Net Zero Community:

D5. A method for developing local net zero scenarios without leaving people behind

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This report contains the views of the University of Exeter as a project partner on NZCom and does not in any way represent the views of WPD.

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Contents

1 Executive summary

"We don't reach net zero simply by wishing it. There must be a process and a sequence by which we reach the goal." (UK Climate Change Committee, 2020 [13])

Action is long overdue to address the interconnected crises of climate change, ecological collapse, systemic oppressions and widening inequalities. National ambitions to meet the magnitude of the net zero target needs to be underpinned by robust analysis of plausible pathways available to society, and backed up by concrete plans for transformative change, across multiple sectors and multiple scales. Without considering the vulnerabilities of individuals and households, there is a risk that progress towards net zero exacerbates existing inequalities or creates new forms of injustice.

In this document we share a methodology for developing local scenarios for moving to a net zero energy system without leaving people behind. This process took place as part of the Net Zero Community (NZCom) project, part of Project VENICE, an Ofgem Network Innovation Allowance (NIA) trio of projects administered by Western Power Distribution (WPD) and led by Wadebridge Renewable Energy Network (WREN).

The report does not focus on the final scenarios as such, but on the processes through which our scenarios were developed. We discuss the meaning and value of scenarios and highlight the importance of being clear about *how* and *why* scenarios might be helpful in the local context. We propose the development of a local scenario framework nested within a regional framework, but tailored to local issues. We highlight how a set of technology adoption curves can be developed for a locality, and we discuss the many interactions between technological options, vulnerabilities and societal engagement. We also highlight some of the key limitations of the methodology and indicate where improvements could be made in future exercises.

This methodology has been developed within a specific geographical area, but it has been designed to be replicated within other communities. It could be replicated in whole, but there is also lots of potential for communities use the document to consider the potential interactions between energy and vulnerability (outlined in Section 6), reflect on local engagement (using Section 7), and adapt parts of the process to suit local goals (e.g. using the ideas in Section 8).

While every area will present context-specific issues, many of the issues being addressed in and around Wadebridge and Padstow are not unique to that community; similar challenges and opportunities relating to energy system decarbonisation while addressing vulnerabilities will be found elsewhere.

2 Introduction

2.1 Context

There has long been interest among local energy actors in understanding and steering local energy systems to become more environmentally sustainable. As the urgency of decarbonisation becomes clear, these discussions are expanding both within communities already engaged in energy issues, and into communities concerned about the rising cost of energy bills. These discussions are also increasingly incorporating issues of equity and inclusion as necessary components of sustainable energy transformations.

This work sits alongside a growing number of initiatives, reports and guides on the issue of local energy system transformation. Some initiatives are bottom-up, led by citizen initiatives such as Transition groups (e.g. Energy Descent Action Plans from Transition Town Totnes, 2010 [1]), whilst others are led by government and private actors (e.g. smart local energy systems within the PFER programme [2]). All highlight the importance of public engagement and developing a positive social mandate for net zero

Community Led Energy Plans (CLEPs): Two neighbourhoods in Oldham (Westwood and Sholver) [3] produced CLEPs. The CLEPs aimed to address the challenges of achieving carbon neutrality whilst achieving equitable economic and social benefits for the neighbourhood, and encourage a social mandate for the plans.

Local Area Energy Plans (LAEPs) which provide a guidance for producing energy plans in defined areas. These plans are primarily aimed at local government organisations [4]. The guide produced by the Centre for Sustainable Energy [5] documents the process to 'inform, shape and enable key aspects of the transition to a net zero carbon energy system'.

Planning locally to address the climate emergency (PLACE). Capacity building project to enable local citizens to use the planning system to ensure carbon reduction is written into local policies and plans [6].

Place based approach to net zero from Mott Macdonald [7] which highlights the value of cities as places for delivering transitions, through developing the capacities of the 4'P's: people, partnerships, powers and platforms.

These approaches are reinforced by the Climate Change Committee's 2022 report to Parliament, [8] which highlights the importance of a focus on energy demand to balance the government and industry's primary focus on the supply side, as well as paying explicit attention to public engagement as a key enabler of net zero.

This report has been put together in the context of this increased focus on localities. It highlights the importance of integrating a) technical and societal solutions in decarbonisation pathways, and b) local experience and knowledge of energy systems.

2.2 The Net Zero Community (NZCom) project

NZCom is one of three Project VENICE work packages funded under the Network Innovation Allowance (NIA) programme administered by Western Power Distribution (WPD) [9]. Its focus is to better understand how the needs of WPD's vulnerable customers (domestic and non-domestic) might change in the future, develop novel ways to support a whole community through the transition to net zero, and understand the role community energy groups can play.

Work Package 2 of NZCom is specifically concerned with the development of future scenarios for the Wadebridge and Padstow Community Network Area (WPCNA). By articulating quantitative and qualitative narratives of potential energy futures, the scenarios articulated the socio-technical context – in terms of technological trajectories and associated narratives - to a set of potential technological interventions. The design of business models to support these interventions without excluding people from the transition will also be critical, and as such, this document should be read in conjunction with outputs from Work Package 5, led by Community Energy Plus (CEP).

2.3 Purpose of this document

This document presents a methodology for the development of local scenarios for moving to a net zero energy system without leaving people behind. It aims to help a range of organisations who plan for, advocate and work towards, an inclusive transformation to net zero. These include those interested in and working towards a net zero energy system at a local (e.g. village, town or city) scale in Great Britain. This could include community energy groups, sustainability, advocacy and campaigning groups, local councils and councillors, localised projects such as Town and Parish Plans, Neighbourhood Development Plans[1] and Local Area Energy Planning initiatives, and others working on aspects of the climate and ecological emergency.

In outlining the work undertaken to develop scenarios for the NZCom project, this methodology – in whole or in part – can be used to support the development and use of local net zero scenarios in

[1] For example, Chacewater has included support for wind in their parish plan, see https://chacewater.net/your-parish/village-car-park-project/ for further information.

other communities. It summarises our general approach to developing scenarios, outlines the key assumptions underpinning scenarios, and identifies relevant sources of data. We also draw attention to some of the key limitations inherent in the development of net zero scenarios. As such, the aim is to open up the process undertaken within the NZCom project for others to adopt and adapt, in whole or in part, for their own purposes.

The document is structured as follows. Section 3 proceeds with a summary of scenarios as decision-support tools. Section 4 highlights the importance of having clear criteria in mind when developing scenarios. Section 5 outlines the overall approach for scenarios NZCom, and describes how the NZCom scenario framework was developed. Section 6 outlines how technology adoption curves for the local area were derived. Sections 7 and 8 describe how vulnerability and engagement aspects were integrated into scenario narratives. Section 9 summarises potential limitations of our approach and suggests and Section 10 concludes the report with some options for applying the methods described here, in part or in whole, in communities elsewhere.

3 Scenarios

3.1 What are scenarios?

Scenarios are tools for exploring possible futures. The purpose of scenarios is to develop a set of plausible perspectives and to 'bound' a wide range of future possibilities that are sufficiently broad to aid deliberation and guide decision-making in the context of complex and uncertain societal changes [10].

Scenarios can usefully be contrasted with forecasts. While forecasts tend to provide narrow, simplistic, and often optimistic perspectives on how systems might change, the role of scenarios is often to highlight a range of contrasting futures, and therefore can help expand and challenge existing worldviews.

While scenario methods are relatively well-established among industry and policy communities, they are less commonly used by civil society actors. This might be explained in part by the resources (in terms of data, analytical capacity etc.) required to generate and interpret robust scenarios for a given application, and the often-limited capacity of community organisations to spend time on analysis.

However, just as scenarios can help guide industry actors in their decision-making, they can also be designed to shape discussions and decision-making within communities. This report seeks to contribute to the emerging discussions in this field [11,12].

3.2 Limitations of existing scenario exercises

A range of scenario exercises exist which explore approaches to net zero, focusing on different aspects of systems across multiple scales. A set of these were explored in a previous review (M2.1), summarised here in Appendix 1. In general, these exercises tend to emphasise supply-side shifts and technologies (e.g. exploring the role of heat pumps and electric vehicles) and de-emphasise the role of the demand side and social/behavioural aspects, such as energy efficiency, retrofitting homes and changes in behaviours and lifestyles, mirroring supply-side emphases within energy policy more broadly. However, an overemphasis on technologies risks ignoring the scale and depth of behaviour change and societal engagement to achieve net zero, and the systemic nature of the challenge more generally [14].

Existing scenario exercises have also tended to neglect the distributive impact of pathways to net zero, which again might be explained by the overemphasis on the supply-side. Some recent local level scenario exercises (e.g. Pathways to a Zero Carbon Oxfordshire – PAZCO [15]) do recognise the importance of addressing vulnerabilities and justice, and the need for differing forms of engagement and support depending on need. Although how this might be achieved is not addressed in detail in the PAZCO report, ongoing projects (e.g. Project LEO and Smart and Fair neighbourhoods) are exploring how this works in practice [16].

Scenarios are valuable tools to aid decision-making, but they are not value free. Top-down, national and international scale scenarios have been criticised for being overly techno-centric and focusing on technical and physical infrastructure [14] and insufficiently addressing: a) the social infrastructure – such as engagement - required to support the transformations needed; b) how such transformations affect different sectors of the population; c) the interactions between local and national scale changes required.

4 Criteria for scenarios

To ensure that scenarios are fit for purpose, it is important to be clear about why the method is right for the challenge at hand. This section outlines the criteria guiding scenario development in NZCom

4.1 General criteria for scenarios

In general, to be of value to decision makers, scenarios are generally expected to [17, 10]:

Plausible	Depict credible futures built on logical assumptions of how change unfolds. Scenarios should therefore depict energy futures for communities that can reasonably be expected to emerge.

Consistent Internally coherent, with mutually compatible assumptions. For example, technological trajectories need to be consistent with the policy and regulatory environments that enable/constrain them.

Relevant Detailed enough to be of value for the intended audience(s). This implies creating scenarios that are a) appropriately bounded in terms of sector, technologies and geography, b) sufficiently simple (i.e. not too numerous) to allow decision-makers to make sense of them, and c) actionable, for example in highlighting specific leverage points for decision-makers.

4.2 Scenarios for NZCom

The NZCom project aims to address these gaps in existing scenario exercises through applying the rigour of national level scenarios to a local scale, detailing how this impacts residents with vulnerable characteristics, and suggesting differentiated engagement pathways and opportunities that address vulnerabilities to provide the best chance that no one will be left behind. Our scenarios were therefore also developed with the following criteria in mind:

Goal-oriented Focused on the two objectives of NZCom of reaching net zero within the boundary of Wadebridge and Padstow area, while addressing the needs of vulnerable residents[2].

Local Reflecting the specifics of the local context in terms of resources, infrastructure, demographics etc. to be able to inform local practices and strategies.

Replicable Approaches and assumptions for the scenarios designed to allow other communities to develop scenarios of their own. This means developing methods that are not dependent on specialist knowledge or analytical expertise and using publicly available data.

Consistent Scenarios for WPCNA should be consistent with pathways developed at larger, i.e. national or regional, scales.

[2] Note: There are many terms for energy end-users, such as customers, consumers, citizens, and residents, all of which carry assumptions about the degree of agency. This report is primarily concerned with domestic residents in the WPCNA, so we have used the term 'residents'. This term recognises that agency is not limited to energy consumption, but includes agency to engage with energy systems at individual and collective levels.

