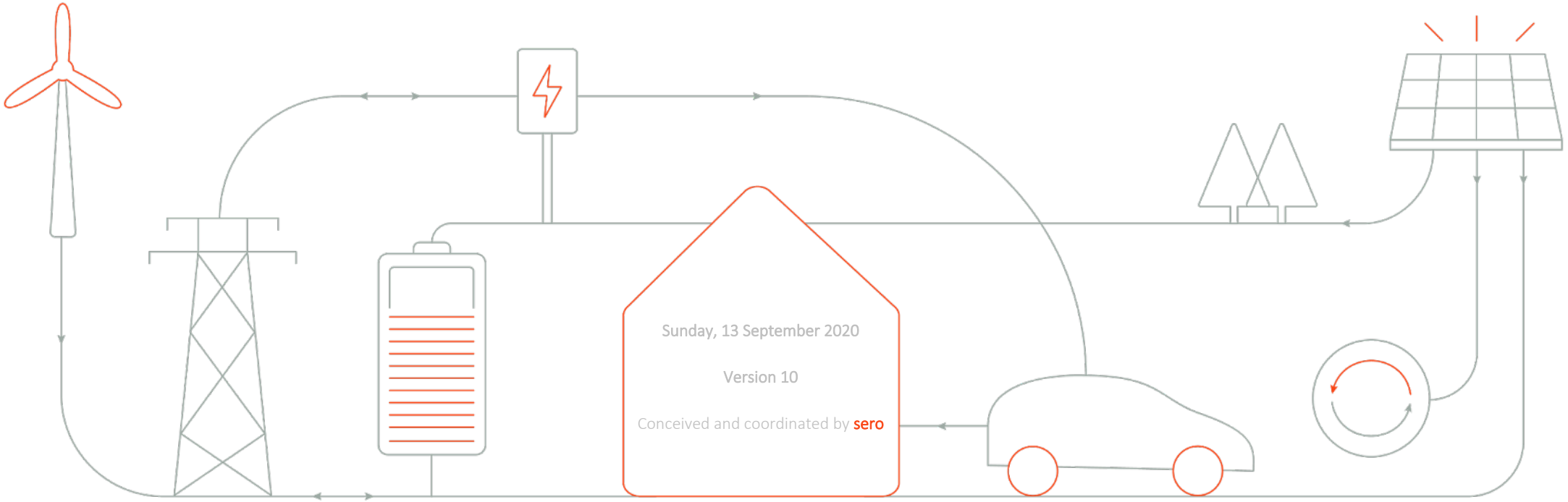
Optimised Retrofit

A collaborative proposal to deliver the pathfinders and processes to power the decarbonisation of Welsh homes



68 Collaborators

Social Landlord Partners

Adra (Tai) Cyfyngedig
Bron Afon Community Housing
Cadwyn Housing Association
Cartrefi Conwy Cyfyngedig
ClwydAlyn Housing Limited
Coastal Housing Group
Cynon Taf Community Housing Limited
Family Housing Association (Wales) Limited
First Choice Housing Association Limited
Grŵp Cynefin
Hafod Housing Association Limited
Linc Cymru Housing Association
Melin Homes Limited
Merthyr Tydfil Housing Association
Merthyr Valley Homes Limited
Newport City Homes Housing Association Limited
Newydd Housing Association Limited
North Wales Housing Association Limited
Pobl Group Limited
Powys County Council
Rhondda Housing Association
Tai Calon Community Housing
Tai Tarian Housing Association
United Welsh Housing Association
Valleys to Coast Housing Limited
Wales & West Housing Association Limited

Other Partners

Active Building Center
Beta Teach Podcast
Build Test Solutions
Cardiff Metropolitan
Cardiff University
Coleg Llandrillo
Coleg Meirion Dwyfor
Coleg Menai
Construction Industry Training Board
Construction Wales Innovation Centre / University of Wales Trinity Saint David
Data Communications Company
Edwards Hart
Energy Systems Catapult
Gibson Specialist Technical Services Limited
Grasshopper Communications
Green Finance Institute
Grwp Llandrillo Menai
Heat 3D
Hinckley & Rugby Building Society
Minerva Marketing
Ministry of Building Innovation and Education
Monmouthshire Building Society
Neath Port Talbot College
National Residential Landlords Association
Octopus Energy
Ovo Energy *(final approval pending)*
PassivSystems
Places for People
Purrmetrics
Reading University
Regulatory Assistance Project
Royal Society of Architects in Wales / Royal Institute of British Architects
Royal Institution of Chartered Surveyors *(final approval pending)*
Rocketmakers
Rounded Developments
Sero
South Wales University
Supply Chain Sustainability School
Sustainable Traditional Buildings Alliance
Tirion Homes
Training Steering Group
TrustMark

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Overview

The Optimised Retrofit Collaboration is a group of 26 Registered Social Landlords alongside other public, private and third sector organisations who are working together to kickstart large scale decarbonisation across Wales.

The primary objective is to create the legacy of tools, skills, frameworks and evidence for the benefit of all, to allow the decarbonisation of Wales' homes to quickly gain scale and pace. The project can be summarised as three main pillars of work:

Pathfinder Retrofits

Across the project partners will deliver 1,372 Pathfinder homes spread throughout Wales, which will each have a detailed pathway to achieve *Zero Carbon by…* target year in the 2030's based on retrofit measures and grid decarbonisation.

Foundational Economy

Pathfinder homes support work to create frameworks, skills and guidance that support retrofit delivery locally, with engagement on training, skills, finance, research and more to enable the Welsh economy to lead decarbonisation in Wales and beyond.

Digital Tools

Using Pathfinders, input from partners, and leading experts the project develops digital tools and mechanisms that support effective decarbonisation considering technical risk, deliverability and coordination of measures, in order to provide a robust toolset and significant evidence base for future expansion.

The collaboration will be collectively governed by those involved. Overall, Optimised Retrofit will leverage the £7m grant and £2m loan funding into £20+m of total anticipated spending on Welsh retrofit projects, and an estimated total Welsh value of £37+m.

What is an Optimised Retrofit?

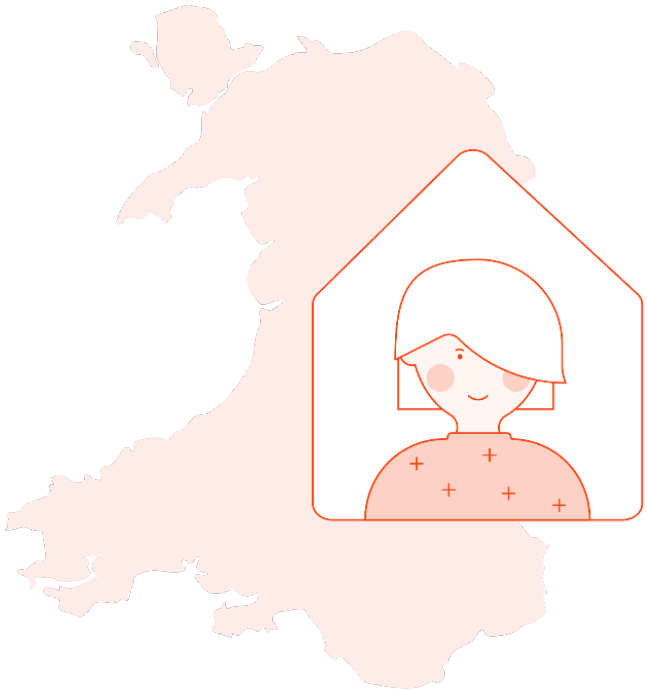
An Optimised Retrofit is a retrofit of an existing home, undertaken in any number of coordinated steps over any time period, that uses a combination of fabric improvements, low/zero carbon technologies, and intelligent ongoing operational controls, to take that home to its lowest achievable carbon footprint, in almost all cases likely to be net zero carbon at a point in the relatively near future.

The Optimised Retrofit approach plots the planned upgrade of a home over time but uniquely also recognises the decarbonisation of the UK's energy networks. This delivers a home that intercepts with grid carbon reductions at the optimum point, supporting both the home and the Grid to be more effective and less expensive, and allowing the home to have a *Zero Carbon by…* year forecast.

Optimised Retrofit supports each unique home to be assessed in significant detail, with all technically viable measures considered in all appropriate sequences. Accepting the paramount importance of the residents, these measures include how to deliver the ongoing real performance of the home to achieve comfort without complexity.

Optimised Retrofit is the means of delivering a clear mechanism for the homes in Wales to take meaningful, coordinated steps to decarbonise in structured, technically robust methodology, whilst remaining as affordable and pragmatic as possible.

Summary



What will this Project Deliver Now?

Optimised Retrofit is a collaboration of partners operating at a significant scale and pace. By the conclusion of the full project, the project will deliver:

- 1,372 Pathfinder homes retrofitted with decarbonisation measures (including a proportion with hybrid heating), each with an Intelligent Energy System, and provided with a Pathway to Zero that shows *Zero Carbon by…* year where net zero carbon operational emissions is technically viable.
- An optional procurement framework for decarbonisation work, allowing tendered rates and separate labour & materials, with support on collaborative 'bulk' buying.
- Wide ranging expert guidance including detailed decarbonisation typologies, resident engagement around 'right to buy' properties, SME support for forming coalition bids, financial lending products, forecasts of grid decarbonisation, and more.
- Mapping of skills gaps and training needs, new training and interfaces with traditional and digital training providers for existing training & upskilling across Wales.
- A Whole Home Survey tool (version 1) that enables quicker, more accurate, better quality assessment of homes in line with PAS2035:2019, and with greater confidence in data.
- A Pathways to Zero assessment tool that supports and coordinates decisions around decarbonisation measures and sequencing, and includes components that check for Fuel Poverty, Overheating, Moisture & Ventilation risks.
- A Building Passport, and the capacity to API export Pathways to Zero into third party planned maintenance software for frictionless implementation of retrofit works through existing systems.
- An network of Social Housing providers better trained and able to use these tools across their entire housing stock.

What will be this Project's Legacy?

The primary objective of the project is to leave a legacy to help decarbonise the remaining homes in Wales and beyond. The project partners alone represent more than half of the social homes in Wales – roughly 123,000 of the total 237,000 – and all Welsh social housing providers will have access to the processes, training, frameworks and tools and more that are built as part of Optimised Retrofit.

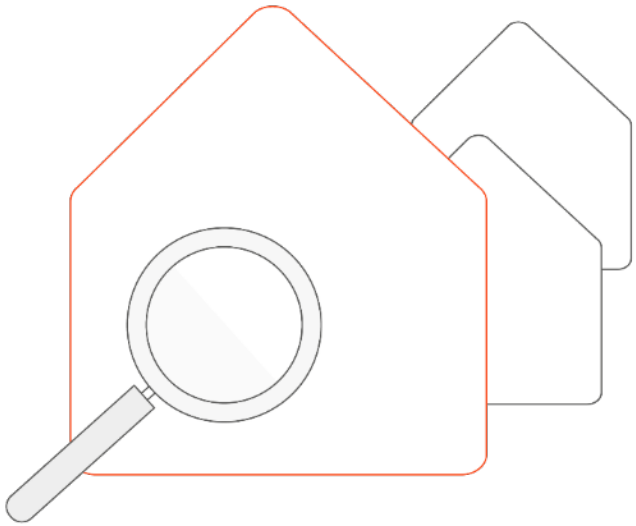
The work outlined on the following pages builds systems during the course of the project, using the Pathfinder homes as raw material, and hence are only complete at the project close. The intention is that these deliverables of the project will continue to be available in Wales and beyond after this funding ends. Chief amongst these legacy elements are the:

- Whole Home Survey digital tool
- Pathways to Zero assessment tool
- Digital Training & Supporting Guidance
- Digital Building Passport repository & data collection

During the project, a sustainable business model will be developed that sets out the costs of operating the core digital tools, framework and relevant foundational economy elements, as well as ongoing dissemination and development activities. The opportunities for ethically generating income to sustain the ongoing operation of the platform will also be reviewed and presented to the Project Steering Group during the project.

Whilst specific advisory support to RSLs and similar activities will not be without costs after the project, the intention is for the Whole Home Survey and Pathways to Zero tools have the lowest possible cost to use, and are free to use within Wales if achievable. This is to reflect Welsh Government's funding of the project, and to drive their wide and quick adoption.

Pathfinder Homes



First 1,372 Homes

The Pathfinders are residential refurbishment projects undertaken by collaborating social housing providers that help develop the Optimised Retrofit tools and mechanisms.

They deliver real decarbonisation for real families across Wales. This ranges from approximately 500 homes starting the decarbonisation journey with a detailed Pathway to Zero and advanced Intelligent Energy System (IES), plus a similar number having an average £11,588 per home for the assessment and deployment of retrofit measures (including the Pathway and IES), and additional homes having nearly £20,000 spent on them by leveraging the Innovative Housing Programme loan funding and Renewable Heat Incentive (RHI) for repayment.

This represents one of the largest scale, choreographed exercises to undertake diverse retrofits, across as many different Welsh home typologies, in as widely varied location, to be undertaken.

It also represents the tip of the iceberg.

The project has identified a further 1,466 homes that could be immediately included in work commenced in this financial year, and a further 74,789 homes that could be progressed in the next financial year (the latter likely to rise to 123,000 or more as further social landlords engage).

Through the Pathways to Zero for each of these homes, and as the supporting framework, SME guidance, digital tools, research and more is produced, Optimised Retrofit becomes a delivery mechanism for powering the Foundational Economy of Wales to deliver the decarbonisation of Welsh homes.

It also makes Wales a true world leader in tackling the challenge of existing homes as part of the Climate Emergency, and does so in time to share this at COP26.

Support for RSL Pathfinder Homes

The Optimised Retrofit project provides expertise and technical support for all the RSL partners engaging in Pathfinder retrofits. This will be 'free issued' to the partners throughout the project as detailed on the following pages.

1 Approach to the Selection of Homes

The selection of homes by each individual RSL has been based on a weighted view, balancing the frequency of those homes within their portfolio, the complexity of the challenge, the potential measures, and the internal planned maintenance budgets available for those homes, or which can be assigned to them. The demographics of the residents have also been considered, and their likely willingness to be part of the pathfinders.

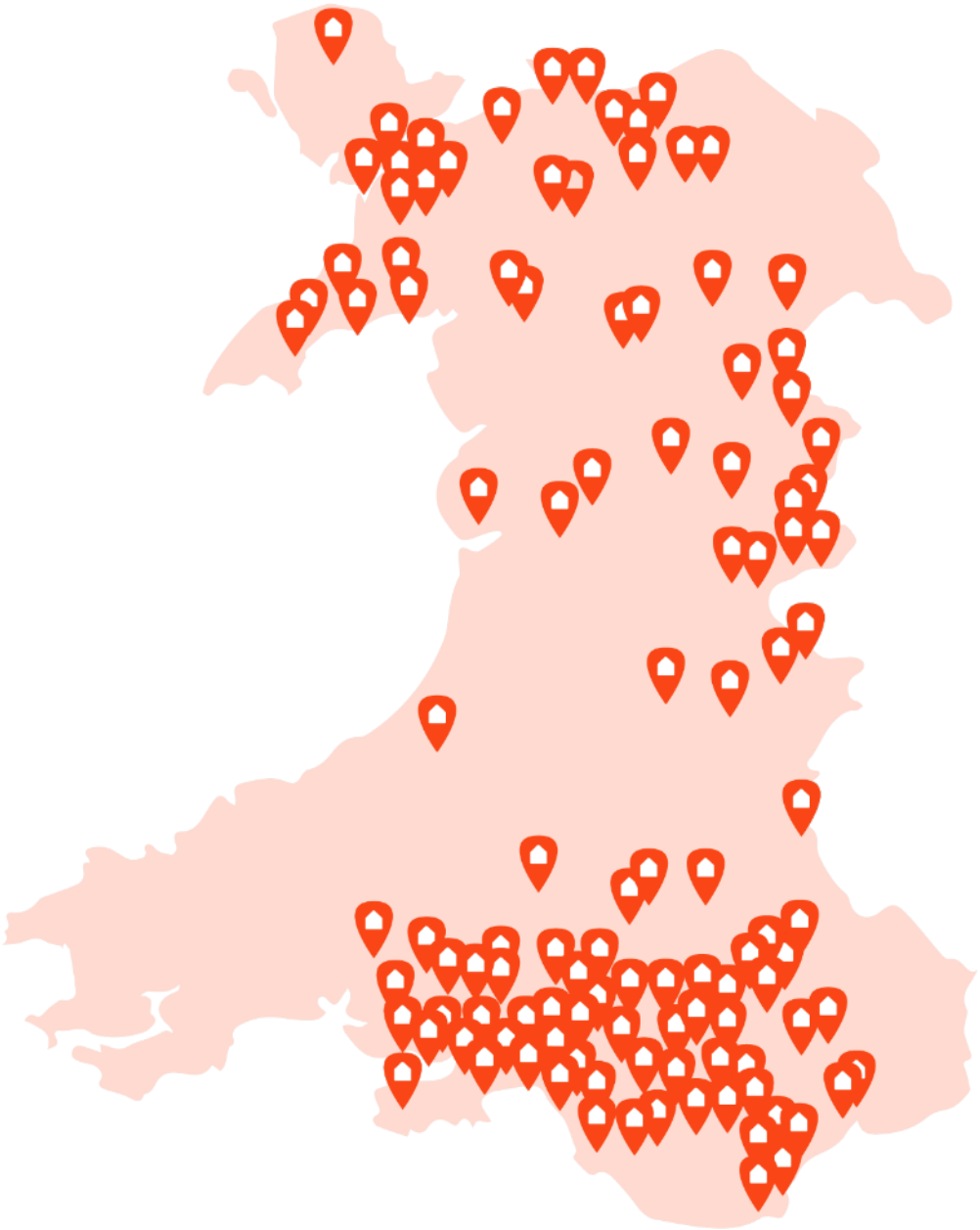
Once each RSL had selected their first choice of homes, this was then moderated between all the RSLs by agreement to achieve the best balance of geographies and home types as a group. Overall, the project therefore achieves an unprecedented diversity of home locations and typologies.

2 Diversity of Retrofit Measures (Inclusion of Hybrids)

The final measures for each home will be determined during the project based on a "homes first" approach that ensures technically appropriate choices. However, homes have been selected with some view of the likely retrofit measures in order to try and achieve a diversity in measures installed, which will support tools and process development in the project.

The project intends to deliver c.100-150 hybrid energy systems as part of this diversity of retrofit measures. This will increase if further funding becomes available (see later).

Pathfinder Homes



[3] Diversity of Geographies

The map on the left indicates the spread of the initial 1,372 Pathfinder homes across Wales.

[4] Total Number and Type of Homes

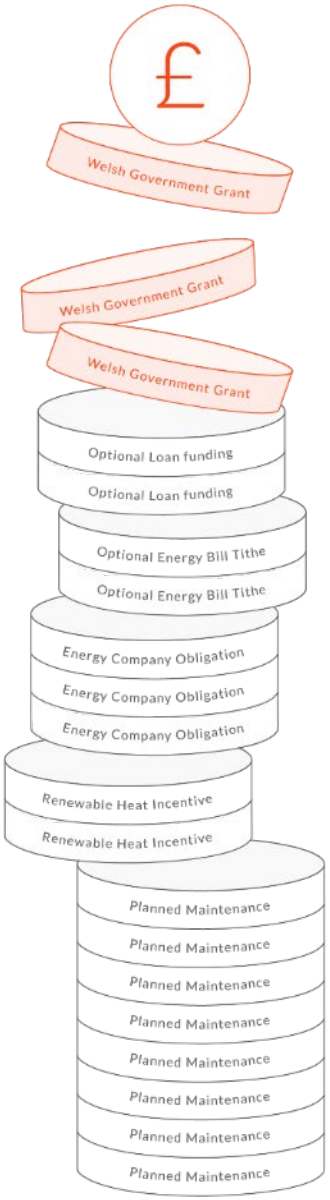
There are 1,372 initial Pathfinder Homes proposed in this project. These are itemised by address for each RSL in the appendix of this document.

Each RSL has reserved the right to substitute homes with alternatives in the event that the nominated properties cannot be used, but the overall number of homes delivered will remain the same, excepting if the grant funding amount varies.

Across the collaboration, these homes break into the following broad types of properties:

Solid Wall construction =	206
Cavity Wall =	518
Non-traditional construction =	244
Solid Wall, off gas network =	45
Cavity Wall, off gas network =	262
Non-traditional, off gas network =	97
Total Pathfinder Homes =	**1,372**

Pathfinder Homes



5 Pathfinder Home Retrofit Budgets

Each RSL will receive approximately £1,589 per Pathfinder of Innovative Housing Programme (IHP) grant funding, issued direct to the individual RSL via a direct Grant Offer Letter from Welsh Government, plus additional free issue Intelligent Energy System equipment (c.£1,543 per home) to be installed in each home.

This represents £4,296,638 of the overall £7m IHP Grant.

Individual RSL partners have also indicated they will look to use the IHP Loan funding, based on a link to RHI repayments. This is estimated to be spread over 350 homes, with the precise homes and amounts dependent on the appropriate retrofit measures and likely energy savings forecasts determined in their Pathway.

This totals £2,000,000 of IHP Loan.

IHP funds will be supplemented by internal budgets and other funding sources by each RSL, to leverage additional activities and retrofit measures, and to coordinate this planned spending with the Pathway to Zero for each home. These budgets are not necessarily 'new' money, but money being aligned to increase the coordinated impact of the project overall.

These total £7,536,179 leveraged from other budgets.

The project will align retrofit works with additional existing grant funding (Warm Homes, NEST scheme, ARBED 3, ECO, RHI, etc.). An estimation of the average leveraged funding at this point is £800 per home, though this will be measures dependent.

This totals £1,097,600 from leveraged other grants.

Combined with the internal time and effort from social housing providers, (c.£2,938,510), the overall impact of Pathfinder retrofit measures into the Welsh economy is forecast at £17,194,227 excluding the other aspects of the project.

6 Pathfinder Home Retrofit Budget Variations

Increased Budget, Increased Impact

The RSL partners also have capacity to increase the impact of the project if further grant funding is available in this financial year, or in future years, with 1,466 additional homes able to start now.

This has a disproportionate effect on the impact of the overall project, given any additional funding is largely after the one-off costs for creating frameworks, tools and processes that form part of the core project proposal. Additional funding can be channelled into impact on the ground in a blend of two ways:

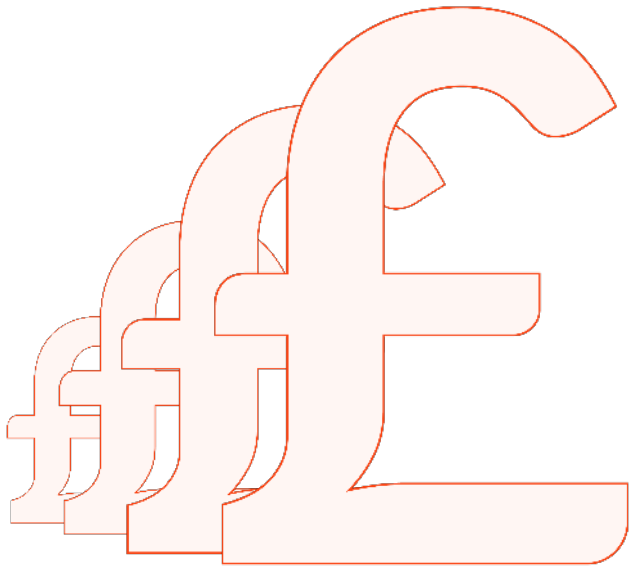
Each RSL has identified a number of additional Pathfinder homes that they could include with further IHP grant funding. This could increase the total number of homes commenced this year to 2,802 for an increase in IHP grant of £5,100,000. Assuming the same leveraged funding from planned maintenance budgets and other grant funding schemes, this would create a retrofit impact primarily into the Welsh economy of £33,229,211.

