Pembrokeshire County Council

Pembrokeshire's Local Area Energy Plan

June 2022

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Contents

This Plan was prepared by Arup and Afallen for Energy Systems Catapult on behalf of Pembrokeshire County Council. Its development was funded by Innovate UK as part of the Prospering from the Energy Revolution (PfER) programme.

Executive summary

In May 2019, Pembrokeshire County Council declared a Climate Emergency, and committed to support Pembrokeshire's journey to net zero carbon by 2050.

This Local Area Energy Plan for Pembrokeshire sets out a vision for what a zero carbon energy system could look like in 2050, and describes key immediate actions for the Council to support our journey.

Our vision for Pembrokeshire's future local energy system is to:

Develop a net zero energy system for Pembrokeshire, as a UK home of green energy.

We will build on our existing strengths, such as a strong drive to decarbonise and involvement in projects like Milford Haven: Energy Kingdom, and achieve this in line with our well-being plan, creating job opportunities and being affordable for all. For our analysis we identified a variety of future whole energy systems scenarios for 2050, to help understand the choices and possible pathways for a net zero local energy system.

We have identified priority intervention areas for the local energy system, taking into account the uncertainties about the future. This plan sets out our key actions for the first five years. We will also monitor progress towards key outputs.

We recognise that we will need support from a wide range of stakeholders and partners to deliver this plan, and look forward to working with you.

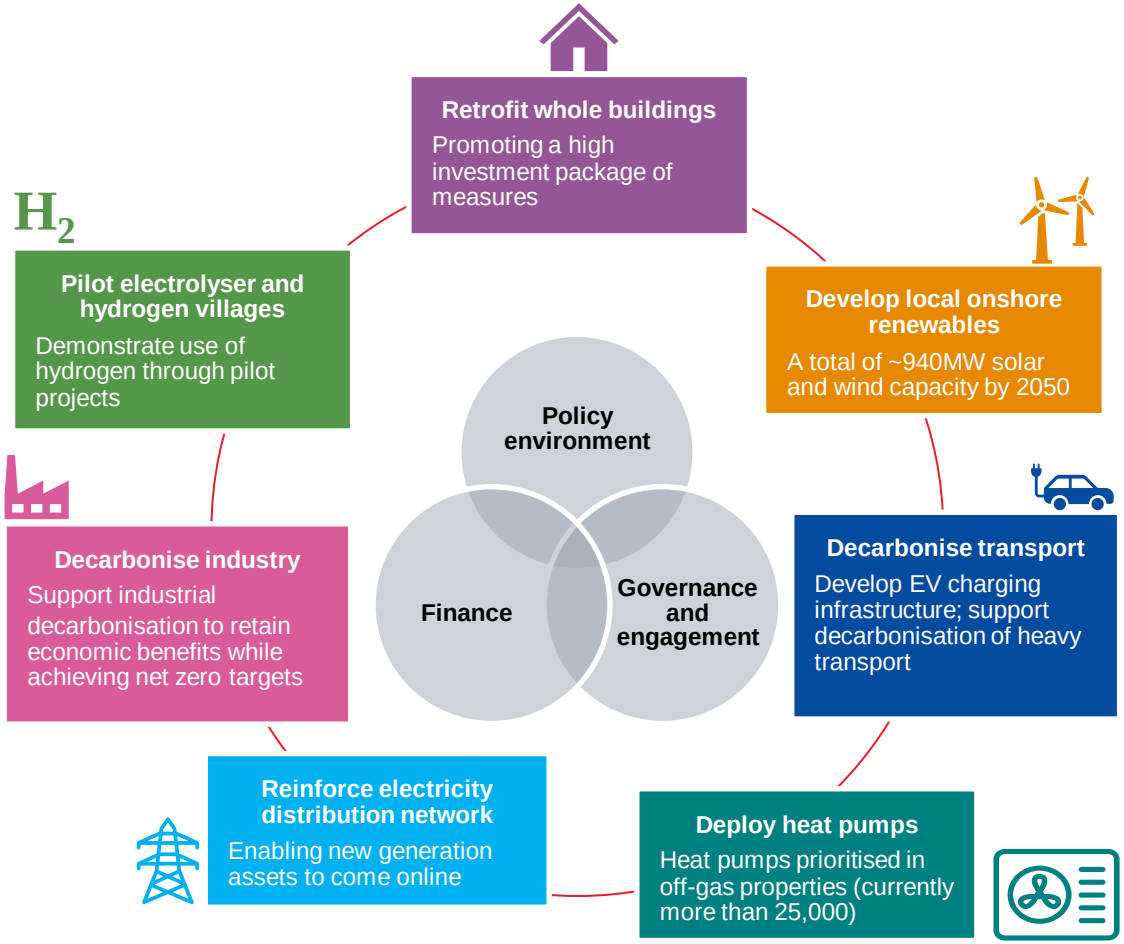


Figure 0: Priority intervention areas in Pembrokeshire

Executive summary

Our Local Area Energy Plan considers several future energy scenarios which we compared based on carbon emissions, energy demand, monetary cost, and jobs creation.

Figure 1 compares projected carbon emissions of our optimised 2050 energy system with the do nothing baseline and the business as usual scenario. The do nothing baseline assumes that Pembrokeshire continues operating as it is today, with no further interventions, resulting in little change from carbon emissions today. This is a baseline for comparison purposes only, and should not be considered as a potential future scenario. The business as usual scenario assumes that Pembrokeshire implements current mandatory UK and Wales carbon reduction targets and policy which almost halves annual carbon emissions, however this does not reach the net zero target.

Our proposed vision for Pembrokeshire's future energy system achieves a net zero emissions energy system by 2050.

Figure 1 highlights the scale of the challenge, and the rapid action that is needed to reach these targets. This LAEP sets out the priority intervention areas for achieving net zero alongside the short- and medium-term routemaps for implementing these strategies shown on the following pages.

Large-scale low carbon interventions across housing, transportation and energy supply will be needed to completely transform Pembrokeshire's energy system by 2050.

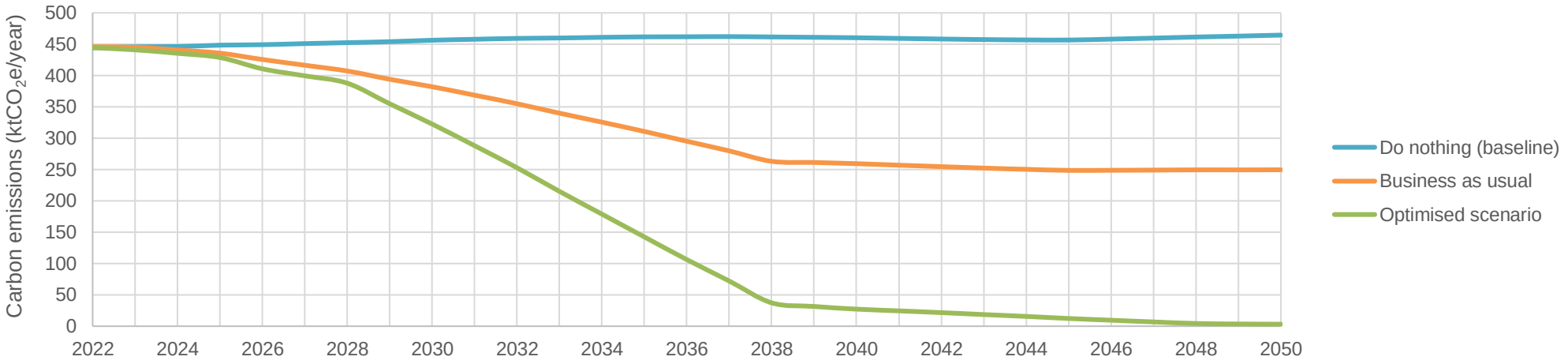


Figure 1: Carbon emissions pathways

Glossary of terms

Term	Definition
Anaerobic digestion	Processes biomass (plant material or biogenic waste) into biogas (methane) that can be used for heating and generating electricity
Batteries	Stored electrical energy to be used at a later time
Bioenergy and waste	Conversion of food waste, energy crops and animal manure into biogas for vehicles
Biomass boiler	A boiler which burns wood-based fuel (e.g. logs, pellets, chippings) to generate heat and/or electricity
Carbon, Capture & Storage (CCS)	The process of capturing and then storing carbon emissions before they enter the atmosphere
Electrolyser	Use electricity to split water into hydrogen and oxygen
Heat pump	Use a heat exchange system to take heat from air or ground and increase the temperature to heat buildings
Hydro-electricity	Use water falling between two reservoirs to turn turbines to generate electricity
Hydrogen	A flammable gas that can be burnt to generate heat or used in a fuel cell to power vehicles. The by-product is water.
Landfill gas	Micro-organisms in a landfill site produce gases such as methane that can be used as a source of energy
LAEP	This is used interchangeably for "Local Area Energy Planning" and "Local Area Energy Plan."

Term	Definition
Lower Layer Super Output Area (LSOA)	Geographical hierarchy comprising populations of1000-300 people or 400-1200 households
Methane reformation	Process of producing hydrogen by heating methane from natural gas and steam, usually with a catalyst
Microgeneration	Small-scale generation of heat and electricity by individuals, households, communities or small businesses for their own use
Power Purchase Agreement (PPA)	A contract between two parties where one produces and sells electricity and the other purchases electricity.
Resistance heating	Generate heat by passing electrical currents through wires
Renewable Energy Guarantees of Origin (REGO) Agreement	A scheme that tells consumers what proportion of their electricity comes from renewable sources
Resistance heating	Generate heat by passing electrical currents through wires
Sewage gas	Use a reciprocating gas engine to convert sewage gas into heat and electricity
Solar PV	Convert solar radiation into electricity using photo-voltaic (PV) cells
Solar thermal	Converts solar radiation into thermal energy used for heating
ULEV	Ultra low emission vehicles
Wind power	Harness wind to turn a turbine to generate electricity

Introduction

Overview

Introduction

In May 2019, Pembrokeshire County Council declared a Climate Emergency and pledged to become a net zero local authority by 2030, including all public sector buildings, streetlighting, and fleet and business mileage.[1] Our Local Development Plan and Well-being Plan outline how we aim to meet local, regional, and national climate targets on the way to Wales and the UK being net zero economies by 2050.[2,3]

By recognising global, national and local climate change trends and taking measured action now through preparation of a Local Area Energy Plan (LAEP), Pembrokeshire not only contributes to the decarbonisation of Wales but also sets the standard for net zero carbon planning in local authorities across the United Kingdom.

What is a LAEP?

Our Local Area Energy Plan (LAEP) provides us with an understanding of the nature, scale, rate, and timings of changes needed for Pembrokeshire's transition to a net zero energy system.

Following Ofgem's methodology, the LAEP process combines robust technical analysis with comprehensive stakeholder engagement to create a routemap for delivering decarbonisation as effectively as possible, identifying actions required by groups including local and national government, energy providers, regulators, industry, and residents.

This process aims to account for the local and national wider conditions to achieve net zero, considering how co-operation with adjacent areas can help to bring success to decarbonising the wider area.

This plan also aims to facilitate increased local stakeholder awareness in Pembrokeshire, resulting in more widespread and meaningful consent for the changes required and credible commitments to deliver the plan.

Please see the technical report for additional detail about the methodology followed, analysis completed and the results of this analysis.

Introduction

Plan contents

Our LAEP presents our vision for a net zero local energy system in Pembrokeshire, with a routemap to achieve it, including a set of actions for us at the Council, whilst recognising the role of other key actors in government, the energy sector and across the community.

Plan structure

This plan is structured in three main topic areas:

1. Where we are now - Description of Pembrokeshire's existing energy system and relevant policies and objectives.
2. Our future vision - Presentation of future scenarios for a net zero local energy system, including risks and "low regrets" measures, which are very likely to be part of the future energy system regardless of uncertainty around certain aspects of the future.
3. How will we get there? - A routemap and action plan for us to use to drive the local energy system transition in Pembrokeshire, including what needs to happen and what we will do.

Figure 2: View of Milford Haven Marina and waterway

2. Where we are now
Socio-economic context

Pembrokeshire's socio-economic context

This section provides an overview of Pembrokeshire through a socio-economic lens, including key statistics on demographic and employment.

Demographic baseline

- The estimated population in 2020 was 126,800 which accounts for about 5% of the population of Wales. Pembrokeshire is one of the most sparsely populated authorities in Wales, at 78.3 people per square kilometre.[4]
- In 2018, fuel poverty affected 15% of households in Pembrokeshire (8,000 households) - higher than the national average for Wales of 12%.[5] Taking account of recent and projected future energy price rises, this figure is likely to be much higher today and will continue to rise through 2022-23
- Pembrokeshire is mainly rural, with various towns including Haverfordwest, Milford Haven, Pembroke, Pembroke Dock and Fishguard
- Higher percentage of 'best and most versatile' agricultural land compared to Wales
- Around 42% of properties in Pembrokeshire are not on the gas grid. This is higher than the average in Wales, at 18%.[6]

Employment

- In Pembrokeshire, the service industry constitutes roughly 70% of the local economy (measured by Gross Value Added (GVA)), similarly to the rest of Wales. Main sectors include agriculture, tourism/hospitality and energy sectors.[7]
- A slightly higher than average proportion of the economy comes from production, at 25% compared to the national 22%. Manufacturing accounts for 64% of this sector – below the 76% average in Wales.[7]
- Construction constitutes a lower than average proportion of the economy, at 6% relative to 7% across Wales, with a high relative proportion of this from civil engineering.[7]

Figure 3: Location of Pembrokeshire in Wales

Description	Information
Area	158,000 hectares
Population (2020)	126,800
Population density	Low
Character	Mainly rural
Off-gas properties	High – 25,300 properties 42 % of total properties
Fuel poverty (2018)	15% of households (8,000)

Table 1: Pembrokeshire profile – key statistics

2. Where we are now
Policy context

Pembrokeshire's policy context

We already have ambitious plans and commitments in place to decarbonise the energy system, and to contribute to wider regional and national sustainability and well-being objectives.

Pembrokeshire

- Pembrokeshire accounts for 3.2% of Wales's emissions (in 2019).[8] Pembrokeshire County Council declared a climate emergency in May 2019, and has a goal to be a net zero carbon local authority by 2030. [1]
- The current Local Development Plan (LDP) was adopted in 2013. This includes 42 policies to enable the delivery of key objectives, including sustainable development. New development proposals must demonstrate a positive social and environmental impact. [9]
- Work on a replacement LDP (LDP 2) is currently underway. An extensive Renewable Energy Assessment was carried out in 2017 as part of this. [10]
- The Well-being Plan for Pembrokeshire includes the following priorities. [3]
    - Living & Working
    - Tackling Rurality
    - Resourceful Communities
    - Protecting our Environment
- The 2022 Well-being Plan consultation identified climate change, loss of biodiversity, and renewable energy capacity as core environmental themes. [3]
- Pembrokeshire Recovery and Regeneration Strategy 2020-2030 highlights Business, Tourism, Place, and People as key themes, with Climate Emergency listed as one of the underpinning themes. [11]

South West Wales

- The South West Wales Energy Strategy aims to reduce emissions in the region by 55% by 2035, in line with achieving net zero by 2050.[12] The priorities outlined for achieving a low carbon vision for South West Wales are:
    - Energy efficiency
    - Electricity generation
    - Smart and flexible systems
    - Decarbonise heat
    - Decarbonise transport
    - Regional co-ordination

Figure 4: South West Wales

2. Where we are now
Policy context

Pembrokeshire's policy context

National

- Both the UK and Welsh governments have set net zero emissions targets for 2050, and the Welsh public sector has set a net zero target by 2030. [13]
- The Welsh Government has set its low carbon delivery plan for 2021-25 and is targeting a reduction of 44% against a 1990 baseline. It considers a just transition to be key, and sees decarbonisation as a means to deliver social and economic justice. [14]
- The Well-being of Future Generations (Wales) Act 2015 provides the legally binding framework for public sector activities to be in line with sustainable development principles in Wales, outlining seven goals for prosperity and sustainability. [15]
- The Net Zero Wales plan, published in October 2021, includes details on how Wales will achieve the second carbon budget, which sets out the goal to reduce emissions by 37% by 2025. [13]
- In Wales, policy commitments include plans for 1GW additional renewables by 2025, and no new builds of fossil fuel generation from 2021. The Welsh Government also aims for 70% of Wales's annual electricity demand to be generated from renewables by 2030, with 1 GW of renewable capacity to be locally owned by 2030. [14]

Figure 5: Wales The Well-being of Future Generations Act

2. Where we are now
Energy system context

Key energy assets and projects

There are existing and proposed energy assets in Pembrokeshire that make a significant contribution to the local and national energy system.

Pembrokeshire's current energy assets are shown in Figure 6. National assets (such as Pembroke Power Station) are directly connected to the transmission network and serve Great Britain, while the solar and wind assets are more likely to be connected to the distribution grid.

In Milford Haven Waterway, 1,200 jobs are related to energy, with around 5,000 jobs in Wales supported by the Waterway.

Milford Haven: Energy Kingdom is a project exploring what a zero carbon local energy system could look like for Milford Haven, Pembroke and Pembroke Dock. The project assessed how hydrogen and renewables can be used to meet the area's energy needs and has a focus on engagement with the community and industry.

The South Wales Industrial Cluster (SWIC) is developing projects to achieve decarbonisation and clean growth. RWE, a partner of SWIC, is developing the Pembroke Net Zero Centre (PNZC). This decarbonisation hub brings together innovative technologies including carbon capture and storage (CCS), floating offshore wind (FLOW), and hydrogen production with the aim of decarbonising industry.

There are a number of proposals for offshore wind off the coast of Pembrokeshire.

The Greenlink interconnector is a 500 MW proposed subsea and underground electricity interconnector cable between Pembroke substation and Great Island substation in Cour Wexford, Ireland. This development will not c deliver further energy security, regional investment, and connectivity with Ireland and Europe, but will also facilitate the integration renewable energy sources.

In Pembrokeshire there are also several community energy groups that contribute to th development of solar rooftop and community wind turbines. For example, Egni Co-operativ a community organisation that develops roofto solar PV projects in Wales and have developed multiple sites in Pembrokeshire including schools, community centres, and village halls.