In this way, local scenarios – such as those developed for NZCom, can help to address gaps in national level scenarios. Conversely, by exploring local pathways, the assumptions inherent in national and regional pathways, and the challenges related to downscaling these scenarios and associated assumptions, is made clear.

The NZCom scenarios aim to stimulate discussion, guide decision-making, and provide foundation for more consultation around:

- **The direction and speed of the local shift to net zero:** how quickly the transition to net zero can take place depends on the ambition and resources of the local community at large and key organisations within it, and how the different sectors of the WPCNA are involved. Engagement, preparation, and involvement of the local community can take time, but when done well can lead to deeper engagement and a positive social mandate for net zero. Through identifying and addressing areas of tension or conflict, forms of participatory engagement can include the needs and experiences of the community and involve them in designing net zero pathways that are acceptable and deemed fair.
- **What the transition means for the most vulnerable**: articulating the different ways that the transition to net zero impacts those with vulnerable characteristics, and what forms of design, engagement and support are required to ensure that the transition to net zero is fair, just and where possible, avoids or minimises possible negative impacts from net zero.
- **Critical decision points / least regret options, and how these align/interact with national government policy**: we highlight key local decision points that can enhance or detract from net zero ambitions. Some of these will be dependent on national government policy, some can be independent, and some could exert influence on local and national government, and other community energy groups.

The boundaries for NZCom are:

- Geographical: the energy (electricity) supply area of WPCNA.
- Energy system: focusing on domestic energy, in particular electricity demand and supply in the local area.

5 The NZCom approach to scenario development

The process through which the NZCom scenarios were developed is illustrated in Figure 1. This section focuses on each of the processes relating directly to scenarios. Other aspects of NZCom, e.g. the development of local interventions, carbon budgeting, and the identification of local business models, are covered in the wider NZCom project. **The final scenario narratives can be found in Appendix 2.**

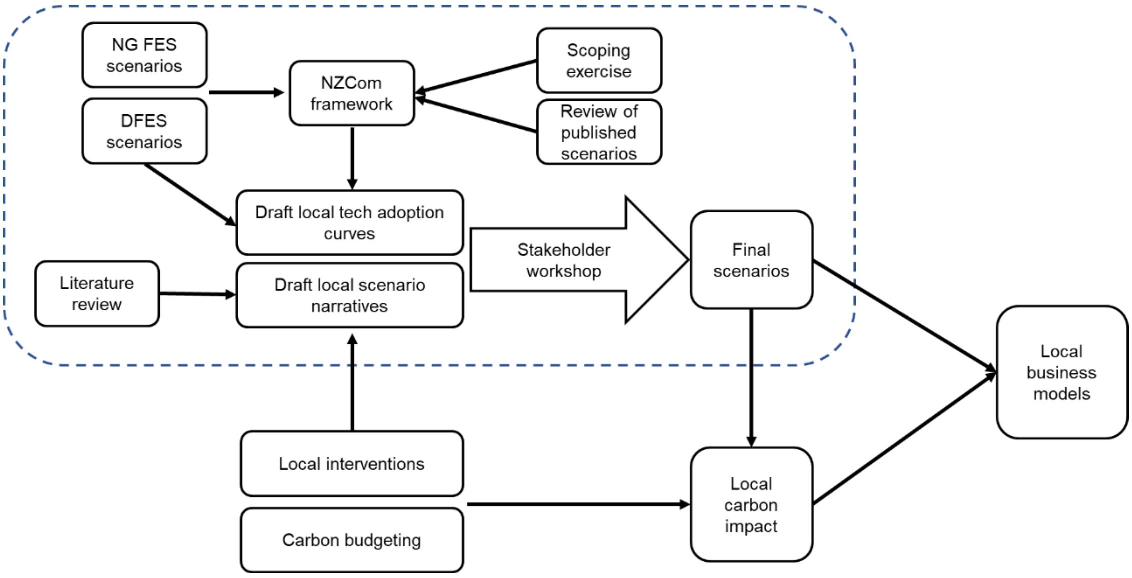


Figure 1. Scenario development within the wider NZCom project

5.1 Scoping exercise

An initial exercise was carried out with NZCom project partners to establish the scoping and framing of scenarios. This step was important in developing consensus within the project about what kinds of discussions the NZCom scenarios should aim to support, what aspects of the local energy system the scenarios should focus on (and what they can ignore), and for which audience(s). This process helped to ensure that eventual scenarios would be fit for purpose. Key points of agreement emerging from this process included:

A focal point of net zero by 2050. By the project's inception, the concept of net zero had been enshrined in UK Government legislation in 2019 [18], and had started to guide scenario analyses elsewhere, such as those by the Climate Change Committee and National Grid. **Including a scenario in which net zero by 2050 is not met** was agreed to be valuable to highlight failure as a plausible future.

The need to define vulnerability. Whether or not we are successful in supporting vulnerable residents will depend on how vulnerabilities are defined, and which metrics are used to measure progress. The scale of vulnerability is likely to change over time in response to technological trajectories, energy prices, and increasing squeezes on public health and social care. The meaning of vulnerability can also be expected to change over time, for example in response to ongoing digitalisation[3]. A decision was taken to **adopt a broad definition of vulnerability** to ensure that scenarios reflect the breadth of circumstances under which a household is (or could become) vulnerable.

The need for clarity around offsetting. The challenges and opportunities experienced in different areas across the UK will result in different technological and societal pathways to meeting net zero. As such, net zero may imply variations in local/regional contributions towards net zero, with some degree of 'offsetting' between geographies. For example, the National Grid's Future Energy Scenarios (NGFES) are based on assumptions around the role of so-called negative emissions technologies (NETS) – primarily Bioenergy with Carbon Capture and Storage (BECCS). However, NZCom takes a more conservative view of the potential role of such options either at a system level or at a local level. **Our focus is on decarbonising the local electricity system without relying on negative emissions, although we accept that some negative emissions options may be required to help decarbonise the energy system as a whole**.

The scoping process also highlighted a list of key uncertainties likely to affect meeting net zero ambitions in WPCNA while supporting vulnerable residents. This included:

Regulatory environment. The regulatory environment is a key factor in determining the nature and extent of inequality in energy system outcomes. Addressing vulnerability is part of the licence conditions which Ofgem gives to DNOs, which includes guidance from Ofgem regarding how vulnerability is defined. Energy market design affects the viability of technologies, business models and energy tariffs, all of which have the potential to interact with vulnerabilities. It was decided that **scenarios should aim to capture a range of regulatory futures**, enabling or constraining pathways towards achieving both net zero and improved outcomes for residents with vulnerable characteristics.

Societal engagement. Meeting net zero is a systemic challenge. It will require traditional forms of energy policy but will also have implications across housing and communities, the environment, welfare, transport, health and digital infrastructure. In short, decarbonisation affects – and will be affected by - all parts of society. For this reason, it was decided that the **NZCom scenarios should explicitly seek to capture the interactions between societal engagement, net zero and vulnerability**.

[3] Cornwall Council's Digital Inclusion Strategy 2019-23 stated that 13% of residents had never used the internet, higher than the national average of 8.4%: https://www.cornwall.gov.uk/people-and-communities/digital-inclusion/digital-inclusion-strategy/

5.2 Review of published energy scenarios and methodologies

Following the scoping exercise, a review of published scenario exercised was undertaken in August 2021 [19]. This helped to identify established approaches and datasets, and as such, provided a foundation for the development of the NZCom scenarios.

5.3 Sense-checking

Findings from the first two stages were discussed with the NZCom project team and Advisory Group in an online workshop in November 2021. This session invited participants to comment on the value of scenarios for their specific organisations. Responses related to several themes including: developing understanding, raising awareness and providing clarity; generating helpful/actionable solutions; and developing processes and findings that are accessible and shareable (Figure 2).

Figure 2. Wordcloud from NZCom stakeholder workshop, November 2021

The workshop was also used to gather views on the extent to which Wadebridge and Padstow should contribute to national net zero targets, and the ways in which targeting vulnerable parts of the community could affect the area's transition to net zero. Feedback on these points fed into the scenario development process.

5.4 Developing the NZCom scenario framework.

Given the need for a method that could be readily adopted by other communities, a decision was made to base NZCom scenarios on two key scenario exercises identified in the Review. First, the NGFES [20], which draws on established quantitative models and an ongoing process of stakeholder engagement, and which has come to represent something of an industry standard for energy system analysis at a national level[4]. Second, the WPD/Regen Distribution Future Energy Scenarios (DFES), which adopts the NGFES framework to develop regional net zero scenarios for WPD's South West license area, which includes Cornwall.

Since both processes are carried out annually and are expected to continue to do so for the foreseeable future, they provide a robust foundation on which to develop more nuanced and tailored local scenarios. Adopting a framework from elsewhere means that NZCom scenarios are aligned and consistent with regional and national net zero pathways in which they are nested. However, it also means that the limitations and assumptions built into the NGFES and DFES processes are also adopted.

The NGFES 2021 framework[5], and the Regen/WPD DFES framework on which it was based, suggests that net zero will be shaped by two key factors: 1) speed of decarbonisation and 2) level of societal change (Figure 3). Speed of decarbonisation is affected by rates of technology adoption and replacement of fossil-fuel based technologies, infrastructural investments, as well as supportive government ambition, policy design and implementation.

[4] The NG FES scenarios follows the 'Intuitive Logics' approach. In short, this involves identifying key driving forces or critical uncertainties that are thought to shape futures, and consideration of plausible outcomes of these forces. A small number of (typically four) scenarios are defined by the most extreme outcomes of two clusters of critical uncertainties, identified by a ranking exercise.
[5] This framework remains in place in the most 2022 FES report.

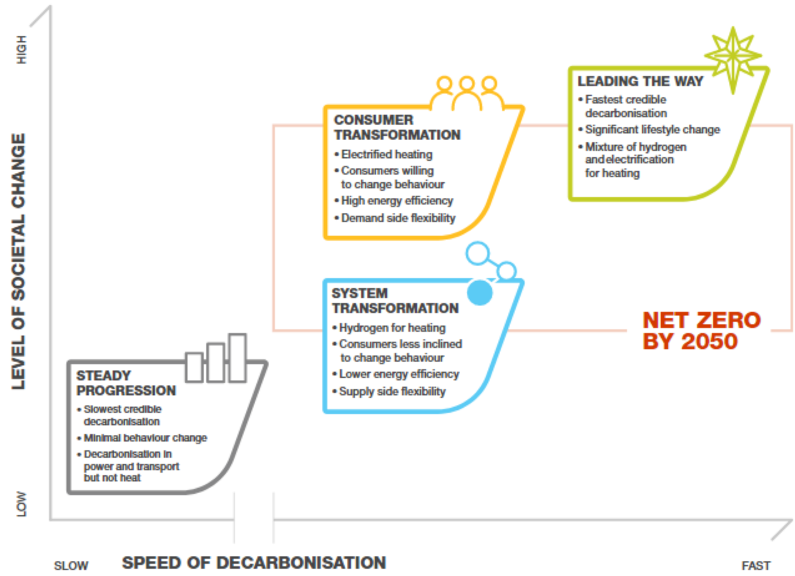


Figure 3. National Grid's Future Energy Scenario 2021 framework and scenarios

Level of societal change in turn relates to innovation, understanding and behaviour relating to avoiding, reducing and shifting energy consumption, reducing dependence on fossil fuel-based technologies and adopting low carbon alternatives.