Secondly, each Pathfinder home can have the retrofit budget increased to allow the home to complete the identified *Zero Carbon by…* Pathway to Zero. Assuming an average spend per home of £19,000, funding of £16,400,000 would take all initial Pathfinder homes' to the end of their Pathways to Zero, with an estimated economic impact of £36,887,747.

Increasing both the number of Pathfinders and completing their Pathways to Zero would require £39,500,000 of funding, generating an economic impact of approximately £71,778,553.

The collaboration could also increase the number and scale of retrofit measures deployed in a blended fashion to match any additional funding that could be made available.

Pathfinder Homes



Reduced Budget, Reduced Impact

In the event that the full Innovative Housing Programme grant and loan funding level requested cannot be provided, the total number of Pathfinder homes would be reduced by agreement with all the collaborators, likely to be via a weighted reduction from those with higher number of Pathfinder homes and lower levels of match funding assigned, to meet lower funding levels.

This can reduce the number of homes down to a minimum of 500, which is considered the lowest viable number to retain a degree of geographic, typology and retrofit measure diversity. Each reduction in the number of homes included as a Pathfinder, however, does disproportionately reduce the impact and breadth of measures, homes and locations that can be included, given the increased proportion of 'one-off' costs in the project.

Grant Funding Change Worked Examples

For ease, the following examples are based on differing IHP grant funding levels, assuming the same leveraged funding and the same average IHP grant contribution per Pathfinder home :

IHP Grant Funding Budget	=	£6,000,000
Number of retrofit homes	=	1,048
Target hybrid homes reduced	=	c.50
Leveraged impact of retrofit works	=	£14,216,650

Applied for IHP Grant Funding Budget	**=**	**£7,000,000**
Number of retrofit homes	**=**	**1,372**
Target hybrid homes	**=**	**100-150**
Leveraged impact of retrofit works	**=**	**£17,194,227**

IHP Grant Funding Budget up from £7m to	=	£14,000,000
Number of retrofit homes	=	3,350
Target hybrid homes increased to	=	c.300
Leveraged impact of retrofit works	=	£39,319,681

IHP Grant Funding Budget up from £7m to	=	£21,000,000
Number of retrofit homes	=	5,100
Target hybrid homes remains at	=	c.300
Leveraged impact of retrofit works	=	£59,701,654

Alternatively, below are based on differing IHP grant funding levels, assuming the same leveraged funding and an average IHP grant contribution per Pathfinder home of £5,000:

IHP Grant Funding Budget up from £7m to	=	£14,000,000
Number of retrofit homes	=	1,700
Target hybrid homes increased to	=	c.100-150
Leveraged impact of retrofit works	=	£26,702,391

IHP Grant Funding Budget up from £7m to	=	£21,000,000
Number of retrofit homes	=	2,725
Target hybrid homes increased to	=	c.250
Leveraged impact of retrofit works	=	£41,540,404

IHP Grant Funding Budget up from £7m to	=	£28,000,000
Number of retrofit homes	=	3,750
Target hybrid homes increased to	=	c.300
Leveraged impact of retrofit works	=	£56,378,417

Increasing or Decreasing the Funding Budget

Submitted alongside this proposal is a budget spreadsheet that can be used to illustrate in more detail the likely variation of retrofit impacts that arises from increased or decreased budget levels. Whilst the above figures and supporting spreadsheet is indicative only, it is offered to support any discussions on this.

The project would generally suggest a combination of increasing the budget per Pathfinder, and increasing the number of homes, is likely to be the optimum combination, and could potentially enable additional social landlord partners to join.

Pathfinder Homes

7 Pathfinder Home Retrofits Measures & Budgets

Each Pathfinder home will have a Whole Home Survey and Pathways to Zero undertaken with support from the project technical experts and administration. These will identify a Pathway to Zero that will, wherever technically viable, demonstrate the home can achieve *Zero Carbon by…* a selected target date (for example 2030 or 2035).

Each RSL will then install into each home the free issued IES equipment, and for selected homes will also implement the first measure or measures on that individual home's Pathway to Zero as part of the Optimised Retrofit budget.

The measures implemented will be limited by the total budget determined as available, comprising IHP grant, optional IHP loan, eligible other funding sources and internal RSL funds volunteered. No RSL will be obliged to undertake any retrofit measures that exceed the total budget identified.

The budget for retrofit measures on the individual homes does not include the 'free issue' IES, which is provided by the collaboration overall. Although figures are given as average spends per home, each RSL will determine the spend on each home individually from the total budget; there is no commitment the spending will be equal across homes for each RSL.

8 PAS 2035 Whole Home Survey Training Support

Each RSL will be given expert training and support for their nominated internal or external home assessor/surveyor teams to help upskill them to be able to undertake the Whole Home Survey for Pathfinder homes. This will comprise:

- Two ½ day training sessions including questions & answer sessions with technical experts, delivered either virtually or in person, and undertaken in small groups. Over the course of the project, the training sessions will be developed in to recorded video presentations to provide the legacy outcome. Question & answer sessions will remain live with a technical expert throughout the project (and beyond for legacy if possible).
- Assisted on-site Whole Home Surveys in actual Pathfinder properties (or similar homes) with a technical expert to provide guidance and support on the assessments in practice. This will be provided to all RSL partners, and for as many home typologies as can be achieved within the project's resources. This will only be 'free issue' for the duration of the project.
- Desktop quality assurance of RSL undertaken Whole Home Surveys, reviewing the information collected and providing feedback to support improved accuracy and understanding. This will also enable the development of automated quality assurance checks, which will be developed to operate beyond the duration of the project once the manual checks cease to be 'free issue'.

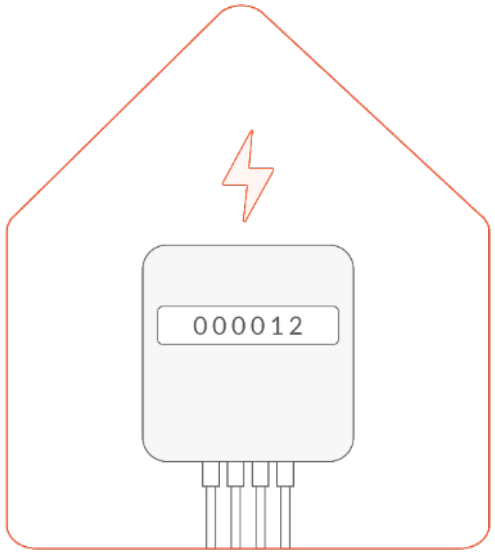
The intention of this training is to leave a legacy of competent home assessors/surveyors across Wales.

9 Whole Home Surveys

Each RSL will undertake, using either in-house staff, inter-RSL shared staff, or external contractors, a survey of every Pathfinder home in the project. This will use a prototype version of the project's digital Whole Home Survey, which will be under development in parallel. These surveys provide three core outcomes for the overall project:

The Pathfinder home has a comprehensive assessment to form a basis for all future decisions on how to decarbonise the property.

Pathfinder Homes



The RSL staff or external contractor gains experience delivering a PAS2035 based assessment, and confidence to be able to continue to undertake these beyond the end of the project.

The Whole Home Survey digital tablet tool has ongoing access to live trials in real homes, with feedback from actual users, to ensure that the tool is as usable and effective as possible.

10 Smart Meter Deployment

The project has identified all Pathfinder homes that already have smart meters installed. Smart meters are not a requirement of the Welsh Government funding, but practically are needed for actual energy optimisation and for most pre-retrofit metering.

Smart meter deployment for homes that do not currently have them will be specifically targeted by all RSLs, and prioritised by partners Octopus to ensure the swiftest practical deployment.

The absence of smart meters will not preclude the delivery of the project outcomes, but is likely to limit some monitoring (primarily gas usage) and will preclude time-of-use energy tariffs being offered to the residents of those homes.

11 Intelligent Energy Systems - Pre-Retrofit Metering

A proportion of the Pathfinder homes will have digital metering prior to retrofit work, with the remaining homes providing a 'control' sample. The devices will preferably be fitted at the same time as the Whole Home Survey to reduce disruption.

These pre-retrofit metering devices will be products developed under the UK Government's "*Smart Meter Enabled Thermal Efficiency Ratings Innovation Competition*", such those created by partners PassivSystems, Purrmetrix and Build Test Solutions. The project will look to deploy at least one of each of these, and at least one home will have more than one device installed to generate comparative results. A proportion of devices will also be left in place after the first retrofit works to calibrate pre-and post-retrofit metering.

The pre-retrofit metering will be primarily to establish the Heat Transfer Coefficient (HTC) of the homes, and as such will require the devices to be in place during the heating season. All devices will transmit their raw data and interpreted HTC estimation to the main Optimised Retrofit platform as a project requirement.

The final mix of devices will depend on supply capacities, device requirements and the characteristics of the homes. This may also be limited by the requirement for smart meters for some devices. The total number of pre-retrofit metering devices deployed will be capped by the project budget allowance of £60,000, based on an estimated price per unit.

Pre-metering devices will default to the ownership of the collaboration at project close, noting there may be ongoing data and other costs associated with reuse

12 Pathways to Zero Support

Each RSL will develop a Pathway to Zero for each Pathfinder home in the project, with the direct support of the technical experts. This will be undertaken in tandem with the development of the Pathways to Zero digital portal, and the underlying technical Retrofit Measures Cards and compatibility matrixes, and the Fuel Poverty component to assess residents' likely bills.

The work to develop the Pathways to Zero will consider all viable retrofit measures insofar as is practical, but the final choice of the Pathway to Zero selected will be made by the RSL.

For the project, the Pathway to Zero will demonstrate how the Pathfinder home can achieve *Zero Carbon by* a selected target year (for example 2030 or 2035), where this is technically viable.

Pathfinder Homes

This does not mean the RSL will implement all those measures in the Pathway during the project, it also does not guarantee the RSL will implement those measures after the project, since technologies or preferred Pathways to Zero may change over time or be influenced by differing future priorities.

Expert technical support to RSLs will be provided to the maximum extent that project resources permit.

13 Targeting *Zero Carbon By…* & Correlation with SAP92

Pathways to Zero will be developed based on achieving a *Zero Carbon By…* nominated target year as the primary objective. This will be in priority over achieving any specific Reduced Data Standard Assessment Procedure (RdSAP) score. RdSAP calculations are likely to form many of the technical assessments, and scores of 92 or higher are likely in many cases, but homes cannot be guaranteed to achieve. This due to the underlying differences in approach between RdSAP, which uses an annualised average historic approach for solely regulated energy, and *Zero Carbon by…*, which uses a forward looking, granular, dynamic assessment of all energy used in the home.

See Appendix 1's letter to the Welsh Government Minister for Housing & Local Government for a more detailed synopsis of why *Zero Carbon by…* has been prioritised over the SAP metric.

14 Procurement & Guidance

Each RSL will be in control of their own procurement to implement the Pathfinder home retrofit measures they have selected from the possible Pathways to Zero identified.

For the initial Pathfinder homes, the project will provide guidance on best practice procurement and will seek to encourage collaboration and maximise the use of the most appropriate existing framework and procurement mechanisms.

The project will also collate learning from all partners during the initial Pathfinder work as part of this exercise in order to feed into the optional Decarbonisation Framework the project will develop in parallel (see section 26).

15 TrustMark Competent Tradespeople

As part of the initial guidance, TrustMark will provide information on all TrustMark registered tradespeople in the area of the Pathfinder homes. RSLs will not be obliged to use these tradespeople, but the project will look at how integration with TrustMark's competent persons scheme might feature in the Decarbonisation Framework being developed.

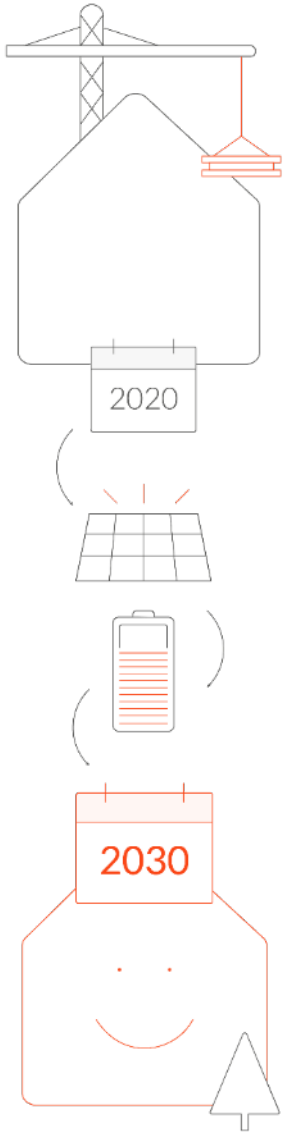
16 Retrofit Work Implementation

Each RSL will project manage the delivery of their own Pathfinder home retrofits on site, but support from the technical experts of the projects will be available throughout. Wherever possible, this will include at least one site visit to the home by one of the project experts. RSL partners will also be strongly requested to take and share extensive digital photographs for the technical team to review and to provide a record of the works to integrate into the digital record. The project will work towards integrating the collection of these site photographs into the digital tools.

17 Intelligent Energy Systems – Post Retrofit Monitoring & Control

All Pathfinder homes will be free issued with an Intelligent Energy System (IES) hub and peripheral metering to be installed as part of the first step of retrofit works. The installation and commissioning of this will form part of the retrofit works

Pathfinder Homes



procured by the RSL, with technical guidance and support available from the project technical team.

The IES will undertake ongoing home performance monitoring to identify the energy and carbon savings from future retrofit measures, and will securely pass this data to the Sero project platform via the internet (exact means will vary by home). The ongoing metering of the Pathfinder homes will be in place for every home with resident's consent, and RSLs will make all reasonable efforts to obtain this.

The IES will give the RSL and/or resident the choice of adopting the Sero Life energy management service, enabling easy scheduling of home comfort preferences. This will not be obligatory, and post retrofit performance metering of the Pathfinder home will occur even where this is not selected.

The IES platform is capable of learning the building physics to predict the home's performance (including any renewable generation), to forecast half-hourly home energy demands, and accommodate energy network signals such as Demand Side Response calls, when connected to the Sero platform (or any future similar compatible digital service).

The capacity of the IES to operate the home in response to this forecast and optimisation is dependent on the presence of appropriately connected low/zero carbon technologies being installed in the Pathfinder home.

[18] Post Retrofit and Ongoing Monitoring

All Pathfinder homes with resident consent will have ongoing digital monitoring for a period of at least three years, excepting any transient or geographic connectivity issues. This will be alongside significant other Post Occupancy Evaluation detailed in the next section.

Beyond Welsh Social Homes

[19] Pathfinder English Social Homes

Places for People will be aligning with the Optimised Retrofit project, and plan to take approximately 100 English homes through the Pathfinder journey alongside the Welsh Pathfinders.

Places for People is an award winning property management, placemaking and regeneration specialist who create and manage thriving, sustainable places. With a stock of over 182,500 homes, and operating across a diverse range of markets with more than 20 specialist companies, each working to build sustainable communities for all, the organisation represents a significant illustration of the potential for the Optimised Retrofit approach.

Any retrofit works, and any directly attributable other costs (such as supported site surveys, IES equipment, etc.), will not be funded from the Welsh Government Innovative Housing Programme but will be met by directly Places for People.

[20] Pathfinder Welsh New Build Homes

Tirion Homes will be working alongside the Optimised Retrofit collaboration to further increase the impact of the project by extending the principles into new build homes.

In parallel with the Pathfinders, Tirion Homes are working to set out their own new build property's Pathways to Zero. This recognises that they cannot currently build net zero today, but anticipates the works that will be required to achieve net zero carbon as part of future planned maintenance.

By aligning this work with the Optimised Retrofit project, Tirion Homes will be the UK's first housebuilder we know of to proactively plan for their homes' future improvements.

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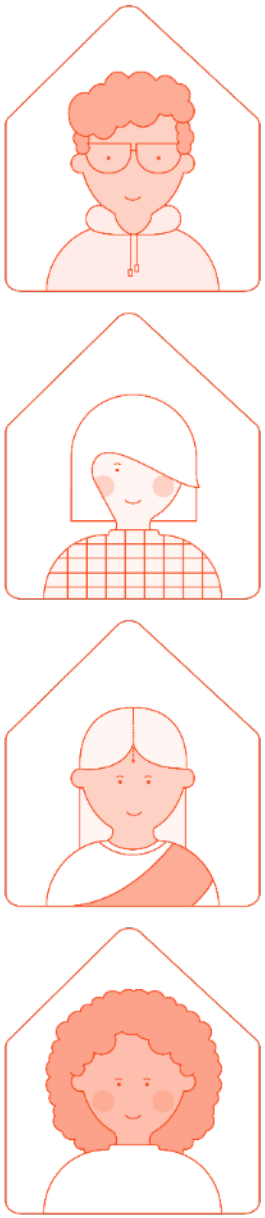

Role of the Foundational Economy

The Optimised Retrofit collaboration is designed to help deliver decarbonisation through the Welsh local economy, and to form an environment that will enable small scale Welsh businesses the opportunity to prosper both in Wales and beyond in a long term, economically, socially and environmentally sustainable fashion.

To achieve this, the collaboration has a significant range of activities that will support these outcomes, ranging from framework development to skills, and from community engagement to financial products. These run concurrently with the Pathfinder homes and digital tools to deliver a legacy for the end of the Optimised Retrofit project.

The Foundational Economy pillar of the Optimised Retrofit project is led by a wider range of project partners, reflecting the diverse nature of the challenges that need to be tackled. Whilst each activity has a lead, these are all established as open groups for any member to engage with, and all report back into the overall project governance structure.

Community Engagement

[21] Community Engagement

Led by United Welsh, with **Linc**, **Melin** and **Tai Calon**, this work will take a place based approach to understanding housing decarbonisation. The aim will be to nurture local assets and capability, and generate lessons for wider implementation.

The work will explore how the “citizen voice” can be stronger in shaping our decarbonisation plans. Work will include early conversations to understand what matters to tenants and residents and what opportunities exist to maximise the impact of this new investment - especially unlocking community involvement on climate change and sustainability issues.

The project will be looking to unlock new opportunities in projects to develop low carbon training and employment pathways; exploring ways of using show homes to stimulate interest and discussion about what is possible; creative use of community funds in targeted area to help nurture local projects that will promote wellbeing; work proactively in local schools; and hold a citizens assembly with a representative sample of Blaenau Gwent tenants and residents to understand what is important to them, and to make recommendations on what a good approach to housing decarbonisation would look like.

The 4 Blaenau Gwent based housing associations will work in collaboration with the local authority, Coleg Gwent, Active Building Centre, Cardiff University, Cynal Cymru and Electoral Learning. Findings will be shared across the Optimised Retrofit collaboration using a Community of Practice approach - and across the wider Innovative Housing Programme.

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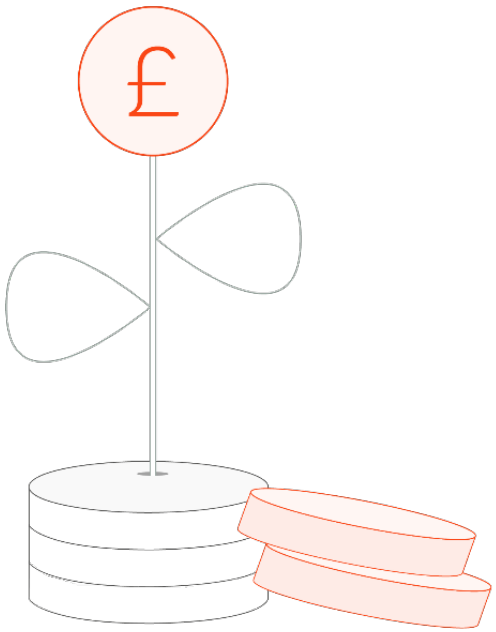

22 Leaseholders and Owner Occupiers

Led by Valleys to Coast, this work will identify ways to tackle the challenge of tenure mixes. Leaseholders within blocks of flats are a particular issue for all RSLs that have been subject to the Right to Buy but especially for stock transfer organisations and stock retaining local authorities. Taking statistics from just 3 of the bid consortium organisations, they have 1,490 leaseholders within 827 blocks that will affect the delivery of retrofit works on 2,751 tenanted properties. Extrapolating these figures for social landlords across Wales results in over 60,000 tenanted properties being impacted by whether leaseholders engage positively in the retrofit works.

Leaseholders cannot be charged for improvement works, just for retrofit works voluntarily. WHQS works have already highlighted the ingrained problems of securing buy in from leaseholders, the majority of whom do not wish to participate and many of whom are now private landlords themselves having inherited their flats from parents.

Allocated bid consortium members will work with the Monmouthshire Building Society, Hinkley & Rugby Building Society and others to identify the challenges faced by leaseholders in making the retrofit works both attractive and affordable to maximise take up whilst being managed and delivered by RSLs; leading to a case study of the issues, the options available and an indication of potential take up.

This piece of work will also extend to owner occupiers since any terraced or semi-detached property will be negatively impacted by the refusal of neighbours to undertake works.

Financing Decarbonisation

23 Residential Decarbonisation Financial Products

The Green Finance Institute, Monmouthshire Building Society and **Hinkley & Rugby Building Society,** aligned with the "Leaseholder and Owner Occupiers" challenge (above), will continue to pioneer the development of financial products to support property owners in installing decarbonisation measures.

This work of Monmouthshire Building Society and Hinkley & Rugby Building Society will consider the capacity for secondary lending secured on the property against both tangible and intangible assets, the level of confidence and metrics required to consider any potential measured energy efficiency savings, and how any such products might transition or close through property sales. Whilst no guarantee can be given at this stage, there is the potential for one or both of the building societies to choose to create new financial products based on these findings.

Meanwhile, the Green Finance Institute and its Coalition for the Energy Efficiency of Buildings will continue to design, develop and launch a portfolio of financial demonstration projects that will channel capital into retrofit projects and help to mainstream the market for retrofit financing.

Whether new products are offered or not, the combined work will produce a summary of the desirable features of such lending, and any barriers to their widespread uptake in residential markets.

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24 VALUER Project Coordination

At no cost to the Optimised Retrofit project, works undertaken throughout will be coordinated with the ongoing work by Rightmove, the Royal Institute of Chartered Surveyors (RICS), Monmouthshire Building Society and Sero. This part-funded UK Government project is investigating evidence and triggers for the value difference in UK homes that arises from energy efficiency.

25 Home Energy Bill – Decarbonisation Tithes

Led by Sero, the project will build on previous work to develop a financial offer for home owners (residents or landlords) to repay capital decarbonisation costs through energy bill savings.

This will draw from activities led by Pobl outside the project to form a Special Purpose Vehicle for funding low/zero carbon technologies (self-funded by them), as well as from work led by Sero with Wates Residential to develop an early prototype for Eastern High in Rumney, Cardiff (with hardware part funded by the Innovative Housing Programme Year 2).

The work will unpick barriers such as Financial Conduct Authority (FCA) compliance, with a view to developing an energy bill tithe option that can be made available to RSLs, private landlords and owner occupiers in future.

Unless regulatory, capital finance or comparable barriers prevent it, the work will result in an energy bill tithe product being available at or shortly after the completion of the project – final timescales are likely to be driven by the FCA.

Local Economy

26 Decarbonisation Framework & Guidance

Led Valleys To Coast Housing, with support from consortium members, the project develop and implement a pan-Wales Decarbonisation Framework which will promote the vital role that Welsh SME's must play in delivering decarbonisation measures to all housing, regardless of tenure.

The Framework will be in place from April 2021, although the consortium will seek to have it set up as quickly as possible, and offers the potential that Welsh Government may seek to link use of the Framework to any future funding initiatives, ensuring that the greatest possible Community Benefits are realised for the economic, environmental, social and cultural benefit of Wales.