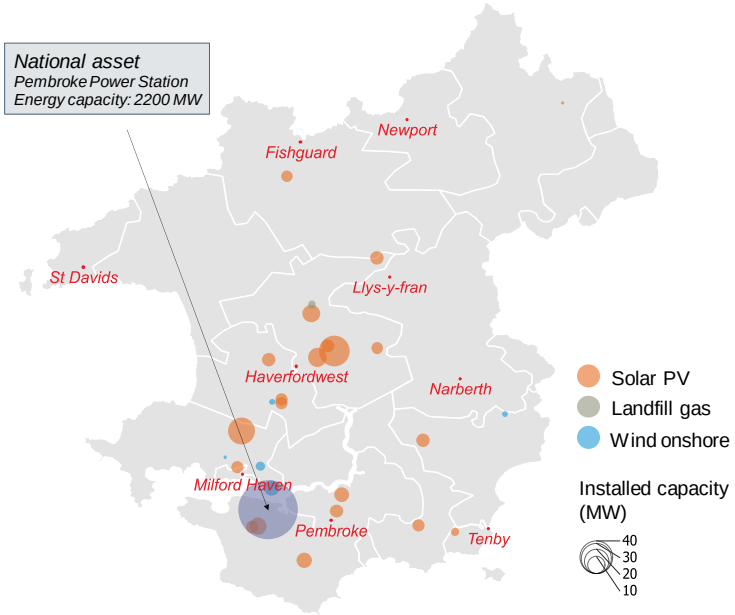


Figure 6: Pembrokeshire's energy assets [16]

2. Where we are now

Greenhouse gas emissions context

Historic greenhouse gas emissions

Pembrokeshire's greenhouse gas emissions have been decreasing over the past 15 years, following the trend of the wider UK emissions. Figure 7 shows emissions by sector in Pembrokeshire since 2005, based on data published by the UK Government.[17] It should be noted that while local industry is included in this data, large national assets, such as Pembroke Power Station, are not.

The historic trend is largely driven by the decarbonisation of the electricity grid, leading to reductions across most sectors, with the greatest percentage reduction in public sector emissions. Land use, land use change and forestry emissions (LULUCF) are slightly positive (+38 $ktCO_2$ in 2005), but from 2013 they become negative (reaching -25.5 $ktCO_2$ in 2019).

These negative emissions reflect the county's extensive and thriving rural and natural areas but they offset only a very small share of the county's total emissions.

Emissions in 2019 amounted to 760 $ktCO_2$.[17]

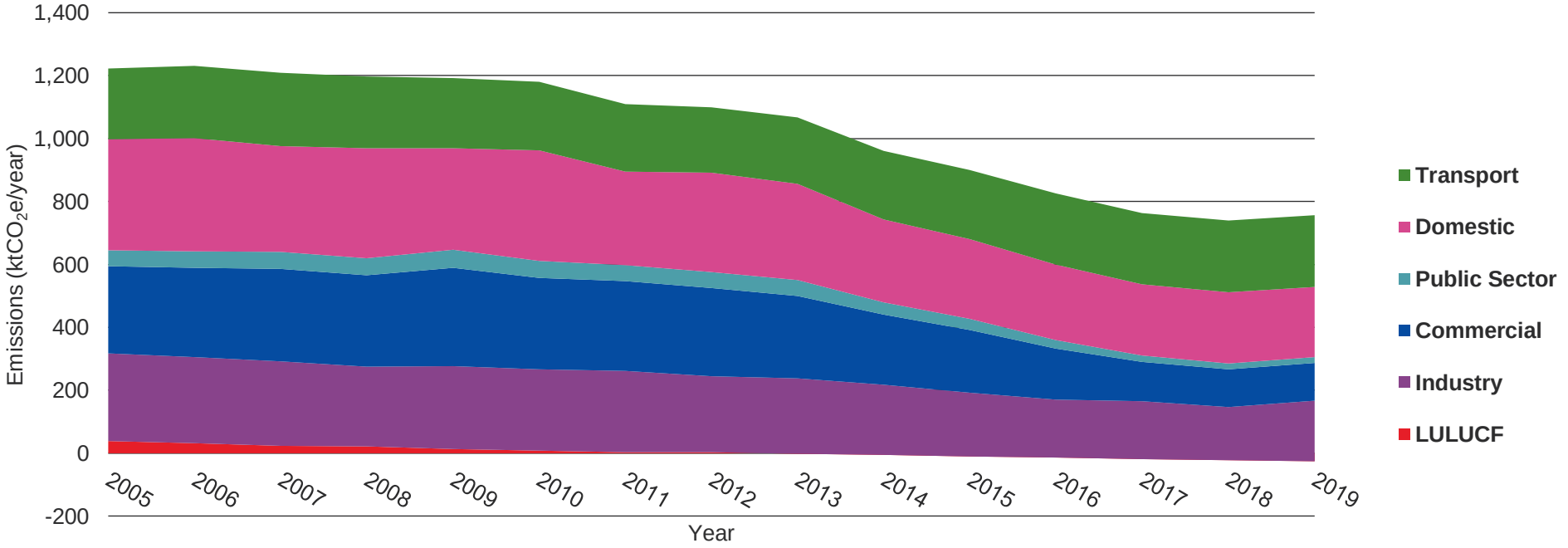


Figure 7: Pembrokeshire greenhouse gas emissions 2005-2019

2. Where we are now
Energy system context

Our control and influence as a Local Authority

We have a varied degree of control and influence over emissions sources. The UK Government reports emissions that are within the boundary of the local authority (territorial emissions), and also notes those that are within the Council's scope of influence.

The emissions from national assets are significantly higher than the local emissions, as shown in Figure 8.[18] As these are outside the local authority scope of influence, these elements have not been modelled.

It was agreed that the modelling boundary should omit any national level generation assets and focus on assets connected to the distribution level energy networks. The items highlighted in red in Table 2 are excluded from the modelling boundary. Those highlighted in green are included in the modelling. Heat demand and production are local, and can be provided locally, whereas national generation assets are assumed to provide for the nation. While national assets have been excluded from the modelling, we have included actions where we can influence and support decarbonisation of these industries.

Our large industrial assets (national assets) include: Pembroke Power Station (RWE Generation UK), Pembroke Refinery (Valero Energy), South Hook LNG Terminal, and Dragon LNG Terminal. These are considered national assets and therefore their electrical requirements are not included in the LAEP.

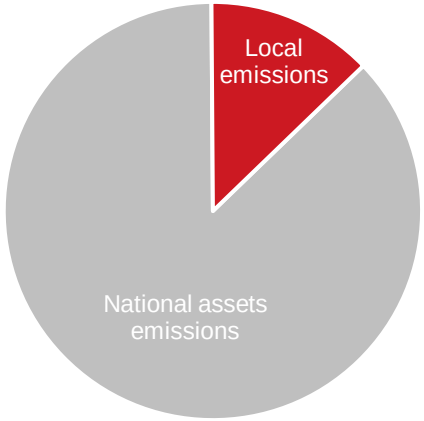


Figure 8: Impact of national assets on Pembrokeshire's 2019 emissions

Sector	Heat included in modelling boundary	Electrical demand or generation included in modelling boundary	Included in LAEP
Local industry (e.g. creamery)	Heat demand included in boundary	Electrical requirements included in boundary	Actions for decarbonisation are included in the LAEP.
National assets (e.g. Pembroke Power Station)	Waste heat has been considered for heat networks	Electrical generation not included	
Offshore wind and tidal lagoons		Electrical generation not included	

Table 2: Modelling and LAEP boundaries

2. Where we are now
Energy system context

Understanding the energy system in 2019

Pembrokeshire's current energy system comprises three mainly separate systems for heating, electricity and transportation. Figure 9 provides a "Sankey" diagram which, when read from left to right, shows how different energy sources (i.e. fuels and renewable energy resources) meet various types of demand via energy vectors or conversion technologies. [18, 19, 20, 21]

The majority of heating comes from gas and other forms of off-grid fossil fuels (oil/solid/coal), while almost all transport demand is currently met by petrol and diesel. Demand for electricity in transport is excluded from this diagram because it is too small to show.

Pembrokeshire's local electricity system is already very low carbon: around 70% of local electricity is supplied by renewables, with the remaining 30% from National Grid imports. In this diagram, local sources of renewable electricity have been shown separately from National Grid imports, even where these local sources are connected to the grid. It is assumed that local renewables are utilized when possible, so the national grid imports shown here represent the net electricity required to supplement renewables.

In order to achieve our net zero ambitions, we need to move away from using natural gas, oil/solid/coal, diesel and petrol. This poses a challenge.

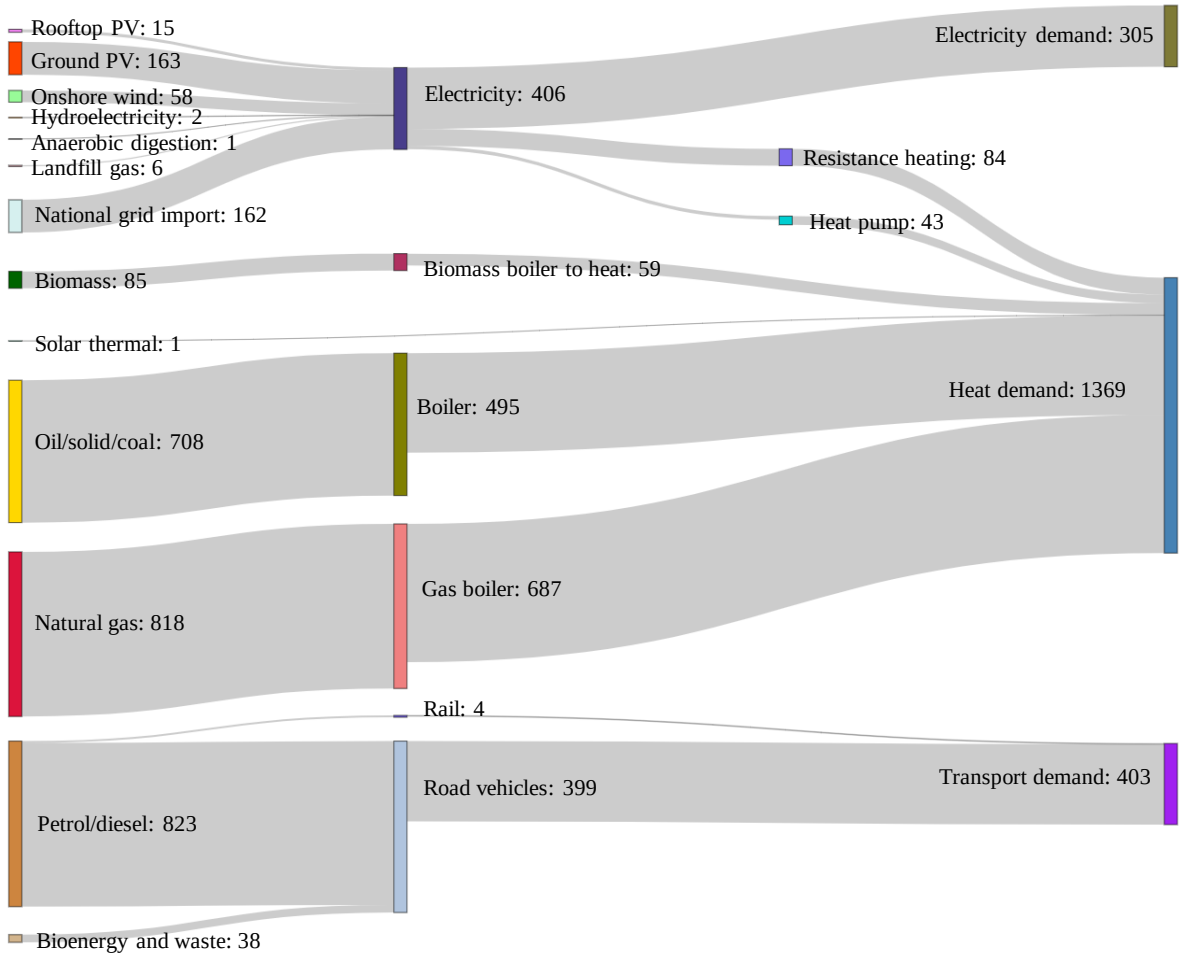


Figure 9: Sankey diagram of energy flows in Pembrokeshire in 2019 (GWh/year)

2. Where we are now
Energy system context

Current energy consumption

In 2019, Pembrokeshire's total energy consumption across commercial, domestic and industrial sectors (excluding national assets) totalled 2,880 GWh.

Electricity

Pembrokeshire's electricity demand in 2019 (excluding national assets) totalled 305 GWh.[19, 22] The distribution of electricity demand is shown in Figure 10. Note that industrial electricity is *assumed* to be a national asset and has been excluded from our modelling because the local authority has limited control over it, and it impacts the national system rather than the local system. In 2019, Pembrokeshire generated aroun 240 GWh of renewable energy.[20] The majority of this was generated from ground PV, onshore wind and rooftop PV.

Transport

In 2019, the total energy demand from transport i Pembrokeshire was 400 GWh, of which 98% was accounted for by road transport. [21]

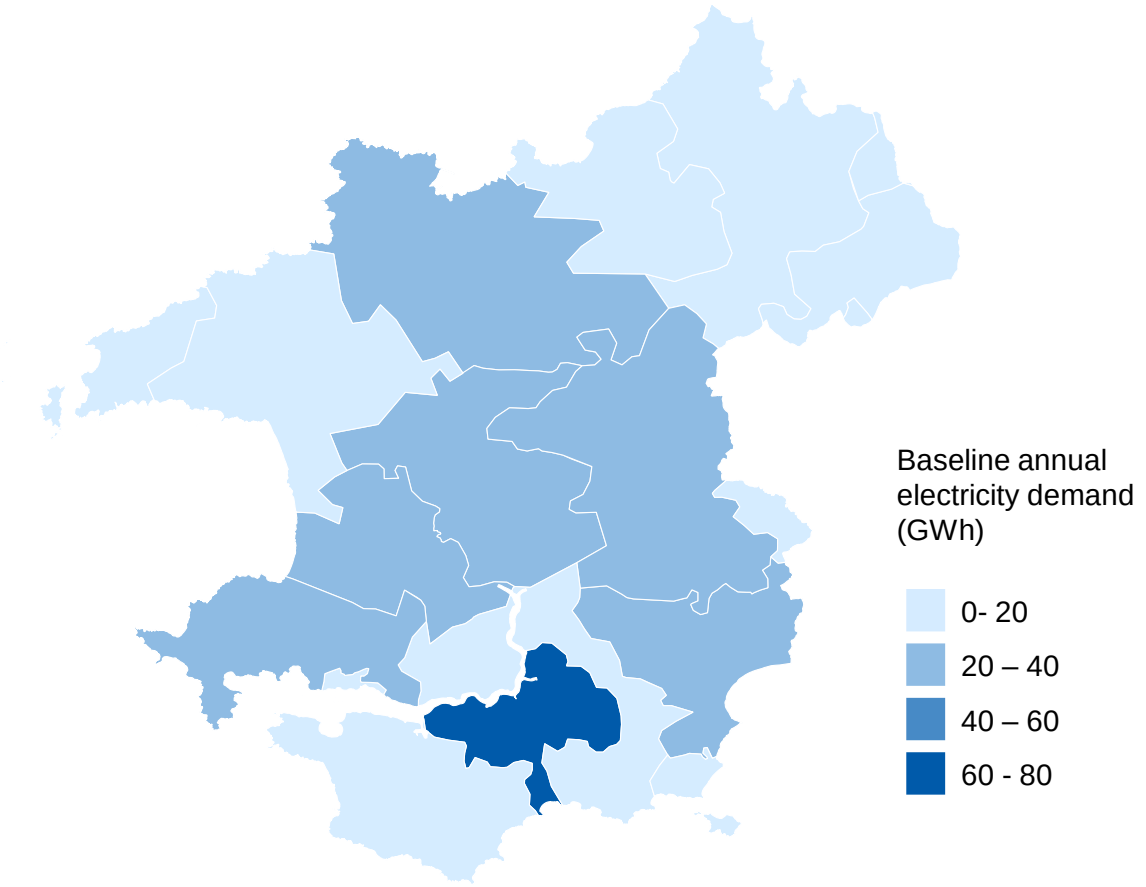


Figure 10: Baseline electricity demand density

2. Where we are now
Energy system context

Current energy consumption

Heat

Pembrokeshire's 2019 heat demand was around 1,400 GWh. The heat demand density has a similar distribution to electricity demand, as shown on page 16 [19, 23]

Figure 11 shows the distribution of properties off the gas grid across Pembrokeshire. Large rural areas are off the gas grid and are either using oil or electricity for heating. More densely populated areas such as Milford Haven, Pembroke Dock and Haverfordwest rely on the gas network for heating.

