Net Zero Communities (NZCom)

Wadebridge and Padstow Community Network Area Net Zero 2050 Report

Version	Written	Released	Notes/Changes
Draft	D. Parish/A. Forman	30/06/2022	
Draft 2	D. Parish/A. Forman	12/07/2022	Comments from project team

Contents

The Net Zero Communities project (NZCom) forms part of a larger project: Vulnerability and Energy Networks, Identification and Consumption Evaluation (VENICE). Project VENICE is funded by WPD under the NIA Call 2020 – 'Energy Transition - Leaving no one behind'.

1.0 Introduction to Project

The Net Zero Community project (NZCom) is designed to understand how the needs of Western Power Distribution's (WPD) vulnerable customers will change in the future, particularly with regards to climate change, creating novel ways to support a whole community through the transition to a net zero energy system and understand the role community energy groups can play. NZCom is investigating the effects and opportunities created by the decarbonisation of the Wadebridge & Padstow Community Network Area, achieving a net zero condition by 2050.

The feasibility study will work towards establishing a sandbox trial of network innovation solutions, as well as developing new community business models that support WPD's customers and provide clean energy at an affordable price.

The outcomes of the project are:

1. Develop future likely net zero carbon scenarios to 2050 based on Wadebridge to help Network Operators to frame the likelihood of impact to vulnerable customers.

2. Develop a carbon accounting methodology to quantitatively compare impacts and interventions.

3. Identify technologies, systems, and approaches to reach NZC in Wadebridge by 2050 that positively support vulnerable customers and inform approaches and policy levers that may be needed from a Networks perspective.

4. Develop community-led business models that have the potential to deliver socioeconomic benefits and are supported by the local community and how this will intersect with Network Operators.

5. Assess the financial impact and effect on home heating relating to heat pump integration and co-ordinated peak time avoidance tariffs.

6. Develop & share methodologies & learnings for other communities to define their own 2050 NZC scenarios and models.

From the outcomes of the project, numbers 1-3 are included within this report.

1.1 Geographical Boundary

The geographical boundary for the project is defined by the Wadebridge & Padstow Community Network Area, as shown in Figure 1. This boundary identifies the residential, business and public service communities that are the subject of the net zero study.

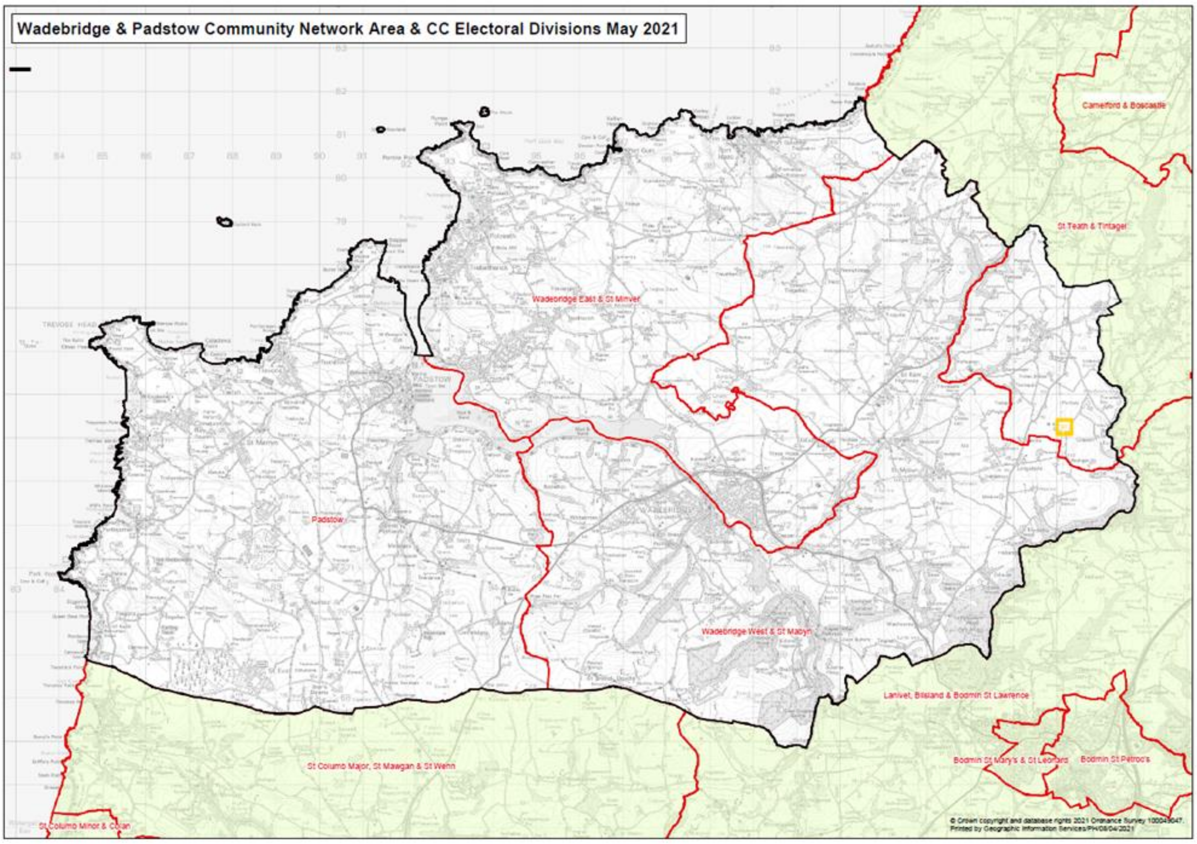

Figure 1: Map showing the project's geographical boundary in black.

1.2 Greenhouse Gas Emissions (GHG) Considerations

GHG emissions are generated by burning fossil fuels, primarily gas, coal and oil. Therefore, the elimination of fossil fuels in the energy mix is paramount to successful decarbonisation. The most secure and effective way to do this (without relying on GHG removal technologies) is to use the electricity network which has a decarbonisation agenda of its own heading towards net zero by 2050. The electricity network has reduced its carbon content by almost 50% since The Paris Agreement (2015), attributed to the large decrease in the use of coal. Decarbonisation of the electricity grid will continue through further integration of renewables and low carbon energy generation (advancing the UKs nuclear and offshore wind capability) and reducing the use of natural gas in the electricity mix.

Through the NZCom work, consideration is given to GHG emissions across three vectors which are responsible for all energy related GHG emissions: heat, power and transport.

The vectors are characterised for residential properties within the geographical boundaries, with consideration and actions relevant also to commercial businesses which should take the same route but have not been modelled.

Businesses may contribute to the reduction of residential emissions reduction through utilisation of resources for renewable energy generation, such as available roof space for solar PV and connection to the pseudo microgrid solution which may be shared throughout the region.

In this case, businesses and residential properties may both be connected to the microgrid, and both may benefit. The project recognises that businesses and homes are *both* vulnerable to energy price rises but will face different impacts as a result. Businesses are likely to face difficulties in decarbonisation but should act as part of a social and business agenda, and may generate revenue in order to do this, acting under different motivation and governance. Some businesses, particularly small businesses, may be left vulnerable to this change, which is recognised, however mitigation may be different and are considered separately.

2.0 Executive Summary

The NZCom project examines the impact of decarbonisation on the community residing within the Wadebridge and Padstow Community Network Area and offers solutions to ease that journey.

The network innovation tested in this work is the operation of a pseudo microgrid. This seeks to replicate the advantages offered by a private microgrid in terms of shared local energy but using the existing DNO infrastructure downstream of a designated boundary point, i.e. a substation. The advantages provided by a pseudo microgrid come from the ability to exchange local energy between generators and users without incurring the additional national system charges and final consumption levies. Multiple pseudo microgrids may be required to cover the whole community network area, each microgrid being defined by its low voltage (LV) or high voltage (HV) substation.

Different scenarios for the future are modelled to measure the results of different actions and the rate at which change may be adopted. Net zero by 2050 is not inevitable. The scenarios are informed by National Grid ESO Future Energy Scenarios [1] described in section 3.3 and developed into altered scenarios for NZCom described in chapter 4.

Falling Short describes how the target may be missed. **System Transformation**, **Societal Transformation**, and the **No Regrets Option** all meet net zero, but rely on carbon capture and storage (CCS) and / or a zero-carbon gas network neither of which are certain and therefore not included in NZCom solutions. Scenarios are constructed according to predicted technology take-up rates that are suited to the area and according to the renewable energy resources available.

The scenarios inform the numerical modelling of 13,407 homes within the area, conducted for 2021 (year 0) and repeated in 5 year increments until 2050. The modelling reflects the scenarios and determines the cost of energy and the GHG emissions for 11 home types with eight variations of home energy supply, for both a standard DNO connection and for the pseudo microgrid.

In the case of the pseudo microgrid, a community operated Energy Service Company (ESCO) type arrangement is assumed, whereby the locally generated energy is sold to homes at an advantageous price compared to ordinarily supplied energy from a utility's provider. In this case, the ESCO applies a four tiered tariff that increases the cost of energy as more energy is used. Therefore, in principle the lower energy users in smaller more efficient homes, or those that are frugal with their energy use (likely to be those who have the least expendable income) have their energy costs subsidised to a degree by the higher energy users in larger homes with the least energy efficiency or are energy extravagant.

The significant outcomes of the analysis are as follows:

1. The implementation of a pseudo microgrid provides a clear advantage to the community in terms of lowering the cost of energy across all housing types. It also **achieves a faster rate of decarbonisation** of the area that it serves.

2. The Societal Transformation scenario allows a small proportion of homes to reject the electrification of heat**. In the absence of a zero carbon gas solution or a carbon capture and**

storage solution, this results in a failure to achieve zero emissions. This strengthens the argument for 100% electrification of domestic energy.

3. The advantage gained from a pseudo microgrid is strongly linked to the capacity and type of renewable energy that is connected to the microgrid. More local generation results in more advantage to the community**. Increasing the capacity of wind energy generation is much more effective than simply increasing PV solar energy.**

4. With sufficient renewable energy generation on a pseudo microgrid**, a significant energy cost saving is achieved in the 'do nothing' action group*.** This action might represent the more vulnerable members of the community over the next 10 years or more.

   *Note *this is not an incentive to take the "do nothing" approach. When a percentage of the community takes positive action to reduce their energy related carbon emissions it affords a significant cost saving to the remaining residents who are least able to afford to make changes.*

5. **The addition of a centralised battery energy storage system (BESS) to a pseudo microgrid, further reduces the cost of energy** for residents and further accelerates the area's decarbonisation. Ownership and operation of a BESS is a potential business model for WPD.

3.0 Net Zero Literature Review

The literature review considers the following five documents as key influencers in delivering the scenarios and solutions to net zero by 2050.

BEIS, Net Zero Strategy [2]
Ofgem, Consumer Vulnerability Strategy [3]
National Grid ESO, Future Energy Scenarios [1]
Mott Macdonald, A Place-based approach to net-zero [4]
Citizens Advice, Navigating net zero [5]

3.1 BEIS Net Zero Strategy

One of the most important documents of last year (2021), the Net Zero Strategy written by the Department for Business, Energy and Industrial Strategy (BEIS) lays out the importance of action now to meet net zero and why the UK should lead the way. There are many policies in this document which make for useful reading, the ones most relevant to the NZCom project are highlighted in this chapter.

As we delve deeper into the pledged commitments of BEIS, it is clear that the focus drives a financial agenda, looking for revenue in the solutions to climate change. The paper presents a favourable outlook on job creation, new market opportunities in low carbon hydrogen, offshore wind, and Carbon Capture and Storage (CCS), and therefore the potential for economic growth. This may well be possible as new sectors emerge, but the reality is likely to be costly, and at times uncomfortable, unless a unified approach is taken, led with clarity, strategy and generous funding schemes.

In the industrial strategy, a new hydrogen economy is supported, with CCS either for residual GHG emissions (those that that have not been reduced or eliminated by 2050) or for the continued use of natural gas as a fuel source offset by CCS. It is worth stating here that the continued use of natural gas under any circumstances is not a safe mechanism for decarbonisation and is open to strong criticism.

For heat and buildings, energy efficiency is a key target. BEIS states in the proposals for heat and buildings "We are setting the ambition that, by 2035, once costs have come down, all new heating appliances installed in homes and workplaces will be low-carbon technologies, like electric heat pumps or hydrogen boilers. We will take a decision in 2026 on the role of hydrogen heating". The ambition is that a heat pump will be as cheap to purchase as a gas boiler, an unrealistic expectation in the near future for the reasons that a heat pump in itself is not enough for it to function effectively for heating and hot water provision. Even if the cost of the unit can be equal to that of a gas boiler now, a property is likely to need a new heating distribution system and some retrofit measures to improve the thermal efficiency to make the cost of heating as affordable as gas been previously. This function is modelled in the work and the results are explained in detail in chapter 6 but is not recognised in entirely in the BEIS strategy.

It remains likely, that the move to net zero will require significant subsidy and a well-informed approach to change. The key policies to support the integration of low carbon technology for heat and buildings are laid out in the strategy, including £5,000 grants available per household to help equalise the cost of eliminating gas boilers, with no new gas boilers being sold after 2035, and a new £60m Heat Pump Ready programme. The programme recognises that heat pumps will "be critical to meeting the UKs legally binding commitment to achieve net zero". The deployment streams do not specifically recognise the need for home improvements, though they do hint at barriers which need to be overcome. This needs to be clearly addressed by Government, as home improvements will play a critical role in achieving a net zero status.

"We are setting the ambition that, by 2035, once costs have come down, all new heating appliances installed in homes and workplaces will be low-carbon technologies, like electric heat pumps or hydrogen boilers. We will take a decision in 2026 on the role of hydrogen heating."

On heat networks, the results have not been published from the government paper Heat Networks Zoning Consultation (2021) but the strategy seems to be focusing on District Heat Network (DHN) zones in urban areas. This will likely comprise of new built developments, planned town or city regeneration. That does not restrict the capacity for a heat network in the Wadebridge and Padstow (WAP) area if the business model shows there are significant benefits.

The BEIS net zero strategy, under Heat & Buildings states:

"Under the £338 million Heat Network Transformation Programme, we will launch the £270 million Green Heat Network Fund to grow the market for low carbon heat networks. We will also pass new legislation to regulate the sector for consumers, give heat networks the statutory powers they need to build, and regulate the carbon emissions of projects from the early 2030s. We will also deliver new heat networks zones in England by 2025 where heat networks are the default solution for decarbonising heating. Finally, we will work with industry to increase the capacity and capability of the UK supply chain to support the sector to reach its growth potential and look to improve performance of legacy networks through the Heat Network Efficiency Scheme."