The Framework will;

- Set up a 4-year Framework splitting the procurement of materials and installation, ensuring SME's are not disadvantaged in their procurement, and realising economies of scale,
- Provide targeted support to Welsh SME's in tendering for the Framework and developing their capacity and capabilities to move from 'Tier 3' or 'Tier 2' contractors through to Tier 1 contractors,
- Support SME's and Micro SME's to develop their understanding and approach to decarbonisation in order that they are able to advise owner occupier clients, thus developing new markets,
- Support and deliver the requirements of the Wellbeing of Future Generations Act, in delivering sustainable employment and training opportunities that identifies the skills required to meet decarbonisation, and working to

ensure these are met and provide opportunities to the citizens of Wales.
- Promote the Foundational Economy, recognising that the delivery of decarbonisation projects provide opportunities to promote and develop skills.

The development of the Framework will build on the successes of Welsh Government Arbed ERDF programme, with an optional framework which is accessed by every social landlord in Wales.

For the Pathfinder homes initially undertaken, in advance of the optional framework, a guidance report on best practice procurement will be produced to encourage local economy outcomes for the initial home retrofits, intended to be available for December 2020.

27 Developing Small Business Coalitions

Led by Gibson Specialist Technical Services, the project will develop guidance for Welsh SMEs. Drawing on past successful examples, this will set out how small businesses can establish coalitions to bid for larger decarbonisation contracts, whilst minimising the legal and financial barriers to doing this.

The ability for such coalitions to form allows procuring bodies to avoid breaking tender opportunities down into very small packages to suit individual SMEs, which can create higher costs and administrative burdens.

The guidance produced will also include encouragement for SMEs to consider how efficiencies can be offered through shared processes across trades to improve efficiencies – such as combining scaffolding and PV installation – and will support identifying available training for any process improvements that come forward.

The work will produce freely available guidance for SMEs, and will be closely coordinated with the guidance and optional decarbonisation framework.

28 Evidencing Future Market Demand

Led by Sero, and using outputs from the digital tools, the project will produce templates for evidencing the size of the future market for decarbonisation in Wales.

This will be targeted at Welsh businesses, and the market size will be split according to retrofit measures, geography, and the annual size of the market per year over the future years. This will be specifically designed to act as supporting evidence from which businesses can develop their own business growth plans, skills and training requirements, and capital investment needs.

The project will deliver these to be automated and online, based on forecasts of works entered into the Pathways to Zero tool. Where statistically appropriate, the future market demands will be extrapolated from data entered into the Pathways to Zero tools, though they will have increasing levels of accuracy dependent on the uptake of that tool.

The project will also look to make links with SME funding options, such as the Development Bank of Wales, Cardiff Capital Region and Swansea Bay City Deal, where these third parties may have finance available to support the growth of Welsh SMEs.

29 Competent Tradespeople

Led by the Federation of Master Builders with **TrustMark**, the project will work with the Welsh supply chain to raise awareness of the TrustMark Tradesperson scheme, and the options within this to become a TrustMark registered business.

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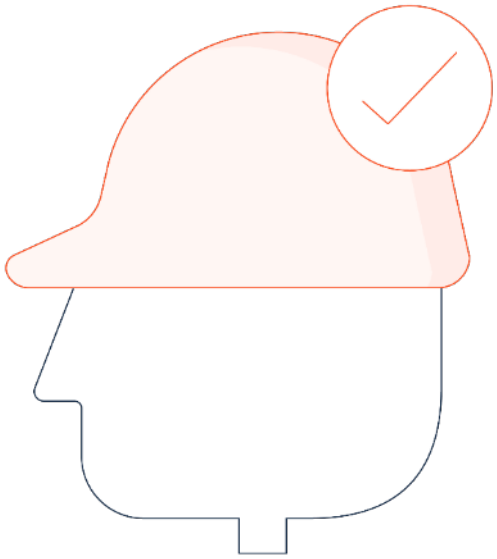
Whilst TrustMark Tradesperson scheme membership is not expected to be a requirement of decarbonisation works, this work will raise the awareness of the scheme. It brings the additional quality assurance and consumer protection set out by the TrustMark Customer Charter and the underlying guarantees obliged by the scheme.

In association with Skills & Training tasks, this work will also look to extend the training and skills offers, including formal certified training, to deliver Welsh providers into the network (see below).



Skills & Training

Led by the Training Steering Group (TSG), the bid contains multiple training organisation and academic partners from Wales, including the Construction Industry Training Board (CITB), Neath Port Talbot College, Construction Wales Innovation Centre (CWIC), South Wales University, Coleg Llandrillo, Coleg Menai, Coleg Meirion Dwyfor, the Supply Chain Sustainability School, and others throughout Wales.

[30] Identifying Existing Skills Gaps

Through the TSG, the project will draw on the Pathfinder homes as well as work undertaken by partners beyond the Optimised Retrofit project (with more than 1,000 additional low/zero carbon new build and refurbishments identified so far), to identify current inefficiencies or gaps in the current primary on-site trade skill sets that arise around decarbonisation measures. Ensuring that the workforce are not only qualified but also competent, and on site assessment will be key to delivering this step chance in knowledge and competency.

These gaps may include lack of general awareness around preserving the airtightness of a home, through to specific extensions to current trade skills, such as plumbers benefitting from basic data connection knowledge.

The project will collate a synopsis of current trade skills and overlay these against required works with decarbonisation, to initially produce a summary of the skills gaps either within trades or at junctions between them, with this knowledge and data being fed into what is anticipated being initially a Training Steering Group which will lead onto a Training Project Board which will be pulled together from all the learning sectors, which will set up by the training providers to identify and pull together

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all the varying streams of learning from schools through to graduates and everything between to provide a coherent approach to retrofit skill provision in Wales. This work will be shared openly with Further Education colleges and other training providers, as well as fed into the Improving Skills for Decarbonisation and related tasks (below).

31 Careers in Decarbonisation

Led by The Future Business, 'Make The Future Yours' is a new careers magazine aimed at 14-18 year olds to provide an informative, impartial resource for young people, parents, tutors and employers. Ultimately targeting UK-wide circulation, but tailored to nations and regions, the magazine will launch a bilingual Welsh version targeting Wales' priority sectors. Construction, renewable energy and Modern Methods of Construction are key examples of these, and the skills required to build, retrofit and decarbonise homes a particular focus.

The project will support the creation of three issues of the Welsh magazine over the course of a year. These issues will be posted to key players in all 183 11-16/11-19 schools and 14 FE colleges (key players typically being Head/Principal, Chair of Governors and Careers lead). A limited print run of 1,000 copies will be supported by unlimited digital distribution via email and social media, and hosted on the Optimised Retrofit website, with any additional grants or advertising fees primarily used to enlarge the print run.

32 Improving Existing Trade Skills for Decarbonisation

Led by the Training Steering Group , and based on work from Identifying Skills Gaps, the project will develop short training sessions aimed at the existing workforce and targeted at the specific gaps identified. These will (initially) be non-accredited training seminars intended to address the issues occurring on sites now, as it must be acknowledged that although a larger better skilled workforce will be required to scale up works, the majority for the foreseeable future will be delivered by the existing workforce that will need targeted support to ensure that the lessons learnt from previous initiatives are built upon and not replicated. It will however be necessary to recognise routes back **for re-training - identifying skilled workers in other sectors/out of work who could be re-trained to deliver retrofit in housing, this will help to build from the research undertaken by the Energy Catapult**

Based on successful live trials of these courses, they will be recorded to form a library of online training content. This will be disseminated through digital media, including popular specialist vlogs and YouTube channels, as well as via the Federation of Master Buildings and the Construction Industry Training Board. The key output on this phase is to recognise that industry learns differently now, and it must be ensured that it is targeted at the right people at the right time, in the right format. It will be essential that the existing trainers are trained in the new issues and developments to ensure courses are relevant and up to date.

Once non-accredited training has been developed, the project will look at what forms of verification might be appropriate to support the existing tradespeople to evidence they have updated with skills to suit decarbonisation with the potential to identify suitable qualifications based on a modular format or transferrable core skills between trades and interventions..

Outputs from this work will be freely available in Wales, and will be designed to be compatible with the intended digital skills platform.

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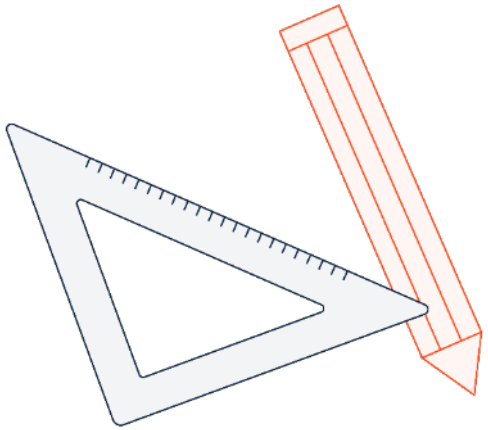

33 Digital Training App Foundations

Led by Sero, the project will undertake initial feasibility work into the creation of a Training App. This will develop prior concept work to establish the viability of a tool to deliver five minute training 'shots' direct to a mobile phone app, with training filtered to suit the individual user based on trade/profession, specialisms/interests, and company requirements.

34 Continued Professional Development

Led by the Royal Society of Architects in Wales (RSAW), a Continued Professional Development (CPD) programme will be put in place to be available for all construction professionals in Wales.

This CPD will be a combination of actual event at heavily discounted rates (not guaranteed to be free solely to avoid the poor turn outs common with free events), and virtual webinars depending on the situation with COVID19.

The CPD will cover the key points of the Whole Home Survey, Pathways to Zero, understanding Zero Carbon By forecasts, delivering retrofit works that support the foundational economy, understanding the likely skills gaps and challenges on site, and how to identify the quality of construction work.

Based on the success of initial delivery, the CPD will be recorded to provide a library of material for future reference, available freely in Wales beyond the completion of the overall projects.

This work will also investigate how to record and verify the attendance and understanding of the professionals attending the CPD, with a view to whether it is possible to hold a register of professionals who have successfully understood the training.

35 Client Guide to Decarbonisation Procurement

Led by Constructing Excellence Wales, the project will collate key lessons from the Pathfinder homes, wider projects and past research, to identify key points of failure that occur based on current common practice for client briefing and procurement.

Intended for primarily for social landlords, though applicable to all residential tenures, this guidance will comprise a short, non-technical summary that highlights pitfalls to the successful delivery of decarbonisation retrofit.

The output of the work will be an infographic or similarly short and easily absorbed synopsis. This will be distributed widely, with a particular focus on likely client bodies.

36 Improving Future Skills for Decarbonisation

Led by the TSG, the project will work to support all interested and relevant Further Education and Higher Education bodies in Wales to embed learning from the project into their course material. The preferred route for this adoption is to integrate into existing construction qualifications or apprenticeships, though new courses could be considered.

The timescales of the Optimised Retrofit project are not aligned with those of training courses, and it is therefore unlikely any formal qualifications will have been updated within the project period. The project, however, will provide regular updates of this progress toward adoption.

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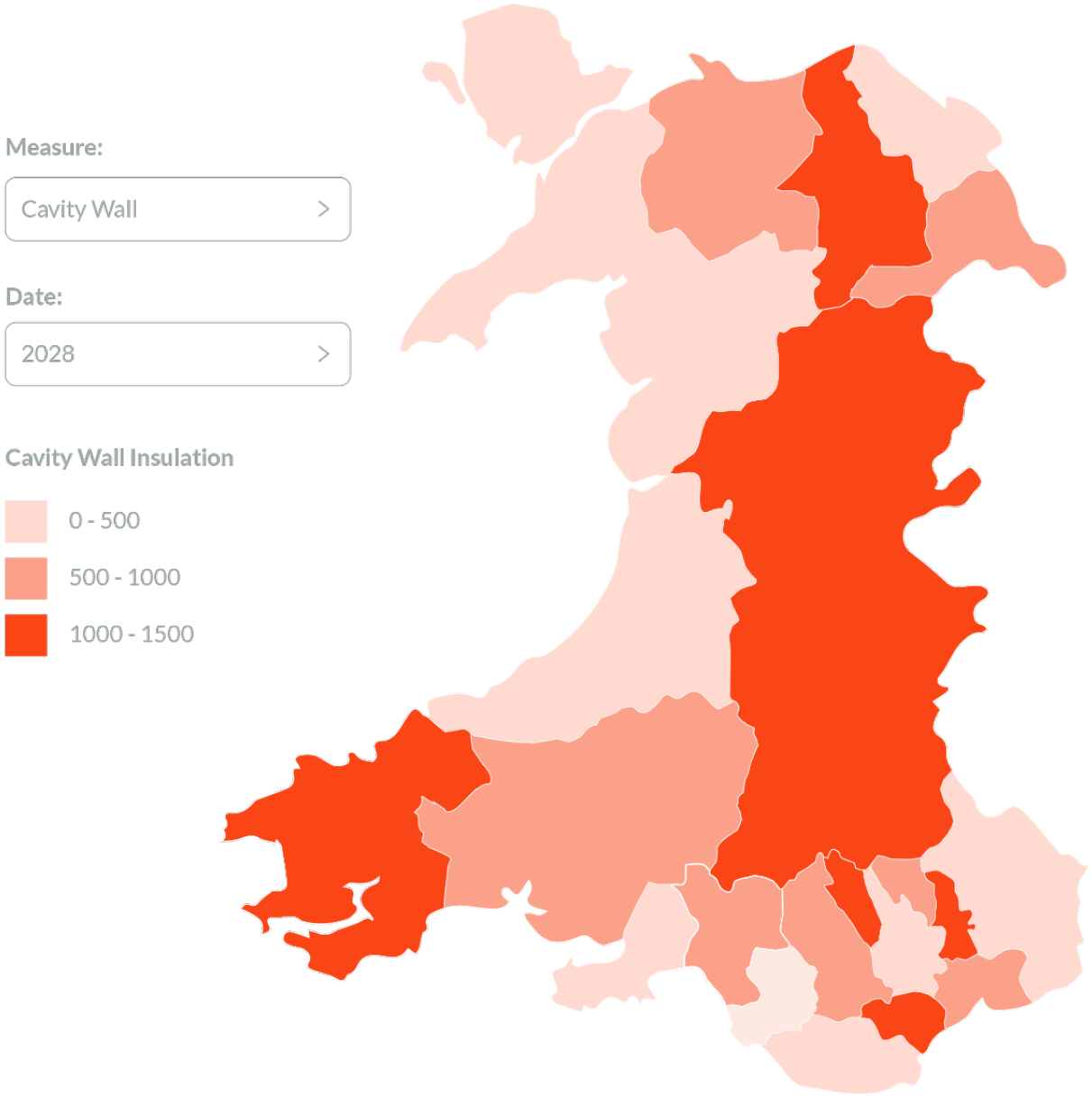

[37] Mapping Future Skills for Decarbonisation

Led by Sero, and working with the Construction Industry Training Board and others, the project will map the future need for skills across Wales based on the forecast measures from the Pathways to Zero tool.

Closely aligned with the Evidencing Future Market Demand, this will split future skills demands according to retrofit measures, geography, and the annual size of the requirement per year over the future years. This will be specifically designed to act as evidence from which Further Education and other providers can develop their own training and course development plans.

The project will deliver these to be automated and online, based on forecasts of works entered into the Pathways to Zero tool. Where statistically appropriate, the future skills maps will be extrapolated from data entered into the Pathways to Zero tools.

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Research & New Learning

38 Researching Retrofit Typologies – Stage 4

Led by the Welsh School of Architecture (WSA), the project will use the Pathfinder homes to develop previous reports directly commissioned by Welsh Government. This will extend the WSA Stage 3 work around example case studies, to bring this towards the earlier WSA Stage 2 work that set out approaches for high level home decarbonisation based on typologies.

This Stage 4 work will create a more detailed set of Pathways to Zero for more specific home typologies than the Stage 2 work, generating a larger range of examples based on the Pathfinder home retrofits themselves. Work to 'normalise' the actual retrofit works will be undertaken to remove site specific issues and costs insofar as possible.

The output of the work, necessarily falling after the completion of the majority of Pathfinder homes, will between case studies and typologies, to provide realistic assessments of potential Pathways to Zero for particular home types across a more detailed and diverse range of property types.

The intention of this work is to provide the RSLs and Welsh Government with a better view of the probable works by home type across the Welsh housing stock, and to therefore make better financial and carbon forecasts based on these.

39 Post Occupancy Evaluation

Led by the Active Building Centre with **Cardiff University**, the project will coordinate and integrate with the pre-established Post Occupancy Evaluation work directly commissioned by Welsh Government, and supplement this with the works overleaf.

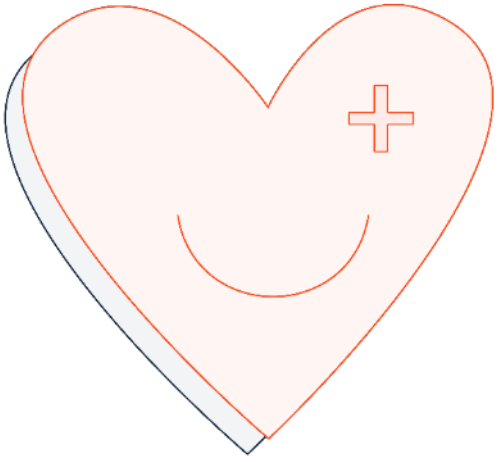
40 Quality of Life - Before & Post Retrofit Occupancy Assessments

Led by Cardiff Metropolitan University, this work will better understand how to assess residents' health and wellbeing through a combination of occupant interviews and dwelling fabric testing (next section). This will enable the project to understand residents' physical and mental wellbeing choices and behaviours, such as feelings, daily activities, work, physical health and safety, emotional health, happiness, physical energy, and social aspects. The work will also enable the project to determine whether a sample of dwellings have any unwanted any leakage in the fabric, that may influence thermal comfort, noise levels and physical wellbeing. These two approaches will enable the project to determine and influence in a positive way residents' future Quality of Life (QoL).

This work will be undertaken after the first step of retrofit works on the Pathway to Zero, in coordination and leveraging the related but different work from ABC & Cardiff Uni.

Occupant Interviews with focus on between 100 to 200 households, depending final suitable homes selected based on the measures, occupancy and home typologies, and agreed by the Project Steering Group, will have an adapted Short Form 36 Health survey, which enables researchers to determine the QoL of the residents before and after retrofit works have been undertaken. The indoor environmental conditions will be noted, to be compared with the interview results.

This work will feed in to the related activities arising from the fabric testing (next section), as well as drawing on digital data collected from the installed IES.



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41 Forecasting Grid Carbon Emissions to 2050

Led by the Active Building Centre, the project will map out future carbon emissions for the electricity and mains gas networks. This will be mapped as CO_2^{eq}/kWh for fifteen minute intervals for every day from 1st January 2021 to 31st December 2050, equating to just over 1 million individual forecasts for these networks.

Provided the data is available, the electricity forecast will be based on Welsh generation assuming a that renewable power is prioritised to remain in Wales, and excess generation exported to supply England will not be counted within the Welsh emissions factors. The work will evidence the decarbonisation of Wales' power divorced from the English exports, and at policy level will provide evidence to support the better measurement of Welsh power based on demand in Wales, rather than the geography of generation.

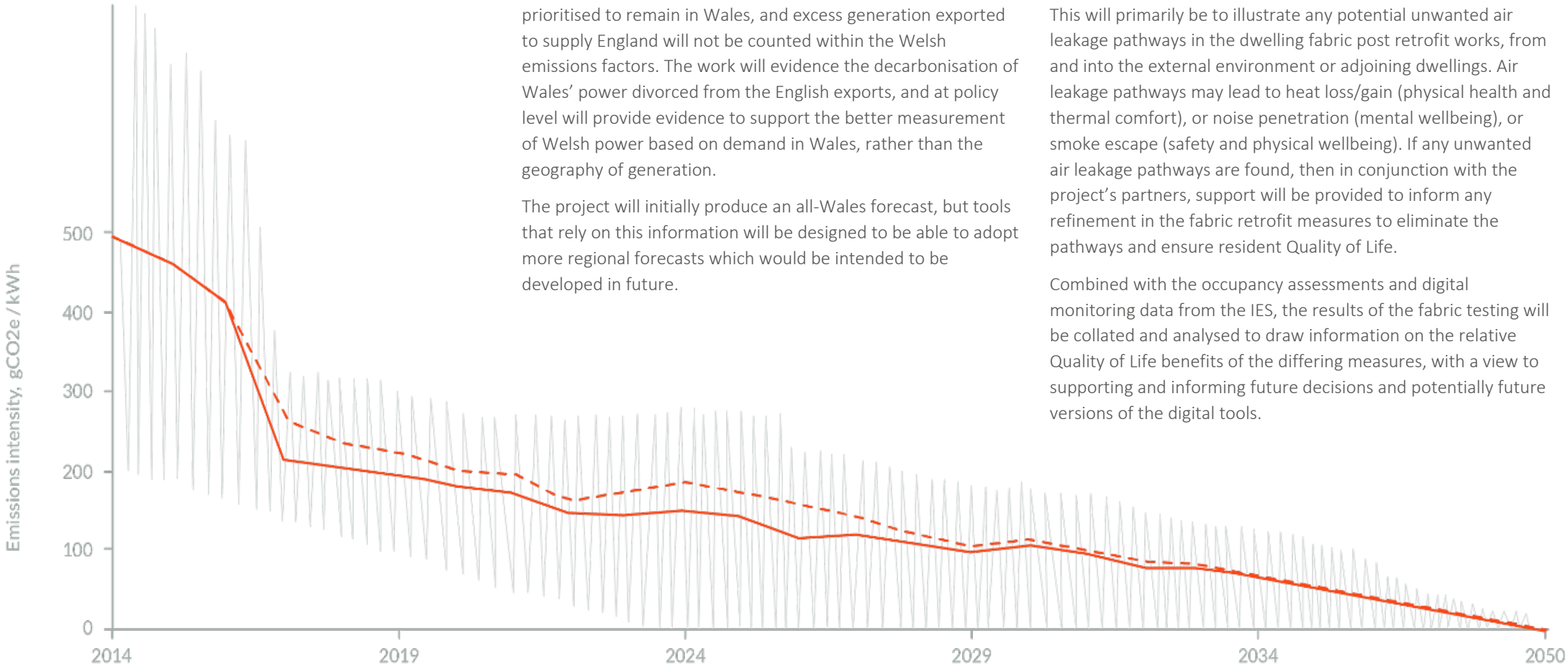
The project will initially produce an all-Wales forecast, but tools that rely on this information will be designed to be able to adopt more regional forecasts which would be intended to be developed in future.

42 Quality of Life - Fabric Evaluation Assessment

Post retrofit fabric testing will be undertaken on between 10 to 20 of the most appropriate homes from the Occupant interviews (or as deemed by the project steering group). These will be tested with a blower door fan and a certified non-toxic artificial smoke assessment, and subject to budget may also include alternative testing approaches such as air pulse tests and thermographic surveys.

This will primarily be to illustrate any potential unwanted air leakage pathways in the dwelling fabric post retrofit works, from and into the external environment or adjoining dwellings. Air leakage pathways may lead to heat loss/gain (physical health and thermal comfort), or noise penetration (mental wellbeing), or smoke escape (safety and physical wellbeing). If any unwanted air leakage pathways are found, then in conjunction with the project's partners, support will be provided to inform any refinement in the fabric retrofit measures to eliminate the pathways and ensure resident Quality of Life.

Combined with the occupancy assessments and digital monitoring data from the IES, the results of the fabric testing will be collated and analysed to draw information on the relative Quality of Life benefits of the differing measures, with a view to supporting and informing future decisions and potentially future versions of the digital tools.



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The project will openly publish the forecast for all energy grids in order to stimulate debate and seek contributions to improve the models. This will be particularly useful for electricity in the 2040's and for the gas network, where these decarbonisation journeys are less clearly defined.

There is no expectation that any individual fifteen minute forecasts will be correct, but rather that the trends these tables illustrate are broadly accurate, and sufficient to inform the connected digital tools that will rely on them.

43 Identifying Value Differentials

Led by the RICS, the project will use the data sources, to support the government's ambition of market transformation within the residential market. Social landlords will be enabled better to monitor and manage their assets and post-retrofit monitoring of tenants' lived experience. Importantly, the data can provide information to valuers to better assess differentials in value between improved and unimproved stock when undertaking book values. Currently such ability is hampered by lack of consistent clear data.