Approximately 42% of homes are off the gas grid, compared to 18% off-gas properties for the whole of Wales. Figure 12 shows further details on the split of fuel sources for properties which are off the gas grid.[24]

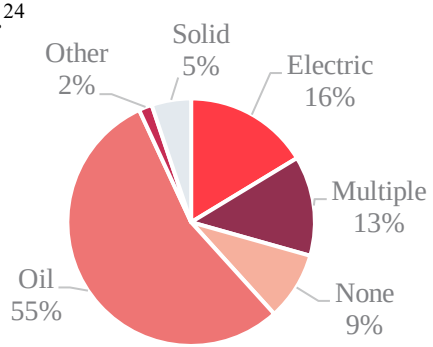


Figure 12: Fuel sources of off-gas grid properties

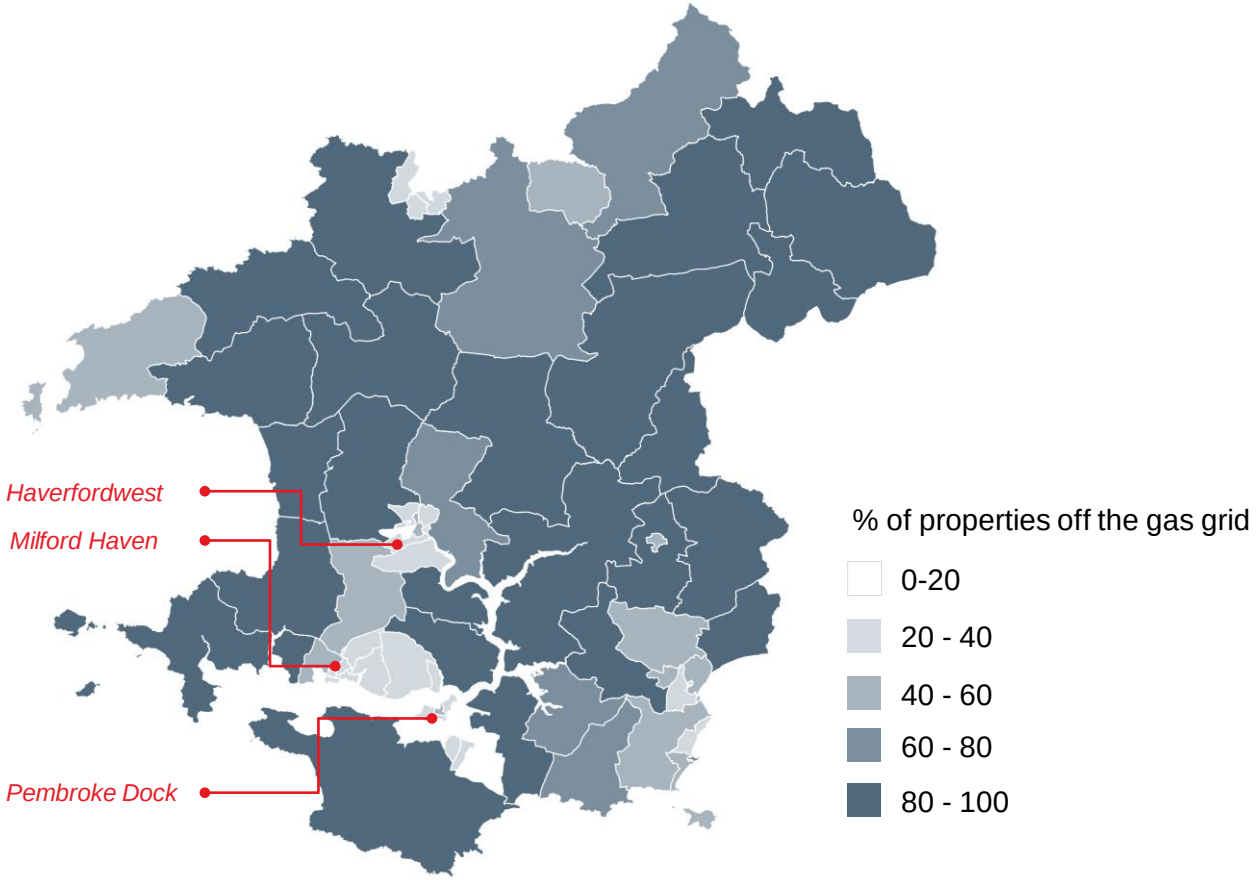


Figure 11: % of homes off the gas grid by Lower Layer Super Output Area (LSOA)

3. Our vision for Pembrokeshire's future local energy system

Our vision

Develop a net zero energy system for Pembrokeshire, as a UK home of green energy.

Objectives of the plan

- *To achieve a 'least cost' net zero pathway.*
- *To empower the local economy, supporting tourism and the creation of local renewable jobs.*
- *To provide community engagement, leadership, and ownership.*
- *To provide a resilient energy system capable of meeting future energy demand and resilient to climate change.*
- *To support agriculture and the rural economy, ensuing the best use of land.*
- *To identify actions which enable local ownership and participation in investments for a net zero energy system.*
- *To deliver affordable solutions for all, reducing fuel poverty and supporting off-gas grid customers.*
- *To facilitate innovation to support UK decarbonisation.*

Developing our vision and objectives

As described in our technical report, we developed our vision and objectives with our stakeholders.

Understanding the future energy system

We know that we need to transition our energy system in Pembrokeshire to net zero by 2050.

However, we know that there are multiple plausible and attractive future energy systems for Pembrokeshire, depending on a range of factors. This includes how the cost of technologies might change over time, as well as wider policy decisions that will be made by Welsh and UK Governments. These factors will influence the uptake of hydrogen, for example.

In order to inform our plan, we modelled a range of scenarios, and from this we identified a number of technologies that are consistently deployed across all future scenarios. These technologies represent low- and no-regrets actions which are very likely to be important parts of the future energy system, regardless of the uncertainty around certain aspects of the future. These low- and no-regrets actions can be taken now to set Pembrokeshire on track to a net zero carbon future.

Through this analysis, we identified the commonalities that will support us in meeting our vision and objectives. This forms the basis of our plan. We are confident that these actions will be required regardless of any future uncertainties.

3. Our vision for Pembrokeshire's future local energy system
Future scenarios and pathways

2050 system scenarios

For our analysis, we identified a variety of future whole energy system scenarios for 2050, to help understand the choices and preferred pathways for a net zero local energy system. The scenarios built on a pair of energy demand scenarios (high and low). These incorporated both different projections of growth in Pembrokeshire and different scenarios for energy efficiency through building retrofit and transport mode shift. Consumer perception is not incorporated in this work because our research shows that consumers do not feel they have a meaningful, real and free choice in the way they heat their homes and perceived lack of guidance and protection makes consumers feel exposed to an unacceptable level of risk and reluctance to engage in the energy transition.[25]

Hourly modelling over a full year was carried out to optimise the scenarios.

The Sankey diagrams on the following pages (Figures 14-17) show a mix of energy sources and vectors that most optimally meet the projected demand over the year, given the conditions set in each scenario.

Each of these diagrams represents a potential energy future for Pembrokeshire, and these have been considered alongside local and regional strategic priorities to identify the actions described in this report. The four scenarios modelled were:

- High demand – higher population and economic growth and shallow retrofit (properties typically achieving EPC C)
- High demand with high hydrogen uptake
- High demand in an islanded scenario (i.e. where Pembrokeshire is not importing or exporting electricity to/from national grid)
- Low demand – low growth and deep retrofit (properties achieving EPC A)

Comparison of all of these with the baseline scenario shown in Figure 9 highlights a key fundamental change in the energy system: moving from three semi-isolated systems for heat, electricity and transport to a single integrated energy system which depends on the complex interconnections between energy vectors. In all scenarios there is a massive growth in the scale of the electricity network, as large parts of heat and transport energy demand are met from electrical power sources.

Energy transition pathway scenarios

We developed a series of pathway scenarios to show the rate at which the energy system change impacts on our ability to reduce associated carbon emissions. These scenarios have been prepared using estimates for the rate of demand increase and potential decarbonisation deployment rates.

In addition to the pathways for the four main 2050 scenarios, we developed two additional counterfactual scenarios:

- Do nothing, following current market trends with limited energy transition interventions
- Business as usual (BAU), based on current policies and market trends

Our scenarios demonstrate the rate and scale of change required at both a local and national level to reach net zero compared to the do nothing and BAU scenarios.

3. Our vision for Pembrokeshire's future local energy system

Future scenarios and pathways

Future scenarios

Radical changes to the current energy system are required to achieve net zero in Pembrokeshire by 2050.

As shown in Figure 13, this requires a transition from fossil fuel based heating and transport to low carbon alternatives using electricity and hydrogen. This results in a significant increase in overall electricity requirements, implying major grid reinforcements. As the system becomes more reliant on the electricity network, local renewables become key to from a resilience perspective.

Demand reduction through retrofit measures and model shift in transport is also required to minimise energy generation requirements and overall costs.

	Key changes from baseline to 2050 scenarios	Variations in specific 2050 scenarios
Transport demand	• Demand reduction from modal shift and active transport	
Heat demand	• Similar demand to current one, demand increase from population / commercial growth offset by retrofit improvements	
Hydrogen demand	• Additional hydrogen demand industries and specific transportation (e.g. HGV)	• High hydrogen scenario – additional requirements for hydrogen boilers
Electricity demand	• 80% increase from current demand due to population / commercial growth, with limited reduction from retrofit	
Transport generation	• Transition from fossil fuel vehicles to EVs and hydrogen vehicles	
Heat generation	• Transition from fossil fuels to 100% heat pumps	• High hydrogen scenario – 58% heat pumps, rest though hydrogen boilers • Islanded scenario – hydrogen CHP network
Hydrogen generation	• Mix of electrolyser and hydrogen import	• Proportions vary across different scenarios
Local renewables	• At least 3x current capacity • Mainly from rooftop and group PV	• Islanded scenario - increased anaerobic digestion to meet demand
Electricity network	• 3x electricity requirements compared to current requirements • Major grid reinforcement required	

Figure 13: Key changes in 2050 scenarios compared to baseline

3. Our vision for Pembrokeshire's future local energy system

Future scenarios and pathways

3x electricity system compared to baseline

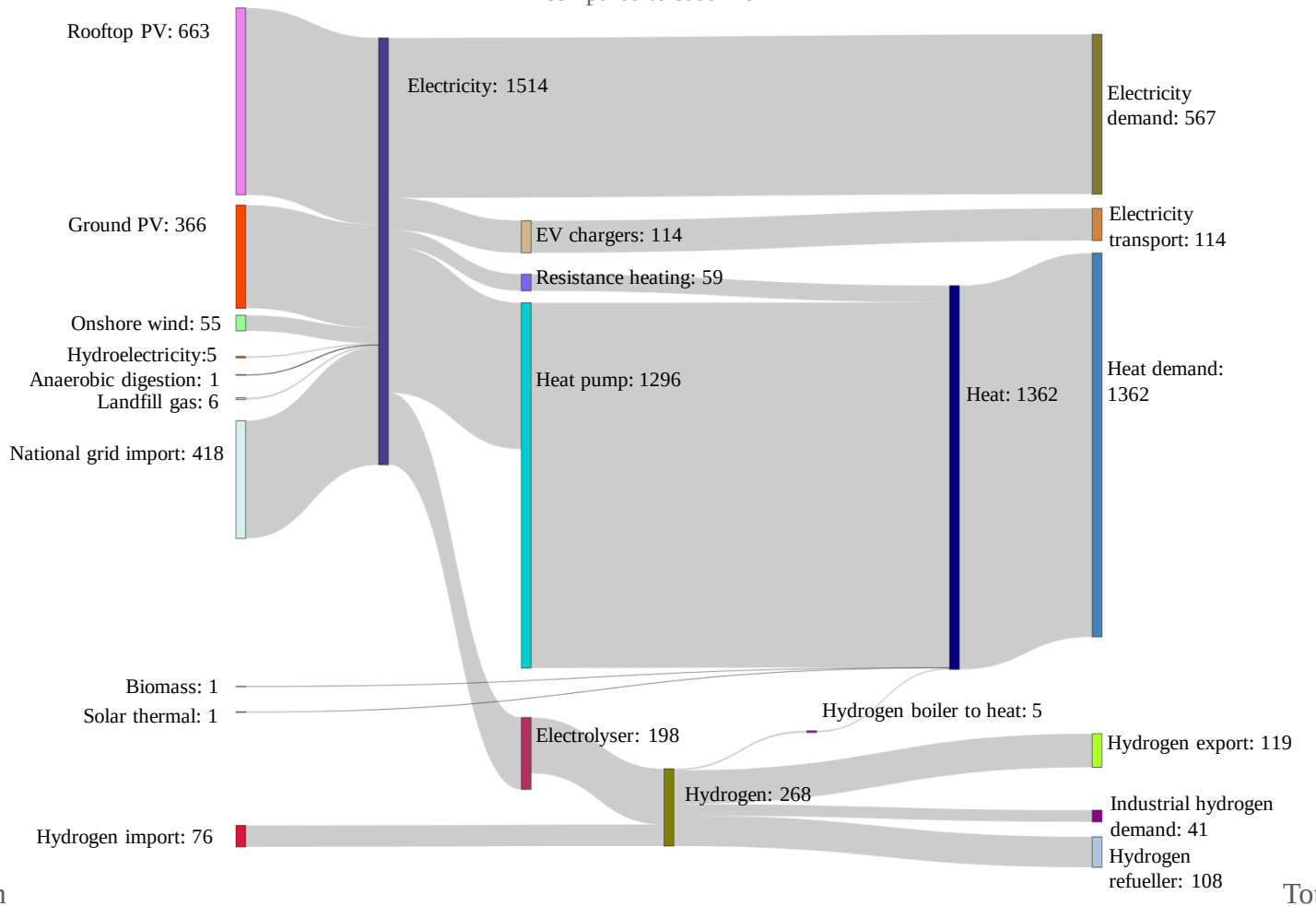
Significant increase in rooftop PV from baseline

Ground PV:
~ 330MW total = 5 km^2 = 900 football pitches = <0.2% land area of Pembrokeshire

Onshore wind remains unvaried from baseline

28% of electricity imported from grid

Hydrogen mainly provided by electrolysis within the LA (93MW)



~ 300GWh/year of total energy demand increase from baseline

Electrification of transport

42% of transport is assumed to become active

Electric demand increased through high population and economic growth

Heat demand met mainly through heat pumps

Heat demand increased through high population and economic growth, low retrofit measures included

Hydrogen used for industrial heat and specific transportation (e.g. HGV)

Total input: 1,591 GWh

Total output: 2,311 GWh

Figure 14: Energy flows in the 2050 high demand scenario (GWh/year)

Text in red shows differences between scenarios

3. Our vision for Pembrokeshire's future local energy system

Future scenarios and pathways

3x electricity system compared to baseline

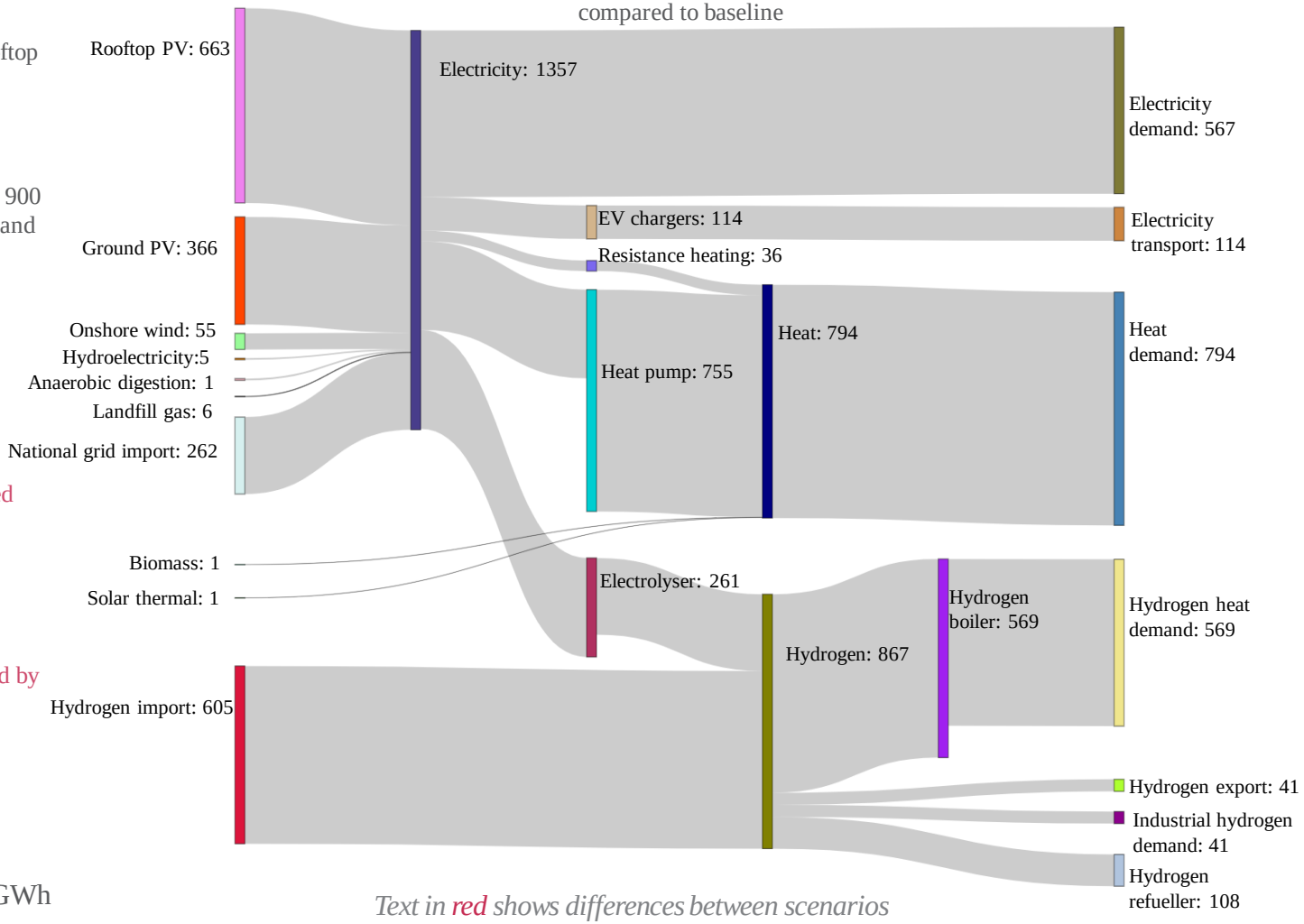
Significant increase in rooftop PV from baseline

Ground PV: ~ 330MW total = 5 km^2 = 900 football pitches = <0.2% land area of Pembrokeshire

Onshore wind remains unvaried from baseline

19% of electricity imported from grid

Hydrogen mainly provided by electrolysis within the LA (105MW) and hydrogen imports (262MW)



Total input: 1,966 GWh

Text in red shows differences between scenarios

~ 300GWh/year of total energy demand increase from baseline

Electrification of transport

42% of transport is assumed to become active

Electric demand increased through high population and economic growth

42% of heat demand met with hydrogen boilers, 58% met with heat pumps

Heat demand increased through high population and economic growth, low retrofit measures included

Hydrogen also used for industrial heat and specific transportation (e.g. HGV)

Hydrogen transport is slightly lower in this scenario as the model prioritized hydrogen for heating.