The key policies in the transport proposal begin to mobilise public and private investment towards the decarbonisation of travel, including the removal of all road emissions and kickstarting zero emissions international travel which are outside the scope of this study.

The zero-emissions transport sector has so far been catapulted largely via private electric vehicle (EV) companies like Tesla, showing the importance of private sector investment in new technology supply chains. Governments (local and national) are slowly moving to supply the infrastructure required to accommodate battery electric vehicles, facing the challenge of integrating enough public on-street charging for a swift move from combustion engine to EV. There is no mention of hydrogen specifically as a transport fuel in the strategy, though it is mentioned in the 10-point plan (point 2) below. It is likely specific detail will evolve after 2026 when the role of hydrogen is clarified particularly where sustainable flight fuel is concerned, long distance haulage, and rail travel.

Greenhouse gas removal (GGR) is discussed as having "a critical role" for residual emissions, and the development of a new sector in which the UK is well-positioned to lead.

The key policies throughout this document promise much needed funding which will be critical to the UK achieving net zero in time. The 10-point plan clarifies the commitments made by the Government in the following areas, which must be upheld and acted on with immediate effect:

Point 1: Advancing Offshore Wind
Point 2: Driving the Growth of a Low Carbon Hydrogen Economy
Point 3: Delivering New and Advanced Nuclear Power
Point 4: Accelerating the Shift to Zero Emission Vehicles
Point 5: Green Public Transport, Cycling and Walking
Point 6: Jet Zero and Green Ships
Point 7: Greener Buildings
Point 8: Investing in Carbon Capture, Usage and Storage
Point 9: Protecting Our Natural Environment
Point 10: Green Finance and Innovation

Points 4, 5, 7, 9 & 10 may be implemented at a community level.

3.2 Consumer Vulnerability Strategy, Ofgem

The consumer vulnerability strategy talks about the importance of digitalisation, decarbonisation, and decentralisation and the effect of these new issues on future business models, "creating new costs and benefits and capability challenges for consumers".

The strategy sets out areas of improvement, defined by stakeholder engagement across Wales, Scotland and England. These are:

- Improving identification of vulnerability and smart use of data.
- Supporting those struggling with their bills.
- Driving significant improvements in customer service for vulnerable groups.
- Encouraging positive and inclusive innovation.
- Working with partners to tackle issues that cut across multiple sectors.

The impacts of low carbon integration will undoubtably be easier for some than for others, so identifying the challenges across the whole demographic is important for the success of critical changes. Labelling some customers as vulnerable can also create sensitivities, of which Ofgem are aware. It is clear with the recent energy price rises, that more customers will now be struggling to pay their bills, and clarification of a strategy to reduce the risk of fuel poverty alongside decarbonisation, is now of paramount importance.

Previously, various schemes such as the Energy Company Obligation (ECO) and, ECO2 and Warm Homes Discount have supported some customers, though the value and accessibility of these schemes is limited. The ECO scheme began in April 2013, and over time it has been amended. The ECO3 scheme closed on 31 March 2022. The latest policy, ECO4, has yet to commence, however it applies to measures completed from 1 April 2022 and will cover a four-year period until 31 March 2026. “This ECO policy will be entirely formed from one obligation, the Home Heating Cost Reduction Obligation (HHCRO). Under HHCRO, obligated suppliers must mainly promote measures which improve the ability of low income, fuel poor and vulnerable households to heat their homes. This includes actions that result in heating savings, such as the installation of insulation or the upgrade of an inefficient heating system”. [6]

There is potentially valuable learning in Ofgem’s strategy, particularly on the support against energy price rises, home efficiency improvements, and protection for vulnerable customers which can be used within NZCom, like price protection on default tariffs which could be avoided with a pseudo microgrid through the use of a clear and constant billing structure using locally generated electricity.

3.3 Future Energy Scenarios, National Grid

The Future Energy Scenario’s (FES) is written by National Grid ESO and is a key influencer in the scenario’s developed by University of Exeter (chapter 4), helping to shape the projections and outcomes within this project.

“With an ambitious target for net zero emissions by 2050, our energy system will need to transform rapidly while continuing to deliver reliability and value for consumers. We believe decarbonising energy is possible but also that it will be complex, not least because there are many ways to reach net zero, each with their own trade-offs.” [7]

FES outlines four different pathways to net zero by 2050, which are used as parameters in NZCom. These ultimately consist of the following routes:

1) Falling Short. Minimal behaviour change, slow progression, and decarbonising power and transport but not heat. This route makes some progress but ultimately **does not meet net zero by 2050**. Falling short forms part of the NZCom scenario narratives as a comparable baseline scenario.

2) Consumer Transformation. This route relies on consumers moving to electric heating, willing to change their behaviour, having high energy efficiency, and using demand side flexibility (time of use tariffs). **This route does meet net zero by 2050** and is heavily incorporated into the NZCom Societal Transformation scenario.

3) System Transition. This route relies on the system changing the way electricity is generated and supplied. This route does meet net zero by 2050. In the FES System Transformation option, hydrogen boilers are used, with hydrogen mostly generated by natural gas and carbon capture and storage. This is considered to be a high-risk scenario, with CCS technology being currently unproven and the use of natural gas meaning a plausible route to net zero is missed. The Government will not release its hydrogen strategy until 2026. **This scenario is represented in the NZCom scenario narrative as System Transition,** to give an example of the applicability of changes that rely on top-down system level interventions.

4) Leading The Way is **the fastest credible way to reach net zero, achieving results before 2050**. This route requires a combination of high consumer engagement with world leading technology and significant investment. **This scenario is incorporated into the NZCom Societal Transformation scenario narrative**, which also integrates interventions appropriate to the existing physical and social infrastructure.

FES 2021 holds some valuable and informative reporting on the value of markets and flexibility, infrastructure and energy systems, policy, digitalisation and a whole energy system view. It sets out the context of net zero, and how we get there. It sets out informative text alongside graphical representation of GHG emissions, and negative emissions, and what those look like in different scenarios.

To summarise, the NZCom scenario narratives draw on all the scenarios, but the NZCom modelling is based on the Societal Transformation scenario, which is a combination of the FES Consumer Transformation and Leading the Way scenarios, whilst also integrating interventions appropriate to the existing physical and social infrastructure in the WAP area.

3.4 A Place-based approach to net-zero, Mott Macdonald

Mott Macdonald's paper focuses on cities, rather than rural areas, but more importantly, recognises the approach to net zero requires "an extensive collaboration between central government, local government, and the private sector" and that outside of the city scape, applying place-based solutions" is equally important. (Clare Wildfire, Global Practice Lead for Cities).

The paper echoes aspirations from the NZCom project, such as "catalysing local solutions" and adopting a systems approach to navigate the complexity of challenges surrounding net zero carbon targets.

The potential to use cities as flexibility assets, means storing unused generation in aggregated loads such as thermal stores and car batteries, whereby surplus generation or locally available green energy tariffs on a time-of-use basis, can be stored and re-distributed locally. This may be possible on a smaller scale within communities and geographical areas.

The key point here is that place-based support and integrated action is the best way to maximise the benefit for carbon reduction schemes. Support from national and local government is important, providing strategic leadership, with accessible funding and ambition for large scale change.

The paper gives example case studies, highlighting the need for action towards policy change now. A case study on reducing congestion through a levy on businesses to limit free parking spaces for staff shows how a city-wide scheme in Nottingham encourages commuters to use alternative methods of travel. It took nearly 10 years to become reality due to political complexity. The scheme is ringfenced by law and heralded as a success to the city's now high use of public transport.

These case studies are a valuable tool in assessing the potential success of the development of solutions and options.

3.5 Navigating net zero, Citizens Advice

This paper by Citizens Advice (CA) discusses the requirements of home energy improvements being necessary in most homes across the country to tackle energy reduction and efficiency requirements to meet net zero by 2050. The scale of this challenge is huge, and support needs to be strategic, effective, and expert. CA state that "over 90% of homes in the UK will need low carbon heating systems, up from just 4.5% today", figures that may sound shocking, but nonetheless are acutely necessary. Most of these properties will also require upgrades to the fabric to make them more efficient, like improved insulation in the loft, walls and floor.

CA calls on the Government white papers to set the guidance, “reiterating its target for all homes to reach an Energy Performance Certificate Band C by 2035 in order to reach carbon targets”.

Engagement and buy-in from the public is paramount to achieving this, with those on higher incomes having to fund at least some of the costs themselves.

Other work by the CA (Taking the temperature [8]) navigates the complexities for those that are not technology savvy. Technology adoption may further complicate the move from traditional heating techniques to low carbon ones without the right support, something NZCom recognises in it’s brief; “not leaving anyone behind” and supports the move for all communities to navigate the challenges together.

The CA paper considers home energy technologies to generally include insulation, heating systems, and electricity generation, this may include additions such as an EV charger for home charging of a vehicle.

The paper finds that environmental motivation is rarely the driving factor behind decisions on making a purchase, and more common drivers are financial and level of comfort. The main barriers to change are upfront costs, uncertain payback, and disruption; highlighting that the mindsets behind motivation need to be changed in favour of finding an affordable, comfortable solution to decarbonisation; a vision that is far from the truth for the future if we fail to act now.

The CA paper lists householders reaction to different technologies, which is a valuable tool in understanding the concerns and mis-information which needs to be addressed in communities. A view is taken across solar, insulation, heat pumps and biomass technologies which portrays more perceived concern than benefit in every case, largely driven by safety concerns and poor quality of work, and a view that heat pumps are complex, niche, and difficult to understand.

In order to de-risk the situation, clear leadership is required. This may include MPs using electric cars or public transport and installing low carbon technologies in all government buildings. Trusted sources of information are required, the paper clearly stipulates there is an element of mistrust surrounding energy companies who are perceived to supply biased information.

Workshop outputs also show awareness of the opportunistic companies which emerge whenever there is a government grant announced, one output from a workshop held by CA states: “and outcome the conmen to take advantage of it all” (Brighton workshop), highlighting here the perception that government funding schemes sometimes lead to poor quality work with bespoke companies setting up to benefit from the new revenue scheme without having the skills to complete the work properly. A higher level of trust is perceived by the public towards not-for-profit organisations which suggests there is a pathway for community groups and CICs to play an integral leadership role in the decarbonisation of energy.

Key output from the paper: Householders want to be confident that the measures they are getting are the right ones.

4.0 Future Energy Scenarios for Net Zero

Three scenarios have been developed for the Wadebridge and Padstow Community Network Area, two of which reach net zero, and one of which falls short (Figure 1). **Net zero by 2050 is not inevitable**.

The **Falling short** scenario represents a baseline scenario in which low levels of ambition at national, regional, and local scales translate to poor progress towards decarbonisation, as well as a persistence of negative impacts on the most vulnerable parts of the community.

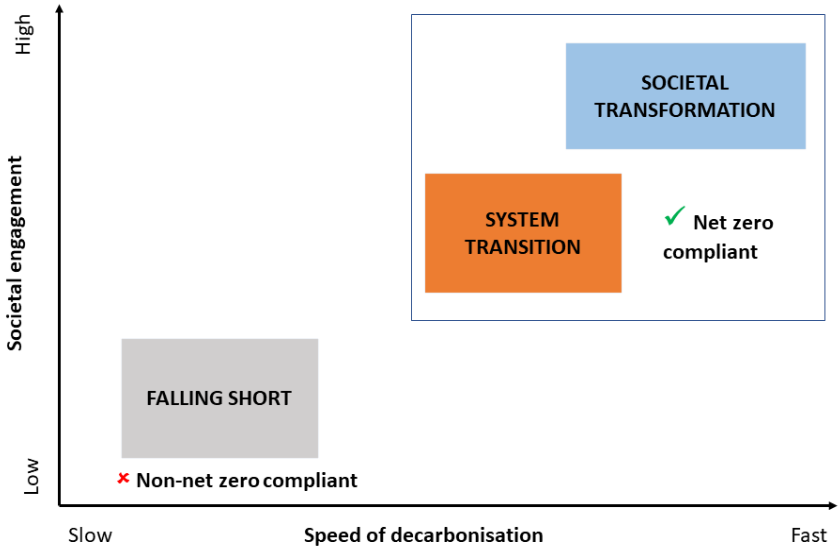

Figure 2: NZ Com Scenarios for Wadebridge and Padstow

The two net zero compliant scenarios, **System Transition** and **Societal Transformation**, can be distinguished by the degree to which systemic feedback mechanisms are exploited. **System Transition** represents a path to net zero which emphasises large-scale, supply side interventions, achievable by conventional supply-side approaches to energy policy and infrastructure. **Societal Transformation** meanwhile emphasises a role for household, business and community-scale interventions alongside changes at the demand-side, necessitating a step change in societal engagement. While net zero is theoretically possible through System Transition, it is likely to a) take longer, and b) exacerbate vulnerabilities compared to the **Societal Transformation** scenario. These scenarios are explored in detail below.

4.1 Falling short

The Falling Short scenario for the area is based on the 'Steady Progression' FES 2021 scenario. This scenario acknowledges the net zero ambition but fails to enact the necessary policy, strategy and infrastructures needed to achieve it. Societal engagement with net zero is patchy and uncoordinated, and public engagement is limited to 'broadcast' style campaigns with limited tailoring and targeting to specific innovations or audiences. Uptake of low carbon technologies progresses but is fragmented and is limited to the most affluent of households, and opportunities to target interventions and engagement practices to those experiencing vulnerabilities are missed. There is little coordination between policy, business models and behaviour change, and as such, opportunities to tap into positive feedbacks are missed. Low levels of flexibility mean that network constraints persist. The limited and piecemeal resource for energy advice and support curtails longer term strategies to support vulnerable members of the community. The impacts of failing to address net zero and address vulnerabilities are felt through rising fuel bills, rising number of people experiencing detrimental physical and mental health impacts of fuel poverty and increasing inequalities.

Technical and social interventions:

Heat: The local area relies on high levels of gas and blended gas for heating households connected to the gas network, whilst existing off gas grid households rely on electric heating, particularly direct electric heating. Electric heating is installed in some but not all new homes from 2025, including heat pumps where it is cost effective. Heat pump installations increase six-fold in the area by 2035 and almost doubles again by 2050. Short term financial support is available for residents with low income or experiencing vulnerabilities such as poor health, disabilities, or caring responsibilities.