The possibilities for enhanced market transformation are even stronger when the project rolls out to private sector housing. It is known from previous and ongoing with which members of the project team have been involved work (Lenders, ReValue; EeMap; VALUER) that lack of accurate and current data has been a barrier to market prices reflecting energy efficiency accurately. marketing and valuing of homes or as providers of secured lender to reflect he improvements in lending policies and asking rental and capital prices.

The intention is that the data gained on retrofitted properties will be used both to monitor how the retrofitted properties are performing in value terms compared with market trends of non-retrofitted assets and to determine which particular technologies are most effective in both social and economic terms, thus enhancing the efficiency of subsequent retrofitting measures.

44 Semantic Conceptualisation of Optimised Retrofits

Led by Cardiff University School of Engineering, this would conceptualise the Sero retrofit vision in a semantic model, linked with the established built environment semantics of buildings. This would encode the retrofit measures proposed by Sero, their impacts and requirements. This would be linked to existing semantic models of buildings, sensors and environmental impacts. The results of this project would provide a semantic baseline for all other work to leverage on. As a second stage, this project would encode a set of initial heuristic rules to enable the matching of retrofit proposals to buildings based on the semantic model. These rules would extrapolate based on human knowledge (in the absence of large-scale data sets of retrofit proposal performance). The process of developing this model would be conducted by reviewing Sero documentation, related background research and discussions/interviews with Sero staff involved. The outputs of this project would be a formalised semantic model and associated rules of the Sero vision able to built upon to add further intelligence to all aspects of the digital tools that Sero create.

45 Automated Data Collection

Led by Cardiff University School of Engineering, this will investigate ways of automating aspects of data collection in homes – further automating aspects of the both the initial SERO building evaluation process and the post retrofit evaluation.

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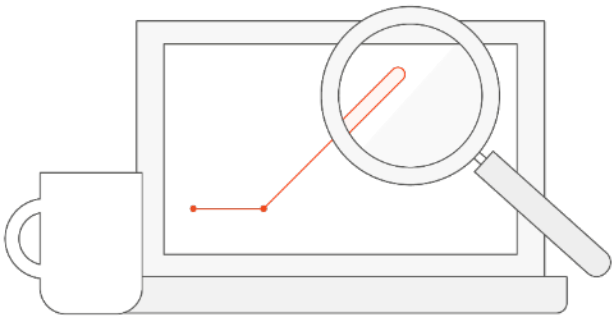

This would include studying and producing prototype (using university buildings) prototype tools that can (semi)automatically collect data about domestic premises, both before and after retrofit. The project would then investigate to automation the process of instantiating a semantic model (as defined in project 1) of a given property based on the collected data and further expand the model with data collected post occupancy.

46 Marketplace Certification

Led by Cardiff University School of Computing, this will develop an initial architecture to provide a marketplace for retrofit components. It will also develop ways to enable vendor certification and a mechanism to allow vendors, homeowners, and Sero to share data about candidate residential properties securely, without breaching the privacy of owners. The output of this project would be a prototype marketplace architecture and technological foundations for its further development.

47 THERMOS Project

Led by Swansea University, THERMOS (Thermochemical heat energy recovery and modelling opportunities for storage), will target the decarbonisation of domestic hot water and space heating provision by modelling the use of low carbon thermal technologies, development and modelling of thermal storage mediums, providing assessment of economic and environmental benefit and finally consulting with specifiers, installers and end users to ensure that the proposed solutions would provide an acceptable system covering the requirements of the general public. The project will focus upon dual scenarios, namely;

- properties that are currently off the gas grid and
- new build properties without gas boilers.

THERMOS is a multidiscipline project combining leading academics from Swansea University (Prof D Worsley, Prof. G Profitt, Dr J Elvins, Dr J Searle, Dr E Jewell, P. Jones) and Birmingham University (Prof. M Freer, Dr G Wilson, Dr H Cao) over a four year period with a targeted £1M budget from the EPSRC Decarbonisation of heat and cooling 2 funding call.

48 Standardised Measurements for the Retrofit Performance

Led by the Energy Systems Catapult, this work will develop a common methodology to measure the effectiveness of the retrofit work carried out. Current approaches estimate savings but don't provide consistent feedback on real life performance. On paper, a poor-quality project is assigned the same value as a high-quality one. This undermines the incentives on suppliers to deliver and increases the risk to consumers that the benefits of the work are not realised. The introduction of MCS and PAS 2035 standards are a breakthrough, but a gap persists around measurement of in-use performance and actual cost and energy savings.

This proposal will develop and test a standardised measurement and verification approach for home decarbonisation that can validate performance and savings predicted, creating the opportunity to compare, analyse and evaluate performance and feedback into the Sero assessment and pathway tools. The methodology created will be applicable to all domestic retrofit work. It will specify what data needs to be gathered as a minimum to provide a robust measurement and verification process, how this data can be gathered and set out how the outcomes of the analysis are managed – e.g. what happens in the event that underperformance is identified.

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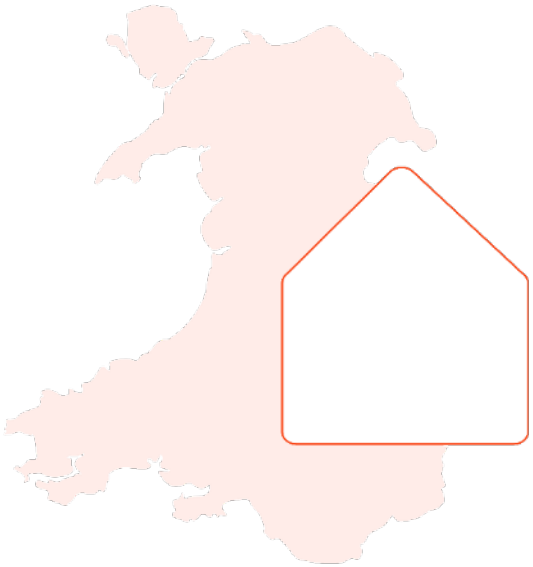


[49] Active Building Centre – Research Programme Coordination

The Active Building Centre Research Programme (ABC-RP) comprises of an academic consortium of 10 University partners with 75+ built environment and decarbonisation experts across multiple disciplines relating to:

- Machines learning and artificial intelligence
- Predictive control
- Building performance evaluation and data science
- Socio-economics
- Energy system modelling and integration
- Building physics
- Thermal storage
- Stock modelling
- Retrofit targeting and urban analytics
- Robotics and automation
- Low/zero carbon architecture and design
- Low/zero carbon communities
- Life cycle analysis
- Healthy aging and well-being

This proposal aligns with the strategic outcomes of the ABC-RP and the Transforming Construction agenda, as such, we are keen to support the proposal to deliver its outcomes for the benefit of consortium partners and Welsh Government.

The ABC-RP support to this proposal leverages £9.3m of resource across the 10 universities via EPSRC grant ref. EP/V012053/1.

Our contribution to the proposal covers the aforementioned areas of research with particular focus on:

- "Zero by when", LCA and LCC
- Data and monitoring specification development
- Data and monitoring infrastructure
- Performance evaluation and analytics
- Energy system integration and modelling
- Foundational economy development and support
- Machines learning and artificial Intelligence led retrofit interventions

[50] Enhancing the Welsh Housing Stock Data

Led by Sero, the project digital team will work closely with Welsh Government to integrate the data captured from the Whole Home Surveys and Pathways to Zero into the Housing and Stock Analytical Resource (HSAR), provided the relevant consents from the RSLs are provided.

Initially, this will work to integrate the outputs from the Whole Home Survey, but once possible, outputs from the owner-selected or auto-optimised Pathways to Zero will also be shared. This will include the "Zero Carbon by…" forecasts, enabling a highly granular picture of both existing home conditions and the likely future improvements to be developed by relevant government bodies.

Optimised Retrofit will also provide data for academic research activities (see later), subject to Welsh Government's agreement. This is proposed to be available through the HSAR enhanced dataset, thereby utilising the procedures, appropriate security and usage checks already in place for accessing any data for research from Welsh Government.

Digital Tools

The Role of Digital Tools

Optimised Retrofit will build on existing work by partners to create and expand digital tools that streamline the process of assessing and designing measures for individual homes.

These tools will be developed by the collaboration partners and trialled through development with the Pathfinder homes. Once developed, the core tools will be freely able to be used to assess and design measures for any home in Wales. The digital tools primarily comprise:

The Whole Home Survey digital tablet tool

An assessment process that meets the requirements of a PAS2035 whole home assessment operating on a tablet, developed from Sero's existing work, and designed to be used by a competent home assessor to accurately and quickly capture the necessary information about any home.

The Pathways to Zero assessment tool

A web-based tool expanding Sero's current work that allows competent home retrofit designers to select and sequence retrofit measures, in line with the principles of PAS2035, ensuring that only appropriate and compatible measures and sequences of works are designed, which highlight the interactions and requirement for a more detailed design to ensure optimum functionality.

Pathways to Zero checking components

Fuel Poverty, Overheating and moisture/ventilation risks are assessed for each step of planned retrofit measures in the Pathways to Zero, ensuring these issues are more easily avoided.

A ***Zero Carbon by…*** date

A complex underlying assessment that provides a clear, simple metric of "Zero Carbon by…" - the anticipated year between now and 2050 that the home will become zero carbon (where this is technically achievable). This links highly granular future energy grid carbon forecasts and home performance, allowing home and energy decarbonisation to be connected.

Building Passports

The digital tools also include third party digital interfaces to connect these tools to those of others, such as planned maintenance software providers, Welsh Government, and TrustMark (the UK government backed quality standard under PAS2035). Together these data warehouses provide differing versions of building passports that are most relevant to the respective home tenures.

Digital Underpinnings

Open standards and interoperability, together with digital security, GDPR compliance and underlying data storage and safety are also core components of the digital activities. All digital tool elements of the project are delivered through Sero and the digital partners, reporting to the overall project steering group.

Digital Tools

Secure Digital Structures

All the digital tools developed under Optimised Retrofit will be built with security and confidentiality of personal data in mind. The project will adopt, and in some cases support development of, best practice data protocols and approaches, supported by close integration of work by the Active Building Centre.

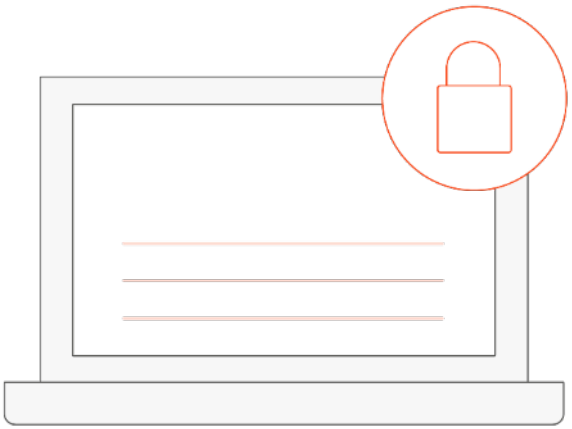
51 Data Formats & Integration with Third Parties

Optimised retrofit merges two distinct environments with respect to data format, adoption and availability. These are construction and operations and maintenance. Construction has not yet fully adopted standard formats with respect to data storage and sharing. We will, therefore, be making the platform support multiple exchange formats to maximise adoption of cross party data sharing , ensuring we maintain a “single source of truth” approach.

BIM related data will be stored within a non-proprietary file format to provide the widest level of industry compatibility. Specifically these focus on .ifc, .ifcXML and .ifcZIP. Exchange will focus on BCF, with static and dynamic transfers dependant on the third party requirements.

Additional data sets will be shared using standard REST APIs in both JSON and XML format, again the view is to ensure that we have the widest level of compatibility with all partners.

Sero’s data storage will adopt the standards set by TrustMark in the public “lodgement data dictionary” paving the way towards full property passport functionality, which will aid in the success of ongoing retrofit design consistency per property



52 Data Security, Personal Data & GDPR

The project recognises that personally identifiable information (PII) is closely linked with property data at the individual home level. Optimised Retrofit will therefore very carefully assess the anonymisation options with respect to PII data and will only expose PII when it is absolutely critical and within agreements, i.e. billing data and survey requirement data. The ethos will be to share the minimum required data to effectively perform the task, using techniques such as encryption, de-identification and aggregation wherever these are plausible. The collaboration will also be continually working with legal teams to ensure GDPR principles are applied and maintained

Optimised Retrofit is reliant on a large amount of quality data, which needs to be stored and exposed with careful planning for confidentiality, integrity and availability. Data stored within the Sero environments will be secured with resilient perimeter and API protection.

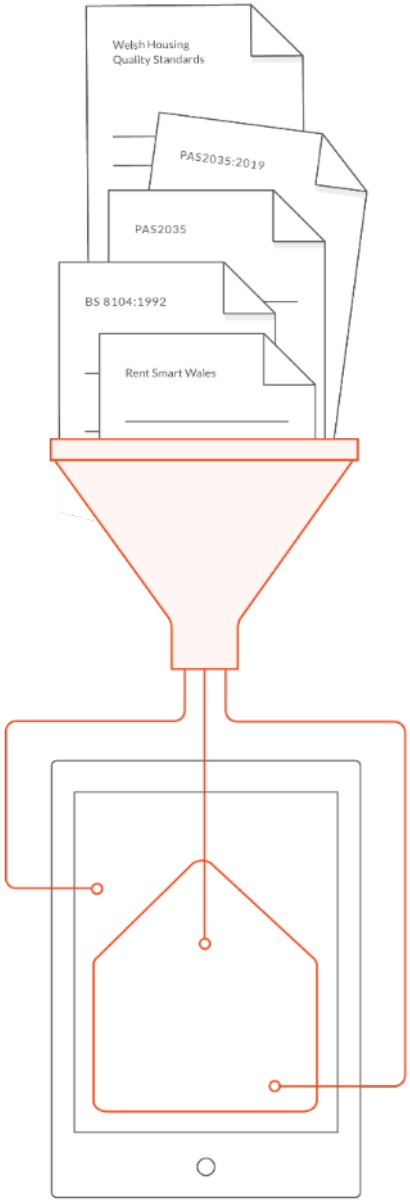
As the system and API connections grow, most likely in the legacy of the project, connectors will move onto an API gateway platform with threat detection and machine learning algorithms. Only data which has formal sharing agreements will be exposed via our APIs, and only then to pre-agreed third parties.

Penetration Testing, Intrusion Detection & Ethical Hacking

As an integral part of the project, the partners will undertake regular and ongoing penetration testing on the system developed. This will be aligned with intrusion detection to monitor for breaches.

Subject to suitable experts, the project may also host a ‘hackathon’ or similar ethical hacking to test the security of the platform through one or more exercises.

Digital Tools



Whole Home Survey

The Whole Home Survey will be a downloadable app or similar software designed for use on a modern digital tablet whilst undertaking the assessment of a home for retrofit works.

The Whole Home Survey tool is designed to be used by Optimised Retrofit Home Assessors – competent individuals trained in compliance with PAS2035 to undertake assessments of individual properties using the digital tool.

These home assessors may be in-house staff or externally appointed, but all will have training and support to ensure they can accurately and professionally assess each home, based on its specific opportunities and barriers to safe retrofit.

The Whole Home Survey, together with the home assessor, is intended to revolutionise the accuracy and speed of a comprehensive home survey, forming the bedrock of all future steps to decarbonise the homes of Wales, whilst ensuring the lessons of the past are embedded in the decision making process, and that measures deliver real improvements and reduce the risk of an increase in fuel poverty.

The tool will be developed in the project from assessment and digital work already completed by Sero, ensuring the quickest achievable scale-up to a viable Whole Home Survey tool.

[53] Technically Robust

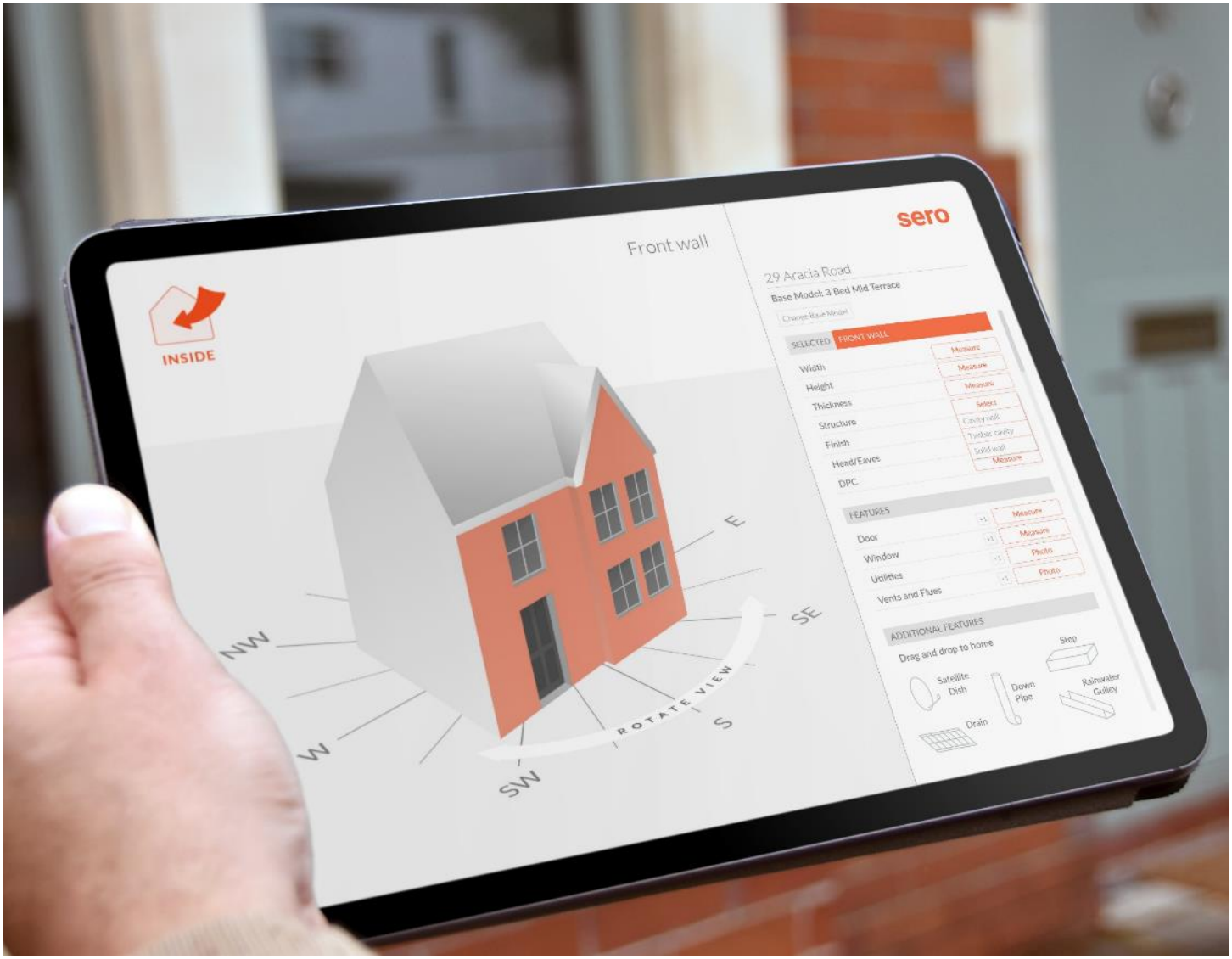
It's a basic rule of any process that "rubbish in = rubbish out". One of Optimised Retrofit's fundamental goals is to deliver quality information with a high level of confidence "in" embracing the principles of the 4 C's approach (Context, Coherence, Capacity, Caution) to optimised retrofit, this approach delivers a retrofit risk management process that is delivered using the principles of the Whole House Approach suggested by the Each Home Counts Report.

The project will lead a team of collaborators and recognised experts to produce the most technically comprehensive set of home survey questions ever compiled (as far as we know!), building on work already underway by Sero.

The master question set will capture all information required to undertake a PAS2035:2019 retrofit assessment across all major home types, though this will exclude park homes (static caravans) due to their unique nature. However, the survey will also cover Welsh Housing Quality Standard, Domestic Energy Assessor surveys, and new needs are identified (likely during the legacy period) other home assessments such as Homes for Human Habitation compliance, mortgage surveys, valuation surveys, and more. This will create an extensive list of questions, any enable them to be rationalised into one common format, given many questions repeat across survey types.

However, this comprehensive question set will never be exposed for any individual home assessment , the process will allow filtering of data required that is specific to the activity being undertaken at survey stage– we therefore anticipate as little as 15-20% actually needing to be entered by the assessor on site, thanks to the digital based nature of the survey.

Digital Tools



54 Tablet-Based, Graphics led

The Optimised Retrofit Collaboration will build a game-changing home survey tool hosted on a digital tablet. Ease of use and integration with other software used by housing stock managers will be core to this tool, designed around enabling a competent home assessor to quickly and effectively collect all the data required.

Led by a graphical interface, the touch screen tablet tool will enable quick and effective construction of a detailed set of survey information. The graphics-driven approach means users can much more quickly and accurately identify queries and validate or enter responses.

Initial data is populated by selecting ‘wireframes’ that most closely illustrate the style of home, entering key measurements and dimensioning features to customise this wireframe to the unique property. As this is undertaken, the wireframe model is graphically rendered to take on an approximation of home’s appearance.

More detailed elements of the homes are added through ‘drag & drop’ options, moving common components such as satellite dishes, rainwater pipes and meter boxes, from a visual menu to drop them into position on the wireframe. Here, the graphical approach leads to a quicker and more intuitive home survey.

Digital Tools

55 Digital Whole Home Survey

The Whole Home Survey tool will work on modern digital tablets and will utilise many of the hardware features of these. The intention is for the tool to develop increasing functions in the legacy scale-up, but the first version of the tool will include:

Individual, Groups & Organisational Settings

Users will have unique, secure log-ins (face or thumbprint where possible) to assess their account, which can be grouped within organisations. Company administrators will also be able to lock/require features by group or whole organisation, creating a workable hierarchy of users.

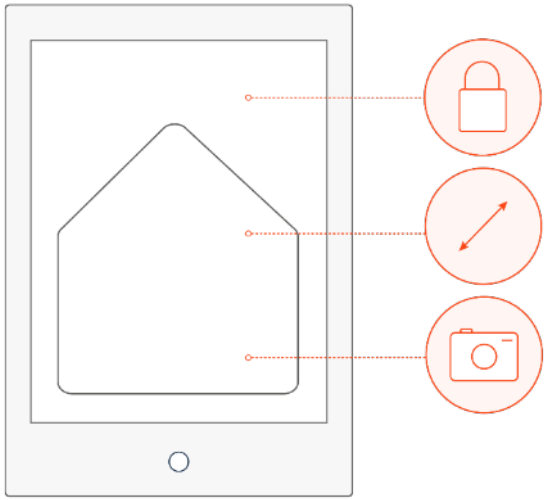
Camera & On Screen Internal Measurements

The tablet camera will be used to capture all internal and external elevations, creating a record of the property and enabling the remote quality assurance functions of the survey. On suitable tablets, on-screen measurements will be able to be taken by tapping either corner of rooms, windows or doors. Whilst not accurate enough for component manufacture, they are sufficient for assessments and installer quotations.

GPS, Compass & Gyroscope

The tablet global positioning system (GPS) location will automatically offer property address details (subject to signal), and using the internal compass will ensure property floor plan orientation is accurately captured. The gyroscope may also be able to provide the home assessor with the capacity to measure roof pitch, thought the usefulness of this will be reviewed first.

Further functionality that could speed the home assessor or improve confidence in the data captured may well be achievable within the project duration, and will be the subject of ongoing development subsequently.



56 Digitally Accelerated Assessments

The Whole Home Survey will use three approaches to accelerating the process of assessing the home. For the conclusion of the project, each of these will have the first examples operational, though all three have significant capacity to be enhanced as the tool develops forward in future.