Total output: 2,233 GWh

Figure 15: Energy flows in the 2050 high hydrogen scenario (GWh/year)

3. Our vision for Pembrokeshire's future local energy system

Future scenarios and pathways

3x electricity system compared to baseline

Significant increase in rooftop PV from baseline

Ground PV:
~ 330MW total = 5 km^2 = 900 football pitches = <0.2% land area of Pembrokeshire

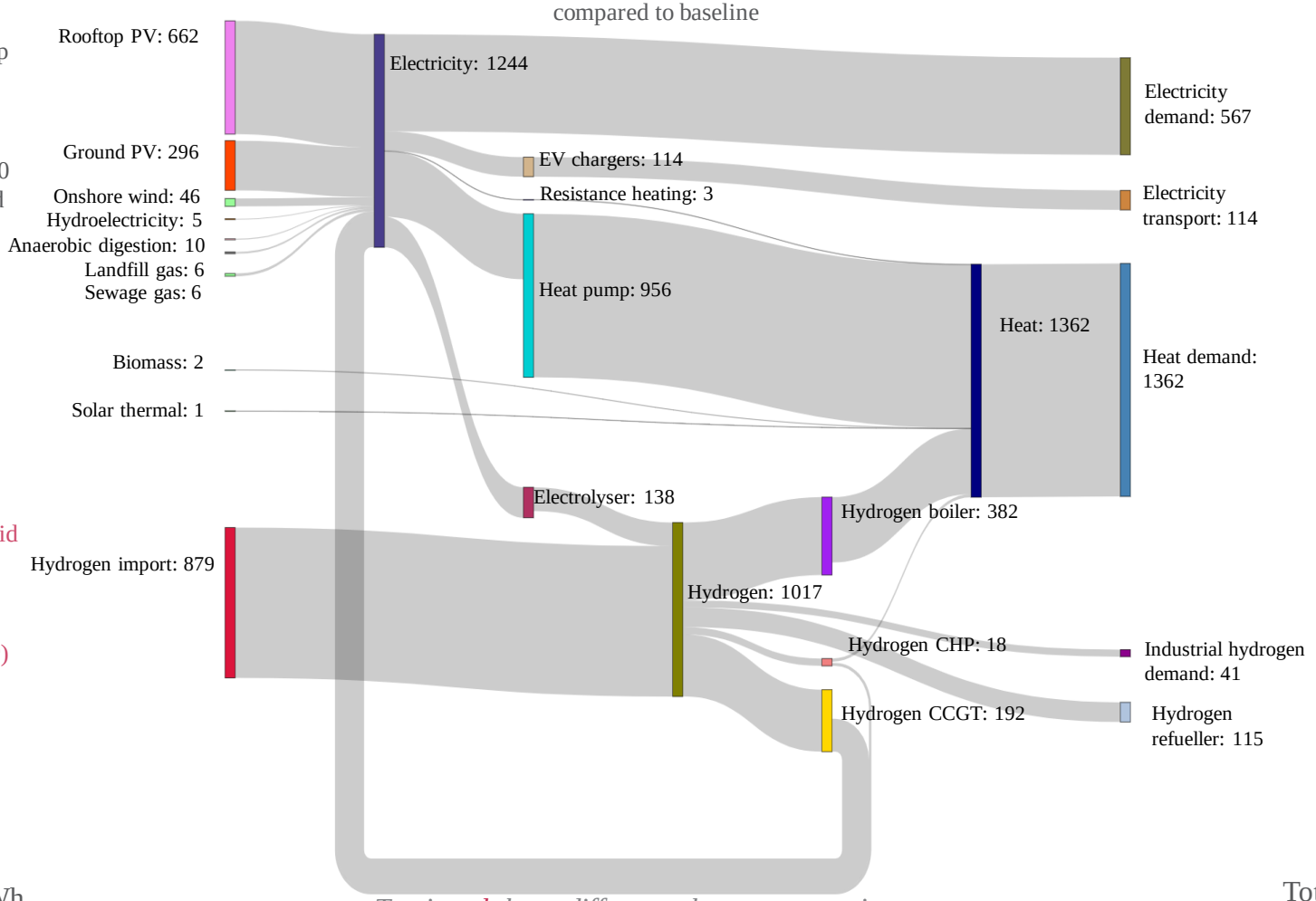
Onshore wind remains unvaried from baseline

Electricity production from anaerobic digestion

No electricity import from grid

Milford Haven Heat Network (fed by Hydrogen CHP boiler)

Hydrogen mainly imported (492MW)



~ 300GWh/year of total energy demand increase from baseline

Electrification of transport

42% of transport is assumed to become active

Electric demand increased through high population and economic growth

Heat demand increased through high population and economic growth, low retrofit measures included

Heat demand met mainly though heat pumps, with some hydrogen for heating

Heat network supplied by a Hydrogen CHP contributing to meeting heat demand

Hydrogen also used for industrial heat and specific transportation (e.g. HGV)

Total input: 1,918 GWh

Text in red shows differences between scenarios

Total output: 2,391 GWh

Figure 16: Energy flows in the 2050 islanded high demand scenario (GWh/year)

3. Our vision for Pembrokeshire's future local energy system

Future scenarios and pathways

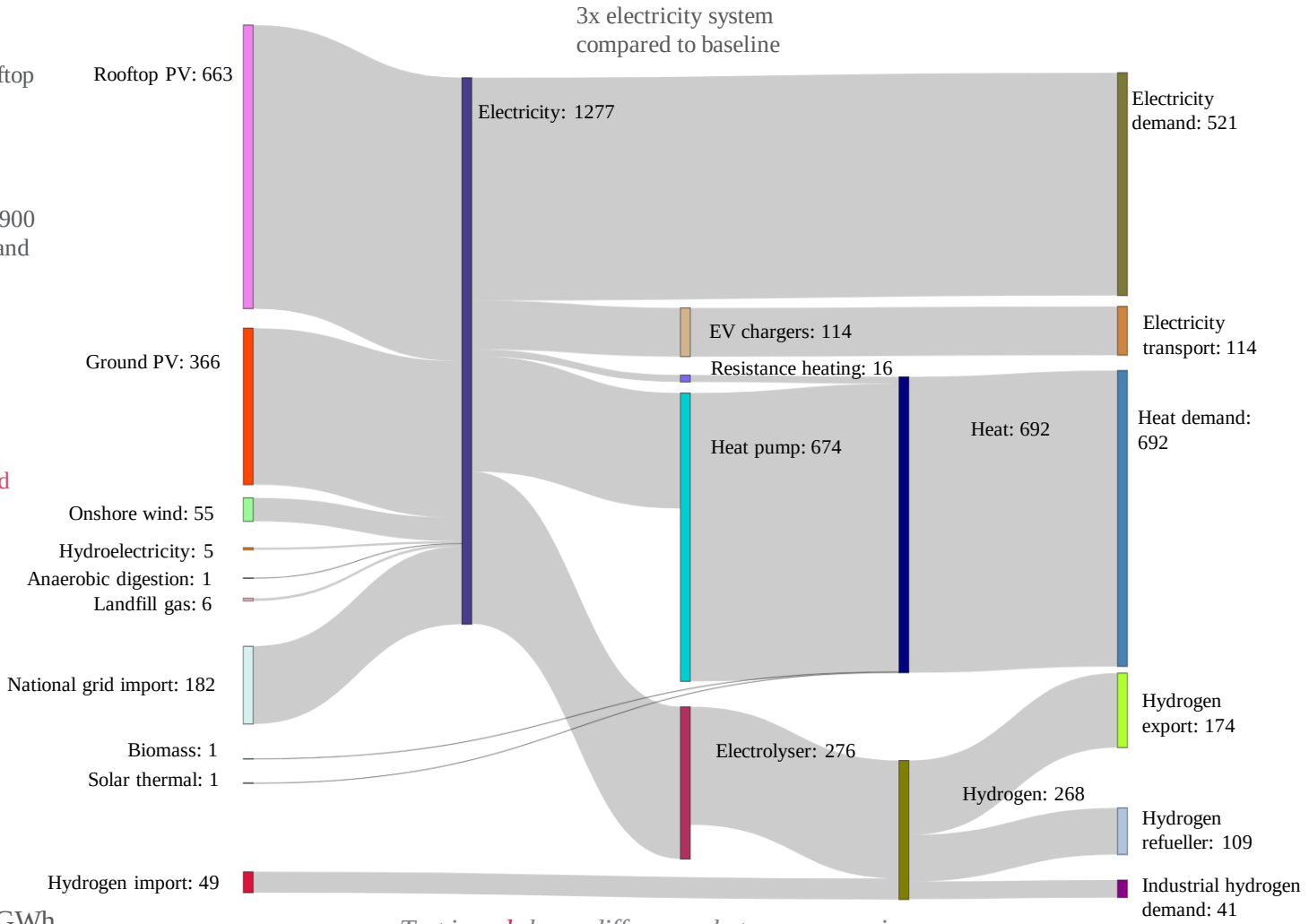
Significant increase in rooftop PV from baseline

Ground PV:
~ 330MW total = 5 km^2 = 900 football pitches = <0.2% land area of Pembrokeshire

Onshore wind remains unvaried from baseline

14% of electricity imported from grid

Hydrogen mainly through electrolysis within the LA (112MW)



Total input: 1,329 GWh

Text in red shows differences between scenarios

~ 400GWh/year of total energy demand decrease from baseline

Electrification of transport

42% of transport is assumed to become active

Electric demand increased through low population and economic growth

High retrofit measures result in significant heat demand reduction

Heat demand met mainly though heat pumps

Hydrogen also used for industrial heat and specific transportation (e.g. HGV)

Total output: 1,651 GWh

Figure 17: Energy flows in the 2050 low demand scenario (GWh/year)

3. Our vision for Pembrokeshire's future local energy system

Energy and emissions pathways

We developed a series of potential future pathways for Pembrokeshire's energy system based on the four optimised scenarios modelled, and compared these to the business as usual scenario. The do nothing represents the baseline and is shown for comparison purposes only. As such, it should not be considered as an option for the future. Our pathways explore how the different deployments of technologies in each scenario affected the energy consumption, carbon emissions, and total cost between 2022 and 2050.

Figures 18 and 19 on page 26 show the annual projected carbon emissions and energy consumption in Pembrokeshire to 2050.

Figure 18 shows how all four of the optimised future scenarios reach net zero carbon by 2050, albeit at different rates due to the different energy mixes and deployment rates. The low demand scenario decarbonises the fastest due to an extensive retrofit programme while the high hydrogen scenario is the slowest as this relies more heavily on green hydrogen infrastructure being deployed before the energy system can become net zero carbon. The do nothing (baseline) remains highly carbon intensive up to 2050; indeed the annual carbon emissions increase due to the growing population's increasing energy demand with no measures put in place to reduce the carbon intensity. The business as usual scenario is situated between the do nothing and optimised scenarios, decarbonising slightly due to some renewable uptake and national grid projected decarbonisation. However, the business as usual scenario does not reach net zero carbon by 2050 (220 $ktCO_2e$ projected in 2020), which suggests that current national policy commitments are not sufficient to reach net zero carbon targets in 2050.

Figure 19 shows how Pembrokeshire's annual energy consumption would change between today and 2050; it can be seen that decarbonisation is not directly related to a reduction in consumption, rather it is attributed to a transition to renewable energy sources. Indeed, every modelled scenario except the low demand optimised scenario sees an increase in overall annual energy consumption due to a growing population in the area.

The high demand scenario results in the highest 2050 energy consumption of 2,300 GWh/year. A small peak can be seen in the years 2028-2031 in this scenario which corresponds to an increase in the amount of hydrogen exported. This increase is countered by retrofitting properties in the 2030s which reduces heating.

The low demand scenario has a significant decrease in annual energy consumption to 1,700 GWh/year in 2050. This reduction in energy consumption is achieved by implementing high levels of retrofit to insulate all properties to EPC rating A, compared with the high demand scenario retrofitting all properties to EPC rating C.

3. Our vision for Pembrokeshire's future local energy system

Energy and emissions pathways

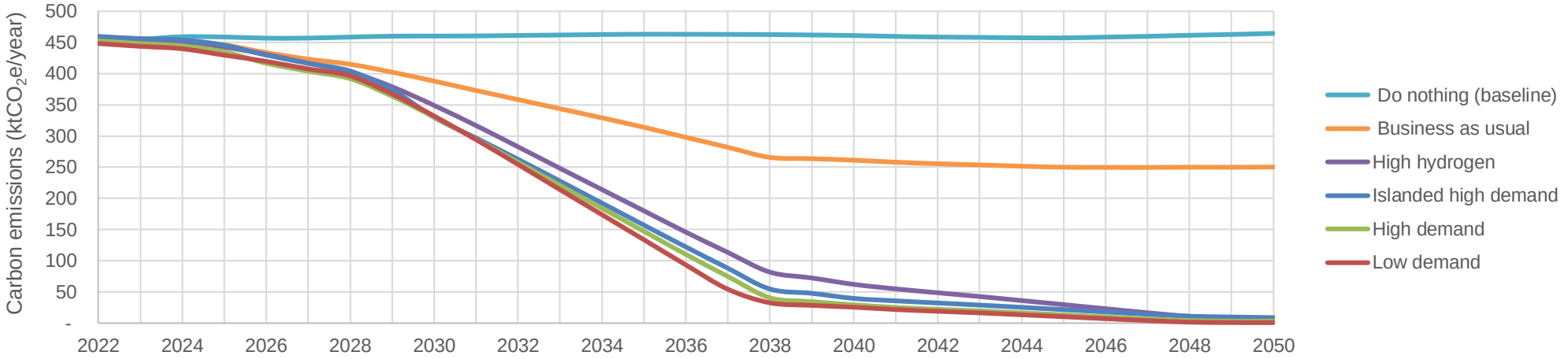


Figure 18: Projected annual future emissions in Pembrokeshire

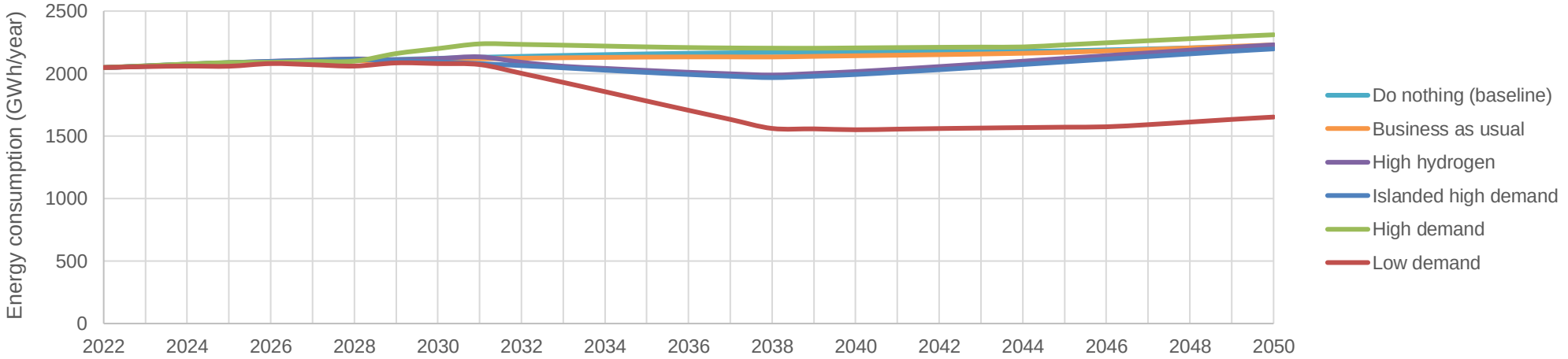


Figure 19: Projected annual future energy consumption in Pembrokeshire

3. Our vision for Pembrokeshire's future local energy system

Energy and emissions pathways

Figure 20 shows the projected cumulative total costs (CAPEX and OPEX) change between 2022 and 2050.

As expected, the do nothing baseline has the lowest cumulative cost. However, this should not be considered as a potential future pathway and is shown just for comparison purposes.

Most of the optimised scenarios have cumulative costs around £5 billion by 2050, with the exception of the low demand scenario.

The low demand scenario is the highest cost scenario, with a cumulative cost of £6.1 billion by 2050, due to the extensive retrofit program, as described on page 25. However, large amounts of retrofit provides several further benefits beyond energy demand reduction: local employment for the installation of the retrofit measures, a greater reduction in fuel poverty, and reduced strain on the electrical grid.

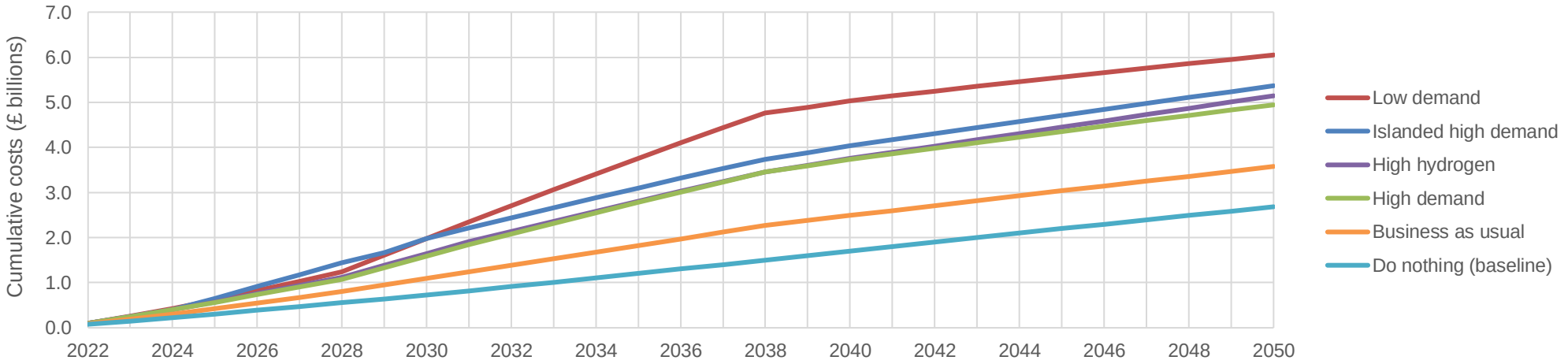


Figure 20: Projected cumulative costs (CAPEX and OPEX) required

3. Our vision for Pembrokeshire's future local energy system

Priority intervention areas

The modelling presented on the preceding pages shows the radical change which is necessary to create a net zero local energy system in Pembrokeshire. Across all our net zero solutions, we conclude that the least cost pathway to net zero will involve huge investment and profound changes to where, when and how we create and use energy, with our priority intervention areas set out in Figure 21.