Impact on energy demand for heating: An unambitious and fragmented national policy landscape and a commitment to 'consumer choice' constrains the potential growth in demand for whole-house thermal upgrades as well as the availability of skills to carry out the upgrades. Thermal efficiency measures such as insulation or triple glazing are promoted but energy demand for heating remains high in the winter months. Grants for home upgrades and boiler replacements provide some financial support for low-income households. Government does little to engage the public around domestic demand reduction or to encourage adoption of highly efficient appliances. The EU target of a 32% increase in energy efficiency by 2030 [9] is not met.

Energy Generation: There is an incremental uptake of renewable energy generation. Rooftop domestic solar PV is installed by able-to-pay residents, doubling the installed capacity in the area by 2050. Rooftop commercial solar PV and ground mounted solar in the area both increase at a similar rate, assuming grid restrictions are overcome. Persistence of planning constraints mean that new onshore wind power generation is constrained.

Flexibility: Smart meters, appliances and markets enable limited flexibility for those with compatible technologies and capabilities and who are willing to participate. Those with vulnerable characteristics are excluded including residents with limited IT or digital capabilities, those in fuel poverty and with low energy usage, and those unable to shift demand due to health or economic demands. This exclusion compounds existing inequalities, as **those benefiting from flexibility do so at the expense of those who cannot**.

Transport, travel and mobility: A reliance on private transport to deliver decarbonisation means that the number of battery Electric Vehicles (EVs) in the area increases to over 5,000 by 2035 and 8000 by 2050. Vehicle to grid (V2G) charging is limited to those with EVs and off-road parking. The reduction in the petrol/diesel infrastructure means that those who maintain such vehicles, or cannot afford to upgrade to an EV, experience a scarcity of refuelling options.

Wider impacts and implications: A failure to address net zero and vulnerability, combined with the current cost-of-living crisis, results in increasing inequalities within the area. The lack of progress on societal inequalities and net zero goals contributes to feelings of stress, anxiety, and despondency.

4.2 System Transition

Our **System Transition** scenario is based on the FES 2021 System Transformation scenario [10]. Net zero is achieved through top-down system-level interventions. Some system flexibility is created with supply side interventions. Societal engagement focuses on 'consumers' and is limited to broadcast-style information campaigns to encourage uptake of new technologies and practices, but those least willing or able to participate are left behind. The narrow view of agency for citizen and organisation actors means that government emphasises policies but underplays the role of policy enablers.

This scenario highlights that reaching net zero is technologically feasible but socially risky. In the absence of public engagement strategies or progressive funding streams, the pursuit of net zero can widen inequalities, benefiting those most willing and able to participate in the transition, but exacerbating existing vulnerabilities in the area and beyond.

Technical and social interventions

Heat: A national hydrogen network underpins the transition from natural gas to hydrogen for residential heating. Residents are engaged to encourage uptake of technologies such as hydrogen-ready boilers, efficient appliances and heat pumps. Heat pump installation in the area increases six-fold between by 2035. All new homes in the area have electric heating or hydrogen-ready boilers and appliances from 2025, depending on gas network connectivity.

Impact on energy demand for heating: There is medium ambition for increasing domestic thermal efficiency. The emphasis on minimal resident disruption such as integrating hydrogen and heat pump technologies underserves those who live in hard-to-treat buildings which require more disruptive interventions. Household investment in highly efficient – and some smart – appliances result in a 32% improvement in energy efficiency by 2032, but there is no policy or engagement strategy to encourage demand side reduction practices.

Energy Generation: Large scale wind and solar is preferred to small-scale wind and rooftop solar. The installed capacities of domestic and commercial rooftop solar PV, and ground-mounted PV in the area both triple by 2050. Onshore wind generation increases only moderately from 2035. The lack of financial incentives means that only owner-occupiers with sufficient capital can afford to install and benefit from rooftop solar PV, and those in fuel poverty are left behind.

Flexibility: Flexibility is primarily automated and delivered by technological solutions. There is some uptake of Time of use tariffs (TOUT) but households without smart appliances and without the capacity or capability to flex, are excluded. The rising numbers of residents unable to afford fuel bills causes increasing pressure on frontline services.

Travel, transport and mobility: Private car use remains high, with a steady uptake of EVs to 2035 which rises rapidly between 2035-2045. This is supported by increases in charging infrastructure on and off-road, in workplaces, public car parks and destinations. There is a slight modal shift to public transport, walking and cycling.

Wider health and wellbeing impacts: Whilst net zero is addressed, vulnerabilities and inequalities are not. Rising costs of living mean that financial vulnerabilities increase, although some positive health impacts arise from housing renovations. Increasing digitalisation brings some co-benefits for vulnerable residents such as increased digital accessibility to services.

4.3 Societal Transformation

Our **Societal Transformation** scenario combines two scenarios from the FES 2021 - Consumer Transformation and Leading the Way scenarios, whilst also integrating interventions appropriate to the existing physical and social infrastructure in the local area. National, regional and local ambition for net zero is high, underpinned by high levels of societal engagement. Additional resources and trainings for agencies and frontline workers mean that residents can easily access tailored advice, information and support. Targeted deployment of technologies, alongside appropriate support, ensures that no-one is left behind [11] and decarbonisation by 2050 is achieved. Investment in the national technical infrastructure and social infrastructure ensures that energy efficiency measures are locked in. Coordinated interventions means that positive feedback between policy, technological infrastructure, business models and engagement channels and organisations can be exploited. The generation of jobs within the building and energy trades provides benefits for the local economy.

Opportunities to participate in decision-making regarding energy means that local concerns about the impact and equity of new infrastructure and technologies are addressed and resolved, and residents experience an expanded sense of agency. Net zero is tailored to local challenges and sense of place, and connections between climate change, and energy encourage a social mandate for net zero.

Technical and social interventions

Heat: Domestic heat is primarily fuelled by electricity. Heat pump installations rise fastest across all scenarios, representing a 25-fold increase in installations in the area by 2050. Installations initially focus on homes with sufficient levels of thermal efficiency and new-build homes from 2025. Coordinated packages of thermal upgrades, boiler replacement, heat pump installation and support for behaviour change is then targeted to those experiencing fuel poverty, those in off-gas homes, and elderly residents. No new gas boilers are installed from 2035 onwards. Hydrogen for heating plays a smaller role than in the System Transition scenario, and existing boilers and appliances are adapted to accommodate blended gas and zero-carbon hydrogen.

Impact on energy demand for heating: Widespread thermal efficiency measures and tailored whole-house retrofits are scaled up and accelerate in the late 2020s and early 2030s. This is supported by a government policy to encourage extensive whole-house retrofitting, an expansive – and localised - retrofit supply chain, and upskilling and resourcing of construction trades. Thermal upgrades are delivered at scale, and net zero expertise is promoted across key organisations and frontline agencies, supported by a one stop shop for health and energy and social learning opportunities. Emerging barriers connected to newer technologies and the impact of changes to energy practices are addressed equitably.

Financial support packages are targeted to ensure that those with vulnerable characteristics, and those living in hard-to-treat properties and social housing receive thermal upgrades. Engagement builds on existing concerns of maintaining comfort and warmth, financial wellbeing, keeping bills low and concern for future generations. There is a 32% improvement in domestic energy efficiency by 2030, achieved through LED lightbulbs and investment in highly efficient and smart appliances. The majority of residents have reduced their thermostats by an average of 1°C to reduce heating demand.

Energy Generation: This scenario achieves the largest installed capacity of solar PV. Domestic rooftop solar PV installations are targeted to achieve the greatest efficiencies, and financial incentives support a range of installation options for those experiencing fuel poverty, alongside schemes for social housing operators and private landlords to enable benefits to be shared with existing residents. The installed capacity of domestic rooftop solar PV in the area quadruples between 2021 – 2035, then almost doubles again to 2050. A similar trend occurs for installation of solar PV on commercial rooftops and ground-mounted solar PV. Some initial resistance to onshore wind is experienced but is managed through participatory engagement, and the distribution of benefits locally via the pseudo micro grid. Onshore wind capacity increases slowly to 2035, then doubles by 2050. The local area continues to be a beacon for community energy generation and distribution, with learning around public engagement and business models shared actively among other communities.

Flexibility: Residents are connected to a pseudo micro grid, with co-designed tariffs and options for both active and automated flexibility ensuring fair fuel costs for residents and visitors in holiday homes. The co-design of equitable business models ensures that those at risks of fuel poverty can afford to heat their homes. Support for digitalisation and I.T. reduces isolation amongst vulnerable residents.

Transport, travel and mobility: EV charging points for residents and visitors are installed in domestic, workplace, destination and other publicly accessible areas to enable maximum flexibility. The number of EVs in the area rises steeply to peak the late 2030s. In the mid-2020s, higher levels of public engagement result in more people opting to use electrified public transport where feasible. HVO fuelling stations provide a low-carbon alternative to diesel for those who cannot afford to upgrade to an EV.

Wider impacts and implications: There is a reduction in fuel poverty and poor physical and mental health associated with cold and damp homes. Increases in active travel provide positive physical and mental health impacts. The local level net zero progress, combined with the visible co-benefits, contributes to a reduction in anxiety related to fuel poverty and the climate and ecological emergency. A networked approach to agency and greater resourcing of, and interaction between, frontline and support agencies results in increases in community spirit, civic pride and social capital.

4.4 No regrets option

While there are multiple plausible pathways to net zero for the community, there are several options that are consistent across net zero pathways. These represent no-regrets options.

Accelerated society-wide domestic retrofit is critical to achieving net zero. Whilst retrofit is central to the Societal Transformation scenario, System Transition also implies a step change in retrofits compared to the Falling Short scenario. Decarbonising the housing stock requires an integrated, holistic and long-term approach, underpinned by national policy frameworks and regulations. This also requires new forms of governance and business models.

Societal engagement is an important aspect of reaching net zero. While comprehensive public engagement is central to Societal Transformation, engagement is still needed for the System Transition pathway. Societal Transformation implies coordination of engagement practices, such as engaging householders around multiple technologies and tariff options, and sequencing interventions. Social learning, efficiencies and additionality is more likely to be achieved through coordinated engagement when compared to the ad-hoc and uncoordinated engagement implied within System Transition.

Long term policies and sustained programmes of implementation is needed across national and local levels. Societal Transformation and System Transition will both require clear direction from government, an industrial strategy that enables supply chains and skills development, reform to electricity market design and planning regimes, and support for emerging business models.

Coordination of technological change, infrastructural improvements and societal engagement is needed. Such coordination will require monitoring and acting on feedback of the success or failure of net zero interventions, the tracking of unintended outcomes. This will likely require a combination of new and updated forms of governance which embeds net zero across policy and supports place-based action, with adaptive capacity to enable system feedback and monitoring to flow between sectors, institutions, and scales of government.

Table 1: Technology Adoption figures across the scenarios

	Baseline	Falling short		Technological transition		Societal transformation	
	2021	2035	2050	2035	2050	2035	2050
Heat pump installation	473	3,020	5,670	2,053	6,995	6,454	12,124
32% improvement in energy efficiency		Not achieved		Achieved by 2032		Achieved by 2030.	
Domestic rooftop solar PV (MW installed capacity)	2.5	3.3	4.6	5	8.6	8.9	17.4
Commercial Rooftop solar PV (MW installed capacity)	2.2	2.8	3.8	4.3	7.3	8.3	15.2
Ground mounted solar PV (MW installed capacity)	6.8	9.7	12.7	14.1	21.9	15.8	24.9
Onshore wind (MW installed capacity)	1.9	1.9	1.9	1.9	2.9	2.2	4.4
Battery Electric Vehicles non-autonomous and autonomous (number of vehicles)	60	5,214	8,054	5,547	7,645	8,766	6,723
Domestic EV chargers, on and off-street. (Number of chargers)	53	2,129	5,998	4,014	6,759	5,762	6,756

5.0 Methodology

Before developing solutions that aid progress towards an inclusive net zero, net zero itself must be defined. At the time of writing this document, the definition of net zero for the project area is being developed together with the means to evaluate current and future positions relative to net zero. Carbon Trust note that there is not a globally recognised definition of net zero emissions for a city or a region but use the following in their work:

"A net-zero city or region will set and pursue an ambitious 1.5°C-aligned science-based target for all emissions sources covered within the BASIC+ reporting level of the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). Any remaining hard-to-decarbonise emissions can be compensated with certified greenhouse gas removal (GGR)." [12]

Carbon Trust go further to explain that this approach includes all scope 1 and scope 2 GHG emissions for the target area, together with scope 3 emissions relating to exported waste, transmission and distribution of energy (including energy carriers), and the transportation of goods. The premise here is that the embedded energy of goods is accounted for in scope 1 and scope 2 emissions assigned to the area of origin and that it is only the emissions resulting from the transportation of such goods to the target area (the area being assessed) that are attributable to behaviours and activity within that area.

5.1 Carbon Accounting (Methodology)

The objective of the NZCom Carbon Accounting is to work closely with Solutions, Impacts and Mitigation (work packages within the project) to develop a hybrid carbon accounting method for communities that is suitable for quantitatively assessing likely technologies, systems, approaches and community-led business models to achieve net zero carbon by 2050 that deliver impact and benefits to Network Operators. This section presents the GHG accounting method developed for NZCom, based on the objective and resources of the project, characteristics of and available data for the case study area, and limitations of existing approaches/tools, while ensuring the accounting principle set out in the GPC are followed.

5.1.1 GHG inventory boundary

- **Geographic boundary**: The Wadebridge & Padstow Community Network Area (CNA) is used in NZCom as the case study area. The method developed will be applicable to other regions. There are 19 CNAs in Cornwall. These groups get involved with local issues including community planning, regeneration, transport planning etc.

- **Time period:** GHG emissions within a calendar year will be calculated for future years up to 2050.

- **Greenhouse gases:** emissions of CO_2, CH_4 and N_2O will be covered as these are the most relevant for energy technologies.

- **GHG emission sources:** Stationary energy for residential buildings and industrial & commercial use as well as public and private road transport will be covered.

- **Categorising emissions by scope:** Scope 1 and scope 2. Scope 3 emissions are excluded as in the context of energy, scope 1 and 2 emissions are the dominant sources of emissions for fossil fuels. Scope 3 emissions for established renewable electricity generation technologies such as wind and solar are much lower than the scope 1 and 2 emissions from fossil fuels on a per unit electricity generated basis and are not very well established for some emerging renewable and low carbon technologies. In addition, local communities are unlikely to be able to influence the scope 3 emissions of most of these energy technologies.

- **Boundaries for mitigation goals:** The boundary for the net zero target is limited to the above-mentioned inventory boundary.