These factors are interlinked. For example, the ability to shift electricity consumption behaviours will be constrained by the rate at which smart meters, appliances and associated infrastructure become available. Similarly, technological cost curves, policies and infrastructures will be influenced by rates of public engagement/support/acceptance or indeed reticence or pushback against technology adoption, opposition of local infrastructures, stability of national policy, and the continuing cost of living crisis and high energy bills.

While we agree that the interplay between these two factors is useful in informing discussion about net zero pathways at national and regional levels, the nature of the NZCom project requires scenarios to be articulated in terms of a) local constraints and opportunities in the WPCNA, and b) implications for local vulnerabilities. **For this reason, the NZCom framework adapts the NGFES framework by changing the focus from 'societal change' to 'societal engagement'**.

The rationale for this is twofold. First, while we accept that 'level of societal change' is a key uncertainty, we consider societal change as being impossible without societal engagement. Explicitly focusing on engagement allows us to open up discussion about a) the depth of societal engagement, i.e. whether one-off or more prolonged, and whether one-way or multidirectional, and b) the breadth of societal engagement, i.e. whether engagement efforts are spread across the whole community, or targeted towards specific parts of the community. These dimensions are captured in

Figure 4. This will allow us to articulate how different technological propositions require different forms of engagement, and interact with different types of vulnerability.

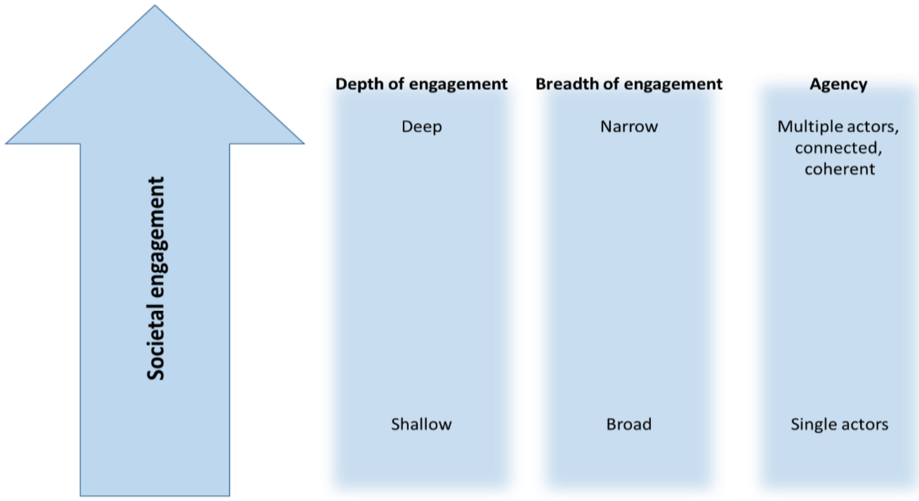


Figure 4. Breadth, depth and nature of societal engagement within the NZCom framework

Second, NGFES 2021's framing of 'levels of societal change' suggests a binary choice in who takes responsibility for net zero: society (which for the most part in NGFES analysis means customers), or wider system actors. Our focus instead on 'societal engagement' seeks to remove the onus of responsibility on system actors or end-users and emphasises the importance of engagement as a two-way process in which users, communities and other actors have agency to work together to identify and develop mutually beneficial value streams. This will allow us to articulate local actors' agency in supporting, mediating and enabling action on the part of users as well as from national and regional policies. This perspective also acknowledges the risks of relying on national level changes (such as hydrogen heating infrastructure and CCS) which may not happen without societal engagement.

The final NZCom scenario framework was published internally in draft form in a High Level Scenarios milestone document [21] which was presented to the project team in January 2021, and to the wider Advisory Group in March 2021. This proposed three scenarios of relevance to the WPCNA, two of which reach net zero by 2050 and one missing that target (Figure 5).

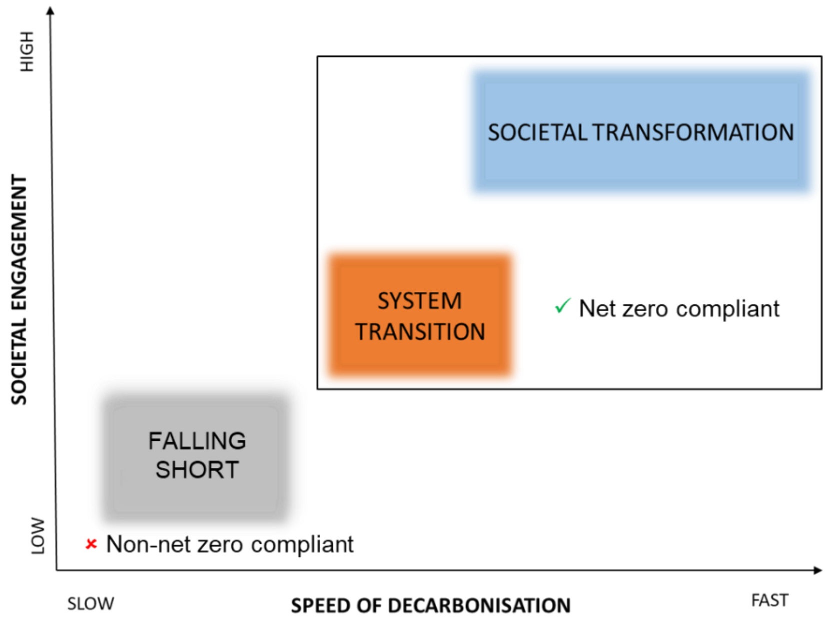


Figure 5. Net zero scenarios within the NZCom framework

Workshop participants were in general supportive of the use of national/regional scenarios as a basis for local scenarios, and of the proposed shift in emphasis from societal change to societal engagement (Figure 6).

Figure 6. Stakeholder views on the NZCom framework

Our three scenarios map onto those used within NGFES (and DFES) exercises. Falling short aligns with the NGFES Steady Progression scenario, and the NZCom System Transition scenario maps on to the NGFES System Transformation scenario. For our ambitious scenario (Societal Transformation), we chose to combine elements from the NGFES 'Consumer Transformation' and 'Leading the Way' scenarios. This means that Societal Transformation comprises consumer-driven change *alongside*, rather than instead of, the emphasis on the demand-side and systemic changes implicit in 'Leading the Way'.

6 Technology adoption curves

As with the NZCom scenario framework, technology adoption curves were adopted from those generated at national and regional levels within the NGFES and the WPD/ Regen's DFES exercises respectively (Figure 7). Again, drawing on established processes means that local pathways such as those developed within NZCom align with other localities, and with the regional and national systems within which they sit. It also means that the processes described here can be replicable in any locality in Great Britain by drawing on the relevant datasets within future NG FES and DFES reports.

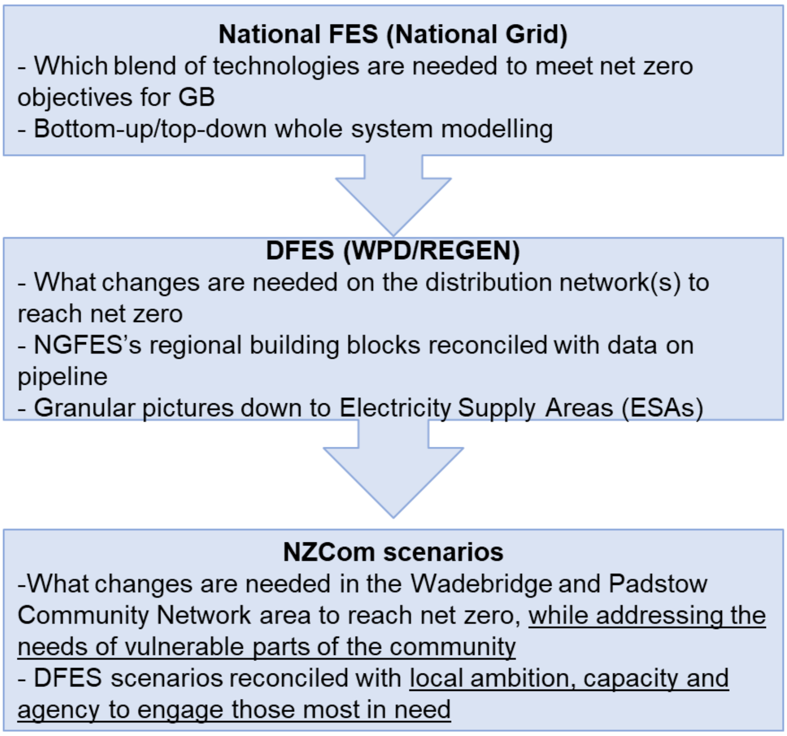


Figure 7. Interaction between national, regional and local technology trajectories

6.1 National (GB) trajectories

The starting point for developing local technology trajectories were the national trajectories developed as part of the NGFES 2021. NGFES reports are published annually alongside a set of common 'Building Blocks' which disaggregate supply and demand from different technologies down to the level of Grid Supply Points (GSPs). This allows for alignment between NGFES projections at the national scale, and regionally-specific DFESs in terms of generation from specific technologies, demand from domestic, industrial and commercial, heat and transport, demand from low carbon technologies, and uptake of storage and flexibility technologies and services. Assumptions and levers used in NGFES 2021 are provided in Excel format at GB [22] and regional levels [23]. This includes demand, supply and flexibility at GB level and for regional building blocks.

6.2 Regional trajectories

The annual WPD/Regen DFES exercises comprise a bottom-up analysis of changes on the distribution network at a regional and sub-regional level, which are reconciled with the 'Building Blocks' established by NGFES [24]. As such, modelling is restricted to providing local context to the assumptions set out in the NGFES. The WPD/Regen DFES 2020 is reported at both Electricity Supply Area (ESA) and Local Authority level, and are reconciled to NGFES 2020 results "as far as possible", although some variance between DFES and NGFES views are expected.

Regional technology trajectories start from a baseline which is created from WPD connection data, subsidy registers, Department for Transport data, and other national datasets to analyse spatial trends within license areas. Pipeline analysis is then carried out to build a picture of supply trajectories (to include sites with connection offers or with active planning applications) and changes to demand (to include prospective domestic and non-domestic property developments) within the network area. DFES projections thus seek to provide a more accurate view of regional developments from granular knowledge about resource availability, historic factors, political factors, pipeline factors and uptake rates. Input from local stakeholders (renewable developers, local authority planners[6] and others) thus forms an important part of the analysis.

As well as providing high-level summary of scenarios in regional reviews [25], the WPD DFES/Regen also includes reports on local assumptions for the South West license area [26], as well as interactive maps and downloadable data associated with projections for individual technologies, at both ESA and Local Authority levels [27].

6.3 Local trajectories

Three ESAs were found within the WPCNA: Wadebridge, Padstow and Polzeath. While these do not map precisely on to ESAs (Figure 8), an assumption was made that adoption curves within the ESAs

[6] While housing and population projections remain consistent across FES scenarios, they interact with DFES scenarios by increasing demand for electricity and heat, but also increase the uptake of new technologies such as electric vehicles, heat pumps and rooftop solar PV

could reasonably be applied to the whole area by adjusting figures to the correct number of homes for the WPCNA.