Delivery of the wider objectives of our plan will need to be supported by the right governance and engagement, policy environment and financing solutions.

There are numerous interdependencies and interactions between the priority intervention areas, as shown on page 31.

This highlights the importance of a whole system approach with a co-ordinated programme of delivery to meet the net zero target by 2050.

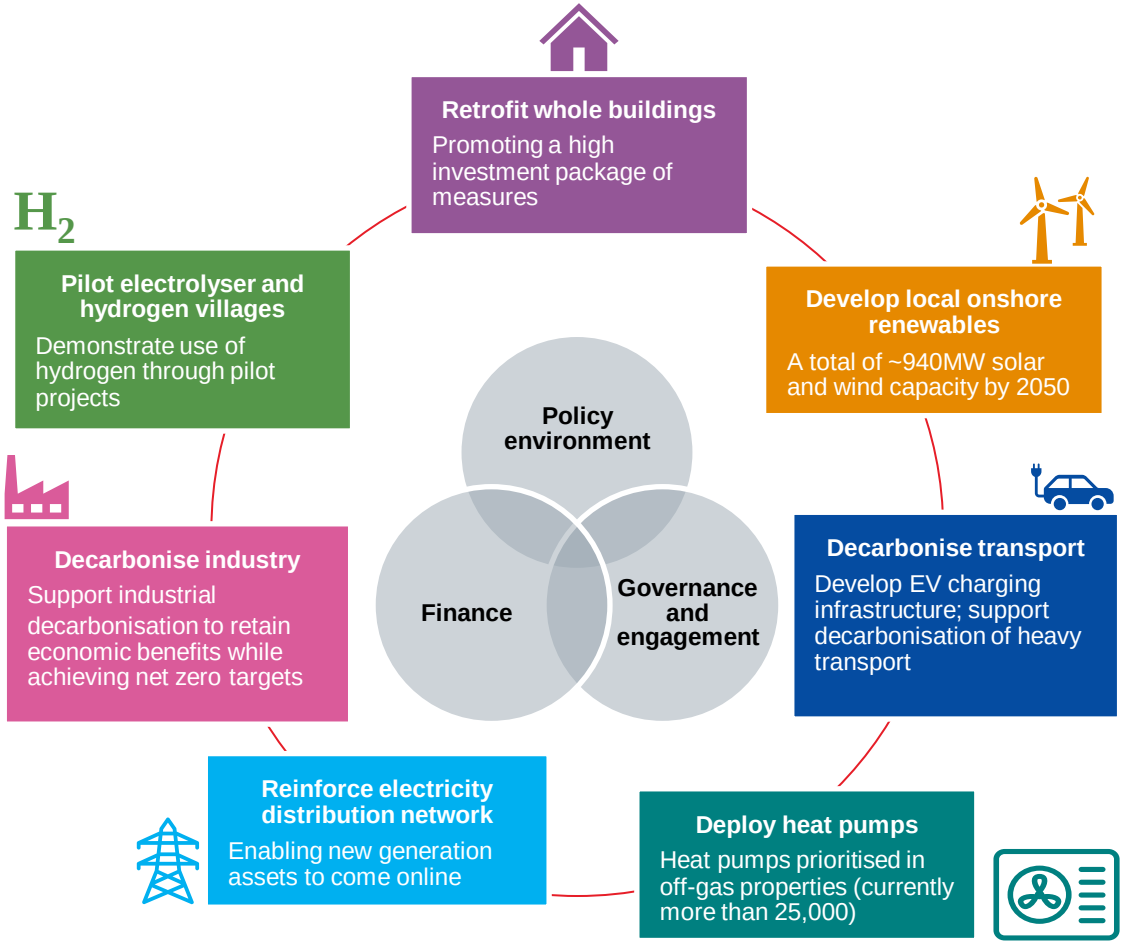


Figure 21: Priority intervention areas in Pembrokeshire

3. Our vision for Pembrokeshire's future local energy system

Priority intervention areas

We plan to deliver actions to support physical changes to the energy system as follows:

1. Whole building retrofit

Reducing energy demand of buildings through retrofit reduces the need for development of new generation assets, and potential associated grid reinforcements. Reduction in energy demand will also reduce energy bills, which will help us to support fuel poor households.

Through community engagement, government incentives and planning measures we will encourage the private sector to pursue high investment in retrofit, which includes external, loft and under floor insulation measures, smart metering, window sealing, external solar devices, triple glazing and air tightness.

We need at least 65% of homes (~40,000 properties) to have retrofit measures installed, representing approximately £300 million of investment, subject to availability of skilled labour. Indeed, skills shortages in the local workforce pose a fundamental barrier to the implementation of all interventions, in particular the large-scale and fast delivery of retrofit in Pembrokeshire. As such, upskilling the local workforce will be a key enabler for all priority intervention areas.

Properties where retrofit is the most viable and cost effective would be prioritised, meaning that retrofit would be limited on historic and listed buildings.

2. Development of local onshore renewables

Scaling up of onshore renewables is an essential component of meeting Pembrokeshire's future energy demand. Current market conditions and trends indicate that ground PV is the most cost effective to deliver.

In addition to the existing 220MW of renewable capacity, Pembrokeshire will need additional capacity of at least 720MW by 2050.

The optimisation modelling carried out in conjunction with this plan primarily meets this capacity through ground and rooftop PV (pages 21-24), but for a more balanced and resilient energy system technologies such as community-scale wind should also be considered.

3. Decarbonise transport

The Welsh Government EV strategy shows that Pembrokeshire requires a mix of rapid and fast public chargers located at workplaces, destinations and other hubs.[31] Our modelling results support the electrification of transport and thus the scaling up of public EV charging infrastructure. The proportion of fast and rapid public chargers depends on which service emerges as dominant. However, by 2025, at least 45 rapid chargers and at least 770 fast chargers are needed, and by 2030 at least 85 rapid and a total of at least 1,420 public chargers will be needed, based on modelling linked to a number of assumptions related to the service that emerges and the rate of adoption of EVs.

We will consider biofuel or hydrogen fuels for our HGV fleet decarbonisation when viable models enter the market.

3. Our vision for Pembrokeshire's future local energy system

Priority intervention areas

4. Heat pumps prioritised in off-gas properties wherever appropriate

In Pembrokeshire there are over 25,000 properties estimated to be off the gas network, many of which are heated by carbon intensive fuels.[19] In order to maximise carbon savings and avoid the need for additional gas infrastructure, these properties will be prioritised for air and ground source heat pump installations. The uncertainty regarding hydrogen in the existing gas grid make off-gas properties our initial focus for decarbonising heat. Further information on the geographic focus for this is set out on page 43.

5. Electricity distribution network reinforcement

Network upgrades are a priority intervention to allow new local renewable assets to connect to the electricity grid, as well as meeting the increased electricity demand from transport and heat demand.

6. Decarbonise industry

Decarbonising Pembrokeshire's large industrial sites is a priority since industry accounts for a large proportion of emissions in the county. Pembrokeshire will also continue to play an active role in the development and piloting of innovative renewable generation technologies to support this decarbonisation in South Wales, through initiatives such as the Milford Haven: Energy Kingdom and Pembroke Net Zero Centre (PNZC).

7. Pilot electrolyser and hydrogen villages

Starting a seed market for hydrogen could place Pembrokeshire at the forefront of innovation and hydrogen future continuing the work undertaken as part of the Milford Haven: Energy Kingdom. This could also help with the transition from fossil fuel jobs to renewable jobs. Two of Pembrokeshire's villages with a high proportion of HDPE (yellow plastic) gas pipework could become the first pilot locations.

3. Our vision for Pembrokeshire's future local energy system

Interdependencies across priority intervention areas

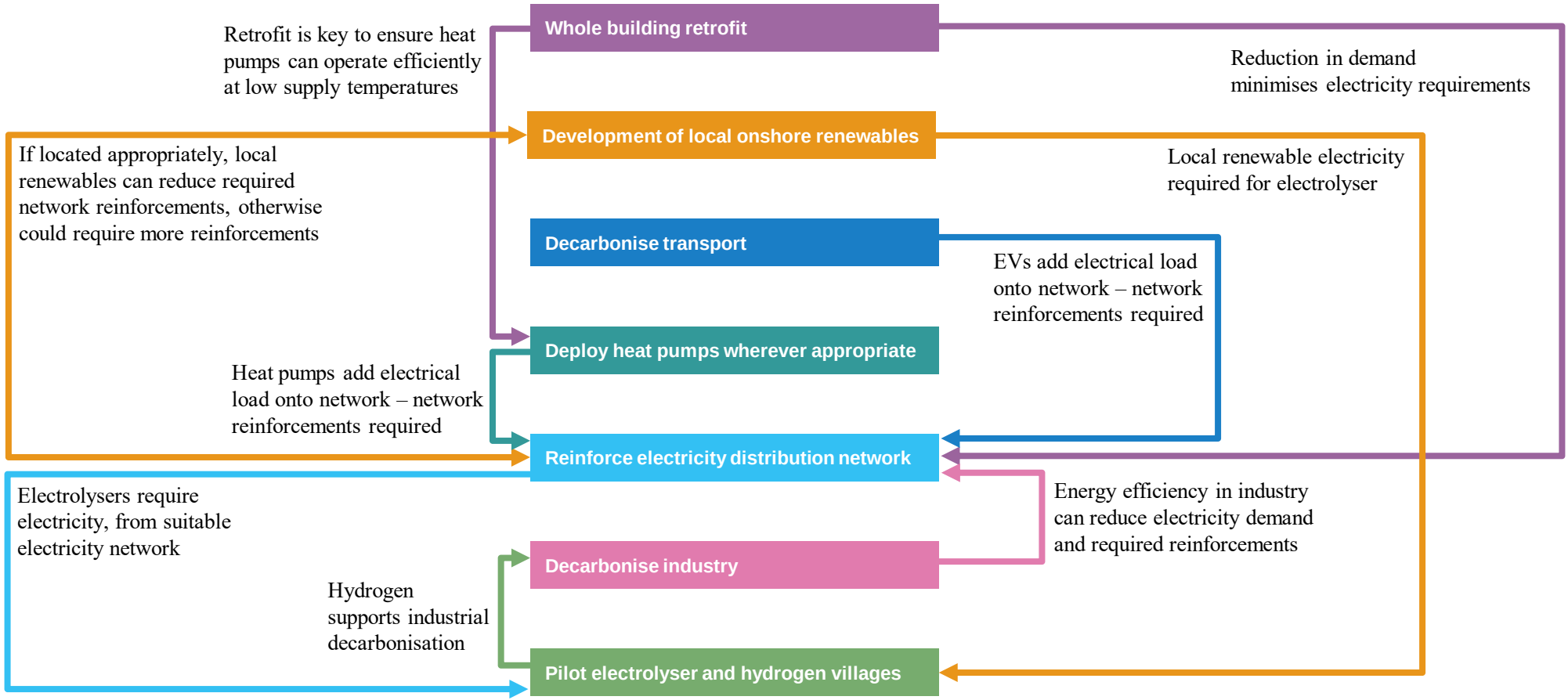
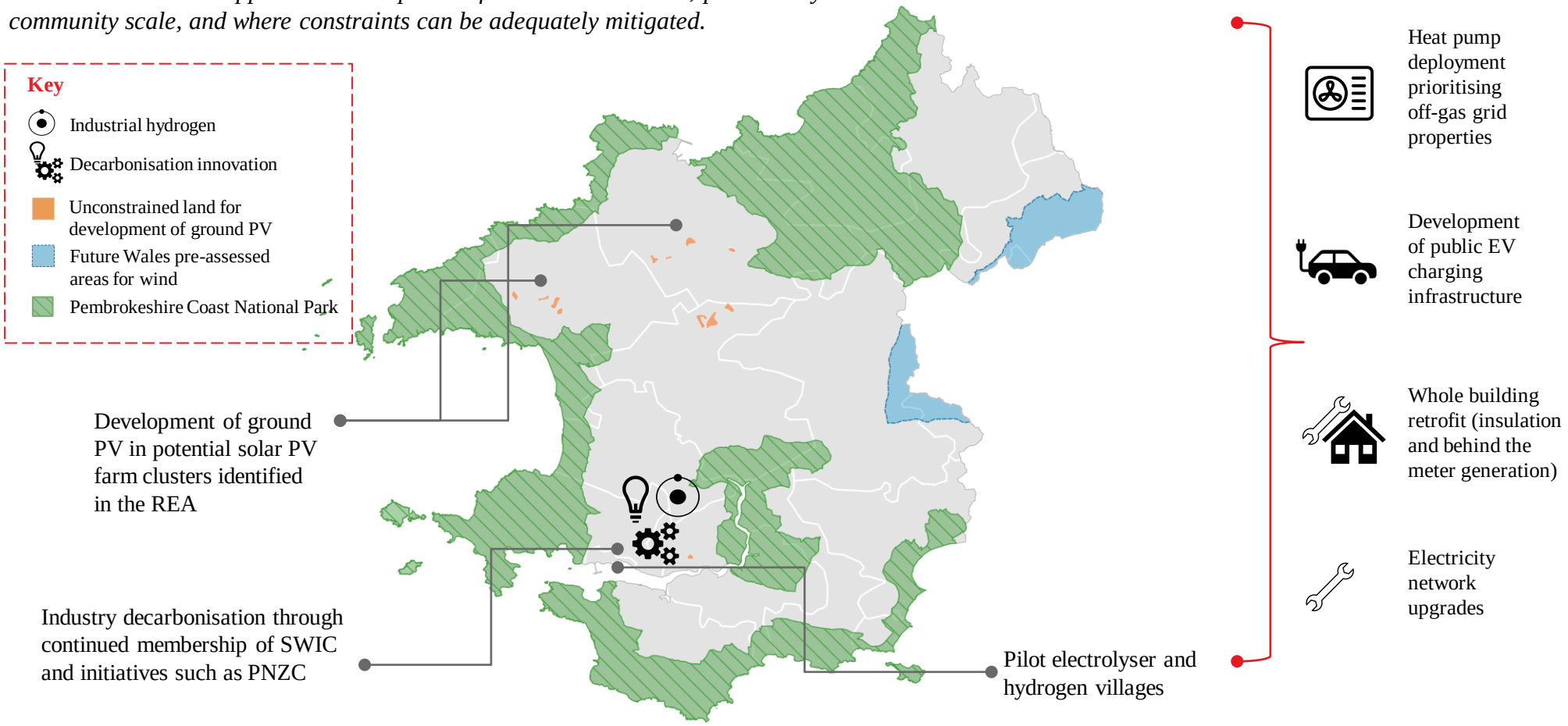


Figure 22: Key interdependencies across priority interventions areas

3. Our vision for Pembrokeshire's future energy system

This map shows the main locations for the priority interventions identified in our plan, with solar and wind potential based on PCC's Renewable Energy Assessment.[10] *PCC and the PCNP support the development of onshore renewables, particularly at community scale, and where constraints can be adequately mitigated.*



4. What needs to happen?

Joined up action and ensuring conditions for success are met

A high level routemap showing the actions that we will undertake, in the context of Welsh and UK Government targets and decisions, is shown on pages 35 and 36. This provides an overview of how the LAEP fits in the wider policy context and direction of travel for energy system decarbonisation.

The actions fall under the following priority interventions areas as set out in Section 3:

- Enabling actions
- 1. Whole building retrofit
- 2. Development of local onshore renewables
- 3. Decarbonise transport
- 4. Deploy heat pumps wherever appropriate
- 5. Reinforce electricity distribution network
- 6. Decarbonise industry
- 7. Pilot electrolyser and hydrogen villages

The priority interventions identified sit within this high level routemap. They require joined up but differentiated efforts by the stakeholders identified in this LAEP.

Although the exact form of the decarbonised energy system in 2050 is uncertain, there are actions we can take now to maintain the ability to meet our 2050 and interim targets.

The routemap provides a focused view of actions that will be taken in the coming decade, while also showing key milestones on the decarbonisation trajectory to 2050.

Each intervention requires four key elements to be successful:

1. Mobilising finance
2. Strong and consistent policy frameworks
3. Delivery owners
4. Community engagement

As Pembrokeshire County Council, our role in each intervention will vary. Some interventions call for council action in the material delivery of programmes, whilst other interventions require the council to act more as a facilitator for market driven change.

Local ownership is a key focus throughout this plan, and where possible the action taken should leverage the progress made through the Welsh Government's recent Co-operation Agreement with Plaid Cymru, which includes key goals on tackling climate change in a way that maximises local benefits.[26]

The following section provides further detail on each of the actions that we will undertake under each intervention area, as well as our key asks of others. Please see page 48 in our technical report fort further details on some of these.

Benefits of priority intervention areas

Each of the priority interventions was compared to the LAEP objectives and the Well-being of Future Generations (Wales) Act.[16] This benefit assessment, shown on page 34, was co-produced with stakeholder input.

