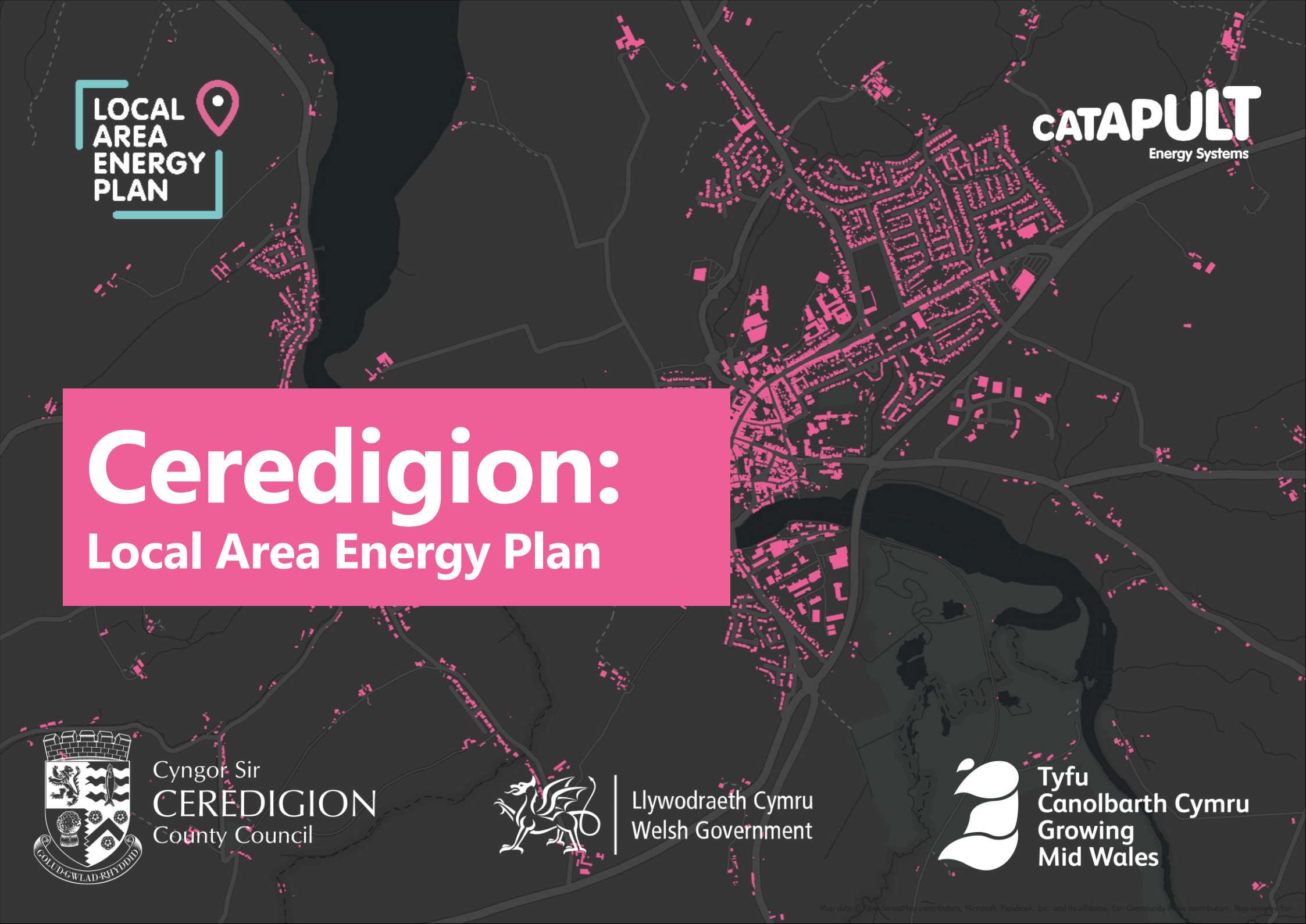

LOCAL AREA ENERGY PLAN
CATAPULT
Energy Systems
Ceredigion:
Local Area Energy Plan
Cyngor Sir
CEREDIGION
County Council
GOLUD·GWLAD·RHYDDID
Llywodraeth Cymru
Welsh Government
Tyfu
Canolbarth Cymru
Growing
Mid Wales

Acknowledgements

This plan was prepared by Energy Systems Catapult, on behalf of Ceredigion County Council, funded by Welsh Government.

Contributors

The development of this Local Area Energy Plan (LAEP) has been overseen by a steering group formed of Ceredigion County Council as the lead organisation, gas and electricity network operators in the region, Welsh Government, and Growing Mid Wales – a regional partnership between private and public sectors. The steering group has been instrumental in shaping the LAEP by being accountable for decision making, supporting data gathering, providing local context and characteristics, defining the modelling scenarios, examining model assumptions, and reviewing and commissioning the LAEP.

Further support was provided by local stakeholders who also contributed to the decision-making process, the data gathering, and the understanding of local context and characteristics.

Contents

Executive Summary

Executive Summary

To reach a Net Zero energy system by **2050**, Local Area Energy Plan for Ceredigion requires capital investment of:

£654 million

total additional investment over business-as-usual (excluding large-scale renewables). This is a 37% increase over the BaU investment of £1.76 billion

Including: £261 million

in domestic properties (including building fabric upgrades, heating systems and rooftop solar PV)

bringing potential local benefits, of approximately:

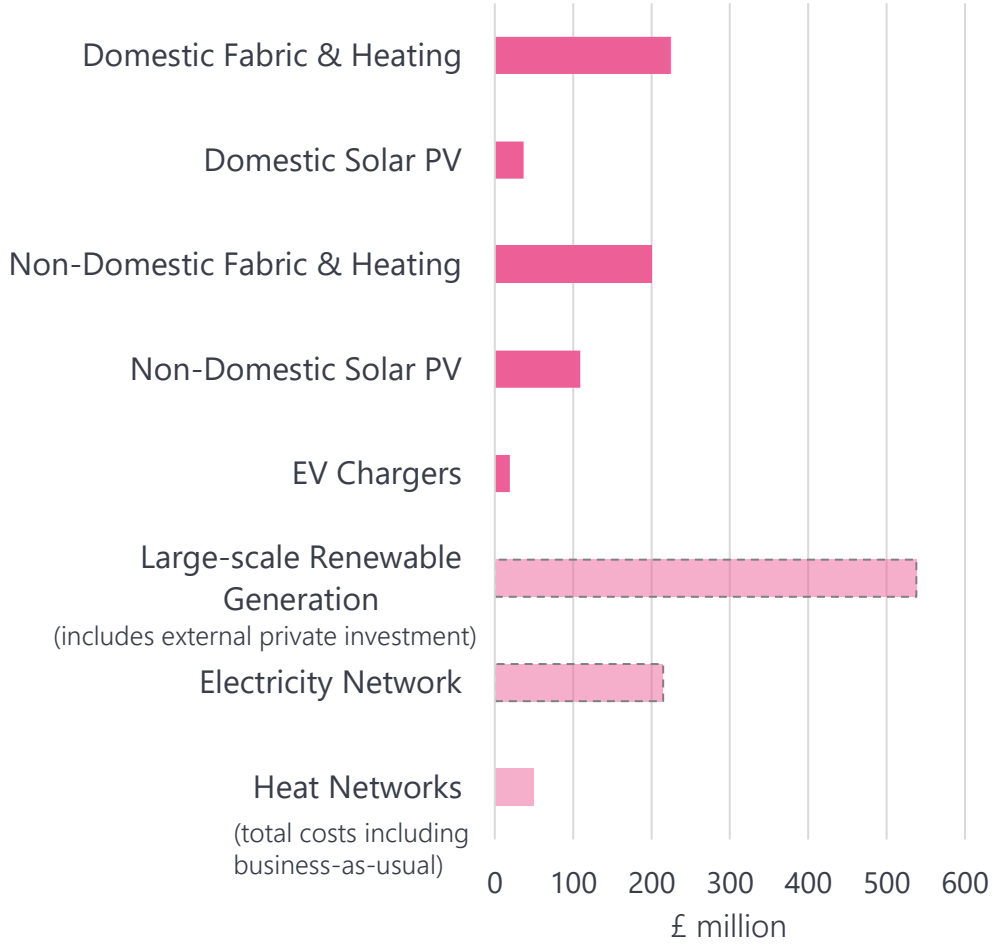
375 jobs

additional full-time equivalent supported to 2050 by the investment in Net Zero

£1,360

indicative annual household bill saving possible (see Household Bill Savings page for details)

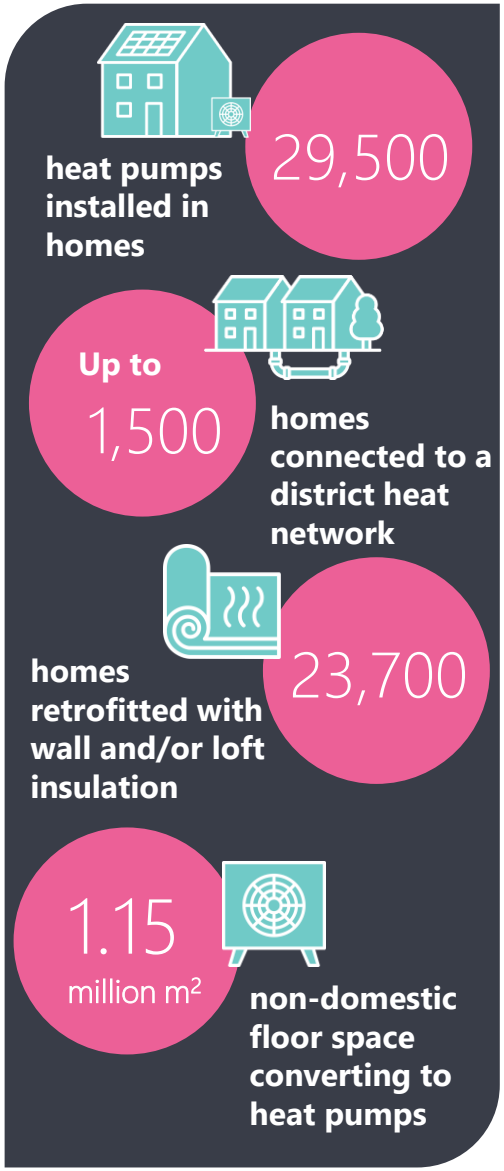
Total Investment to 2050

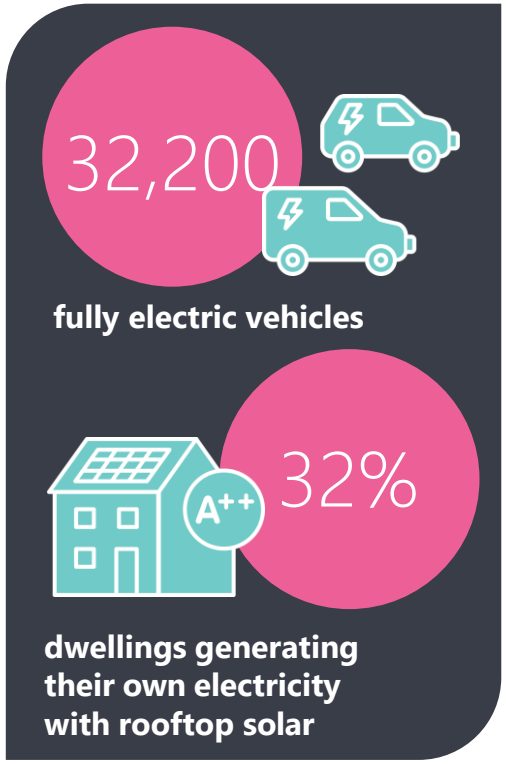


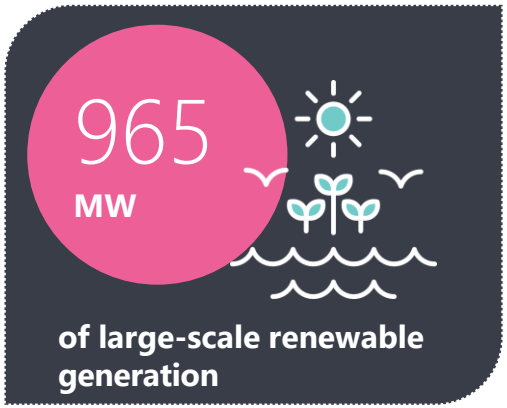
Additional investment over business-as-usual to reach Net Zero. Figures based on National Net Zero scenario. Explanation of scenarios and comparison of results across scenarios are detailed throughout this document. All costs shown are discounted unless otherwise stated. See Implementation: Costs & Benefits section for a more detailed explanation.

Executive Summary

Ceredigion's energy system will have been transformed, with:







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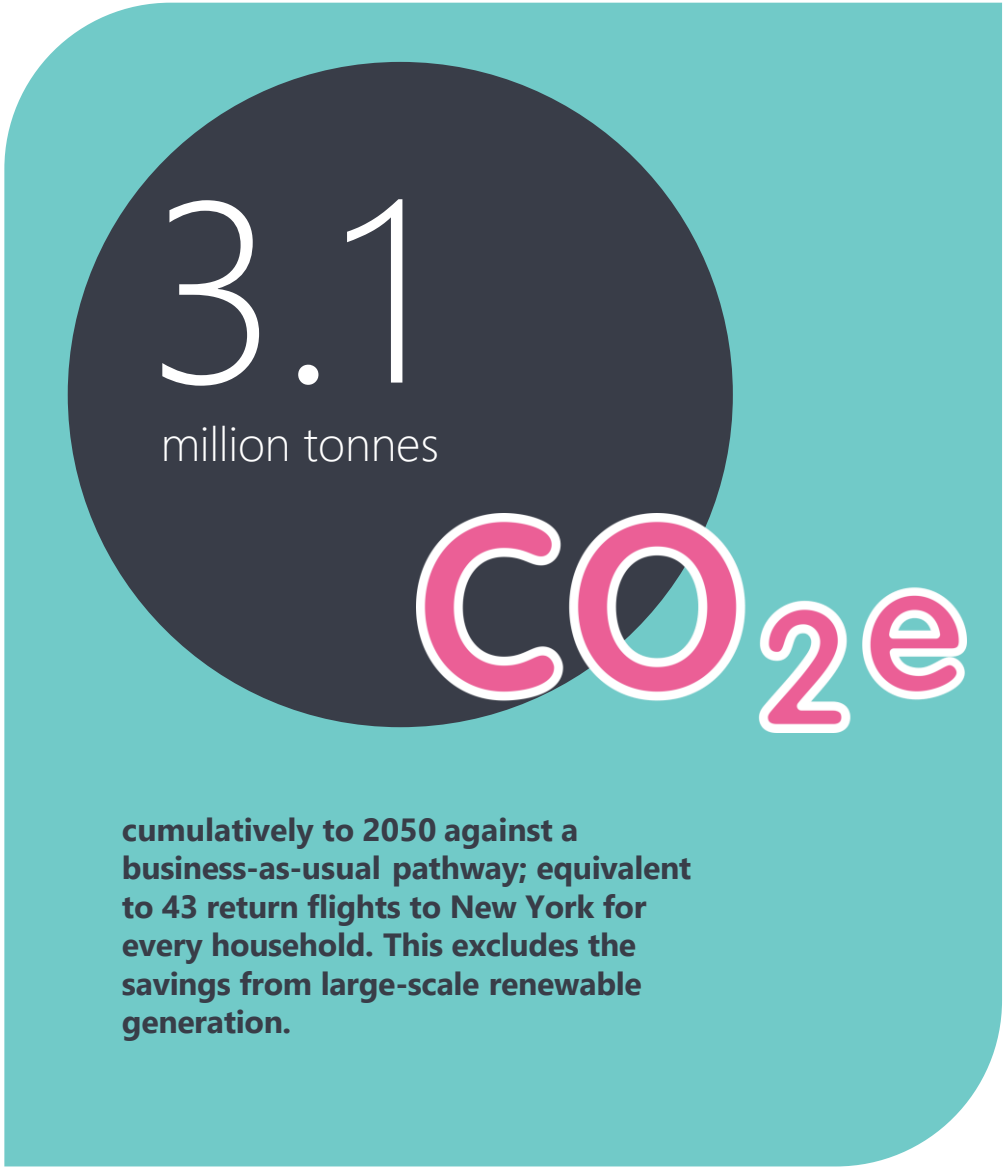


Executive Summary

What is a Local Area Energy Plan?

A Local Area Energy Plan (LAEP) identifies the most cost-effective way for a local area to decarbonise its energy system to help the UK meet its net zero target for 2050. It is led by local government and developed collaboratively with key stakeholders.

How does the LAEP help us plan for the future?

This report provides a fully costed, spatial plan that identifies the change needed to the local energy system and built environment, detailing 'what, where and when and by whom'.

It signposts opportunities for investment, which could bring significant local benefits, such as employment creation, air quality improvements, reduced rates of fuel poverty and better health outcomes. It highlights changes which are low regrets, and some which are more uncertain, to help decision-makers prioritise the next steps.

What electricity network upgrades are required in Ceredigion?

This plan indicates that around £215m needs to be spent on the distribution network by 2050 to ensure sufficient capacity is available to support the rapid growth of local carbon technologies required to transition to net zero. The modelling shows that with timely upgrades to the distribution network, Ceredigion can meet its expected increase in electricity demand to transition to net zero.

The outputs from the LAEP will be used by the energy networks to inform their strategic business plans for network investment. Ceredigion County Council, Growing Mid Wales, Welsh Government and the energy networks will continue to work together to tackle current grid constraints to unlock opportunities in Ceredigion. The energy networks have expressed a clear commitment to facilitating the transition to net zero throughout their engagement with this LAEP process.

What renewable energy generation infrastructure is needed in Ceredigion?

Ceredigion can meet its own energy needs through local renewable energy generation (existing and consented) and the addition of 220 MW of rooftop solar PV. Additionally, there is potential to install a significant amount of ground-mounted solar and wind generation locally to contribute to the decarbonisation of the whole of the UK. It is suggested that a proportional contribution to national energy targets would involve installing 965 MW of new generation, but decisions are needed around how much of the potential to develop.

Stakeholders strongly believe that renewable energy generation within Ceredigion should benefit local people, enabling bill reductions, economic development and job creation within the area. Shared and local ownership could play a key role in enabling this.

How can local renewable energy generation and use be maximised?

Maximising the generation and use of renewable energy locally has been identified as a key priority for Ceredigion. Flexibility from technologies such as smart electric vehicle chargers and batteries can help reduce the need for network upgrades, and unlock grid capacity constraints in the near term.

A smart local energy system which brings together different energy assets and infrastructure in a local area to make them operate in a smarter way, could help Ceredigion meet its carbon targets more quickly and cost effectively whilst delivering wider social and economic value for residents and businesses.

What is the potential role of hydrogen in Ceredigion?

Ceredigion has significant hydrogen generation potential (up to 6.3 TWh per year), however lacks concentrated demand. Further work is needed to explore small-scale industrial, transport and energy storage opportunities for hydrogen in Ceredigion.

Executive Summary

What changes will be needed to Ceredigion's homes?

Heating system changes: 100% of homes in Ceredigion currently using fossil fuel heating will need to be converted to low carbon heating systems to reach net zero by 2050. Air source heat pumps are the most widely suitable low carbon heating technology for homes in Ceredigion, so are expected to be the predominant solution, installed in 76 % of homes by 2050.

In more densely built-up areas, and where space is constrained, alternatives such as district heat networks or shared ambient loop systems may be advantageous. Decisions are needed around which technology options to pursue in these locations. While homes using electric resistive heating (including storage heaters) will not necessarily need to change to reach net zero, they do stand to reduce running costs by using more efficient heat pumps.

The UK Government will be making a decision on the use of hydrogen for heating in 2026., and Welsh Government intend to publish a clear statement on the role of hydrogen in meeting buildings' heat decarbonisation ambitions in their upcoming hydrogen policy position statement. The LAEP explores the potential role of hydrogen for heating in Ceredigion, but this option is very uncertain and likely to play a niche role at most.

Fabric efficiency upgrades: Carrying out fabric efficiency upgrades (insulation, draught proofing and/or glazing replacement) has been identified as a low regret option for many homes across Ceredigion. These measures would reduce both carbon emissions and fuel poverty rates within the county.

61 % of homes could benefit from loft and/or wall insulation. It would also be beneficial to steer the natural end-of-life replacement of windows towards high thermal performance options, such as triple glazing.

Programmes focussed on social housing, such as Optimised Retrofit Wales, will be need to be adapted to the private rented and owner-occupier sectors to scale up retrofit measures.

What changes will be needed to non-domestic buildings in Ceredigion?

The solutions for non-domestic buildings look similar to those for homes, with fabric efficiency, heat pumps and rooftop solar being the path to Net Zero for the majority. As with homes, connection to district heat networks in some town centres, and the potential role for hydrogen, have also been explored.

What is the role of sustainable transport solutions?

Reduced dependence on private cars is a feature of the pathway, thanks to improved public transport and active travel options, as well more remote work, teleconferencing and so on. However, this plan acknowledges the realities of rural life in Ceredigion, where significant car dependence is unavoidable. Decisions are needed around how much ambition on modal shift will be appropriate, tying in with Welsh Transport Strategy.

All private petrol and diesel vehicles need to be replaced by electric vehicles at their natural end of life to reach net zero by 2050. As electric car costs come down, and they become a common option in the second-hand market, the switch to electric need not impose additional costs. This transition is supported by the buildout of public charging infrastructure, reaching over 1,500 public chargers by 2050, while the demand from home charging is accounted for in network planning. Charging infrastructure to cater for tourist requirements is particularly important for Ceredigion.

This LAEP also considers the shifts to electric buses and goods vehicles. There is the potential for hydrogen to play a role in decarbonising certain vehicles which could be pursued further.

Executive Summary

Is it possible to decarbonise Ceredigion's energy system by 2050?

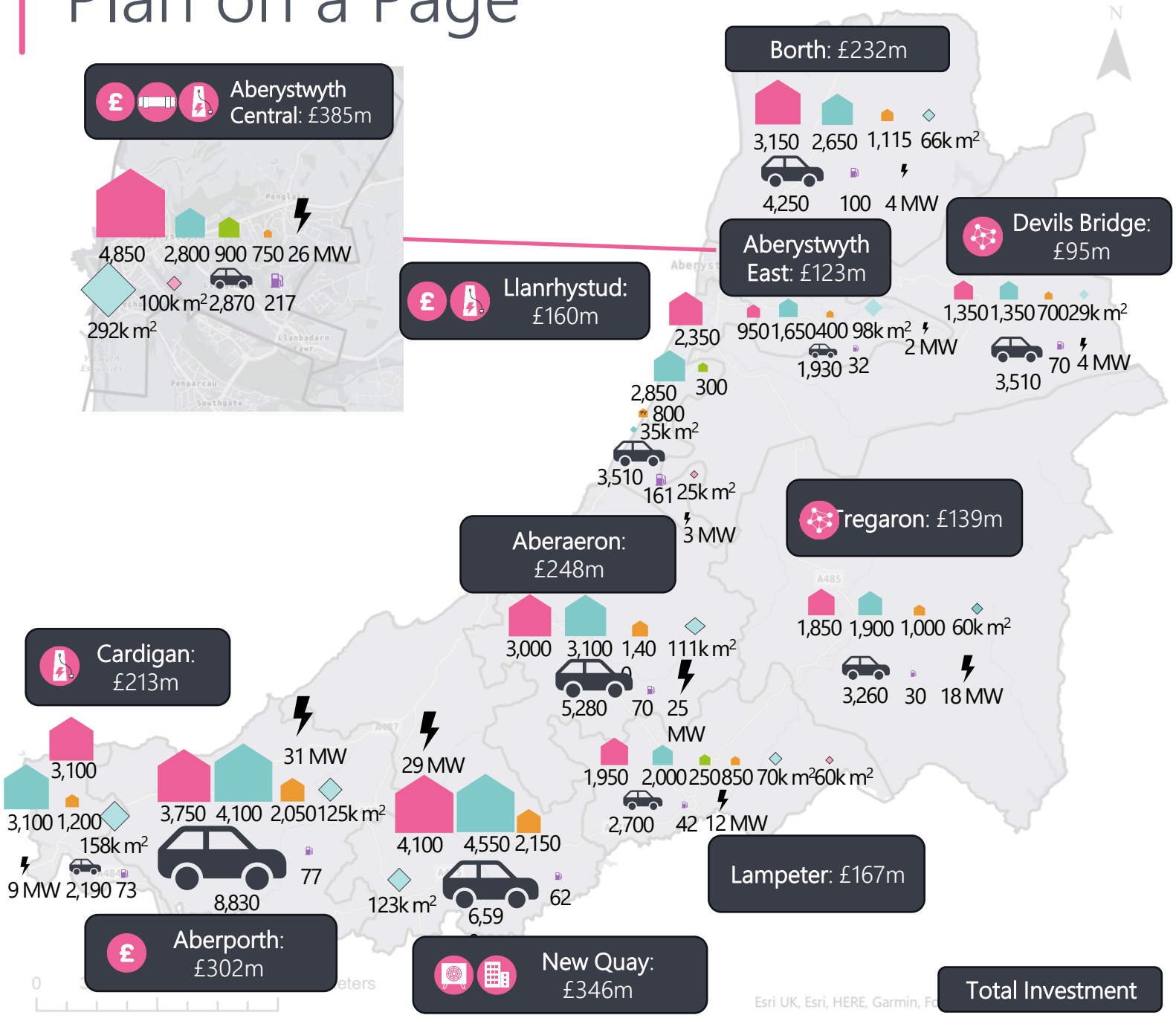
This LAEP identifies that it is possible to achieve a net zero energy system in Ceredigion by 2050. This will, however, be highly dependent on financial and technical support, policy changes, supply chain development, addressing current skills gaps and behavioural changes.

There is a risk that interim carbon targets could be missed. For example, the installation rates of heat pumps, insulation and other low carbon changes required by 2030 will be extremely challenging to deliver given the time it takes to scale up supply chains and skilled personnel. In addition, any delays in network investment would result in interim carbon targets, and potentially the 2050 target, being missed in Ceredigion, highlighting the criticality of investment in the grid.

What's next?

The Implementation section of this report highlights the next steps required to achieve a transition to net zero in Ceredigion by 2050. Various priority projects have been identified in specific locations, such as smart local energy systems, heat networks and social housing retrofit packages.

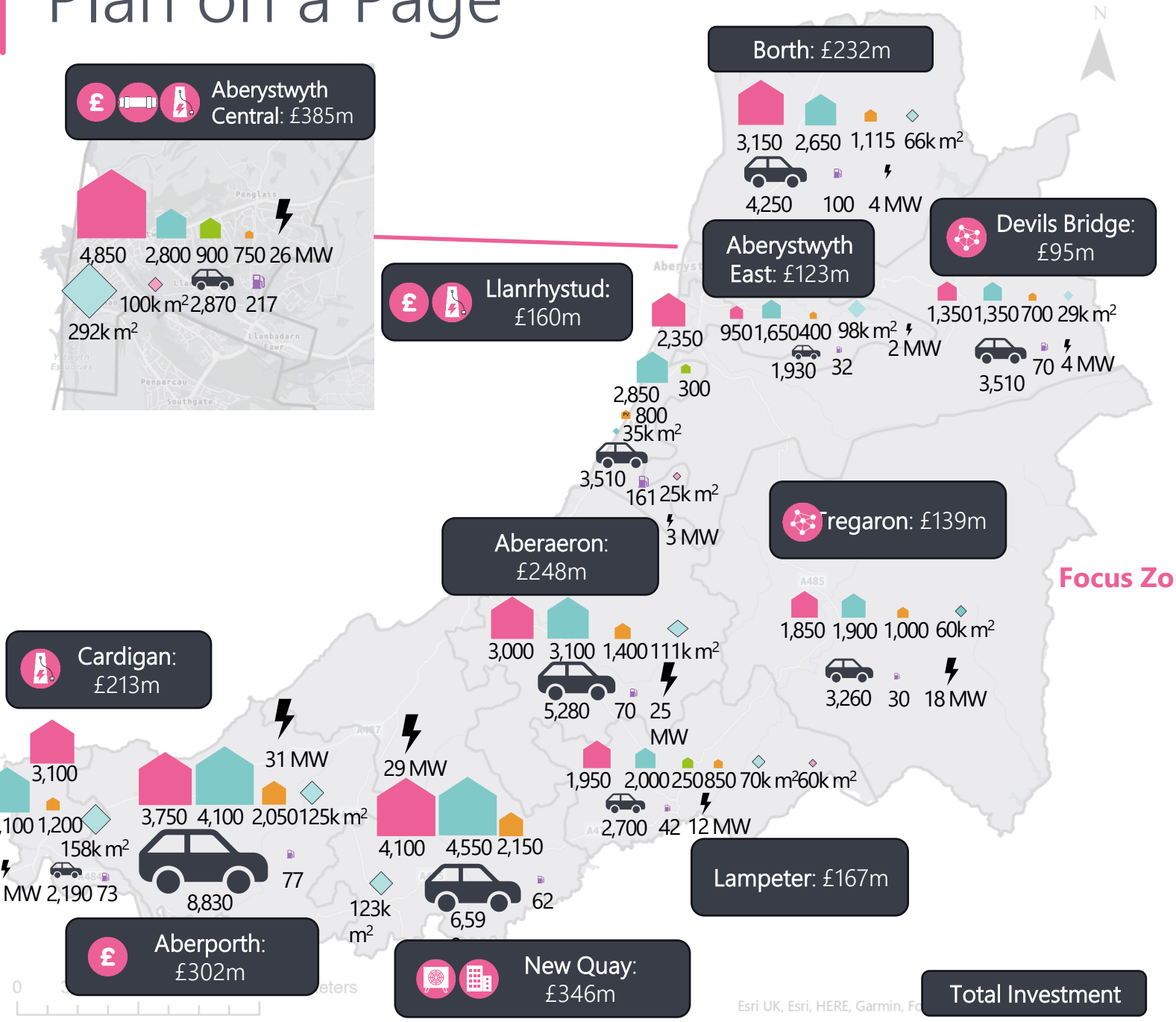
Plan on a Page



The size of the icons show the extent of changes required in each zone of Ceredigion to achieve a Net Zero energy system by 2050. Focus zones are areas where a zone is particularly well-suited to a major effort on deploying a particular solution. This could be because of particular social benefits to the area, favourable infrastructure, or a high concentration of a particular technology type or housing type.

Numbers shown based on National Net Zero scenario

Plan on a Page



Quantities of Technology Deployment

- Fabric Efficiency Upgrades for Homes
- Heat Pumps for Homes
- Heat Network Connections for Homes
- Rooftop Solar PV for Homes
- Home EV chargers
- Public EV chargers
- Heat Pumps for Non-domestic Buildings
- Heat Network Connections for Non-domestic Buildings
- Increase in required substation capacity (megawatts)

Focus Zones

- Home fabric efficiency for areas with high fuel poverty
- Home heat pumps in zones with spare network capacity
- Heat networks
- Non-domestic buildings fabric efficiency and heat pumps in area with spare network capacity
- Public chargers for electric vehicles in areas with high anticipated charging requirements
- Smart Local Energy Systems to Overcome Network Constraints

Numbers shown based on National Net Zero scenario

Example Priority Projects

Near-term projects have been identified where early progress could be made. These are bitesize parts of the overall Net Zero pathway, where it is believed that conditions may be favourable for getting implementation off the ground. Clusters of particular solutions are highlighted, particularly where the network is unconstrained, strong social benefits are likely to result, or learnings can be taken forward to scale-up. Click the project boxes for more details.

Heat network in Aberystwyth
Serving 1,500 homes and 184,000 m^2 commercial and public buildings
Total investment: £145.5m (includes building connections and non-domestic efficiency upgrades*)

Social Housing in Aberystwyth
- cavity wall insulation for 200 homes
- solid wall insulation for 190 homes
- loft insulation for 300 homes
- rooftop solar PV for 590 homes

Total investment: £6.2m

Public EV Chargers to South of Aberystwyth
In addition to the clear need for public chargers in Aberystwyth, the zone to the south also has significant opportunity for 150 chargers, while being less restricted by a need for network capacity upgrades
Total investment: £0.8m

Social Housing in Cardigan
- cavity wall insulation for 60 homes
- solid wall insulation for 35 homes
- loft insulation for 110 homes
- rooftop solar PV for 200 homes
- heat pump installations for 350 homes

Total investment: £4.4m

Rural Owner-occupiers in the New Quay Zone
2,500 homes switching from oil boilers to heat pumps
Total investment: £28.8m

Smart Local Energy System in the Tregaron Zone
Demonstrator project to explore the potential for smart technologies to overcome network capacity constraints

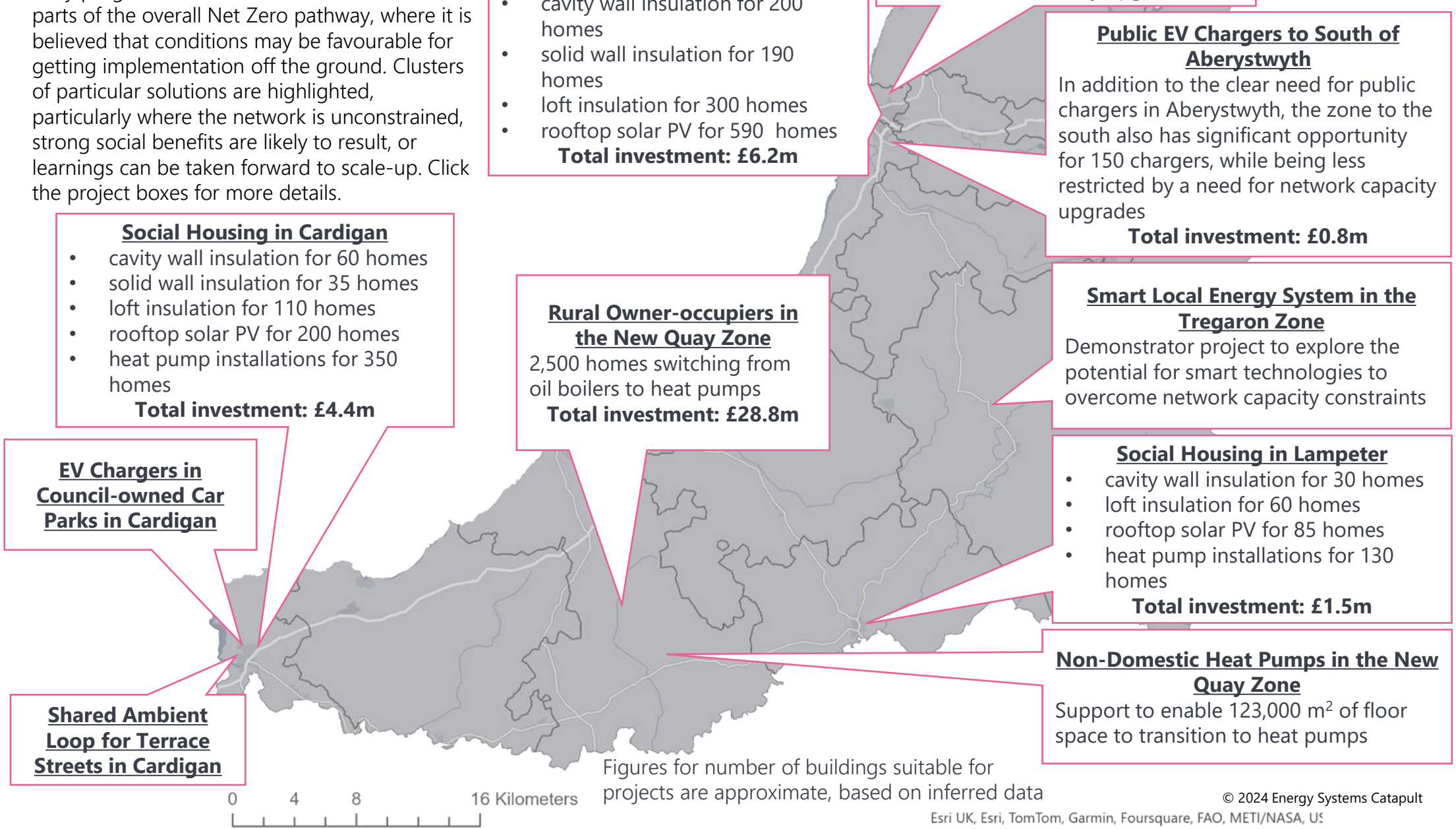
EV Chargers in Council-owned Car Parks in Cardigan

Social Housing in Lampeter
- cavity wall insulation for 30 homes
- loft insulation for 60 homes
- rooftop solar PV for 85 homes
- heat pump installations for 130 homes

Total investment: £1.5m

Shared Ambient Loop for Terrace Streets in Cardigan

Non-Domestic Heat Pumps in the New Quay Zone
Support to enable 123,000 m^2 of floor space to transition to heat pumps



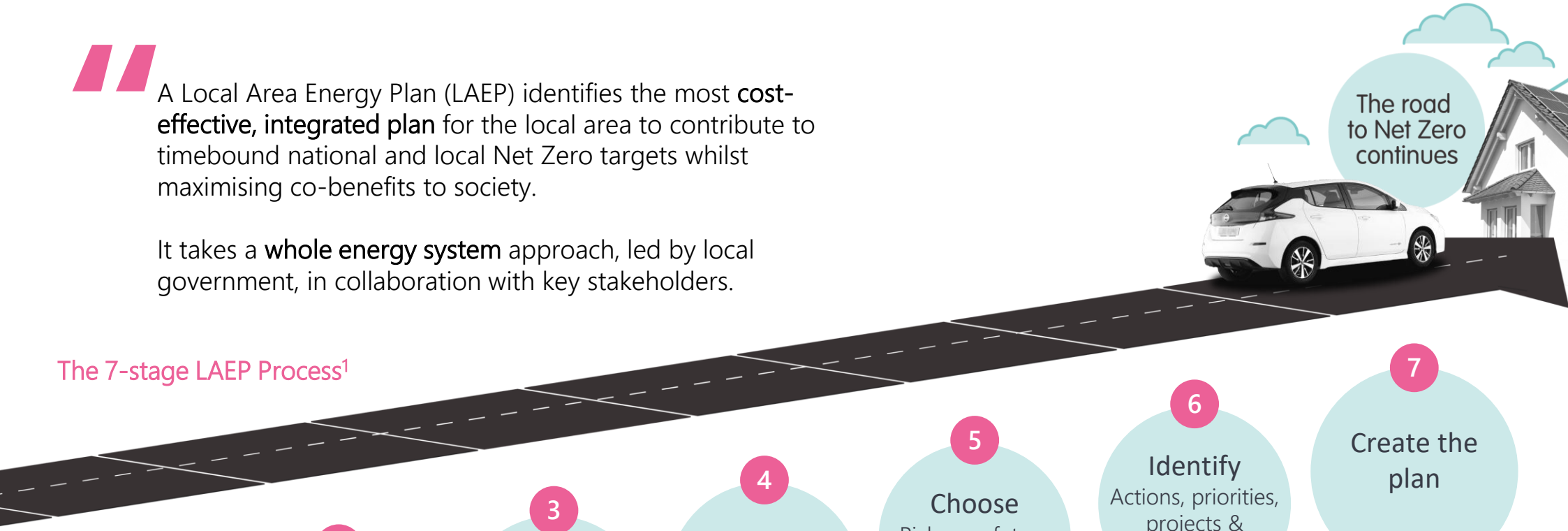
Figures for number of buildings suitable for projects are approximate, based on inferred data

Introduction

What is a Local Area Energy Plan?