5.1.2 Calculating GHG emissions

The consumption of various types of building and transport energy by the Wadebridge & Padstow Community Network Area are output from the modelling; GHG emissions from the area can then be calculated based on the appropriate GHG emission factors for different types of energy carriers such as electricity and transport fuels. GHG factors for direct combustion emissions (scope 1) for most solid, gaseous and liquid fuels as well as for UK grid electricity (scope 2) are available from the "UK Government GHG Conversion Factors for Company Reporting" document [13]. However, some emerging renewable fuels such as hydrogen are not covered in this document. Given that green hydrogen (hydrogen produced from electrolysis of water using renewable electricity) is the only type of hydrogen included in the technological solutions assessed, the emission factor for hydrogen is zero. All the emission factors used will be detailed in the Excel-based community scale NZC 2050 carbon accounting tool.

As the GHG emission intensity of UK grid electricity is expected to change significantly over time, the calculation of emissions from the consumption of grid electricity in future years will be based on a future emission intensity trajectory estimated by Planet A Solutions CIC using historical trends and carbon targets set in UK legislation. It should be noted that this trajectory can and should be revised periodically to reflect actual changes in emission intensity of the UK grid electricity.

5.2 Outcome

5.2.1 Advantage of the method developed

The GHG accounting method developed for NZCom has a reasonable representation of the baseline for the target area in terms of buildings and transport based on available data and the ability to project GHG emissions in annual steps in future years. It allows for the assessment of the effects of different interventions such as adoption of lower carbon energy technologies and changes in energy consumption behaviours as the emission calculation is based on disaggregated energy consumption produced by the solutions modelling. The method should be relatively easy to implement in other areas in the UK given the similar level of data availability and therefore forms a replicable approach to guiding communities towards Net Zero Carbon.

5.2.2 Limitations of the method developed

The main limitation of the method developed is the focus on stationary energy for residential buildings and industrial & commercial use as well as road transport in terms of emission sources and scope 1 and 2 emissions in terms of the coverage of emissions of different scopes. However, this limitation, resulted mainly from data availability and project resources, does not affect the core aim of the NZCom project, i.e., to develop a replicable approach to identifying local solutions that can prevent the more vulnerable energy users from being disadvantaged by the transition to net zero.

5.3 Solution Concept Development

The solutions modelling undertaken shows an all-electric solution to meet full decarbonisation is both viable, and possible, but not without housing retrofit work and more local electricity generation, particularly by wind. To electrify heating efficiently, the integration of locally generated renewable electricity must co-inside with retrofitting properties to reach a higher level of thermal efficiency, thereby reducing heat loss. An all-electric scenario is supported by green hydrogen and HVO for the transport sectors, alongside battery electric vehicles.

In the lead up to the production of this report and subsequent solutions for the geographical area to meet net zero, the project considered a large variety of technical and social solutions to the climate crisis. This was done through the production of two outputs:

- Review of Technical and System Options
- Characterisation of Confining Factors

The key outputs from these papers are included here. The papers are attached in Appendix A and B in full.

5.3.1 Review of Technical and System Options

A brainstorming session was conducted within the project to carefully consider all viable technical and system solutions for the area. The concepts were initially ranked by technology suitability to convey the ease or difficulty within each category, with one symbol showing the least advantage and three symbols showing the greatest. The categories against each ranking are as follows:

- Technical feasibility
- Regulatory feasibility
- GHG emissions reduction
- Community benefit
- Simplicity

The results of the initial ranking suitability are in order of vector.

As an example, electrification of heat is a feasible solution. It ranked highly in terms of ease, GHG emissions reduction (knowing that the national grid has the capability and ambition to fully decarbonise), regulatory feasibility and technical feasibility, however it has a cost implication so is penalised on economics.

A second ranking process was subsequently undertaken to choose the best fit solutions for the geographical area based on GHG Reduction and Community Benefit which are deemed to have the most positive impact.

The development of the NZCom microgrid solution provides costs benefit for the electrification of heat by providing locally generated electricity from renewables shared within an area using the DNO infrastructure and smart metering. The cost of electricity per kWh is stabilised when it is used within the boundary of the network area, providing regulatory changes are put in place to reduce fees currently payable for transmission and distribution.

The national grid and DNO network face external factors which influence and increase the cost of energy (and is currently in a state of flux) putting a large number of people at risk of fuel poverty and therefore reducing the ability to put home improvement measures in place to reduce greenhouse gas emissions. This solution reduces that risk.

The solutions package developed as an outcome of this study can be seen in Table 2.

5.3.2 Characterisation of Confining Factors

The purpose of characterising confining factors is to identify and list the likely confines which could prevent technological and behavioural solutions from being deployed. Potential barriers to implementation are identified which must be overcome to enable progress to be made in the energy sector. In previous work (Review of Technical and System Options) solutions are ranked as possible ways to meet the critical mark of net zero by 2050, looking at electricity, heat, transport and cross vector. In Characterisation of Confining Factors, the top solutions package is defined within this context to identify current constraints and challenge the networks to address these.

This solution package is primarily electric; the development of a pseudo microgrid driven by local renewable energy generation to subsidise costs to the end user, using existing DNO infrastructure for transmission and delivery, coupled with home upgrades and retrofits. This is supported by hydrogen and HVO for transport alongside battery electric vehicles, driving the argument for an electric solution to meeting the energy demand to be the most tangible. In essence, the replacement of fossil fuel with an electric solution to net zero, and a large proportion of electricity is generated locally. Table 2 shows the solutions taken forward by the project.

The constraints addressed are varied and abounding and can be read in detail in Appendix B of this report. As this is a network innovation project, part of the innovation is to challenge existing regulation so it can be amended, adapted, and improved to assist the movement towards decarbonisation without restraint.

In particular. challenge is raised against current regulatory policy and the regulatory body Ofgem, to assist the transition that is required to meet net zero. Areas where network capacity is poor and grid constraints cause difficulties with the implementation of renewable energy generators on the grid, microgrids and local private networks may help to relieve the electrical traffic and improve efficiencies across the national network. This has been done in part by innovative companies like Energy Local, and Octopus Energy, who offer time of use tariffs matched to renewable energy generation and are largely successful but could be developed further. The pseudo microgrid concept developed within NZCom takes this concept further forward, delivering network innovation and benefit to DNO's and local communities, by improving network services, reducing costs of energy to the end user, and driving forward the net zero agenda through a whole system socio-economic change to how energy is generated, transmitted and consumed.

The existing Government ban on onshore wind is heavily challenged in this solution, as onshore wind is cheap, reliable and provides a good annual electricity yield. The same is true for micro hydro, where schemes are often thwarted before they have begun due to extensive and expensive legislation which could be reduced for low-risk schemes.

Table 2: Primary Solutions Package, taken from solution development work.

E2, E3, E4: Pseudo Local Microgrid at LV, HV and EHV level.
E6: New Community / Commercially Owned PV
E7: New Community Owned Wind
H3: Community Heat or DHN
H1: Electrification of Heat
T1: Zero Emissions Vehicle Fleet
T2: HVO Fueling Stations
XV5: Upgrade of fuel poor houses via offsets
XV3 / T6: Hydrogen electrolyser for transport

5.4 Solutions Modelling (Methodology)

This section describes the methodology by which the solutions were developed, in detail.

5.4.1 Input Data and Assumptions - Energy

Numerical modelling is conducted to represent 13,407 homes within the project area. These homes are divided into eight groups according to the energy vectors used for heating as shown in Table 3. The information used to formulate these groups is given by Energy Performance Certificate (EPC) data available via the Government's open database. EPC results were obtained for 5,267 homes and this information was extrapolated on a proportionate basis to match the 13,407 total. A ninth group is added to represent new homes that will be built during the evaluation period up to 2050.

Table 3: 13,407 homes grouped according to heating energy use.

Group no.	Energy vectors used for heating	No. homes	Further description
1	Gas heating and DHW	6,457	
2	Electric storage heaters – Economy 7	2,578	Electric immersion DHW
3	Oil heating and DHW	2,128	
4	Electric heating (standard tariff)	732	Electric immersion DHW
5	Electric heat pump	827	
6	LPG/bottled gas heating and DHW	412	
7	Wood/biomass heating	221	Electric immersion DHW
8	Coal heating	51	Electric immersion DHW
9	Electricity	0 – 1,318	Future additional homes

Each group is sub divided into residence types with assumed gross internal areas (GIA), occupancy, space heating load, domestic hot water (DHW) heating load and unregulated electricity use. The assumptions align with information from the EPC data and the CO_2e emissions calculated for all groups, closely aligns with the figure provided for the project area via the Impact Community Carbon Calculator. [14]

Table 4 shows these factors for the group 1 homes.

Table 4: Example of group sub division according to energy loads.

Group 1	48.85%	Large house		Medium house		Terraced house		Large flat		Small flat		Park home
Gas heating and DHW		A	B	C	D	E	F	G	H	J	K	L
GIA	m^2	130	130	93	93	70	70	80	80	60	60	60
Occupants	Qty	3	2	3	2	2	1	2	1	2	1	2
DHW demand	KWh/yr	2,103	1,628	2,103	1,628	1,628	1,153	1,628	1,153	1,628	1,153	1,628
Heating load	$kWh/m^2/yr$	100	70	100	70	80	50	80	50	80	50	80
Heating demand	kWh/yr	13,000	9,100	9,300	6,510	5,600	3,500	6,400	4,000	4,800	3,000	4,800
Unregulated electricity	kWh/yr	4,300	4,300	2,900	2,900	1,800	1,800	2,900	2,900	1,800	1,800	1,800
Total gas use	kWh/yr	16,781	11,920	12,670	9,042	8,031	5,170	8,920	5,726	7,142	4,614	7,142
Total electricity use	kWh/yr	4,300	4,300	2,900	2,900	1,800	1,800	2,900	2,900	1,800	1,800	1,800
number of properties	Qty	205	204	2001	2002	612	612	43	43	368	368	0

Heating degree data (base 15.5 °C) from Cardinham weather station for 2019 and 2020 [15] is used to construct heat load duration curves according to the annual space heating loads.

DHW assumptions are based on the Energy Savings Trust formula [16] where a home's hot water use is given by: *litres per day = 40 + 28N* where *N* is the number of occupants including children. A water temperature increase of 40 °C is assumed and a specific heat capacity of 4.181 kJ/kg K is applied. Assumptions for unregulated electricity use align with the typical domestic consumption values (TDCV) published by Ofgem. Elexon's profile class 1 [17] is assumed to represent the pattern of unregulated electricity use. Occupancy levels are assigned to match the known population represented by the 13,407 homes.

Boiler efficiency is assumed at 90% for gas, oil and LPG. Space heating by wood and coal is assumed to have 50% efficiency. Direct electric resistance heating is assumed to be 100% efficient. Heat pumps are assumed to be installed together with effective heat delivery apparatus for circa 45 - 50 °C flow and COP of 3.5 is assumed for space heating and 3.0 for DHW.

Where applicable, domestic roof mounted photovoltaics (PV) is always assumed to be equitable with the G98 code (< 16 amps per phase). Larger houses are assigned 3.55 kW capacity each, smaller houses have 2.27 kW and flats have 1.42 kW solar PV systems installed per dwelling.

5.4.2 Input Data and Assumptions – Carbon

Carbon dioxide equivalent emissions factors are taken from the BEIS GHG Conversion Factors [13] publications for year zero. The factors for natural gas, heating oil, LPG, wood/biomass and coal are assumed to be constant throughout the period up to 2050. The factor for electricity (including transmission & distribution) is decreased according to the projection shown in Figure 3.

Note: The projected exponential does not quite reach zero. This results in a small associated emission which is notable in the results for 2050.

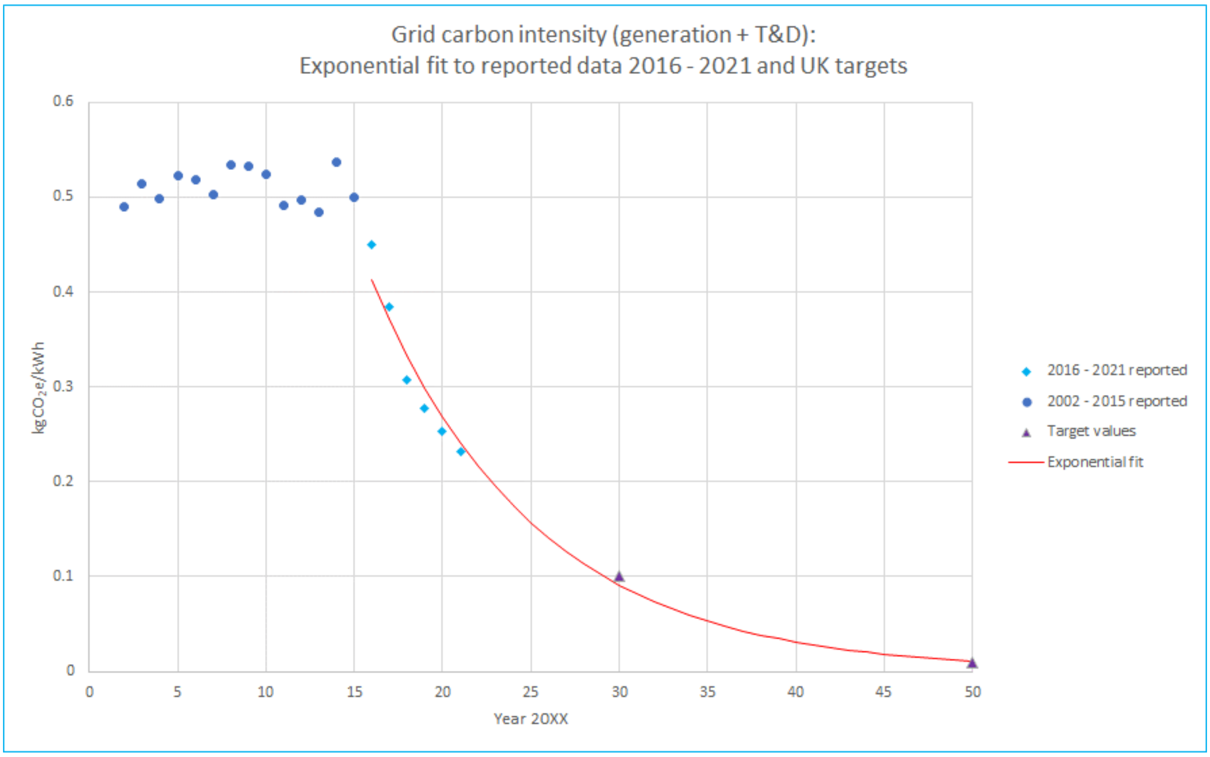

Figure 3: Projected grid carbon intensity
Source: Planet A Solutions (data from BEIS)

5.4.3 Input Data and Assumptions – Costs

The cost of electricity and gas are set at May 2022 price cap levels [18] throughout the analysis period up to 2050. This constant pricing assumption provides clarity with respect to the impact of various actions. The full set of energy prices assumed is given in Table 5.