4. What needs to happen?

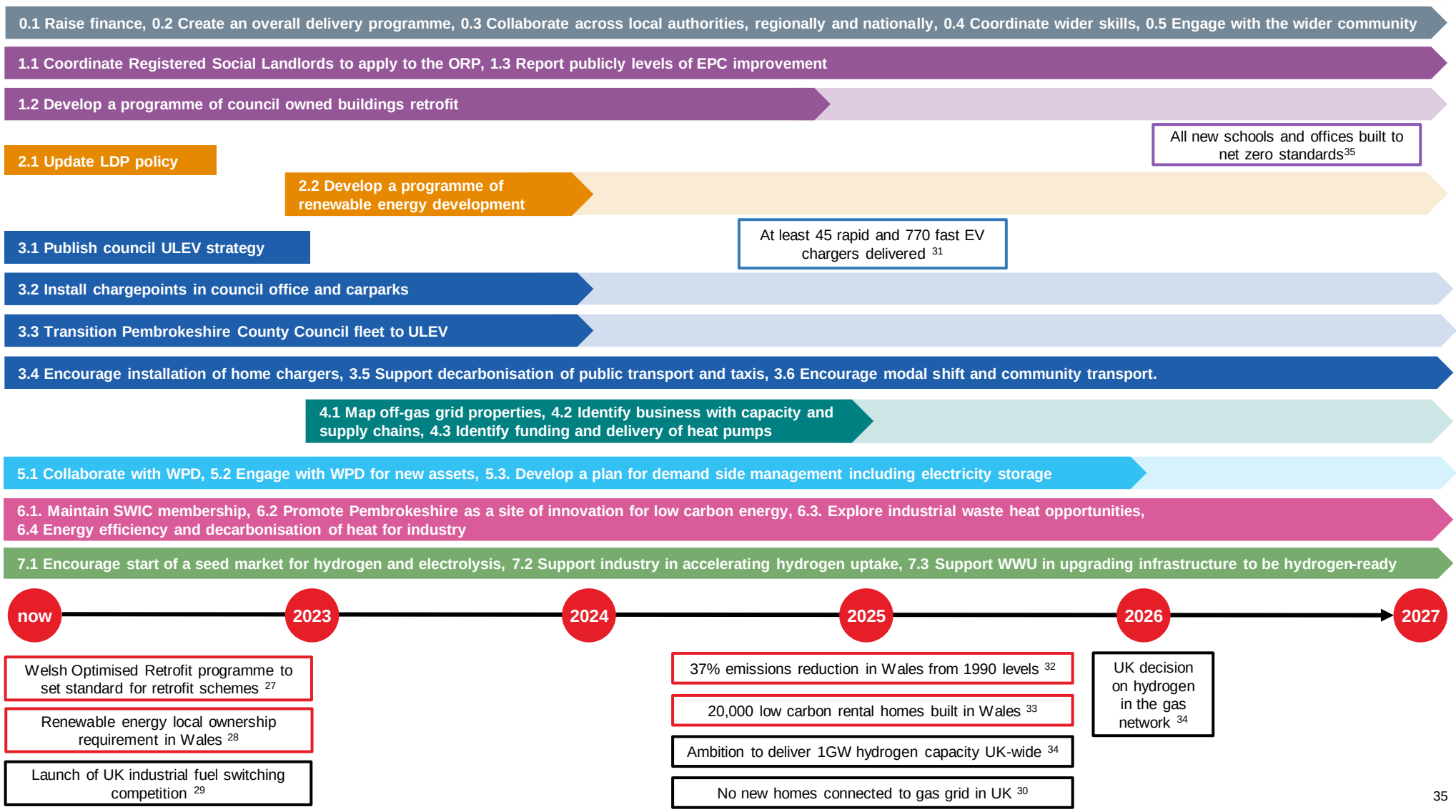
Benefits of priority intervention areas

LAEP objective	Local jobs & economy	Reduce fuel poverty	Community engagement and ownership	Agriculture and best use of land	Just transition	Resilience	Innovation
Relevant well-being goals	Prosperous Wales; Cohesive Communities	More Equal Wales; Healthier Wales	Prosperous Wales	Globally Responsible Wales	More Equal Wales	Resilient Wales	Prosperous Wales
Whole building retrofit	High	High	Medium	Medium	High	High	Medium
Development of local onshore renewables	High	Medium	High	Medium	Medium	High	Low
Decarbonise transport	Low	Medium	High	Not applicable	Medium	Medium	Medium
Deploy heat pumps wherever appropriate	Medium	Medium	High	Not applicable	Medium	Medium	High
Reinforce electricity distribution network	High	Medium	Low	Not applicable	Low	High	Low
Decarbonise industry	Low	Medium	Medium	Medium	Medium	Low	High
Pilot electrolysers and hydrogen villages	High	High	Medium	Not applicable	High	High	High

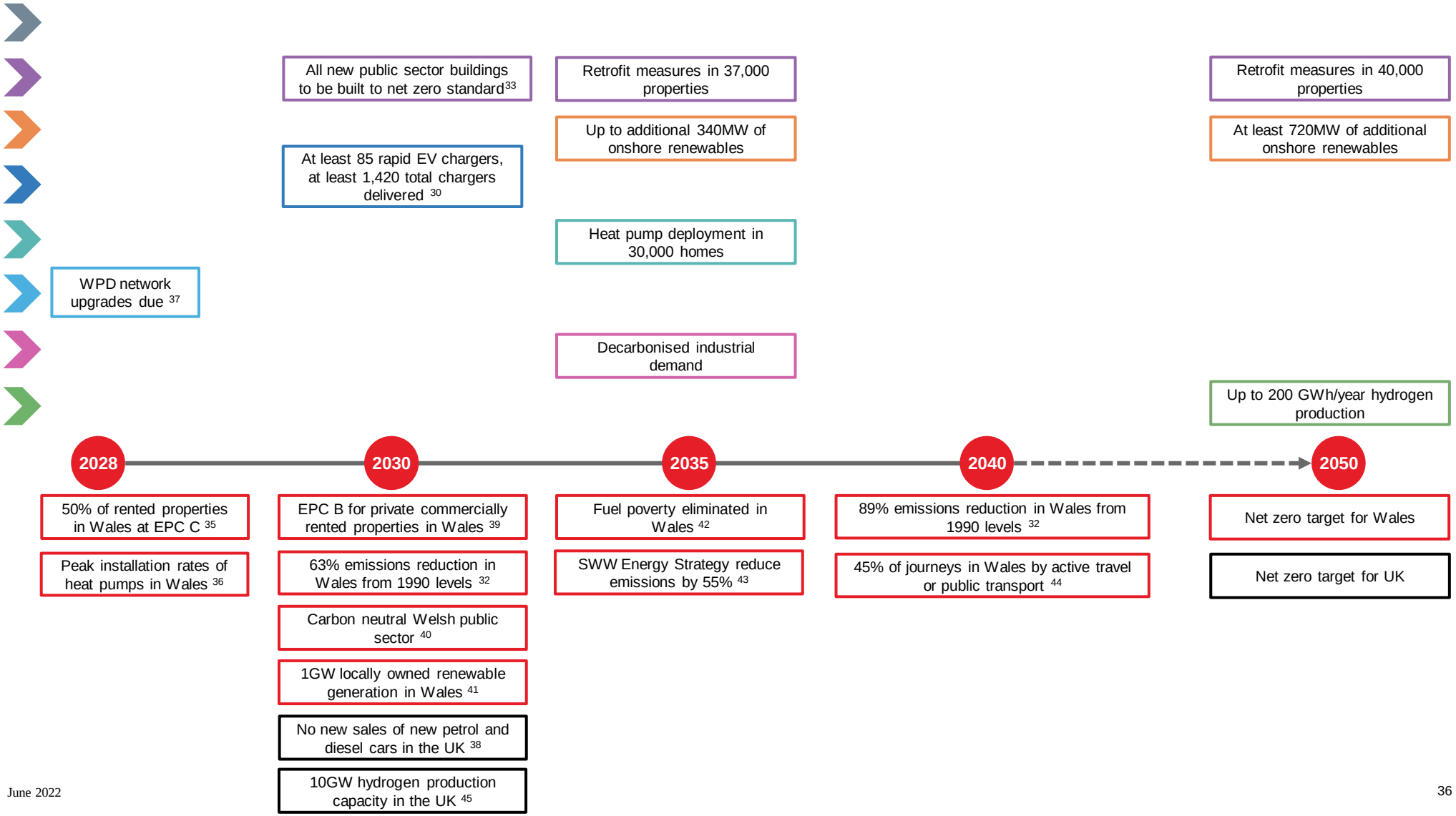
Key: High impact | Medium impact | Low impact | Not applicable

Figure 23: Multi criteria assessment of priority intervention areas

4. What needs to happen?
Short term routemap



4. What needs to happen?
Medium-long term routemap



5. What are we going to do?
Our actions and asks from others

1. Retrofit whole buildings (insulation, efficiency measures and behind the meter generation)

Action 1.1 Coordinate Registered social landlords (RSLs) to apply to the Optimised Retrofit Programme (ORP). We will partner with registered social housing providers to monitor plans for future ORP phases and put in an application if/when appropriate.

Benefit Learnings from retrofitting the social housing sector will support the decarbonising of private rented and owner occupied sectors. Prioritising work on social housing is progressive and will also help accelerate the growth of Welsh small and medium enterprises (SMEs).

Risks Landlord involvement in the ORP may be low due to lack of incentive, complex application processes and not meeting qualifying criteria.

Timescale 2022-ongoing.

From others we need Co-ordinated efforts by Welsh Government and skills bodies to address the skills and materials shortage in the construction sector. Funding may be needed for a dedicated role to coordinate this action.

Action 1.2 Develop a programme of council owned retrofit, leading to approaches for private sector retrofit. We will design and launch a programme of building retrofit firstly focusing on council owned buildings. We will support bulk retrofit programmes to keep costs down and accelerate the uptake of energy-saving measures while minimising costs. Learnings from retrofitting public sector buildings will support the decarbonisation of the private sector.

Benefit This will support the PCC Net Zero 2030 Action Plan priority area to deliver fabric improvements in existing buildings and build all public sector buildings to net zero standards by 2030. It also aligns with the Swansea Bay City Deal Homes as Power Stations project, which aims to retrofit at least 7,000 homes in the area.[46] This project could also provide a potential funding source.

Risks Retrofit may not happen at scale in the private sector due to lack of incentive for private citizens - limited funding and a lack of understanding of the benefits will limit uptake.

Timescale The development of the programme and establishing costs is already underway, and the programme of works will launch in 2022.

From others we need Grant funding to support the transition from gas boilers to low carbon heat, with continuation of schemes such as the Nest scheme. Investment and education services to address skills deficit and training needs. Collaboration between home owners, community groups, businesses, council, and government.

Action 1.3 Report levels of EPC improvement publicly. We will publicly report progress in improving privately rented domestic and commercial buildings.

Benefit This will hold the council to account and ensure that minimum requirements are met. We will raise public awareness and provide links to comprehensive guidance to raise consumer awareness. We will support behaviour change programmes led by community groups.

Risks Awareness campaigns and behaviour change may not be enough if there is no access to funding in order to carry out necessary retrofits.

Timescale Underway and ongoing .

From others we need: Funding to support advertising and awareness raising.

5. What are we going to do?
Our actions and asks from others

2. Develop local onshore renewables

Action 2.1. Update local development plan (LDP) policy on onshore renewables The council is re-running the deposit-stage consultation on LDP2, based on a revised plan. Here we will look at the policies and proposals for renewable energy within the emerging replacement plan, to provide clear guidance to developers on our expectations for local ownership, commercial arrangement, environmental stewardship and co-benefits.

The National Park Authority's current LDP (to 2031) supports the development of individual and community-based renewable energy projects.

Benefit The LDPs will support development of onshore renewables where constraints can be satisfactorily mitigated, particularly in relation to community-based projects.

Risks No land suitable. Schemes become demotivated by lack of positive signals, reducing the capacity of Pembrokeshire to deliver onshore renewables.

Timescale LDP2 process already underway.

From others we need Update to national guidance so local planning authority can use a balanced approach in weighting different views of stakeholders. Decisions to be made by Welsh government about priorities for land use to enable reduction of some of the current barriers and support further onshore renewable growth.

Action 2.2 Develop a programme of renewable energy development We will develop a programme of renewable energy development with appropriate commercial models. We will learn from previous renewable energy planning applications and consider the merits of different ownership strategies and commercial models: from self developing land, to acquiring a finished or a commissioned project from a third part, to community-led renewables projects. Schemes such as private wire, local energy arrangements, and local PPAs may further diversify ownership and facilitate more renewable development.

The efficacy of renewable technologies will be maximised through a range of solutions, including east-west facing solar PV (to smooth generation profiles) and storing energy locally.

Repowering of existing renewable sites could also increase capacity and annual energy outputs. PCC and PCNPA would consider proposals for the repowering of existing renewable sites on their individual merits as recommended in Future Wales. [47]

Benefit Developing a plan for renewable energy development and the risks and benefits of different ownership models will streamline council decision making. Community-owned renewables projects will meet the Welsh policy to achieve 1GW of locally owned renewables by 2030.[13] Working with Welsh Government Energy Service is also key to ensure alignment.

Risks Deployment of renewables may continue to stall due to lack of incentives, grid constraints and local planning, meaning that Pembrokeshire becomes reliant on imports.

Timescale To be completed in 2023-2024.

From others we need Collaboration with National Grid and WPD to ensure grid connections and transmission infrastructure are reinforced in line with the increase in electricity demand, and are resilient to increases in variability of supply. Reinforcements should allow for electricity experts from Pembrokeshire.

5. What are we going to do?
Our actions and asks from others

3. Decarbonise transport

Action 3.1 Publish regional ULEV strategy. The regional ULEV strategy is currently being drafted, this is based on the Welsh Government's EV strategy, including our strategy for heavy transport decarbonisation. We will set out priority geographical areas for the roll-out of EV charging infrastructure, considering the large rural population. We will also advertise standards and guidance on EV charging, incorporating published guidance and standards such as those produced for the Scaling On-Street Charging Infrastructure (SOSCI) project.

Benefit Setting out the priority areas will enable the systematic and transparent roll-out of the technology. This will support our 2030 ambition to have transitioned our public sector fleet to ULEVs where possible. Investment in hydrogen for transport will add resilience to any potential grid failures.

Timescale Pembrokeshire's ULEV plan is to be published by 2023

From others we need Advice on considering different management and ownership frameworks. Continued funding to support roll-out and access to parking from TfW and WG. Consultant support will be required via WG Energy Service to assist in this process.

Collaboration with industry and commerce to ensure buy-in, and support in developing suitable technology for heavy goods vehicles.

Action 3.2 Install charging points in council offices and carparks. We will ensure that charging points adhere to accessibility standards so that all users can benefit from these, including easy-to-use interfaces and charging points suitable for both standing and seated users.
Benefit This will signal council intent, and provide a testing ground for the delivery of public EV infrastructure in the local authority, supporting the wider take up in market driven schemes elsewhere. With Pembrokeshire's rural landscape and limited capacity for public transport expansion, personal vehicle charging infrastructure remains a priority.

Timescale Already underway; by the end of the current roll-out phase (funded by a grant from the Pembrokeshire Coast National Park Authority), our combined network will comprise 131 fast chargers and 17 rapid chargers across 36 geographically dispersed car park locations. By early 2023, we hope to have deployed 169 fast chargers and 31 rapid chargers. We will continue to deliver EV charging points.

Risks Global supply chain challenges resulting from the ongoing COVID-19 pandemic may delay acquisition and roll-out of EV charging infrastructure.

From others we need Technical advice on grid connections from WPD and installers, access to funding sources to support charging infrastructure, as well as extra resources (capital and revenue) to increase the pace of installation.

Action 3.3 Transition our fleet of vehicles to ULEV We will transition the council fleet to electric and hydrogen vehicles. As fleet contracts expire, they will exclusively be replaced by ULEVs from 2024/25 onwards, with electric vehicles favoured in the nearer term.

Benefit This will signal council intent on the transition to ULEV. It will support the PCC Net Zero 2030 ambition to have all public sector vehicles transitioned to ULEVs by 2030.[1] As part of this transition we will support home charging infrastructure for our fleet.

5. What are we going to do?
Our actions and asks from others

3. Decarbonise transport

Risks Ongoing global BEV component supply shortages may delay acquisition and drive up prices. Commercial arrangements for fleet may need more consideration.

Timescale This is already well underway. We will complete the fleet transition plan by 2023 and transition the council owned fleet by 2030.

Action 3.4 Encourage installation of home chargers. We will advertise examples and benefits of home EV chargers, and share potential funding routes to increase the number of home owners that explore this opportunity.

Benefits Home chargers are key for the uptake of EVs. We need to support on-street charging, which comes with increased liability.

Timescale 2022 onwards

From others we need Funding to support installation of home chargers, such as the EV chargepoint grant. Implementation of new building regulations to include requirements for EV chargers in residential and non-residential buildings. DNOs to explore models for cheaper tariffs for households that balance the grid with EVs.

Action 3.5 Support decarbonisation of public transport and taxis. We will engage with local bus companies to encourage them to explore ways to reduce carbon emissions, such as by reaching out to the Bus Decarbonisation Task and Finish Group (run by Welsh Government).

We will also encourage major transport providers to explore opportunities to decrease electrification costs (such as though a private wire) and increase resilience through the use of renewables and battery storage.

We will work on the licensing of private taxis, and consider if there is a time that it will be appropriate to only support ULEV taxis.

Benefits Transitioning to public transport fuelled by electricity or hydrogen can help with the overall transport decarbonisation, and will be particularly important if significant modal shifts occur.

Timescale 2022 onwards. Pilot already begun.

From others we need Welsh Government to provide advice and funding options for bus companies to transition to electrified and/or FCEV buses. Licencing to facilitate ULEV taxis.

Action 3.6 Encourage modal shift and community transport. We will encourage active travel, modal shift from private cars to rail/buses and community transport solutions. This could include car sharing. This should feed in to, and be fed by, our regional transport planning which will also outline how we plan to reduce commuting, such as support of extended home and virtual working schemes. [48]

Benefits A reduction in transport demand from lower reliance on private cars is key for the transport decarbonisation. This can help minimise the electricity and hydrogen requirements for vehicles, with potential benefits in terms of grid capacity.

Timescale 2022 onwards.

From others we need Investments for new dedicated walking and cycling routes.

An increase in public transport services (i.e. bus frequency / routes).

5. What are we going to do?
Our actions and asks from others

4. Deploy heat pumps wherever appropriate

Action 4.1 Develop a detailed map of off-gas grid properties according to ownership. We will map in more granular detail the off and on gas grid properties and their ownership types to prioritise properties for fuel switching.

Benefit This will allow us to prioritise properties for intervention based on ownership type and heating fuel source. It will allow us to identify the extent of electric infrastructure upgrades needed to enable heat pump installation.

Risks Even if priority areas are identified, there may be lack of incentive for the uptake of heat pumps due to limited funding and a lack of understanding of the benefits. Higher upfront cost than replacing existing system

Timescale Commit to start in 2023.

From others we need We ask that Welsh Government further incentivises households off the gas grid to switch their domestic heating system, either through taxing solid fuels, incentives, or mandating retrofit measures in critical parts of the building lifetime such as change of owner or tenant. Retrofitting properties is a key enabler for heat pump roll-out.

We will require funding and support to form a full time office to lead on heat pump deployment which may sit within PCC Housing team.

Action 4.2 Identify businesses with capacity and wider supply chains. We will identify and champion local businesses and SMEs with the capacity and skills to deliver installations of heat pumps in off-gas grid properties, prioritising those transitioning from high carbon intensive industries.