A Local Area Energy Plan (LAEP) identifies the most **cost-effective, integrated plan** for the local area to contribute to timebound national and local Net Zero targets whilst maximising co-benefits to society.

It takes a **whole energy system** approach, led by local government, in collaboration with key stakeholders.



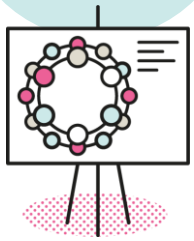
The 7-stage LAEP Process[1]

1. **Prepare** – Outline area hopes, ambitions, and get ready to mobilise

2. **Engage** – Identify key stakeholders and start conversations

3. **Map** – Understand your current local area

4. **Model** – Get your options for the future



5. **Choose** – Pick your future pathway

6. **Identify** – Actions, priorities, projects & decisions

7. **Create the plan**

* A LAEP will require updates as progress is made on the path to Net Zero

https://es.catapult.org.uk/guide/guidance-on-creating-a-local-area-energy-plan/

What is a Local Area Energy Plan?

Definition of a LAEP

A Local Area Energy Plan (LAEP) sets out the changes required to transition an area's energy system to Net Zero carbon emissions against a specified timeframe. This is achieved by exploring a range of technologies and scenarios through whole energy system modelling and analysis. By identifying the most cost-effective preferred pathway to Net Zero, additional benefits for the local area can also be realised[1].

Being data-driven and evidence-based, a LAEP uses a whole energy system approach that is led by local government and developed collaboratively with defined stakeholders. It sets out to identify the most effective route for the local area to meet its local Net Zero target, as well as contributing towards meeting the national Net Zero target[1].

A LAEP results in an indicative costed spatial plan that identifies the change needed to the local energy system and built environment, detailing what changes are required, where, when and by whom. The level of detail for an area is equivalent to an outline design or master plan; additional detailed design work is required for identified specific actions, projects, and programmes to progress to implementation[2]. Rather than a detailed schematic, a LAEP provides a proposed future sector-specific action plan that sets out how each part of the area will be designed and built.

Vision of a LAEP

A LAEP defines a long-term vision for an area but should be updated approximately every 3–5 years (or when significant technological, policy or local changes occur) to ensure the long-term vision remains relevant.

Scope of a LAEP

The UK government's 2021 Net Zero Strategy estimates that 82% of the UK's emissions are "within the scope of influence of local authorities."

The scope of a LAEP covers the current energy consumption and associated greenhouse gas emissions, as well as the projected consumption in a defined area to 2050, primarily focussing on the area's built-environment (all categories of domestic, non-domestic, commercial, and industrial buildings), some aspects of energy used for transportation, as well as the local renewable generation and energy networks needed to support this usage.

A LAEP addresses electricity, heat and gas networks, future potential for hydrogen, the built environment (industrial, domestic, and commercial), its fabric and systems, flexibility, energy generation and storage, and providing energy to decarbonised transport (i.e., electricity to electric vehicles and charging infrastructure). It identifies near-term actions and projects, providing stakeholders with a basis for taking forward activity and prioritising investments and action. Site-specific data is used where available, with remaining areas covered by the national dataset.

Benefits of a LAEP

A benefit of Local Area Energy Planning is the 'whole systems approach'. This provides consideration to the most cost-effective solutions to future energy system as a whole. For example, deploying different heat decarbonisation technologies to avoid a high-cost upgrade of the electricity network. By working closely with local stakeholders, incorporating their data, knowledge and future plans, a LAEP is built on a common evidence base. The outputs can then be used reliably by stakeholders from council planners to network operators to community groups, knowing they are working towards a common goal built on strong foundations.

[1] https://es.catapult.org.uk/report/the-future-of-local-area-energy-planning-in-the-uk/ and https://es.catapult.org.uk/guide/guidance-on-creating-a-local-area-energy-plan/

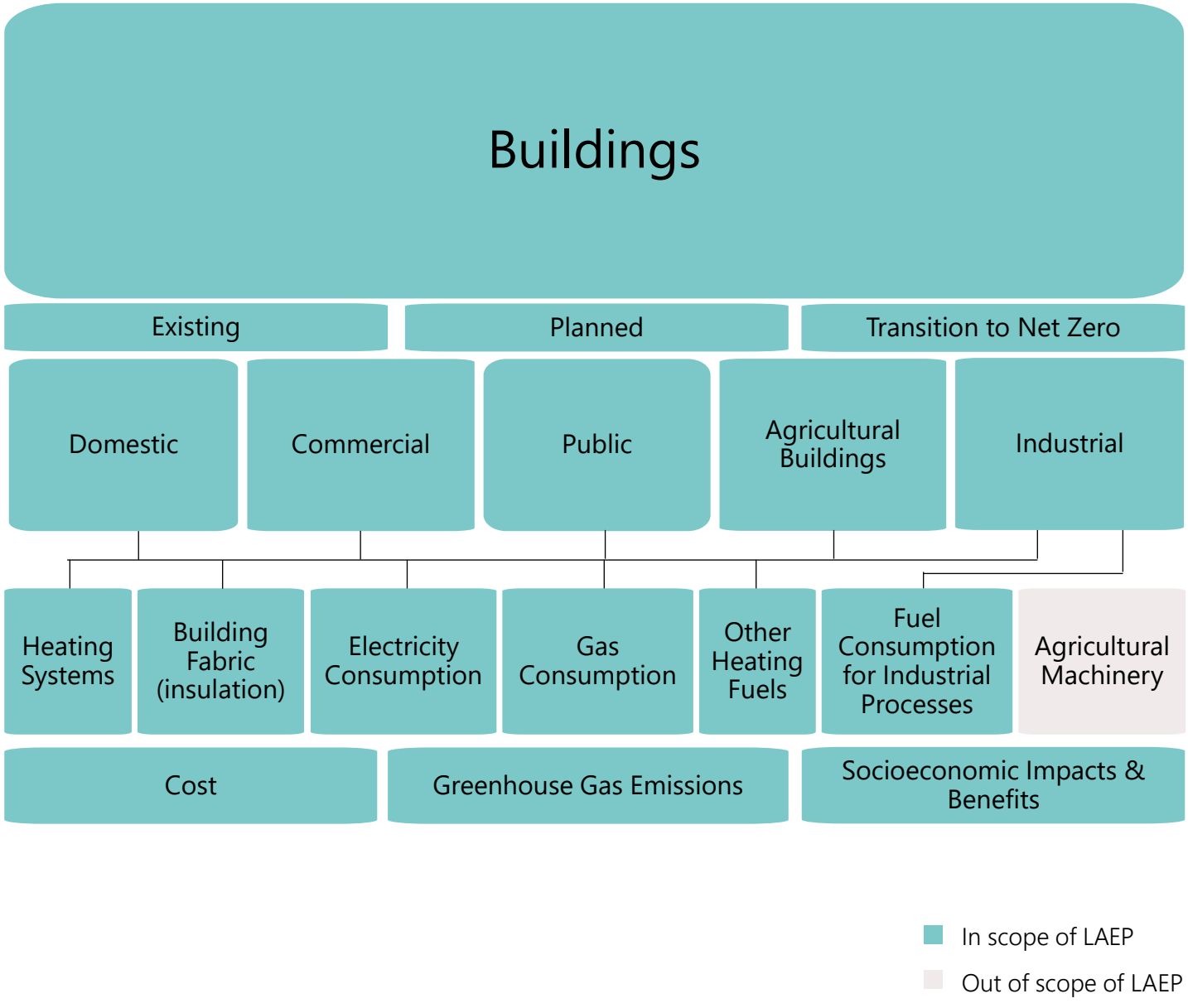
[2] For example, a LAEP may identify a zone that is best suited to a district heat network by assessing the types of buildings in the zone, their characteristics, and density; however, to deliver the district heat network it would require a full feasibility assessment by an appropriately qualified installation or design company, along with assessment of commercial viability and delivery mechanisms.

What is a Local Area Energy Plan?

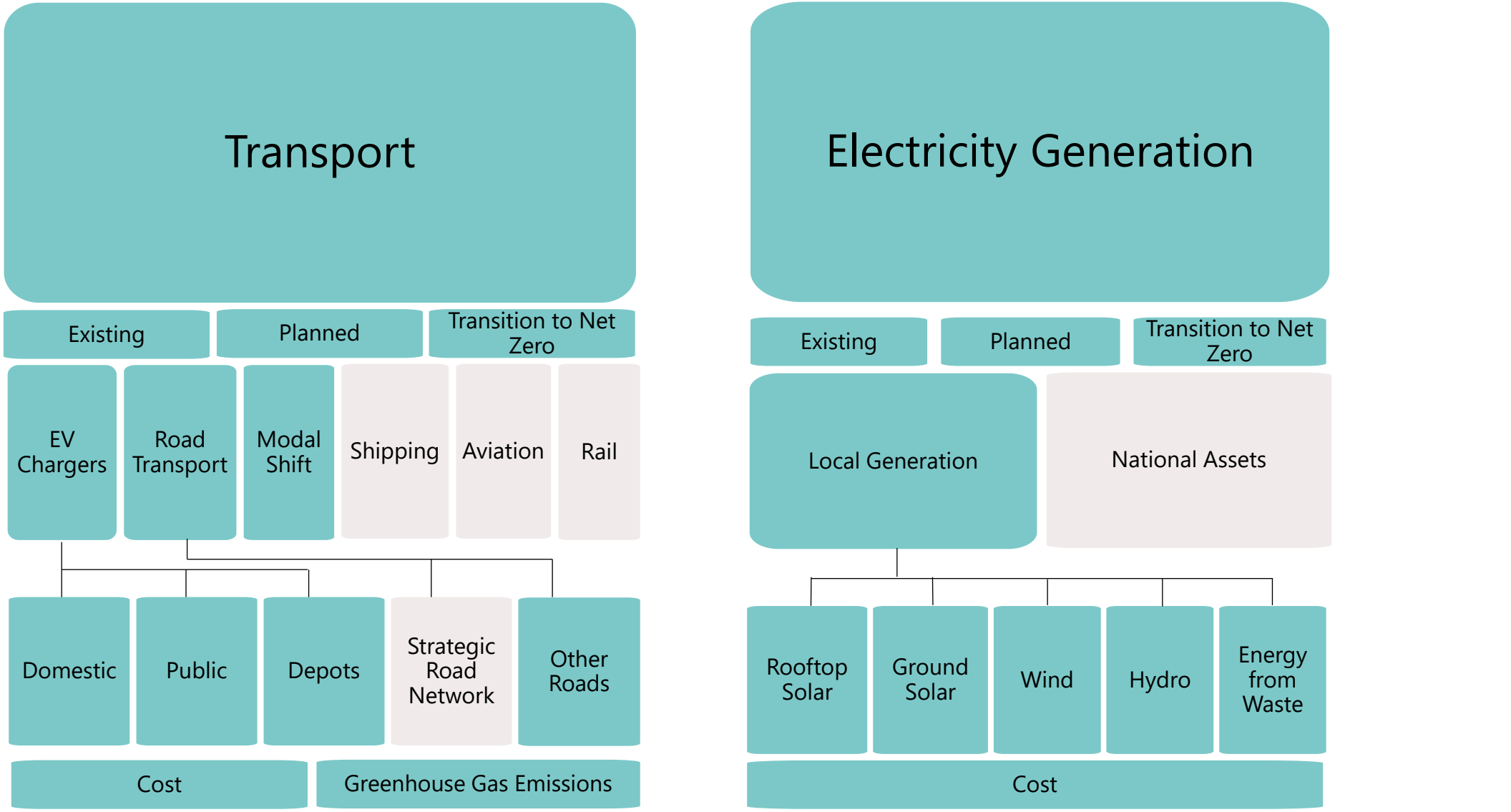
The diagrams indicate the parts of the local energy system and emissions which are in-scope for the LAEPs across Wales. This scope is defined by the document *Method for Delivering Local Area Energy Plans in Wales* by the Catapult.

The LAEPs consider the energy system as it is today, changes which are already planned, and changes which would be needed to transition to Net Zero carbon emissions. Energy consumption, carbon emissions and costs are calculated for these components.

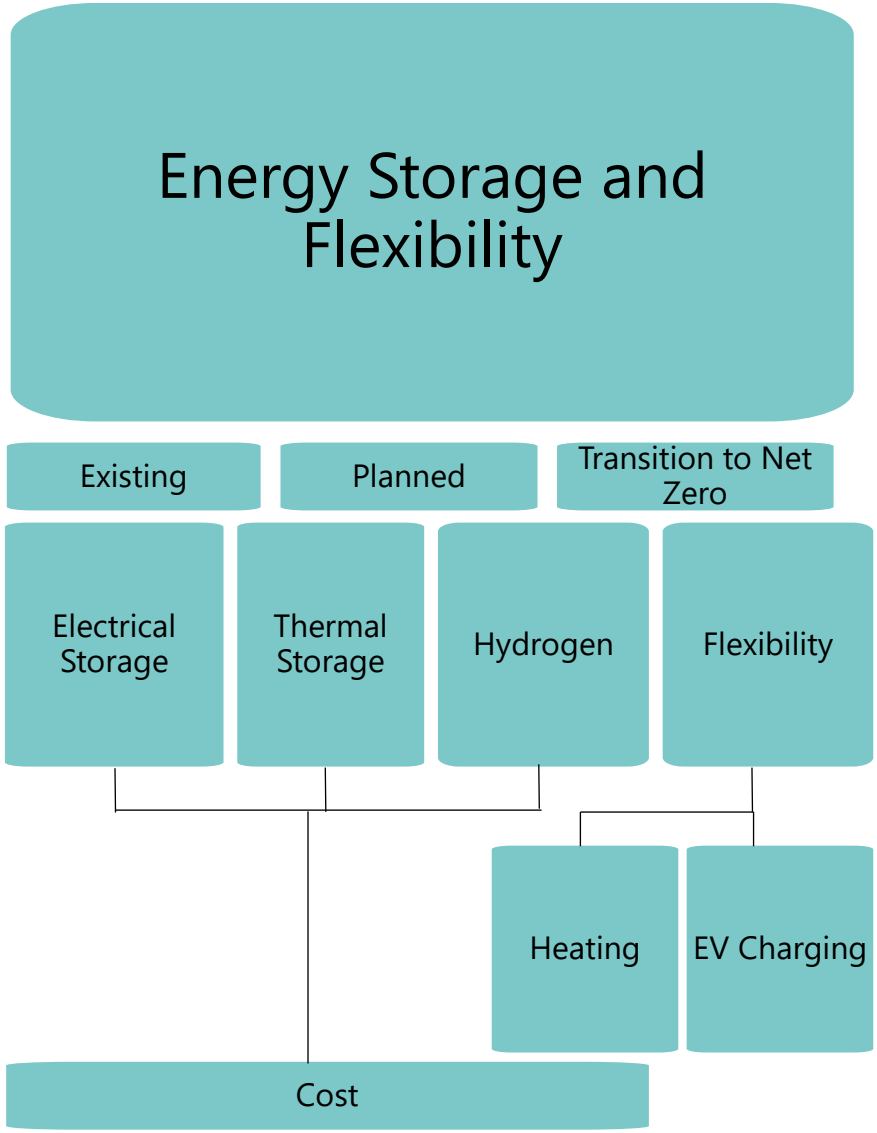
Local Area Energy Planning does not consider aspects of the energy system which are expected to be overseen by central government, or non-energy sources of greenhouse gas emissions. Shipping, aviation, rail, the strategic road network, and large electricity generators connected to the transmission network are aspects considered to be national rather than local. Greenhouse gas emissions from agricultural land use and livestock are outside of the energy system, and decarbonisation options for agricultural machinery are not yet sufficiently mature to select for the plan, though this can be revisited in future updates.

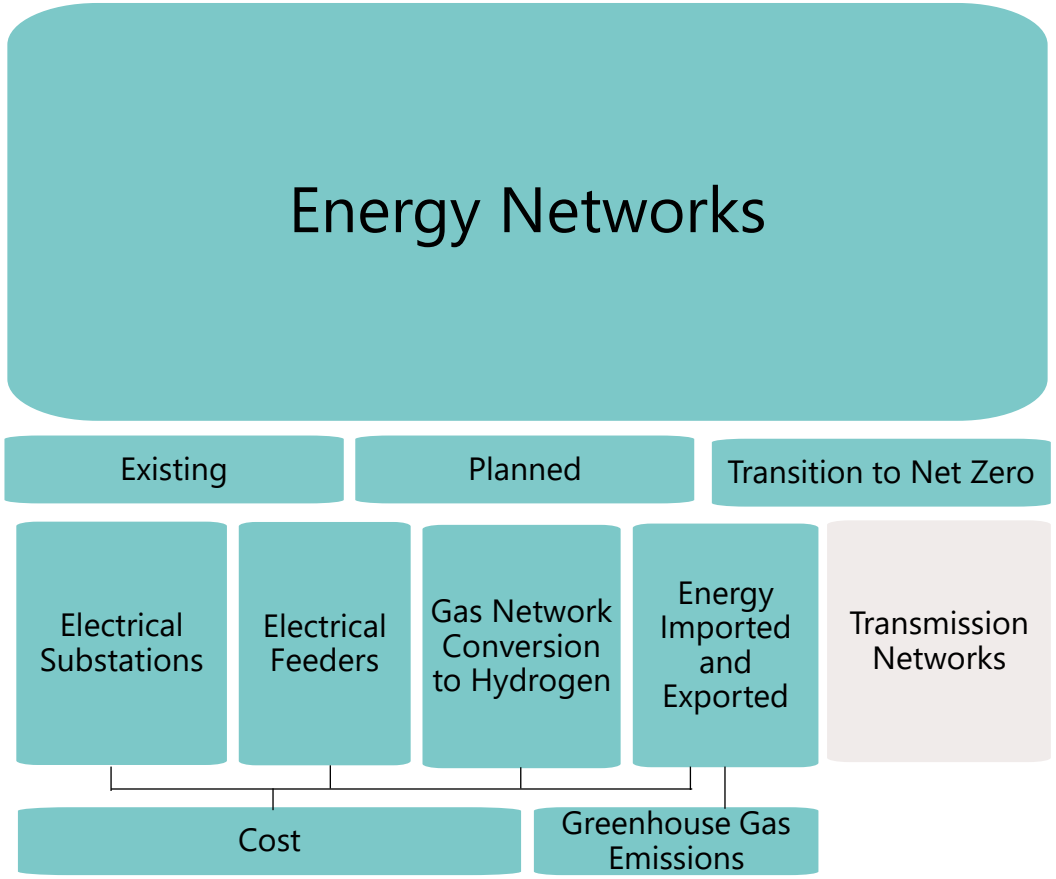


What is a Local Area Energy Plan?



What is a Local Area Energy Plan?





In scope of LAEP

Out of scope of LAEP

What is a Local Area Energy Plan?

Land

Waste

Land Use

Land Use Change

Forestry

In scope of LAEP

Out of scope of LAEP

Purpose of this LAEP

The purpose of this LAEP is to support Ceredigion in meeting its carbon targets, enabling transition to an affordable and decarbonised energy system as well as supporting wider socio-economic goals.

This LAEP provides a vision of how the local energy system could look in a Net Zero Greenhouse Gas (GHG) emissions future, and the pathways and steps which can be taken to get there, starting from the present day. It is intended to be used for several purposes by different stakeholders including as:

A primer

- The LAEP provides a high-level overview of the future Net Zero whole energy system, the investment required to achieve this, and priority projects to deliver immediate progress and decarbonisation impact.

A communication aid

- Visualisation of the changes involved can be a powerful engagement tool to give stakeholders clarity and consensus around the energy transition.

A detailed description

- Accelerating the planning process by providing the what, where, when and how much for a range of decarbonisation interventions deployed across the local area. The LAEP may help to provide clarity and key insights to drive critical decision-making processes.

A catalyst for investment

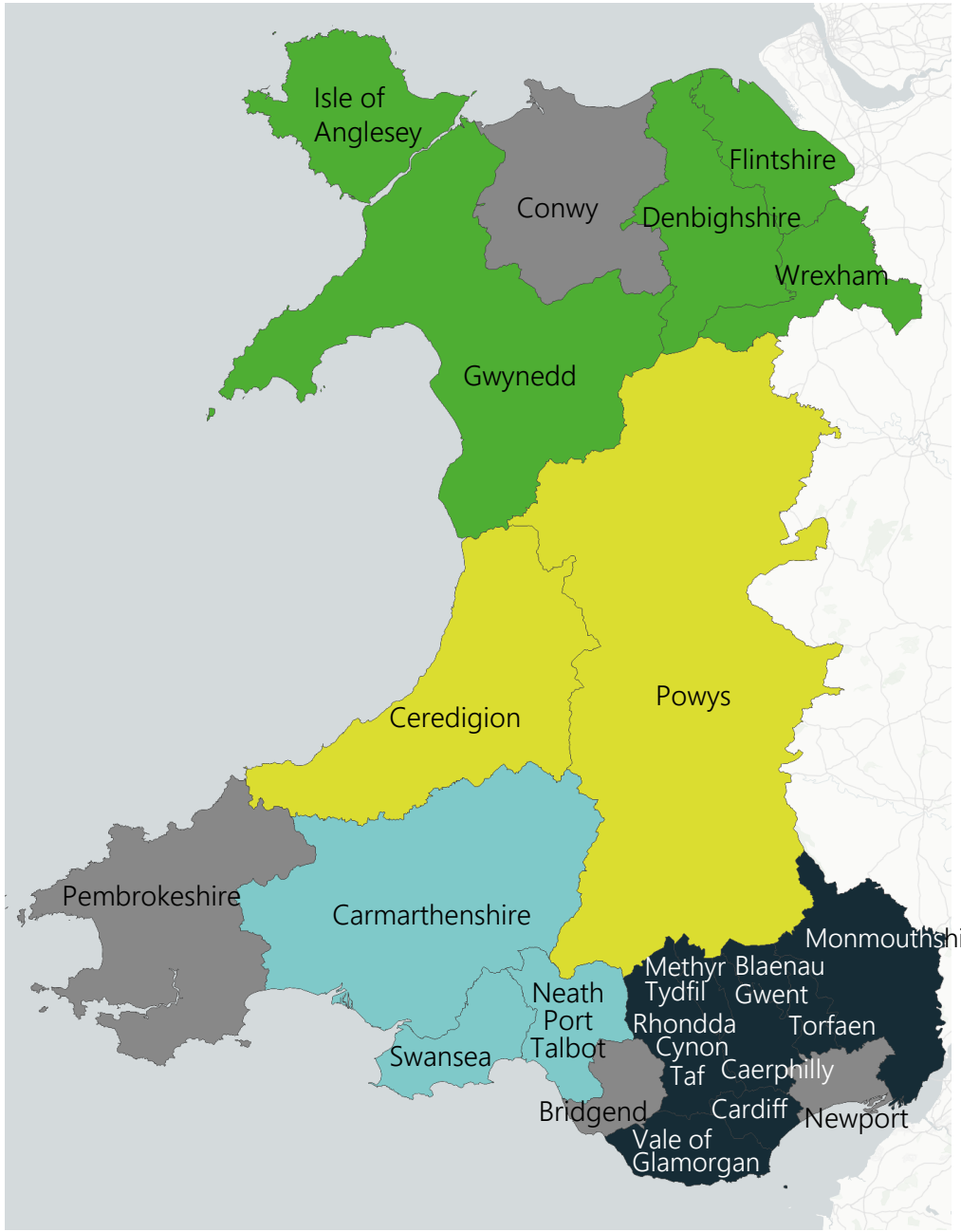
- An evidence base containing investment figures, key enablers, supporting infrastructure requirements can help build the strategic case to attract the capital needed for the energy transition. For example, the evidence base may help to inform investment in energy network upgrades or investment in impactful community energy schemes.

The Energy Transition Across Wales

The Welsh Government's "Net Zero Wales" plan establishes an increased level of ambition on decarbonisation, with a legally-binding target to reach Net Zero emissions by 2050. It is the first national government to fund the roll-out of LAEPs to all its local authorities. The programme is being coordinated through a regional approach, where LAEPs are being developed for local authorities in North Wales, Mid Wales, South West Wales, and the Cardiff Capital Region. A number of suppliers have been selected to produce the LAEPs for each region, as detailed in the map.

To contribute to the Welsh Government's commitment of producing a "National Energy Plan" in 2024, upon completion of the LAEP programme Energy Systems Catapult[1] will aggregate the LAEPs into a national view. To support this task, they are working with the Welsh Government to create and import standardised LAEP outputs for aggregation into the DataMapWales platform. The Catapult is also providing technical advisory support to the Welsh Government throughout the programme.

The LAEPs will also form the basis of the 'National Energy Plan' Welsh Government have committed to produce in 2024.



[1]Afallen is working with both Energy Systems Catapult and Arup, providing stakeholder engagement support.

Ceredigion's Local Context

Ceredigion County Council declared a climate emergency in March 2020 and has pledged to make Ceredigion a Net Zero carbon local authority by 2030. This is in line with the Welsh public sector target and supported by Ceredigion County Council's Achieving Net Zero Carbon Action Plan (2021-2030)*.

The county of Ceredigion is a largely rural area with 50 miles of sandy coastline, hilly landscapes, and some sizeable towns: Aberystwyth, Cardigan and Lampeter. It covers a total of 1,780 km^2 and is home to around 71,500 people. Tourism and agriculture form the core of the economy.

For this LAEP, Ceredigion's geographical area is divided into 11 zones as shown in the adjacent map. Zones help to highlight the possible hotspots for decarbonisation activity and locations for investment opportunities. Presenting the LAEP in terms of zones helps to break the transition into more manageable pieces and can make the changes more relatable for local communities.

Zones are determined based on areas served by primary substations on the electricity network, so may not match familiar geographic boundaries such as local wards. Note that zones take the name of settlements within the area, while covering an area beyond those settlements.

*https://council.ceredigion.gov.uk/documents/s1476/Achieving%20Net%20Zero%20CCC%20v1.2.pdf?LLL=0#:~:text=Ceredigion's%20Net%20Zero%20Carbon%20Action,important%20to%20tackling%20climate%20change.

Stakeholders

The delivery of this LAEP will require all stakeholders in the local area to take forward the recommendations, working together on the shared goal of reaching Net Zero. Ceredigion County Council have selected a community of stakeholders to support the LAEP decision making, shown in the logos opposite. Stakeholders, comprising a primary steering group and a secondary group, have the power to influence the LAEP and are best placed to advise on the local interests through the governance structure offered by the LAEP process.

An in-depth exercise to identify stakeholders with expertise and / or knowledge of all aspects of the local energy system was undertaken. Once local stakeholders had been mapped, an engagement plan was developed with the aim of enabling them to contribute directly through a series of workshops. This structured approach to stakeholder engagement ensures the plan is built around the views and interests of the local area. A series of workshops were held over 2023-24, giving stakeholders the opportunity to co-create the LAEP.

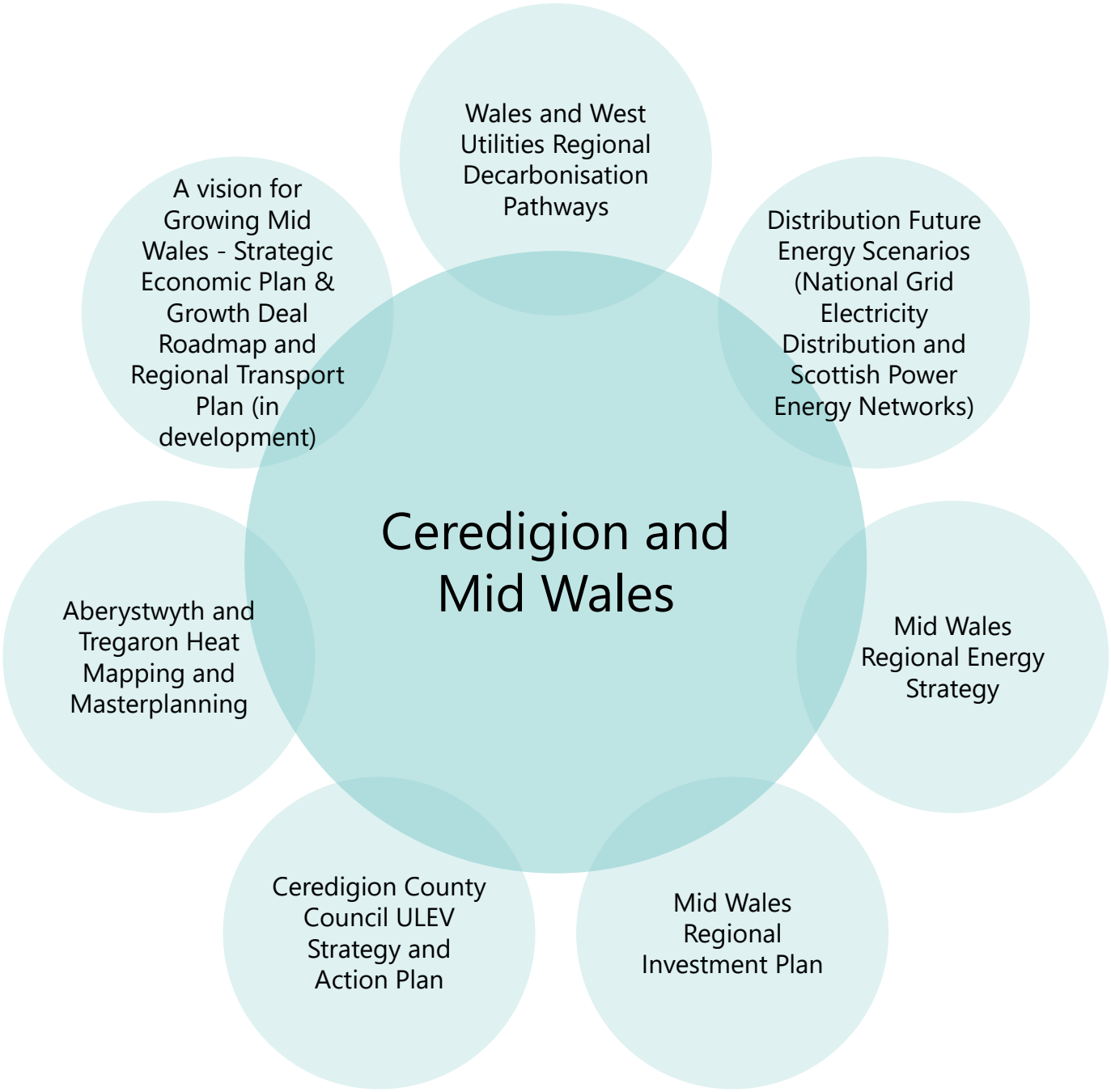
Key decisions to shape the LAEP have been made by primary stakeholders. Primary stakeholders also support data gathering, provide local context and characteristics, define the modelling scenarios, examine model assumptions, and review and commission the LAEP. The primary stakeholders group includes Ceredigion County Council, the local energy networks, Welsh Government (various departments), and the UK government.

Other key stakeholders (secondary stakeholders) are relevant organisations, groups, or individuals from the local area who can support the LAEP process through data gathering and helping the understanding of local context and characteristics. These stakeholders need to be kept informed of the LAEP process, but they are not key decision makers.

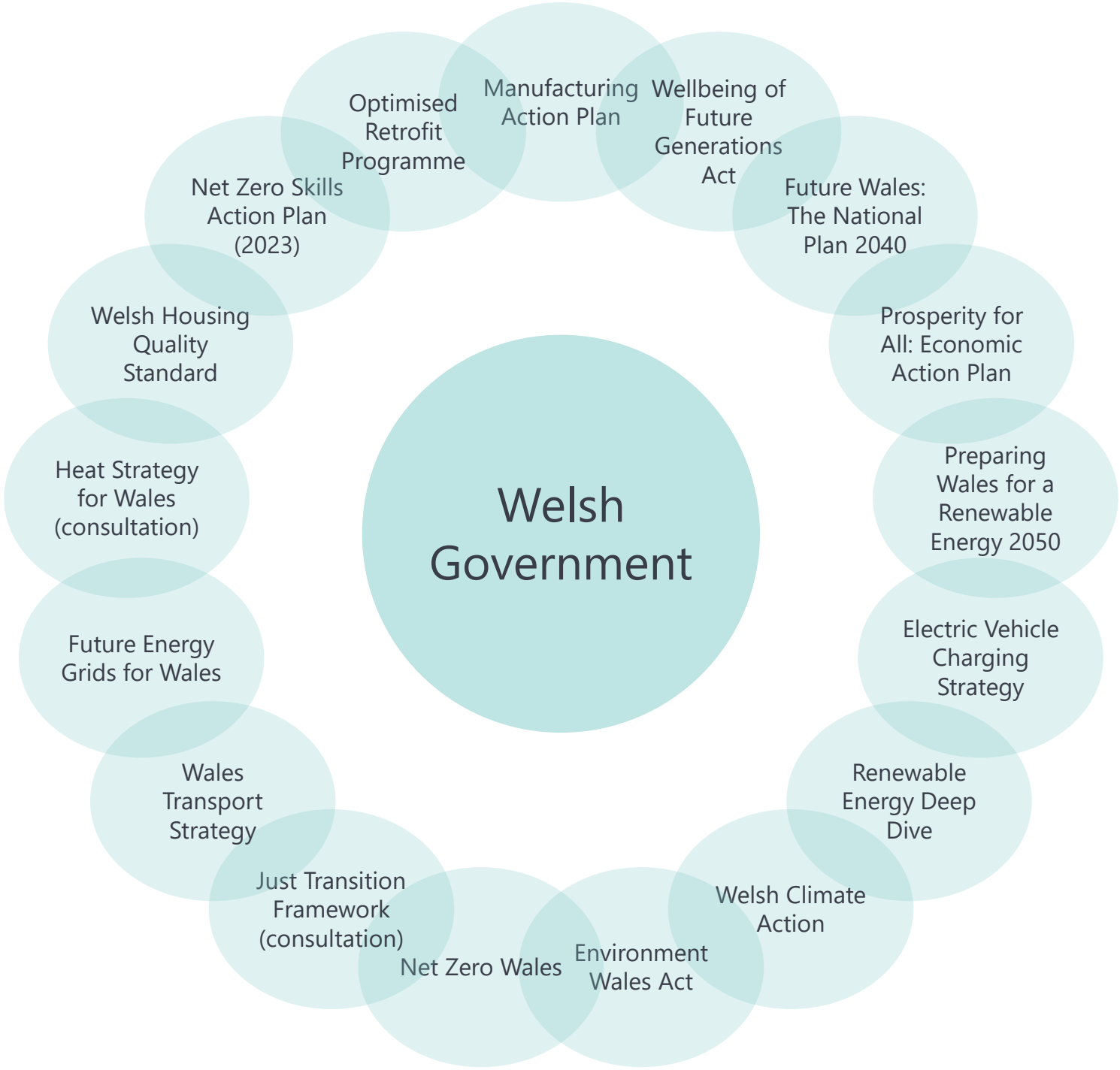
Energy Systems Catapult undertook a small number of interviews with a representative sample of the general public, and Growing Mid Wales published an online survey to understand the general public in Mid Wales' views on the energy transition. Key findings will be published on Growing Mid Wales' website. Note further public engagement is currently being organised.

Policy

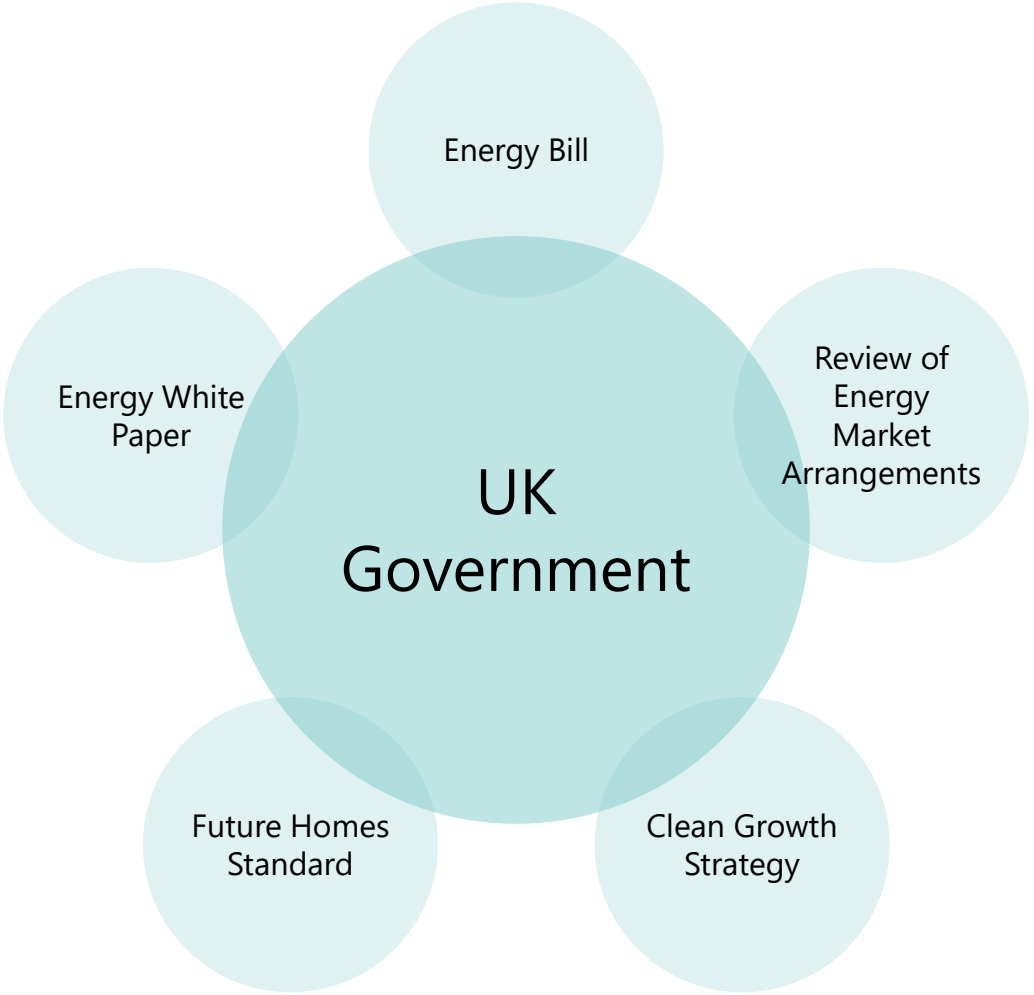
This LAEP builds on the existing policies, strategies and action plans relevant to Ceredigion, considering their implications for the local situation and aligning the local plan to the direction of travel at regional and national scales. The diagrams illustrate many of the policies and documents which have some relevance to Ceredigion's energy transition.