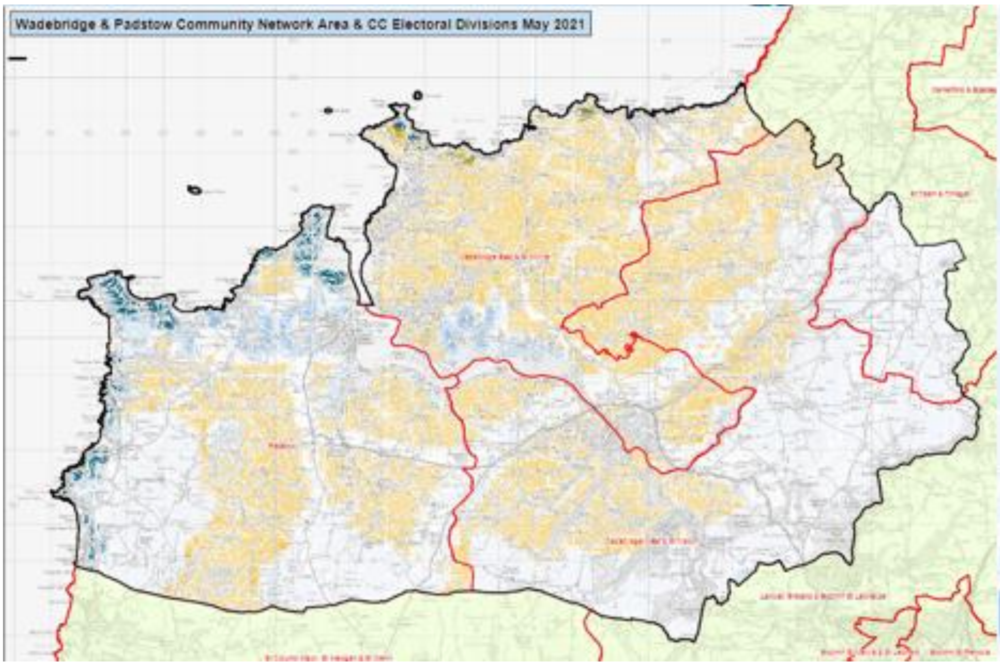


Figure 8. Electricity Supply Areas covering the Wadebridge and Padstow Community Network Area
The relevant ESAs (Wadebride, Padstow and Polzeath) are indicated by the orange areas, whereas the Community Network Area is the total area within the black line.

Since figures provided in the DFES worksheets are for distribution-connected generation only, i.e. customers connected below 33kV only, large-scale wind and solar are typically not modelled. Including them in projections is however possible by applying county-level growth projections to known baselines for these technologies.

For some technologies, a local 'acceleration factor' of no more than 10% was applied to technology adoption rates drawn from DFES data. This reflects the likelihood that the WPCNA may be able to foster higher rates of adoption of technologies and business models compared to neighbouring communities, by virtue of a higher than average renewable share of resources and assets, a population that is relatively engaged in energy issues, and levels of affluence that could support further investment in domestic and community-scale assets. It is difficult to quantify the degree to which such factors can catalyse further changes, but in the absence of empirical evidence, 10% was regarded as a conservative but achievable estimate.

NZCom focused on a subset of the technologies modelled by DFES as those deemed most relevant to the project. This included:

- New dwellings: number of units

- Heat demand: Residential heat demand by fuel type
- Onshore wind, large scale (>=1MW): installed capacity[7]
- Onshore wind, small scale (<1MW): installed capacity
- Solar, ground mounted (>1MW): Installed capacity
- Solar, domestic rooftop (<10kW): Installed capacity
- Solar, commercial rooftop (10kW - 1MW): Installed capacity
- Heat pumps: Units
- Resistive heating: Units
- EV charge points, domestic: Units
- EV charge points, workplace: Units
- EV charge points, public: Units
- Electric vehicles, autonomous and no-autonomous: Units

As with the scenario framework, draft technology trajectories were presented to the project team and Advisory Group by way of an online workshop in March 2021. This was used to gather insights around a) the degree to which individual technologies can be expected to meet, fall short of, or exceed proposed adoption rates and b) the extent to which technology deployment should be focused on specific parts of the community.

7 Scenario narratives: articulating vulnerabilities and engagement

Alongside the quantitative technological adoption curves described in the previous section, we also developed qualitative scenario narratives. These narratives make sense of pathways by articulating change in terms of more meaningful and relatable dimensions. Given the focus of NZCom, our scenario narratives are articulated in terms of the impact of net zero pathways on a) vulnerabilities and b) societal engagement.

This aspect of the process draws heavily on the literature – from academia and elsewhere - on these themes and the interconnections between them, to help illustrate how specific pathways and associated technological and infrastructural decision-points can open up or close down opportunities for societal engagement, and similarly, how coordinated societal engagement can help to unlock pathways to systemic transformation. Our opening assumption was to understand how vulnerability and societal engagement interact with decarbonisation in general terms, that is,

[7] We note that while onshore wind is included within DFES scenarios, the near-term pipeline for the study area is constrained by the existing de-facto ban on the technology in England via planning restrictions in place since 2015. Projections for an uptick in onshore wind developments in the medium and long-term growth are based on an assumption of a return to a more favourable planning environment.

beyond the local context of the WPCNA. This general view provided a useful starting point for considering the ways in which net zero *might* interact with vulnerability and engagement in the area. **This also means that the themes explored in this section are likely to be of direct value to other communities exploring similar issues**. This section is structured into two main sections – vulnerabilities and societal engagement. As we go on to discuss, these issues are far from discrete and interact dynamically and in multiple ways.

7.1 How net zero technologies interact with vulnerabilities

The transformation to net zero entails disruption and change across all sectors of society [14, 28] , although the level and nature of disruption will vary. This section focuses on the relationship between net zero interventions and residents with vulnerable characteristics, which requires an understanding of:

a) How vulnerabilities are experienced in the existing energy system,
b) How net zero interventions could exacerbate and/or mitigate vulnerabilities, and
c) How unaddressed vulnerabilities could undermine the adoption of and participation in net zero interventions.

7.2 Vulnerabilities experienced in the existing energy system

Within the existing energy system, factors that contribute to the degree of vulnerability experienced include:

Personal circumstances relating to physical or mental health, income levels and fuel poverty, and the degree of digital and energy literacy;

Physical circumstances relating to the location, condition, and tenure of their place of residence; and

Interactions with energy actors such as energy companies, repairs, maintenance and installation trades, and those providing or assessing forms of financial or practical support such as grants and assistance for paying bills.

While personal and physical circumstances provide a basis for vulnerabilities to manifest, these can be compounded by challenges associated with interacting with energy system actors. These interactions are illustrated in Figure 9. Table 1 then draws on the literature to highlight potential dynamics.

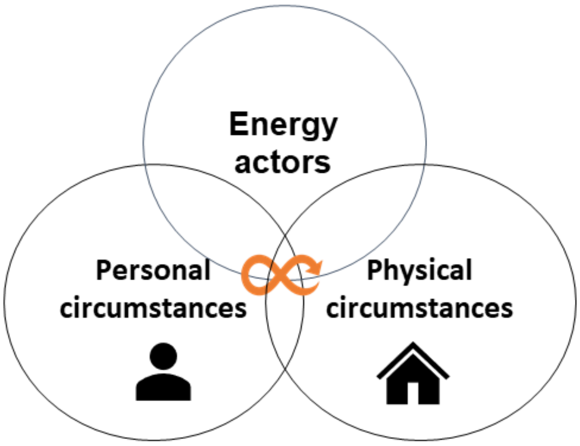


Figure 9. Interaction between personal circumstances, physical circumstances and energy actors

Table 1. Personal and physical circumstances contributing to vulnerability in the energy system, and confounding factors related to interactions with energy actors

Personal/social circumstances contributing to vulnerability	Physical circumstances contributing to vulnerability
Personal - Poor physical and/or mental health - Having a disability - low income/ unemployed - Degree of functional literacy - Digital tech readiness: degree of digital literacy/interest **Social** - Caring responsibilities: full time carer/lone parent - Social isolation and loneliness, living alone, degree of isolation from social relationships and networks - Lack of access/ mobility to services/employment	**Building** - Hard to treat/heat property - Dwelling type: lack of space for low and zero carbon technologies - Pre-payment meter: residents penalised by premium tariffs - Tenure: e.g. private rented, temporary or precarious accommodation: less control over costs of heating and fuel. **Infrastructure** - Off gas grid - Living in rural area: Lack of access to services - No internet access / living in internet 'not spots'

Vulnerabilities exacerbated by interaction with energy actors
Complexity and inaccessibility of information - Complexity can limit appropriate decisions, particularly for those with cognitive impairments - Information about net zero options inaccessible to those without energy literacy - Hard to treat properties not cost efficient to address if account solely for energy savings payback, and don't include health - Retrofitting: Residents struggle to find clear and accessible information for retrofitting [29] - Complexity of dealing with a range of different installers/contractors to access retrofit services **Communication** - Communication barriers if English is not first language - Communication channels reliant on websites and automated services are not accessible or inclusive [30] (continued overleaf…)

(…continued)

- Communication with energy actors limited by no/limited/intermittent smart phone / email access [31,32]

Exclusion by suppliers

- Those on pre-payments may not be able to benefit from deal offered to those on automated payments, such as direct debits.
- Residents in fuel poverty pose a higher debt risk to energy companies

Grants and support

- Grants/funding/support not easily accessible or poorly designed
- Those renting can fall through the gaps of support offered for energy efficiency measures
- Some grants/support not accessed due to shame/stigma of application process

Resource-intensive interventions

Those with more complex needs may require more resource-intensive interventions, so not cost-effective to meet needs [32]

Vulnerable characteristics can accumulate and compound negative impacts to physical and mental health [33], (see Box 1). Additionally, personal characteristics can contribute to residents being *hard to reach*, whilst many of the physical characteristics can contribute to properties being *hard to treat,* thus multiple points of intervention and engagement need to be designed. In practice this requires recognising and understanding how the personal and physical characteristics of vulnerability interact.

Box 1: Accumulation of vulnerabilities

Vulnerabilities can accumulate and be exacerbated if not addressed. For example, '*thermal discomfort from a cold home x financial worries caused by high energy prices x stigma'* [33, p. 198] sets up a feedback loop, which could increase financial worries and stress, and increase the negative physical and mental health impacts of a cold and unhealthy home. The perception/experience of stigma and shame can deter residents from accessing the support needed to mitigate financial worries of high and increasing energy prices and to address thermal discomfort. The increasing severity of poverty experienced from 2021 onwards is contributing to increasing numbers of residents with poor mental health.

Access to energy underpins the quality of life and access to further goods and services [30, 34]. In Cornwall, an average of 12.6% of households (and up to 23.9% of households in some areas) currently experience fuel poverty [35]. Note that these figures are based on statistics from 2020, so does not reflect the rise in fuel poverty relating to the COVID-19 pandemic, or the fuel price increases and cost of living crisis in 2021/22. Furthermore, the below average incomes in Cornwall, plus higher dependency on non-grid / off gas-network fuels, contributes to the drivers of fuel poverty in Cornwall. This indicates a market and policy failure to enable ensure equitable access to the essential service of energy [36]. It also highlights the importance of addressing regional vulnerabilities, recognising that different sectors have different needs, and designing and implementing an inclusive and just transformation to net zero which leaves no one behind, in design and in practice.