Table 5: Assumed energy prices from suppliers [18] using "other payment method" for the southwest region.

Item	Price	Units	Notes
Electricity unit price (standard)	£0.3284	£/kWh	
Electricity (E7 mean)	£0.2969	£/kWh	
Electricity standing charge (both of above)	£0.4917	£/day	
Gas unit price	£0.0791	£/kWh	
Gas standing charge	£0.2592	£/day	
Kerosene heating oil (500 L delivery)	£1.0174	£/litre	10.04 kWh/litre (HHV)
LPG	£0.70	£/litre	7.35 kWh/litre (HHV)

The cost of local electricity via the pseudo microgrid is set to a tiered tariff whereby the price increases with increased consumption. These prices are also fixed in the modelling through to 2050 and are shown together with the tier limits in Table 6. These rates may change and alter with relevance to the development of an Energy Services Company (ESCO) formation in the NZCom business modelling work.

Table 6: Assumed domestic electricity prices via the pseudo microgrid together with tier limits.

Item	Price	Unit	Tier limit (units)
Tier 1 local electricity	£0.15	£/kWh	1000
Tier 2 local electricity	£0.175	£/kWh	next 1000
Tier 3 local electricity	£0.20	£/kWh	next 1000
Tier 4 local electricity	£0.25	£/kWh	open

5.4.4 Base Model Construction

The base model represents energy use across all home types (A – L, see table 4) for a given heating fuel at year zero. It is a 12 day year model whereby each month of the year is represented by an average day for that month. Time increments are 30 minutes, i.e., half hourly. Each day's heating load is smoothed across an 18 hour period from 05.00 to 23.00 and where this is an electrical load, it is added to the class 1 electricity profile. The model has a separate heat load duration curve and a separate half hourly electricity demand matrix for each home type (A – L). These are then aggregated according to the number of each home type (large house, small house, apartment etc). When private electric vehicle charging is selected, prescribed charging patterns are added to the aggregated load profile accordingly.

A half hourly PV generation profile is scaled to match the capacity required by the model with a 10% capacity factor. Wind generation is assumed as a steady generation aligning with the capacity required by the model and 28% capacity factor.

In the first instance, the model resolves the use and spill (or curtailment) of renewables on a half hourly basis according to the home type (A – L) and the aggregated loads. In a secondary analysis, this unused energy is available to all users on a pseudo microgrid with the option of invoking a battery energy storage system (BESS).

5.4.5 Modelling the Scenarios

The scenarios taking the Wadebridge and Padstow Community Network Area to net zero emissions are modelled in five year increments from year zero (2021) to year 20 (2050). The actions described by the scenarios are grouped into eight action groups (a – h) as shown below in Table 7 which is shown for group 1 homes as an example. The base model is re-configured repeatedly to produce a model for every action in groups 1 - 4 for all of the seven time increments. Groups 5 – 9 are modelled for actions a, b, and d only.

Note: Groups 1 – 4 represent 89% of the homes in the area.

Table 7: Group 1 homes – no. homes taking each action (EV = electric vehicle, HP = heat pump)

	a	b	c	d	e	f	g	h
		Install PV						
Year no.	Do nothing	By itself	With EV	With HP	With both	EV only	HP only	EV with HP
0	6012	416	10	0	0	19	0	0
5	5341	135	177	209	177	177	241	0
10	2637	0	553	277	277	1477	1236	0
15	0	0	768	384	384	2650	1898	373
20	0	0	975	487	487	1237	1453	1817
25	0	0	1182	591	591	392	2008	1694
29	0	0	1343	672	672	5	2837	929

For each row in Table 7, the total number of homes matches the group total, and the number and capacity of technology(s) matches the year's requirement under the given scenario.

Improvement to existing residential building fabric is characterised in the scenarios and translated to the models as shown in Table 8. The energy saving given by the scenario is assumed to apply to the less efficient version of each home type, reflecting the relative ease of improving a poor fabric compared to a good fabric.

Table 8: Incremental reductions to the poor fabric home heat loads.

Space heating (kWh/m^2/yr)							
Year no.	0	5	10	15	20	25	29
House ID							
A	100	94.0	87.5	83.7	83.7	83.7	83.7
B	70	70	70	70	70	70	70
C	100	94.0	87.5	83.7	83.7	83.7	83.7
D	70	70	70	70	70	70	70
E	80	75.2	70.0	66.9	66.9	66.9	66.9
F	50	50	50	50	50	50	50
G	80	75.2	70.0	66.9	66.9	66.9	66.9
H	50	50	50	50	50	50	50
J	80	75.2	70.0	66.9	66.9	66.9	66.9
K	50	50	50	50	50	50	50
L	80	80	80	80	80	80	80

The existing and assumed growth of local wind and solar energy (non domestic) is taken from the scenarios and converted to a per home capacity as shown in Table 9.

Table 9: Wind and large scale solar capacity on a per home basis.

Wind and large solar capacity - per home (kW)				
	Wind	PV roof	PV grounc	PV total
Year no.				
0	0.0740285	0.0406877	0.167523	0.208211
5	0.07534	0.06115	0.17213	0.23328
10	0.07537	0.10533	0.251	0.35633
15	0.09366	0.15729	0.39724	0.55453
20	0.15338	0.1959	0.49605	0.69195
25	0.1505	0.22735	0.53958	0.76693
29	0.14829	0.25735	0.55973	0.81708

5.4.6 Stronger Renewables Scenario

A revision to the scenarios for renewable energy generation was tested. This revision increased the capacity of small - medium sized wind energy projects and large scale roof mounted PV but capped the predicted capacity of ground mounted PV after 2036. The revised capacity is based on the following:

- Increasing from the current 2 MW wind capacity in the project area to 25 MW in 2050.
- Increasing the assumed spill (to the microgrid) from commercial rooftop PV from 25% to 40%. This will encourage such schemes as the pseudo microgrid will provide revenue.
- Capping the growth of ground mounted PV at the predicted 2036 level of 10.5 MW.

These adjustments are shown in Table 10.

Table 10: Revisions to the wind and large scale solar capacity on a per home basis.

Wind and large solar capacity - per home (kW)				
	Wind	PV roof	PV grounc	PV total
Year no.	Revised	40% spill	capped	
0	0.0740285	0.0406877	0.167523	0.208211
5	0.36494	0.09784	0.17213	0.26997
10	1.08487	0.16853	0.251	0.41953
15	1.42975	0.25166	0.248094	0.499754
20	1.61562	0.31344	0.243781	0.557221
25	1.6542	0.36375	0.239202	0.602952
29	1.69779	0.41176	0.235685	0.647445

5.4.7 Centralised Battery Energy Storage

The addition of a centralised battery energy storage system (BESS) to the pseudo microgrid was also tested alongside the stronger renewables scenario. The assumptions made are as follows:

- Power capacity = 1 kW per home served by the microgrid.
- Storage capacity = 3 kWh per home served by the microgrid.
- Charging efficiency = 92%
- Discharge efficiency = 92%

6.0 Outcomes

The results given here relate to the mean outcomes for the 11 home types A – L, not a weighted mean that reflects the number of each home type in the project area.

Figure 4 shows the mean CO_2e emissions across the 11 home types for groups 1 – 4. Groups 2 and 4 achieve close to zero emissions in 2050 but groups 1 and 3 do not. This is because the Societal Transformation scenario that is tested here allows a small proportion of homes to reject the electrification of heat. In the absence of a zero carbon gas solution or a carbon capture and storage solution, this results in a failure to achieve zero emissions.

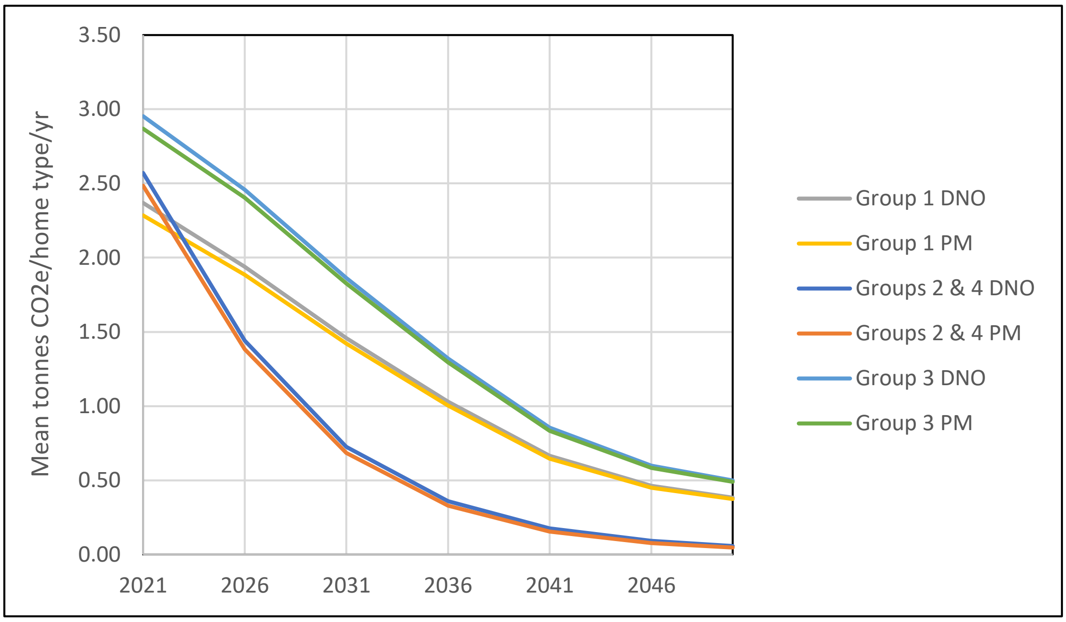

Figure 4: Mean home type emissions for groups 1 – 4 modelled on a standard grid (DNO) connection vs a pseudo microgrid (PM) connection

Whilst it is clear that the pseudo microgrid accelerates decarbonisation with respect to a standard DNO connection, the difference is quite minimal with the original scenarios (not including the stronger renewables scenario). However, with the stronger renewable's scenario, the effect of the pseudo microgrid is a little more pronounced as shown in Figure 5. The addition of a centralised battery energy storage system does not increase the rate of decarbonisation in this case.

The impact of the pseudo microgrid is more pronounced for the cost of energy, particularly with the stronger renewable's scenario. Figure 6 shows the cost per home for the mean home type fitted with a heat pump from 2026 onwards and the cost reductions are given in Table 11.

Table 11: Cost of energy savings per mean home type that result from the implementation of a pseudo microgrid with a heat pump only intervention.

Heat pump only intervention	2026	2031	2036	2041	2046	2050
Group 1	3.7%	4.8%	6.9%	9.4%	9.9%	10.2%
Group 1a	10.5%	22.5%	26.0%	27.4%	25.9%	28.1%
Group 1a BESS	10.5%	23.9%	28.0%	29.5%	29.8%	30.2%

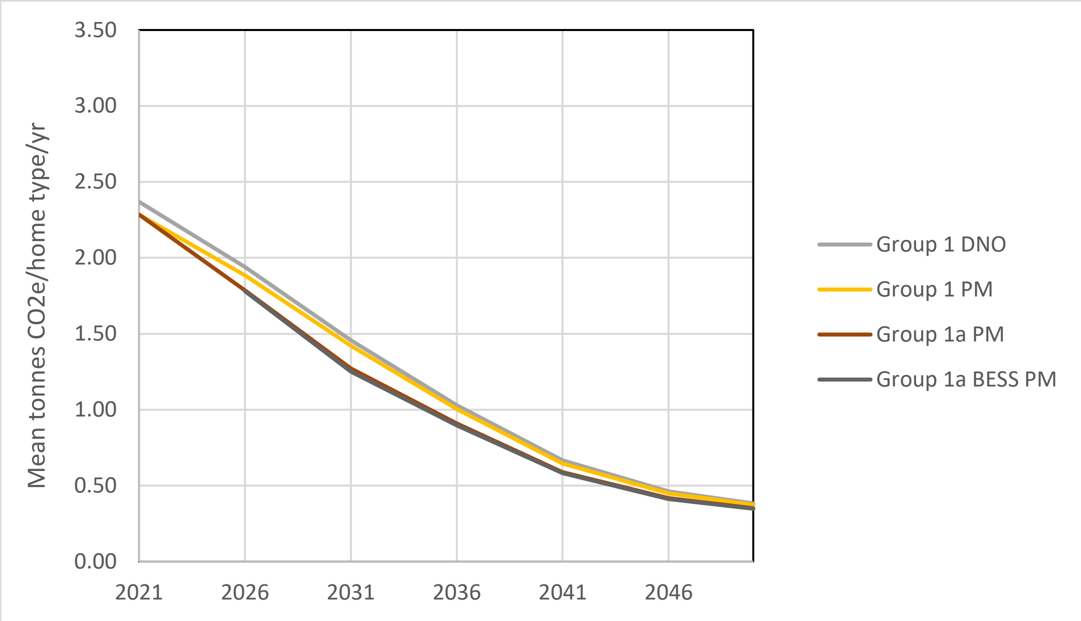

Figure 5: Group 1 mean home type emissions according to Societal Transformation (Group 1), Stronger Renewables (Group 1a) and Stronger Renewables with a centralised battery (Group 1a BESS).