Policy



Policy

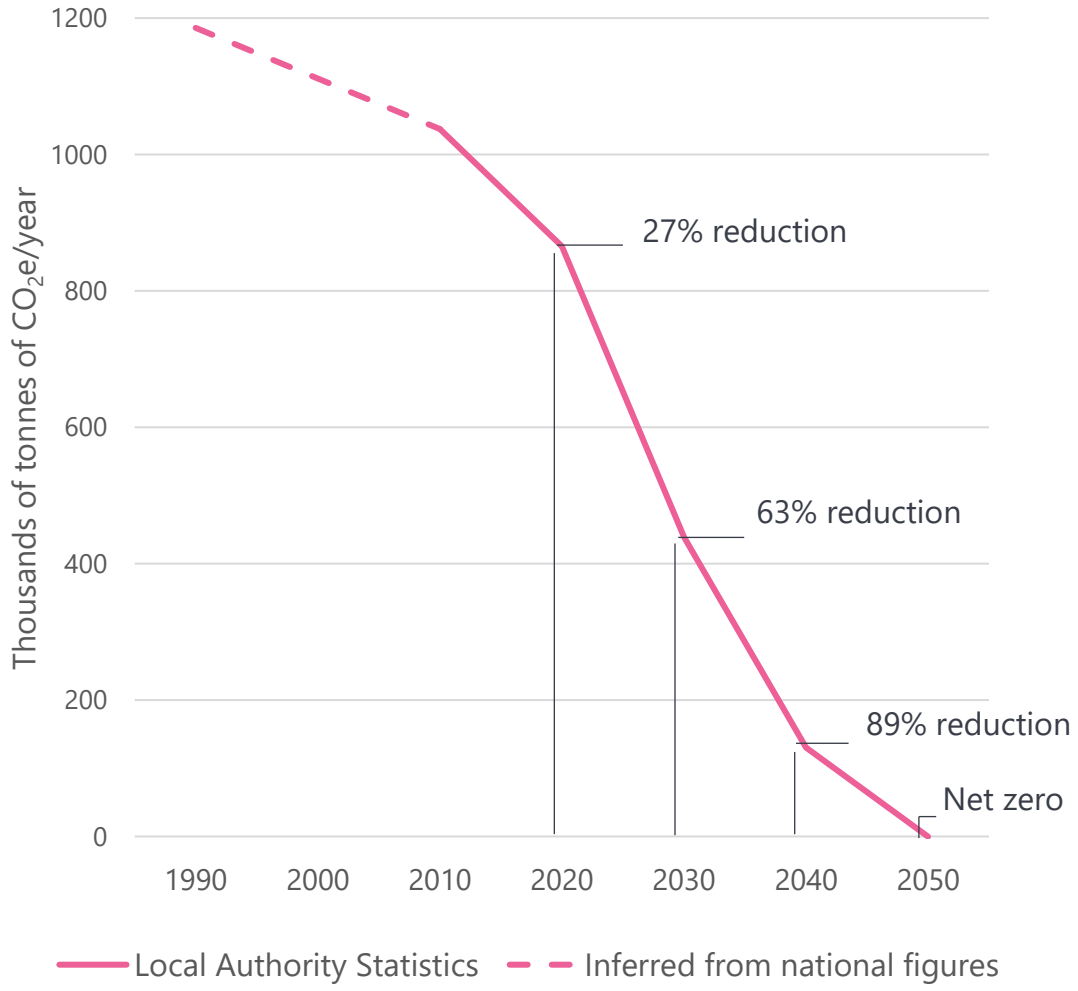


The Journey to Net Zero

Emissions and Targets

In 2021, Ceredigion's greenhouse gas emissions totalled 892 thousand tonnes of CO_2 equivalent[1]. The chart to the right shows Ceredigion's emissions broken down according to their sources, such as buildings and transport. To reach Net Zero by 2050, all of these emissions must be eliminated or offset, including those not covered by this LAEP. In terms of CO_2 emissions only, the LAEP covers the majority. This is because agricultural emissions are mostly methane, so they dominate the greenhouse gas figures but not the CO_2 figures. In contrast, emissions from using fossil fuels for energy are primarily CO_2. Work is ongoing to tackle agricultural emissions with the farmers unions, Welsh Government, and the public service boards.

Net Zero Wales Carbon Budget[2] details the interim emissions reductions targets over the period to 2050, shown below applied to Ceredigion's emissions.

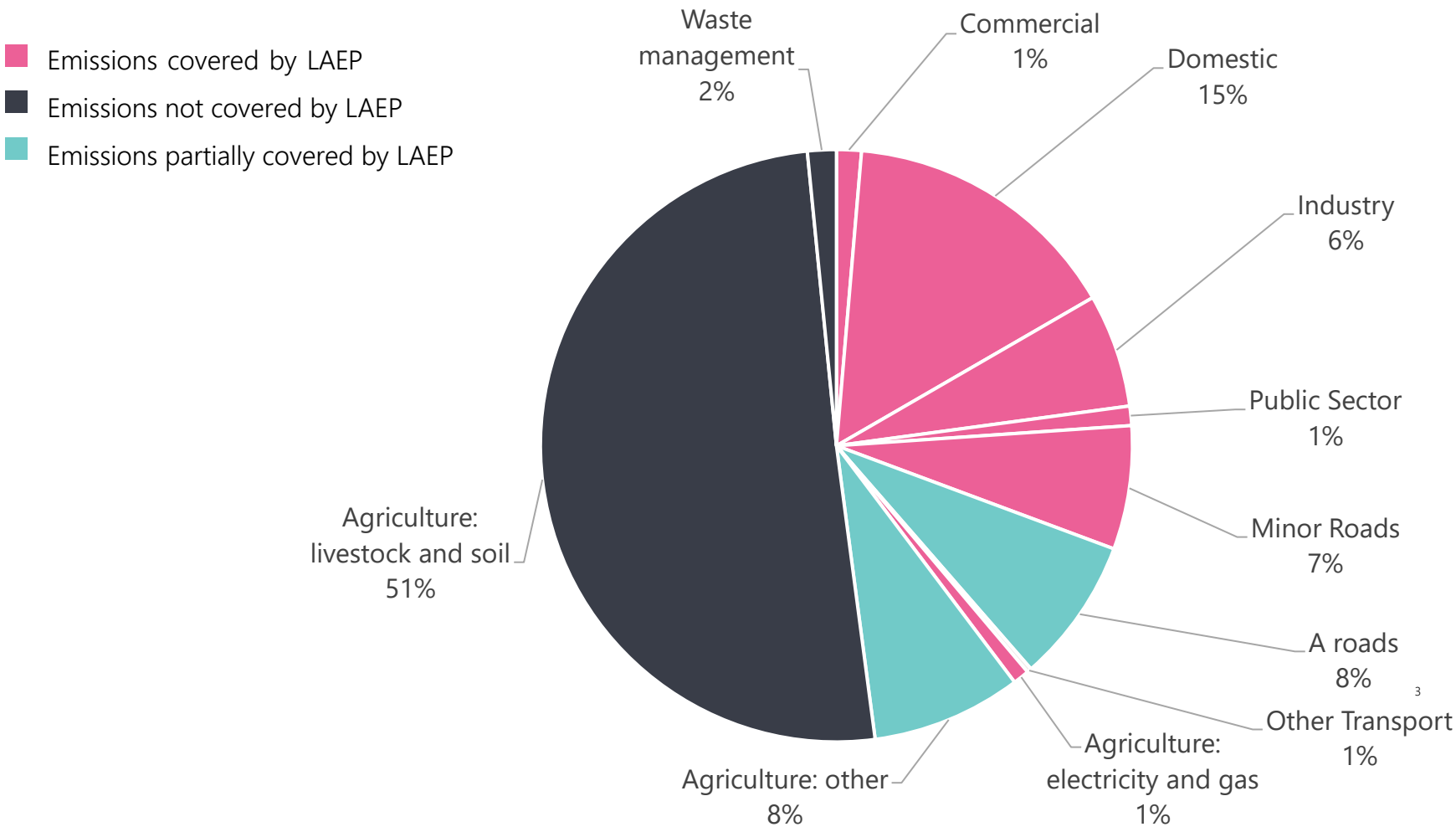


[1] CO_2 equivalent (CO_2e) converts the impact of multiple different greenhouse gasses of different strengths (including carbon dioxide, methane and nitrous oxide) into the amount of carbon dioxide that would have the same greenhouse effect.

[2] The strategic road network is out-of-scope for this LAEP due to the limited influence that the local area has over them. This covers trunk roads, which are some but not all "A" roads.

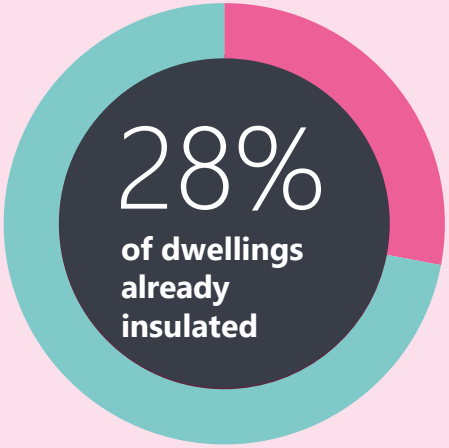
Emissions and Targets

Approximate proportion of 2021 greenhouse gas emissions in Ceredigion (CO_2 equivalent) covered by this LAEP[3]



[3] The category "Agriculture: other" includes oil used for heating buildings, which is in scope, as well as diesel used for agricultural machinery, which is out-of-scope.

Setting the Scene: Ceredigion Today



Efficient Buildings

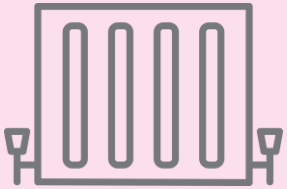
Currently 28% of the homes in Ceredigion are insulated to a good standard.

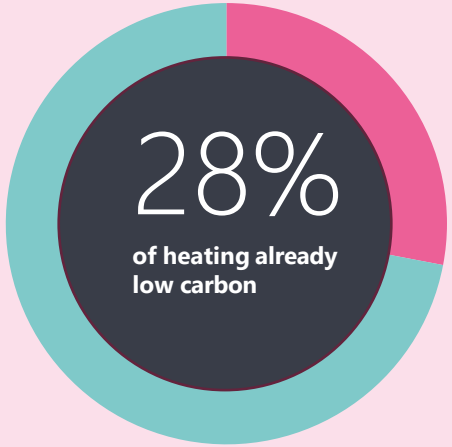
This is defined as homes with at least 200mm loft insulation (if they have a loft), insulated walls and double or triple glazing.

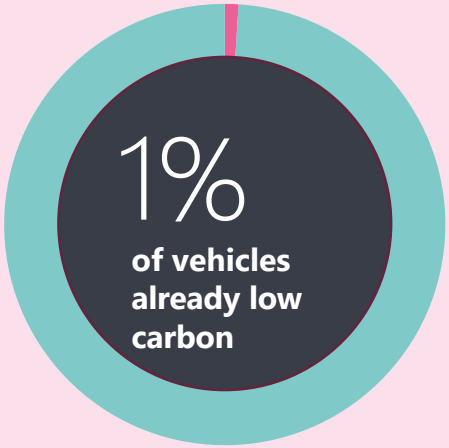
Low Carbon Heating

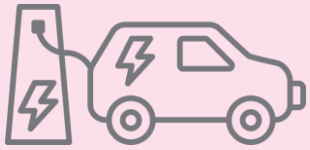
28% of homes currently use biomass, electric resistive or heat pump heating. As the electricity grid continues to decarbonise, electric heating moves towards Net Zero.

The remainder use some form of fossil fuel heating such as gas or oil.







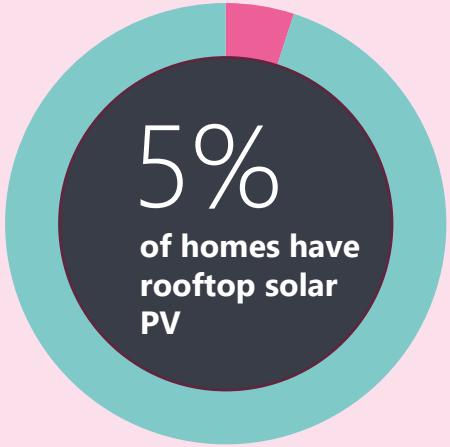


Electric Vehicles

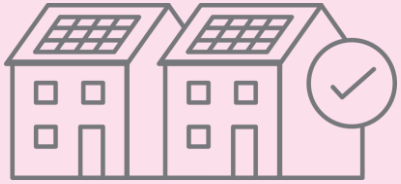
Around 490 cars and vans currently registered in Ceredigion are pure electric, making up 1% of vehicles. The remaining 37,960 are petrol, diesel or hybrid.

Rooftop Solar PV

Around 5% of homes generate their own renewable electricity with rooftop solar PV.



The Destination: Net Zero by 2050

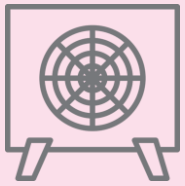


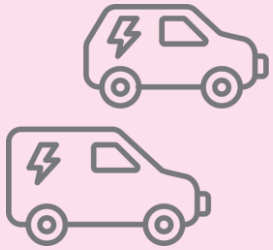
Efficient Buildings

Around 60% of homes in Ceredigion could benefit from fabric efficiency upgrades, bringing the majority of dwellings up to a high standard of building fabric performance.

Low Carbon Heating

Virtually all fossil fuelled heating systems need to be replaced in order to reach Net Zero. This can occur as current heating systems reach their natural end-of-life but scrappage (or similar) schemes will need to be considered to ensure that all heating systems are decarbonised before the target date.



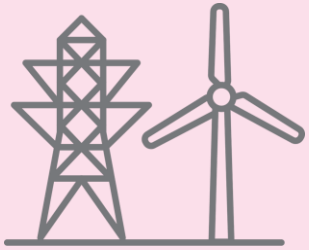


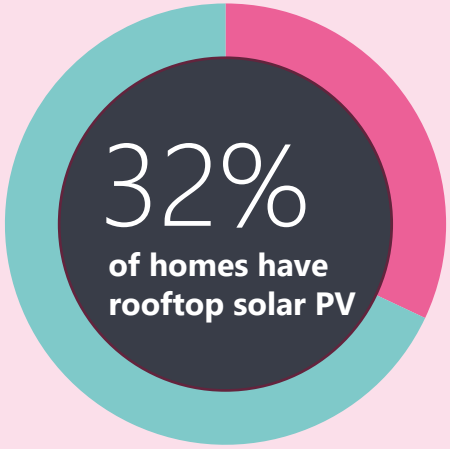
Electric Vehicles

Electric vehicle use is projected to rise rapidly and would need to reach 100% by 2050 to achieve Net Zero.

Rooftop Solar PV

Rooftop solar PV is fitted to all suitable roofs in the pathway, amounting to 32% of homes.





Scenarios and the Pathway

Scenarios are co-developed with stakeholders and used to explore different possible futures. The pathway describes the sequence of changes needed to transition to that future scenario from the present-day energy system.

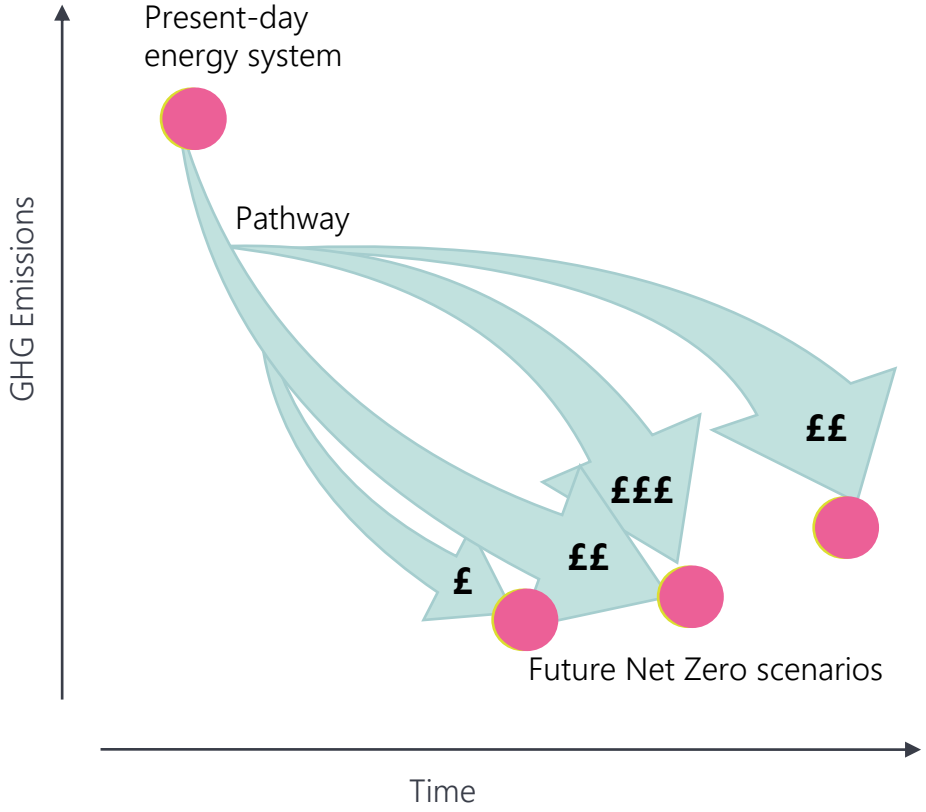
A single pathway is developed from the scenarios. It is primarily built up from recurring components (such as low regret activities) which are consistent across multiple scenarios, making it one of the key parts of the process in decision making. Using low regret components across the scenarios to build the pathway allows for a higher level of certainty, and therefore, confidence in the decisions.

It is essential for long-terms plans to make allowances for uncertainty about the future, as no projection can ever be completely certain. There is uncertainty about how the world will change over the coming decades, and there are different choices which can be made within the local area; hence there is no single “right answer” to the question of what the transition should look like.

By modelling multiple cost-optimised plausible scenarios for how Ceredigion and the wider world will look by 2050, the plan can remain flexible to changes and unknowns. For the pathway to progress from the present day to 2050, options are kept open for local decision makers to make choices along the way which best fit their circumstances, as new developments, priorities and information emerge.

Scenarios and the Pathway

The pathway has early actions and long-term scale-up activities to reach the target in a cost-effective way, along with key enabling actions and decision points to stay on track and navigate future uncertainty. The following symbols are used in the pathway:



In the near-term, this LAEP illustrates the proposed activities for the area to progress towards Net Zero by identifying 'quick wins', 'focus zones' and specific 'outline priority projects' which could be taken forward into a feasibility stage. The scenarios and pathway are detailed throughout the following pages.

Quick Wins — Established technology and market conditions allow these actions to be delivered in the near-term with straightforward investment cases

Low Regrets — While not as established or straightforward to deliver as quick wins, these options are high confidence, unlikely to be surpassed by an alternative solution

Demonstrators — Small delivery projects of innovative solutions to build experience, which feed into scale-up

Enabling Actions — Changes required to policy, perception, market conditions, supply chains, etc. before a solution is likely to be deliverable

Scale-up — Moving beyond demonstrators and early adopters to the mass uptake of a solution, to deliver required scale of emissions reductions

Scale-up with Uncertainty — Solutions which have lower levels of confidence. Overreliance on their delivery is risky, and alternative approaches should be prepared.

Decision points, where a fork in the pathway needs a choice to be made, in order to stay on schedule. At this point in the future, more information may be available to make the choice clearer.

Risks to delivery, which warn against overreliance on an uncertain solution, and call for alternatives to be considered ahead of time.

Expected changes and milestones in policy and regulation which will have an impact on the delivery of the plan.

Scenarios

Standard Required LAEP Scenarios

Do Nothing

- No decarbonisation target; only decarbonisation activities already committed to happen are modelled.
- Not intended as a realistic view of the future.
- Required by Treasury to provide a cost counterfactual.

National 2050 Net Zero Target

- A "core" or "central" decarbonisation scenario.
- Uses a cost-optimal balance of technologies to meet the national Net Zero target.
- Consistent across all Welsh LAEPs produced as part of this programme.

Tailored Ceredigion Scenarios

Critical Network

- Explores a hypothetical scenario where the electricity network is unable to carry out upgrades at the intended pace due to technical and social barriers; instead, the current investment rate (price control period 2023-2028 known as RIIO-ED2) is maintained.
- Shows additional cost and carbon emissions incurred if investment in the network is delayed, emphasising the importance of network investment for rapid decarbonisation.

Efficiency and Equity

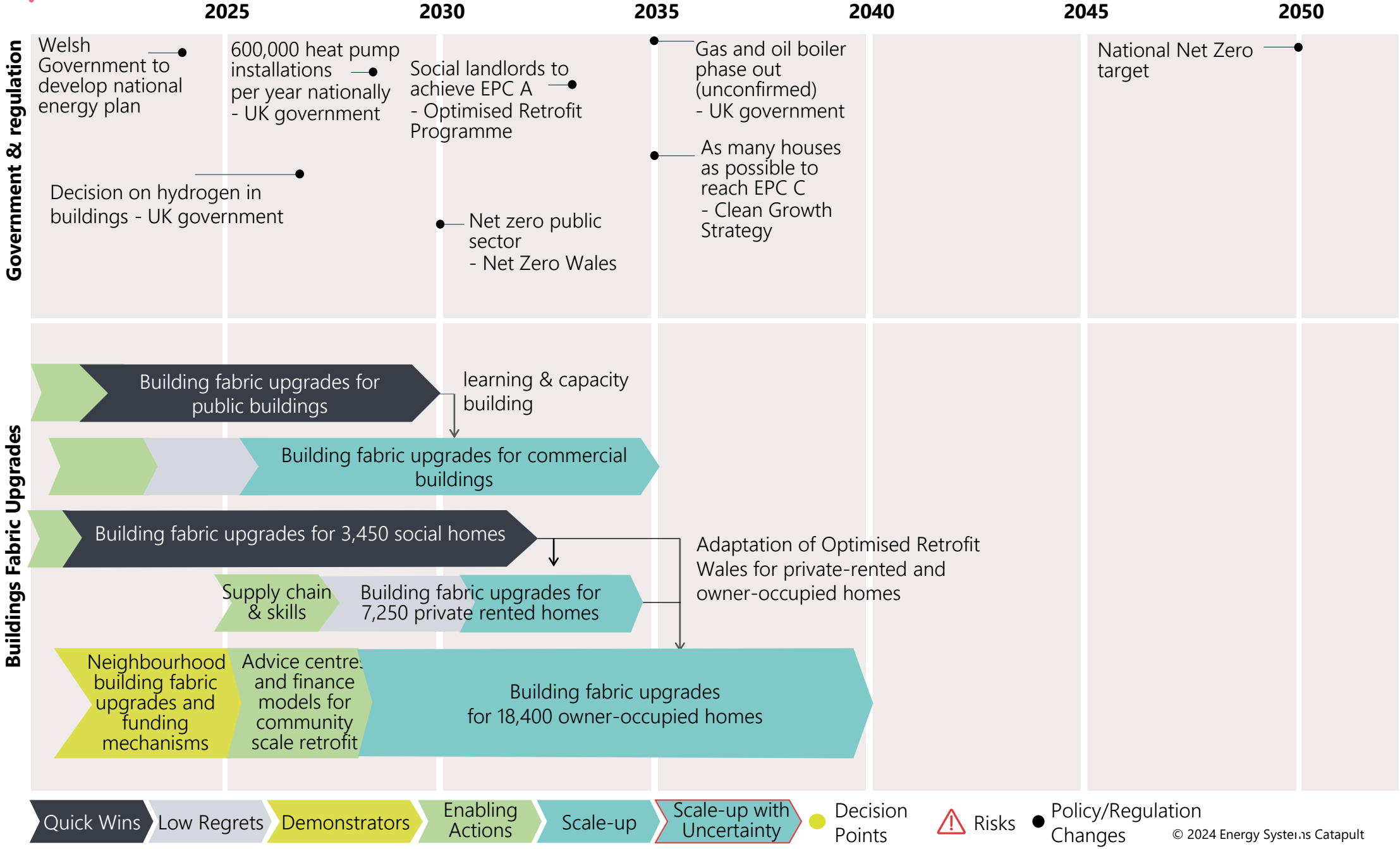
- Maximum ambition on building fabric efficiency, public, private and active transport, with reduced EV usage.
- Prioritising opportunities where energy efficiency also has social justice benefits, such as affordable mobility and warmth.

Local Resources

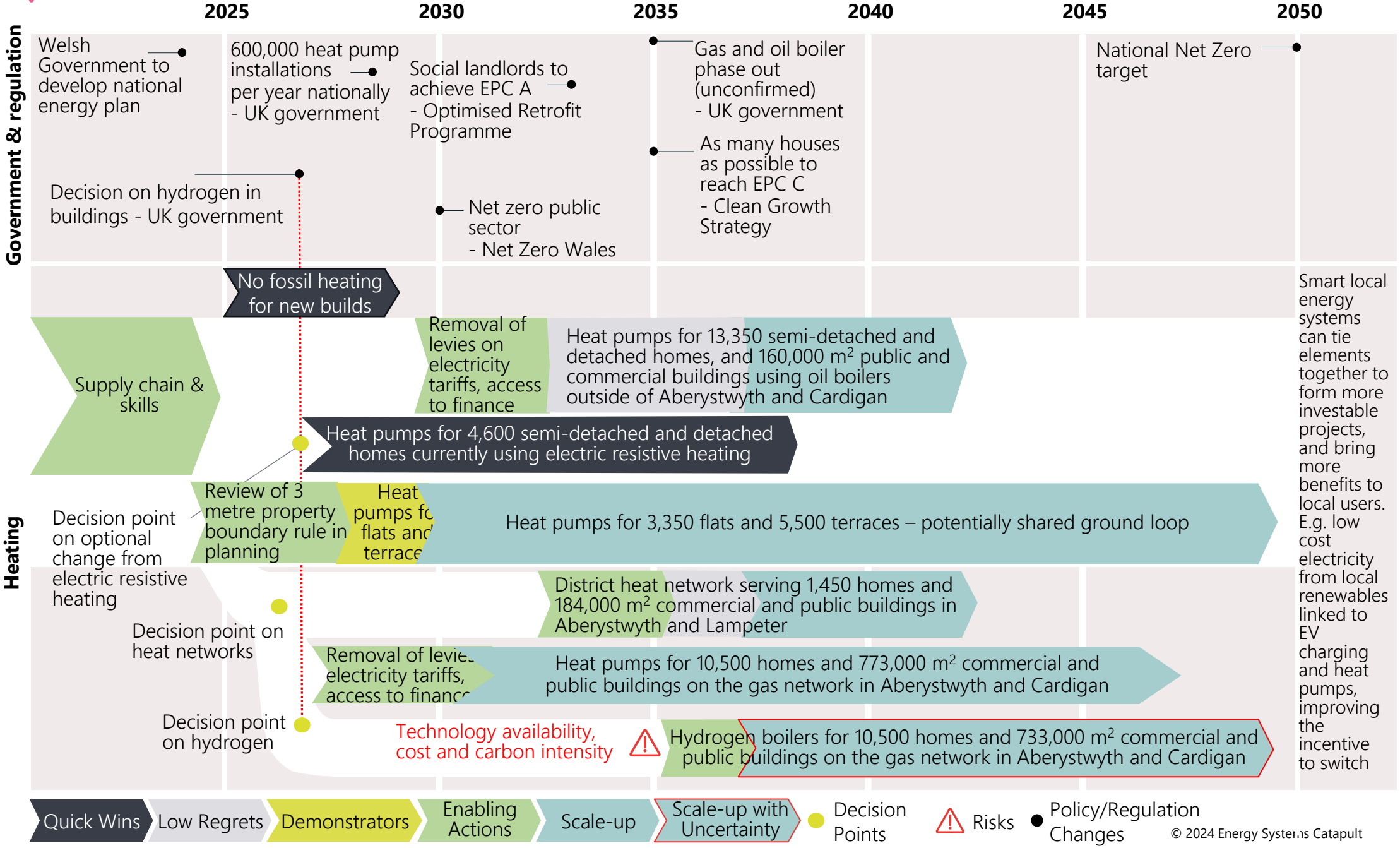
- Exploring how smart co-ordination of local assets such as EVs, storage and flexibility can maximise the use of locally-produced energy.
- EV usage is slightly higher in this scenario.

Hydrogen has been included as an **option** for the model to select in all scenarios, but whether it is selected depends on various factors such as alternatives available at lower cost or earlier in time

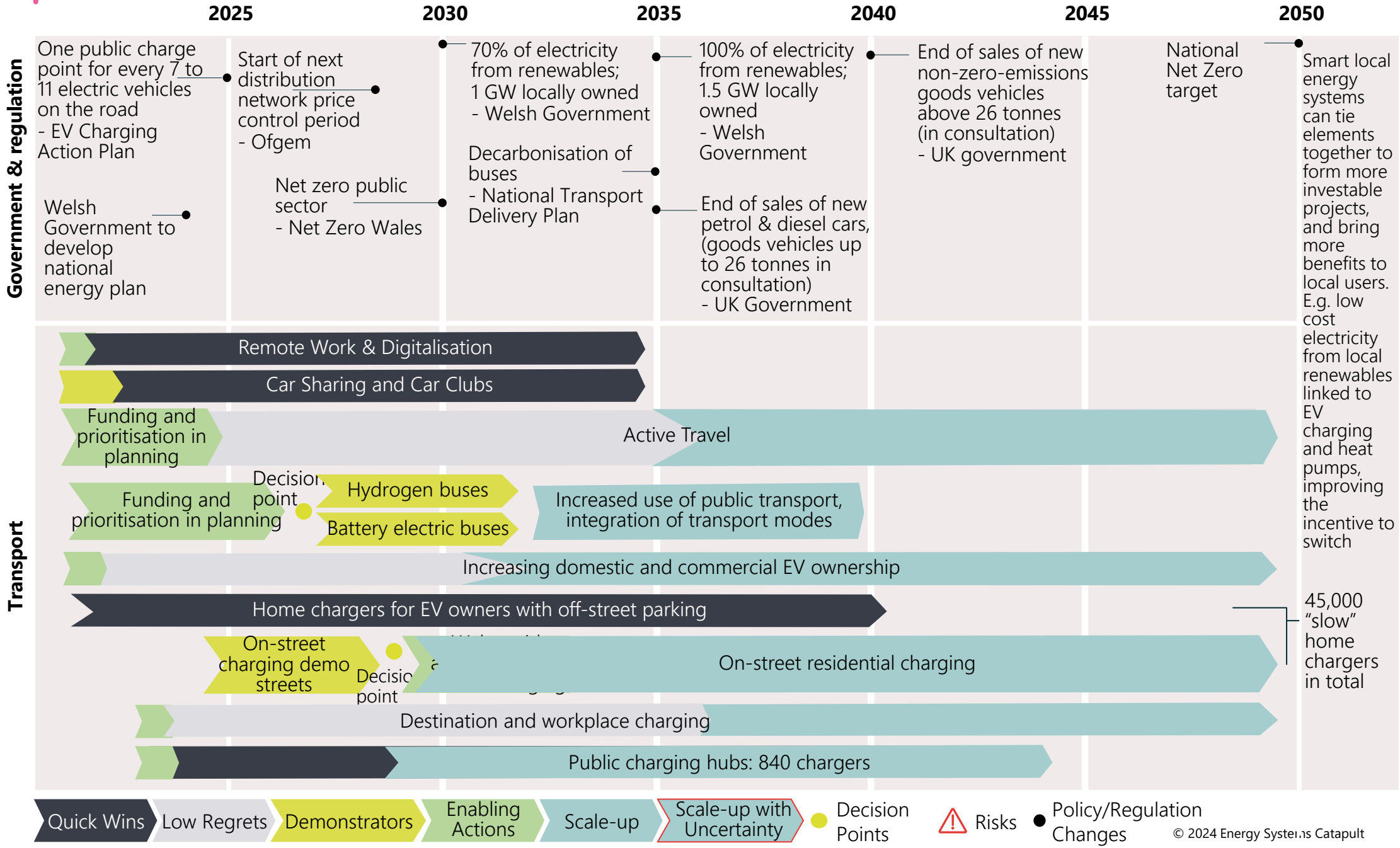
The Pathway (page 1/4)



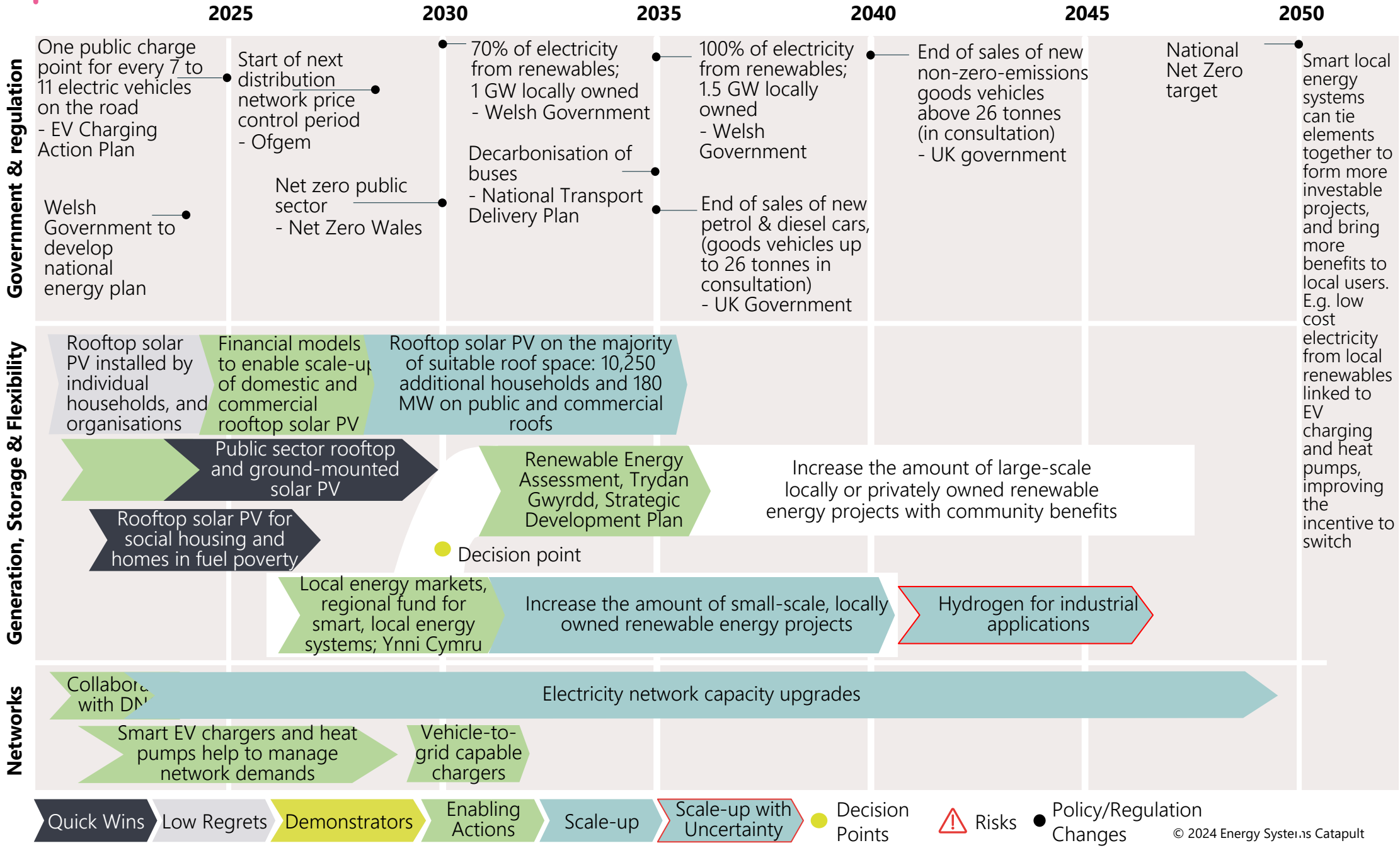
The Pathway (page 2/4)



The Pathway (page 3/4)



The Pathway (page 4/4)



The Energy System Transition: Buildings

Domestic Insulation

A significant level of insulation upgrade to the domestic building stock in Ceredigion is required to achieve a Net Zero energy system in a cost-optimal way. This is reflected across the four scenarios, with 60% of existing homes installing insulation upgrades to their walls and/or loft under the National Net Zero scenario and rising to 70% under the Critical Network scenario. Insulation can also alleviate fuel poverty and improve health – see Fuel Poverty Focus Zone section. Upgrades at this scale will require a rapid increase in supply chain delivery capacity, with more certified, skilled tradespeople to ensure work is carried out to a good standard – see Deliverability section. Trustmarks and guarantees can protect homeowners from exposure to risks as they make changes to their homes. A one-stop shop in the area could provide homeowners with trusted advice, and direct them to trades and sources of funding to make the journey easier. Available data suggests that approximately 3,450 social homes could benefit from insulation upgrades, as well as 7,250 private rented homes, and 18,400 owner-occupied homes.

Enablers	Barriers
• Grants • Public engagement	• Affordability and funding • Skills gap

60%
Homes benefiting from loft and/or wall insulation

Filling cavity walls with insulation provides relatively large thermal benefits for relatively low cost and disruption, and so can be considered low regret. Almost all homes which currently have unfilled cavity walls therefore undertake this upgrade across all four scenarios as shown on the graph. Note that careful management of moisture is essential during insulation to ensure no damp problems are created – see the appendix for further information on cavity wall insulation and damp prevention. The level of loft insulation upgrade is also quite consistent between scenarios, suggesting this too is a low regrets intervention.

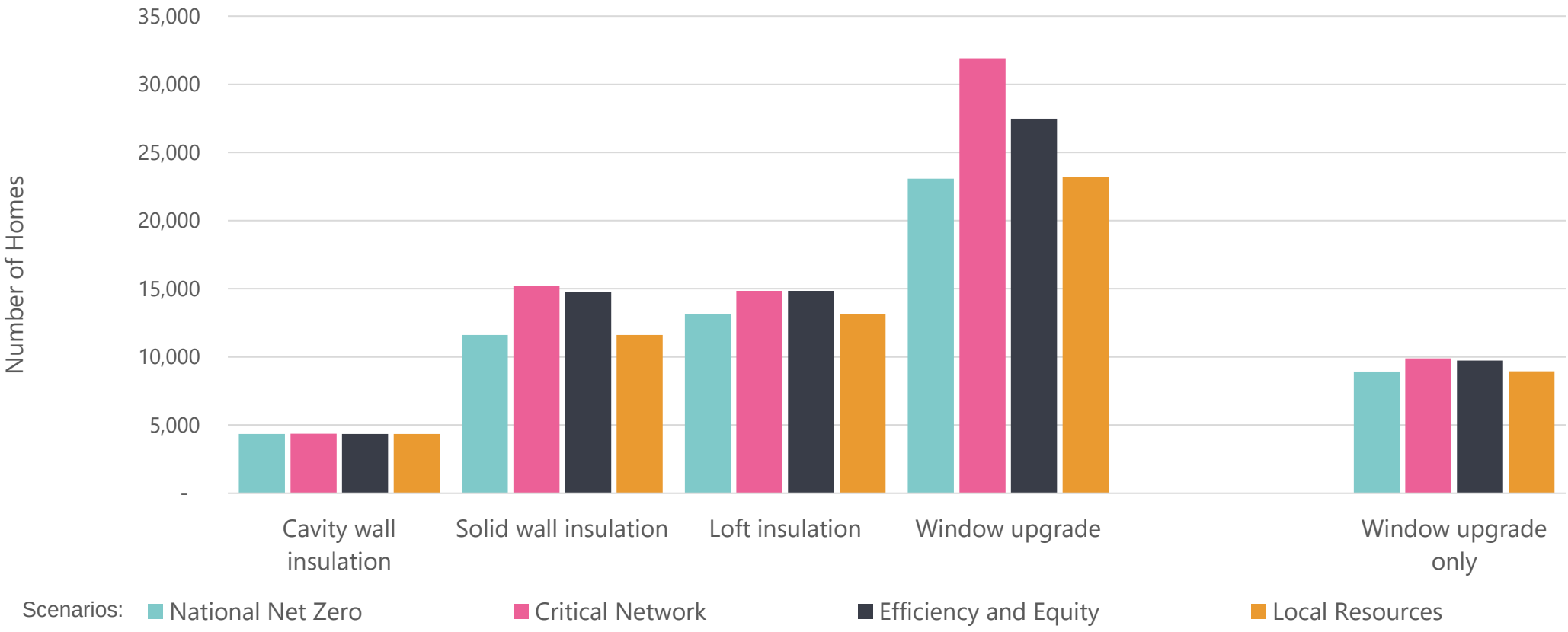
There is more variation in uptake of solid wall insulation and upgrades to windows. This is because the cost-benefit trade-off for these measure can be more marginal. The Critical Network scenario sees the highest uptake of each measure. This is because improved thermal performance of homes from upgrades relieves pressure on the electricity network due to reduced peak heating demand. It is assumed in the Efficiency and Equity scenario that all homes which are not currently insulated to a good standard receive improved insulation. This scenario therefore also sees a relatively high level of insulation. Slightly lower levels of upgrade are seen in the National Net Zero and Local Resources scenarios where insulation measures are installed based on cost-optimality.