7.3 How net zero might exacerbate or mitigate vulnerabilities

Net zero technological and fabric interventions are disruptive to existing practices and/or fabric of property [28], and impact sectors of the population in differing ways. Interventions at both individual and system levels are required to ensure that risks associated with novel technologies or practices are not disproportionally borne by those with least capacity to have flexible usage of energy, or to tolerate financial risks or disruption [29]. Some of the risk-factors are age related, such as the degree of energy and digital literacy, interest and capacity to change behaviours and lifestyles.

In Table 2 we present how specific interventions intersect with vulnerabilities, how to mitigate detrimental impacts, and the engagement needed to support an inclusive and equitable transformation to net zero. This is based on non-systematic literature reviews of relevant academic and grey literature to explore the interactions between vulnerabilities, the uptake of low and zero carbon technologies, initial and ongoing engagement and support needs, and the local level implications for societal engagement with net zero.

The range of technological interventions were selected by Planet A[8] to represent the best fit solutions for the geographical area based on greenhouse gas reduction and have positive community benefit. Technologies which are not currently feasible at scale (such as a zero-carbon hydrogen infrastructure) or are unsuitable for the dwelling density in the area (such as community or district heat networks) were not included in the selection.

[8] Planet A, 2022, Net Zero by 2050 report

Table 2 Engagement for an inclusive and equitable net zero transformation

How net zero intersects with vulnerabilities		Inclusive net zero needs	Engagement needed
Flexible / time-of-use tariffs which requires	Risk of penalising those with no or limited flexibility who cannot participate, or effectively subsidise those with more flexibility [37, 38]. Flexibility reduced if residents do not have, or cannot afford, compatible white goods.	Develop understanding of what flexibility means, how residents manage their energy usage, and how benefits can be realised for different sectors [39]. Co-design inclusive flexibility options and tariffs to explicitly recognise needs of vulnerable residents and those with limited flexibility. Time of use tariff opt-in information and tariffs need to be clear, accessible and understandable [29].	Clear and compelling value proposition to attract tariff opt-in, and flexibility to opt-out [29]. Unbiased advice to select most appropriate tariff. Ongoing support to ensure most suitable flexible usage.
Digital/ energy literacy and capabilities	Digital technologies such as smart meters and smart heating systems risk exclusion if residents do not have: - digital and/or technical literacy, confidence or interest [31] - reliable internet connection - smartphones/ tablets	Those who are unable to participate through lack of smart phone/internet connection should not be penalised. Information needs to be accessible to all.	Trusted intermediaries are important for providing in-person support, explaining new technology and providing support over time [40, 41, 42].
New domestic/ community owned wind and solar PV	Risk of fuel poor subsidising new renewables through levies on bills. How does the location of new wind and solar impact vulnerable residents?	Involvement in deliberation and decisions about siting and beneficiaries of community wind and solar. Explore risk perception of renewables for vulnerable residents [12]. Ensure just and equitable distribution of risks and benefits.	Place attachment and new renewables Importance of deliberation and inclusion [43].

Upgrade of fuel poor houses	Retrofit options currently not clear or accessible. Risk of financially excluding those with vulnerable characteristics. - Financial and technological risk burden higher for those with least capacity to absorb the risk.	Retrofit options needs to be clear and accessible Ensuring adequate sources of funding / grants for vulnerable residents. Relative level of financial and technological risk to resident requires careful consideration. Forms of government guarantees on novel technologies required [44]	- Accessible advice at upgrading opportunities (e.g. through routine repairs and maintenance). - Landlords require specific targeting to outline obligations and options. - Business models need to reflect beneficial value proposition for vulnerable residents [45].
Electrification of heat	- Need for energy literacy regarding heat pump and electric heating systems. - Where does burden of risk assurance / guarantee lie?	As above	Pre-installation advice for: - Choosing heating system (heat pump/ other electrical heating) - replacing boiler - upgrading radiators - Interaction / sequencing with retrofits Ongoing support required to understand and make best use of heating controls [38, 40, 46].

To assess the level and type of vulnerabilities experienced in the WPCNA area, and comparisons to the rest of Cornwall, the national level data and research was tailored to the local area through the knowledge and experience of local partners. Fuel poverty levels in WPCNA were around average compared to the rest of Cornwall. In common with other holiday destinations, WPCNA experiences wealth disparity, and contains a large number of second or holiday homes (around 40% in WPCNA based on 2012 figures) [47] It has a rising number of residents who are living in temporary accommodation, or accommodation not suited for year-round living, such as holiday chalets and static caravans.

7.4 Co-benefits of health and energy equity

'the deliberate acceleration of low-carbon transitions is most politically effective when climate benefits are combined with more politically resonant issues, such as personal health, jobs, or security' [48 p.305].

Addressing vulnerabilities and reducing inequalities experienced in the energy system is currently high on the public agenda. Energy advice agencies are experiencing intense and urgent demand for services, often from residents with complex and severe needs compounded by fuel price rises, highlighting the impact of fuel price rises on wellbeing, and physical and mental health.

Societal drivers of ill health often correlate with personal and physical circumstances of vulnerabilities experienced in the energy system. Energy and health research sources highlight the importance of an integrated and holistic approach to fuel poverty, net zero and public health [28, 48, 49, 50]. Such an approach can address the inequalities and injustices present in both the energy and public health systems.

Identifying the synergies between these agendas can help ensure that co-benefits of net zero - such as job creation, improvements in physical and mental health and wellbeing [point to the co-benefits table] - are locked in, and not pitted against social concerns. Opportunities for synergy exist throughout the design, planning, ongoing implementation and feedback stages of local net zero transition.

Key points of synergy include:

Taking a systems approach. Designing with and for the whole system, building on the synergies and needs of net zero and public health, and working across scales [23, 48, 49, 51, 52].

Strengthening and adequately resourcing inter-agency working and cross-sector collaboration. Training and resourcing frontline workers, intermediary organisations and community networks across energy and public health. This can support the net zero and public health agendas, through triaging responses to vulnerabilities associated with - or exacerbated by - the energy system and ensure signposting to/ assistance from appropriate agencies. [40, 53, 54, 55].

Designing in digital and social inclusion. Co-design, training and support to increase digital inclusion and access to services [56]. Addressing physical inclusion to increase connectivity to services, employment and leisure facilities. For some, group training can enable social learning within and between different user sectors.

Targeting and sequencing: Decisions need to be made regarding how to sequence and target NZ interventions so that: the risks of novel technologies do not fall disproportionally on those already experiencing vulnerabilities; thermal upgrades are installed prior to heat pumps; the social infrastructure and support to assist those with vulnerable characteristics is in place before technologies are installed [29, 44].

8 How net zero interacts with engagement

Societal change and transformation to net zero requires societal engagement with energy and decarbonisation more broadly. A focus on societal engagement seeks to shift the onus of responsibility from either organisations (e.g. energy companies or installers) or end-users to emphasise the value of a networked system in which all actors are engaged. It emphasises the importance of engagement as multi-directional processes in which residents/users, private and public sector organisations, develop the relationships, skills and capacities necessary to achieve a social mandate for decarbonisation interventions. Table 3 sets out some broad principles for societal engagement

Table 3. Principles of societal engagement and associated rationales

Principles of engagement	Rationales
Tailored around different system aspects, and parts of society	Engagement should be targeted depending on the complexity, novelty and level of disruption that the intervention brings, the type and tenure of residence, and the nature of local vulnerabilities. For example, installing a community battery will require different forms of engagement when compared to domestic heat pump adoption.
Deep and sustained	Deeper, sustained engagement and support will be needed to ensure that Net Zero interventions are not to the detriment of residents with vulnerable characteristics. For example, interventions such as heat pumps may require shifts in behaviours to be used efficiently.
Place-based engagement	Engagement needs to pay attention to local contexts, i.e. how people interact with energy systems in communities [11,12]
Use of trusted local messengers	Cascade models and trusted local messengers can ensure multiple channels of engagement to ensure that those with complex needs or

	who are isolated from social networks are engaged and supported appropriately. For example, this includes follow up support for those learning to interact with interventions such as heat pumps [34, 40] .
Integration of engagement with net zero with engagement for public health	Addressing health and environmental inequalities can create synergies, contribute to holistic and efficient interventions and engagement, and encourage a social mandate for net zero (see Section 7.4).

8.1 Depth/breadth of engagement

Different modes and depths of engagement are needed for different interventions.

Shallow forms of engagement may be more common around ‘upstream’ technical interventions such as network innovation, which may be expected to have no or minimal impact on energy practices. This may include provision of information in a broadcast manner, but may also include non-engagement.

Medium depths of engagement refer primarily to one off fit-and-forget interventions, such as installation of smart meters, or adoption of time of use tariffs. Engagement may be needed at the outset. There is also likely to be some need for more sustained engagement, particularly to support those with vulnerable characteristics.

Deep levels of engagement will be needed for more ‘disruptive’ interventions, i.e. those where there is a degree of financial outlay or risk for the resident, such as home energy upgrades or changing heating systems, or those implying significant changes in energy practices. This could require ongoing engagement to support shifts in behaviour.

Alongside depth of engagement, breadth of engagement is a key dimension in determining the trajectory to net zero as well as the ways in which vulnerable parts of the community are affected. Technology interventions may be of interest, or value, to different parts of the community. Different interventions (e.g. tariffs, off-street charging) might also be actively designed with, and marketed to, different consumers in mind. Breadth of engagement interacts with depth of engagement, as discussed above.

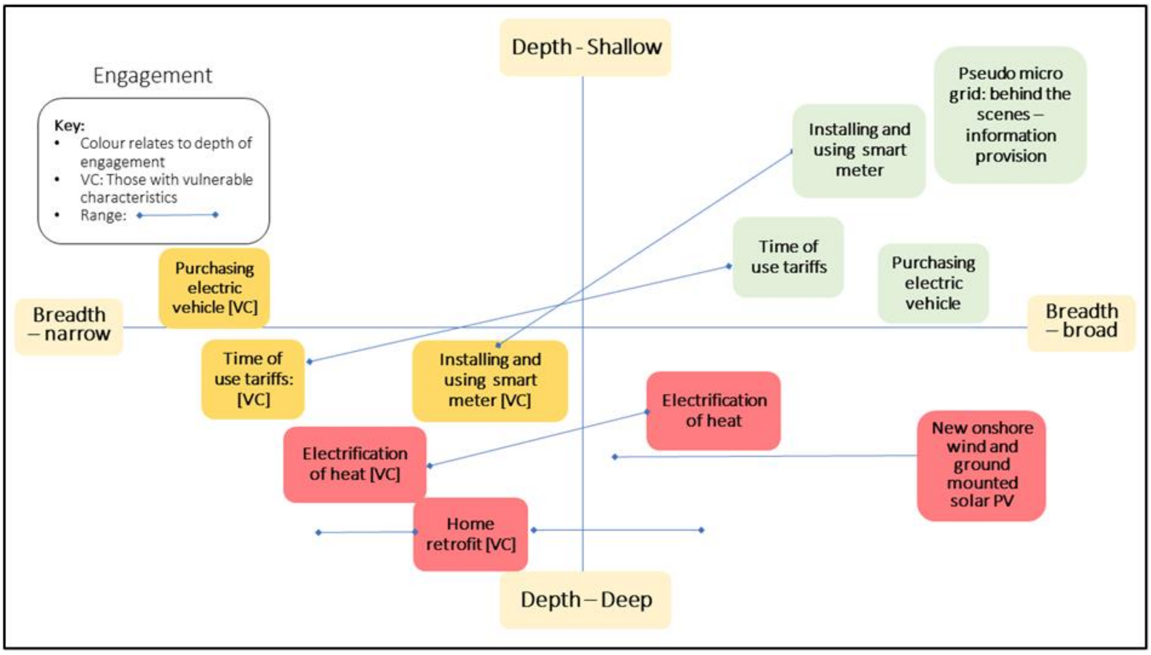
Broad engagement is spread across whole communities. This may include informing residents about grid investments, or encouraging opt-in to local business models

Narrow engagement is targeted towards specific parts of the community. This might include the design of energy tariffs to support fuel poor households, or the deployment of off-street EV charging for those with suitable homes).