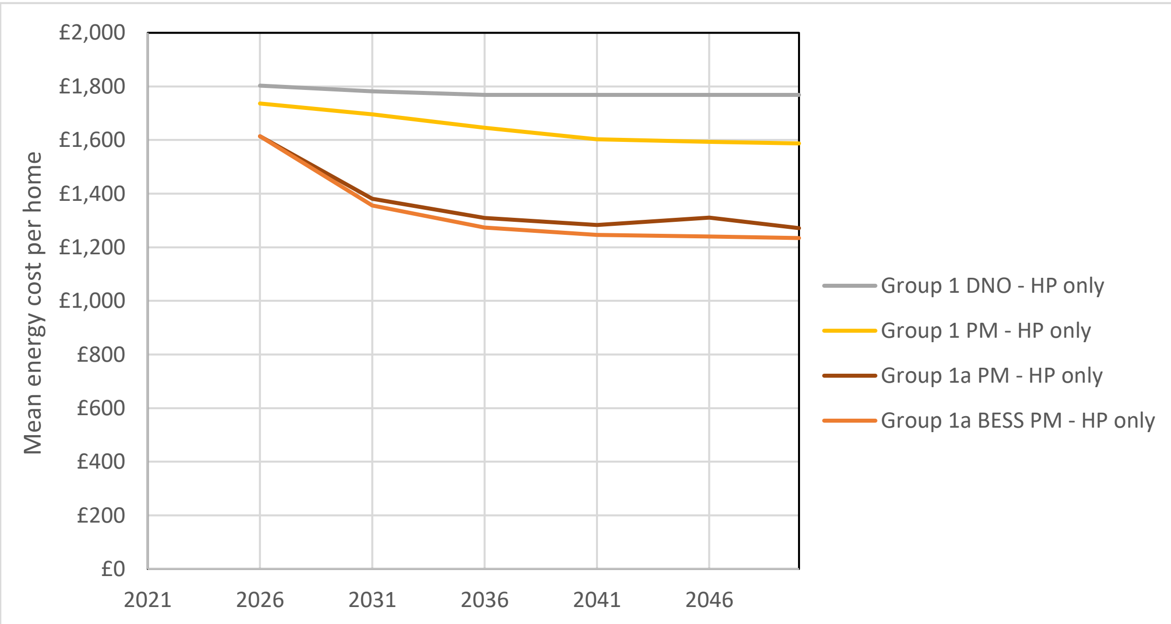

Figure 6: Cost of energy per home with a heat pump only intervention, for the mean home type in group 1 with standard DNO connection, pseudo microgrid, pseudo microgrid with stronger renewables (Group 1a) and pseudo microgrid with stronger renewables with a centralised battery (Group 1a BESS).

Where two interventions are made, a heat pump and rooftop PV, the cost of energy per home reduces further and the advantage gained from the pseudo microgrid also increases. Figure 7 shows the cost per home for the mean home type fitted with a heat pump and rooftop PV from 2026 onwards and these cost reductions are given in Table 12.

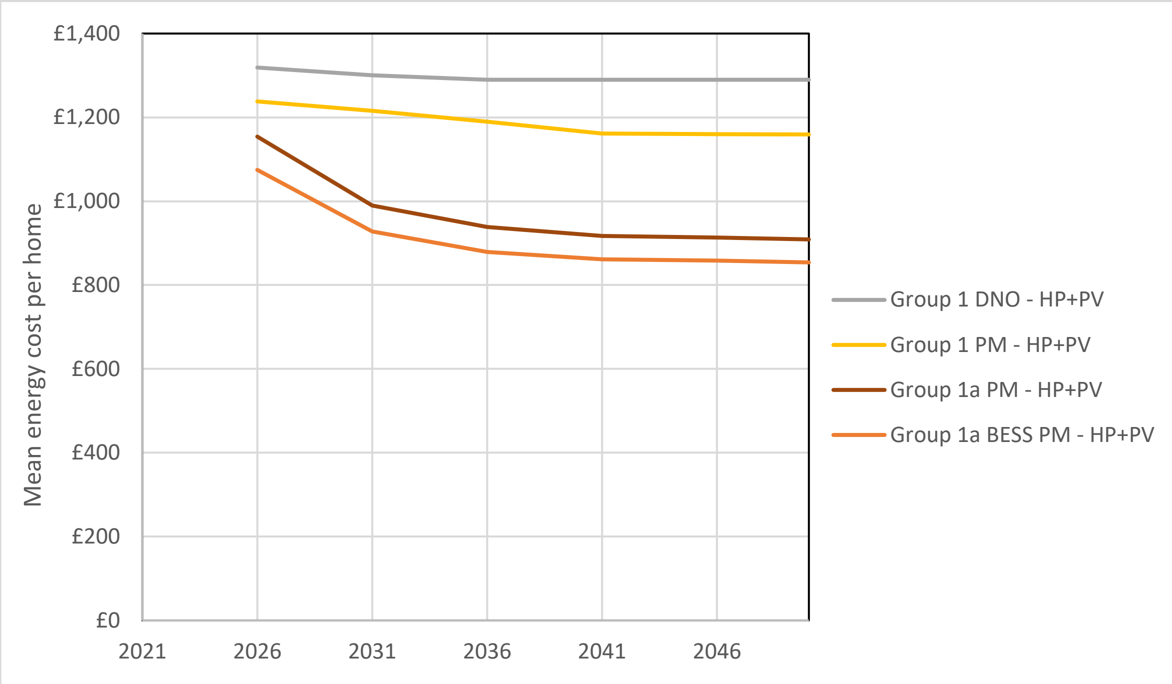

Figure 7: Cost of energy per home with a heat pump and rooftop PV, for the mean home type in group 1 with standard DNO connection, pseudo microgrid, pseudo microgrid with stronger renewables (Group 1a) and pseudo microgrid with stronger renewables with a centralised battery (Group 1a BESS).

Table 12: Cost of energy savings per mean home type that result from the implementation of a pseudo microgrid with heat pump and rooftop PV interventions.

Heat pump + PV intervention	**2026**	**2031**	**2036**	**2041**	**2046**	**2050**
Group 1	6.1%	6.6%	7.7%	10.0%	10.1%	10.1%
Group 1a	12.5%	23.9%	27.3%	28.9%	29.2%	29.5%
Group 1a BESS	18.5%	28.7%	31.8%	33.2%	33.5%	33.8%

Where no interventions are made (do nothing action), the implementation of a pseudo microgrid still achieves a cost saving for the home as shown in Figure 8. Again, this cost saving is much enhanced with the stronger renewables scenario. These savings are given in Table 13.

Table 13: Cost of energy savings per mean home type that result from the implementation of a pseudo microgrid without any other interventions.

No interventions	**2021**	**2026**	**2031**	**2036**	**2041**	**2046**
Group 1	3.5%	3.8%	4.9%	-	-	-
Group 1a	3.5%	10.7%	20.2%	-	-	-

Note: The do nothing action ceases in 2031, following the Societal Transformation scenario.

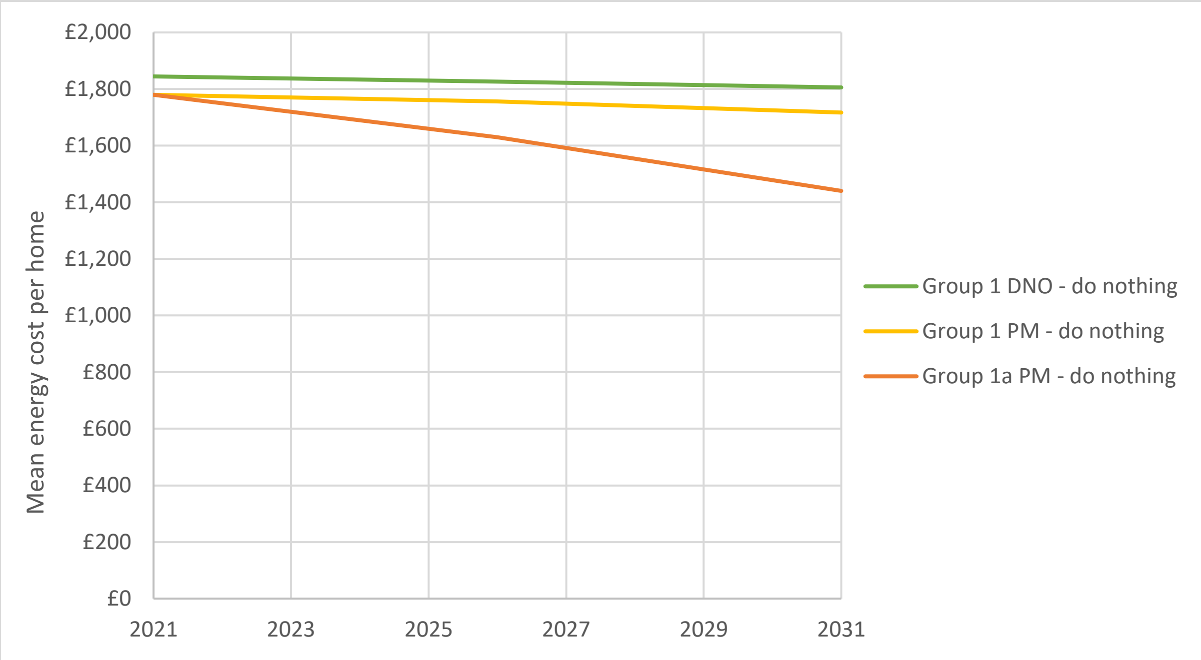

Figure 8: Cost of energy per home for the mean home type in group 1 without any intervention, with standard DNO connection, pseudo microgrid and pseudo microgrid with stronger renewables (Group 1a).

Figure 9 shows the mean cost of energy for the typologies in groups 1 – 6 from 2021 until 2031 for the 'do nothing' action. The gentle decrease in cost is attributable to the modest improvements made to building fabric efficiency during this period.

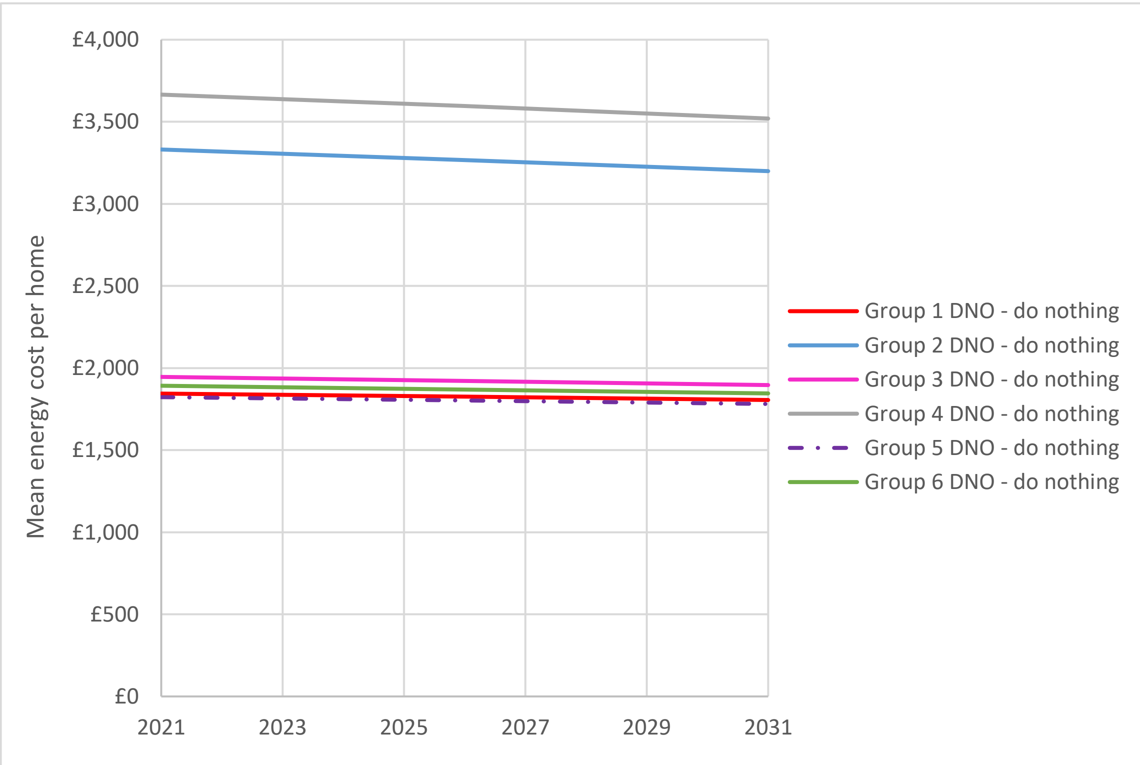

Figure 9: The mean cost of energy for home typologies in groups 1 – 6 from 2021 until 2031 for the 'do nothing' action.

7.0 Describe the Journeys

This section gives examples of the journey a home may take, using different sequences and options from the following actions:

a = Do nothing
b = PV only
d = PV with heat pump
g = heat pump only

7.1 Journey 1

Journey 1 shows the associated **mean** result for Group 1 houses. Group 1 represents 48.48% of the housing area and they are all currently on central gas for their heating and domestic hot water. These will mostly be in towns and villages where a gas network is accessible. The mean result across the housing typologies considers a range of properties in the area from large houses to small flats.

This group of houses is now going to fully electrify and move away from mains gas on their journey to decarbonisation and connect to the pseudo microgrid between now and 2031. A typical journey for a group 1 house is exemplified below.

a = Do nothing
b = PV only
d = PV with heat pump

Example: Journey 1.

This group 1 home uses gas for its heating and hot water. The mean cost of energy per year is £1,844 with a greenhouse gas emission of 2.23 tonnes of CO_2e per year

Step 1. Within five years from present day, the house has moved onto the PM for its electricity supply. It remains on gas for its hot water and space heating. Mean cost of energy per year is now reduced to £1,756 and the carbon footprint drops to 1.89 t/CO_2e per year. This is action (a), as it has taken no additional steps to install renewable energy, but locally generated electricity on the PM provides clean electricity at certain times of day at a lower cost than the national supply.

Step 2. Within five years of present day the house installs solar PV on the roof. It can use electricity generated for free, with any unused solar spilling onto the PM. It buys electricity back from the PM when needed. Mean cost of energy per year is now £1,454, and the carbon footprint drops to 1.76 t/CO_2e per year. This is action (b).

Step 3. It is now 2031. The house has installed a heat pump to supply its space heating and hot water using electricity from the PM; gas is no longer used. This means it now uses less electricity to heat the home and produce hot water, than gas, and the mean cost of energy per year to heat this home has reduced to £1,215, the carbon footprint is now significantly reduced to 0.24 t/CO_2e per year, compared to 2.23 tonnes at the start of the journey.

The results for 'on gas' homes show the mean cost of energy per year is reduced when compared to a standard DNO connection for electricity, even on the 'do nothing' action, which does not include a heat pump or solar installation on the property. This is action (a). The incremental actions over the next 30 years show a cost benefit, and importantly, a large reduction in carbon, if steps 1 - 4 are taken by a group 1 home. The reduction in energy cost, and reduction in carbon footprint, is shown in figures 10 and 11.