Domestic Insulation

Solid wall insulation substantially reduces the heat loss of some of the hardest-to-heat buildings but comes at a high upfront cost. A coordinated, street-by-street approach for this measure could achieve economies of scale, bringing this measure more within reach and reducing payback periods.

A large proportion of homes receive window upgrades between now and 2050, often in the form of triple glazing. A significant driver of this is that it is assumed that due to their limited life span, existing windows will need to be replaced between now and 2050. It is often cost-effective to upgrade the window at the same time as the replacement is taking place which results in widespread window upgrades.

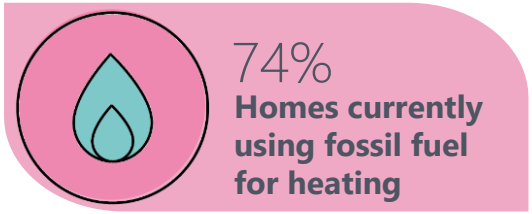
Total Installed Insulation Measures by 2050



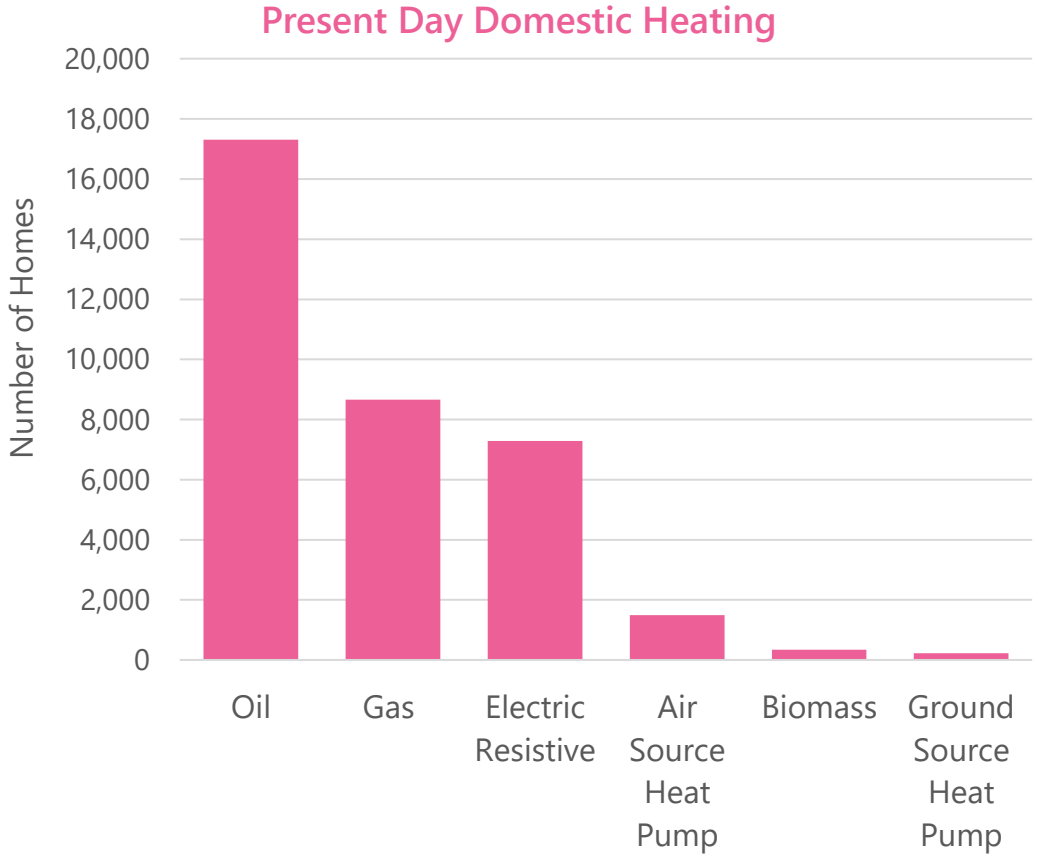
Domestic Heating: Today

Today, fossil fuel boilers make up the majority of heating systems in homes in Ceredigion (74% - see chart below), with fossil fuel use in homes accounting for 16% of total CO_2e emissions. Around 68% of Ceredigion homes are off the gas network (see top map), making it the area with the greatest proportion of homes off gas in Wales. As a result, most of these fossil fuel systems are expected to be oil boilers. In a number of towns in Ceredigion on the gas network, gas boilers are the most common system (see lower map*). To achieve a Net Zero energy system, both oil and gas boilers will need to be replaced with low carbon heating systems.

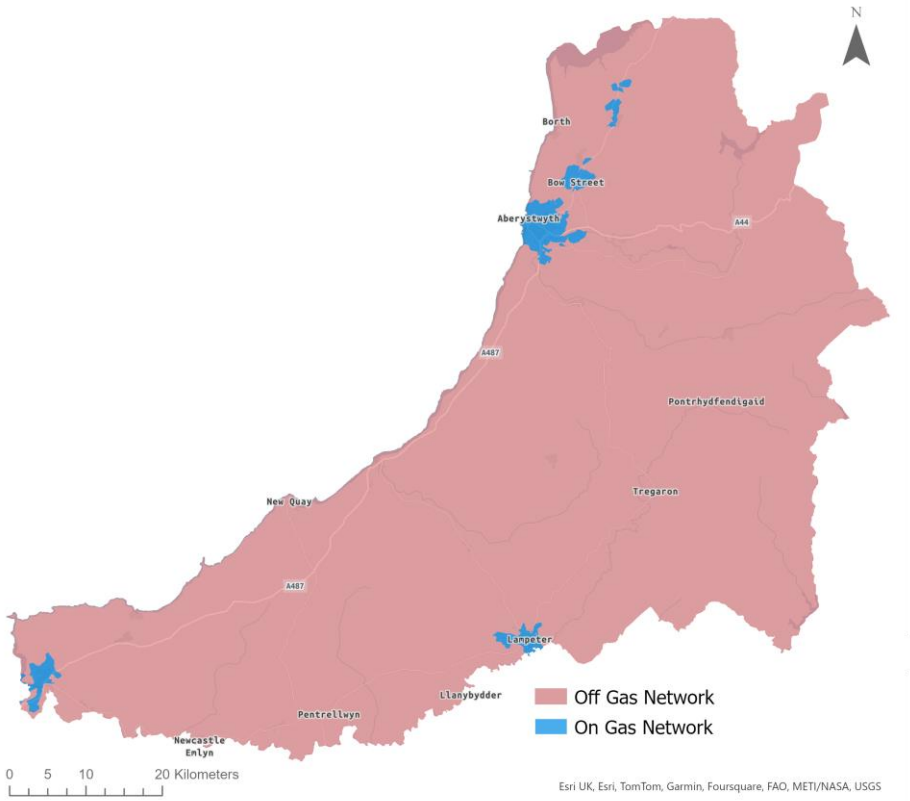
Heating systems can be replaced at their natural end-of-life. However, supply chain capacity, including skilled installers, and household awareness will need to be built ahead of time to ensure the low carbon options are available, straightforward and attractive when replacements are needed, which can often be during a break-down. As with insulation, trustmarks, guarantees, and one-stop shops could help homeowners on this journey. The sale of new fossil fuel heating systems would need to end by 2035 to achieve a Net Zero energy system by 2050 with minimal premature replacements of boilers (assuming a 15-year lifespan).

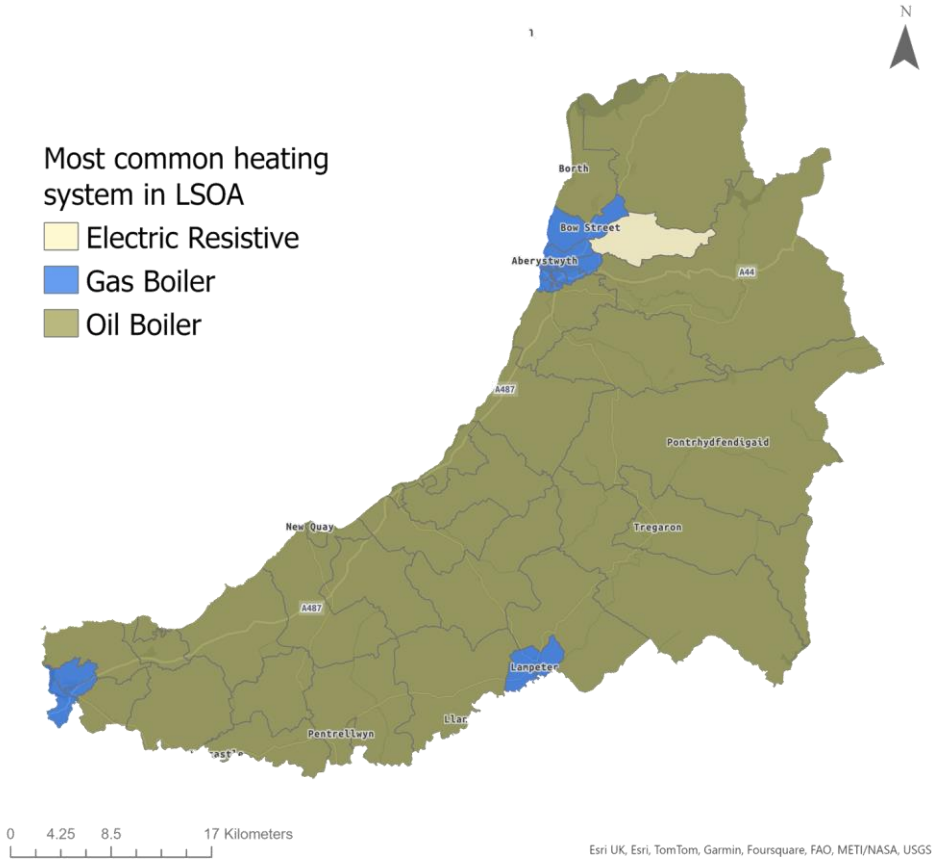


74%
Homes currently using fossil fuel for heating



Domestic Heating: Today





* LSOAs (Lower Layer Super Output Areas) are geographical boundaries typically comprising between 400 and 1,200 households with populations between 1,000 and 3,000 persons.

Domestic Heating: The Transition

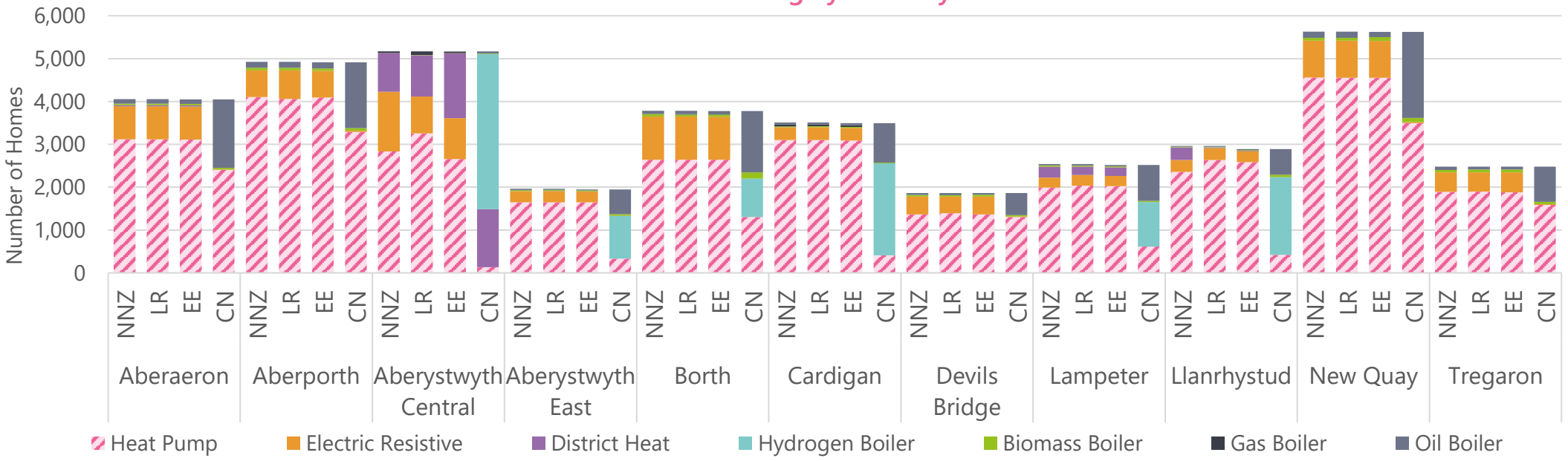
The graph below summarises the mix of heating systems in use by 2050 in each scenario by zone. The largely rural nature of Ceredigion makes heat pumps the most widely suitable technology for decarbonising heating*. This is reflected across the scenarios, with 76% of homes being heated by heat pumps by 2050 in the National Net Zero scenario.

76%
Of homes heated by heat pumps by 2050

Aberystwyth Central is a partial exception to this trend. With its dense buildings, the use of district heat networks is feasible as an alternative to heat pumps for 1,500 homes in this zone. Additionally, flats represent a larger proportion of dwellings which results in greater use of electric resistive heating. The Aberystwyth network extends into the boundary of the Llanrhystud zone, and small heat network could be feasible in Lampeter, primarily serving non-domestic buildings

* Further information on domestic buildings heating can be found within the appendix. Maps show the most common types of heating system installed across the four scenarios in 2050.

Domestic Heating Systems by 2050



Scenarios - NNZ: National Net Zero LR: Local Resources EE: Equity and Efficiency CN: Critical Network

Domestic Heating: The Transition

Electric resistive is the second most common heating system in 2050 in three out of the four scenarios. These are installations which already exist today, and as they are low-carbon already due to running on electricity rather than fossil fuels, are not replaced between now and 2050 in the National Net Zero scenario as the grid decarbonises.

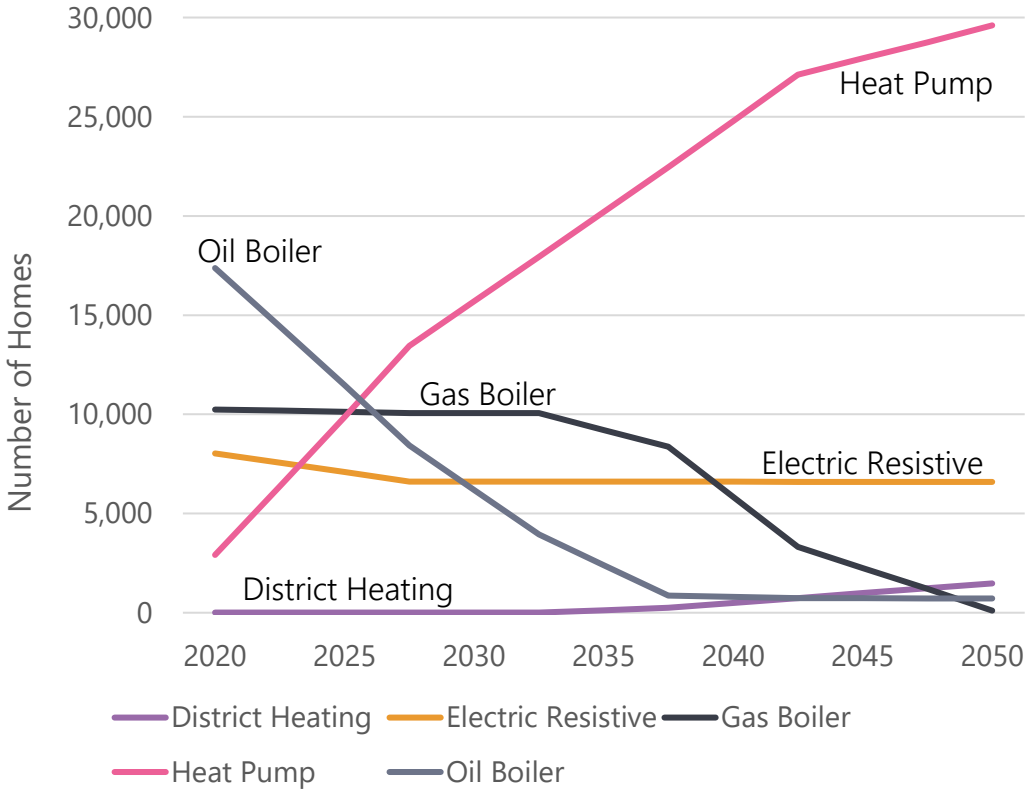
This is advantageous as it avoids the upfront cost of replacing these heating systems with heat pumps. However, as they are less efficient this has the drawback of both higher running costs and of contributing more demand to the electricity network. This trade-off is reflected in the 2050 technology mix for the Critical Network scenario. As the capacity of the electricity network is more limited, it becomes preferable to replace most of the existing electric resistive systems; 6,200 homes replace their electric resistive heating system with a heat pump by 2050, compared to 1,400 in National Net Zero. Hence the replacement of electric resistive heating with heat pumps in scenarios other than Critical Network is a choice for bill saving, rather than a necessity for carbon reductions.

Two other notable features of the Critical Network scenario are that it's the only scenario where hydrogen for domestic heating is used and is also the only scenario where domestic heating does not fully decarbonise, meaning the Net Zero target would be missed. Due to limits on electricity network capacity availability in this scenario, use of hydrogen boilers is required as an alternative to heat pumps for 10,500 homes. It is assumed that hydrogen would be supplied to homes via repurposing of the existing gas network. Therefore, hydrogen boilers are only installed in zones which are currently on (or partially on) the gas network. For many homes which are off the gas network, this means there are limited routes to decarbonisation in this scenario. This results in around 10,900 homes still using oil boilers by 2050 in this scenario. This highlights the critical role for network investment and co-ordination with DNOs to ensure that network capacity is sufficient for the energy transition, if carbon targets are to be reached.

Domestic Heating: The Transition

13,350
semi-detached and detached homes transitioning from oil boilers to heat pumps

Domestic Heating Systems



Enablers	Barriers
• Grants • Public engagement • Hydrogen potential • Policy change • Smart local energy systems	• Affordability and funding • Skills gap • Technology readiness (hydrogen) • Public attitudes

The graph shows the changes in heating systems over time between now and 2050 under the National Net Zero scenario.

Of particular note is the rapid replacement of fossil fuel heating systems - especially oil boilers - by heat pumps between now and 2030. Oil boilers transition to heat pumps sooner than gas boilers as they have higher emissions and running costs.

13,350 semi-detached and detached homes transition from oil boilers to heat pumps as a "low regrets" action. These homes are most likely to have the space to install heat pumps, and least likely to be in an area which might be served by a district heat network or hydrogen. There are also 3,350 flats and 5,500 terraces which appear unlikely to be served by heat networks or hydrogen, and these could benefit from shared ambient loop heat pumps.

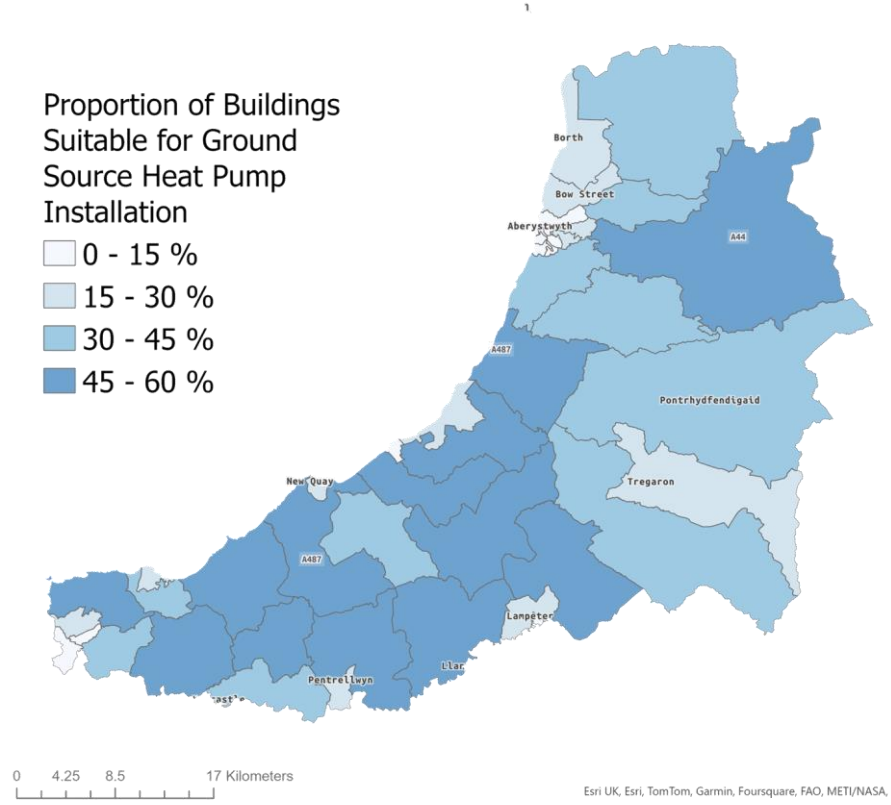
This rapid replacement is necessary to achieve the 2030 Wales Carbon Target. See the Implementation: deliverability section for further discussion on the rates of technology roll-out.

Studies by the Climate Change Committee have concluded that the use of biomass for heating should be limited to niche uses, as it is too essential to other sectors to use where alternatives exist.

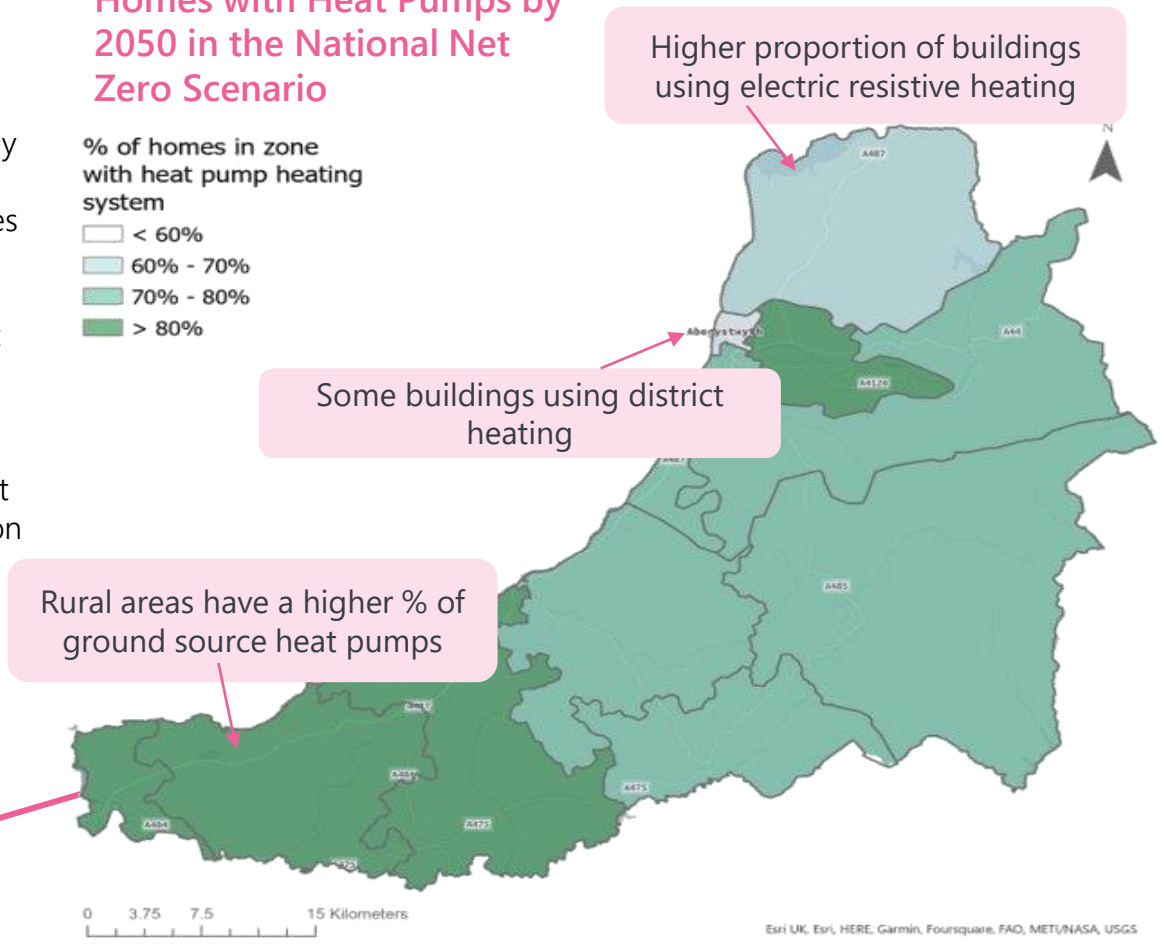
The bioeconomy however has been identified as a key part of decarbonising agriculture and providing carbon sequestration benefits to the UK as a whole. Supporting the bioeconomy has been identified as a strategic economic priority for Mid Wales therefore this is a topic which will be explored in parallel to the LAEPs.

Domestic Heat Pumps

Both air source and ground source heat pumps could be used to supply low carbon heat in Ceredigion. Contrary to common belief, there is no technical barrier to heat pumps efficiently and effectively heating homes of any particular age, type, or level of insulation, given correct design and installation – see the FAQs in the appendix for more information. When installing a low carbon heating system, it's advisable to carry out any planned building fabric upgrades at the same time or beforehand to avoid needlessly oversizing the new heating system or incurring higher running costs. The current requirement to qualify for the government's Boiler Upgrade Scheme (open till the end of 2027) is that there is no outstanding recommendation for loft or cavity wall insulation in the building's energy performance certificate.



Homes with Heat Pumps by 2050 in the National Net Zero Scenario



Ground source heat pumps tend to be more suited to rural areas, where larger properties and more garden space can make them a viable option. However, air source heat pumps would also be suitable for many of these properties, reducing installation costs in exchange for slightly higher running costs. Property specific consideration would be needed to determine the preferred solution. The map below reflects an initial assessment of the suitability of the domestic building stock in Ceredigion for ground source heat pump installation. This is based on the suitability of gardens for installation of a ground loop based on size and accessibility for the necessary machinery.

Domestic Heat Pumps

Lower running costs relative to gas and oil would help incentivise the switch to heat pumps. Government is considering rebalancing levies on energy bills, which currently put electricity at a disadvantage to fossil fuels for heating and transport, despite lower emissions and higher efficiency.

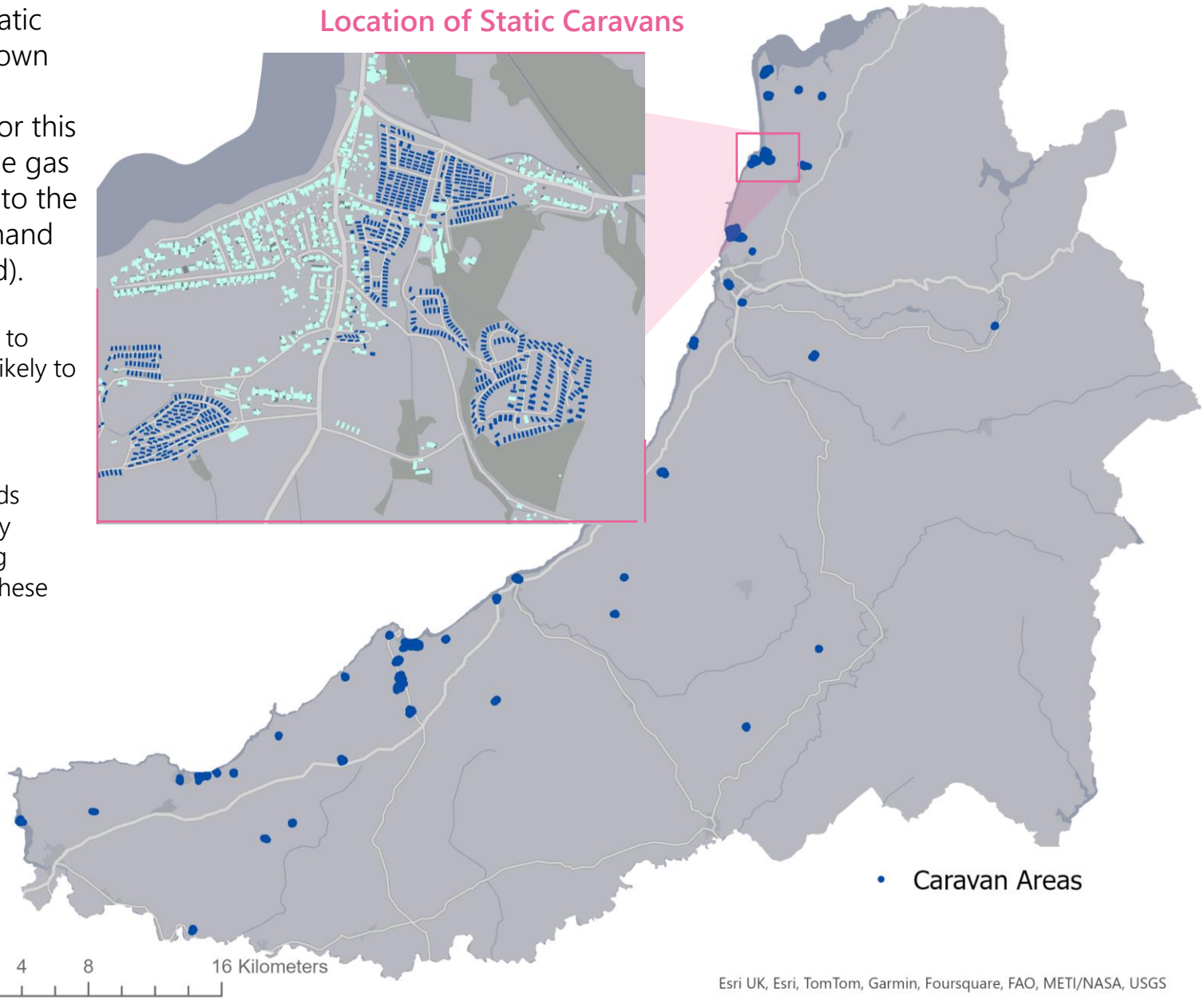
Certain planning requirements for heat pumps to be installed under permitted development are particularly restrictive, such as requiring the volume of the unit to be no more than one cubic metre, not installed on a wall or roof which fronts a highway, and not within three metres of the property boundary. The latter requirement is significantly more onerous than England's one metre requirement, which itself is the subject of debate as being excessively restrictive. Supporting a relaxation of these requirements will be essential for many homes to be able to install heat pumps without encountering discouraging planning obstacles.

Static Caravans

There are believed to be around 6,400 static caravans in Ceredigion, with locations shown on the map to the right. Accurate heat demands for caravans were unavailable for this study, but they have been assumed to use gas canisters for their heating, be connected to the electricity network and not have any demand over the winter (due to being unoccupied).

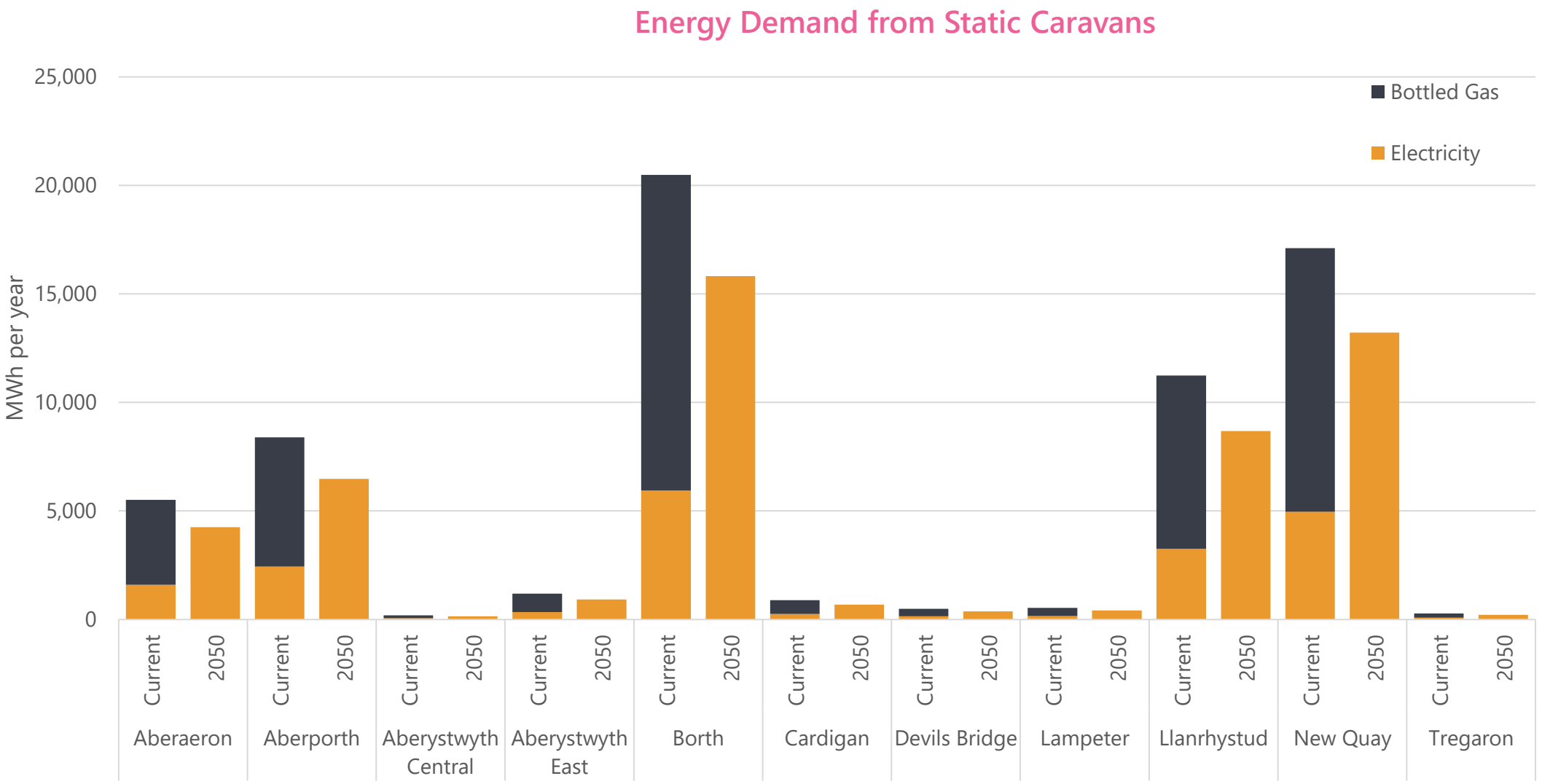
Caravans will need to decarbonise and are likely to switch to electric heating. However, they are unlikely to be in use over the winter peak.

It is likely that local substations may need to be reinforced at caravan parks as electricity demands increase. With increased electric vehicle usage by tourists and owners of the caravans, EV charging demand is expected to increase significantly in these locations.



Static Caravans

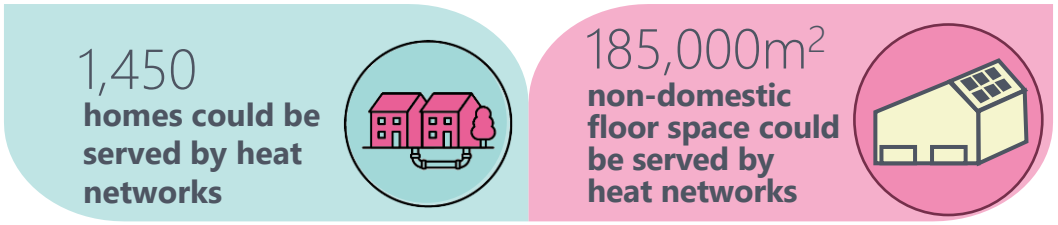
The graph below shows the assumed demands for the caravans within the modelling and how they are distributed between zones.



District Heat Networks

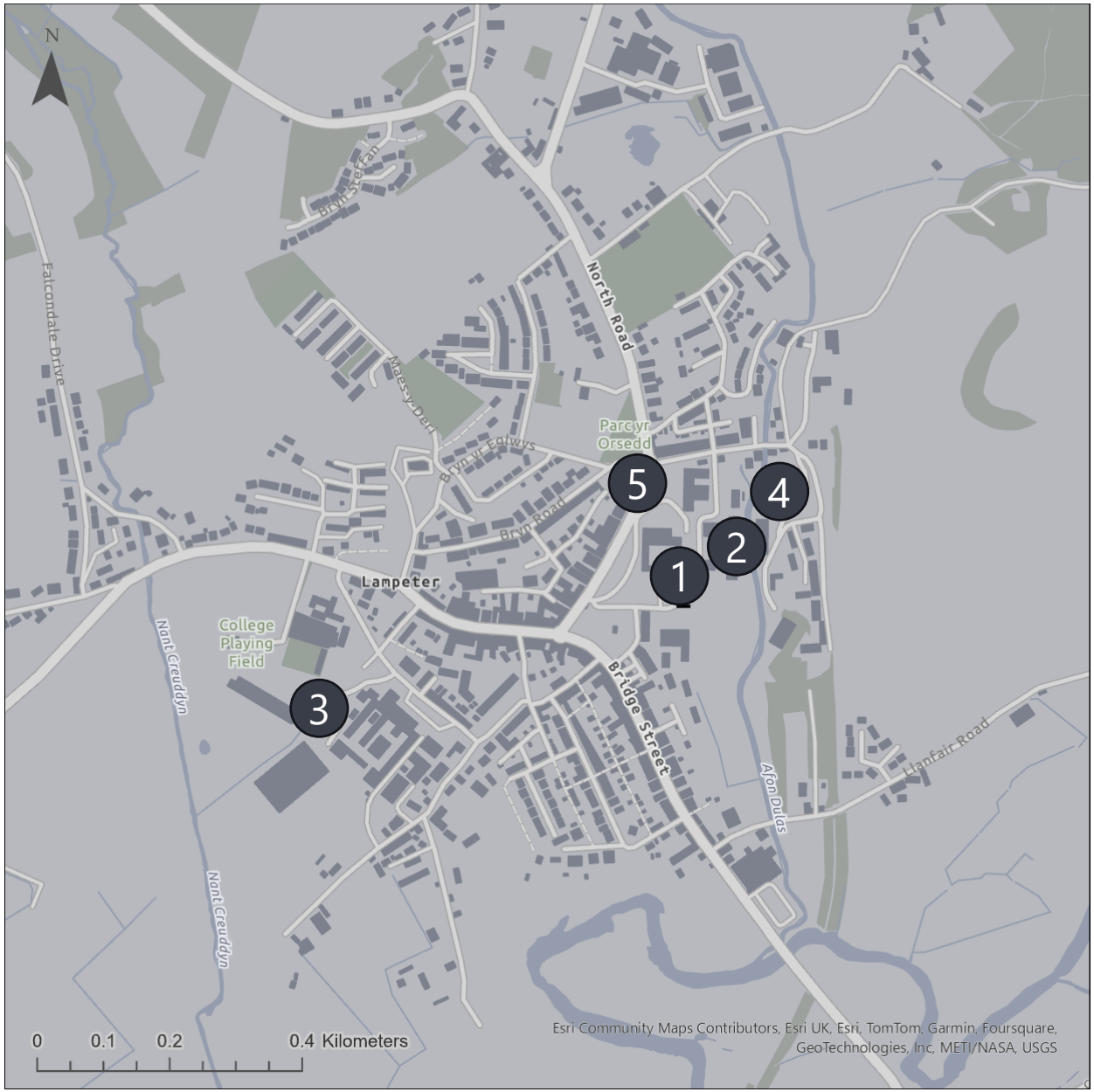
The domestic heating analysis has illustrated that there are a few opportunities for district heat networks, primarily in Aberystwyth Central (see the *Implementation: Priority Projects* section), where 1,200 homes and 125,000 m^2 of non-domestic floor space could be served by a heat network. A feasibility study for Aberystwyth has been carried out previously by Element Energy, which could be taken forward with the required financing. There may be additional opportunities for district heat networks when planning the heat transition for individual areas (e.g. towns), particularly where there are suitable characteristics (such as public sector sites or other large sites with suitable heat loads) and where both domestic and non-domestic buildings are considered in more detail together.

