dwellings or more, this cost increase could be offset by economies of scale.

Findings – energy costs

For all narratives other than ‘rural’, annual energy costs are predicted to **rise** when retrofit focusses on cleaner energy supply and retrofit of heating systems.
The average increase in energy costs for the ‘best practice’ narrative is:

Scenario 1 (assumes no increase in fuel tariff): 47% (range 26% to 59%)

Scenario 2 (assumes 50% increase in fuel tariff): 120% (range 89% to 138%)

Strategies focusing on cleaner energy supply and retrofit of heating systems (e.g. mains gas to electric heat) are likely to impact negatively on fuel bills for occupants in the short to medium term, with attendant increases in fuel poverty.

When holistic retrofit is implemented, the predicted average **reduction** in energy costs compared to current energy costs (Scenario 1) is:

Good practice narrative:	33% (range 14 to 49%)
Best practice narrative:	29% (range 20 to 42%)
Heritage narrative:	71% (range 58 to 78%)
Rural narrative:	11% (range 1 to 28%)

Recommendations

- UK Government must be lobbied to ensure the national grid exceeds 60% clean energy by 2050.
- Action must be taken to protect vulnerable households, to ensure that increases in fuel costs or retrofit of new heating systems do not increase fuel poverty.
- The Welsh housing stock should, as a whole, be retrofitted to the equivalent of EPC ‘A’ rating.
- There should be no distinction between performance standards for retrofit and newbuild*. There should be no distinction between standards due to tenure, house type or condition.
- Retrofit of some Welsh houses is constrained by character. However the justification for ‘acceptable fails’ must be carefully defined so as not to jeopardise decarbonisation targets.
- Retrofit must overcome the performance gap - targets should be delivered, not just predicted.
- Retrofit is easier to enforce for social housing and PRS sectors. Work must be undertaken to explore how to initiate retrofit in the owner occupied sector.
- A flexible approach requiring all homes to achieve appropriate standards by 2050 is the only way to anticipate achieving 90%+ decarbonisation under assumed energy supply scenarios.

* The Independent Review of Affordable Housing Supply (WG, 2019) recommended that “all new affordable homes be built to EPC ‘A’ using a fabric first approach from 2021”.