Digital Filtration

This automatically removes survey questions that are not applicable, based on previously entered or known information about the property or assessor. Hence confirming this is a top floor flat removes all questions on foundations, or confirming a wall structure is concrete block removes all questions on breathability. The filter will also be based on the competencies of the home assessor, so those using the tools for home valuations won't be asked to validate the wiring is IEEv18 compliant, for example.

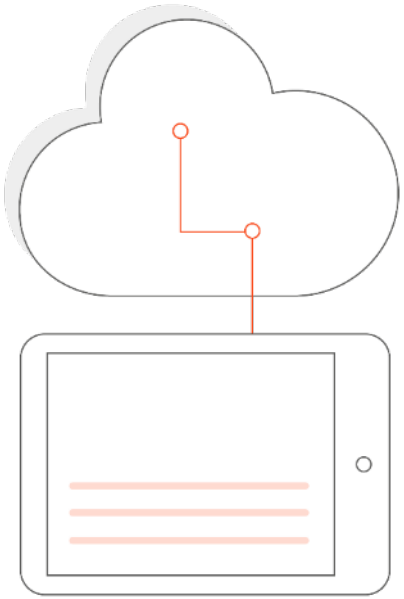
The second filtration uses the digital functions. Here automated input can filter the survey questions. This will be used, in conjunction with suitable third party mapping where available, to hide questions irrelevant to that location, such as Conservation Area questions being hidden in a 1990's housing estate.

Pre-Population

Pre-population uses previously entered data to either shorten the survey or fill in anticipated answers, which will be presented to the competent home assessor for validation. Pre-population will work from both data that existed prior to the start of the assessment (native and third party where available), and from data entered earlier in the survey.

Pre-Population includes simple steps such as automatically completing the home assessors' professional details from their user settings, or downloading the local weather conditions.

Digital Tools



It will also search connected databases for previous information on the homes, importing relevant past information. This both speeds the survey process this time, but allows validation to improve confidence in the data captured, updating all the datasets with the more reliable results. Searching and downloading data sources will be done live, but will also be able to be preloaded onto the tablet. This lightens the mobile data demands and avoids connection 'not spots'.

Pre-population will also work during the survey, using the answers from previous questions to propose answers to later questions. In simple terms, this means the home assessor will answer details on window frames, double glazing, lockable latches and similar for the first window in a home. The second window will have this information pre-populated and presented back for the home assessor to "tap" their confirmation, or overwrite where different.

Automation

Automated completion of survey presents one of the most powerful strengths of this approach. For the work within the funded project, this will be primarily through looking up data from libraries either native to the platform or third party (where connected). This will enable survey questions to have suggested answers that can be validated by the home assessor. The project will also look to include Optical Character Recognition (OCR) to capture boilerplate information can be quickly and accurately.

However, the tool will be developed with the intention to scale up the automation elements in the survey significantly in future, as the underlying dataset becomes sufficiently robust.

From GPS, to accelerometers, from LiDAR (or multi-camera triangulation) to triple axis gyroscopes, the tablet can speed the survey process.

57 Data Quality Assurance

The Whole Home Survey will provide a vastly greater quantity of data, using trained home assessors and digital tools as outlined to ensure high confidence in the data that is captured.

As a further check, the project will begin to develop digital data quality checking on information received. This will require time to develop a large enough dataset, but the principles will be built in from the outset, to enable the use of pattern recognition in the data once datasets are sufficiently mature (likely to occur during the ongoing operation of the tools).

Pattern recognition will identify trends in the data received from individual home assessors, property types, devices or similar elements of the survey response. For example;

- One home assessor only entering the same make & model of gas combination boiler for all homes
- One device consistently dimensioning doorways 1.2m wide
- One company's home assessors not completing the electrical questions on the Whole Home Survey

The capacity to identify trends in the dataset will be developed as the volume of data grows, allowing the pattern recognition to flag potential problems ranging from a need to retrain home assessors, recalibrate devices, or review the activities of companies involved.

58 Optional Extensions

The core tools are intended to support collaboration and the wider decarbonisation of homes, and one of the goals of this approach is to make the Whole Home Survey as ubiquitous as possible, in part achieved through being freely available.

In order to encourage collaboration with third parties who have developed their own tools that can help surveying and

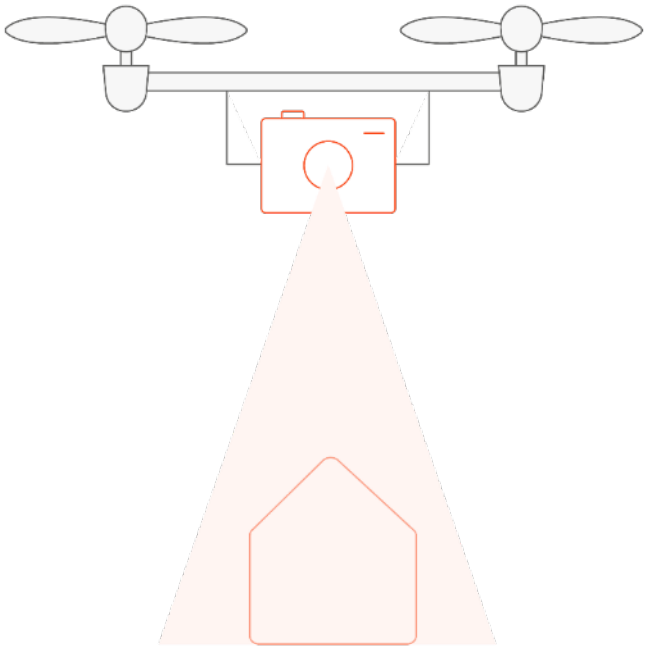
Digital Tools

decarbonisation, a means for those third parties to generate a commercial return is needed.

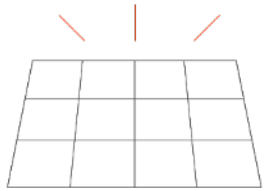
The solution is the inclusion of a ‘marketplace’ of optional extensions to the core tools. These will enhance the functionality or connectivity, but will not be an obligatory part of achieving an Optimised Retrofit.

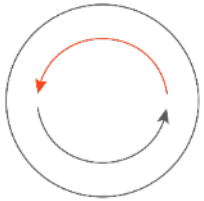
Optional upgrades will include potential enhancements such as:

- HTC pre-retrofit metering integration, though this will be included for those Pathfinder homes in the project as set out in Section 11 earlier.
- Thermal Camera Performance, which uses an FLIR infrared camera to ascertain thermal performance values to a higher granularity than simple assumed performances based on construction build-ups, and can help identify thermal bridges and areas at risk of mould.
- Drone Surveying, using unmanned aerial vehicles to undertake detailed surveys of the homes external elements.
- 3D Models, converting ‘point cloud’ home survey information into editable CAD/BIM models to form the basis of more complicated retrofit work for designers.
- Third Party Connectivity, accessing or uploading to pay-for-use property datasets (where the preferred reciprocal data sharing offer cannot be agreed), to integrate additional services such as planned maintenance software.



Digital Tools





Pathways to Zero Platform

The Pathways to Zero Platform is designed to be used by Optimised Retrofit Home Designers – competent individuals trained in compliance with PAS2035 to undertake retrofit designs for individual properties using the digital tool.

These home designers may be in-house staff or externally appointed, but all will have training and support to ensure they can accurately and professionally design the retrofit measures for each home.

The Pathways to Zero tool, together with the home designer, provides a guided means of quickly and efficiently selecting technically appropriates decarbonisation steps.

The tool will be developed in the project from retrofit measures work already completed by Sero, ensuring the quickest achievable scale-up to a viable Pathways to Zero tool.

[59] Technically Robust Measures

Led by Sero's Colin King, the project will coordinate a team of experts who develop and then populate a template of information that represents as many retrofit measures as possible, spanning fabric, technology, and operational controls.

These digital summaries of retrofit measures will be generic rather than product specific, though capable of expansion in future. The summaries will include fields for:

- Key performance details of the measure
- Incompatibilities with other measures or home features
- Sequencing requirements, and pre/post installation work requirements
- Cost bands, known risks, known product suppliers
- For future expansion to include embodied energy, end-of-life recycling & circular economy

Through the Optimised Retrofit Collaboration, these retrofit measures cards will be initially populated based on the expertise and experience of the group. Moving forward, the intention would be for these to be widely peer reviewed and updated.

Learning from Experience

As structured digital data, these individual measures summaries are not static. As new measures are invented, or new data on existing measures shows changing risks, costs or considerations, these measures summaries can be updated to ensure this learning (once captured in the updated measure) is automatically shared to all using the Pathways to Zero tool, re-filtering existing options and setting new options for consideration.

Digital Tools

60 Digital Measures Cards

Every retrofit measure, whether fabric improvement, low/zero carbon technology or operational control system, will be represented as a digital 'card' summary. These individual digital measure summaries illustrate at a glance the key features of every measure from carbon and cost reductions through to complexity of installation and lifespan.

Underpinning these top-level summaries additional fields cover the particular property features to which the measure can be safely applied, sequencing requirements, safety measures, incompatibilities, consequential works, and so forth. These fields are accessible if desired, but automatically apply to filter which measures are available for the property being considered.

Formed into structured data, these individual measures summaries form the technical backbone of the Optimised Retrofit toolset, and the basis of the digital filtration that ensures only technically appropriate measures are ever presented to the home designer as options on the Pathways to Zero. Digital checks will ensure that multiple measures are compatible and any interfaces, connections or interactions between them are identified and flagged to attention.

61 Graphically Led Intuitive Tool

The objective of the Pathways to Zero tool is to present the competent home designer with all technically viable retrofit measures for them to be able to select the optimal route for the retrofitting of that individual home, in one or more steps.

As with the survey, a graphical interface for the Pathways to Zero will support a quicker, more intuitive, and user-friendly tool, helping the home designer to process large amounts of information effectively (we also think it helps if it's fun!).

The Optimised Retrofit individual improvement measure summaries can each be thought of as a digital card, with the deck of cards comprising all the measures that are technically viable for that home based on the underlying robust data.

The Pathways to Zero graphical interface enables the competent home designer to 'play' digital cards, weighing up the different benefits between the measures and their sequence for that unique home.

The designer can also play the cards into steps (or 'hands'), representing the groups of measures intended to be undertaken during each step of physical refurbishment at the home, and the home designer chooses how many. This could represent works done in 2021, 2026 and 2029, with the *Zero Carbon by…* date predicted for each 'hand' to show progress towards the overall target.

Your selected measures

1 Step One Retrofit Works

Zero Carbon By:	2045	Innovation:	Proven Tech
Energy Bills:	Down 3%	Cost Range:	£3,000-£4,500
Overheating:	Low Risk	Funding Options:	RHI Grant, Arbed

2 Step Two Retrofit Works

Zero Carbon By:	2032	Innovation:	Proven Tech
Energy Bills:	Down 18%	Cost Range:	£2,500-£4,000
Overheating:	Low Risk	Funding Options:	Energy Bill Sacrifice

3 Add Step?

Your available measures

Optimise

OPTIMISE | BATCH SETTINGS | TYPOLOGY DEFAULTS | GENERAL SETTINGS

Digital Tools

62 Cloud Based Intelligence

As with the Whole Home Survey, the Pathways to Zero tool will be built to utilise modern information technology and cloud-based intelligence, running as a portal on the local machine. The intention is for the tool to develop increasing functions in the legacy scale-up, but the first version of the tool will include:

Individual, Groups & Organisational Settings

Users will have unique, secure log-ins to assess their account, which can be grouped within organisations. Administrators will also be able to lock/require features by group or whole organisation, including batch processing and typologies work.

Intelligent Energy System Pre-Meter Interface & Survey Data

The platform will automatically import both the Whole Home Survey data and any IES device calculated HTC as the basis for the Pathways to Zero for the home.

Drag & Drop Retrofit Play Deck

The individual retrofit measures cards are designed to drag and drop in to as many steps as the competent user wishes to create. Each card can be expanded to give further information, but the platform itself will ensure only technically appropriate measures can be deployed.

Live Component Recalculation

Through cloud based processing, the tool will update the ‘checker’ elements for each step of the retrofit journey. Gives real-time feedback to the competent user to inform their next measure decision, or allow them to review previous ones.

Further functionality that could speed the home designer or improve confidence in the data captured may well be achievable within the project duration

Digital Tools

63 Zero Carbon By…

Each home will have a "Zero Carbon by…" date – the year when that home, with the given set of retrofit measures, anticipated occupant behaviours and energy grid interfaces, will achieve net zero operational carbon emissions.

This date assumes no further physical interventions are made to the home beyond those set out in the measures. Homes not achieving net zero by 2050 will simply be reported as "Zero Carbon after 2050" until other measures improve this date.

This measure of carbon includes both regulated and unregulated energy usage. "Zero Carbon by…" therefore provides a simple, compelling metric for the public, as well as valuers, public organisations and policymakers.

The underlying calculations will build from work already established by Sero, using our HEDGEHOG tool (Home Energy Demand & Generation Estimator for Holistic Optimisation to Grid) to anticipate the energy used by the home in fifteen minute intervals across the year, and modelling this for every year to 2050.

Combined with anticipated grid emissions for energy, the energy model can identify the year in which the home's energy usage will be net zero carbon. This calculation tool runs parallel to the Pathways to Zero measures selection – as you 'play' a measure, the "Zero Carbon by…" date is recalculated forwards (or backwards) on screen.

RdSAP Integration

The Pathways to Zero tool will also provide capability to output an RdSAP assessment of the home, providing a comparator between the *Zero Carbon by…* date and the SAP score, which will provide data to the WG to undertake an analysis review to policy and mechanisms for setting any future improvement targets in the WHQS or other standards..

64 Fuel Poverty Checker

Increasing the burden on residents by increasing fuel bills is a risk of some retrofit measures, especially where measures switch to more expensive energy supplies on the presumption that less will be used (most commonly a switch from gas to electric), or that residents will use low/zero carbon technology 'as designed' without suitable ongoing intelligent management.

Running parallel to the main Pathways to Zero selection tool, the fuel poverty checker runs a comparison between the fuel usage of the original home, and the same home with retrofit measures applied. This is calculated for each individual retrofit installation stage in the sequence in which the competent home assessor has selected to apply them, ensuring every step of the home's decarbonisation journey can be checked to avoid fuel poverty.

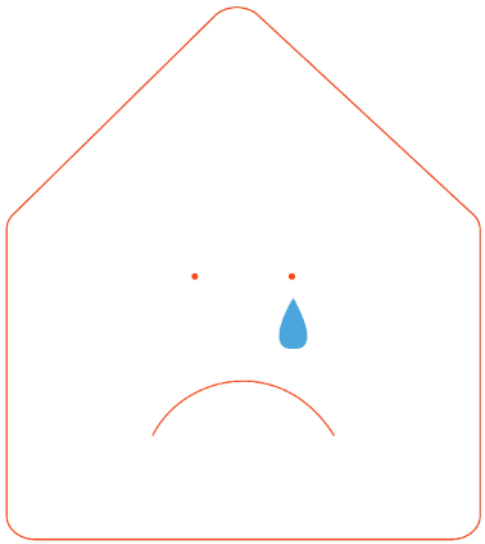
Similar to the *Zero Carbon by…* calculation, this develops from pre-existing work by Sero in the HEDGEHOG and Sero's underlying dataset, and utilises future pricing forecasts for the main fuel types (all major fuel types are covered). The checker will therefore anticipate likely energy price changes, and outputs whether the resident's bills will increase not just at the end of the Pathway to Zero, but at any step along the way.

This checking tool also feeds into the financial planning tools, covered latter, to help identify how to fund measures over time

65 Overheating Protection

Increasing insulation, tackling unintended air leakage, and changing heating systems, together with a warming climate,

Digital Tools



means homes face an increasing risk of overheating in the coming decades.

In tandem with the main Pathways to Zero function, the overheat protection checker assesses whether the risk of internal overheating as a result of any measure has increased. This factors in the sequencing of measures as well as using climate forecast data to model up to 2080 (the furthest such datasets currently model to).

66 Ventilation & Moisture Checker

Just like overheating, changes to the physical fabric and systems in homes can affect the ventilation quality and rate. As importantly, they can impact the movement of moisture in the home that has the potential to cause damage to the building fabric and the occupants' health.

Whilst Pathways to Zero measures won't offer technically inappropriate measures for consideration on homes (for example, vapour impermeable insulation outside of a vapour permeable structure), this checker that considers moisture risk runs alongside the main tool to monitor the likely risks of ventilation and moisture movement, endeavouring to achieve moisture balance.

The initial version of this will operate as a guide for the competent home designer, helping to inform their decision by highlighting the risk profile. Over time, the checker itself will move to more advanced modelling of moisture movement inherent in the process, giving still more protection.

67 Batch Retrofit Preferences

The Pathways to Zero tool allows the home designer to choose the route and timeframe to decarbonise an individual home, and for eventual owner-occupiers this will be all they need.

For landlords managing more than one home, the portal provides for grouping. Batch retrofit preferences allow landlords of property portfolios to adjust the use of the Pathways to Zero tool (and the "Optimise my Retrofit" tool) to recognise and prioritise their own preferred planned maintenance and property upgrade strategies.

This can be used, for example, to prioritise general fabric improvement works ahead of low/zero carbon measures, or to specifically prioritise one measure (such as window replacement), where the landlord is looking to undertake these works in volume. The batch tool allows this to be done through time as well – for example, if a social landlord is looking for a major External Wall Insulation programme in 2027, this measure and date is reflected on the Pathways Retrofit Measures card to everyone working on a home owned by that landlord, helping them align works across the portfolio.

Importantly, the batch tool will never recommend technically inappropriate or ineffective measures for any property – this remains the underpinning directive – but this will allow sequencing changes or minor changes to the Pathway to Zero route in order to allow grouping of measures across portfolios

68 Retrofit Typologies

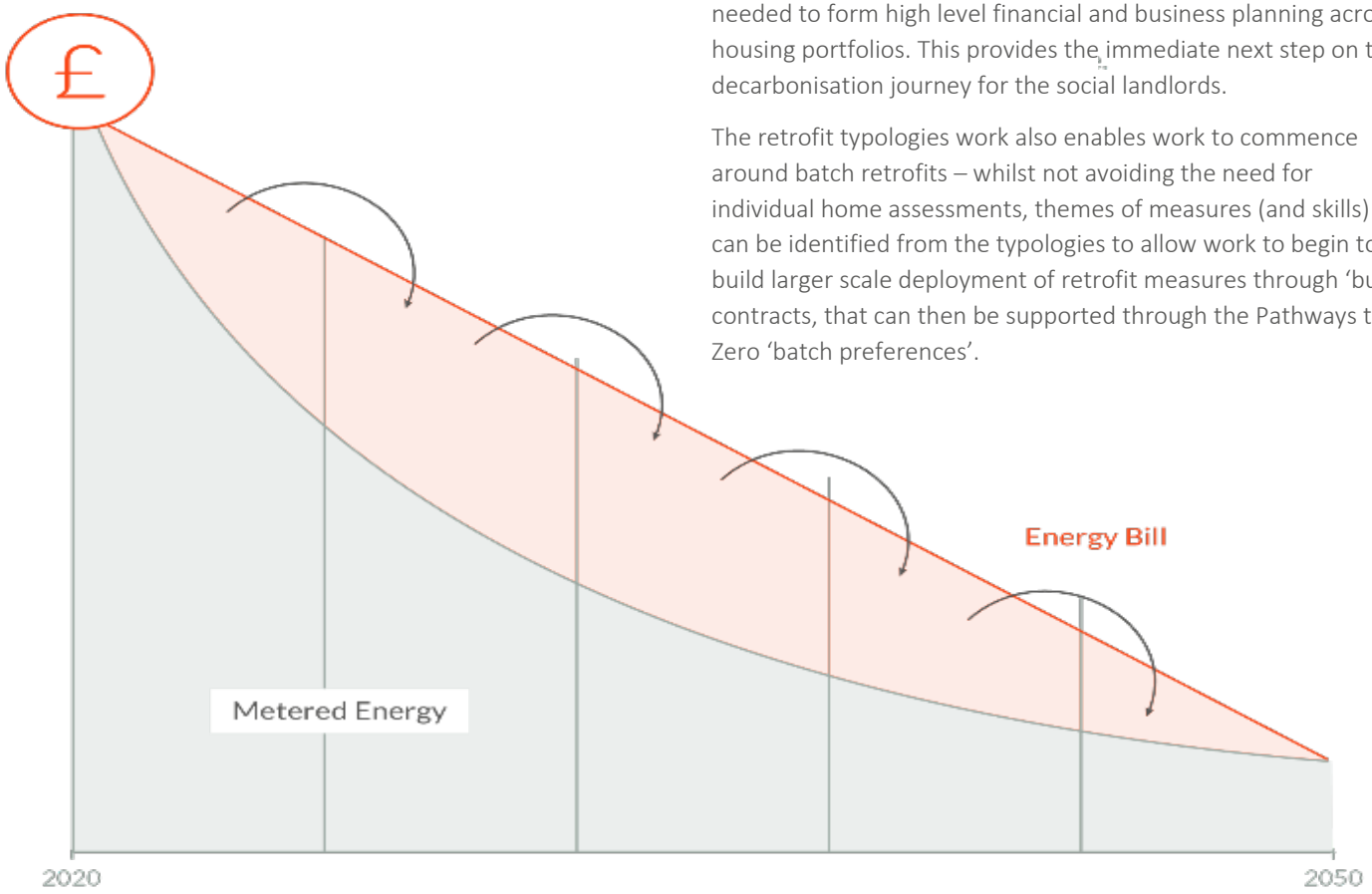
The Whole Home Survey and Pathways to Zero tools are ultimately designed for individual homes, since every home should be assessed before retrofit work can be undertaken.

Digital Tools

However, the Pathfinder homes will look at typologies across the social landlords and throughout Wales. Building from the Welsh School of Architecture's work, this individual home assessments will be the next level of detail for a greater array of home types, separating out into more than the current fourteen to capture types of construction and technologies installed.

These pathfinder Pathways to Zero provide a key stepping stone for the social landlords – linking the 'bottom up' Whole Home Survey and Pathways tools with the 'top down' work that is needed to form high level financial and business planning across housing portfolios. This provides the immediate next step on the decarbonisation journey for the social landlords.

The retrofit typologies work also enables work to commence around batch retrofits – whilst not avoiding the need for individual home assessments, themes of measures (and skills) can be identified from the typologies to allow work to begin to build larger scale deployment of retrofit measures through 'bulk' contracts, that can then be supported through the Pathways to Zero 'batch preferences'.



[69] Energy Bill Sculpting & Financing the Future

When not undertaken as a single whole house retrofit, decarbonisation measures for homes tend to yield diminishing energy bill savings, since each measure is sequentially dealing with a smaller energy footprint. This means early measures deliver the residents the biggest savings to compensate them for the disruption and (for owner-occupiers) likely capital costs.

This can mean that later measures in a Pathway to Zero might not be adopted, since judged by that point of the decarbonisation journey alone (rather than holistically), they may not seem worthwhile.

The energy bill sculpting component allows the disconnection of the energy savings from the measures to resolve this challenge.

Whilst the true energy bill and carbon savings are forecast in the Pathways to Zero platform, this component allows a decision to be made about how much of those savings will be passed onto the residents' energy bill. The resident could, therefore, be given a consistent 10% energy bill saving at each retrofit intervention step, whilst the underlying energy bill savings may be weighted more heavily to the first measures and least to the last.

Financing the Future

This Energy Bill Sculpting typically does not pass through early, larger, bill savings. The component estimates the capitalised values of these deferred savings and highlights these as potential funding towards future Pathway steps. For example, a deferred bill saving of £20/month from retrofit measures in 2022 would highlight as a potential capital contribution of £1,440 if the next step is scheduled for 2028.