District heat networks can range from large schemes (as proposed for Aberystwyth Central) or smaller schemes, such as domestic shared ambient loop systems (as proposed as a priority project for Aberystwyth and Cardigan). As this LAEP has been developed at local authority scale, rather than having a LAEP for every town, it has not been possible to evaluate if there are other district heat networks opportunities for every built-up area; therefore, further consideration will be needed in the future. Where individual heat pumps are shown in this plan, they could be substituted with ambient loop networks where suitable, e.g. for terraces. District heat networks also provide an opportunity for local ownership, and combination with other technologies such as EV charging and solar PV to form a smart local energy system.



A good example of a potential district heat opportunity exists in Lampeter, where 250 homes and 60,000 m^2 of non-domestic floor space could be served. Lampeter has a cluster of non-domestic heat loads around the University of Wales Trinity Saint David campus which have a density suited to a heat network. From this core, it could be cost-effective to connect some nearby homes as well. Around Lampeter Wellbeing Centre (a leisure centre), there is also a secondary school, a swimming pool, a care home and a number of community buildings. UK government are currently developing a national approach to heat network zoning.

District Heat Networks



Locations of the five non-domestic buildings with the greatest heat demand that are connected to district heat in the Efficiency and Equity scenario. Buildings 1, 2, 4, & 5 belong to the University of Wales Trinity Saint David campus and building 3 is Lampeter Wellbeing Centre.

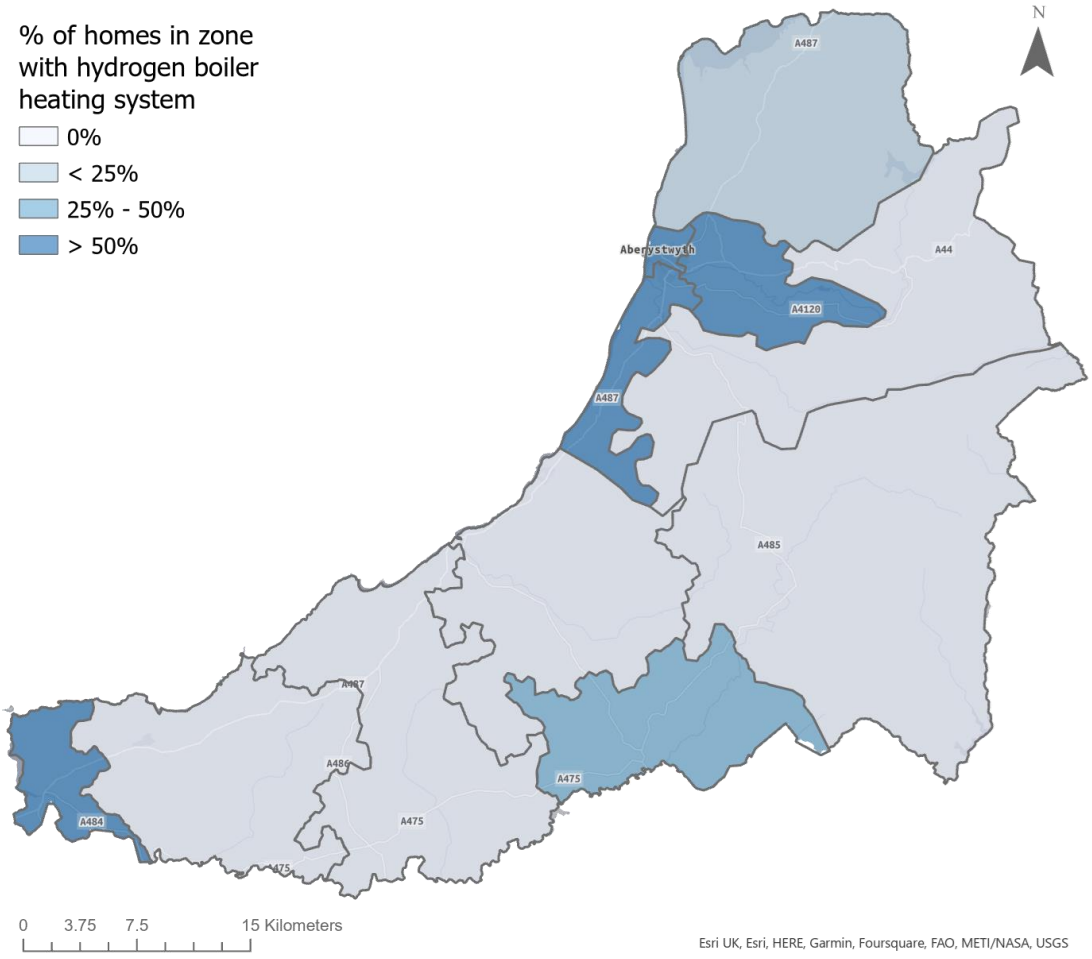
Hydrogen for Heating

Hydrogen boilers are only used in the Critical Network scenario. This is driven by limits on the ability to heat buildings using electricity in this scenario due to constraints on electricity network capacity. Hydrogen boilers are therefore installed as an alternative to heat pumps. Since hydrogen for home heating is not selected in any scenario aside from one with onerous constraints, this suggests that it is a low confidence option for the area. Hydrogen for heating is contentious, particularly due to the expected scarcity and cost of low carbon hydrogen, and uncertainty around the timescale of availability. Considering also that Ceredigion has limited gas network coverage or industrial gas use, the case for hydrogen for heating does not appear strong.

In the Critical Network scenario, approximately 10,500 homes are heated by hydrogen by 2050. In the National Net Zero scenario by contrast, these 10,500 homes would instead adopt heat pumps (84%) and connect to district heat networks (13%) due to a less constrained electricity network.

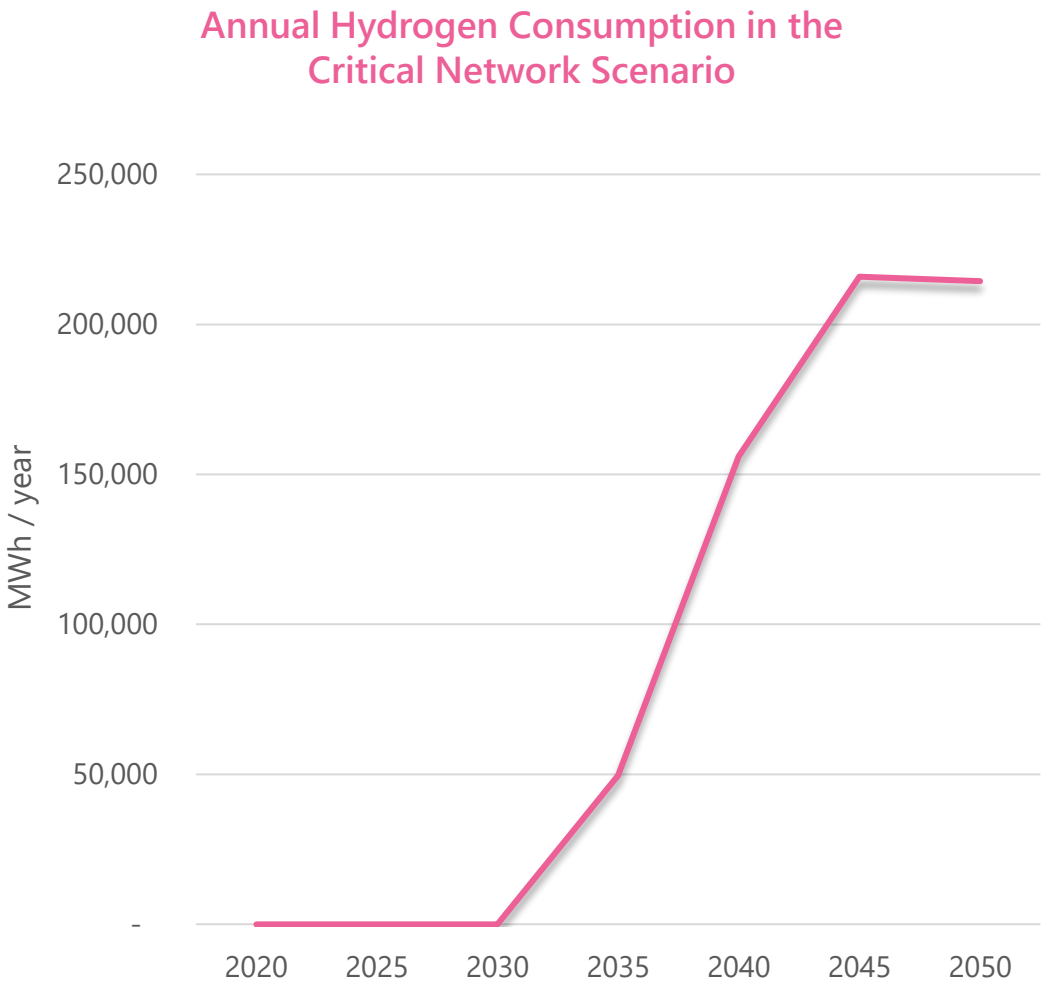
As using hydrogen for heating at scale relies on repurposing of the existing gas network to distribute hydrogen to homes, the uptake of hydrogen boilers is restricted to just those homes which are currently on the gas network. This makes the Aberystwyth Central, East and Llanrhystud zones the highest density areas for uptake of hydrogen boilers. It also means that in 5 out of the 11 zones, there is no hydrogen for heating used due to homes being off-gas.

Homes with Hydrogen Boilers by 2050 in the Critical Network Scenario



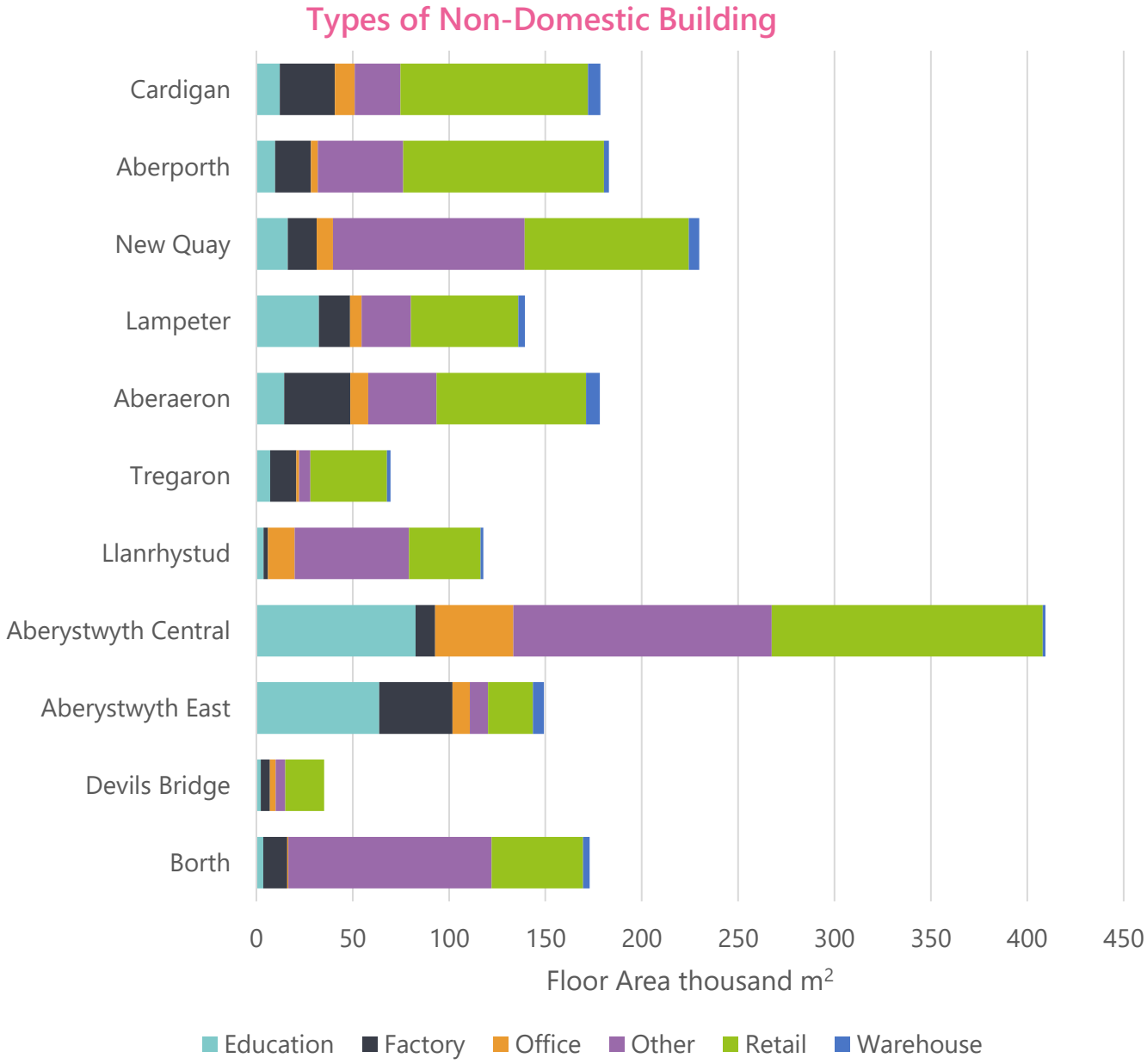
Hydrogen for Heating

It is assumed that hydrogen for heating would become available to Ceredigion in 2035, though a significant amount of uncertainty surrounds this date. UK Government intends to make a decision on the use of hydrogen for heating buildings in 2026, which will be a key moment for increased certainty in the pathway. In Critical Network, annual hydrogen consumption in Ceredigion peaks at around 216,000 MWh/year in 2045. This could be supplied by local electrolysers powered by renewable electricity, or imported from industrial areas in North or South Wales, where hydrogen may be produced for industry. The potential to generate hydrogen locally is explored in further detail in the Renewable Generation section of the plan.



Non-Domestic Heating: Context

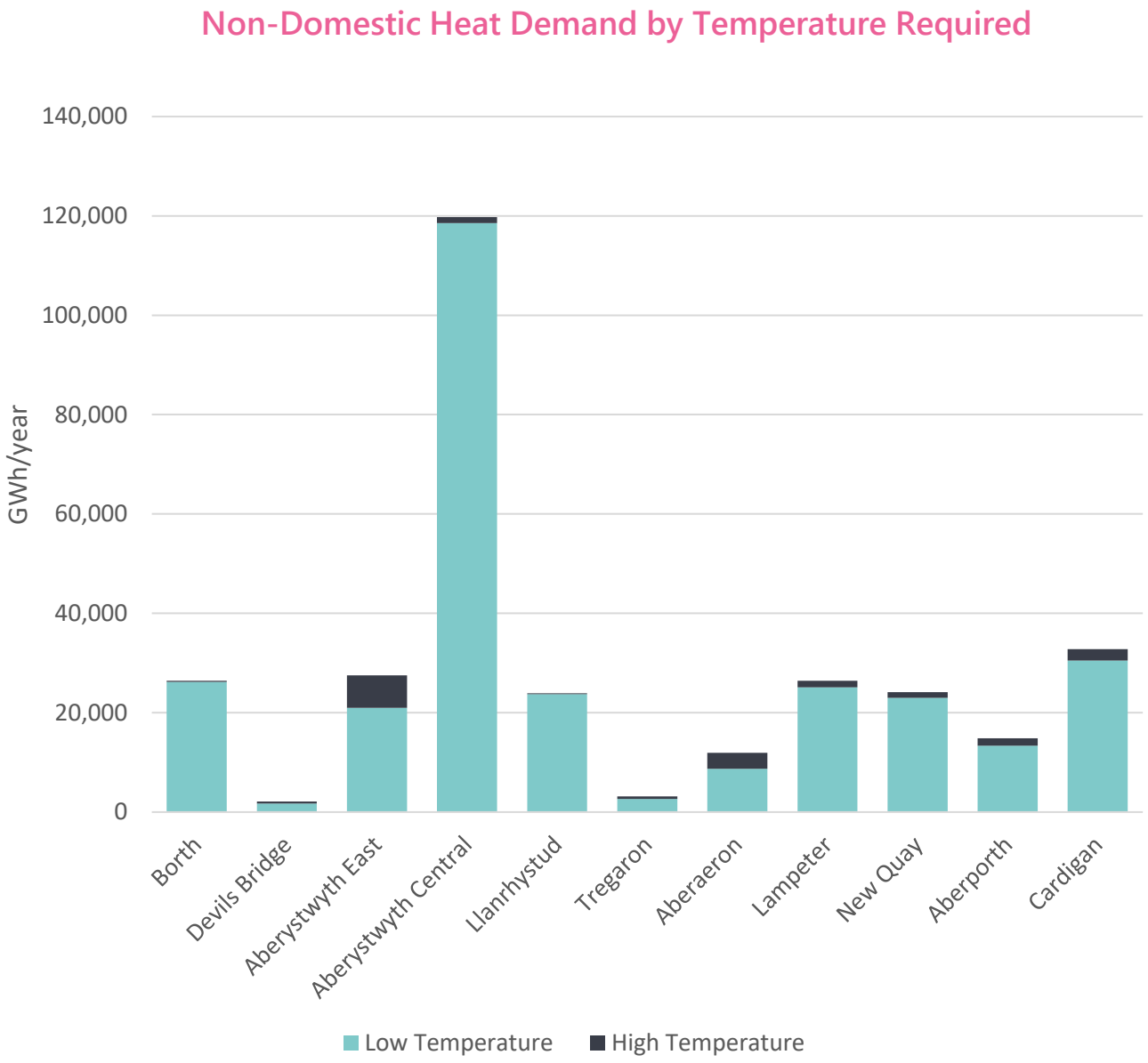
Non-domestic buildings are categorised into a range of uses, shown in the chart. Most of the heat demand in non-domestic buildings is for space heating and hot water, and can typically be decarbonised using heat pumps, or by connecting to district heat networks in areas of high demand density. It's common for some types of non-domestic buildings, such as retail and offices, to already use heat pumps for heating and cooling. These buildings would already be Net Zero ready with no changes, though may still benefit from efficiency upgrades.



Non-Domestic Heating: Context

A small portion of heat is likely to be required at high temperature for specialised industrial processes, as shown on the chart. High temperature heat can in some cases be more difficult to electrify or provide from district heat networks, making a stronger case for hydrogen to replace fossil fuels for these applications. Since industrial sites tend to have bespoke designs, it is hard to generalise on the best decarbonisation approach. Each site will need to be assessed individually.

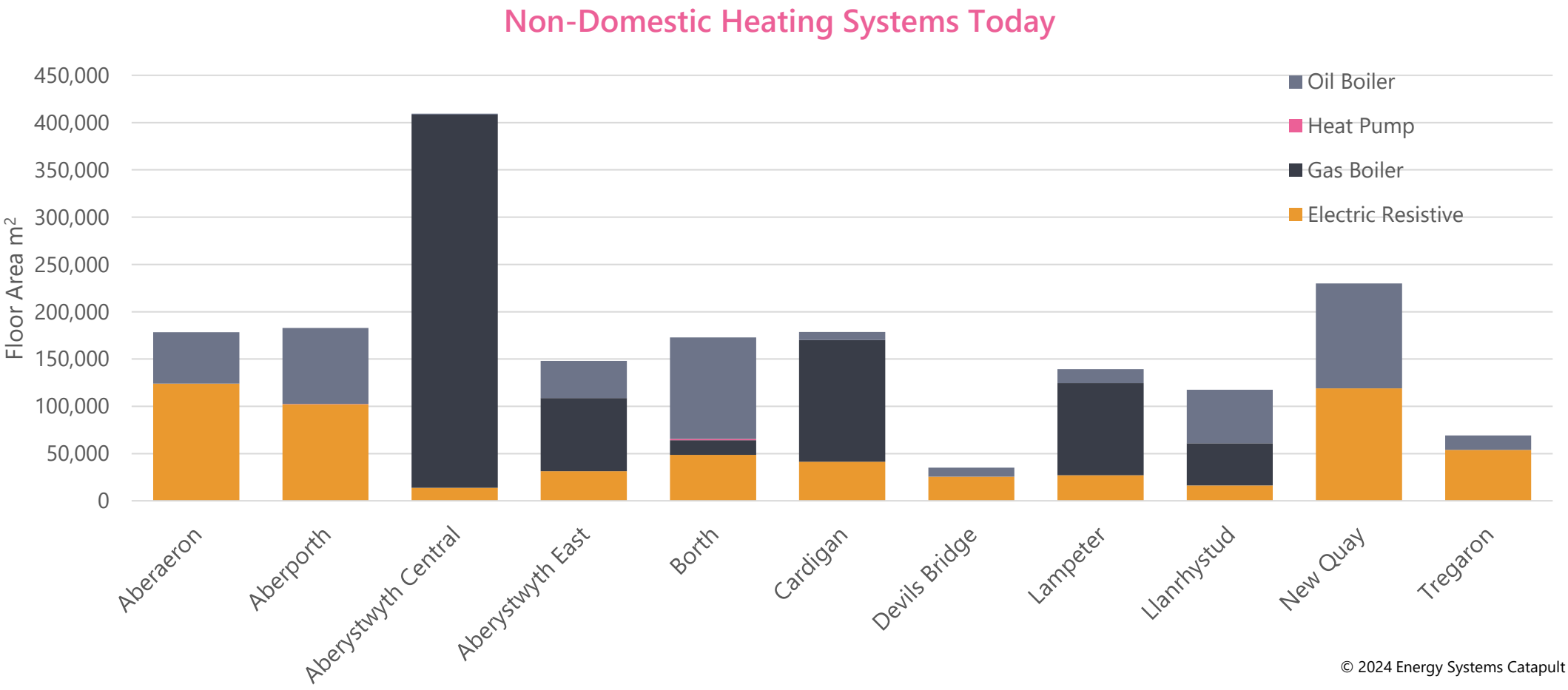
The Heat Strategy for Wales seeks to align with the Climate Change Committee's recommendation to phase out the sale of gas boilers to commercial properties by 2033. The Wales Funding Programme allows public sector bodies to apply for interest-free loans for up to one hundred percent of the costs of energy-saving or renewable energy projects.



Non-Domestic Heating: Today

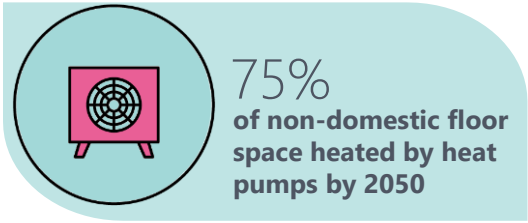
The graph below shows the assumed present day heating systems for non-domestic buildings. This is primarily a mix of gas boilers, oil boilers and electric resistive.

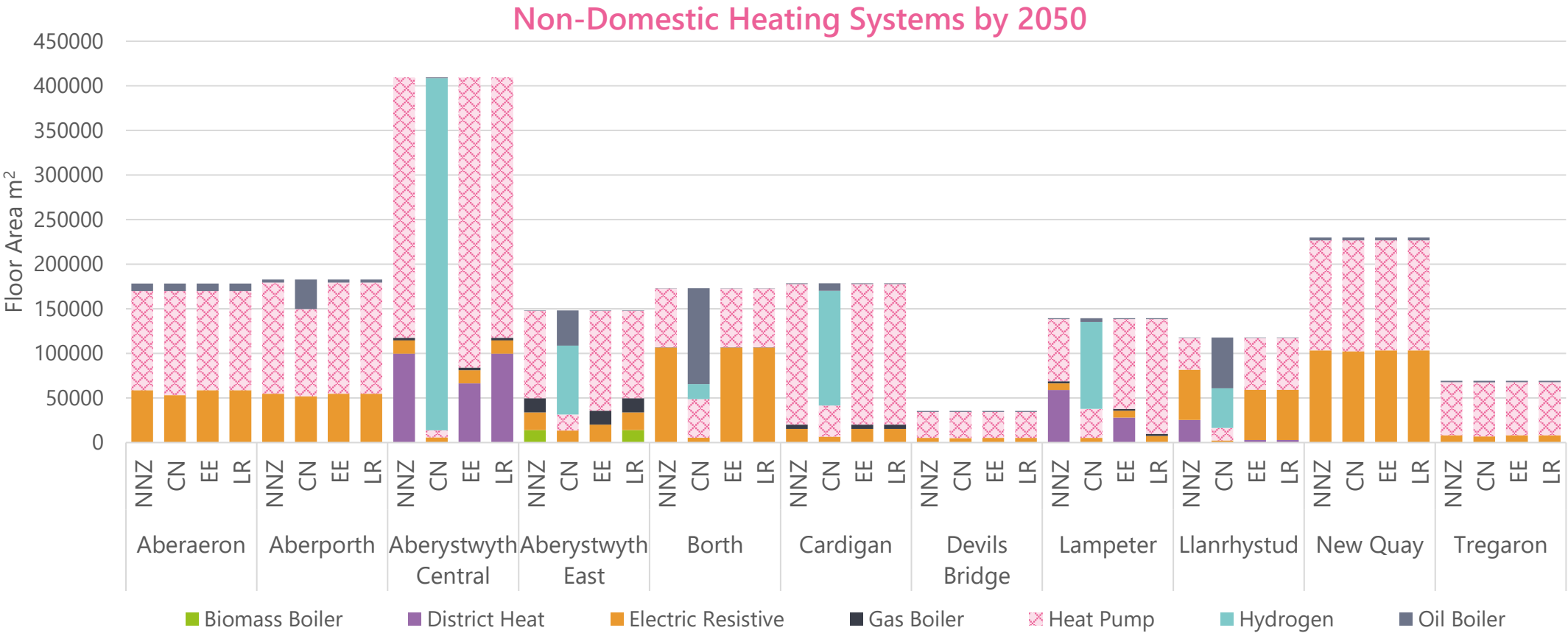
In Aberystwyth Central, Aberystwyth East, Cardigan and Lampeter the heating systems are dominated by gas boilers, as most buildings in these areas are on the gas grid. In areas off the gas grid there is more reliance on oil boilers or electric resistive.



Non-Domestic Heating: The Transition

The decarbonisation of low temperature heat, used to provide space heating and hot water in non-domestic buildings, follows a similar pattern to domestic decarbonisation, with much of the fossil fuel systems being replaced with heat pumps (1,150,000 m^2, 75% of floorspace), or by connecting to a district heat network in the dense town centres of Aberystwyth and Lampeter (180,000 m^2, 12% of floorspace), as shown in the chart. Although in Lampeter there is only a high level of district heat in the National Net Zero scenario, showing it is likely less of a priority compared to in Aberystwyth Central, where it is high in three of the four scenarios.





Scenarios - NNZ: National Net Zero LR: Local Resources EE: Equity and Efficiency CN: Critical Network

Non-Domestic Heating: The Transition

In the Critical Network scenario there are high levels of hydrogen in Aberystwyth Central, Aberystwyth East, Cardigan and Lampeter. In other zones unable to connect to hydrogen, many heating systems don't switch from oil boilers, meaning this scenario is far from being Net Zero by 2050.

Building fabric upgrades are bundled with the heating system upgrades shown here, and other efficiency measures such as recommissioning and upgrades of building management systems, LED lighting and lighting control can be implemented at the same time, often improving the economics of the project. Oil is the dominant fuel today outside of major towns, while sizeable towns tend to favour gas. Further studies are required to understand the full extent of the interventions required for agriculture as a whole to reach Net Zero by 2050. Locally produced biofuels from agricultural waste could pair well with agricultural machinery, which may be difficult to electrify.

Non-Domestic Heating: Gas

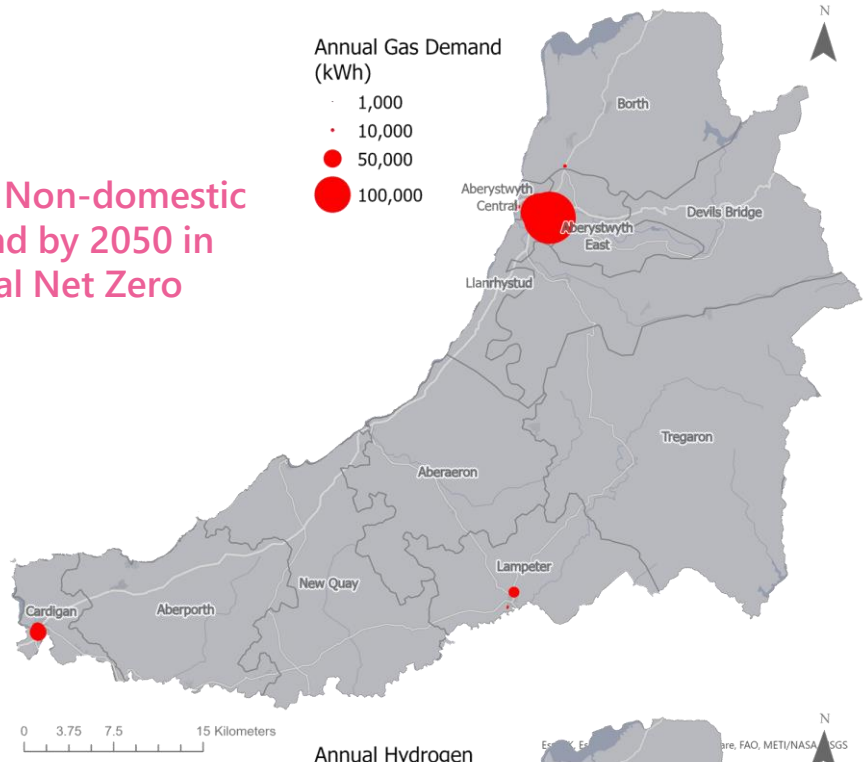
The map on the upper right-hand side shows the location of the non-domestic sites which continue to rely on some form of gas in 2050 in the National Net Zero modelling scenario. These sites are concentrated around the three towns of Aberystwyth, Lampeter and Cardigan. These buildings stay on gas in the model as the input data suggests they may be using high temperature processes, but more detailed assessments of these buildings would be required to determine if these locations do need to stay on gas. However, this does highlight that there may be locations that may struggle to switch away from gas and where hydrogen could be a solution.

The map on the bottom right-hand side shows the very high levels of hydrogen usage in the Critical Network scenario. This includes the processes described above which may have an unavoidable requirement for gas, but also extends to other uses which would have electrified were greater network capacity available, such as space heating of buildings. In this scenario, around 4,400 buildings would use hydrogen. In total the estimated annual hydrogen demand is approximately 135,000 MWh, with the majority of that found again in the area where the Llanrhystud, Aberystwyth Central and Aberystwyth East zones intersect.

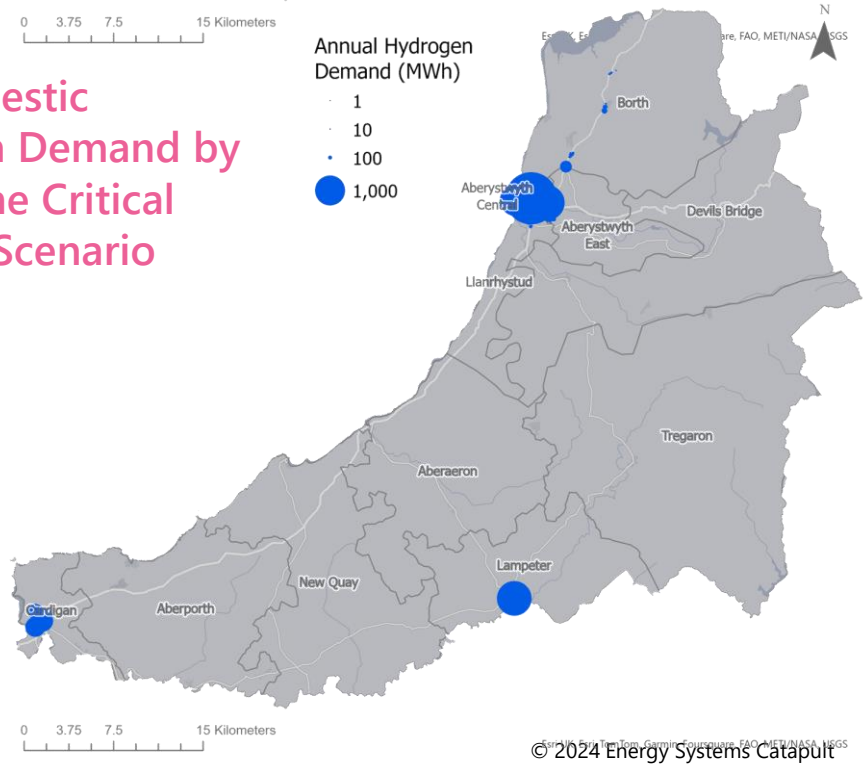
These two scenarios give a range of possible requirements for low carbon gas in high and low electrification futures. Data on non-domestic buildings is limited, and more detailed analysis of the energy uses in these buildings will be required to plan their energy transition.

Enablers	Barriers
• Collaboration • Grants • Hydrogen potential • Smart local energy systems	• Funding • Skills gap • Ownership • Technology readiness (hydrogen)

Remaining Non-domestic Gas Demand by 2050 in the National Net Zero Scenario



Non-domestic Hydrogen Demand by 2050 in the Critical Network Scenario



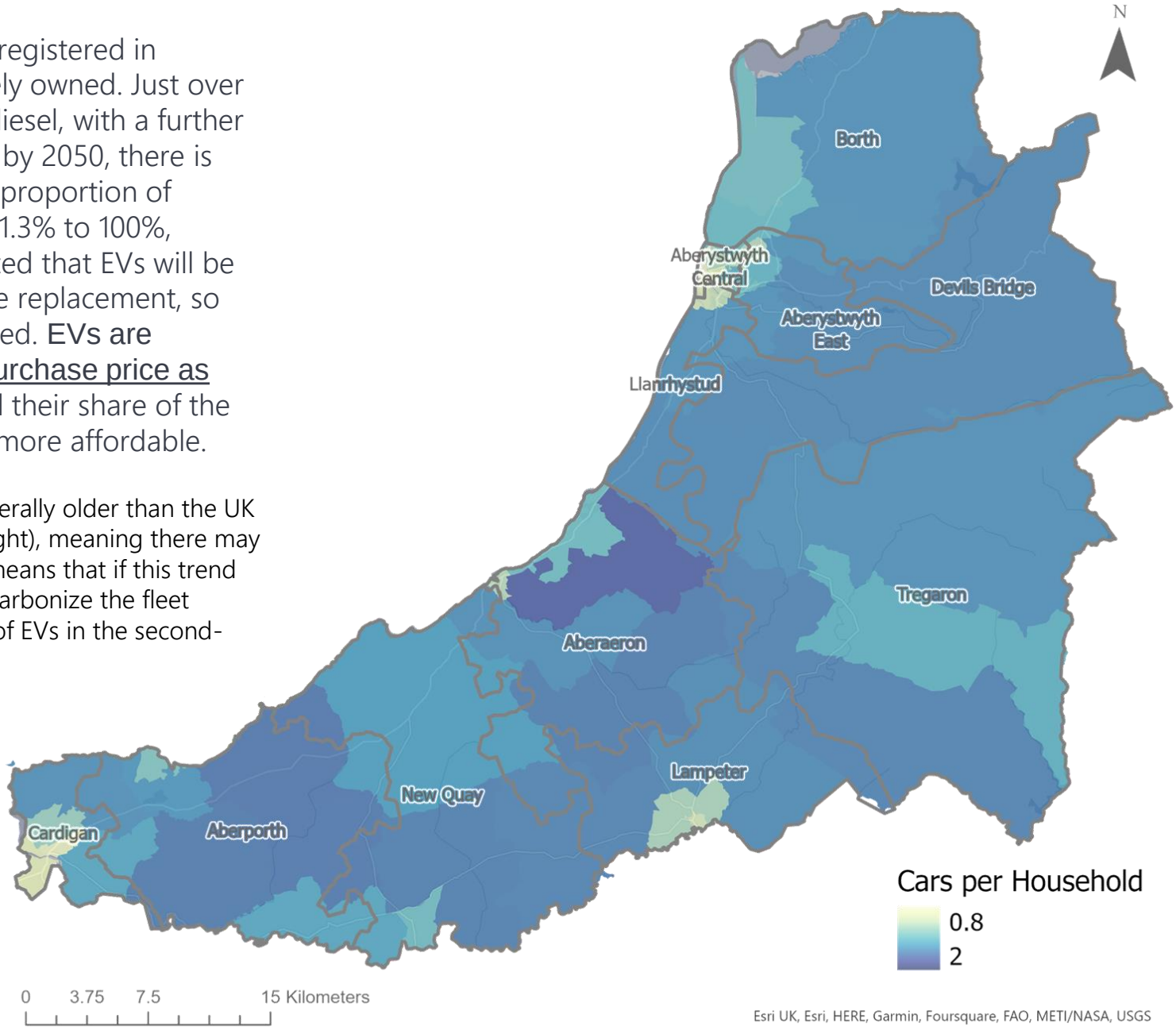
The Energy System Transition: Transport

Car Ownership Today

There are currently almost 38,500 cars registered in Ceredigion, of which 36,800 are privately owned. Just over 96% of these cars are either petrol or diesel, with a further 2.6% being hybrids. To reach Net Zero by 2050, there is going to need to be an increase in the proportion of electric vehicles (EVs) from the current 1.3% to 100%, posing a significant change. It is expected that EVs will be purchased at the natural time of vehicle replacement, so that minimal additional costs are incurred. EVs are expected to reach the same upfront purchase price as petrol cars this decade. As EVs expand their share of the used vehicle market, they will become more affordable.

The private cars owned in Ceredigion are generally older than the UK average (shown in the figure in the bottom right), meaning there may be more reliance on second-hand cars. This means that if this trend continues, Ceredigion may take longer to decarbonize the fleet compared to the rest of the UK, as the share of EVs in the second-hand market gradually grows.