To achieve the aims of reaching net zero whilst addressing vulnerabilities, societal engagement will need to be tailored, targeted, flexible and responsive to local or topical concerns.

Figure 10 shows how the breadth and depth of engagement differs according to how the technologies interact with different vulnerability characteristics. In general, those with vulnerable characteristics (denoted by 'VC'] require targeted and deeper forms of engagement than those who are deemed able to pay. 'Able to pay' includes owner occupier households who are able and willing to carry out energy efficiency improvements, are in good physical and mental health, and with sufficient digital and technology literacy to be able to interact with smart technologies. However, they may experience some barriers, resistance, or conflicts of interest. For example, those with existing solar PV and a good feed-in-tariff rate may not perceive an advantage from participating in a pseudo microgrid, or existing contracts may prevent their participation. Some may be unwilling to take a financial risk on novel technology without technology guarantees or assurances [29].

Figure 10. Breadth and depth of engagement required for specific innovations



Alongside the depth and breadth of engagement, the frequency of engagement over time is important to consider. Residents who are able to pay, with high energy and digital literacy, high flexibility capital, and smart-compatible goods and devices may need minimal – if any – ongoing support regarding choosing and using a time of use tariff (ToUT). If they have solar PV already, and sufficient flexibility, some may have already changed their practices to be able to easily take advantage of ToUTs. Those who are fuel poor and have limited flexibility may need ongoing support to achieve most efficient use of ToUT and new heating systems such as heat pumps. The engagement needs over time will also vary depending on strategies to encourage more ambitious voluntary demand reduction, such as reduction in thermostat temperatures, or reducing private car usage.

8.2 Leveraging social networks for engagement

In order to be able to provide opportunities for users and community members to participate fully across multiple parts of the system, multiple actors from across the system will need to be involved. Rather than envisaging new actors with responsibility for energy system vulnerabilities, there are opportunities to build on the trusted social networks of existing actors as 'intermediaries' (Table 4). Many such actors are already engaged either in the energy space and/or in local communities. Giving responsibility to multiple actors is important in a) being able to reinforce messaging from multiple directions, b) linking energy to other (e.g. health and environment) agendas, and c) increasing the likelihood of messaging being received from a trusted actor.

However, it is important to point out that societal engagement by way of multiple organisations will not be possible without a significant step change in resourcing. There will also be a need for coordination across these networks.

Table 4. Energy system actors and potential roles in engagement

Actor	Example	Energy engagement roles Addressing vulnerability roles	Breadth of engagement
Energy supplier	Conventional supplier / ESCO	Providing feedback on energy usage; information about tariffs. Alerting for vulnerability risks, signposting to wider support, targeting tariffs for fuel poor	Blanket approach, tailored feedback via bills and smart meter
Tradespeople / installers	SMEs, builders, plumbers etc.	Offering advice about materials, retrofit options during routine repairs and maintenance	1-1, tailored to resident's need
Energy advisors / intermediaries	Community Energy Plus (CEP), WREN	Information; Specialist or general advice about local energy options Alerting for vulnerability risks, signposting to wider support	1-1, general and sector-specific information
Local community groups	Schools, residents' associations, village halls, shops, clubs & societies, foodbanks, Parish council	Pooled investments; information sharing; influencing decisions; Alerting for vulnerability risks, signposting to sources of energy advice and support	Tailored to groups and opportunities, enabling social learning

Wider sources of advice and support	Local Authority, Citizens Advice, primary care providers	Signposting to sources of energy advice and support Alerting for vulnerability risks, signposting to wider support	Tailored, 1-1
Social networks	Friends, colleagues, family, neighbours	Sharing information with wider networks Alerting for vulnerability risks, signposting to wider support	1-1
General public	People / citizens / consumers	Decisions about electricity and heat demand; appliance and building fabric upgrades, tariff choices; information sharing with wider networks; influencing decisions; Signposting to wider support	Informal, 1-1 or social learning in existing groups or networks/

9 Limitations

A key aim of NZCom was to develop an approach that could be replicated by other communities. This section explores some of the key tensions and limitations encountered in drawing up the scenarios.

9.1 Degree of participation and resource required

The scenarios developed in NZCom are largely desk-based, that is, they do not draw heavily on the participation of local stakeholders, citizens or businesses. These constituencies were represented by project partners and the wider Advisory Group, but limited resources and the need to develop a readily transferable method guided us towards a hands-off approach, and as such represents a key limitation. Highly participatory scenario exercises have been undertaken within communities [e.g. 11, 12]. These can engage a wide range of participants and have been shown to be valuable exercises in discerning the applicability – and gaps – of national scenarios at a local level, involve a wide set of citizen perspectives on energy system change, and lend agency to actors who may traditionally be excluded from decision making around energy. However, these processes can be labour intensive and require significant funding and involvement of academics or other facilitators, meaning they can be difficult to replicate. NZCom sought to strike a balance between participation - through inviting feedback from organisations within a short project timescale - and replicability, so that the exercise could be applied in different geographical locations.

Given more time and resource, more comprehensive feedback could have been achieved through testing scenarios with a wider variety of local stakeholders (e.g. members of parish or town councils, business community, staff and volunteers involved in frontline services) through deliberative workshops and discussions.

The scenarios developed in NZCom were used in conjunction with a model developed by Planet A to examine the interplay between sets of interventions, and a carbon tool to assess the environmental implications of these interventions. The NZCom Carbon Tool seeks to make this modelling more widely available, to enable community groups to develop their own scenarios.

9.2 Limitations of using existing scenarios

By using the NGFES and DFES, we sought to use publicly available, robust and frequently updated scenarios that enabled replicability and cross-comparison at different levels of scale. However, feedback received during the production of scenarios and reflection revealed limitations and further underlying assumptions of these approaches, which we detail below.

Carbon sequestration: A degree of CCS is incorporated into the scenario models to balance CO_2 emissions from unabated gas, blue hydrogen or minimal demand reduction. Figures are not assigned to the level of CCS infrastructure, which is spatially displaced. This gives a distorted view of the infrastructure implications of net zero at a local level, specifically regarding *where* such CCS facilities will be located. If NGFES / DFES scenarios included figures denoting the proportion of CCS needed if certain decisions are taken (e.g. continuing the use of unabated gas, or less demand reduction), this would open up discussions about 'where' carbon sequestration 'should' be (if not in the local area).

Estimates of renewable uptake: Some forms of renewable energy, such as wind power, seemed to have a conservative projection and low technology adoption curve when compared to less contentious, but less consistent, forms of renewables such as solar PV. Whilst this may reflect current political thinking and controversies surrounding certain forms of renewable infrastructure, it also limits and forecloses the potential for exploring a higher penetration of renewables. The potential of wind energy will need to be tailored to the specific area, taking into account the physical potential and social acceptability (e.g. as depicted by the 'Strong Renewables' scenario suggested in Planet A's 'Net Zero by 2050' report).

Conservative estimates of behaviour change and demand reduction. Whilst the scenarios highlight the importance of behaviour change and demand reduction, the assumptions of the potential of demand reduction are conservative. For example, the *Societal Transformation* scenario incorporates the most efficiency and demand reduction portrayed in the NGFES, which amounts to a 32% improvement in domestic energy efficiency by 2030, primarily achieved through LED lightbulbs and investment in highly efficient and smart appliances, and the majority of residents reducing their thermostats by an average of 1°C.

9.4 Changes to national policy

During the course of the NZCom project, the British Energy Security Strategy [57] (and now Act) was released, and Russia invaded and went to war with Ukraine, limiting supplies of gas to Europe and Great Britain. Soaring energy bills have increased the cost-of-living crisis, have made energy bills and costs centre stage. Organised political opposition to net zero is evident [58], and there is a risk of the net zero agenda being even less of a priority under the new Conservative government.

Gaps between current political intention and the scope of possibilities contained within the NGFES are widening, reflected in political policy preference for large-scale supply side solutions such as offshore wind and new nuclear [57]. Net zero may be possible with large-scale technological and social change, and it might still be possible to reach net zero with an emphasis on supply side interventions. However, if attending to vulnerabilities is considered an important dimension of developing the social mandate for net zero, there will be urgent need for social infrastructure for societal engagement to be resourced.

In lieu of supportive national policy, Planet A (as reported in the 'NZ by 2050' report, p.27) has modelled the local potential to reach net zero and address vulnerabilities. Their analysis includes an additional 'Strong Renewables' scenario, which increases the capacity of small to medium sized wind, and caps the development of ground mounted solar PV. For this to be achieved at a local level with sufficient resource, it requires local stakeholders to consider local ambition and (conversely) the degree to which their local area should be reliant on upstream technologies, infrastructures and policies.

9.5 Focus on engagement and resourcing social infrastructure:

The NZCom scenarios have highlighted the importance of resourcing the social infrastructure. At present, engagement activities are primarily reliant on scarce grant funding[9]. Some business models for community energy projects exist, which generate revenue from renewable energy, and use a proportion of the surplus to reinvest in local energy group activities, including engagement and

[9] For example, the UK Government decided not to continue funding the National Community Energy Fund [National Community Energy Fund (https://communityenergyengland.org/news/government-decides-not-to-fund-a-national-community-energy-fund).](https://communityenergyengland.org/news/government-decides-not-to-fund-a-national-community-energy-fund)

demand reduction programmes (e.g. Low Carbon Hub [59]). However, it is difficult to see where funding for such projects can come from without revenue making projects.

10 Applying scenarios

This section outlines some ways that the methods outlined here – in full or in part - might be applied by other communities.

10.1 Use NZCom's scenarios as a proxy for other communities

Many of the issues encountered in the NZCom project will be similar to those experienced in other communities. At a very basic level, this report could be useful for other communities to:

- **Support calls for action** and approaches that support net zero and addressing vulnerabilities, for example by sharing the examples developed here.
- **Challenge 'business as usual':** The scenarios developed within NZCom, and indeed all net zero scenarios developed at regional and national scales, make a poor case for business as usual. For NZCom, this is especially the case for the **Falling Short** scenario, which misses net zero completely. Greater shifts away from business as usual will be necessary to unlock the many co-benefits of addressing net zero.
- **Make the link between social infrastructure and net zero**: Our Societal Transformation scenario reflects the levels and forms of societal engagement required to reach Net Zero whilst addressing vulnerabilities. Again, this will not be unique to Wadebridge and Padstow. Understanding how local decarbonisation and societal objectives are aligned could help decision making concerning the resources, capacities and training needed for forms of engagement in your locality.