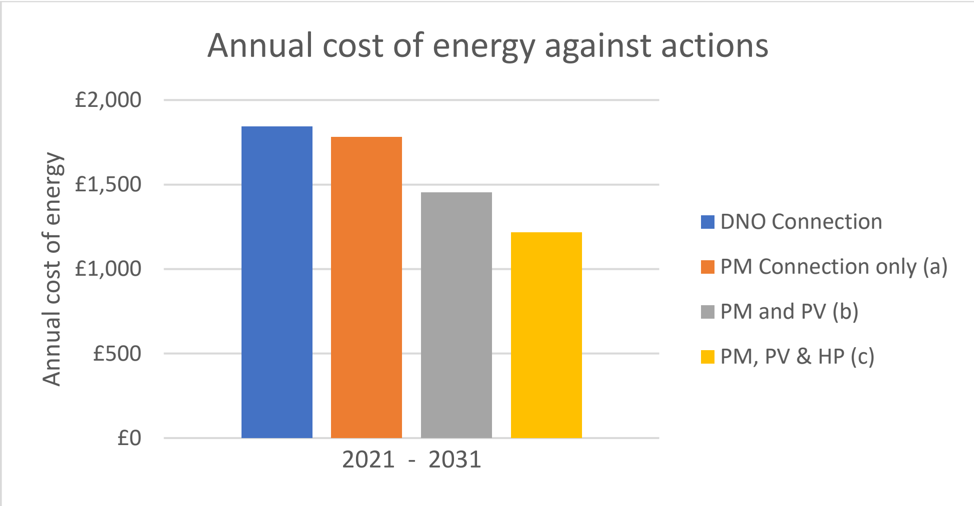

Figure 10: The annual cost of energy against actions based on journey 1

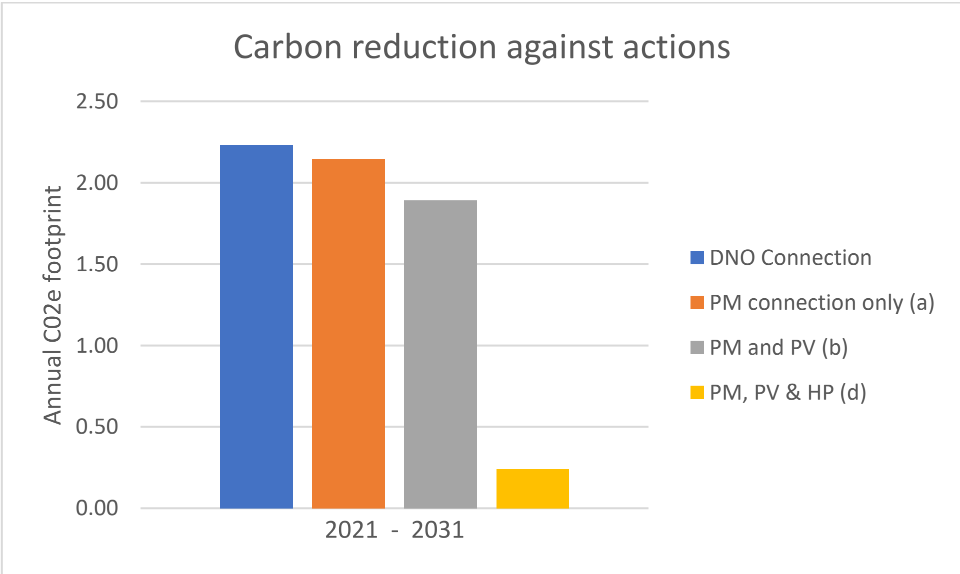

Figure 11: Carbon reduction against actions based on journey 1

If the boundaries of the mean results for group 1 homes are examined with regard to housing typologies, the annual energy costs will be greater for the larger homes, and lower for the smaller homes.

7.2 Journey 2

Journey 2 shows another group 1 house. This one performs similar interventions but in a different order.

g = heat pump only
d = PV with heat pump

Journey 2: This group 1 home uses gas for space heating and domestic hot water, starting from the same position as the house in Journey 1, with an average annual energy bill of £1,844 and a carbon footprint of 2.23 tonnes of CO_2e per year.

Step 1. This homeowner needs to replace their boiler, so makes the move to replace their gas boiler with a heat pump. There may be a government grant available for this which helps to finance the move. The energy bill for the house remains largely the same at £1,803, however the heat pump uses fewer kWh of electricity than it used kWh of gas, so the carbon footprint is dramatically reduced. The carbon footprint is now 0.69 tonnes of CO_2e, compared to 2.23 tonnes when using gas: a 69% reduction. This is action (g).

Step 2. By 2026 the house has solar PV installed on the roof to supplement electricity use. The household benefits from free electricity during the day, and excess electricity is exported back to the national grid. This is action (d). Energy bills are reduced by £500 a year to £1,319 and the carbon footprint is 0.49 tonnes of CO_2e annually.

Step 3. It is 2031. The pseudo microgrid has been up and running for a few years now and the homeowner wants to support the development of more locally owned renewables on the network. Joining the pseudo microgrid saves a further £100 a year and mean energy bills are now £1,215 per year. More importantly, the homeowners carbon footprint is further reduced by 50% to 0.24 tonnes per year. The solar PV generation the homeowner doesn't use now goes onto the microgrid to be used within the local community rather than exported to the grid.

Step 4. Due to the community uptake of the PM and the success of using locally generated electricity, new wind turbines are added to the local energy mix. This massively increases the benefit of the PM and energy costs fall to £990 per year. The carbon footprint of this home falls to 0.12 tonnes of CO_2e in 2031, and with the continued success of the PM and the simultaneous decarbonisation of the national grid, the carbon footprint is predicted to fall to 0.01 tonnes of CO2e annually by 2050.

7.3 Journey 3

Journey 3 shows a group 3 home using oil for space heating and domestic hot water.

d = PV with heat pump

Journey 3: a rural stone farmhouse in group 3 using oil for space heating and domestic hot water. The starting position of the house is an average annual energy bill of £1,946 and a carbon footprint of 2.79 tonnes of CO_2e per year.

Step 1. Within five years, the owner makes fabric improvements to the house, insulating the loft and replacing and repairing old windows and doors to reduce the heating demand. Some wall insulation is considered.

Step 2. With fabric efficiency improved, the use of oil and the bills reduce for this property. The house then switches from oil to a heat pump with solar PV. The domestic hot water and space heating is now using electricity from a normal DNO connection. Solar electricity supplements mains electricity use during the day, and contributes to running the heat pump. Due to the seasonal difference in generation, the PV contributes to hot water production in the summer but doesn't cover all the space heating demands in the winter. The annual energy bill is reduced to £1,319, and the carbon footprint is reduced to 0.49 tonnes of CO_2e annually. This is action (d).

Step 3. The household joins the pseudo microgrid in 2026 and annual bills are reduced to £1,233. The carbon footprint is now 0.42 tonnes of CO_2e annually. As more households join the local network, bills fall instead of rising each year, enabling more local generation to be added to the network, further reducing cost and carbon content.

Step 4. Each year the carbon content of electricity falls both on the PM and the national grid, and by 2050 the annual carbon footprint is 0.03 tonnes CO_2e annually.

7.4 Journey 4

Journey 4 shows a Group 2 house in the area, currently using electric storage heaters and immersion heater. It's a 2-3 bed house in a small village with medium fabric efficiency. The starting position of the house is an annual energy bill of £3,331 and a carbon footprint of 2.45 tonnes CO_2e annually. It is expensive to run electric heating without a heat pump, and prices reflect recent cost increases. The carbon footprint is high, because it uses a lot of grid electricity to supply space heating and hot water with an immersion. Grid electricity still has a relatively high carbon content because of its reliance on gas generators for electricity production. This house has decided to improve its efficiency and reduce running costs, whilst supporting the community incentive to buy locally generated renewable energy.

g = heat pump only
d = PV with heat pump

Journey 4: 2-3 bed house in a village with electric storage heaters and electric immersion for hot water. The starting position of the house is an annual energy bill of £3,331 and a carbon footprint of 2.45 tonnes CO_2e annually.

Step 1: The house moves onto the pseudo microgrid, this is an easy step and reduces bills to £3,214 over 5 years. The carbon footprint falls from 2.45 to 2.37 tonnes CO_2e. The house consumes a lot of electricity and still relies heavily on the grid supply.

Step 2: The house makes some improvements to fabric efficiency, insulating the loft and cavity wall to reduce the heat load requirement.

Step 3: The household realises quickly that a heat pump will reduce its electricity bill and takes advantage of a government grant to help fund the cost of it. This is action (g). The cost of annual energy now falls to £1,736 and the carbon footprint falls to 0.64 tonnes CO_2e. This action gives a 46% reduction in energy costs and a 73% reduction in carbon.

Step 4: The owners have now saved enough money to invest in solar PV and install a 3.5 kW system on the roof. This now becomes action (d) as they have a heat pump and solar PV. By 2030 their carbon footprint is down to 0.24 tonnes CO_2e and annual bills are in the region of £1,215. With continued support and further integration of renewable energy onto the local network bills continue to decrease as 2050 approaches, as does the carbon content of the electricity, reaching 0.03 tonnes by 2050.

7.5 Journey 5

Journey 5 shows a Group 4 house, this is modelled using instantaneous electric heating and immersion, it doesn't have the benefit of night storage, so the bills are higher than the group 2 homes in journey 4. The starting position for this house using grid supplied electricity is an energy cost of £3,666 per year and a carbon footprint of 2.45 tonnes CO_2e.

b = PV only
d = PV with heat pump

Journey 5: A semi-rural 4-bedroom house using instantaneous electric heating and immersion. The starting position for this house using grid supplied electricity is an energy cost of £3,666 per year and a carbon footprint of 2.45 tonnes CO_2e.

Step 1: The house installs solar PV as a first step, because the owners are at home every day and they feel it's the most cost-effective solution to help reduce their bills. This is action (b). The bills are now reduced to £2,967 annually and the carbon footprint is reduced to 1.96 tonnes CO_2e.

Step 2: The house installs a heat pump. Subsidised by the solar PV during the summer months and reducing the electricity load dramatically in the winter through the co-efficient of performance on the heat pump, bills are reduced to £1,319 and the carbon footprint is 0.49 tonnes.

Step 3: By 2031 the house is connected to the local PM and bills are £1,215 annually, set to continue falling up to 2050 as more renewables are added to the network. Any solar PV not used at their home is now exported to the local network and bought by their neighbours. The carbon footprint of the house is now 0.24 tonnes CO_2e in 2031. A reduction in carbon of 89% from the starting position and a cost reduction of 67%.

Step 4: The house continues to make fabric improvements in the run up to 2050, insulating the walls, replacing old windows, and using government initiatives and grants to help finance the property upgrades. As a result, bills continue to decrease as the house becomes more effective and cheaper to heat. By 2050 the carbon footprint is 0.03 tonnes CO_2e.

8.0 FAQs

Why do some of the journeys not meet zero carbon by 2050?

The strategy we have deployed **is designed to meet net zero by 2050**. The detail in the modelling means that some of the lines of best fit on the graphs do not quite meet 0.
See the note 5.4.2 Input Data and Assumptions – Carbon

Where do I start?

The journey starts in different places for different building types. The biggest cost saving and biggest carbon reduction saving is from installing a heat pump, particularly for those homes on direct electric heating or oil. Then supplementing that with solar PV. This can be an expensive capital outlay and the government publish their intentions to support this move here 3.1 BEIS Net Zero Strategy.
Have a look through the example journey's in Chapter 8.0 for more insight.

Should I improve my building fabric first?

Improving building fabric means better energy efficiency, therefore using less and paying less. The modelling has accounted for building fabric improvements, sharing the benefit across all the typologies. Doing it this way means the results recognise that some buildings will be better insulated than others, but overall, there will be a measured approach to electricity required from the PM.

How well does the pseudo microgrid really work?

The modelling shows the PM can reduce costs of electricity supply and reduce the carbon footprint of each property that joins the network. The PM works best when more renewables are put on the local network, primarily this means more wind energy generation and more roof top solar. The modelling also shows that on a large community scale, a commercial battery will help to offer zero carbon energy at all times of the day and reduce the cost of electricity to the members.

It sounds complicated…

It might be, but not to the community. The aim of the PM is to provide a network innovation to the Distribution Services Operator, in this case, Western Power Distribution. The PM uses infrastructure and assets belonging to the DSO. This requires some changes in current regulation which needs to be addressed.

Is more wind energy really necessary?

Yes!! Wind energy is vital to supply consistent year-round electricity. Solar is great, but it has two large drawbacks 1) it doesn't contribute enough in the winter months when electricity demands are highest 2) large ground mount solar takes a lot of space – it is much more effective to utilise ground space with wind turbines. This still allows the land to be used for farming, agriculture, and recreation. The evidence shows that seasonal energy production is paramount to achieving a successful and affordable renewable energy mix.

Should I get an electric vehicle?

Yes. EVs are the most viable zero emissions vehicle on the market. We expect hydrogen fuel cell vehicles to catch up in the next 10 years. The electricity demand of electric vehicles has been accounted for in the modelling and there can be enough generation on the local network to support the growth in demand for EVs. There will be a net benefit in cost of getting an EV, as drivers will not have to buy fuel, and the cost of electricity to run an EV is less than the price of petrol or diesel.

I can't afford / don't want an EV, what are my options?

The transport strategy to meet net zero relies heavily on several things. Firstly, better public transport. This is particularly important in our rural areas where the bus network is so poor, and the train network is limited. For diesel cars, there is another option on the market which presents a significant reduction in carbon emissions. HVO offers a direct fuel swap with no engine modifications. It is available on the market but not yet at regular fuelling stations. The cost is about the same as regular diesel. Other transportation options for the future are likely to include hydrogen fuel cell vehicles, more walking / cycling with adaptations to make this easier and safer, car sharing / pooling options.

Why is it my responsibility to address climate change and net zero?

Climate change is a global responsibility and requires effort from everyone. The government cannot be relied upon to make the changes required across the whole country. To mitigate the effects of climate change, it is important that each area makes an effort towards creating a future we can all survive in.

How are holiday homes treated?

Holiday homes, holiday lets, and any property which is not the sole residence of the same owner are treated as normal homes which will be expected to meet the same levels of decarbonisation as every other home. Within the geographical boundary each home needs to contribute to the strategy to meet net zero, regardless of whether they are occupied year round.

What about a hydrogen gas network?