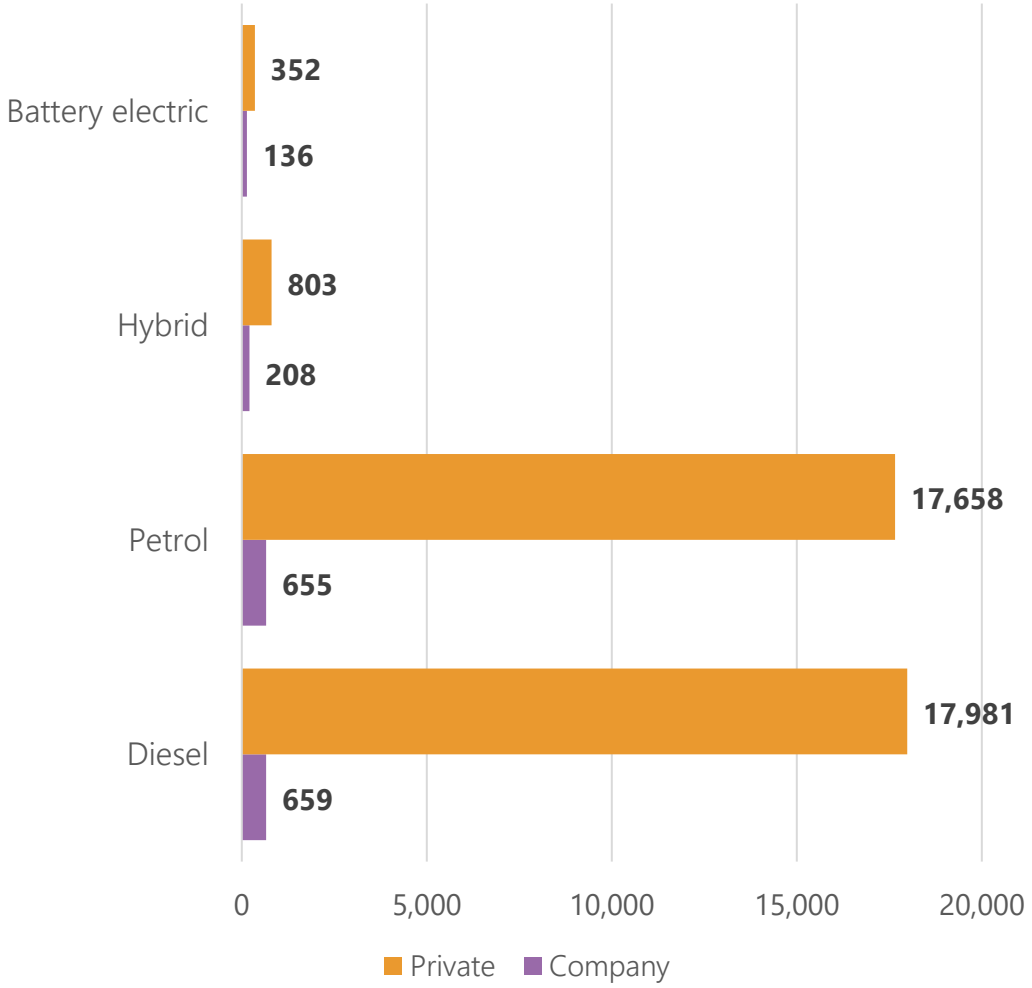
The map on the upper right shows the average number of cars per household from the 2021 census. This highlights lower car ownership levels in the more urban areas of Ceredigion, such as Aberystwyth, Cardigan and Lampeter. There are higher car ownerships levels in the rural areas, likely down to the greater need for a car in areas away from more frequent public transport or the possibility of active travel.



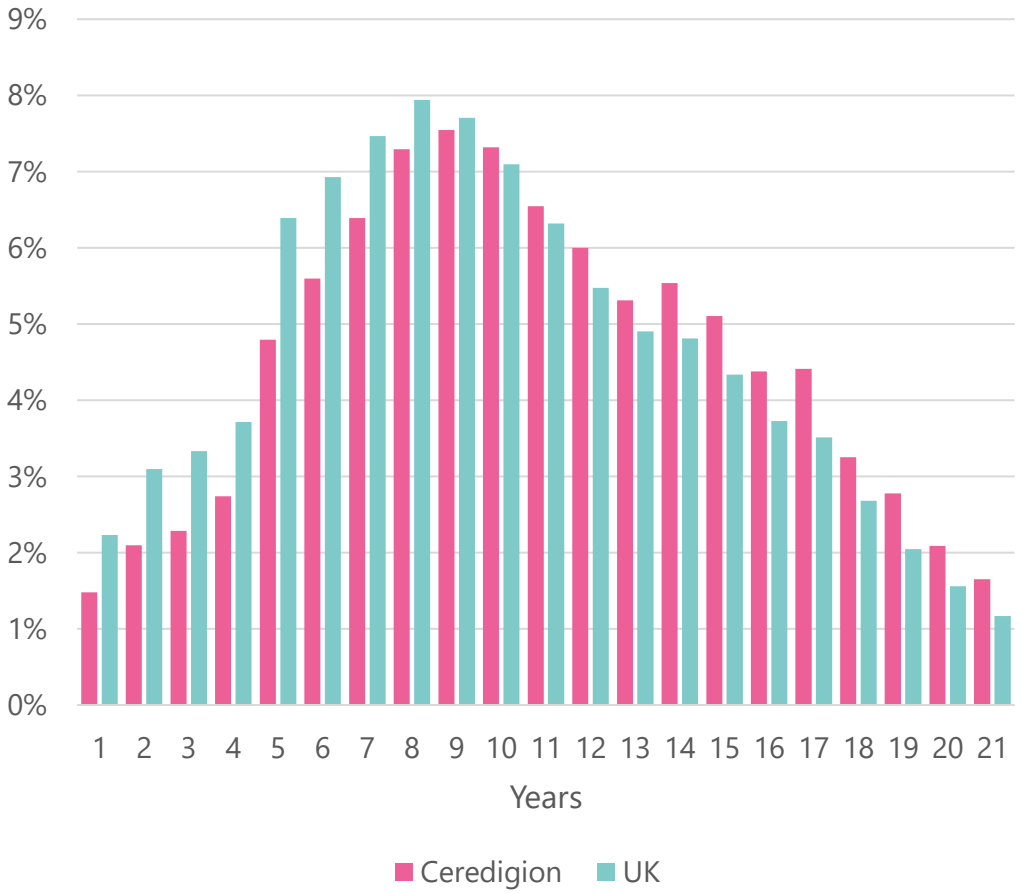
https://www.gov.uk/government/statistical-data-sets/vehicle-licensing-statistics-data-tables

Car Ownership Today

Fuel Type of Licensed Cars Today



Age Profile of Private Cars Today



https://www.gov.uk/government/statistical-data-sets/vehicle-licensing-statistics-data-tables

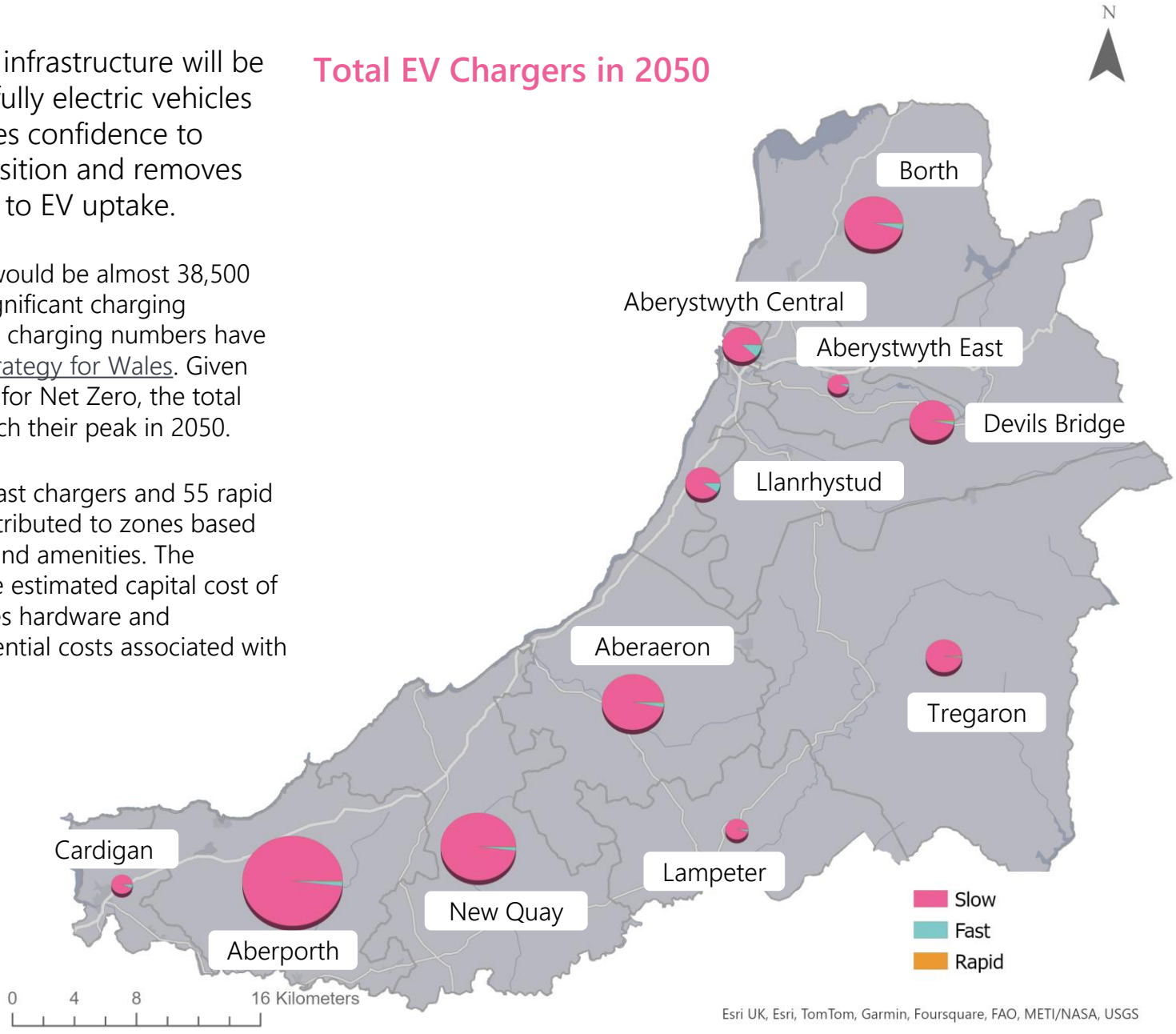
EV Charging Infrastructure

Access to abundant and reliable charging infrastructure will be important to encourage the transition to fully electric vehicles and to keep up with demand. This provides confidence to residents that they can be part of the transition and removes the 'range anxiety' often cited as a barrier to EV uptake.

If car ownership remains at today's levels, there would be almost 38,500 EVs in Ceredigion by 2050. This would require significant charging infrastructure to accommodate. For this LAEP, EV charging numbers have been taken from the Electric Vehicle Charging Strategy for Wales. Given the reliance on older cars and the target of 2050 for Net Zero, the total numbers for chargers have been assumed to reach their peak in 2050.

This gives a total of 23,070 slow chargers, 1,490 fast chargers and 55 rapid chargers across Ceredigion. These have been distributed to zones based on car ownership levels, key transport corridors and amenities. The distribution is shown in the map on the right. The estimated capital cost of installing these chargers totals £19m. This includes hardware and installation costs and does not include other potential costs associated with planning.

Total EV Chargers in 2050

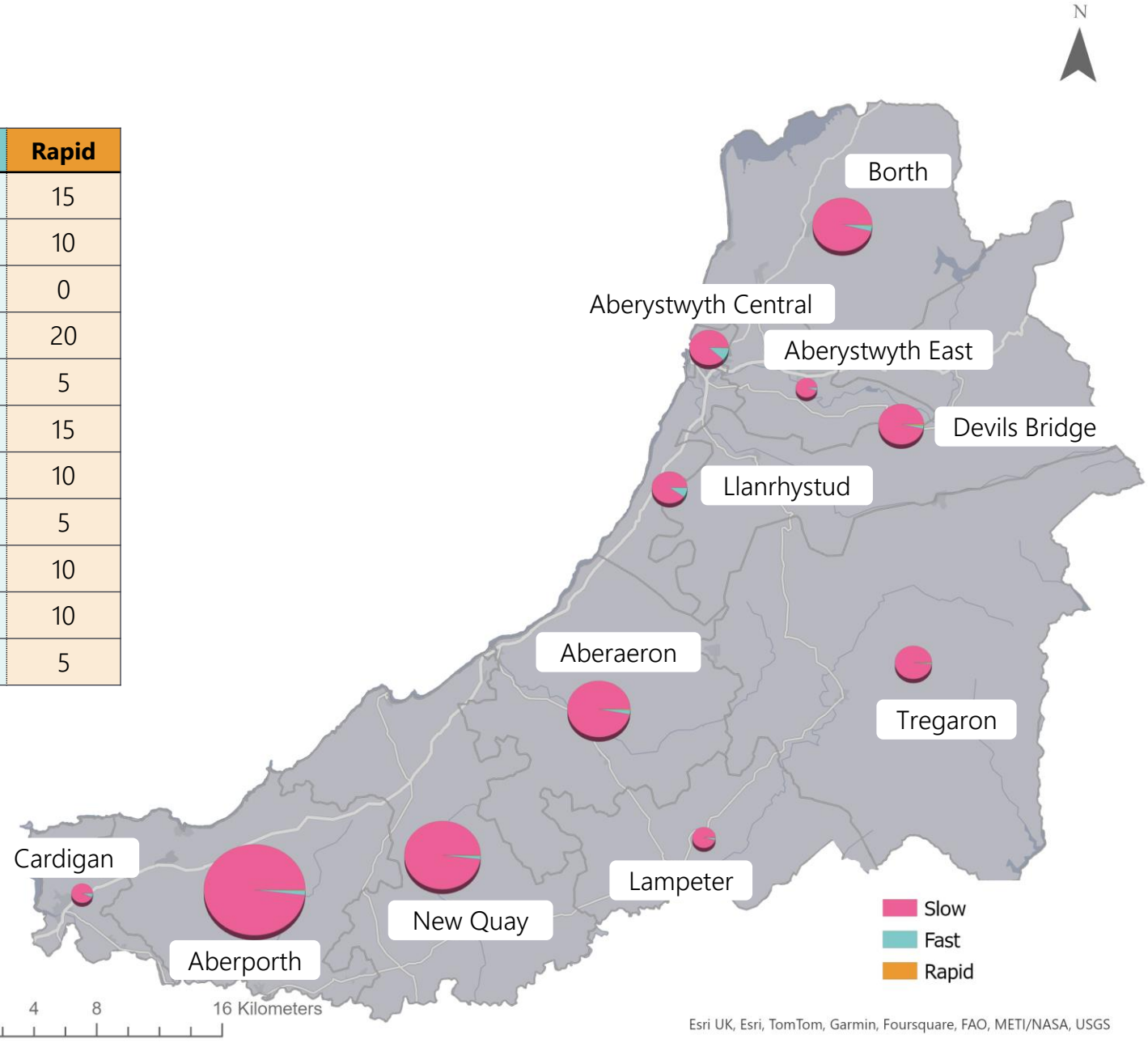


EV Charging Infrastructure

Total EV Chargers in 2050

	Slow	Fast	Rapid
Borth	2,600	85	15
Aberystwyth Central	1,680	205	10
Aberystwyth East	700	30	0
Devils Bridge	2,060	50	20
Llanrhystud	1,590	155	5
Aberaeron	2,750	65	15
Tregaron	1,780	20	10
Lampeter	1,220	40	5
New Quay	3,300	50	10
Aberporth	4,290	65	10
Cardigan	1,110	79	5

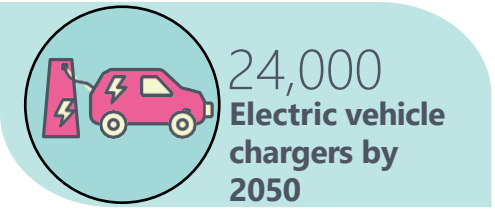
Total:
23,070 slow chargers
1,490 fast chargers
55 rapid chargers



EV Charging Infrastructure

In Aberystwyth and Cardigan there are low numbers of slow chargers as there is a lower number of cars per household (so less need for home charging or on-street charging). However, they have a higher proportion of fast and rapid chargers as they are likely to have more homes without off street parking, so may need faster charging, or may have more tourism parking. The charge point numbers used account for the seasonal variation of demand arising from tourism.

A lower dependency on private vehicle use, and hence a lower uptake of EVs is assumed in the Efficiency and Equity scenario. This is due to an assumed reduction in demand by enabling greater shift from private cars to other transport modes, including public transport and active travel, as well as a reduced overall travel demand enabled by remote work.

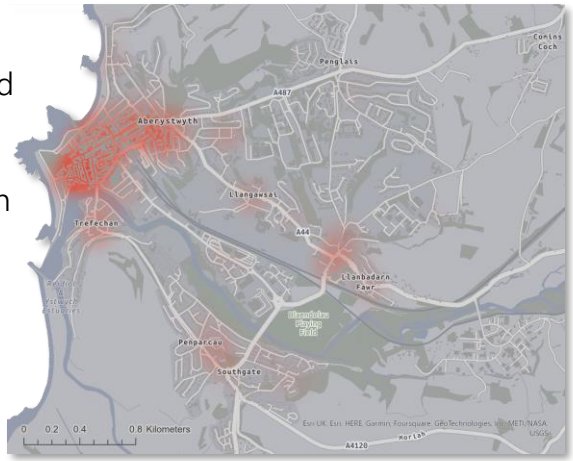


EV Charging Infrastructure

Areas of high-density housing without off-street parking are found in several areas, particularly in towns and villages. For example, around 23% of the residents in Aberystwyth Central do not have potential for off-street parking; this zone would need to be prioritised for public charging infrastructure to ensure an equitable transition to low carbon transport.

Those residents without off-street parking will require ready access to charging hubs, kerb-side charging, destination charging, workplace charging, etc.

However, given it is estimated that around 90% of residents in Ceredigion may have potential for off-street parking, it is expected that home charging will be dominant.



Aberystwyth

Cardigan

90%
Households have potential for off-street parking, suitable for home charging

Numbers indicate the percentage of homes without off-street parking

Transport	Enablers	Barriers
	• Car clubs • Modal shift • Reduce car ownership • Smart local energy systems	• Affordability • Public attitudes

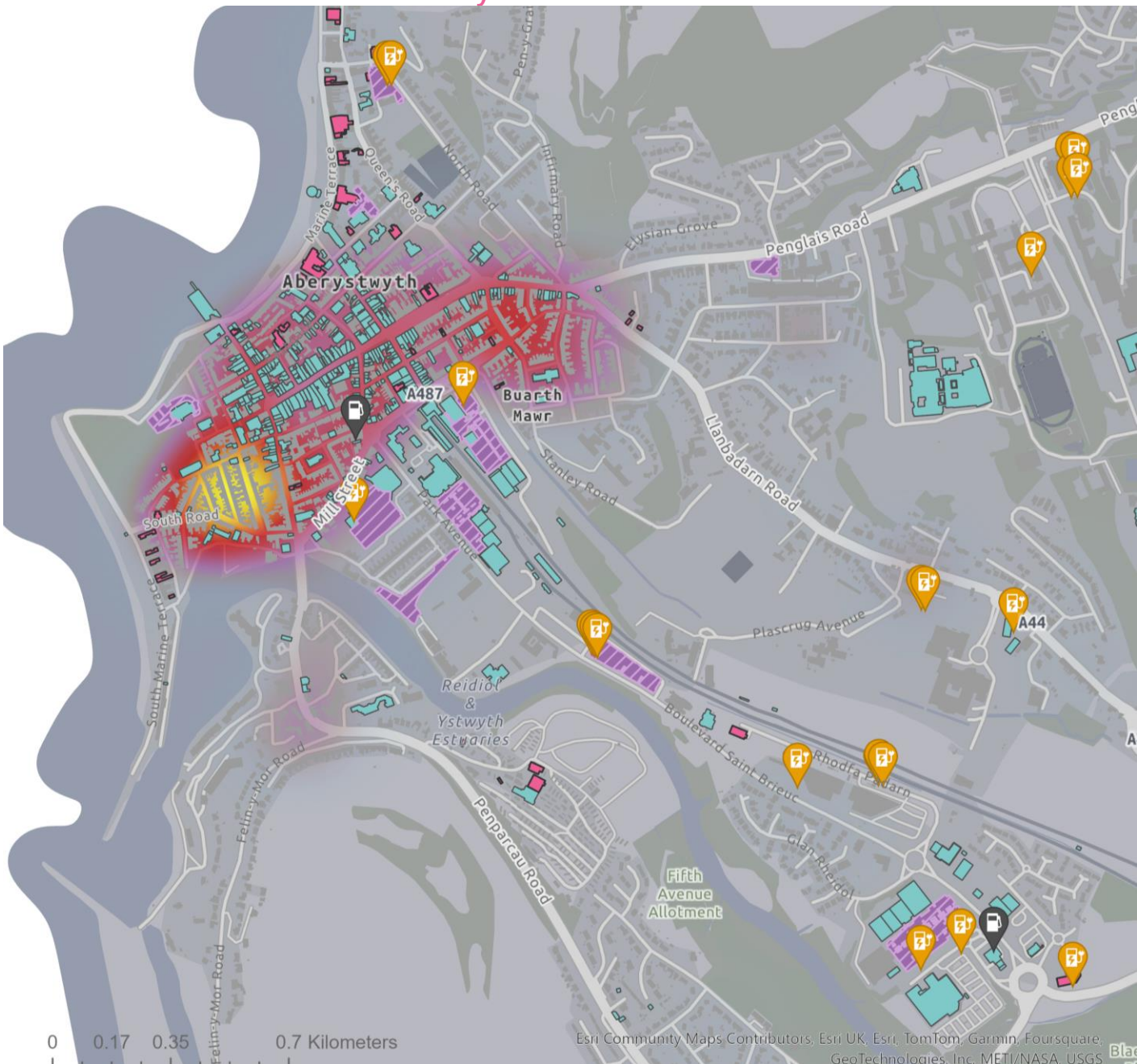
Public EV Chargers in Aberystwyth

Even though Aberystwyth is expected to have a lower proportion of EVs compared to other areas (due to the lower car ownership levels), it is expected to have a high number of public chargers. This is due to the high level of buildings without access to off-street parking and due to the retail and tourist nature of the town.

In the Aberystwyth Central zone there are expected to be around 205 fast chargers and 10 rapid chargers by 2050 in the National Net Zero scenario.

The map on the right shows locations of existing charge points as well as some types of non-domestic buildings. Locations with large retail floor areas could be priority areas for fast and rapid chargers, as consumers can charge their vehicles while they shop.

Amenities Today

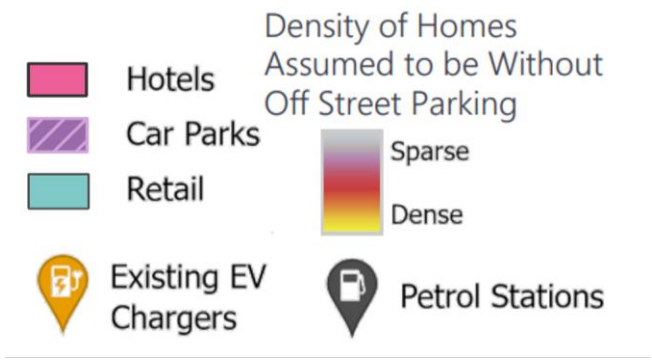


Public EV Chargers in Aberystwyth

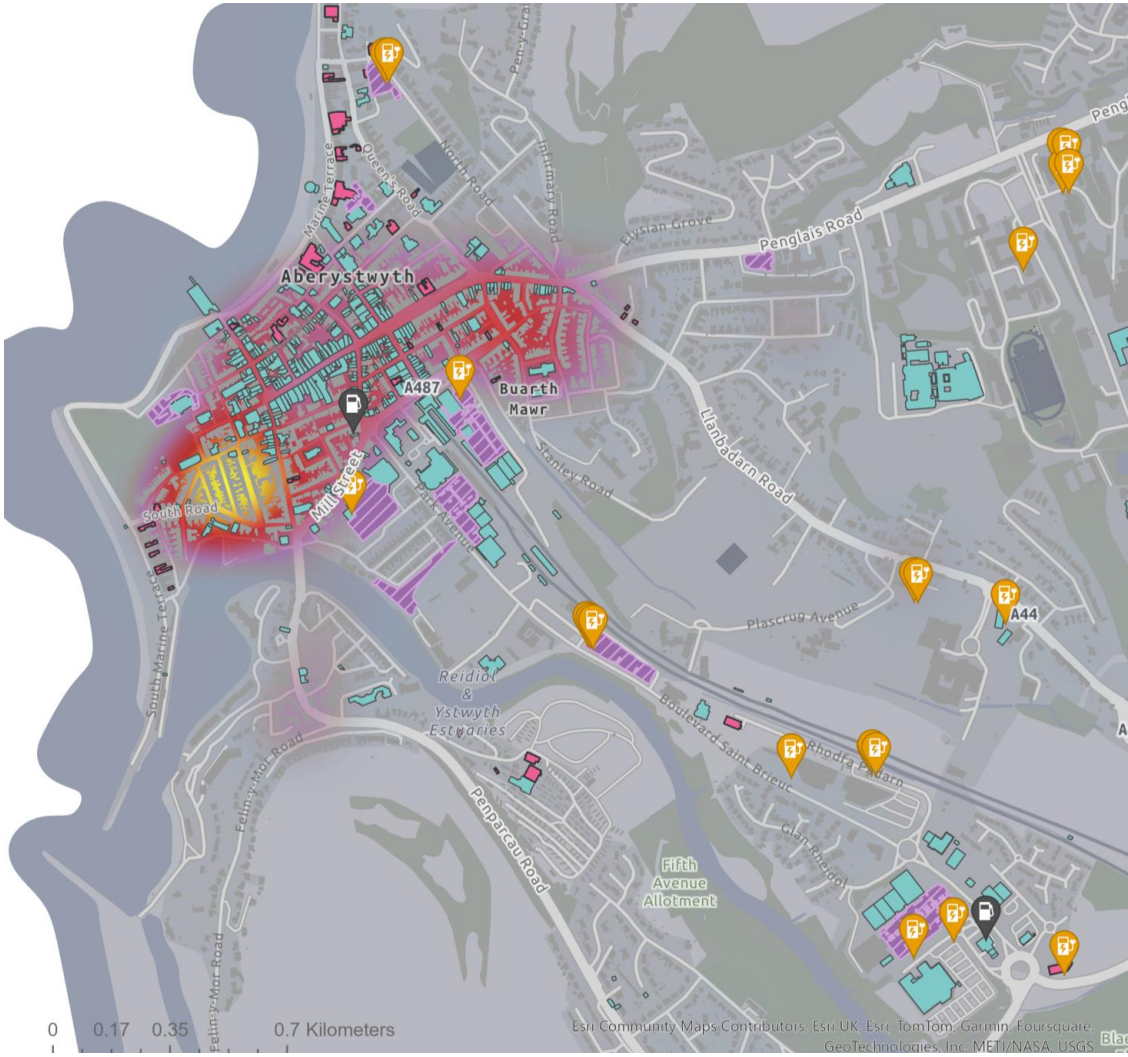
Areas with a low density of off-street parking are also shown. These locations could be priority areas for on-street charging. Current petrol stations have been shown as they are expected to be well located for en-route charging, and could therefore be viable locations for some types of rapid chargers.

Within the zone, there are several bed & breakfasts, hotels and guest houses. Given that the demand in these buildings is likely to be seasonal, it is expected that there will be a larger energy requirement at charge points in this area in the summer periods. It is unlikely that all visitors would have access to EV charging infrastructure at their hotel and therefore policy decisions will need to be made to around where and how to cater to these users' needs.

In areas where demand is likely to be high, Ceredigion should work with private providers to increase provision of charge points. Public sector funding can be prioritised towards areas where lower charge point utilisation could make it challenging for the private sector to build a business case, or where problems with network constraints or high connection costs could pose additional barriers.



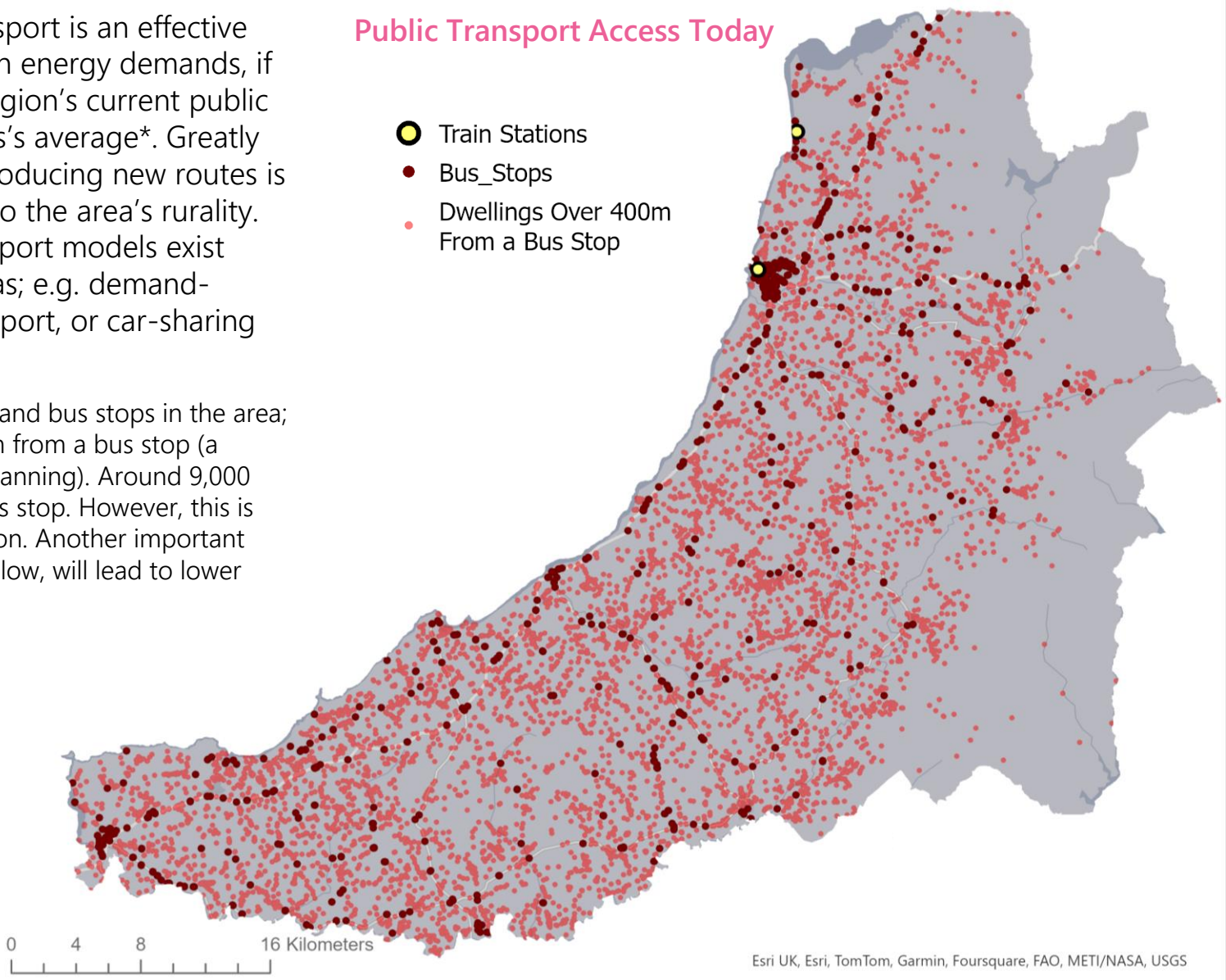
Amenities Today



Public Transport

Increasing the provision of public transport is an effective way to reduce a region's transportation energy demands, if well utilised. It is estimated that Ceredigion's current public transport provision is lower than Wales's average*. Greatly increasing service frequencies and introducing new routes is likely to be economically difficult due to the area's rurality. Alternatives to the normal public transport models exist which may be more viable in rural areas; e.g. demand-responsive transport, community transport, or car-sharing schemes.

The map shows the location of train stations and bus stops in the area; along with homes which are more than 400m from a bus stop (a standard accessibility measure in transport planning). Around 9,000 homes (24%) are more than 400m from a bus stop. However, this is only one measure of accessibility and provision. Another important measure is the frequency of service, which, if low, will lead to lower modal shift from cars.



* Based on analysis of sub-national road transport fuel consumption statistics. Data is available from: https://www.gov.uk/government/collections/road-transport-consumption-at-regional-and-local-level

Map data from National Public Transport Access Nodes (NaPTAN) https://beta-naptan.dft.gov.uk/

Public Transport

Existing and new bus services will need to be provided either by battery-electric or hydrogen fuelled vehicles. UK Government are currently considering setting a date for the end of sales of new non-zero emissions buses between 2025 and 2032, and the Welsh Government is committed to delivering a zero-emission bus fleet by 2035 in the National Transport Delivery Plan. Currently in the UK, the majority of zero-emission buses are battery electric. The choice of battery- or hydrogen-powered buses will need to consider the balance of improved range and refuelling time of hydrogen buses versus their higher initial investment and operational costs compared to their electric counterparts, as well as the availability of green hydrogen and associated infrastructure requirements. In a future scenario where the gas grid does not convert to supplying hydrogen, hydrogen will need to either be produced locally by electrolysers, or transported from outside of Ceredigion.

The table below shows the estimated current energy demand for buses in Ceredigion, and the equivalent demand for electricity or hydrogen, were these vehicles to be decarbonised via either method. This is assuming that the mileage of buses remains constant. On an energy input basis, the electricity and hydrogen demands are lower than the current (likely majority diesel fuel) demand due to the differing efficiencies of the drivetrains.

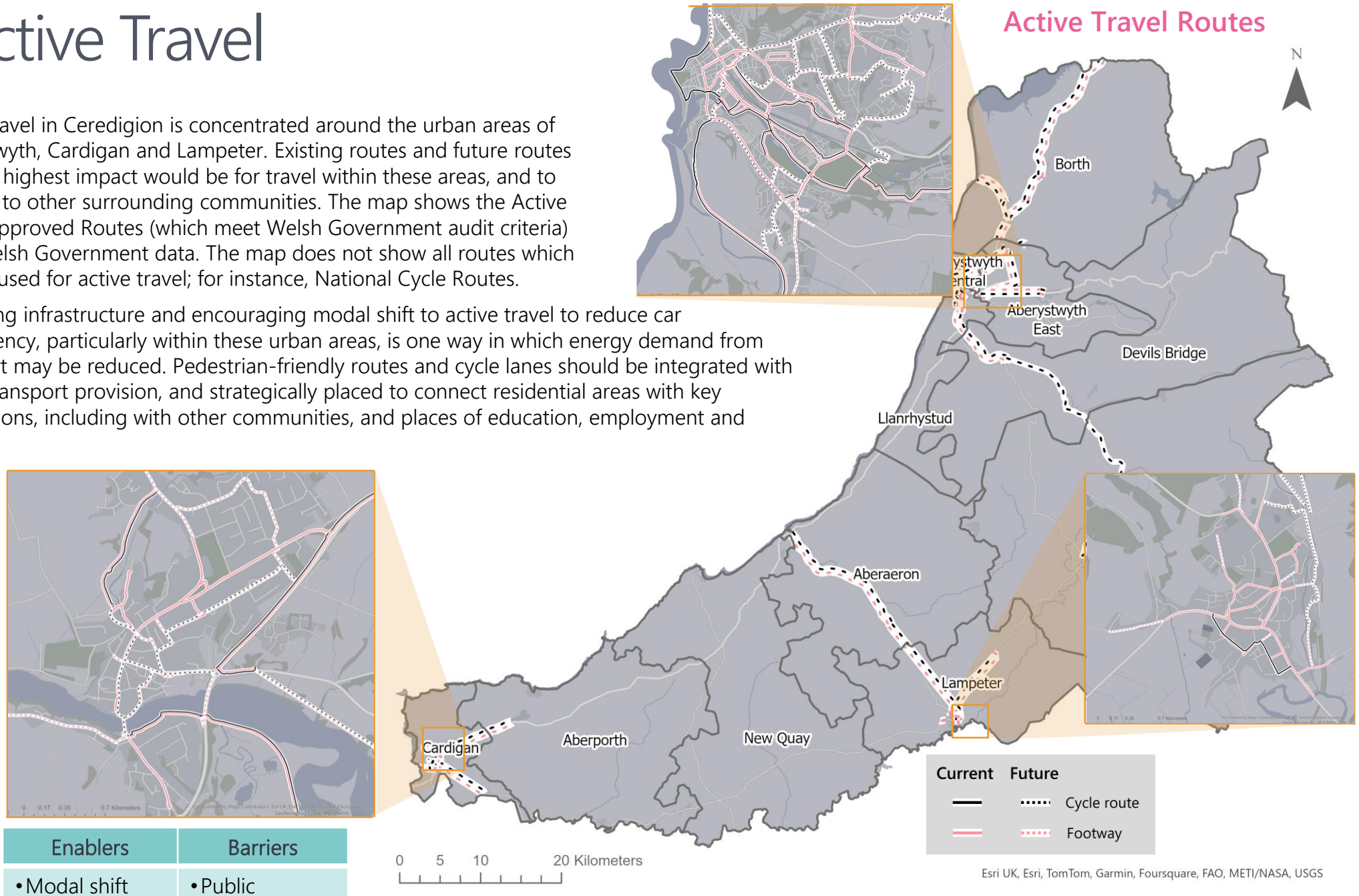
Current fuel demand	Demand for converted buses	
Current bus fuel demand (GWh)*	Electricity demand (GWh) (fully electrified bus future)	Hydrogen demand (GWh) (Hydrogen Fuel Cell bus future)
24	7	14

Public transport planning should consider integration with other modes of transport, considering links between active travel routes and rail and bus services, as part of full transport planning study beyond of the scope of this LAEP.

Active Travel

Active travel in Ceredigion is concentrated around the urban areas of Aberystwyth, Cardigan and Lampeter. Existing routes and future routes with the highest impact would be for travel within these areas, and to connect to other surrounding communities. The map shows the Active Travel Approved Routes (which meet Welsh Government audit criteria) from Welsh Government data. The map does not show all routes which may be used for active travel; for instance, National Cycle Routes.

Improving infrastructure and encouraging modal shift to active travel to reduce car dependency, particularly within these urban areas, is one way in which energy demand from transport may be reduced. Pedestrian-friendly routes and cycle lanes should be integrated with public transport provision, and strategically placed to connect residential areas with key destinations, including with other communities, and places of education, employment and leisure.