10.2 Adopting general principles from the NZCom scenarios

The scenario narratives developed for NZCom could be used as examples of how to reach NZ at a community scale, whilst addressing vulnerabilities. The information contained in this report contains information on the interaction between net zero and vulnerabilities, the range of engagement approaches needed, and the synergies of addressing energy and health equities together. Many of these will be transferrable to other communities. As such, the scenarios could be used as examples to support calls for action in their own communities. For example, our scenarios echoed key findings from analyses at national and regional scales. For example:

- Multiple plausible energy system futures exist, as does the possibility of not reaching net zero at all.
- Change is systemic, and which pathways is realised will be influenced by a huge number of interconnected technological, economic, behavioural and political factors. These factors can align to support decarbonisation, but they can also align to frustrate decarbonisation.
- Improvements to thermal efficiency of existing buildings is universally accepted as a no-regrets option. Failing to upgrade buildings will mean net zero targets are missed.
- Some progress towards decarbonisation may be made with minimal societal engagement. However, the question remains as to how more controversial / disruptive forms of change could be achieved without meaningful societal engagement.
- Equally, it will be possible to address decarbonisation – to an extent - without addressing vulnerabilities. Again, progress towards decarbonisation will be frustrated if we fail to obtain a broad social mandate for Net Zero, and/or existing vulnerabilities are neglected
- A plausible scenario exists in which decarbonisation is aligned with environmental, societal and economic co-benefits. Again, this will require societal engagement across and beyond the energy system, tailoring engagement to specific technologies and sectors of society, and coordination of energy system actors.

10.3 Questions for communities

By integrating a wealth of information relating to technological and societal change, scenarios can help to provide structure to decision-making relating to housing, energy infrastructure, transport and social engagement, so can be valuable tools for a range of stakeholder including (but not limited to) investors, community groups, parish or town councillors, and the local public. This section suggests some points for discussion which communities might focus on to explore engagement with different sectors, or within local decision-making more broadly.

The following questions cover themes relating to overarching social and technical issues as well as issues relating to infrastructure developments such as housing, renewable generation and transport. These could be a) used as a starting point for discussions (in place of a full-blown scenario development process), b) built into the process of scenario development, or c) used alongside locally-derived scenarios to shape discussions.

Local engagement

- *How engaged is the local community in sustainable energy issues?*

- *How do different publics interpret and interact with NZ scenarios at a local level and how this relates to engaging with issues of NZ and/or vulnerability?*
- *How can parts of the community that are currently unable or unwilling to engage in energy issues be considered, in outcomes as well as in decision-making processes?*
- *How can existing social capital within local organisations be leveraged to engage the community, particularly those who might be difficult to engage?*
- *How could your group increase the range of people and organisations advocating and working towards inclusive net zero pathways?*
- *Which aspects of the scenarios particularly resonate with different publics? What further information might be needed?*
- *How does energy relate to people's 'sense of place'? How does energy resonate with local issues?*

The social feasibility of reaching net zero

- *What social resources are needed for retrofitting at a local level, e.g. levels of advice, skills, installers, maintenance of infrastructure?*
- *What are the range of local attitudes in support of / opposition to increased wind/solar power?*
- *What avenues are there to engage those who are not currently engaged with energy issues?*

The technological feasibility of reaching net zero

- *What grid constraint issues exist?*
- *What renewable resources exist in the local area?*
- *What is the potential for renewables in your area? How do regional projections (e.g. as assumed in the DFES scenarios align with local ambitions for new renewable installations)?*
- *What are the specific challenges relating to retrofitting the local building stock?*

The relationship to carbon capture and storage (CCS) technology

- *If net zero is not pursued here, where should CCS infrastructure be sited locally?*
- *What are the trade-offs between installing onshore wind (which could generate revenue for the local economy, or reduce electricity prices), and CCS (which would require revenue for construction and maintenance)?*

Housing

- *What are the housing challenges and opportunities for the community?*
- *If proposed new homes are not net zero-compliant, what are the implications for local and national progress towards net zero? Are we at risk of locking new local homes into high-carbon*

infrastructure? If so, what assumptions are being made about carbon capture and storage within and beyond the community?

- *What plans are there for retrofitting existing housing stock locally? What investment in skills will there be locally? Are there local exemplars of low carbon homes that could be replicated?*
- *How can vulnerable households be targeted in plans for decarbonising local buildings?*

Renewable Generation and infrastructure

- *What are the key energy challenges and opportunities for the community?*
- *What does the existing neighbourhood or community plan say about renewable generation in the area? What opportunities exist to develop forms of renewable generation (e.g. solar PV or wind)? Where could they be sited*
- *What forms of governance are most appropriate (e.g. community ownership or part-ownership, share offer) that can maximise success in terms of both local carbon energy and social outcomes?*

Transport

- *What are the key mobility challenges and opportunities for the community?*
- *What plans are there to introduce or extend active travel plans, for environmental and health reasons?*
- *What plans are there to introduce Electric vehicle (EV) charging points to ensure accessibility, and to ensure that EV ownership is not dependent on being a home-owner of having access to an off-road charger?*

Local engagement

- *How engaged is the local community in sustainable energy issues?*
- *How can parts of the community that are currently unable or unwilling to engage in energy issues be considered, in outcomes as well as in decision-making processes?*
- *How can existing social capital within local organisations be leveraged to engage the community, particularly those who might be difficult to engage?*

Cross-cutting issues

- *What jobs and skills could be created through the transformation to net zero locality?*
- *What opportunities are there to align health and environmental targets and infrastructures?*
- *What activity or plans are in place to refer patients to support and advice for paying energy bills, or making homes more thermally efficient?*
- *How might a local transformation to net zero build on and support changes in neighbouring communities?*

11 Appendix 1. Summary of relevant scenario exercises

Geography	Project	Lead partner (reference)	Area of focus	Focus/framing of scenarios
National	Future Energy Scenarios (FES) 2021	National Grid ESO [20]	GB	Technological and societal changes needed to meet net zero by 2050.
	Zero Carbon Britain (ZCB)	CAT [60]	UK	Technically plausible scenario for meeting net zero by 2030
Regional	WPD Distribution Future Energy Scenarios (DFES) 2020	Regen [61]	South West England	Technological and societal changes needed to meet net zero by 2050 (aligns with FES 2020)
	Net Zero South Wales 2050 (NZSW)	Regen [62]	South Wales	Impact of heat decarbonisation trajectories on electricity and gas networks (aligns with FES 2019/20)
	Zero2050 South Wales	NG [63]	South Wales	Optimisation of technological mixes to meet net zero by 2050
	Pathways to a Zero Carbon Oxfordshire (PAZCO)	ECI [15]	Oxfordshire	Technological and societal changes needed to meet net zero by 2050 (aligns with FES 2020)
	4D Heat	SSEN [64]	Scotland / Isle of Skye	Technological and behavioural options for flexible electrified heat in absorbing otherwise curtailed wind generation, and analysis of associated reduction in emissions.
Local	Green City Vision	WWU [65]	Swindon	Analysis of feasibility and disruption of different heat trajectories aligned with (80%) emissions reduction targets
	Communiheat	OVESCO [66]	Barcombe	Impact of planned versus unplanned heat transition on networks
Other relevant projects	Smart and Fair	CSE [67]	n/a	Distributional impacts of shift to smart energy system, defined by technologies and behavioural changes identified by FES 2019.
	Distributional impact of UK climate change policies	CSE & ACE [68]	n/a	Cost recovery options for meeting (15%) emissions targets
	An Electric Heat Pathway	SSEN [69]	n/a	Role of electric storage and hot water tanks in existing heat decarbonisation scenarios

12 Appendix 2: Scenario narratives

A2.1 Overview

Three scenarios have been developed for the WPCNA, two of which reach net zero, and one of which falls short (Figure A1). **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.

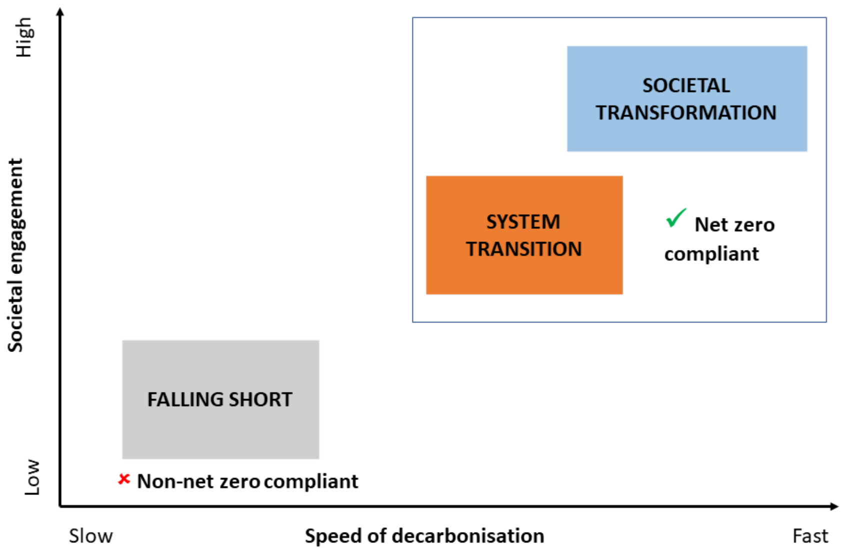


Figure A1: Net Zero Community Scenarios framework

Notes. The framework in which these scenarios sit is based on National Grid's Future Energy Scenarios 2021, but with a new emphasis on societal engagement rather than societal change.

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 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.

A2.2 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 residents. The impacts of failing to address net zero and address vulnerabilities are felt through rising fuel bills, rising numbers of residents 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-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 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: A 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 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[10] is not met.

[10] FES, 2021. Steady Progression, route to 2050, p.75. 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

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. 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.

A2.3 System Transition

Our **System Transition** scenario is based on the FES 2021 System Transformation scenario[11]. 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.

[11] 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.

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.

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.

Transport, travel 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 impacts and implications: 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.

A2.4 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 W&P 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, and decarbonisation by 2050 is achieved[12]. 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 buildings tradespeople. Thermal upgrades are delivered at scale, and net zero expertise is promoted across key organisations and frontline

[12] 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.

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 W&P 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 (PMG), 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.

A2.5 No-regrets options

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.