Benefit This will support the development of low carbon jobs in Pembrokeshire and a just transition.

From others we need We will require support to upskill and train the workforce (see action 0.3). We will promote and advertise heat pump installers by using local contractors in council owned buildings. We will also need UK government to help develop and drive suitable standards for heat pump installation.

Action 4.3 Identify funding and delivery options. We will identify existing funding and delivery opportunities for heat pump deployment at both a national and local level. We will investigate a variety of delivery models including 'heat as a service' to accelerate the uptake of low carbon heating technologies and promote customer support. As part of this we will assess the suitability and potential of the Warm Homes Funding (WHF) and Boiler Upgrade Scheme (BUS).

Benefit This will help us identify and unlock potential funding opportunities for heat pump deployment across Pembrokeshire.

Risks The funding schemes currently in place do not cover the total costs of heat pump installation. Even with funding support, uptake will require significant private investment from citizens.

Timescale: Commit to start in 2023.

5. What are we going to do?
Our actions and asks from others

4. Deploy heat pumps wherever appropriate

As shown in Figure 24, there are different routes to decarbonise heating in properties, depending on their connection to the gas network and on UK government decisions on hydrogen.

Whilst this diagram depicts the most likely pathway to decarbonising heat for properties that are on the gas grid and off the gas grid, each property is different and the most suitable solution (e.g. air source heat pump versus ground source heat pump) would need to be assessed on an individual level.

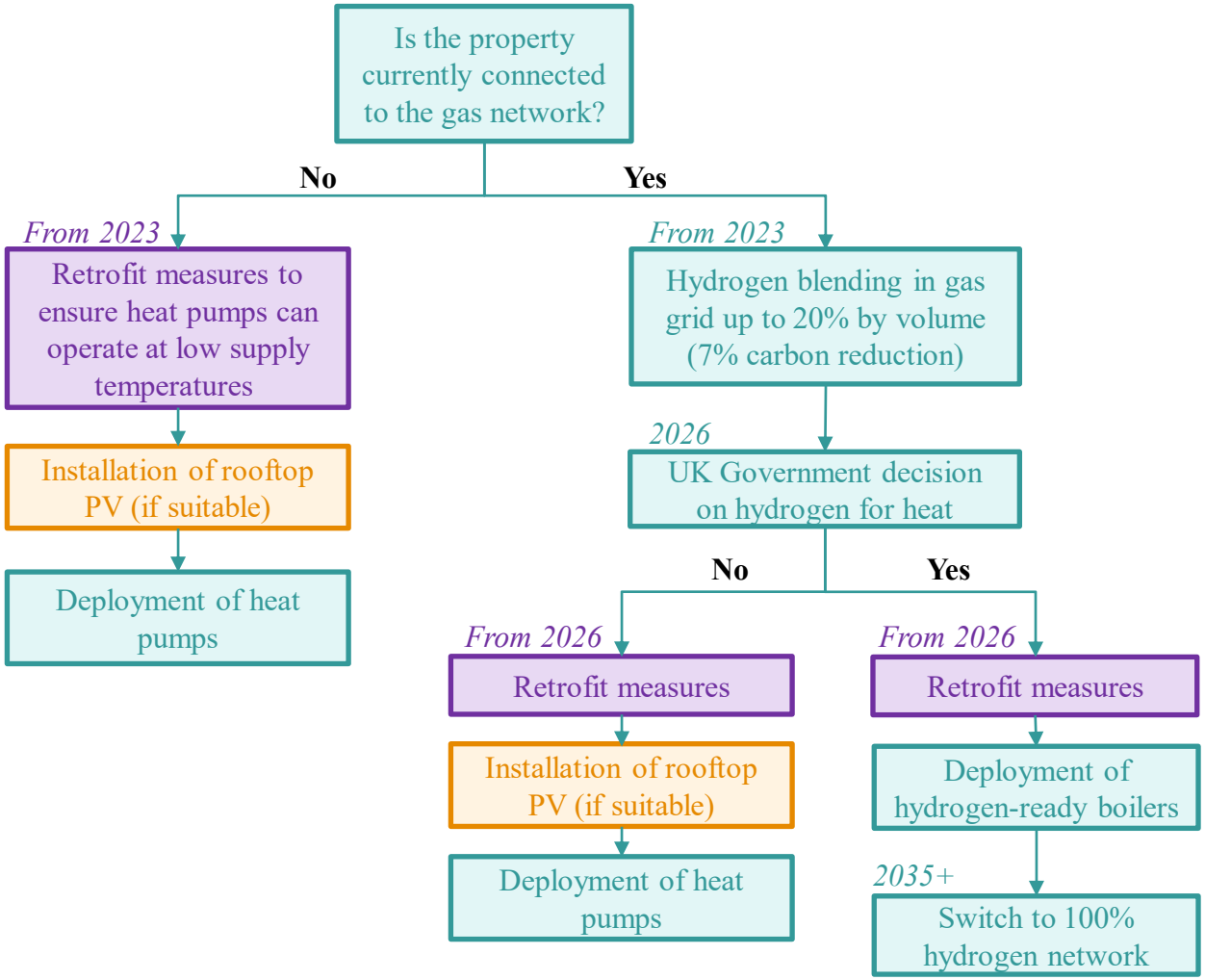


Figure 24: Heat decarbonisation for off-gas properties and on gas properties

5. What are we going to do?
Our actions and asks from others

4. Deploy heat pumps wherever appropriate

Figure 25 shows key areas for heat pump deployment, based on their priority level:

1. Priority 1 = Areas with high dependence on carbon intensive heating (e.g. oil) and available capacity on the electrical network. This enables heat pumps deployment while minimising network upgrades.
2. Priority 2 = Areas with high dependence on carbon intensive heating (e.g. oil) and constrained electrical network. Network upgrades should be rolled out before / along with heat pumps deployment.
3. Priority 3 = Areas with properties on the gas network. Hydrogen heating should be considered as an alternative to heat pumps, particularly in areas where the electricity network is constrained.

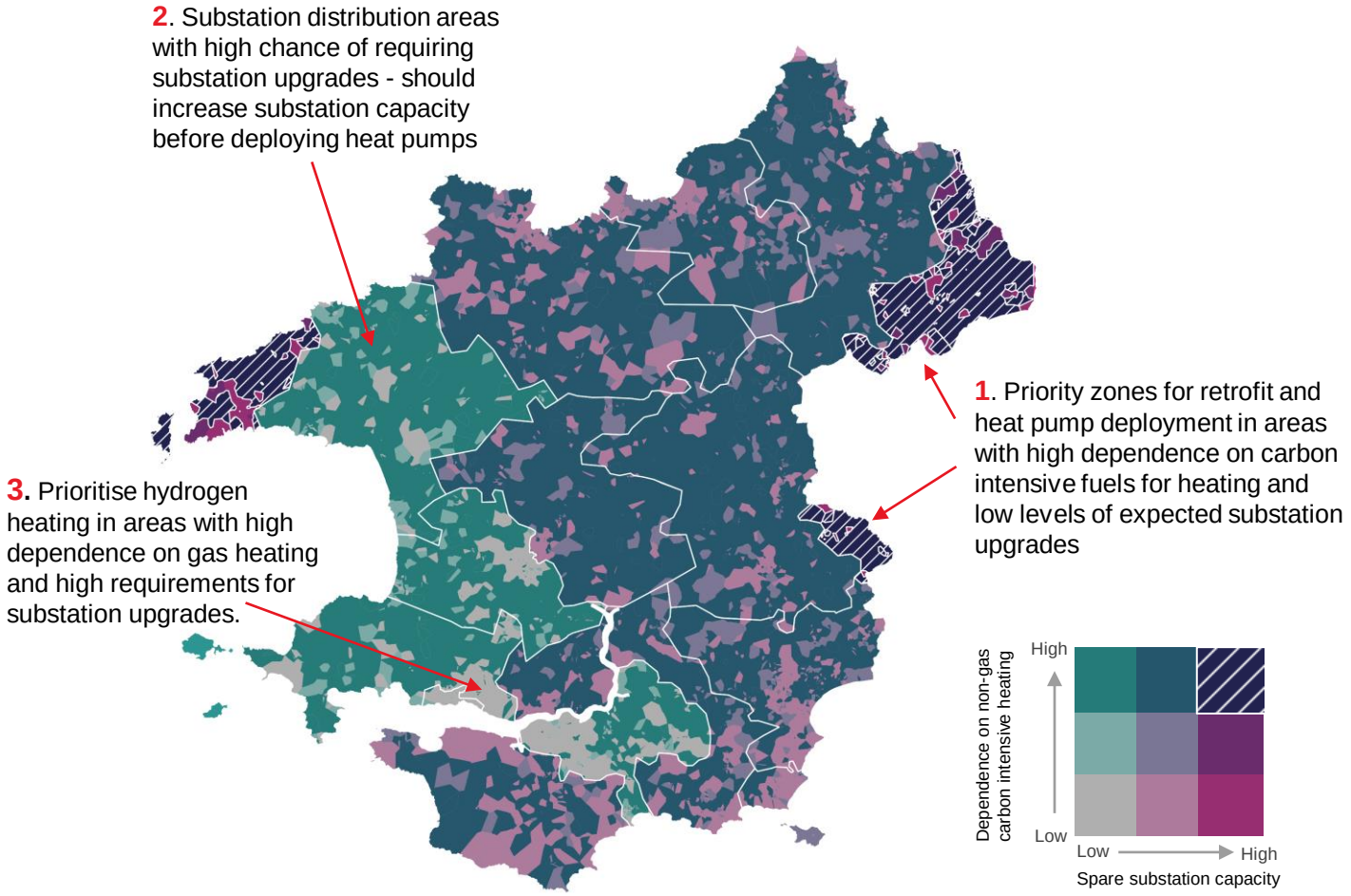


Figure 25: Priority zones for heat pump deployment

5. What are we going to do?
Our actions and asks from others

5. Reinforce distribution electricity network

Action 5.1 Collaborate with WPD We will collaborate with WPD to ensure alignment between LAEP and DFES, to support requirements for their investment profiles. Transparency over the available grid capacity will enable its optimisation while understanding future energy requirements will facilitate investment planning.

Benefit Forward investments will be better suited to renewable generation technologies that are deployed on shorter timescales than traditional national assets.

Risks Investment in grid doesn't happen until too late in the delivery programme, and grid becomes overloaded – leading to black outs.

Timescale Develop investment schedule plan by 2026.

From others we need The UK government to reform the regulatory process to support the deployment of renewables. Incentives to support demand side response which will help meet intermittent, dynamic energy system of the future. Regional and national resource development plans for training and development. We would like to arrange quarterly/monthly meetings with the networks to ensure ease of information sharing and strong levels of engagement.

Action 5.2 Engage with WPD for new assets We will engage early with WPD regarding the connection of new generation and demand assets in advance of its next price control - RIIO-ED3 (Revenue, Incentives, Innovation & Outputs: Electricity Distribution) which will run from 2028 – 2033.

Benefit This will ensure network upgrades aligned to the LAEP are prioritised.

Timescale To start now, ongoing until 2026.

From others we need More detailed programme design needs to be undertaken to finalise delivery plans for network enhancements.

Action 5.3 Develop a plan for demand side management including electricity storage

Benefit As increases in renewables affect variability of supply, demand side management and electricity storage will be essential. Exporting excess generation adds pressure to the grid infrastructure, while placing storage near to generation assets reduces the needs for export. Overall reinforcement costs may be further reduced by grouping assets together.

Smart meters could also play a key role in enhancing demand side management.

Timescale Commit to begin plan in Summer 2022, to be completed by 2026.

From others we need DNOs to perform modelling and undertake pilots to develop innovative balancing and commercial models for network reinforcement scenarios. We will work with DNOs to implement time-of-use charges to incentivise off-peak energy use and therefore smooth daily demand profiles.

Figure 26: Community rooftop PV on Ysgol y Frenni

5. What are we going to do?
Our actions and asks from others

6. Decarbonise industry

Action 6.1 Maintain SWIC membership. We will continue working with SWIC to maximise opportunities for all.

Benefit A seat in discussions about the future direction of industry in South Wales more broadly will enable us to link up with industry, ensure co-ordinated action and joined up priorities.

Timescale Ongoing

From others we need Co-operation from SWIC. UK and Welsh governments to support collaborative working to resolve challenged and achieve multi-organisational support.

Action 6.2. Promote Pembrokeshire as a site for innovation around low carbon energy.

We will engage innovative energy technology stakeholders and encourage them to consider Pembrokeshire as a nationally-significant hub for cutting edge renewable generation technologies. Milford Haven: Energy Kingdom is a pilot project, demonstrating how hydrogen and renewables can drive a transition to net zero buildings, power, and industry. Pembrokeshire Net Zero Centre, led by RWE as part of SWIC, will work to decarbonise Pembroke Power Station through technologies including green hydrogen and CCUS, allowing industry and power production to thrive while becoming net zero carbon.

Benefit An investment in innovative renewable energy technology in Pembrokeshire would site generation assets in a cluster of demand and also retain the economic benefits. Technologies such as CCUS and CO_2 shipping will enable the achievement of a net zero economy, aligned with regional and national goals. There may also be potential to utilise waste heat from large industrial sites to provide low carbon and low-cost heating for the local area.

Timescale Ongoing

From others we need Industry to make their development plans within Pembrokeshire clear, and GDN and DNOs to plan for the future grid and network requirements of industry within the county. Linked to action 7: Pilot programmes for hydrogen and electrolysers will help to establish supply chains, enabling industry to transition to low carbon fuels.

Action 6.3. Explore industrial waste heat opportunities. We will seek opportunities for industrial symbiosis and use of waste heat, including heat from hydrogen production. New developments should also consider the use of waste industrial heat.

When possible, we will also explore opportunities to locate new developments with heat requirements nearby major waste heat producers.

Benefit This will enable efficient use of waste heat, minimising the need for additional new generation.

Timescale Ongoing

From others we need Industrial waste heat producers to share plans with potential heat users to enable opportunities to be captured.

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5. What are we going to do?
Our actions and asks from others

6. Decarbonise industry

Action 6.4 Energy efficiency and decarbonisation of heat for industry. We will support industries by sharing example projects where energy efficiency or decarbonisation has been achieved, and we will advertise funding options available bringing together consortiums as we did for Milford Haven: Energy Kingdom where appropriate.

Benefits Energy efficiency measures can reduce the overall energy requirements for industrial users, with potential benefits in terms of grid reinforcements required.

Decarbonisation of heat can be challenging in the industrial sector, particularly where high temperatures are required for manufacturing processes or similar. Sharing best practice examples of energy demand reduction, optimised use of waste heat (potentially feeding into heat pumps or boilers) and decarbonised heat generation systems can help other industrial users to develop a successful decarbonisation strategy.

Timescale Ongoing

From others we need Funding options for industrial decarbonisation.

5. What are we going to do?
Our actions and asks from others

7. Pilot electrolysers and hydrogen villages

Action 7.1 Encourage the start of a seed market for hydrogen through pilot schemes. Building on the success of Milford Haven: Energy Kingdom, we will look to develop more pilot sites where hydrogen will be a core component of the energy mix. We will also develop demonstrations and exhibitions to explain hydrogen to the public.

Benefits By setting up pilot schemes, we will encourage the development of supply chains for hydrogen infrastructure and thus drive demand-led change. Gradual introduction of hydrogen, along with demonstrations and exhibitions, will allow the public to gain acceptance of the new technologies.

Risks UK government and regulations not moving at pace with hydrogen development. Hydrogen schemes need to be well thought out to not disincentivise people because of high costs, hydrogen use should be prioritised. Consumer perception of hydrogen can be a barrier.

Timescale Immediate start.

From others we need We would need funding form the Welsh government to help us to set up these pilot schemes and demonstrate viability. We would need UK policy change to allow the amount of hydrogen in the gas mains to increase to 20% then to 100% to allow for a full transition to hydrogen.

Action 7.2 Support industry in accelerating hydrogen uptake and usage of electrolysis. We will support RWE's plans to deliver 2 GW of hydrogen projects by 2030 which include a green hydrogen production facility in Pembroke. We would also support other smaller scale hydrogen projects.

We will work with industry to establish the likely hydrogen production and link this to the likely transport hydrogen demand.

Benefits Industrial uptake of hydrogen will drive the need for more electrolysis which will increase generation capacity. This will therefore ensure hydrogen is cost effective elsewhere by establishing a robust local supply chain. This will help achieve the UK's goal to achieve 10 GW of hydrogen generation capacity by 2030.[49]

Timescale Ongoing since Milford Haven: Energy Kingdom

From others we need Industrial actors to continue investing in and developing green hydrogen production.

Action 7.3 Support WWU in upgrading infrastructure to be hydrogen-ready. We will engage early with WWU regarding the hydrogen network required to support industry and the potential for hydrogen fuelled vehicles (likely HGVs) in advance of their next price control - RIIO-GD3 (Revenue, Incentives, Innovation & Outputs: Gas Distribution) which will run from 2028 – 2035.

We will support the national REPEX programme which aims to replace low-pressure cast iron gas pipes with plastic pipework by 2030.

Benefits This will support the prioritisation of appropriate network upgrades and enable Pembrokeshire to be hydrogen-ready by 2032, so that the county is ready to make a phased transition to hydrogen.

Timescale Ongoing until 2032

From others we need More detailed programme design needs to be undertaken to finalise delivery plans.

5. What are we going to do?
Our actions and asks from others

Enabling actions

Action 0.1 Raise finance. We will develop a plan for funding arrangements to support the delivery of local authority programme of works to enable the delivery of the LAEP. This may be from usual capital markets or through more innovative financing mechanisms such as community municipal investments, Pay as you Save or net-metering. Innovative finance options to be explored for individual energy consumers such as green mortgages.

Benefit Funding is required to deliver the plan.

Risks Private sector funding is difficult to raise, and depends on consumers' willingness to spend on decarbonisation. This is particularly challenging for heat pumps and retrofit, however the Boiler Upgrade Scheme goes someway to support heat pumps, and there are community schemes which could support rooftop PV and heat pump delivery.

Timescale Immediate start, full plan to be in place by mid 2026.

From others we need Initial gap funding to deliver a pipeline of works.

South West Wales region to support with funding, through the Homes as Power Stations project.