Public Transport and Active Travel

Enablers	Barriers
• Modal shift • Reduce car ownership	• Public attitudes

https://datamap.gov.wales/layers/inspire-wg:activetravel_routesection_approvedroutes

Active Travel Routes

Aberystwyth current and future travel routes

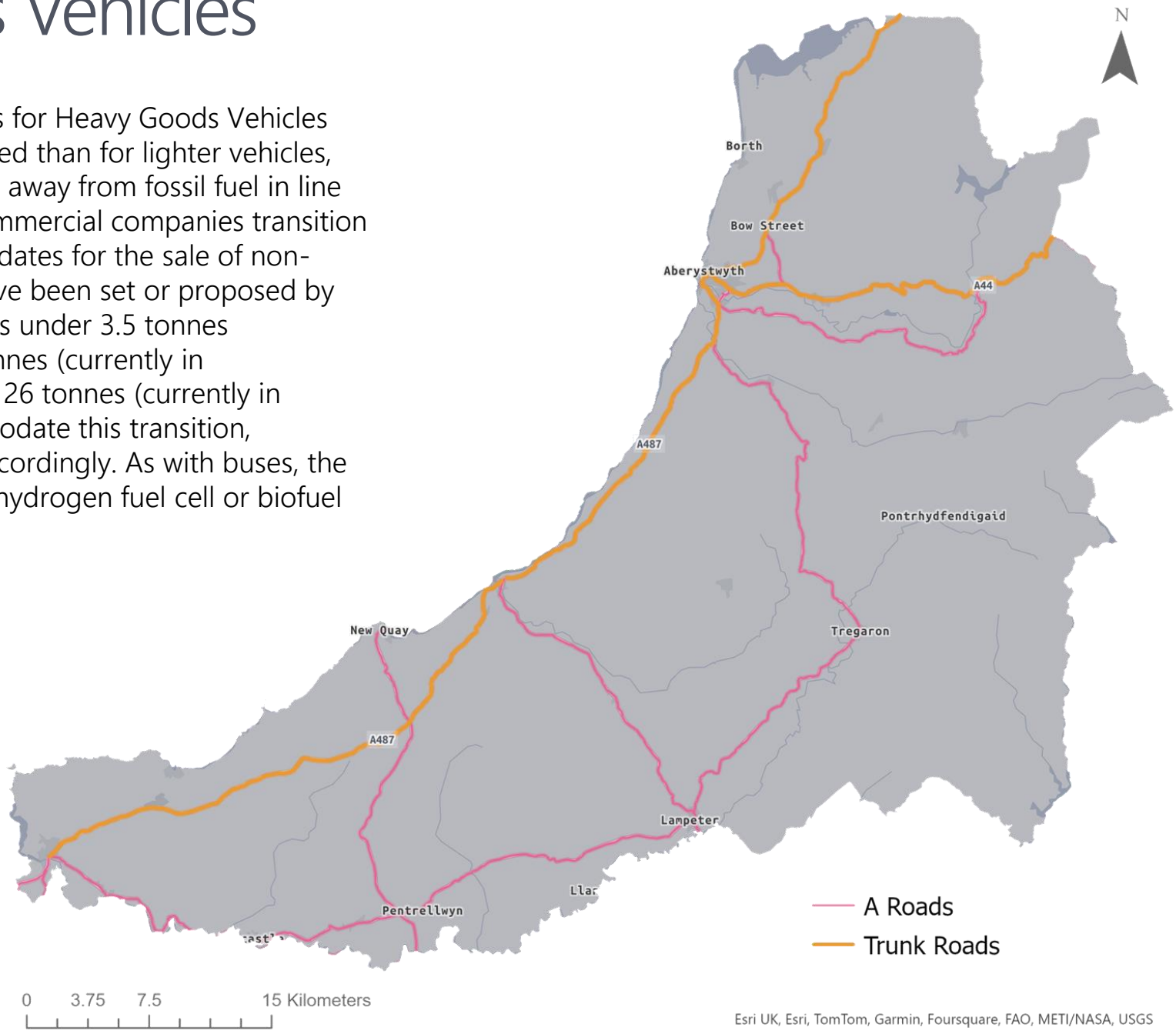
Lampeter current and future travel routes

Cardigan current and future travel routes

https://datamap.gov.wales/layers/inspire-wg:activetravel_routesection_approvedroutes

Heavy Goods Vehicles

While the decarbonisation options for Heavy Goods Vehicles (HGVs) are currently less established than for lighter vehicles, these vehicles will be transitioning away from fossil fuel in line with the rest of the UK, and as commercial companies transition their operations to Net Zero. End dates for the sale of non-zero-emissions goods vehicles have been set or proposed by UK Government*: 2030 for vehicles under 3.5 tonnes (confirmed), 2035 for 3.5 to 26 tonnes (currently in consultation), and 2040 for above 26 tonnes (currently in consultation). In order to accommodate this transition, infrastructure must be planned accordingly. As with buses, the main options are battery electric, hydrogen fuel cell or biofuel vehicles.



* https://assets.publishing.service.gov.uk/media/610d63ffe90e0706d92fa282/decarbonising-transport-a-better-greener-britain.pdf

Heavy Goods Vehicles

The table below shows the estimated current demand for HGVs in Ceredigion, and the equivalent demand for electricity or hydrogen, were these vehicles to be decarbonised via either method. This is assuming that the mileage of HGVs remains constant. On an energy input basis, the electricity and hydrogen demands are lower than the current (likely majority Diesel fuel) demand due to the differing efficiencies of the drivetrains.

Current fuel demand	Demand for converted HGVs	
Current HGV fuel demand (GWh)**	**Electricity demand (GWh) (fully electrified HGV future)**	**Hydrogen demand (GWh) (Hydrogen Fuel Cell HGV future)**
66	21	40

Ceredigion does not have large industrial clusters attracting high volumes of HGVs to singular locations. As such, charging or refuelling infrastructure may need to be focused on common stopping points (e.g. retail and distribution centres) and/or distributed along common routes. The map shows Ceredigion's A roads and trunk roads, where HGV volume is expected to be greatest, and where infrastructure may be most useful. However, a more detailed HGV decarbonisation strategy would be required to explore this in more detail, considering the volume of HGVs along each route. The decision to develop hydrogen refuelling infrastructure would be made at a national level.

** Based on analysis of sub-national road transport fuel consumption statistics. Data is available from: https://www.gov.uk/government/collections/road-transport-consumption-at-regional-and-local-level

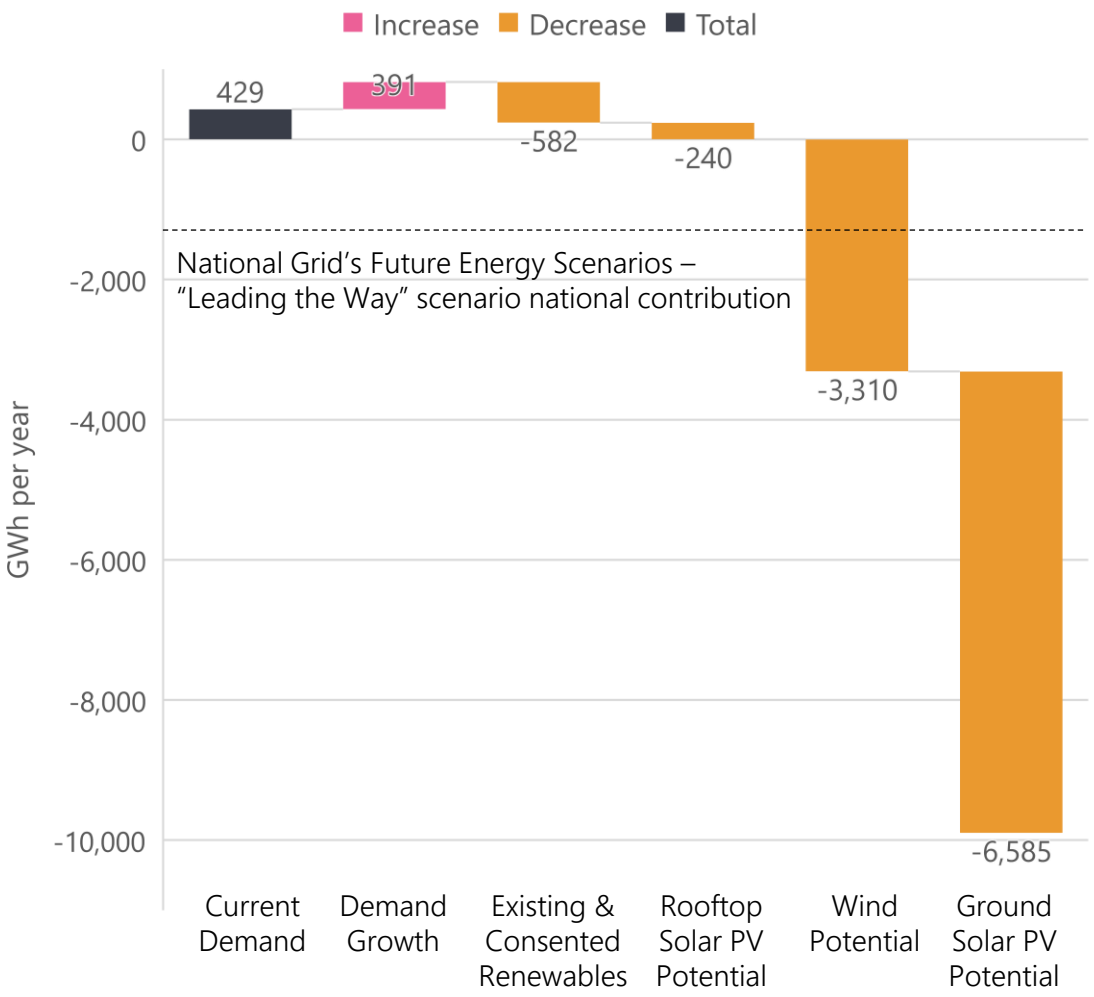
The Energy System Transition: Renewable Generation

Local Renewable Generation

Ceredigion's annual electricity demand would increase by 91% by 2050 with the electrification of heating and transport described in this plan. This demand can be met locally by existing and consented large-scale renewables, plus the additional rooftop solar PV detailed on following pages. Existing and consented renewables in Ceredigion will contribute 582 GWh per year primarily from wind power (257 GWh), but also hydropower (190 GWh), biomass CHP (60 GWh) and solar farms (47 GWh). The rooftop solar PV potential highlighted in this LAEP could contribute around 240 GWh per year.

Ceredigion could generate more electricity than it uses in the future, as there is significant potential for installing ground-mount solar and onshore wind. The amount of renewable capacity required to make a proportional contribution to national decarbonisation (see discussion on following pages) could easily be met by developing only a fraction of Ceredigion's resource. This would require an additional 582 GWh of production per year from solar (from 604MW of installed capacity after taking rooftop solar into account) and 855 GWh per year from wind (from 359MW of installed capacity). At this level of deployment, Ceredigion would export around 1,491 GWh of electricity a year. The investment required to develop this capacity would be around £538m between now and 2050, exclusive of network connection costs. This investment could come from a mixture of community energy funding for local ownership, and private investment.

Annual Electricity Demand and Production Potential



Local Renewable Generation

Beyond this national contribution, remaining suitable land would allow a further 6,000 GWh per year of generation from solar, and 2,455 GWh per year from wind. Excess electricity generation could be used to attract businesses into the area or used locally to generate hydrogen. Unlike the transition away from fossil fuels in vehicles and buildings, there is a degree of flexibility around how much renewable generation is developed locally, as the electricity grid is decarbonising at a UK level as well.

If large-scale energy infrastructure was hosted in Ceredigion, local ownership and community benefit schemes would be essential to ensure benefits were retained within the local area. Smart local energy systems are one possibility for capturing benefits locally. The LAEP workshops highlighted that stakeholders wish to prioritise using electricity generation locally in the first instance.

Enablers	Barriers
• Private wire • Smart local energy systems	• Land access • Public attitudes

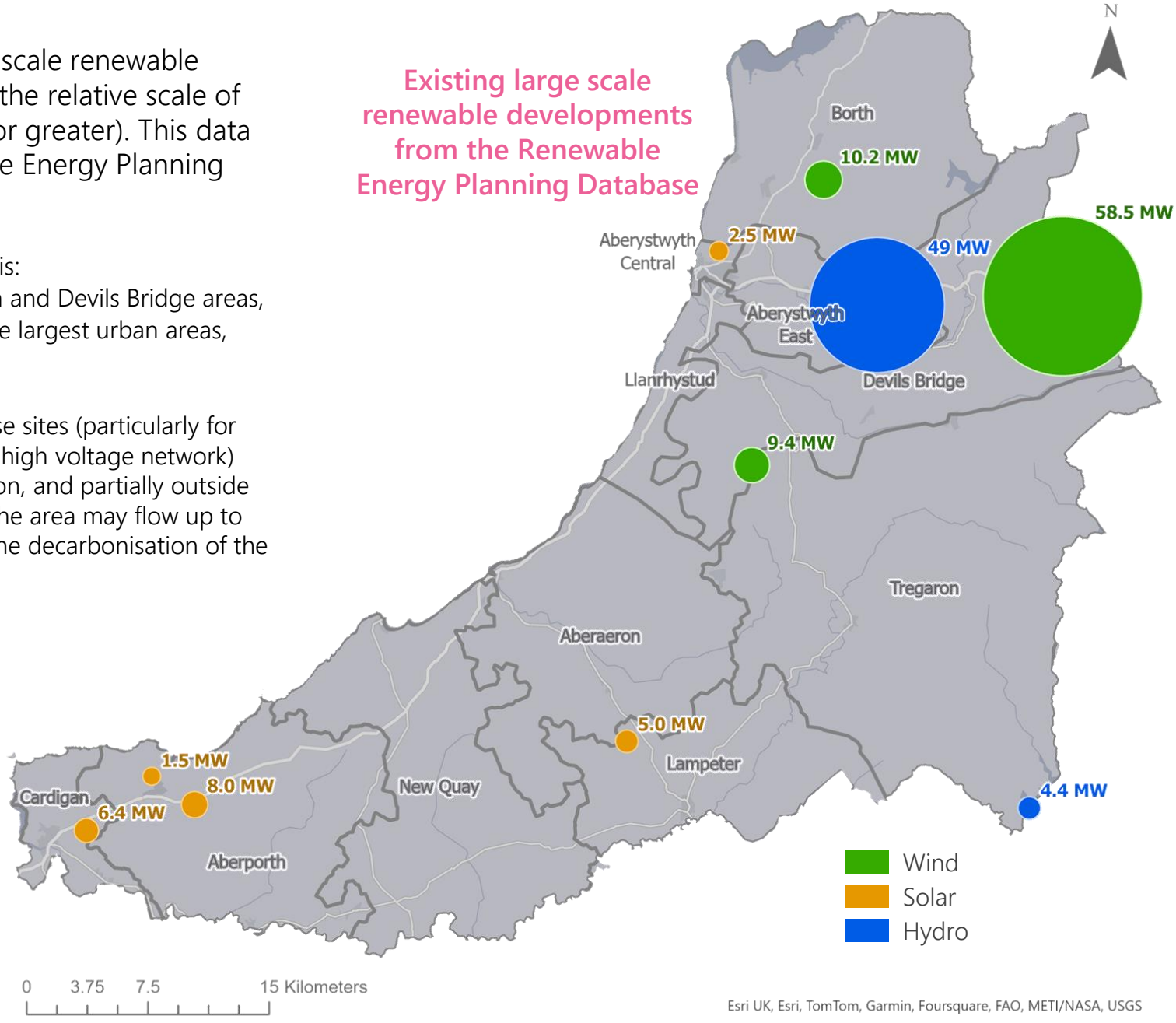
Existing Large-Scale Renewables

Ceredigion has multiple existing large-scale renewable generation sites. The map here shows the relative scale of installed capacity (from sites of 1 MW or greater). This data has been gathered from the Renewable Energy Planning Database.

Of schemes greater than 1MW, in total there is:

- 80.5MW of wind concentrated in the Borth and Devils Bridge areas,
- 23.4MW of solar located in proximity to the largest urban areas,
- and 53.4MW of hydro generation.

The zero-carbon energy generated from these sites (particularly for larger assets which may be connected to the high voltage network) would be consumed partially within Ceredigion, and partially outside of Ceredigion. Energy consumed outside of the area may flow up to the transmission network and contribute to the decarbonisation of the wider electricity grid.



Rooftop Solar Overview

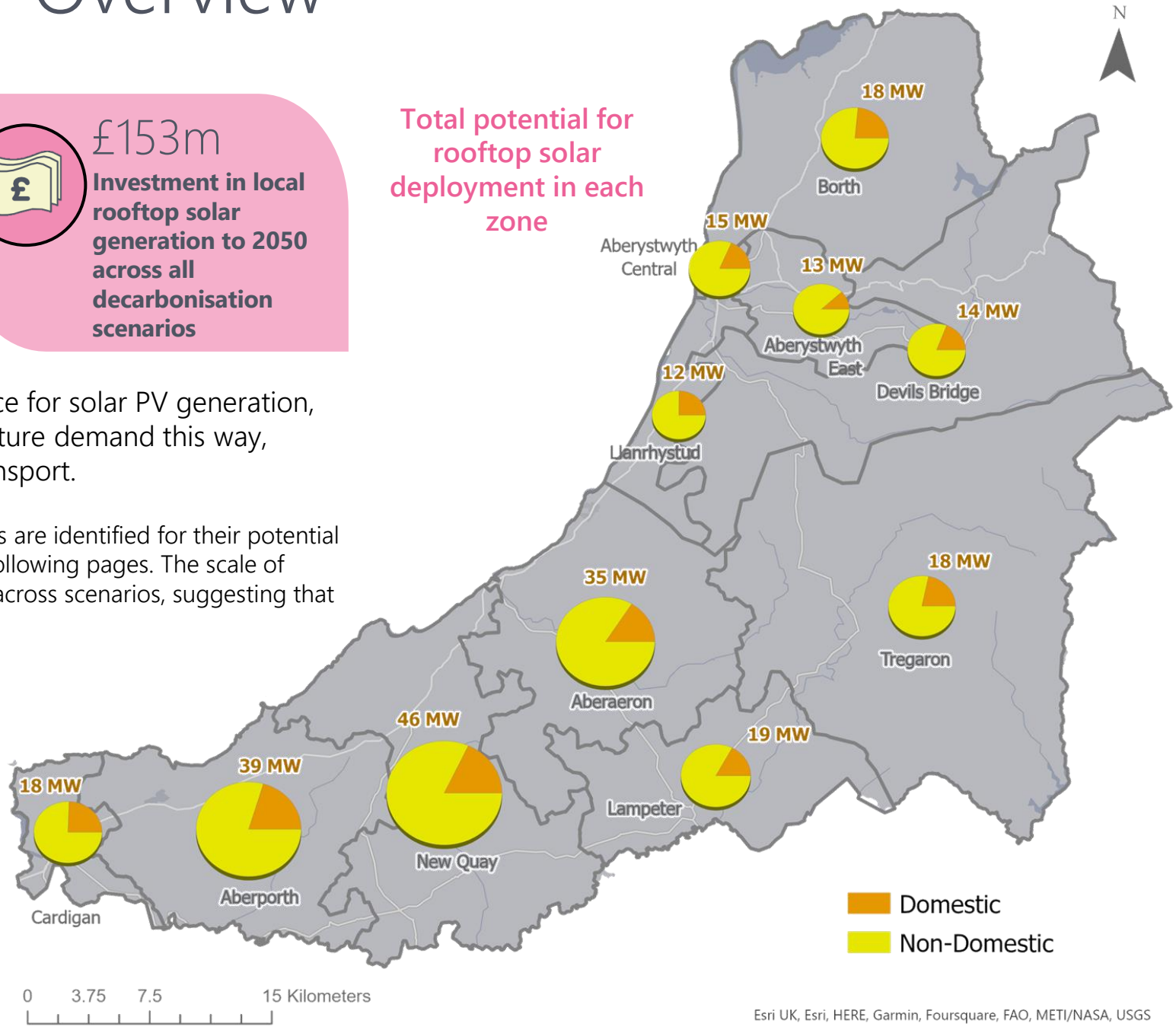
220 MW
of additional rooftop solar generation capacity could be developed

£153m
Investment in local rooftop solar generation to 2050 across all decarbonisation scenarios

By fully utilising all suitable roof space for solar PV generation, Ceredigion could meet 36% of its future demand this way, including electrified heating and transport.

Both domestic and non-domestic buildings are identified for their potential to host rooftop solar PV, detailed on the following pages. The scale of deployment of rooftop solar is consistent across scenarios, suggesting that it's a low regrets action.

To further reduce the spend on imported electricity from the grid, Ceredigion may wish to explore the use of power purchase agreements (PPAs)* and novel approaches such as local market places and peer-to-peer (P2P) networks. These all aim to maximise the consumption of local production within the area.



* For an example of a virtual PPA with large solar developments, see https://www.novartis.com/news/media-releases/novartis-set-achieve-100-renewable-electricity-its-european-operations

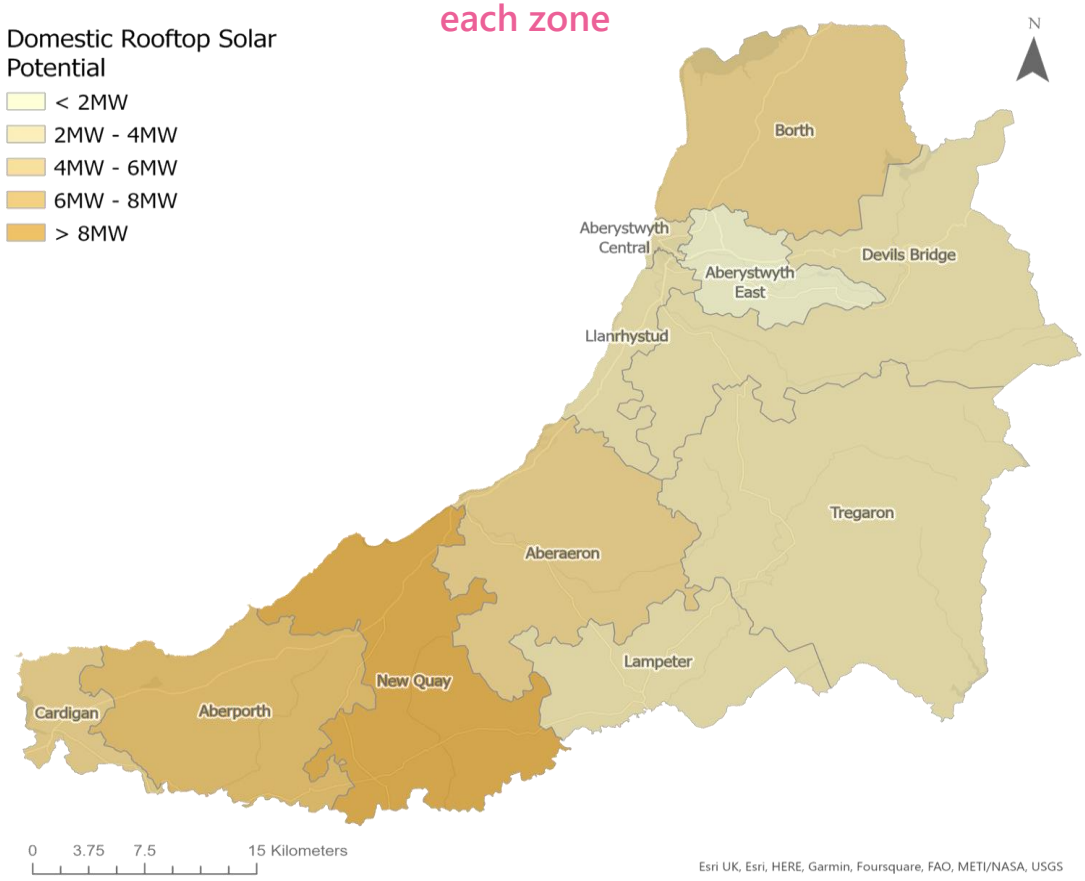
Domestic Solar PV

Although more expensive per unit of energy generated than ground mounted solar, domestic rooftop solar photovoltaics (PV) make use of roof space that would otherwise be unused and can provide direct financial benefits to householders. The recent energy crisis has resulted in rising costs of wholesale energy, which further improves the investment case for rooftop solar. A large rollout of domestic PV is found to be valuable across all scenarios, so is considered low-regret.

Based on roof orientation and pitch, dwellings are identified for solar PV suitability. The pathway sees the roll-out of 40 MW of additional rooftop solar for around 10,250 homes, for a total investment of £41 million, representing a low-regret, cost-effective and realistic deployment scenario. Finance can enable homeowners to make this investment.
Utilising all potential for domestic rooftop solar would contribute 45 GWh per year of electricity (including existing installations).

Social housing could be prioritized for roll-out of domestic PV in Ceredigion. This approach could reduce bills while stimulating the supply chain and skills in the area, preparing them for a larger roll out in private rented and owner-occupied residences. Programs such as group solar buying schemes, which can be initiated by the LA or community energy organisations, can be utilised to develop economies of scale and to reduce costs to residents.

Total potential for domestic rooftop solar deployment in each zone



The New Quay zone has the highest potential for domestic rooftop solar PV

10,250
homes with potential to install rooftop solar PV across Ceredigion

Non-Domestic Solar

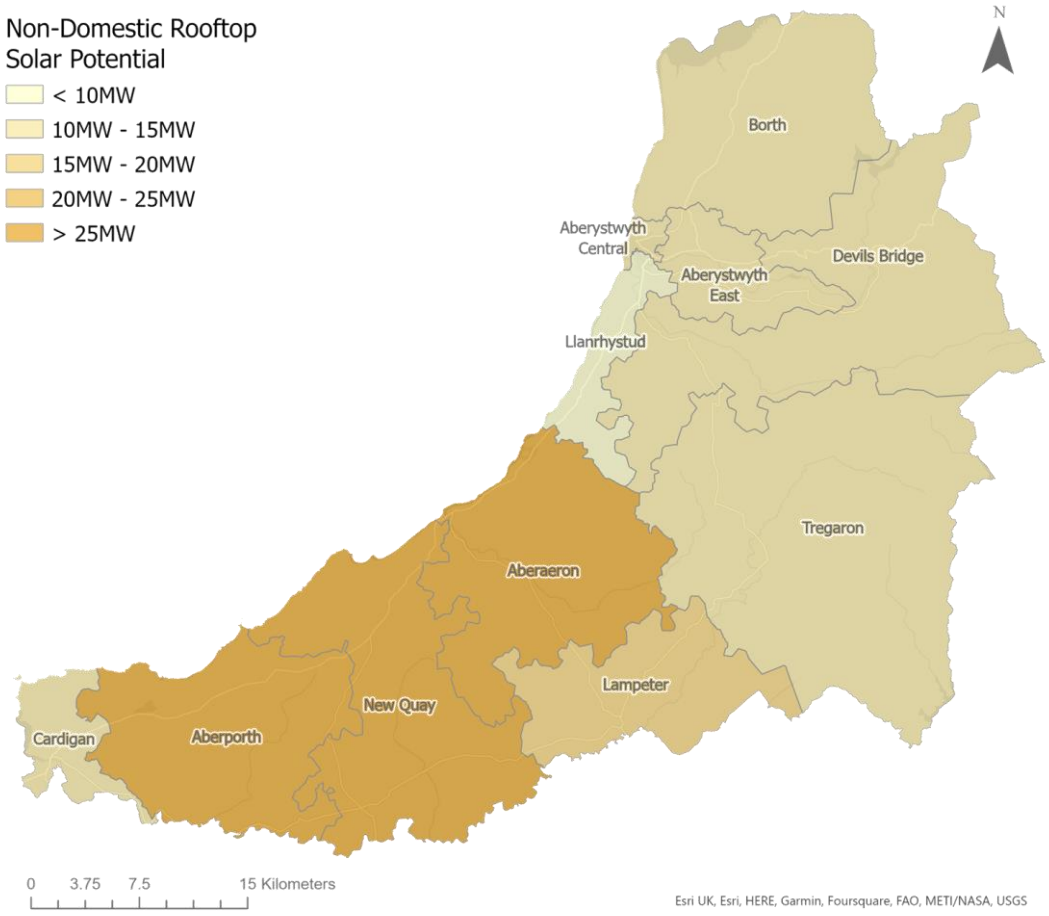
Non-domestic rooftop solar PV installations also contribute to cost-effective decarbonisation plans for Ceredigion, with the full potential utilised across all scenarios. They have the potential to be more cost-effective than domestic solar and can be considered low-regret, although there are some challenges that arise when the building owner is not the bill payer. Non-domestic building construction is more variable than domestic, and it is not possible to say if a building is suitable for PV without a site survey of the roof construction, load bearing capacity and the extent to which other building services such as cooling vents are present.

The map shows the potential capacity for non-domestic solar deployment, based on available roof space and assumptions about the extent to which it could be developed.

With over 22 MW of rooftop solar already deployed on non-domestic sites, there is a potential to develop a further 180 MW of capacity for an investment of £112m. Non-domestic solar in Ceredigion could generate 195 GWh/year (including existing installations).

Given that many of the non-domestic buildings are also in areas with significant potential for onshore wind or ground mounted solar, this is also potential for these buildings to connect to renewable generation sites, through arrangements such as power purchase agreements.

Total potential for non-domestic rooftop solar deployment in each zone



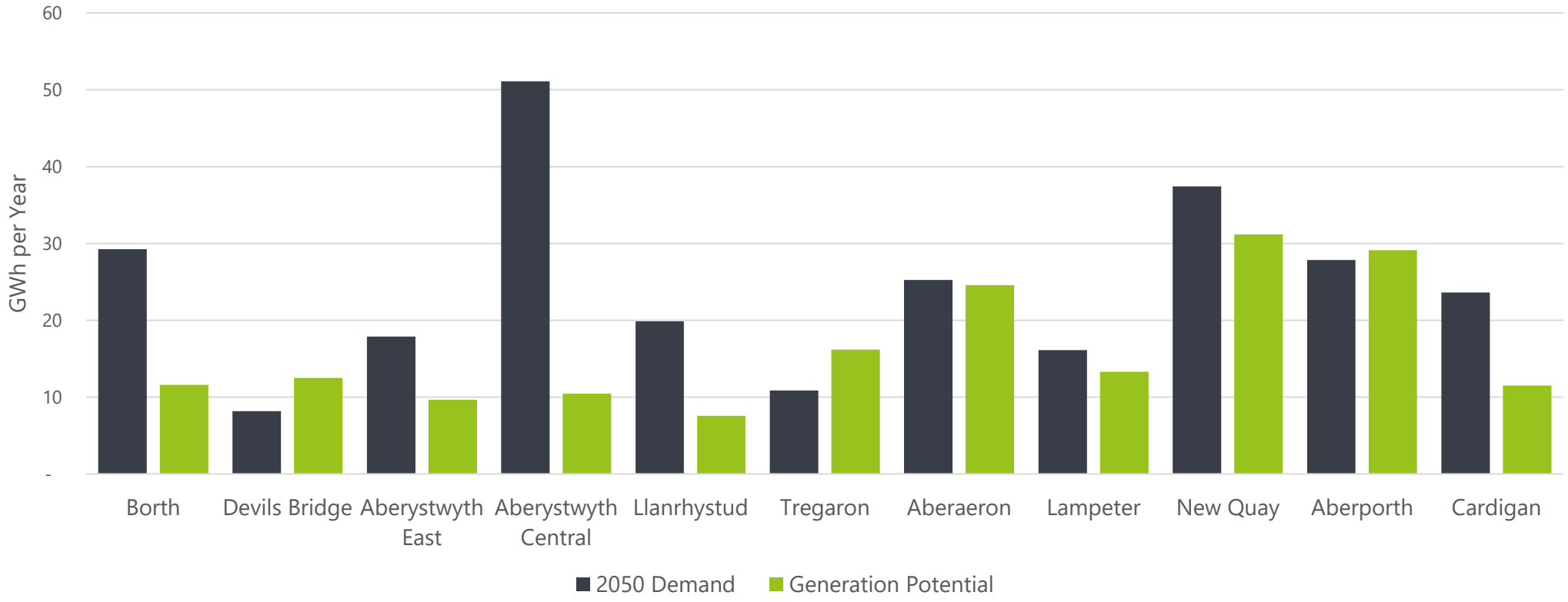
180 MW
Additional non-domestic solar PV potential

The New Quay zone has the highest potential for non-domestic rooftop solar PV

Non-Domestic Solar

Across Ceredigion, around 66% of the net non-domestic electricity demand in 2050 could be met if all potential non-domestic rooftop solar PV is deployed. Localised storage systems could also be deployed to utilise as much of the generation on-site as possible. It should be noted that most generation would be produced in the summer, whereas high heat demands are in the winter.

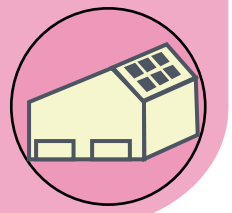
Non-Domestic Electricity Demand by 2050 and Non-Domestic Generation Potential



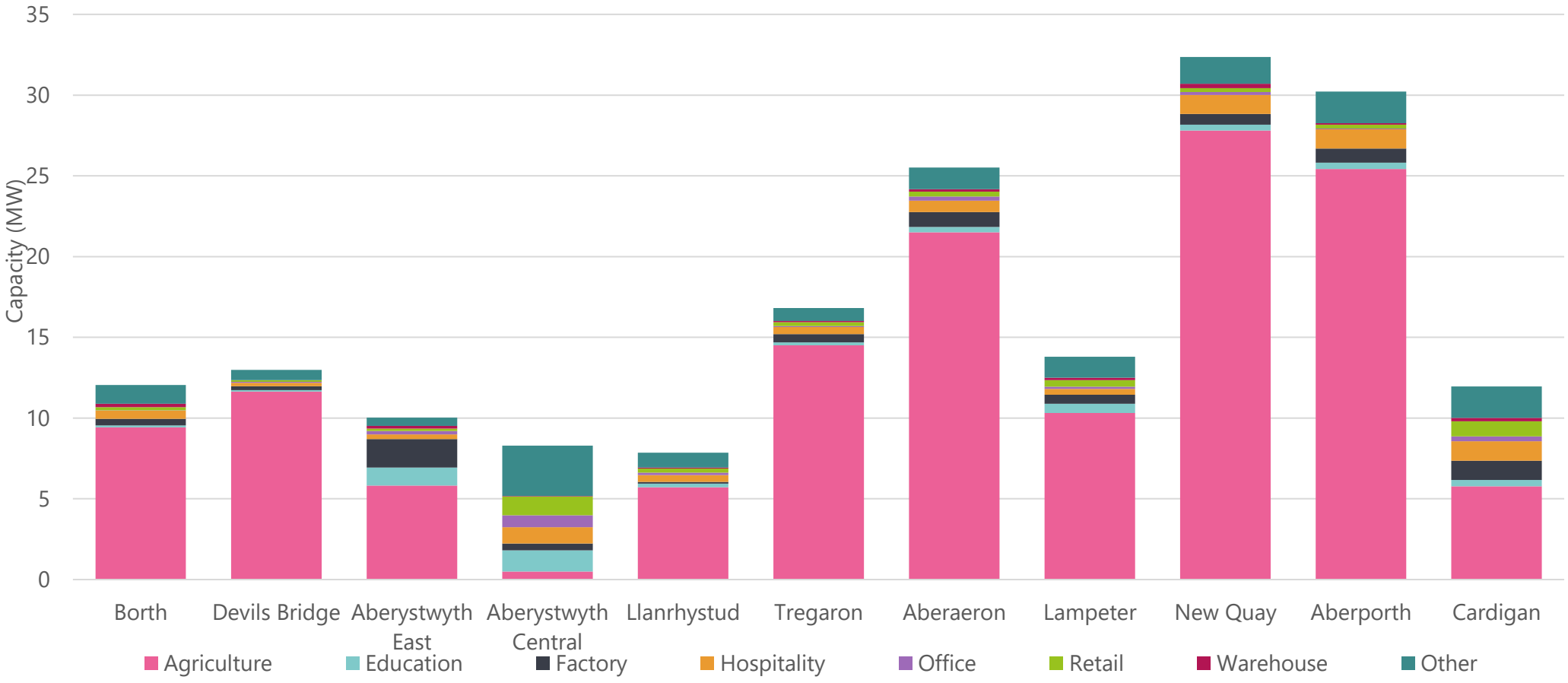
Non-Domestic Solar

The large majority of non-domestic roof space which could be used for solar PV is on agricultural buildings. Some of these buildings may not be connected to the electricity network, so additional costs may be incurred to install PV on some buildings.

66%
non-domestic electricity demand could be met from solar PV on non-domestic roof space



Potential for Rooftop Solar PV on Non-Domestic Buildings



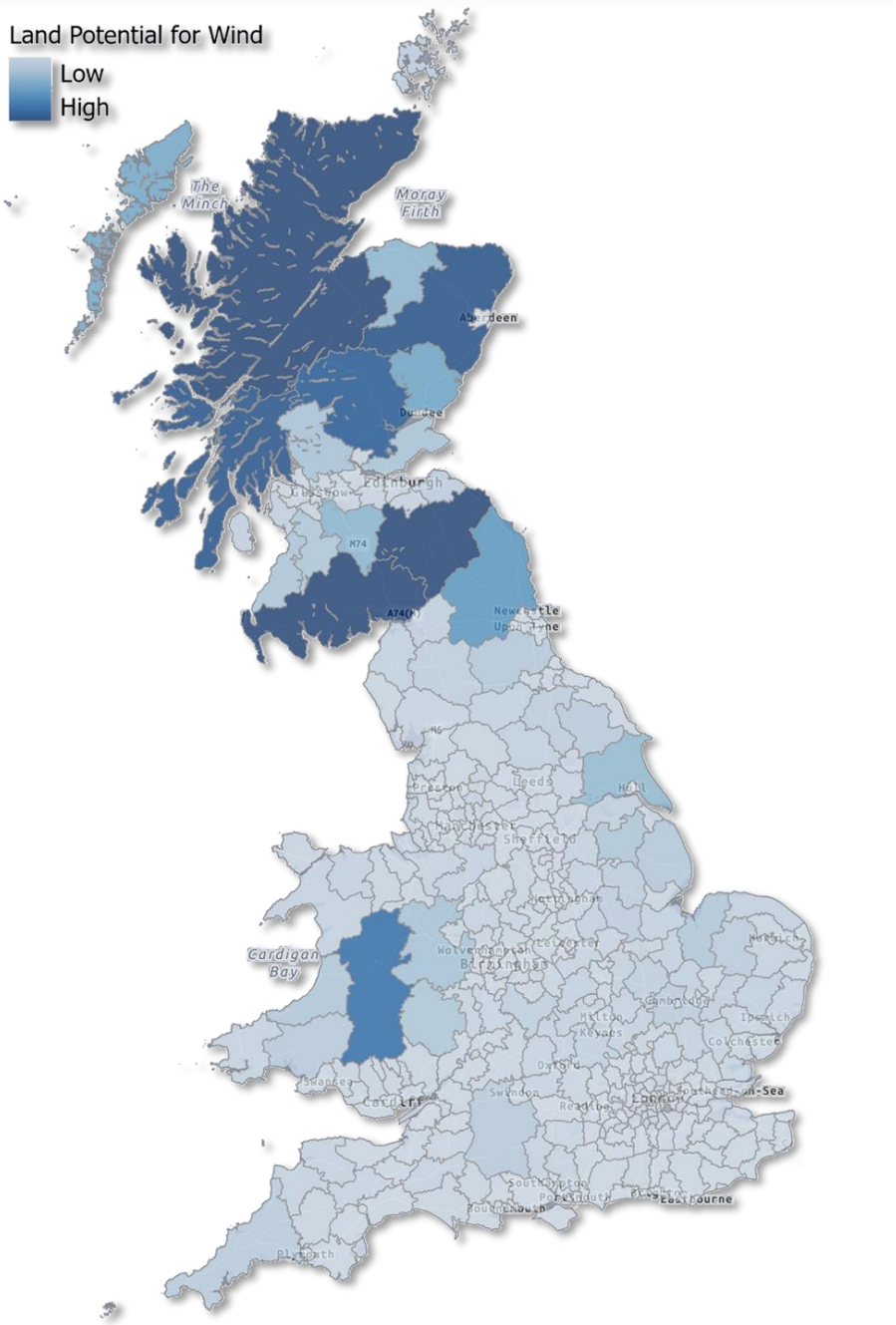
How Much Local Generation is Needed to Reach Net Zero?