Digital Tools

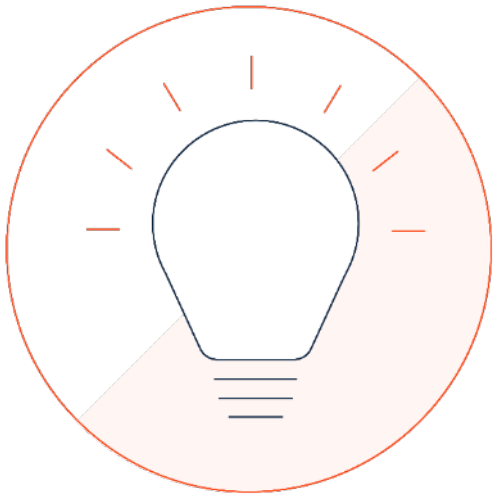
70 Measure Innovation Level Estimates

Different home owners, landlords, insurers and funders of retrofit measures have differing ‘appetite’ for risk. This is reflected through the Technology Innovation Levels built into the Pathways to Zero.

Whilst the Pathways tool only enables measures that are technically appropriate, following a “4C’s” approach (Context, Coherence, Capacity, Caution), new products and technologies are entering the market all the time. The Measure Innovation Level Estimates how novel the individual retrofit measure is with regard to proven evidence of performance – this forms a guide for the Pathways assessor and property owner.

The Pathways to Zero can be preconfigured to limit measures beyond a certain level of Innovation, either by landlord’s portfolio or by measure type. This leaves the home owner in control of whether they are selected from decades-long evidence base measures, or willing to consider more modern innovations with a less robust dataset of proof.

Whilst MILEs will initially be developed to cover generic retrofit measures rather than specific products, the intention is for future work to cover individual products and materials.



Digital Tools

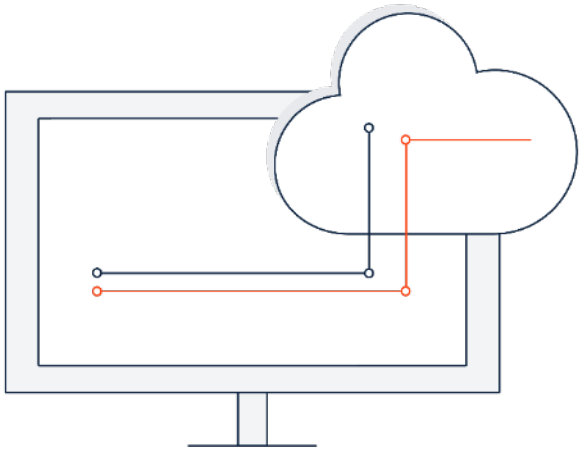
Building Passports

71 Building Passport Principles

The collected Whole Home Survey and Pathways to Zero information forms an invaluable picture that captures the history of the home, akin to a logbook, and a programme of future measures, akin to a plan of works.

Furthermore, the core of this information can be supplemented by a wealth of other useful material that could be of benefit to residents or home owners of any scale, ranging from the instruction manual for the fitted oven, through paint colour references, to the site photographs of a past refurbishment.

The project will develop four distinctly different ways for the information arising from Optimised Retrofit to be appropriately and securely shared – four different views of a Building Passport appropriate to the needs of the user.



72 Social Landlords – Planned Maintenance Integration

To best enable social landlords to scale up decarbonisation from the Optimised Retrofit project, the collaboration will work with project partners and third parties to interface with existing planned maintenance software, such as Civica's "Keystone" and emerging "CX" platform.

Data from both the Whole Home Survey and the Pathways to Zero will be securely routed to the housing providers nominated planned maintenance software provider, integrating, and updating their records.

Subject to suitable security and consents, this same digital link will also allow the pre-population of surveys from the existing dataset held by the provider, shortening the time for future Whole Home Surveys.

Routing landlord's data from the Optimised Retrofit platform to their preferred planned maintenance platform will be a core feature and will not incur costs during the project, as the project-side's integration will be funded as part of the works. Third party software providers may charge landlords for this, the collaboration will work to encourage this not to be the case.

73 TrustMark Property Hub

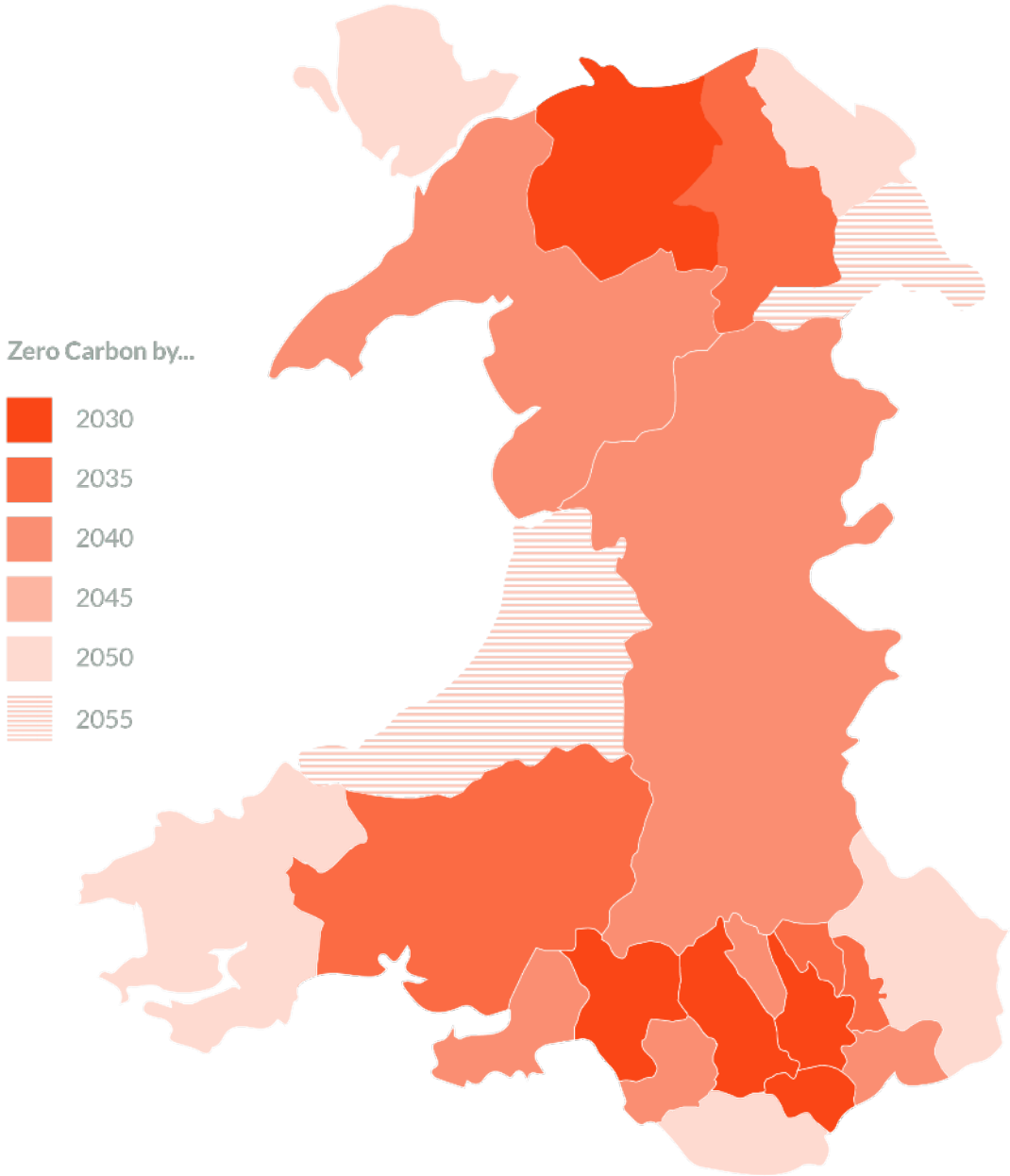
Individual home owner-occupiers aren't normally associated with having planned maintenance software, instead, here the Optimised Retrofit collaboration will integrate with TrustMark's Property Hub and underlying Data Warehouse.

Aimed at individual owners, TrustMark's Property Hub provides a secure data repository for storing information about what works have been undertaken to homes, alongside warrantees and details of who undertook them.

In tandem with TrustMark, the collaboration will enable as much of the Optimised Retrofit captured and created data to be uploaded to the Data Warehouse and accessed by homeowners through the Property Hub.

Homeowners seeking further information will also have the option of accessing the additional data stored in SQUIRREL – this could be linked through TrustMark's Property Hub or directly through the online interface to the SQUIRREL data.

Digital Tools



[74] Welsh Decarbonisation Maps

Alongside integrating data outputs into the Housing and Stock Analytical Resource (HSAR), the project will produce maps of Wales aggregating Zero Carbon By… forecasts by region, as well as measures and other reportable outcomes.

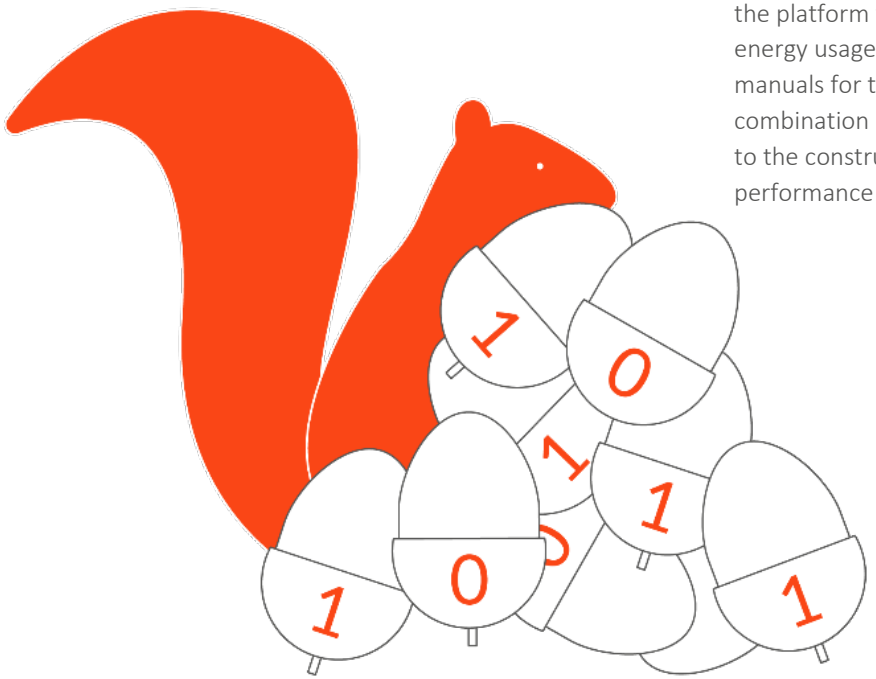
Hosted on the Optimised Retrofit dissemination platform, the home data collected in both the Whole Home Survey and the completed Pathways to Zero, stored in SQUIRREL, will be the aggregated into all-Wales maps, modelling the housing stock in Wales as it currently stands, and as it is forecast to decarbonise.

These all-Wales maps will show high level analytics of the Optimised Retrofit work, including for example, data on each county to illustrate:

- The average *Zero Carbon by…* date for homes that have had their Pathways to Zero entered, together with their current *Zero Carbon by…* date (at the stage of works implemented)
- The number of homes assessed, and split of tenure, age, typology, and other relevant high level metrics.

This interactive map is intended to provide at-a-glance information about progress across Wales towards Zero Carbon, but is also hoped to encourage good mannered competition between regions by virtue of providing an easily compared metric – for example, would Cardiff councillors be happy to see a county-wide "Zero Carbon by…" date for the capital's homes that is later than (say) Newport's…?

Digital Tools



75 Sero's Home Safe

Included for those residents using the Sero Life home comfort service, and available to anyone wishing to use the service, the SQUIRREL data can be accessed directly through Home Safe.

Intended as a supplementary or alternative option, Home Safe allows secure access to appropriately authorised parties to the full dataset being stored on SQUIRREL. Both the Planned Maintenance software integration and TrustMark's Property Hub only look at subsets of the stored data (not through restriction from Optimised Retrofit, but due to their own intentions), though in coming years both these may enlarge the data they support.

Home Safe therefore provides access to the full dataset from the outset. Whilst this will be limited by the actual data uploaded, the platform will support accessing everything from historic energy usage of the home, through to copies of the instruction manuals for the oven, and much more. Home Safe provides a combination of an Operational and Maintenance Manual familiar to the construction industry, with a live repository of operational performance data closer to a digital twin.

76 SQUIRREL Enhanced Storage

In parallel with the integrated third party data holders and platform providers, Sero will expand our existing property data store to form SQUIRREL (Secure, Queriable Universal Information Repository for Refurbishment, Energy & Lifestyle).

This enhanced data store will automatically retain all information from Whole Home Surveys and Pathways to Zero shared with partnered platforms (unless specifically opted out), providing a back-up repository for core data that has been shared with planned maintenance providers, TrustMark's Property Hub or the HSAR dataset.

Furthermore, unlike the partnered & linked stores, SQUIRREL will retain the full dataset generated from Whole Home Surveys and Pathways to Zero, for example, 3D 'point clouds' and survey photographs. SQUIRREL will also have the capacity to retain relevant extra useful information received by upload, such as digital plans and construction drawings, new home handover packs (as required by Building Regulations), user guides, maintenance instructions and similar materials.

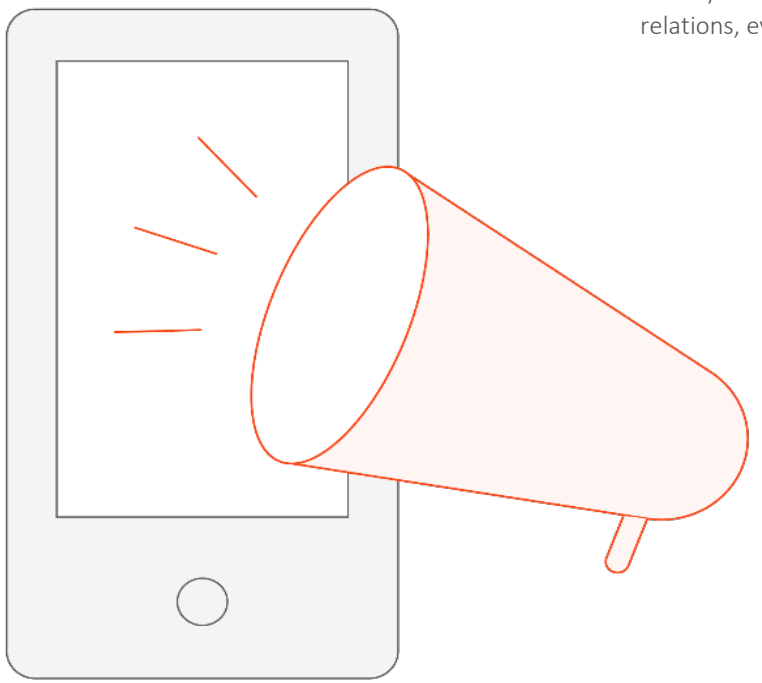
To support the core data backup function, SQUIRREL will be offered on a paid-for basis to new developers as a means to satisfy regulatory requirements, and to landlords to support their tenants. The additional information not stored on any of the third party platforms will form one of the Optimised Retrofit platforms' Optional Extensions services.

Dissemination

Role of Dissemination

The project will undertake a planned, coordinated campaign of dissemination throughout the funded period. The primary goal will be to raise awareness of the principles of Optimised Retrofit, enabling better understanding and sharing evidence and leaning.

Within our programme 'communications' or dissemination will be a collaborative exercise, but in order to ensure a joined-up approach that creates impact, activity will be coordinated and managed by Grasshopper Communications who will lead a communications steering group. A core function will be to ensure consistent messaging and use of language across all communications, community engagement and dissemination activity as well as managing a coordinated approach to media relations, events, content and digital activity.



77 Optimised Retrofit Website & Digital Library

The project will create and actively maintain a website as the hub for information on Optimised Retrofit targeted at a range of audiences including residents, homeowners, suppliers, developers, industry professionals, stakeholders and media.

This will be updated with the media & communications activities as well as hosting a full library of project output materials, from training through to research papers, breakdown of technical terms and database of partners, materials and technology used during the project. The website and digital library will be maintained throughout the project and beyond.

The members of the programme and approved contractors will be able to access a 'private' user-only section of the website, acting as an Intranet, and this will contain communications guidelines, process and sign-off, information, advice about tone of voice, FAQs regarding language, terminology and technical listings.

78 Media & Communications

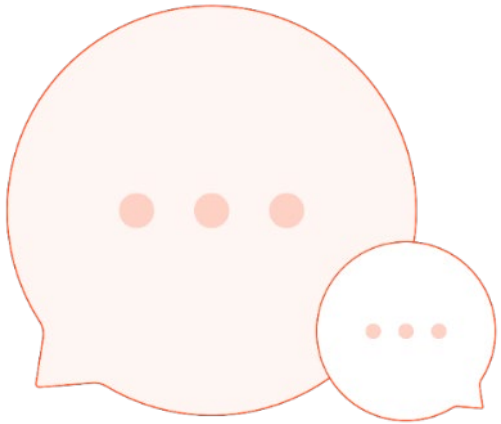
Led by Grasshopper Communications in conjunction with all partners' communications teams, the project will undertake notable dissemination around activities and lessons. These will include:

- Weekly social media updates and posts (LinkedIn & Twitter primarily) – general messaging about the programme, and taking opportunities to educate, inform and encourage relevant sectors or the general public.
- Frequent press relations activity including targeted messaging to the Welsh broadcast and print media (bespoke messaging to sector media is covered below and will be coordinated). As well as informing and educating as the programme progresses these statements will serve as

Dissemination

updates, giving latest stats and in time promoting the benefits and sharing performance data from homes that have undergone Optimised Retrofit.

- Monthly commissioned industry media feature articles – general messaging plus specifically targeting the installers and SMEs via magazines such as Professional Builder and the builder's merchant media, such as BMJ and Professional Builders Merchant as well as energy specific trade media and broader construction media such as Building, Construction News, Inside Housing and Construction Manager.
- Monthly newsletter/email updates – we will publish monthly emailed newsletter (also uploaded to the web site) to go out to interested parties (and anyone that signs up for updates through the website) covering the full spectrum of the project.
- Quarterly consumer/lifestyle media in Wales – targeting homeowners/consumers and geared to educate, inform and encourage the public about the benefits of Optimised Retrofit and begin the groundwork for owner-occupier awareness.
- Quarterly press briefings – either on a one-to-one basis or as a group we will aim to facilitate regular Q&A sessions with the media and share/summarise the updates posted on social media, issued via press statements and uploaded to the Optimised Retrofit web site. These sessions will be geared towards keeping the media 'onside' and fully briefed and allow an open forum for feedback.



79 Sector Specific Media & Sector Oriented Communications

Alongside the 'mainstream' media outputs, specific project partners will manage communications that are targeted to particular sectors relevant to decarbonisation.

These will include:

Social Housing Sector

Led by a suitable housing collective, the project will set up and run a monthly online Q&A session specifically for RSL partners. This will be a 'Chatham House' forum for discussing issues and findings.

The project will also produce a RSL-specific monthly email "executive summary" update.

SME Sector

Led by the Federation of Master Builders (FMB), the project will produce a monthly email update on the project's progress from an SME perspective.

This will be in parallel with podcasts by Beta Teach, which will focus specifically at heating engineers and sharing lessons and insights gleaned from the Pathfinders and other project work.

FMB will also undertake promotional events via builders merchants targeting installers and SMEs to allow for product demonstrations, direct questions of the team and learn of the benefits of Optimised Retrofit as a business opportunity. These sessions will be managed to an agreed template and backed by consistent communications material, social media posts and prior briefings with the specific local media.

Financial Sector

Led by the Green Finance Institute (GFI), the project will tailor output relevant to the residential financial sector, particularly including where work is supporting parallel activities ongoing in the Coalition of Energy Efficient Buildings (CEEB).

This activity will be aimed around identifying barriers and opportunities for financial products and services to support

Dissemination

decarbonisation. Since the GFI are UK government funded, this work is not funded by the project other than for coordination and management beyond existing GFI activities.

Energy Sector

Led by the Renewable Energy Association and the Active Building Centre, the project will disseminate findings to the energy industry to share learning from both successes and any failures in the work undertaken. The project will aim to deliver clear, unbiased evidence to act as the basis for progress across the energy sector, and will endeavour to ensure suitable peer reviews that help to enable this.

Political Stakeholders

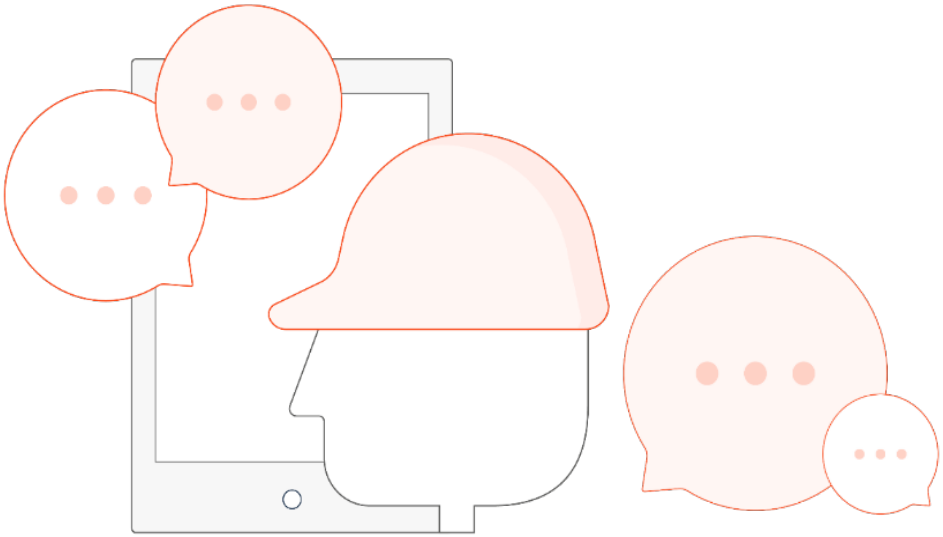
Led by Grasshopper with Constructing Excellence Wales, we will aim to set up a quarterly briefing to go out to key political stakeholders/influencers (MSs, MPs and senior councillors etc) – as well as the inclusion of stakeholder briefing events.

Where possible due to COVID19 and other factors, one or more events at the Senedd for to raise the profile of the scheme.

80 Construction Webinars & Events

Led by Constructing Excellence Wales, the project will deliver pan-industry events hosted and/or facilitated by consortium partners, most commonly as virtual events (though physical events will be considered where possible).

This will provide information and engagement opportunities about the whole project, and where appropriate due to demand, will work with sector specific partners to produce more focused events.



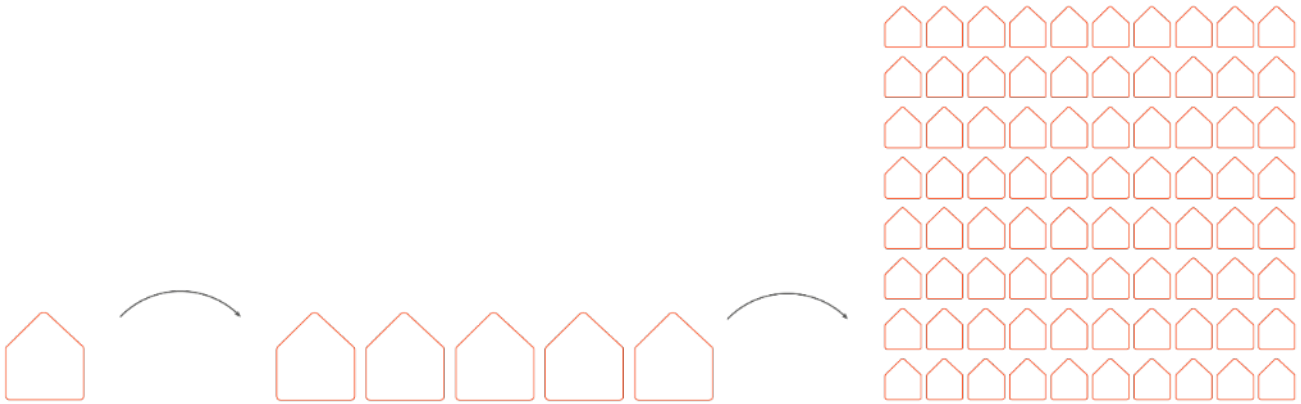
Project Legacy & Influence

The Role of Legacy & Influence

Optimised Retrofit is primarily about building robust tools and processes that allow the homes of Wales, starting with social homes, to decarbonise quickly, effectively and reliably, and to do so with the biggest possible benefit to the Welsh foundational economy.