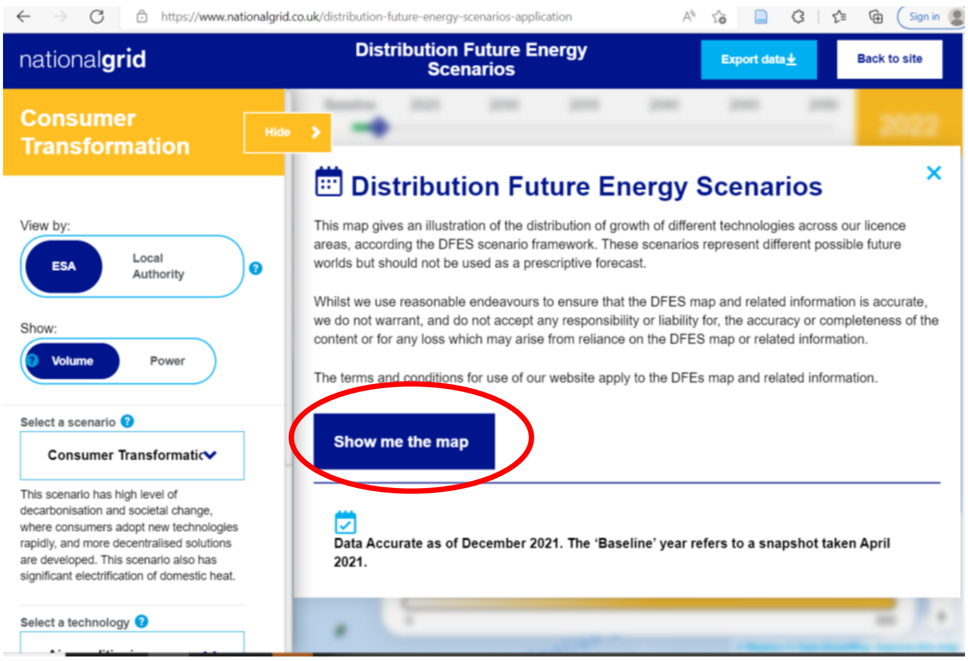
13 Appendix 3: Extracting data from DFES scenarios

Below we have shared some screenshots which provide an example of how to explore and use DFES data.

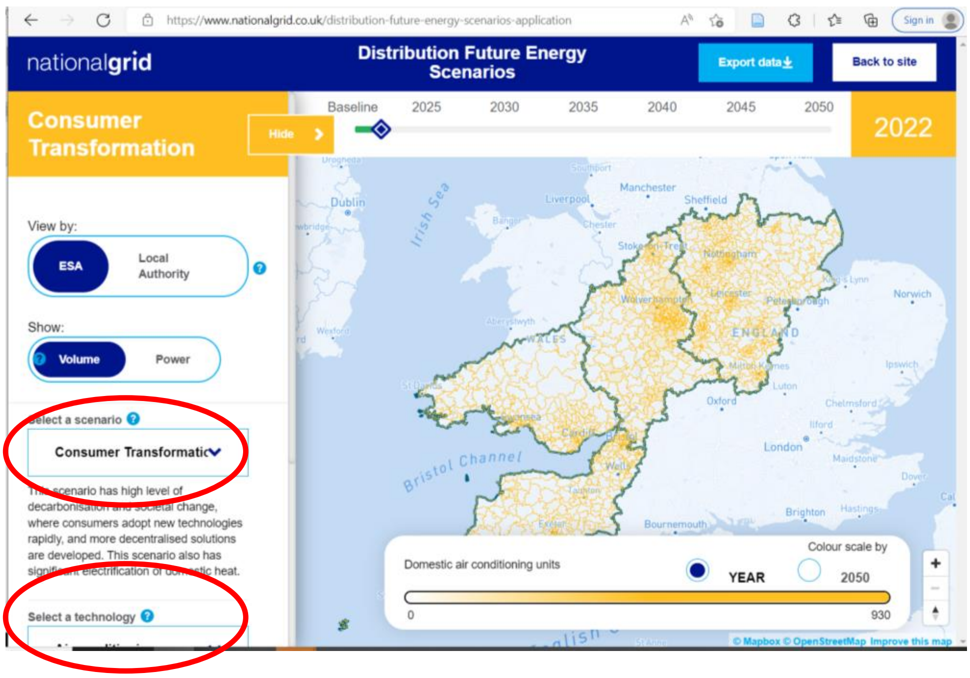
1. Go to the Future Energy Scenarios Application

https://www.westernpower.co.uk/distribution-future-energy-scenarios-application

Click on 'show me the map'

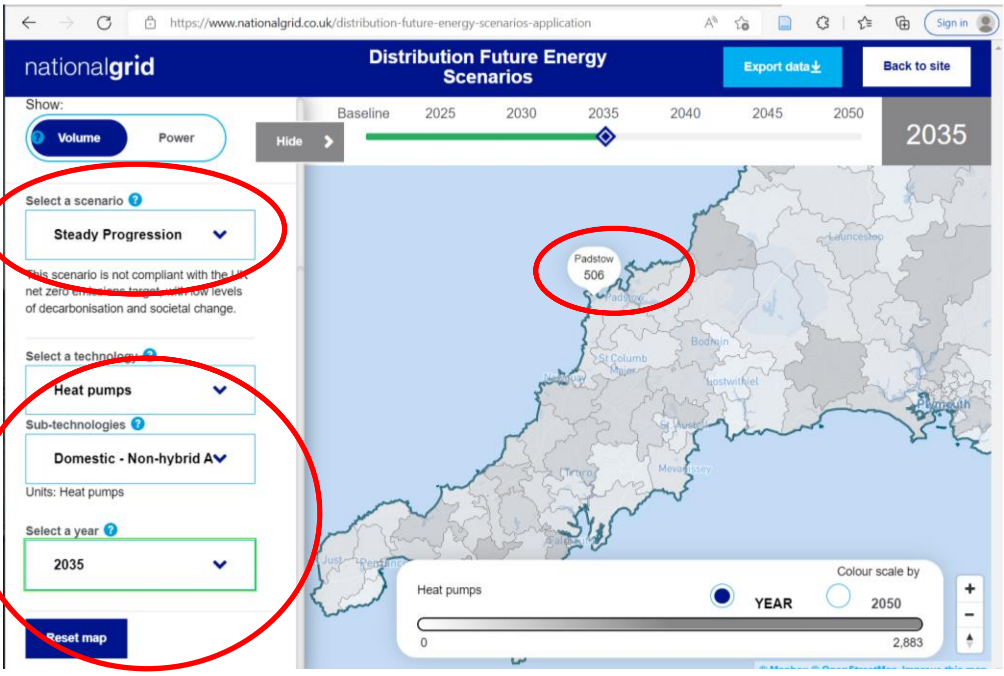


2. Select scenarios, technology and year on the right hand panel

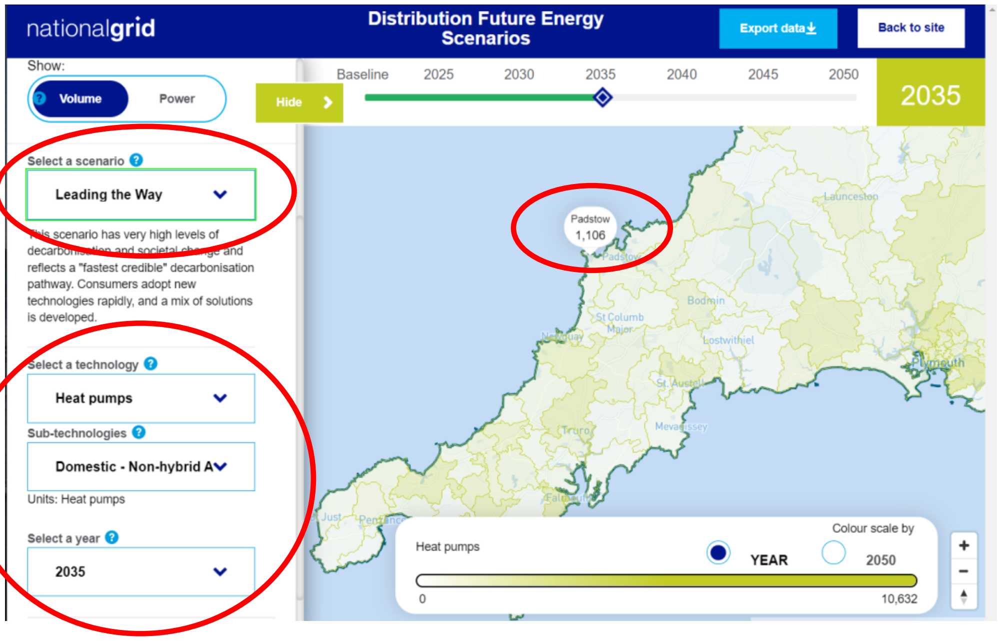


3. You can zoom into the map to focus on where you want to explore, and the technologies.

In the example below, the Scenario selected is 'Steady progression', technology is 'Heat pumps, domestic, non-hybrid Air source heat pumps, and the year is 2035. The mouse is hovered over the energy supply area of Padstow, and is shows a projection of 506 installed heat pumps.



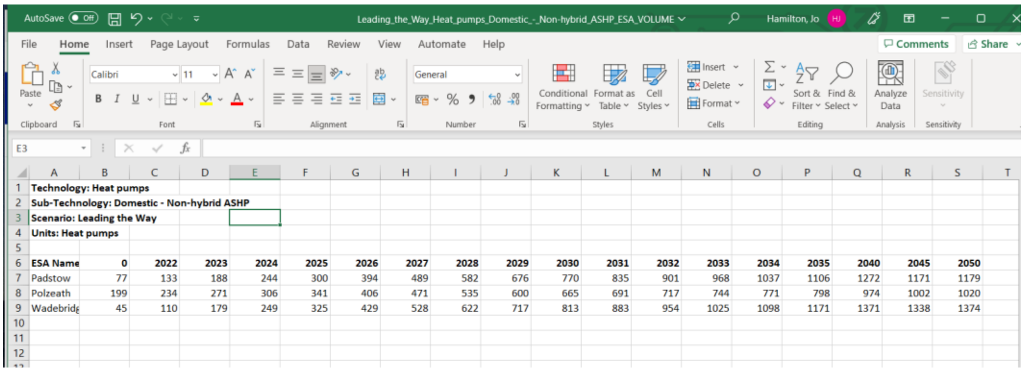
4. Changing the Scenario to 'Leading the Way' now shows a higher projection of 1,106 installed ASHP.



5. Depending on what technology, sub technology and scenario are exploring, you can export the data as an Excel spreadsheet.

This enables you to extract the projected figures for the technology, sub technology and scenario, according to the Electricity Supply Area (ESA) you would like to explore. The figures are presented in yearly increments until 2035, and 5-yearly between 2035-2050.

The relevant ESAs for Wadebridge and Padstow Community Network Area are shown below, other areas have been deleted. Using these figures, you can build up scenarios according to your area.



Technology: Heat pumps
Sub-Technology: Domestic - Non-hybrid ASHP
Scenario: Leading the Way
Units: Heat pumps

ESA Name	0	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2040	2045	2050
Padstow	77	133	188	244	300	394	489	582	676	770	835	901	968	1037	1106	1272	1171	1179
Polzeath	199	234	271	306	341	406	471	535	600	665	691	717	744	771	798	974	1002	1020
Wadebridg	45	110	179	249	325	429	528	622	717	813	883	954	1025	1098	1171	1371	1338	1374

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 A1. Technology adoption in 2035 and 2050 across the three NZCom scenarios

	Baseline	Falling short		Technological transition		Societal transformation	
	2021	2035	2050	2035	2050	2035	2050
Number of homes in area	11980	12,381	12383	12,389	12,396	12,372	12,374
Heat pumps installed	473	3,020	5,670	2,053	6,995	6,454	12,124
32% improvement in energy efficiency by 2030 target		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	4.3

Battery Electric Vehicles non-autonomous and autonomous (number of vehicles)	60	5,214	8,054	5,547	7,645	8,766	6,723
Number of domestic EV chargers (on and off-street)	53	2,129	5,998	4,014	6,759	5,762	6,755

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