Hydrogen is a fantastic resource when it is generated from renewables (green hydrogen). However, the government hydrogen strategy encompasses using natural gas to produce hydrogen (blue hydrogen) and it is not zero carbon. They would rely on GHG removal technologies to offset the emissions. This is not a sustainable or a viable approach and comes with a huge risk that net zero may not be met. In addition, replacing the gas network with hydrogen requires an entirely new infrastructure, as hydrogen pipe work is different to natural gas. Hydrogen escapes through the smallest of spaces, making a leak or a poor connection in a mains network extremely volatile. Additionally, hydrogen causes embrittlement of steel which leads to mechanical failure. These two factors mean that the majority of existing pipeline would require replacement or significant upgrading before the network is fit to operate with 100% hydrogen.

What happens if we don't meet net zero?

This is covered in the falling short scenario here. Falling short is the trajectory we are currently on, with some people taking action but the majority are not. Actions are sporadic and not aligned to a strategy, there is poor leadership from the government. If net zero is not met, devastating consequences will be faced globally. The effects are already being observed and it is widely believed those effects will increase in intensity and frequency. Loss of biodiversity, severe weather patterns, extreme temperatures, leading to the loss of fresh water and food production, and subsequently changing the Earth into an inhospitable place to live.

Why aren't district heat networks included?

The project acknowledges that District heat networks can be a valuable tool in delivering heat pump technology within geographical areas. The benefit of heat pumps as referred to in the results, may include DHNs where it is viable to use them. The barrier to DHNs is usually in cost and infrastructure when retrofitting is concerned. It is therefore considered to be a business case question, rather than a technology and solution-based question. If a site is suitable for a DHN using heat pumps and it provides a cost advantage to the supply of heat, then they should be deployed. The carbon benefit is considered to be the same, whether the heat pump is individually installed, or linked to a wider network.

UK strategy for heat networks is largely centred around urban areas, though they may also be utilised in new build developments, and rural towns and businesses.

DHNs are not omitted from the solutions development in this project, rather they are regarded as heat pumps more generally, and only where they may be practical. Conducting the technical design and specification of heat pump viability is outside of the remit of the NZCom project.

Is biomass a good alternative to electrification of heating?

No. Biomass is a carbon-based fuel and would rely on GHG removal technologies to balance the emissions from burning. Trees are best used as a carbon sink and should remain planted. The older a forest grows, the more carbon it may capture. Fallen wood will slowly release methane back into the atmosphere but burning it accelerates GHG emissions by releasing carbon at a much faster rate. Fallen wood should be left to create habitats and enhance biodiversity.

How is the private rental market affected?

Cornwall has a larger private rented sector compared to social housing provision, which is different to the ratio elsewhere in England. About 70% of Cornwall's private landlords lease only 1 or 2 properties [19], who are class as non-commercial or 'accidental' landlords. They have become landlords because they have inherited a home or where a couple have decided to live together after living separately, and so the consequence is that they are not renting their property as a business activity or as their sole source of income. Private landlords' income may be similar to their tenants and therefore they don't have access to their own funding to make energy efficiency upgrades. Cornwall has a large number of properties that are privately rented that fail to meet the current Minimum Energy Efficiency standard of EPC E – estimated to be between 8-10,000 properties that are non-compliant [19].

The challenge of about half of Cornish properties being off the mains gas network means for those rental properties off-gas and low EPC rating the tenants are paying a high fuel poverty premium – high energy costs and poor thermal quality driving heating costs higher. In the context of decarbonising heating and transitioning to low carbon options, social housing providers have a variety of drivers to improve their properties and the Social Housing Decarbonisation Fund allows them to access capital to deliver retrofit at scale. There are not similar opportunities to incentivise private landlords, and at the moment there are regulatory barriers preventing landlords to act. For instance, to access any Government subsidies, e.g. the Energy Company Obligation which is directed at helping fuel poor households, landlords have to have achieved Energy Performance Certificate (EPC) E or registered a valid exemption to the Minimum Energy Efficiency Standard (MEES) [20] regulations before the tenant can qualify for ECO [6] or ECO Flex support. In some cases, a landlord may meet ECO eligibility, but their tenant has income above the threshold, preventing ECO measures proceeding, and due to the limited income the landlord has they cannot afford to invest in the fabric improvements needed to improve the tenant's situation.

9.0 Discussion and Conclusions

The major outcomes of the modelling are as follows:

1. **The Societal Transformation scenario that is tested here allows a small proportion of homes to reject the electrification of heat. In the absence of a zero carbon gas solution or a carbon capture and storage solution, this results in a failure to achieve zero emissions.**

The Societal Transformation scenario relies on consumers moving to electric heating, having high energy efficiency, and using demand side flexibility (time of use tariffs). There should be appropriate engagement that supports and enables behaviour change.
There is a gap in this scenario whereby some boilers and appliances are adapted to accommodate blended gas and hydrogen, therefore not adopting the all-electric framework. This presents a problem, as it cannot be assumed that net zero is met in this scenario. It is not made clear at this point in any published government strategy that a zero-carbon hydrogen gas network will become a reality. The Government will not release their final statement on hydrogen until 2026. Even if it is positive, the hydrogen strategy as it stands relies heavily on blue hydrogen rather than green (using natural gas over renewables) and therefore leaves a carbon deficit to be tackled later by GHG removal technologies – which at the time of writing do not exist at a mature technology readiness level.
This leaves a position of uncertainty in the Societal Transformation scenario, which does not then meet net zero by 2050. It highlights a gap between local and national scale models of achieving net zero, and the relationships - and risks - between net zero pathways at local level which are depending on a degree of national government leadership and systemic change. All electric scenarios map a more assured pathway.

2. **The implementation of a pseudo microgrid provides a clear advantage to the community in terms of lowering the cost of energy. It also achieves a faster decarbonisation of the area that it serves.**

The PM facilitates community use of the locally generated renewable energy. In so doing it allows the community to draw on this energy without paying the additional national system costs and support levies that are attached to conventionally supplied electricity. In this way the PM acts in a similar way to the Energy Local business model and the Octopus Fanclub business model but with more consideration of the implications on the network and the restrictions that accompany it.

Energy savings can be seen across all home types connected to the PM. Those that are not connected to the PM will still need to electrify but will pay more for their energy. The biggest benefit is seen with properties which take action to install solar PV and a heat pump. However, even homes that connect to the PM and do not install PV or heat pumps, see the benefit of decreasing energy costs compared to standard DNO connection.

This is particularly advantageous and likely to become more so with the current energy crisis. The increase in the price of gas affects the price of mains electricity, making locally generated renewable energy more appealing with a better business case. Communities will grow stronger by taking back some independence in energy generation and gain a better understanding of energy fundamentals by doing so.

Lower energy bills are exemplified in figure 7 (p31) for group 1 homes which install a heat pump and solar PV.

Figure 5 on (p30) shows a faster decarbonisation route for the community with a pseudo microgrid when compared to a standard DNO connection. This is because more of the locally generated renewable energy is kept for the community use rather than being exported onto the national system. Clearly, any renewable energy that is exported from the project area still acts to decarbonise the UK as a whole but doesn't contribute to the decarbonisation of the project area.

3. **The advantage gained from a pseudo microgrid is strongly linked to the capacity and type of renewable energy that is connected to the microgrid. More local generation results in more advantage to the community. Increasing the capacity of wind energy generation is much more effective than simply increasing PV solar energy.**

In the first instance, the scenario limited wind energy growth from 2 MW to 4 MW over the next 30 years but included a growth of ground mounted PV from 6 MW to 25 MW over the same period. In the Stronger Renewables Scenario the wind energy generation increases to 25 MW by 2050 but the capacity of ground mounted PV is capped at the 2036 level of 10.5 MW. Adding more wind energy onto the network reduces costs of energy from the PM further by providing more seasonally available electricity. At night, and during the winter months when electricity demand is highest, wind offers a distinct advantage over solar.

A major constraint factor here, is the 2015 government ban on onshore wind development which may only be avoided by allocating a permitted wind development area into the Local Plan. Although time consuming, it is effective, and currently the only way for a community to progress with the development of wind turbines within UK planning policy.

As an added benefit, the design of the renewable energy integration to the PM creates local work and employment, upskilling and enhancing the renewable energy sector. The social benefits of which should not be ignored.

4. **With sufficient renewable energy generation on a pseudo microgrid, a significant energy cost saving is achieved in the 'do nothing' action group. This action might represent the fuel poor within the community over the next 10 years or more.**

The benefit of the 'do nothing' action is shown in figure 8 on P32 showing the cost of energy per home falls without any further intervention. The 'do nothing' approach requires no additional solar PV or heat pump technology at the property, it requires only a switch to the PM from the standard DNO connection. In every case, the benefit is enhanced by the stronger renewables scenario, where more renewables on the local network directly results in more cost saving to the user.

This is a hugely important as a project outcome when it is related to not leaving anyone behind in the energy transition.

The ability to decarbonise on an individual basis is largely driven by cost and financial position. Many homeowners cannot afford to invest in heat pumps, fabric improvements and solar without additional financial support being available. These groups are left vulnerable to energy price rises as a result of not being able to make home improvements and invest in their property. This group may well relate to new homeowners, young people, families, older people and those with disabilities.

The same may be said for the private rented sector; those who rely on a landlord to consider and implement property upgrades. In fact, the group who can afford individual property upgrades (under current market conditions) is likely to be smaller than those that cannot, limited to those on secure medium to high incomes.

Another limiting factor to property and energy retrofit is knowing where to start and what to do first. Driving forward a solution such as the PM which creates an easy, cost-free change to lower carbon emissions and lower energy bills is of great benefit to creating a fair and equal society. Reducing fuel poverty and achieving decarbonisation goals has the ability to meet critical social and environmental goals at a community level.

The results show a saving could be made simply from utilising the PM, without making any further changes to the property individually (figure 8 p32). Currently, 'do nothing' action is modelled up until 2031. This has flexibility in the timeline, however, at some point prior to 2050 these homes will need to be included in the transition actions in order to achieve net zero.

In the BEIS Net Zero Strategy, reference is made by the Government to financially assist homes in the decarbonisation journey, with particular reference to heat pumps.

Assisting the less affluent groups in the community (and those who are unable or unwilling to make changes in fabric or fuel type) with a reduction in energy bills from the PM only, is a positive outcome from NZCom.

5. The addition of a centralised battery energy storage system to a pseudo microgrid, further reduces the cost of energy for residents and further accelerates the area's decarbonisation.

A centralised battery energy storage system may be operated as an asset by the future DSO, providing services to the PM and relieving stress on the network. The DSOs face challenges in upgrading local infrastructure to accommodate an all-electric future not only in the cost of upgrades, but in managing electrical traffic on the network. Constraint points are a hindrance and a blockage to putting more renewable energy onto the network, and the PM assists with this by balancing local generation with local demand; a battery energy storage system can be used to enhance this local balance.

A battery will hold electricity locally and allow it to be used at different times. This frees up the national network, reducing constraints and providing flexibility.

6. Subsequent business modelling will determine the actual price of viability for community owned renewables to enter the PM market.

It's a preference for communities to be offered the opportunity to invest in any new wind and solar assets connected to the PM. The price of this locally generated energy to the PM users will be defined in the business modelling that is yet to be undertaken by the NZCom project team. The prices shown in Table 6 are an assumption in advance of this business modelling and it is possible that these prices might be reduced which will further increase the benefit afforded to the community by the PM.

References

1. National Grid ESO, Future Energy Scenarios, Stakeholder Feedback Document (2022)
2. Department of Business, Energy & Industrial Strategy (BEIS) Net Zero strategy (2021)
3. Ofgem, Consumer Vulnerability Strategy (2019)
4. Mott Macdonald, A Place Based Approach to Net Zero
5. Citizens Advice, Navigating Net Zero, A Framework to Give People the Confidence to Invest in New Technologies (2021)
6. Energy Company Obligation – ECO. Ofgem (2022) Energy Company Obligation (ECO) | Ofgem
7. Future Energy Scenarios (FES), 2021. Steady Progression, route to 2050, p.75.
8. Citizens Advice, Taking the Temperature (2020)
9. National Grid ESO, Future Energy Scenario's, steady progression, route to 2050, p75 (2021) The Energy efficiency target is an EU target, which is included in their modelling: 'Despite leaving the European Union (EU), we expect the EU target of increasing energy efficiency by 32% by 2030 will continue to drive UK policy, and our models are based on this.' see FES p.71 National Grid, Future Energy Scenarios, (2021)
10. "For this scenario we emphasise the concept of 'transition' rather than 'transformation' since the latter often implies more profound, far-reaching and irreversible change than is represented by this scenario"
11. This is based on the assumption that all homes embrace electrification of heat, and/or green hydrogen is used instead of gas for homes connected to gas/hydrogen network.
12. Carbon Trust (2022) For Cities and Regions from: https://www.carbontrust.com/what-we-do/net-zero
13. Department for Business, Energy & Industrial Strategy. UK Government GHG Conversion Factors for Company Reporting. 2021.
14. Impact - Community carbon calculator n.d. (accessed January 28, 2022). Impact | Community carbon calculator (impact-tool.org.uk)
15. Bizee Degree Days (2022) from: https://www.degreedays.net/
16. Energy Saving Trust (2008), Measurement of Domestic Hot Water Consumption in Dwellings (p9)
17. Elexon Profile Class 1 https://www.elexon.co.uk/operations-settlement/profiling/
18. Ofgem, Average Price Cap (2022) Default tariff cap level "other payment method" for average cost via direct debit payment to energy supply in the south west region
19. Community Energy Plus (2022)
20. Department for Business, Energy and Industrial Strategy, Domestic private rented property: minimum energy efficiency standard (MEES) – landlord guidance (2020)
21. Nicol, S., Roys, M., Garrett, H., 2015. The cost of poor housing to the NHS. Building research Establishment Briefing Paper. Available from: https://www.bre.co.uk/filelibrary/pdf/87741-Cost-of-Poor-Housing-Briefing-Paper-v3.pdf
22. Cornwall Council, 2021/22. Cornwall Local Transport Plan to 2030, Available from: https://www.cornwall.gov.uk/media/ugjl1wmz/cornwall-transport-plan-to-2030-12_04_22.pdf (accessed 15th May 2022)
23. Ranganathan J, et al. The Greenhouse Gas Protocol - A Corporate Accounting and Reporting Standard. World Resources Institute; 2015
24. Fong WK, et al. Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. World Resources Institute; 2014.
25. Centre for Sustainable Energy, University of Exeter. Impact Tool Method Paper. 2021.
26. Place-based carbon calculator. Place-Based Carbon Calculator n.d. https://www.carbon.place (accessed January 28, 2022).
27. Liddell, C., Guiney, C., 2015. Living in a cold and damp home: frameworks for understanding impacts on mental well-being. Public Health 129, 191–199. https://doi.org/10.1016/j.puhe.2014.11.007