The conclusion of the funded project will, therefore, only be "*the end of the beginning*" for the delivery of decarbonisation in Wales (with apologies to Churchill for the quote!).

The section below maps out activities that are anticipated to be progressed beyond the end of the funded project. These cannot be completed within the project due to funding or timescales of the project, however the foundations of these will be laid where possible within the initial work.



Pathfinder Homes – Future Phases

[81] Pathfinder Phase 2 – 5,000 Social Homes

If additional "top up" funding can be identified, starting in financial year 2021/'22, the project would look to undertake a second phase of Pathfinder Homes targeting 5,000 homes to be retrofitted to have Zero Carbon by 2030 Pathways (or other target date as determined by any future government policy).

Phase 2 Pathfinders will use Version 1 digital tools developed to assess and design the homes, and the support to identify both grant and loan finance that can supplement internal budgets for the properties. This will form large scale "beta testing" of the digital tools, enabling glitch fixing and usability improvements.

Ideally, some supplementary grant funding will also be identified to support Phase 2 retrofit works beyond grant and loan schemes, though the intention is for these works to continue regardless (potential with less intensive retrofits).

[82] Pathfinder Phase 3 – All Tenure Welsh Homes

Optimised Retrofit seeks to create a common mechanism and approach to retrofitting all homes in Wales, in order to support their decarbonisation in a structured and coordinated fashion.

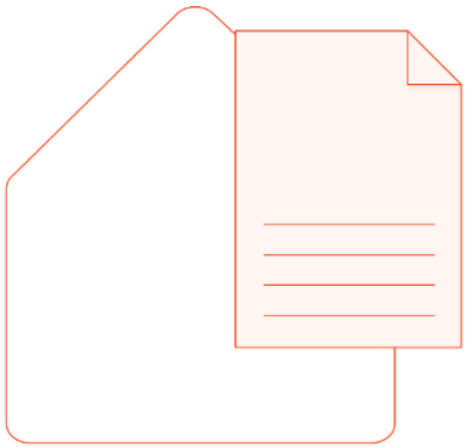
Following the successful construction and testing of the Optimised Retrofit approaches under Phase 2, and subject to the sustainable economic case that enables the tools to be available for free, the collaboration would work with Welsh Government to add expand the usage of the Optimised Retrofit approach. This would include investigating how the Whole Home Survey and Pathways to Zero tools could be integrated to:

Project Legacy & Influence

- be required for all existing homes having work undertaken (via requirements under Welsh Building Regulations).
- be a requirement for all new build homes (via a requirement of Building Regulations). Noting the Whole Home Survey could be replaced by accurate as built construction information in this instance.
- be required for all private rented homes (via requirements under the Welsh Landlords Register).

Integrating the Optimised Retrofit mechanisms into these regulatory systems would embed the Pathways to Zero and simple *Zero Carbon by…* metric at these key intervention points.

In the case of landlords, the creation of the *Zero Carbon by…* date, once widely implemented, could provide a more sophisticated obligation with clear threshold, such as homes are only lettable with Zero Carbon By… dates of 2035 or earlier.



Foundational Economy

[83] Homebuyers Surveys

The Optimised Retrofit project has building society partners at launch, as well as backing from the Green Finance Institute (the UK Government arms-length body).

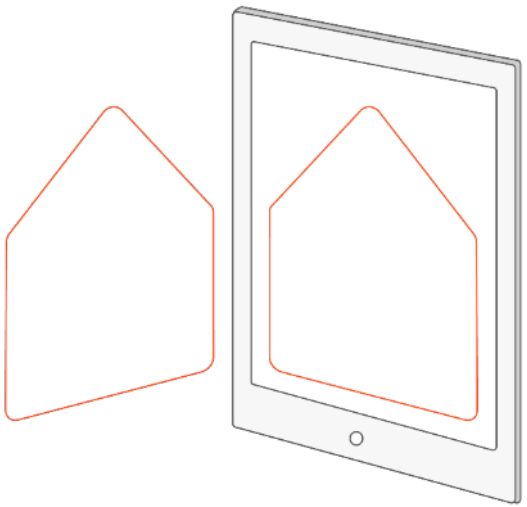
From the outset, work will be ongoing to align the Whole Home Survey with the needs of the financial sector both to underpin their understanding of their mortgage portfolios, and as individual improved product offerings to their customers.

A key goal of this is to deliver the digital Whole Home Survey to be cost efficient enough to allow it to replace “Homebuyers Surveys” (taken to be £500). Those purchasers willing to pay the uplift from the basic mortgage survey, or those mortgage providers willing to package them, would have a Pathways to Zero and *Zero Carbon by…* forecast alongside the home survey.

This would detail the technically appropriate retrofit measures at the point of sale - a key intervention point in any home’s life. It would also provide the mortgage lender with greater understanding of their asset (and inherent risks), and give them the opportunity to offer additional lending products to support the decarbonisation works of the new owners.

Given the typical UK homes is sold every 7-8 years, if widely adopted or otherwise required, by 2030 more than 66% of the homes in Wales could have a Pathway to Zero and *Zero Carbon by…* date to provide a clear, trusted means of the owners knowing how they can decarbonise.

Project Legacy & Influence



Sustainable Digital Tools

[84] Freely Available – in Wales First

The intention is that the Optimised Retrofit digital tools will become widely adopted, initially amongst Welsh social housing providers, but ultimately for all tenure types and expanding beyond Wales to the rest of the UK and internationally.

For widespread adoption, the digital tools will have the lowest possible cost of use for the core elements, aspiring to achieve a zero cost through identifying alternative (ethical) income sources, including from the optional "in app purchase" extra functions and the data generated by the tools. A detailed investigation into income streams will be undertaken as part of the Optimised Retrofit project to develop these.

In parallel with identifying income streams, work during the project will develop an operational cost model for the maintenance, regular updating, and operational support of the digital tools. This will include updating retrofit measures, circular learning and other features to be developed and maintained.

Based on the operational costs and identified income streams, the digital tools will be either free or at the lowest practically achievable costs in the following order of priority:

- Welsh Homes - Registered Social Landlords
- Welsh Homes – All Other Tenures
- UK Homes (beyond Wales) - Registered Social Landlords
- UK Homes (beyond Wales) - All Other Tenures

The tools will be made available in England as soon as possible. Whilst the objective remains to offer the Optimised Retrofit tools at the lowest possible cost beyond Wales, but this is not likely to be free. Revenue from these activities will come into Wales to support the ongoing operational costs of the digital tools.

Digital Tool Expansions

The platform will be built with the intention to expand this once the core functions have been developed during the funded project. These expansions are likely to include those set out below:

[85] Whole Home Survey Augmented Reality

The Whole Home Survey developed at the close of the funded project will be an advanced home survey tool, but will have been built with the capacity to further enhance its capabilities during the ongoing legacy of the project.

The ambition is to increasingly automate the collection of Whole Home Survey data, using on-board hardware such as LiDAR to generate three dimensional, full colour surveys within homes, displayed through screen of the tablet as overlays to the 'viewfinder' to form an Augmented Reality view.

This will then use the increased processing power and the established survey dataset to automatically identify features, tagging and dimensioning windows, doors, fireplaces and more. The transitional stage of this development will then seek verification of each with the home assessor, but over time this would move to full automation with an underlying quality assurance review both automated and manual.

[86] Whole Home Survey Digital Twin

The Whole Home Survey will be forming the starting point of a digital record for each home assessed, creating a form of Building Information Model (BIM) that can be supplemented through metering and monitoring to create a true Digital Twin.

Project Legacy & Influence

The medium term goal for the Whole Home Survey is to have most common home features automatically captured and recognised. This will enable the Whole Home Survey to be undertaken remote from the competent person, providing the potential to reduce travel time and associated emissions as well as increase efficiencies.

87 Retrofit Measures Cards Future Expansion Pack

Measures will include additional fields for to be bought forward into the tool once developed, which may be during the project or subsequent to the end of the funded stage. These will include risks, price bands, skill requirements and known quality issues to watch for during installation, and reference applicable funding, insurance factors and more. This will include a time factor to interface with future energy network integration (see below).

88 Pathways to Zero Embodied Carbon

Zero Carbon focuses on net zero operational energy, ignoring the energy and carbon embodied in the manufacturing and construction of homes, and their ongoing maintenance. The initial work for the Pathways to Zero will follow this approach, accepting that this is only part of the picture.

This is an area we anticipate the collaboration working closely with academic and research partners to create a new embodied energy carbon calculation component in future.

89 Pathways to Zero Energy Grid Interface

The future maintenance and upgrade of the energy networks, particularly any roll out of hydrogen or expansion of electrical capacity, will bring into consideration new retrofit measures for homes in those areas. Developing a future interface with these plans will allow those measures to be anticipated, even before the energy networks are in place. For example, if a hydrogen local network is planned for 2040, then hydrogen fuelled measures should be 'playable' on the property from that date. Similarly, energy networks can use outputs from the Pathfinders to inform their decisions about network support and expansion.

Work here is anticipated to develop in concept with Western Power Distribution during the funded project, but to continue towards a fully operational interface in the platform, if possible, beyond the close of the work.

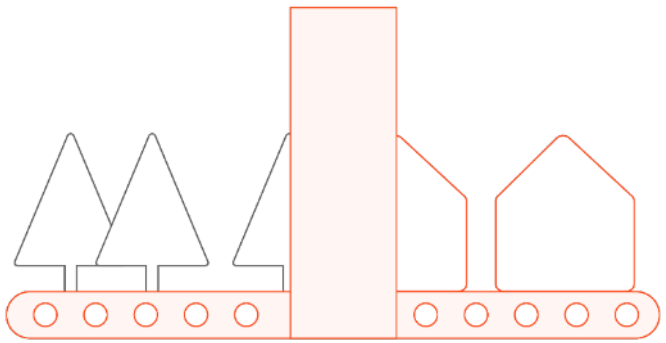
90 Pathways to Zero Optimise My Retrofit

Whilst the selection of the measures and their sequencing are the choice of the home retrofit designer, and will be influenced by factors beyond the Pathways to Zero tool such as the owners' preferences, budgets and maintenance plans, the Pathways to Zero tool will have an "Optimise" function. The groundwork for this will be undertaken during the funded project, with the full function coming on stream later.

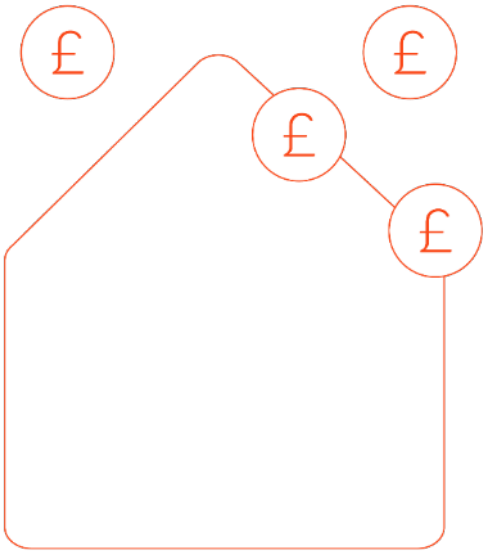
Based on the technically feasible measures outlined in the 'cards' and underpinned by the extensive structure data for each of them, the Pathways to Zero tool will be able to show the home designer the combination of measures and sequencing that will plot either the fastest or cheapest pathway to zero (based on estimated price banding at that time).

This will not oblige the designer or property owner to follow that route, but will set out what is technically possible to achieve on that individual home, and a logical sequence that the installation of the measures could follow.

The few homes that don't achieve a *Zero Carbon by…* date, but are instead reported as Zero Carbon after 2050, will still have the



Project Legacy & Influence



optimum fastest and cheapest paths shown to get them to a lower carbon footprint.

91 Pathways to Zero Price Estimator

The collaboration will work with the supply chain to produce reasonable price estimates for all the measures outlined under Pathways to Zero. Wherever possible, these will be using area or similar rates, allowing the tool to pro-rata total cost ranges based on property sizes and other relevant factors.

This cost information will be developed from the Pathfinders and will (wherever possible) be guidance ranges per measure, to allow an overall estimated cost range for the retrofit work.

92 Pathways to Zero Circular Learning from Experience

Once data from the post-occupancy monitoring and performance of the homes and associated retrofit measures becomes available, this data will begin to be used to inform the Digital Retrofit Measures Cards and update them.

This circular system will ensure that estimates regarding the costs, energy and carbon savings, risk of overheating and much more, are updated based on the best available information. This will also update compatibility matrixes, to inform where measures are found to be inappropriate or where they can have their use expanded.

The updating of existing measures will sit alongside the addition of new measures, where these become suitable for retrofit work. Collectively, these measures cards will capture the lessons from the retrofits undertaken, and embed these lessons automatically into future homes that use the Pathways to Zero platform.

93 Pathways to Zero Certified Products & Materials

The platform will also work with product and materials manufacturers, as well as seek integration with collaborators such as RIBA Enterprises or Barbour Index, to connect the generic non-proprietary performance specifications outlined in the measures with suitable proprietary products that deliver the requirements.

Initially, as outlined earlier, this will rely on manufacturers registering their products against the Retrofit Measures Cards via a secure portal, which will be reviewed by the technical team.

The intention is that this first version will be developed in later phases to support independent validation of the products that are being connected to particular measures, drawing on a combination of installed performance data and technical review. Such validation would result in the product being noted as achieving stated levels of performance, and would mean the product or material is ‘certified’ on the Optimised Retrofit platform. This process would be paid for by the manufacturer, but would be a robust independent assessment.

94 Pathways to Zero Preferred Products & Materials

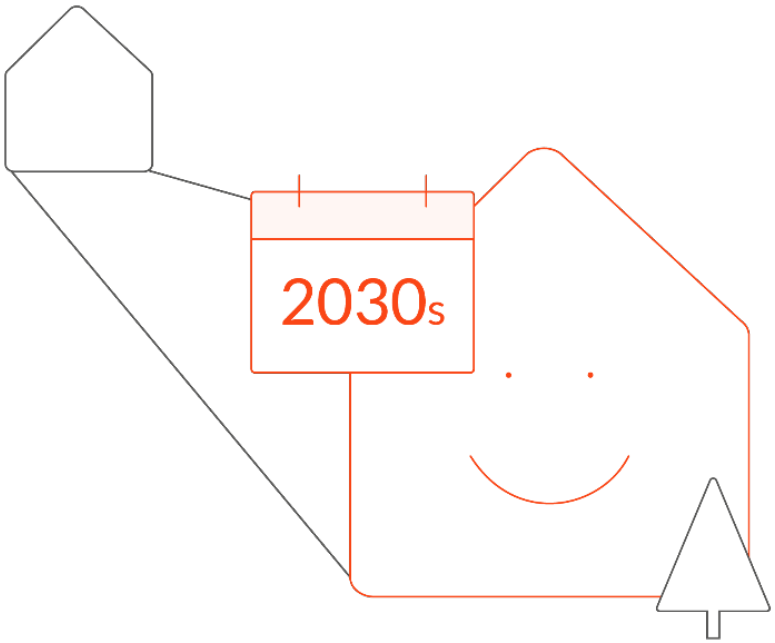
Construction, like most other commercial activities, sees individual unit prices fall as number of units rise. Many networks, frameworks and similar have been established in the past to try and realise this benefit for residential works with varying success. For retrofit, the typical approach is most commonly to identify a measure, then coordinate one large order from a property owner to identify and apply that measure to homes. This is a “measure first” approach – the measure is fixed, the homes are found that (hopefully) fit the need.

Project Legacy & Influence

Optimised Retrofit instead reverses this process. Commencing in Phase 1, the collaboration will instead engage with the product and materials manufacturers. Using the all-Wales maps, manufacturers will be challenged to price multiple, structured smaller orders as if they were one large order (or towards that).

Manufacturers that agree to implement a pricing structure for Optimised Retrofit will be deemed “Preferred” and their goods will be prioritised in the platform (in order of pricing discount).

This approach removes the need to try and coordinate large orders between property owners, but instead exposes the potential market size to the manufacturers and gives them the opportunity to price aggressively in order to gain scale. Such a having this fully operational ahead of Optimised Retrofit being opened to home owner-occupiers.



[95] Decarb By Sero

As part of Phase 3 of the works, Sero will deploy its own decarbonisation offer aimed at primarily home owner-occupiers. This will offer them a managed home retrofit that will transform their home to be zero carbon by a determined date, in an agreed number of steps.

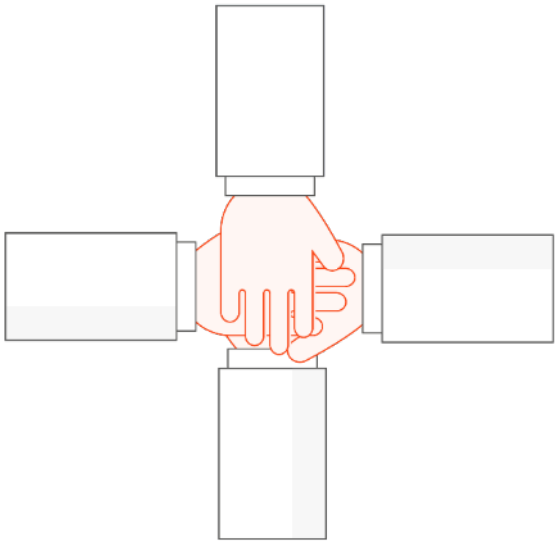
This holistic service will come with no capital costs to the homeowner, and will fix their energy bills at their existing price, assuming no significant changes to their occupancy behaviours.

In effect, Sero will decarbonise their home for free.

The fully managed retrofit works will use approved installers and products and be managed by trained retrofit coordinators. Combining many of the tools here, and supplementing these with automated quoting, project management and control processes, this will provide a ‘one stop shop’ to net zero.

The resident’s energy bills will be capped at their pre-retrofit levels, with the energy savings from the installed measures being directed to repay the capital construction costs incurred. Once these are repaid (including the financial backers interest, service fees etc.), the resident’s energy bill benefits from the retrofit measures saving henceforth.

Collaboration Delivery



Governance

96 Project Steering Group

All named partners have one seat on the Project Steering Group, along with one seat for Welsh Government. Additional individuals may attend as observers, and additional parties by majority agreement of the Steering Group – neither additional individuals or parties having any voting rights.

Partners will have an equal say in strategic decisions for the whole project. The Project Steering Group will meet quarterly for the duration of the funded project, and beyond insofar as is necessary or agreed as desirable.

All partners will have the right to attend or review all works being undertaken and to nominate individuals to sit on Technical Groups involved in delivering tasks, in all instances covering their own staff costs and overheads.

Partners undertaking retrofits on Pathfinder homes will have complete and sole control over their own homes' refurbishments, including finances and procurement, but undertake to use the Optimised Retrofit tools and share their experiences and learning as part of the project.

Partners nominated as the lead of tasks or workstreams have budgetary and delivery responsibility for those elements of the project, and are funded to undertake these as outlined in the financial pages. These are "Funded Partners".

A project partner may be added or removed from the Project Steering Group (and thereby the Optimised Retrofit collaboration) by a simple majority vote unless they are a funded partner or the project manager.

97 Project Board

The Project Steering Group will agree a Project Board, comprising the smaller operational group making tactical decisions for the delivery of the project. The Board will be accountable to the Steering Group.

The Project Board composition will be representative of the project. The Project Board can have additional members at the behest of the Project Steering Group, though to be quorate will include as a minimum four Pathfinder Homes Partners and the project managers. All Project Board members have one vote.

This group will meet monthly and reports to the Project Steering Group, and will be chaired and administered by the project managers on behalf of the Project Steering Group.

The Project Board will invite specific partners to attend meetings as necessary to undertake the proper control and delivery of the project. Welsh Government will be invited to attend the Project Board meetings as an observer.

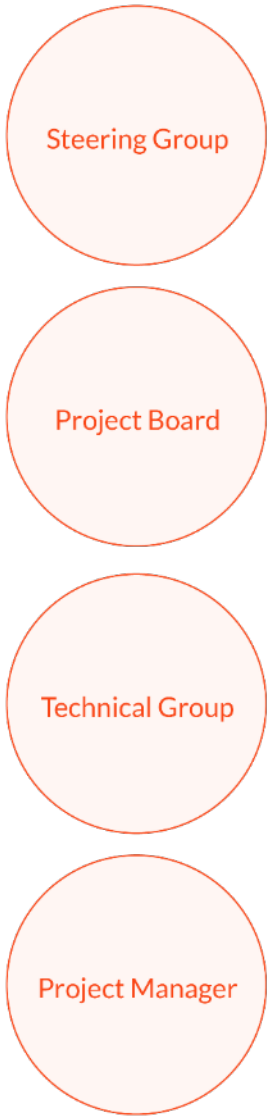
98 Funded Partners

Funded Partners are those collaborators in the project receiving grant payments. They form two types:

- Pathfinder Homes Funded Partners are stock holding registered social landlords who are using funds from the project to support the costs of undertaking retrofit works on specified homes, to deliver refurbished homes and to trial the Optimised Retrofit tools.
- Delivery Funded Partners are organisations who are named as undertaking specific work in the project, and receiving funds for time, expenses etc. in regard to this.

It is possible some organisations will be both Delivering Funded Partners and Pathfinder Homes Funded Partners.

Collaboration Delivery



Funded Partners can be removed in the event of failure to deliver their funded tasks on the project by two-third majority vote of the Project Steering Group, unless they are the project manager. The Funded Partner's reasonable costs up to the point of their notification of removal remain payable, subject to normal checks on delivery and appropriateness of the work undertaken.

99 Unfunded Works & Partners

Attendance at the Project Steering Group and Project Board are unfunded activities, as are peripheral supporting activities for specific workstreams – for example, reviewing & commenting on a press release, or attending Optimised Retrofit events.

100 Technical Groups

Project tasks or workstreams may have a Technical Group to advise and guide the delivery of the tasks by the Funded Partners. These groups are convened and administered by the respective Funded Partner to provide technical review and monitoring of the work being undertaken in that workstream.

The membership of the Technical Groups comprises all named project partners who wish to attend, plus all selected technical or specialist experts nominated by the relevant Funded Partner. With the exception of specialist experts and the responsible Funded Partner, attendance at Technical Groups is not funded.

The Technical Groups are advisory to the Funded Partner. The Funded Partner retains the obligation to deliver the outlined objectives for the workstream.

101 Project Management

Optimised Retrofit has been conceived and coordinated by Sero, who will provide the collaboration's project management and administration for the overall project, including secretariat to both the Project Board and Project Steering Group.

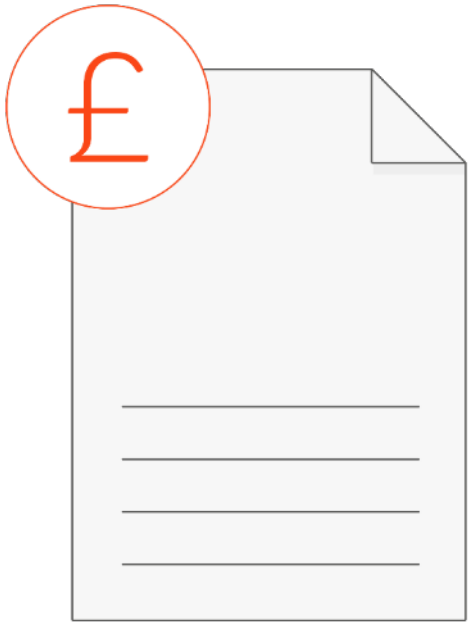
Individual work activities will be managed by Funded Partners within this, reporting to project management and ultimately to the Project Steering Group.