Action 0.2 Create an overall delivery programme. We will develop an overall delivery programme that follows a whole systems approach, so that initiatives are not siloed.

Benefit A co-ordinated delivery programme to ensure that available funding arrangements are utilised in the most appropriate ways, and that the interdependencies are considered.

Risks Target is not met because of lack of resource and co-ordination. Continuous monitoring should be undertaken until 2050 to ensure target is met.

Timescale Immediate start, full plan to be in place by mid 2026

From others we need Support and resources to grow Energy and Climate Change team.

Action 0.3 Collaborate across local authorities, regionally and nationally. We will work with the Welsh Government, the South West Wales region and local authorities across Wales to develop opportunities for investment in energy projects at scale.

We will also work with others (including community groups) to provide unbiased advice for energy consumers around energy efficiency and renewables, based on the advice developed at regional or national level.

Benefit Pooling potential investable opportunities across multiple local authorities makes them more attractive to potential investors. Could provide local employment opportunities.

Energy consumers need advice which is trustworthy to enable an effective energy transition of households.

Risks Lack of action if relying on someone else.

Timescale Immediate start, ongoing.

From others we need Other local authorities and South West Wales to work with us and Welsh Government's support in the roll-out of their LAEP programme. If virtual PPA agreements are established between local authorities, development of offsetting ability, e.g., with REGO agreements.

5. What are we going to do?
Our actions and asks from others

Enabling actions (continued)

Action 0.4 Coordinate wider skills The transition to net zero requires co-ordinated skills investment, with a priority in retraining those in sectors that are likely to be impacted more by the transition. We will work with our regional skills partnership to understand employer needs, skills gaps and funding requirements.

We will also develop an educational programme to achieve behavioural change and onboarding of energy consumers.

Benefit In order for Pembrokeshire to benefit from the net zero transition we can be proactive in encouraging government and the private sector to release funds for developing skills and expertise in established and emerging low carbon technologies, building retrofit, and heat pump installations.

We will work with education providers and local businesses to address skills deficits and training needs for the installation of renewable technologies, heat pumps and building retrofits. We will ensure the current workforce is upskilled and new workforce is trained, as well as raise public awareness on topics such as optimising heat pump usage.

We will also work with energy consumers to educate them about the benefits of these new systems (e.g. heat pumps and EV chargers) and ensure they understand how to use them in the most efficient way. Peer-to-peer education, learning and adoption would also support the energy transition.

Risks Lack of appropriately skilled workforce in local area limits scale and speed of roll-out of decarbonisation measures. This is manifested even within PCC struggling to recruit a lead for Energy and Climate Change. Delays in starting the LAEP programme may reduce likelihood of reaching net zero.

Timescale Immediate start, ongoing.

From others we need Businesses and community groups to support education programmes. Welsh Government to publish a Net Zero Wales Skills Action Plan in Spring 2022. South West Wales will develop training opportunities and incentives for supply chain development. Swansea Bay City Region to support with skilled jobs, especially through the Homes as Power Stations project. We need defined industry requirements, regulation to stimulate skills demand, consistent National Occupational Standards.

Action 0.5 Engage with the wider community As we progress with this plan, we will continue to engage widely with our community – ensuring that their changing priorities and concerns are addressed and mitigated. Empower and enable consumers to make meaningful decisions to decarbonise their heat supply.

Benefit Decarbonising our energy system not only requires supply side interventions, but buy in from the community to change the way we use energy. This can only be achieved through widespread engagement. Incorporating the views of the community ensures all impacted parties are heard, which will facilitate a just transition.

Risks Negative consumer perception of elements such as hydrogen or heat pumps may inhibit uptake of measures and therefore delay change.

Timescale Immediate start, ongoing.

5. What are we going to do?

Five-year propositions: Actions up to 2027/2028

Whole building retrofit

Retrofitting properties is crucial to both tackle fuel poverty and reduces strain on the network. This will be prioritised in areas with high levels of poor quality housing and where there is expected to be little electrical network reinforcement.

Capex: £45 million by 2028

Capacity: 6,000 properties retrofitted to EPC C by 2028

Develop onshore renewables

Deployment of onshore renewables will be crucial to reduce fuel poverty and strain on the electrical grid. Rooftop PV will be prioritised on social housing and new builds while ground PV and community onshore wind will be prioritised in identified unconstrainted areas.

Capex: £150 million by 2028

Capacity: 30MW ground PV, 100MW rooftop PV

Decarbonise transport

We will prioritise transitioning council-owned vehicle fleet to ULEVs by 2030, with the target to reach 45% transitioned to electric or hydrogen vehicles by 2025.

Capex: £580,000 excluding installation

Capacity: Up to 10 MW EV charging capacity

Deploy heat pumps

Heat pumps will be prioritised in those places where there are low electrical grid upgrades required and where properties are not currently connected to the gas grid.

Capex: £31.5 million by 2028

Capacity: 5,000 heat pump installations

Electric grid reinforcement

The electrical grid will be reinforced in alignment with WPD's projected expenditure 2023-2028. This reinforcement is essential for the grid to be resilient to increased demand loads and to increased variability of supply from renewables uptake.

Capex: Up to £15.4 million by 2028

Capacity: Up to 600 MW by 2028

Industry decarbonisation and hydrogen

Working with industry to pilot hydrogen projects within Pembrokeshire.

Capex: £2 million on local electrolysers by 2028

Capacity: 12 MW of local electrolyser capacity by 2028

6. Governance, monitoring and review

Governance

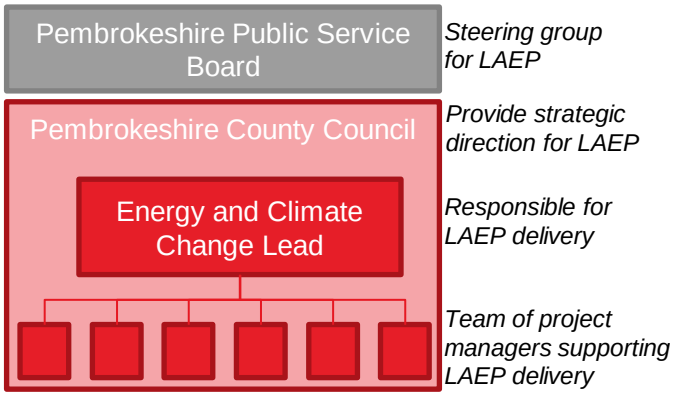
Pembrokeshire County Council is responsible for the strategic direction for the LAEP. We will appoint an Energy and Climate Change Lead to deliver this plan, by the end of 2023. They will need to be supported by the correct resources and budgets to work towards this important energy transition.

The Pembrokeshire Public Service Board (PSB) will provide a steering group to the LAEP, made up of representatives of key organisations who have particular expertise to lend to the LAEP. The PSB would provide advice and ensure delivery of the LAEP outputs and outcomes.

Recognising the different stakeholders who play an important role in delivering the change that will be required to meet the objectives set out in this plan, we will also work with partners across South West Wales to set up an advisory board to enable wider input into our plan.

Our ask of others

Support us to grow our Energy and Climate Change team, to start the transition we need a team of at least five technical project managers to integrate with our existing teams to implement GHG reduction and mitigation measures.



Monitoring and review

This plan sets out our key actions for the first five years that will set us on the right journey to achieve the ambitions in our longer-term routemap. The plan needs to be flexible to adapt to changes in the future.

We will produce an annual monitoring report, building on the Welsh Government's *Energy Generation in Wales* reports, which will describe our progress against the actions set out in this plan, and also against key output metrics as follows:

- Number of homes retrofitted
- Number of non-domestic buildings retrofitted
- Number of EV charging points installed
- MW renewables installed
- Number / MW of heat pumps installed
- Number of low carbon energy innovations

To monitor these metrics we will make use of publicly available datasets such as the Energy Performance Certificate Register, the Micro Generation Certification Scheme and the Renewable Energy Planning Database.

We will develop a baseline understanding of these metrics based on existing data and monitor changes annually.

We will also track carbon emissions reduction, but recognise that available data will lag a few years behind.

The whole plan will be updated at least every five years to take account of key factors, including:

- Policy changes at a UK and Welsh Government level
- Changes in costs and effectiveness of technologies
- Progress to date

6. Governance, monitoring and review

Control and influence

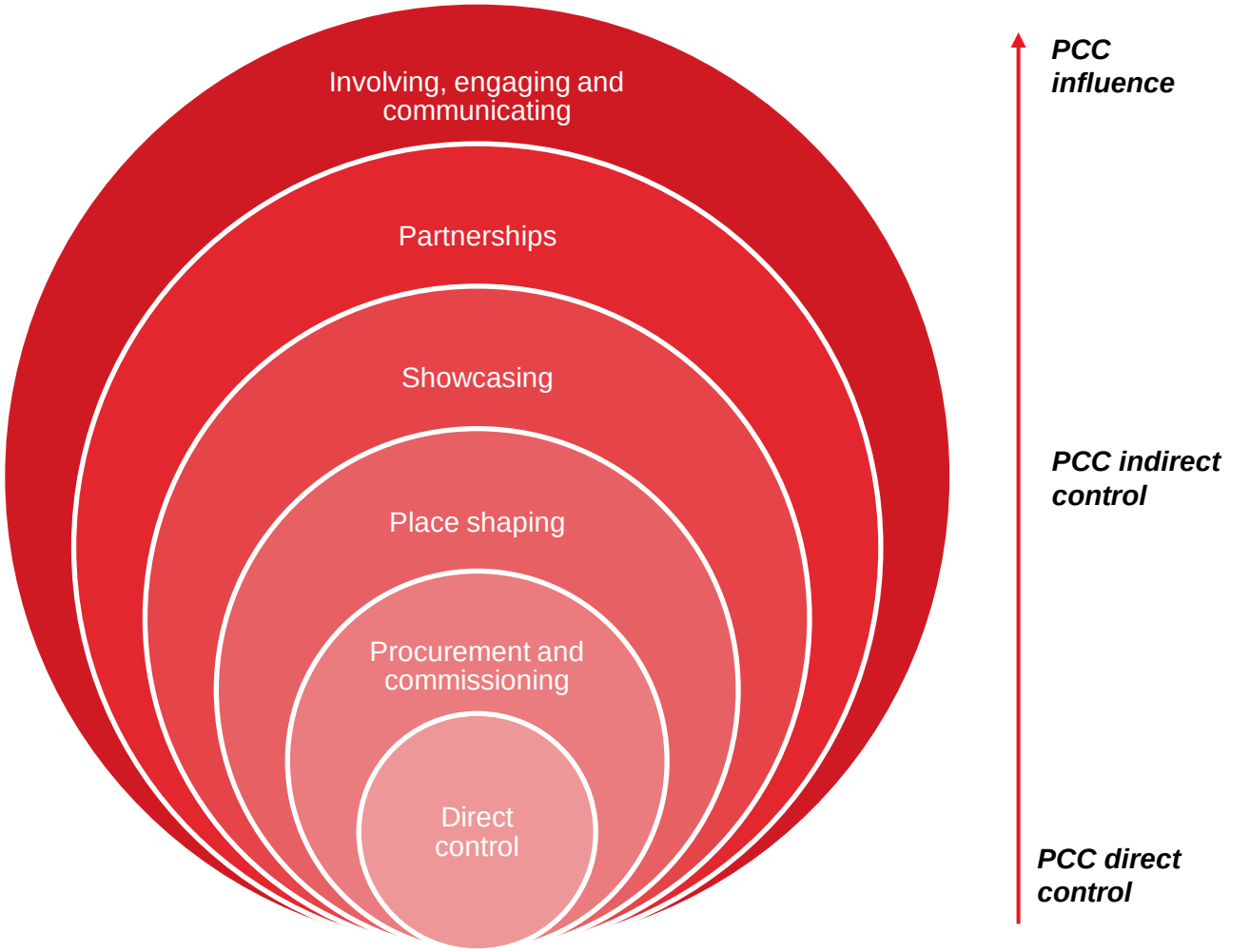
The Pembrokeshire Local Area Energy Plan (LAEP) outlines what a zero carbon energy system could look like for Pembrokeshire by 2050.

To deliver this, we (as Pembrokeshire County Council) will decarbonise assets within our direct control, such as council buildings and the council transport fleet. Further, we will drive and influence the decarbonisation of the wider Pembrokeshire area through showcasing, collaborating and engaging the community.

Our sphere of influence might include:

- Budget and finance
- Defining and helping to achieve the project outcomes
- Identifying the priorities
- Identifying potential risks and monitoring risks
- Monitoring timelines
- Monitoring the quality of the project as it develops

We are involved in a range of projects, initiatives and partnerships with different levels of control. Some of these examples are shown on page 53.



6. Governance, monitoring and review

Direct control	Procurement and commissioning	Place shaping	Showcasing	Partnerships	Involving, engaging and communicating
• Business pool car fleet • Renewable energy systems on Council land/buildings • New build Social Housing • Council Housing retrofit • Streetlighting • Active Travel • Public transport interchanges • Circular economy, waste, recycling and environmental services • Sustainable schools education	• Sustainable procurement • Net zero carbon new buildings • Low lifetime embodied carbon new buildings	• Haverfordwest Town Centre & Castle regeneration • Pembroke South Quay regeneration • Scolton Manor enhancements • Planning & Development • Land use & GHG sequestration • Biodiversity • Coastal protection, flooding, drainage, civil contingencies, emergency planning, climate change adaptation	• MH:EK hydrogen electrolysis, refueller and HFCEV car demo • MH:EK hydrogen ready hybrid boiler and air source heat pump heating system • PV solar car parking canopies	• Working with Welsh Government e.g. smart living initiative • Pembrokeshire Public Services Board • Private sector collaboration – e.g. RWE Pembroke Net Zero Centre • Swansea Bay City Deal Partners • Milford Haven : Energy Kingdom (PCC, PoMH, WWU, OREC, Arup, ESC) • Milford Haven Waterway Strategic Energy Group • Milford Haven Waterway Enterprise Zone Board • Community & 3rd Sector e.g. Marine Energy Pembrokeshire, Pembrokeshire Coastal Forum, Community Energy Pembrokeshire, Egni/Awel Aman Tawe, Cwm Arian Renewable Energy, Transition Bro Gwaun	• Engagement with wider community in Pembrokeshire. • Engaging with schools and holding events such as the very successful MH:EK community day.

Bibliography

[1] 13.1 20201113 Final PCC - Net Zero - Action Plan v1.10.pdf (pembrokeshire.gov.uk)
[2] https://www.pembrokeshire.gov.uk/objview.asp?object_id=3821&language=
[3] Well-being Plan - Pembrokeshire County Council
[4] Labour Market Profile - Nomis - Official Labour Market Statistics (nomisweb.co.uk)
[5] https://gov.wales/sites/default/files/statistics-and-research/2020-03/welsh-housing-conditions-survey-whcs-2017-18-local-area-fuel-poverty-estimates-modelling-and-results-summary-071.pdf
[6] MSOA estimates of properties not connected to the gas network - GOV.UK (www.gov.uk)
[7] Regional gross value added (balanced) by industry: all ITL regions - Office for National Statistics
[8] UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2019 - GOV.UK (www.gov.uk)
[9] Adopted Local Development Plan - Pembrokeshire County Council
[10] LDP Renewable Energy Assessment - Pembrokeshire County Council
[11] Pembrokeshire Recovery and Regeneration Strategy 2020-2030 - Pembrokeshire County Council
[12] App 1 - South West Wales Regional Energy Strategy.pdf (npt.gov.uk)
[13] WG44621 Working together to reach Net Zero: All Wales Plan 2021-25 (gov. wales)
[14] 42949 Second All Wales Low Carbon Delivery Plan (2021-2025) (gov.wales) Proposal 5
[15] well-being-of-future-generations-wales-act-2015-the-essentials.pdf (gov.wales)
[16] Digest of UK Energy Statistics (gov.uk)
[17] UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2019 - GOV.UK (www.gov.uk)
[18] subnational_total_final_energy_consumption_2019.xlsx (live.com)
[19] MSOA estimates of properties not connected to the gas network - GOV.UK (www.gov.uk)
[20] Energy Generation Wales
[21] Transport for Wales
[22] Lower and Middle Super Output Areas electricity consumption - GOV.UK (www.gov.uk)
[23] Lower and Middle Super Output Areas gas consumption - GOV.UK (www.gov.uk)
[24] Non-gas map (nongasmap.org.uk)
[25] The role consumer choice in decarbonising heat - Arup
[26] The Co-operation Agreement: 2021 | GOV.WALES
[27] Written Statement: The Optimised Retrofit Programme 2020-21 (6 November 2020) | GOV.WALES
[28] Local ownership of energy generation in Wales: policy statement | GOV.WALES
[29] Industrial Fuel Switching competition - GOV.UK (www.gov.uk)
[30] Gas heating ban for new homes from 2025 - BBC News
[31] Electric Vehicle Charging Strategy (gov.wales)
[32] Climate change targets and carbon budgets | GOV.WALES
[33] £250 million towards 20,000 low carbon homes for rent | GOV.WALES
[34] UK Hydrogen Strategy (publishing.service.gov.uk)
[35] HM Government – Heat and Buildings Strategy (publishing.service.gov.uk)
[36] 42949 Second All Wales Low Carbon Delivery Plan (2021-2025) (gov.wales) Proposal 5
[37] WPD communications
[38] Government takes historic step towards net zero with end of sale of new petrol and diesel cars by 2030 - GOV.UK (www.gov.uk)
[39] The non-domestic private rented sector minimum energy efficiency standards: the future trajectory to 2030 (publishing.service.gov.uk)
[40] Welsh public sector to be carbon neutral by 2030 | GOV.WALES
[41] Local ownership of energy generation in Wales: policy statement | GOV.WALES
[42] Tackling fuel poverty 2021 to 2035 [HTML] | GOV.WALES
[43] App 1 - South West Wales Regional Energy Strategy.pdf (npt.gov.uk)
[44] Llwybr Newydd: the Wales Transport Strategy 2021 [HTML] | GOV.WALES
[45] UK net zero strategy
[46] Homes as Power Stations | Swansea Bay City Deal
[47] Future Wales: the national plan 2040 | GOV.WALES
[48] Joint LTP 300115 (gov.wales)
[49] British energy security strategy - GOV.UK (www.gov.uk)