The project managers of the Optimised Retrofit can be replaced based on a unanimous vote of the Project Steering Group.

102 Bilingual Outputs

A budget of £20,000 has been assigned for bilingual outputs across the whole project. This will be prioritised on the public facing materials (such as magazines or similar outputs), in preference to technical industry facing materials (such as technical training or guidance notes).

Collaboration Delivery



Legal Structures

103 RSL Direct Grant Funding Agreement

Welsh Government have agreed that Grant Offer Letters can be provided to individual RSLs for the funding amount relating to their homes proportion of the total retrofit works budget.

By prior arrangement, one or more RSLs will also act as custodian for the grant funding assigned to non-RSL partners ("Nominated RSL"), which will be drawn down for each non-RSL partner to Sero against budgets approved by the Project Board. These funds are held on behalf of the non-RSL partners and draw down will be for a combination of good & services and transfer of grant as appropriate. A Collaboration Agreement will outline the terms between Sero and the Nominated RSL (s) only, linked to all RSL partners through the Multi RSL Agreement (see below).

Delivery Funded Partners will then funded via a bilateral service/goods contracts with Sero. This streamlines the grant claim process and ensures effective project management across the delivery, whilst also enabling bulk orders for the IES equipment for the project.

Appendix [2] outlines the relationship between the partners.

104 Multi RSL Agreement

This agreement will be entered into by all of the RSL partners and will govern the sharing of information and collaboration principles. Any IP rights required from Sero (and the reciprocal) will be sub-licensed via the Nominated RSL with rights provided through the Collaboration Agreement. This agreement will also manage how new RSL's are added or may cease to be involved in the project.

105 RSL Free Issue Goods and Services

On behalf of the collaboration, Sero will bulk order goods and services required by all the partners, including the Intelligent Energy System (IES). These will be issued free to the RSLs in proportion to their number of Pathfinder homes

The Multi RSL Agreement and Collaboration Agreement will detail these items and provide legal reliability for each RSL.

106 Non RSL Goods & Services

To support the delivery of the project, non-RSL partners will be sub-contracted to Sero for the delivery of their activities. This avoids multiple individual contracts to one or more RSLs, and supports the hands-on project management of the project overall.

107 Background Intellectual Property

All partners bringing background intellectual property into the collaboration retain their ownership of this, and non-exclusive rights will be granted as part of the Agreements for use in the project, for the duration of the project only unless otherwise specifically agreed.

A full intellectual property register will be created and maintained throughout the project, including declared background IP.

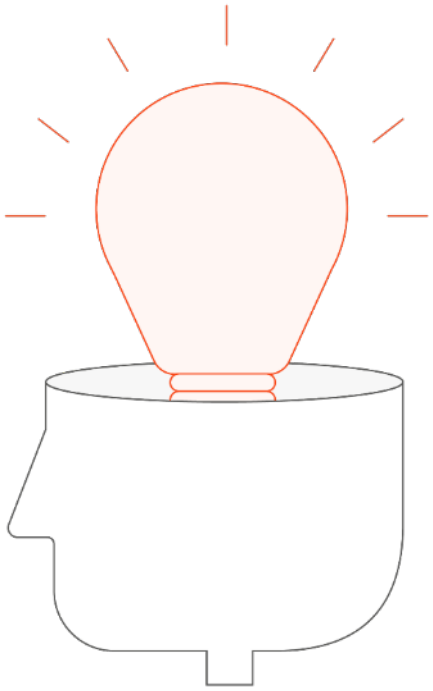
Sero Background Intellectual Property

Sero note background intellectual property comprising:

- The term "Optimised Retrofit" insofar as it can be protected
- The Whole Home Survey, technical survey content and digitalised tablet design, processing, and content

Collaboration Delivery

- The term “Pathways to Zero”, the technical content and digitalised platform, interface style and content
- The term “Zero Carbon by…”, the technical engine and means of calculating the date
- The HEDGEHOG, and the technical engine therein
- The SQUIRREL, and the data storage and processing therein
- Sero’s Home Safe Building Passport service



[108] Foreground/New Intellectual Property

The objective of Optimised Retrofit is to develop tools that can become freely available to use in Wales and beyond, and have an underlying sustainable economic model to maintain them.

Foreground intellectual property will be clearly tracked through the project. The allocation of foreground intellectual property will generally be as follows:

- Where new IP has been developed building from a partners’ previous background IP, the new IP will be owned by that background IP partner in order to ensure the enhance tool can be readily maintained in a sustainable ongoing model.
- Where the ownership of the background IP is split, both parties have joint ownership and rights to exploit.
- Where the owning partner does not actively try to exploit IP, other project partners may apply for rights to utilise it.
- Where new IP has been developed in the project without any background it is the ownership of the developing partner.
- Where the development of the new IP is split, both parties have joint ownership and rights to exploit.
- Where the owning partner does not actively try to exploit IP, other project partners may apply for rights to utilise it.

Appendix 1 – Letter to Minister

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For Attention of: The Minister for Housing and Local Government
Welsh Parliament
Cardiff Bay
Cardiff

CF99 1SN

RE: SETTING THE TARGET FOR ZERO CARBON

Monday, 13 July 2020

Your Ref.:
Our Ref.: 20-07-01 Letter to Minister v2

Dear Minister,

I am writing to highlight a concern about how Welsh Government sets and communicates the goals of delivering net zero operational carbon ("Zero Carbon") across the various regulatory and funding frameworks. This concern is not the target of zero carbon, nor timescales to deliver them, but rather that the wrong metric will deliver the wrong results, and embed unintended consequences and costs.

The wrong metric most commonly used to convey this zero carbon target is the Energy Performance Certificate (EPC) or its underlying Standard Assessment Procedure (SAP).

The SAP score and resultant EPC rating were designed by the BRE for UK Government as a minimum standards compliance tool to fulfil the EU obligation for a state-wide mechanism. It assesses whether a home is no worse than a nominal equivalent to achieve this. In recent years, it has been co-opted to try and fulfil all sorts of other functions that broadly support the drive towards zero carbon. It is this expansion of the use of SAP and EPCs that is the root of this particular concern.

A zero carbon home, as defined by the UK Green Building Council (UK GBC) (and Sero's own approach), is one which over the course of the year, emits or causes emission of, no carbon dioxide or equivalent climate change gases (0.0 gCO_{2eq}). This would consider the heating, lighting, hot water, fans and pumps permanently fixed into the building ("regulated energy"), but also the plugged-in energy usage from the residents such as TVs, fridges, phones and more ("unregulated energy").

Typically, to be zero carbon, a building will generate zero carbon energy on-site from renewables and share some of this generation with the UK's National Grid (when it is not required in the home). This power fed to the grid puts zero carbon energy in, and is deemed to displace the equivalent grid generation carbon emission at the prevailing rate. By balancing what is fed in to the National Grid with what is drawn from the National Grid over the year, a home (or any other building) achieves net zero operational carbon.

No SAP or EPC rating is equivalent to zero carbon for one fundamental reason: time of demand.

To achieve its intended function as a compliance check, SAP uses a fixed constant conversion factor from energy (kWH) to carbon emissions (gCO_{2eq}) for all fuel sources. Whilst adequate as a regulatory check, this simplification ignores the time of demand of the energy. All energy generation, but most notably electricity, causes emissions that vary for each kWh depending on time. For electricity, during a single day one kWh can result in emitting anything below 75gCO_{2eq} to above 300gCO_{2eq}. This variation is driven by a combination of the renewables on the National Grid, and the demand for power (the latter triggering 'dirtier' Grid generation in order to meet the demand).

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Cardiff Gate
Business Park,
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The consequences of what may seem to be a small detail are huge.

Any delivery mechanism using SAP or EPC will inherently value all kWh the same regardless of time. Buildings will therefore consider pushing photovoltaic excess power to the Grid at noon (at c.75gCO_{2eq}) to be equivalent of when they draw power back during the evening peak (at c.300 gCO_{2eq}). In this scenario, SAP will claim 1kWh balances 1kWh out due to the fixed constant conversion factor, but in carbon terms they have caused c.225 gCO_{2eq} of emissions.

Not only does this not equate to zero carbon, but pushing power to the Grid at peak Grid renewable generation times is more problematic than helpful. It can lead to increased payments for grid renewables to 'switch off', and does not mitigate the need for higher carbon emission power generation at times of high demand. It therefore risks undermining the commendable and ongoing achievements of the National Grid to reduce the carbon intensity of large scale electricity generation over the last few decades.

Time is also a forgotten factor in the wider journey towards zero carbon. The SAP and EPC metrics result in a drive for these ratings being achieved now, whereas the real ask is for zero carbon by a date in the future (albeit as soon as practicable). The zero carbon date approach allows the National Grid's ongoing decarbonisation to support the homes, and the decarbonisation of the homes to support the National Grid. Conversely, the SAP and EPC approach ignores the future decarbonisation of the Grid, forcing homes to 'go it alone' to zero carbon. Inevitably, this makes the challenge for our homes greater.

We would therefore strongly encourage the Minister to stay true to goal of "Zero Carbon by" and setting relevant year targets for differing sectors, perhaps starting with social housing to be zero carbon by 2030.

We acknowledge that this requires new assessment tools, though thanks to the foresight of the Welsh Government's Innovative Housing Programme we are already funded by you to build and make freely available one such example (our H.E.D.G.E.H.O.G.). Regardless of whether that particular tool is adopted or others built, the costs of any tools will be inconsequential compared to the costs incurred by building and retrofitting Welsh homes to the wrong metric, and the costs incurred by the energy grids to mitigate the uncoordinated supply and demands uncoordinated homes will inflict. Not to mention that they will almost certainly fail to deliver zero carbon in practice.

We would be delighted to explain this further should you wish,

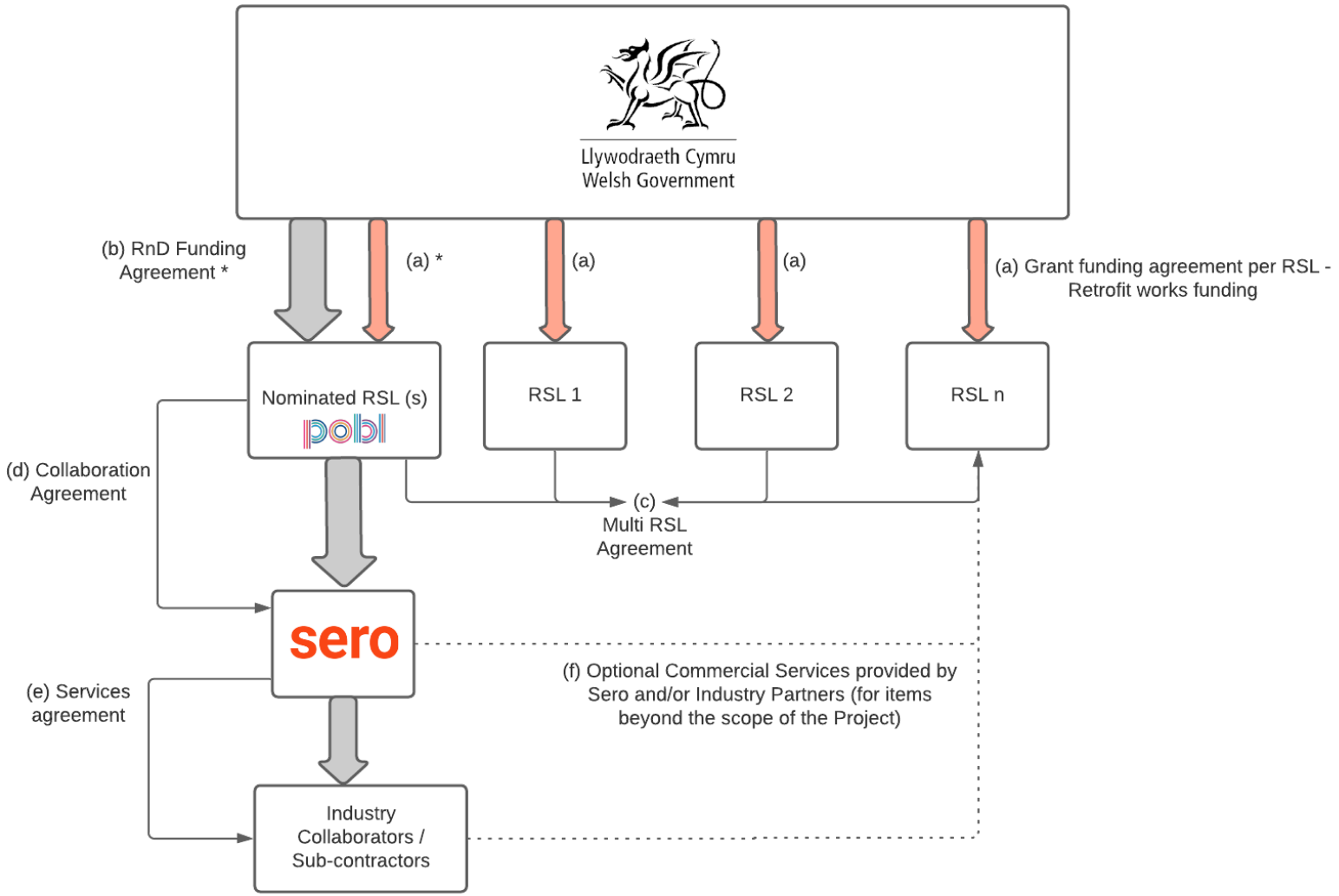
Yours sincerely,

Andy Sutton RIBA
Co-Founder & Design+Innovation Director

CC: James Williams, CoFounder & Managing Director

Enc.:

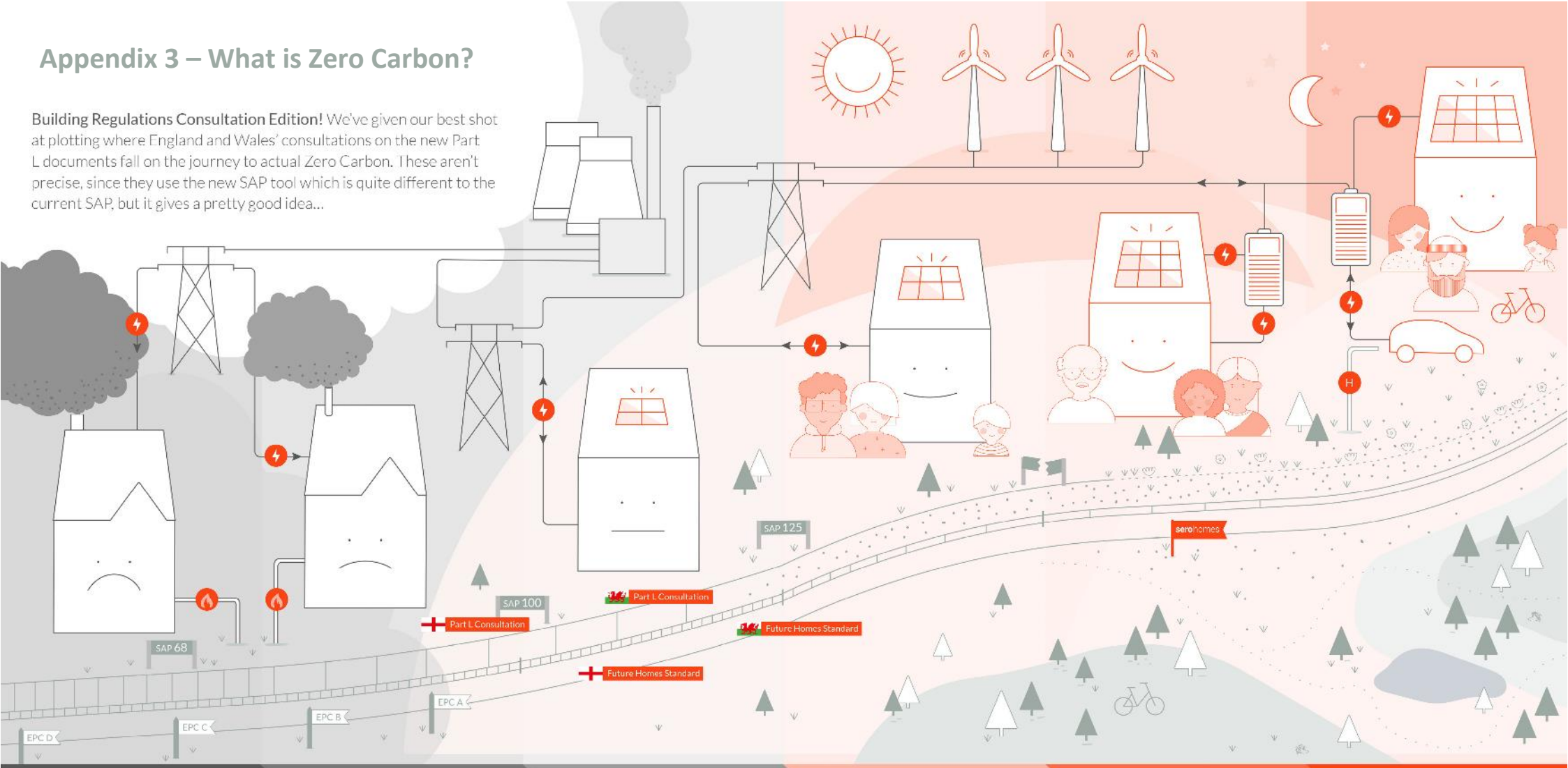
Appendix 2 – Legal Structure



** These different funding streams may be combined into one Funding Agreement*

Appendix 3 – What is Zero Carbon?

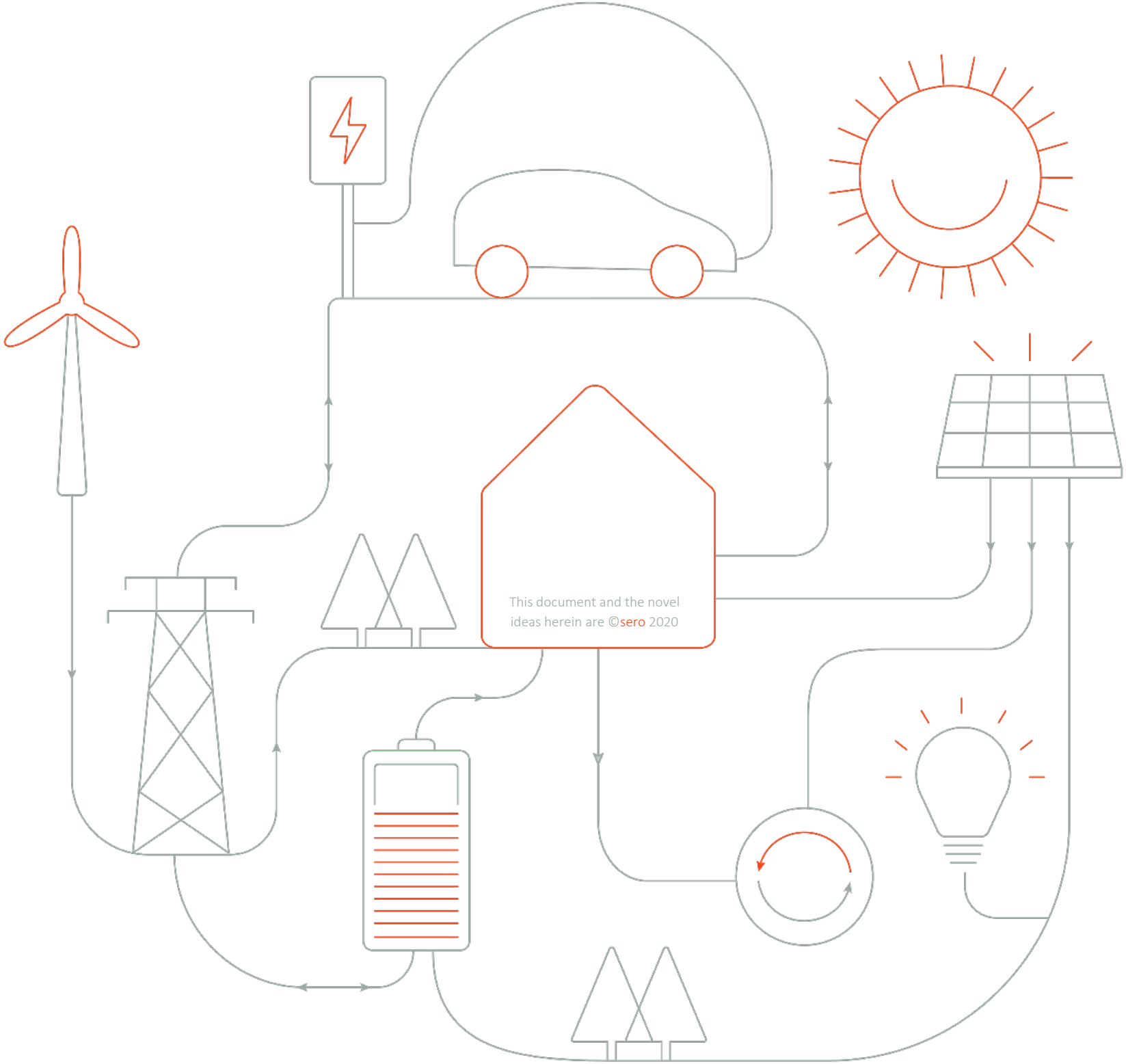
Building Regulations Consultation Edition! We've given our best shot at plotting where England and Wales' consultations on the new Part L documents fall on the journey to actual Zero Carbon. These aren't precise, since they use the new SAP tool which is quite different to the current SAP, but it gives a pretty good idea...



8,159 $kgCO_{2e}$	2,704 $kgCO_{2e}$	1,165 $kgCO_{2e}$	143 $kgCO_{2e}$	0 $kgCO_{2e}$	... $kgCO_{2e}$
Average Home	**New Build Home**	**Zero Regulated Energy**	**Zero Energy**	**Zero Carbon**	**Beyond Zero Carbon**
What's average? Well, every home is different, but for this we've used a typical 100m2 1930's UK semi-detached home with a family of four living it in, using an efficient gas condensing boiler for heating and hot water. We've used reliably published data for occupancy energy demand and National Grid electricity carbon intensity data for 2019 (thanks www.CarbonIntensity.org.uk!)	We've transported our family of four into a new home that's the same size, built to 2014 Building Regulations with an efficient gas boiler for heating and hot water. We've assumed the house is actually built as it was designed, so haven't made an allowance for any issues with construction faults or failures (we know, that might be a bit optimistic of us!).	This is basically everything without a plug socket. So it includes extract fans, fixed lights, heating and hot water, but not washing machines, floor lamps and so on. The oven is in, the fridge & freezer isn't! Zero means that over a year, the home generates as much energy as it needs to power the regulated equipment. To do this, our family are now in a matching size home that has a 14 panel photovoltaic array on the roof, facing South.	This is the first level to allow our family's to plug in their stuff – home + humans! All the energy used in the home over the course of a year, whether from kettles, games consoles, heating, lights or mobile phone charging, is balanced by the same amount of power being generated. Our much-relocated family have now moved into an efficient home with a pretty big PV array on the roof, generating just over 9MWh of electricity a year!	Our family can finally settle down! Their zero carbon home goes beyond the zero energy home by using energy storage, so the electricity they generate can be stored for their use, or exported to the National Grid when it can help avoid the most carbon emissions. This supports the National Grid to decarbonise their large scale generation, and with intelligent energy services from Sero, our family also get cheaper electricity bills too.	At Sero, we're aiming to go beyond zero carbon homes with humans in them, we also want to cover our family for their transport. With electrification of cars and bikes, we're working to include the energy demands of these into our intelligent systems. So our families can live, work and play, knowing they're effortlessly zero carbon and saving money. Happy Days!

We're happy to discuss our workings if you'd like to get in touch. We might even buy the coffee...

seroenergy.com


This document and the novel
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