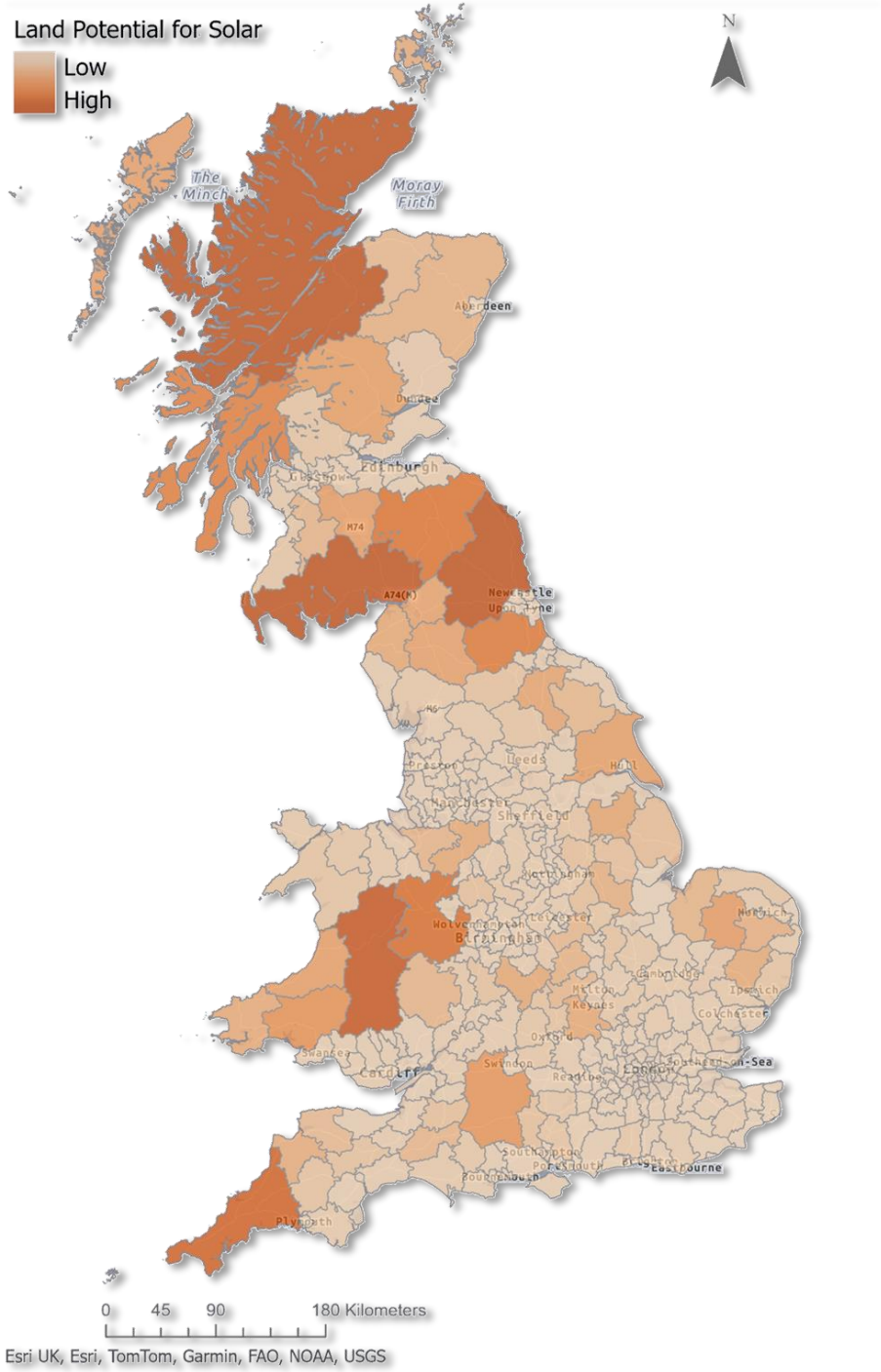
It is estimated that Ceredigion has 1.11% of Great Britain's total land suitable for large-scale ground mount solar based on Energy Systems Catapult's *Net Zero Data*. In National Grid's *Future Energy Scenarios* (FES) "Leading the Way" scenario there is a total of 83 TWh of annual solar generation in 2050. On the basis of Ceredigion providing a share of renewable generation proportional to its share of suitable land, Ceredigion would produce 921 GWh of generation per year. This would require around 1 GW of solar PV capacity, taking approximately 16 km^2 of land. However, the total solar in the FES includes rooftop solar, meaning land can be saved by utilizing rooftops. The potential for expansion of hydroelectricity is very small in comparison to wind and solar

In the FES "Leading the Way" scenario there is a total of 143 TWh of onshore wind generation. In proportion with Ceredigion's estimated 0.78% share of Great Britain's total land suitable for large-scale onshore wind, it could produce 1,112 GWh of generation per year. This would require around 467 MW of wind capacity, taking approximately 34 km2 of land. Electricity network capacity required for large scale renewables has not been costed as part of this LAEP, as it is considered to be national infrastructure.

A mixture of small-scale local ownership and large-scale private investment could deliver this capacity. Local ownership could improve public perception of this development by capturing more of the socioeconomic benefits within the area. Community energy organisations can help to facilitate this local ownership. Many examples of community ownership models can be found in the UK, with residents enjoying income or bill savings from the schemes.

Based on total national installed capacity of renewable generation from National Grid's Future Energy Scenarios 2023, "Leading the Way" scenario





Large-Scale Renewable Land Use

The map on the right shows the amount of land required for both current and future renewables, depending on the scale of future renewables deployed. The circles are to scale, so show the actual area of land which would be needed, with yellow circles for solar and blue for wind.

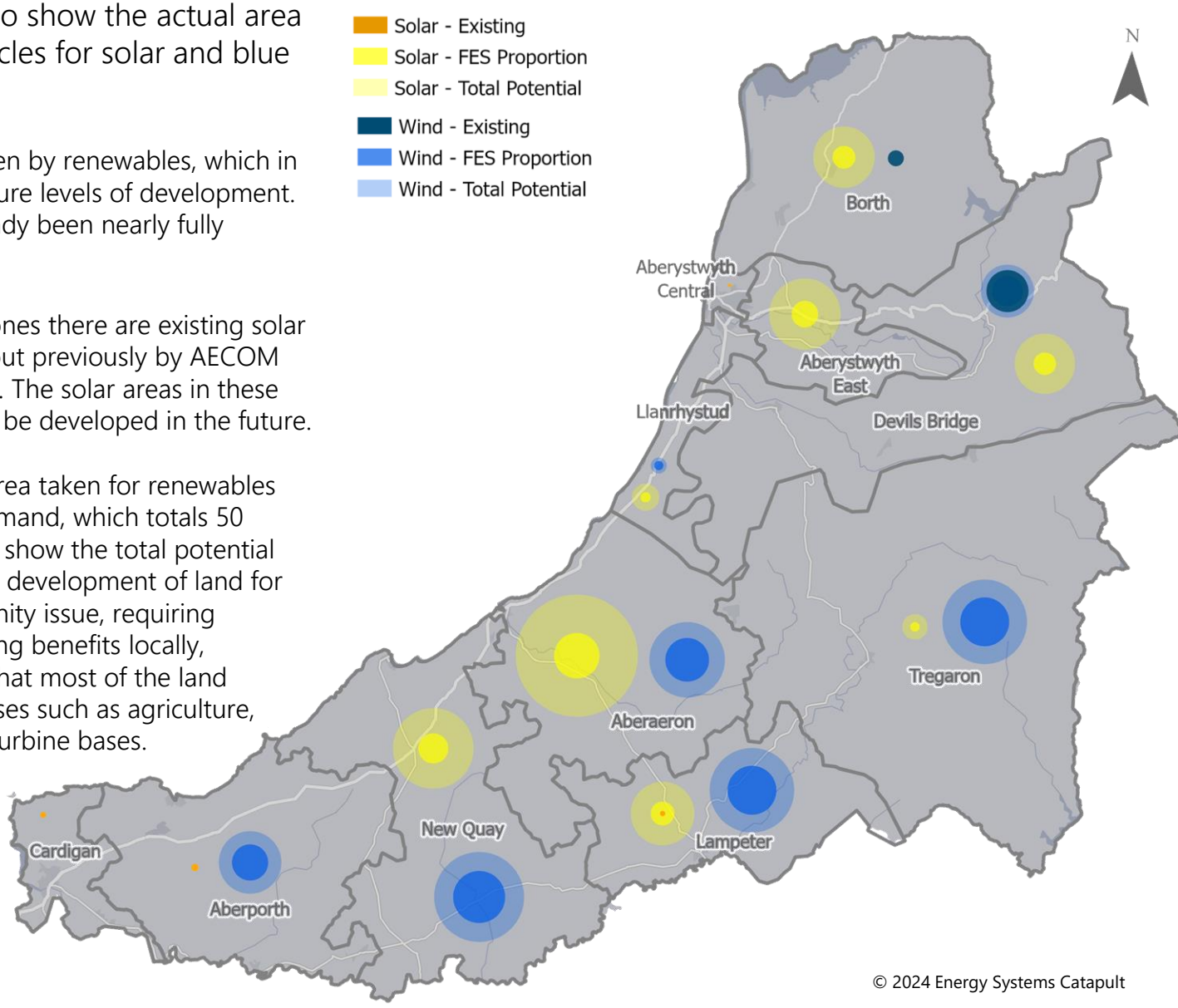
The dark orange and blue areas show existing land taken by renewables, which in most cases is a small amount compared to possible future levels of development. The only area where most of the suitable land has already been nearly fully developed is for wind in the Devils Bridge zone.

In the Aberystwyth Central, Cardigan and Aberporth zones there are existing solar sites, but in the *Renewable Energy Assessment* carried out previously by AECOM (not published), there was no deemed further potential. The solar areas in these zones is very small compared to how much solar could be developed in the future.

The yellow and middle shade of blue circles show the area taken for renewables to meet Ceredigion's proportion of the FES national demand, which totals 50 km^2 of land across Ceredigion. The lighter shade circles show the total potential suitable land, covering around 215km^2. Such large scale development of land for renewable generation will clearly be a sensitive community issue, requiring robust public engagement and an emphasis on capturing benefits locally, including through local ownership. It should be noted that most of the land assigned to wind farms remains usable for other purposes such as agriculture, with only a small fraction of the land area taken up by turbine bases.

Land for solar can be saved by installing solar on rooftops, with an expected 2.8km^2 of rooftop solar space in Ceredigion.

Area of land for renewables



Hydrogen Potential

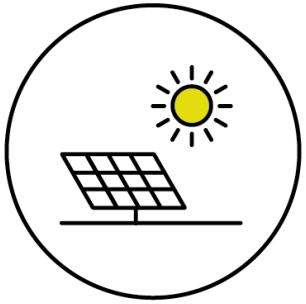
There is significant potential to produce hydrogen from local renewable energy in Ceredigion. After accounting for Ceredigion's own consumption and contribution to national renewable generation, there would still be sufficient suitable land for a further 8,500 GWh per year of generation from wind and solar.

One option for local use of this energy would be for hydrogen electrolysis. Converting the full excess potential discussed above to hydrogen would yield around 6,340 GWh (160,000 tonnes) of hydrogen per year. If hydrogen demand exists with favourable economics, renewable sites may be developed solely to cater for on-site electrolysis, possibly negating the need for a grid connection.

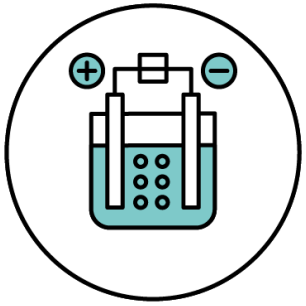
For reference, it is estimated that by converting all buses and HGVs to hydrogen, Ceredigion's hydrogen demand for these vehicles would total 53 GWh per year*. This is based on pre-pandemic demand figures for these vehicles and demonstrates the level of capacity for green hydrogen production to meet local demands.

It should be noted that electrolysis consumes around 9kg of water for each 1kg of hydrogen produced. An estimated 12,000 tonnes of water would be required per year to produce the above 53 GWh. The transportation of the hydrogen will also need to be considered, with options including bottled hydrogen transported by road, or pipeline. Transportation via a converted gas network may be possible, however considering the highly off-gas grid nature of the area, dedicated new infrastructure would likely be required.

This should be considered in balance with the findings of the Mid Wales Hydrogen Study, which highlighted that there is a lack of concentrated demand for hydrogen in the region, therefore producing hydrogen locally in the near-term is unlikely to be commercially viable. Ceredigion can look to other rural hydrogen projects to understand lessons being learnt. Feasibility studies will be required on a project-by-project basis to determine suitable projects in Ceredigion. A starting point would be to explore businesses which have high temperature processes which may not be able to be electrified (see Non-domestic Heating).



8,455 GWh per year "additional potential" renewable generation, leading to:



6,340 GWh per year green hydrogen potential production

53 GWh per year hydrogen demand for zero-carbon HGVs and buses*

* The data source used for the current fossil-fuel consumption of these vehicles are the 2019 values from:
Sub-national road transport fuel consumption statistics, UK Government.
https://assets.publishing.service.gov.uk/media/64988cc69e7a8b0013932b1a/road-transport-fuel-consumption-tables-2005-2021.xlsx

The Energy System Transition: Energy Networks

Network Investment

Analysis shows that with timely upgrades to the distribution network, Ceredigion can meet its expected increase in electricity demand locally to transition to a net zero energy system. The following pages provide detail that will be used by the energy networks to inform their investment decisions to ensure Ceredigion's energy networks are upgraded to ensure the area can achieve its carbon reduction targets.

The cost of this investment, including operational costs, is estimated to be around £215m between now and 2050 in the National Net Zero scenario. These costs do not include the upgrades required for large scale renewable generation, as national infrastructure is out of scope for this LAEP. More detailed modelling of the network will be required by the Distribution Network Operators (DNOs) to understand the full extent of the costs. Both DNOs in Ceredigion – Scottish Power Energy Networks (SPEN) and National Grid Electricity Distribution (NGED) – are proactively investing in their network to support the load growth forecast within their Distribution Future Energy Scenarios (DFES); this LAEP provides additional supporting evidence to justify investment in the distribution network to resolve the network constraints.

Working closely with Welsh Government and Ceredigion County Council, the DNOs are using the DFES to identify how customers will use the network, as well informing NGED's RIIO-ED2 Final Determinations Core Methodology document (a business plan submission to Ofgem). This will help to coordinate the strategic planning of distribution, resolving the challenges of a constrained network.

Work has already begun on the following:

Strategic Network Planning: Strategic planning across Wales benefits DNOs, consumers and the wider energy system using load-related investment, allowing for quicker connects and a more coordinated development of the network.

Resolving Constraints: Assessing the suitability of flexible solutions, including reinforcement, to manage constraints across the network.

Short to medium-term upgrades of distribution network: As of April 2023, the DNOs are able to make strategic investments if sufficient evidence is provided.

Quicker connections: Removed the need for permissions from the DNO to connect low-carbon technologies such as heat pumps and EV charge points. Wait times are reduced for low voltage network assessments, allowing for an increase in customers connecting to the network.

The connection of large scale renewable energy to the transmission network may take longer due to more significant upgrade requirements. While national infrastructure is out of scope for a LAEP, further energy system planning work will be required that considers Ceredigion's relationship with the wider energy system, both regionally (Wales) and nationally (UK).

Network Investment

With considerable change on the horizon, it will be essential for Welsh Government, Growing Mid Wales, Ceredigion County Council and the energy networks to work together closely. The approaches to strategic regional and national energy system planning are currently being refined. The Energy Act 2023 legislated the creation of the Future System Operator who will be responsible for the strategic planning of both electricity and gas networks. The FSO will be creating Regional Energy Strategic Planners who will work with organisations at a local level to improve understanding of the infrastructure needed in different parts of the country and attract investment for projects.

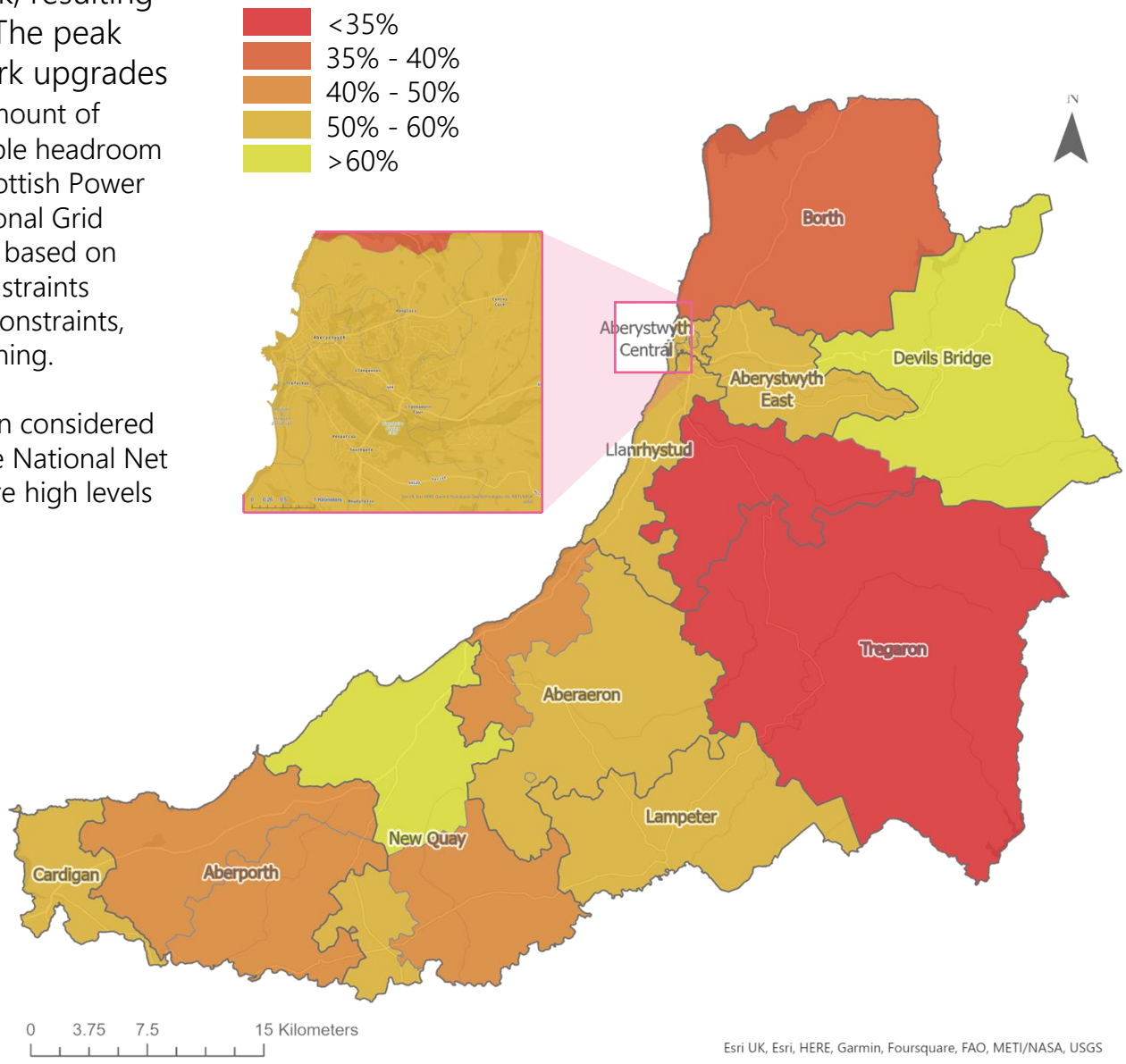
Enablers	Barriers
• Collaboration • Smart local energy systems	• Public attitudes • Uncertainty

Primary Substation Network Upgrades

The electrification of heating and transport described in this plan places an increased demand on the electricity network, resulting in a requirement for investment in network capacity. The peak electricity demands directly impact the level of network upgrades required. However, the level of upgrade also relates to the amount of available capacity, with the map on the left showing the available headroom at each primary substation. This data has been provided by Scottish Power Energy Networks for the northern part of Ceredigion and National Grid Electricity Distribution for the southern. These assessments are based on thermal capacity of substations; this does not consider any constraints relating to statutory voltage limits, fault levels or wider circuit constraints, which would be identified by the DNOs' detailed network planning.

The amount of headroom and present day demands have been considered against percentage increases in peak electricity demands in the National Net Zero and High Peak scenarios to highlight areas likely to require high levels of network upgrades. This is shown in the map on the right.

Current Primary Substation Headroom %

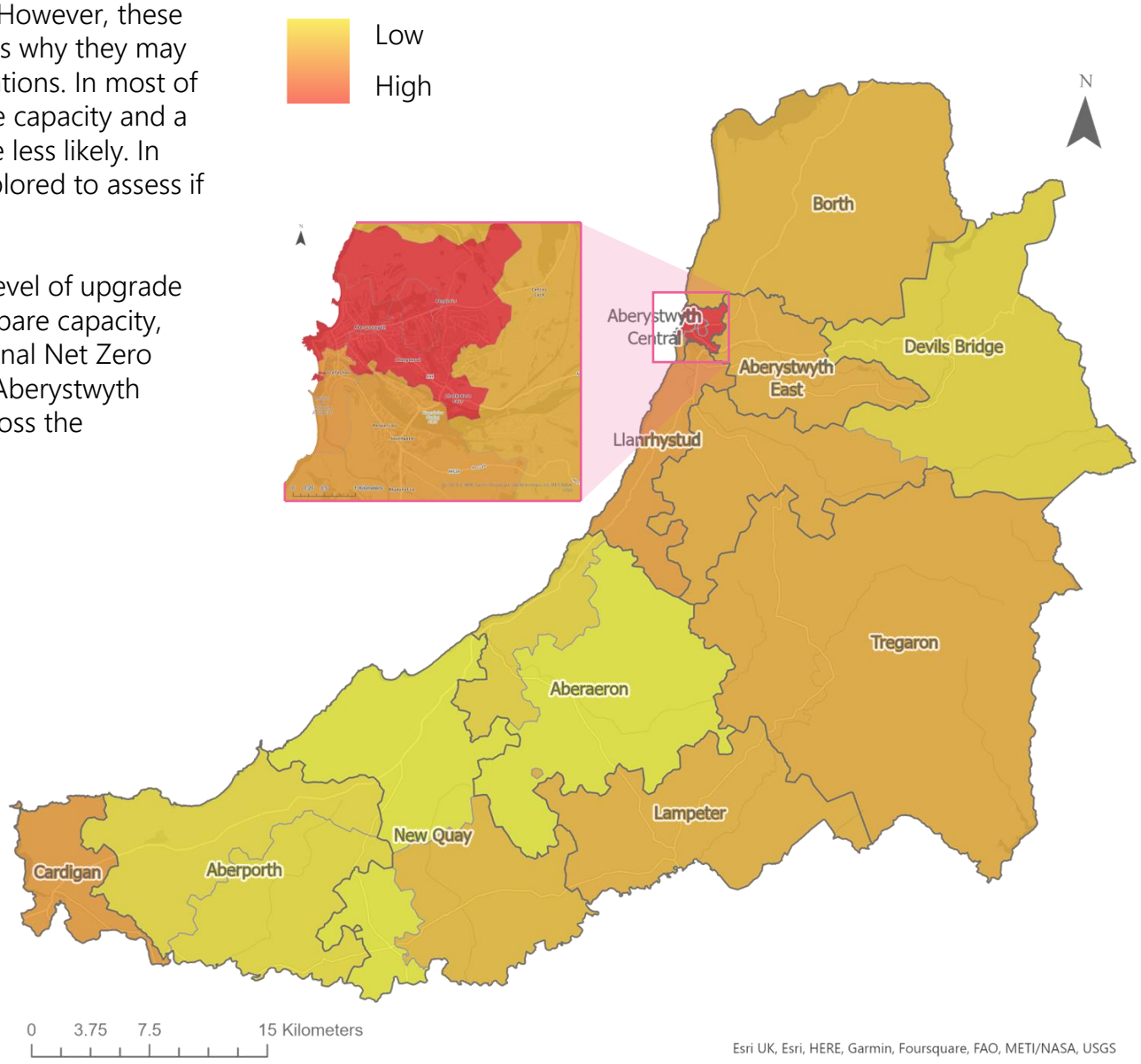


Primary Substation Network Upgrades

The primary substations in the Tregaron zone and the western portion of the Devils Bridge zone have a low level of spare capacity. However, these areas see a relatively low increase in peak demand which is why they may not require as extensive upgrades as other primary substations. In most of the southern rural areas of Ceredigion there is some spare capacity and a low level of peak demand increase, meaning upgrades are less likely. In these areas solutions at the low voltage level could be explored to assess if upgrades could be deferred through flexibility.

The primary substations expected to require the highest level of upgrade are for Aberystwyth. While these substations have some spare capacity, there is a significant increase in peak demand in the National Net Zero scenario, likely requiring high levels of upgrade (with the Aberystwyth Central zone getting upgrades in the region of 20MW across the substations in the High Peak sensitivity) .

Primary Substation Potential Level of Upgrade Required by 2050



Secondary Substation Upgrades

The low voltage network consists of smaller neighborhood substations, supplying feeders which run under pavements or roads to each building or on overhead wires in rural areas.

Generally, in the more rural areas of Ceredigion the peak increase is low at each secondary substation. This is due to a lower number of buildings connected to each substation. However, because of this the existing capacities are low, and with fewer consumers connected to each substation, it is more likely demands will occur simultaneously (lower diversity effect). Therefore, these rural secondary substations may need upgrading in the short term, but by lower amounts than in more urban areas.

The largest increases in demand at individual secondary substations are in the main towns in Ceredigion. Examples are shown below for Aberystwyth (left) and Cardigan (right).

In the daytime in Aberystwyth (mid left figure) the highest peak increases are primarily in areas with a high density of non-domestic buildings. The campus of Aberystwyth University is expected to have a significant increase in demand in the National Net Zero scenario as it fully electrifies. In the evening peak (far left) the areas with the highest demand are in more residential areas, with a high demand increase at the student accommodation by the University.

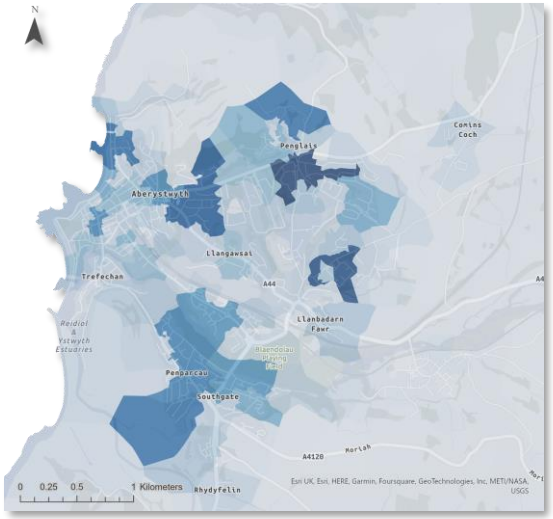
In the daytime peak in Cardigan (far right) the main areas of peak increase are around the cafes and shops by the river, Cardigan Health Centre and Teifi Leisure Centre. Then in the evening the largest increases are again in the dense part of the town by the river, but also in the more residential parts to the north.

These areas of high peak increases are likely to be areas requiring substation upgrades. In addition to substations requiring enhancement, the associated feeders are likely to need upgrading.

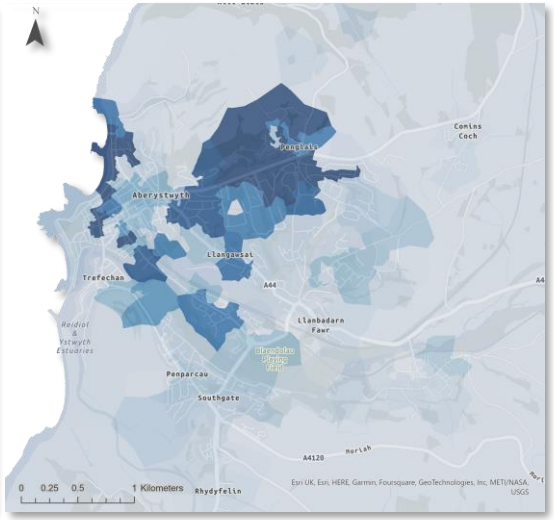
Low
High

Peak Electricity Demand Increase by 2050

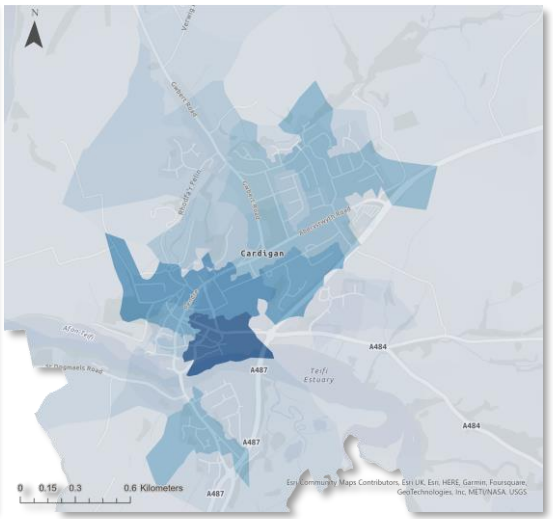
Aberystwyth Evening



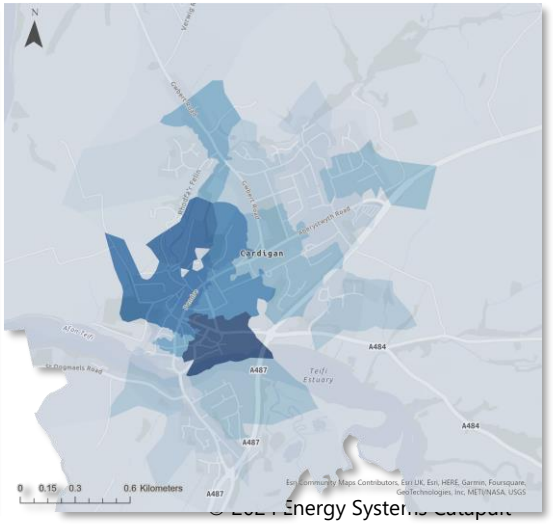
Aberystwyth Daytime



Cardigan Evening



Cardigan Daytime



Flexibility

Innovations in flexibility have the potential to delay and reduce the scale of electricity network reinforcement required by shifting peak demands to periods of lower demand. These flexibility solutions could take a variety of forms and can be small or large scale. They may form part of a smart local energy system, where elements of local generation, flexibility and storage, and electrified demand are coordinated.

In some cases, through flexibility more low carbon technologies could be installed earlier in areas where network upgrades are likely to take many years, or network upgrades could be postponed. This could help Ceredigion meet the challenging near-term emission targets. An example of where this could be relevant is Llanilar in the Devils Bridge zone. This village is served by a primary substation with little headroom, but also low levels of peak demand. Therefore, in the short term flexibility could help reduce the need to upgrade the substation, allowing more heat pump and EV uptake.

Flexibility

Llanilar is shown on the map, with properties expected to be suitable for rooftop PV highlighted in orange and areas with the potential to accommodate off-street parking* shown in green. There is a lot of potential for rooftop PV which could be used to charge electric vehicles and to store hot water during the day as part of a smart local energy system. This can help avoid using grid capacity during peak times. Additionally with a home battery further flexibility can be provided, allowing stored electricity to be used in peak times. With improvements to EV charging technology such as vehicle-to-grid (V2G) it could be possible in the future to use the car as a battery and draw electricity from it on demand.

However, during the winter peak there may not be much sunlight, so the yield from the rooftop PV may be low. Therefore, other solutions may be needed to avoid large demand increases. Batteries or V2G can still help with this, as electricity could be stored outside of peak times and then used when needed. Additionally, heat pumps could store water and EVs can charge outside of the peak.

These solutions are not limited to locations like Llanilar and could be used anywhere in Ceredigion. The Tregaron zone is another example of an area where flexibility could help overcome network constraints. NGED is currently procuring for seven low voltage flexibility zones across Ceredigion.

To make flexibility solutions appealing, there may need to be interventions like price incentives to make it cost effective to store electricity rather than relying on the grid. There would need to be a balance between costs of batteries and the cost to reinforce the network in these areas.

Small scale batteries are not the only solutions to flexibility, with large scale batteries being a possibility at some substations to balance supply at times of low generation. Additionally, if hydrogen were being produced within Ceredigion, then some could be stored and used to generate electricity at times of low renewable generation.

*Note: these possible areas for off-street parking just show potential based on the area of land available between a property and the road, and do not take into account what is currently on the land

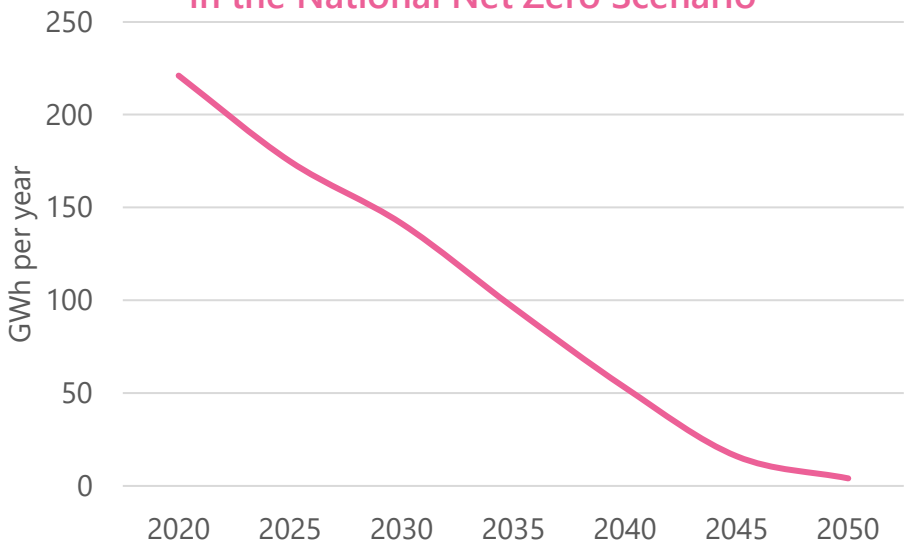
Gas Network

The gas network in Ceredigion is operated under license by Wales & West Utilities and currently supplies fossil gas to around a quarter of homes in the area (just over 10,000). The map illustrates the extent of the existing network according to the classifications of pipeline.

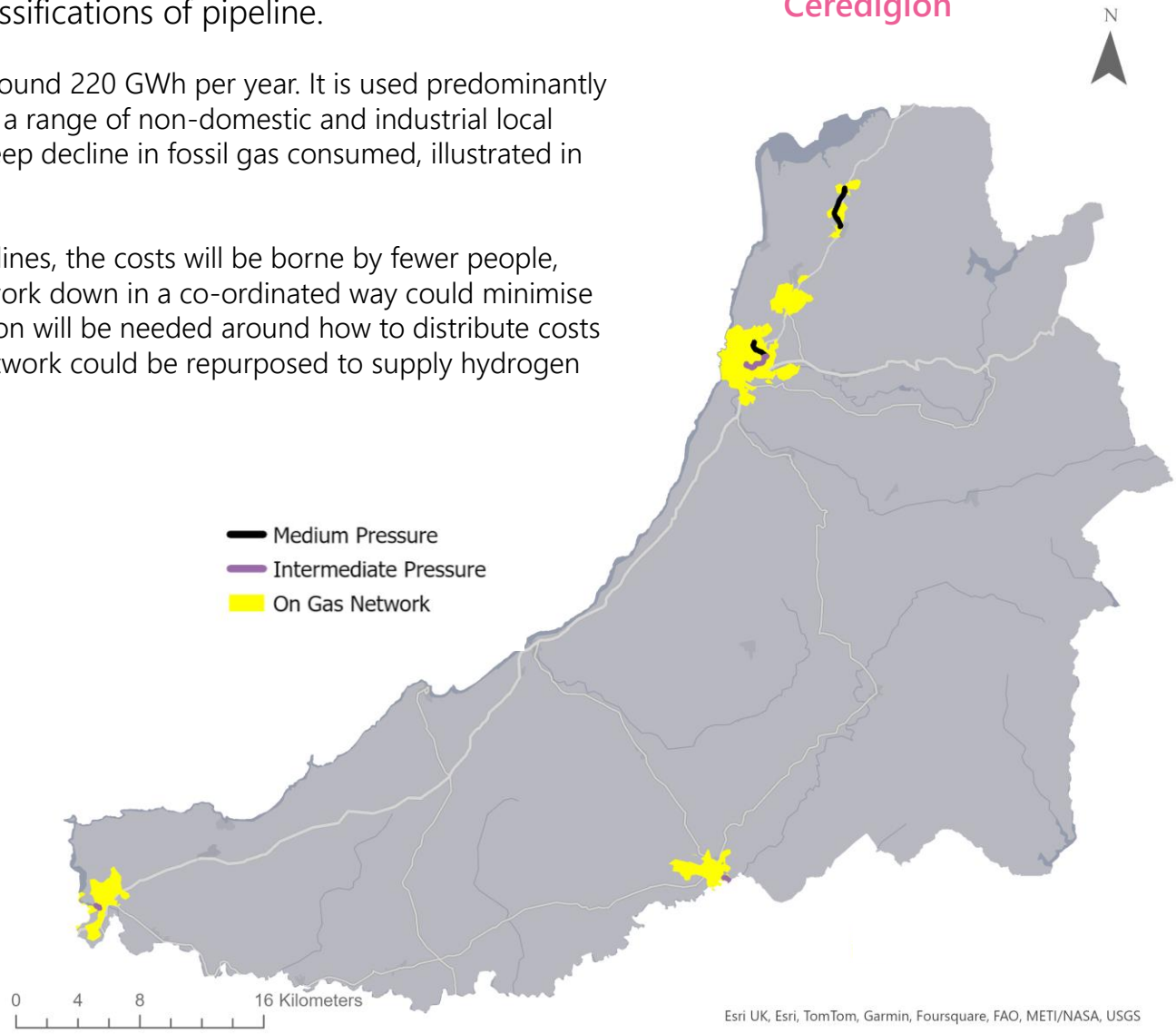
The current total fossil gas consumption across Ceredigion is around 220 GWh per year. It is used predominantly for domestic heating, hot water and cooking, but also supports a range of non-domestic and industrial local energy demands. Meeting the Net Zero goal would mean a steep decline in fossil gas consumed, illustrated in the graph below (based on the National Net Zero scenario).

As the number of customers connected to the gas network declines, the costs will be borne by fewer people, which could lead to increases in bills. Shutting areas of the network down in a co-ordinated way could minimise the overall costs that customers are faced with, and consideration will be needed around how to distribute costs with a shrinking customer base. Meanwhile, parts of the gas network could be repurposed to supply hydrogen around industrial areas.

Change in Fossil Gas Annual Demand in the National Net Zero Scenario

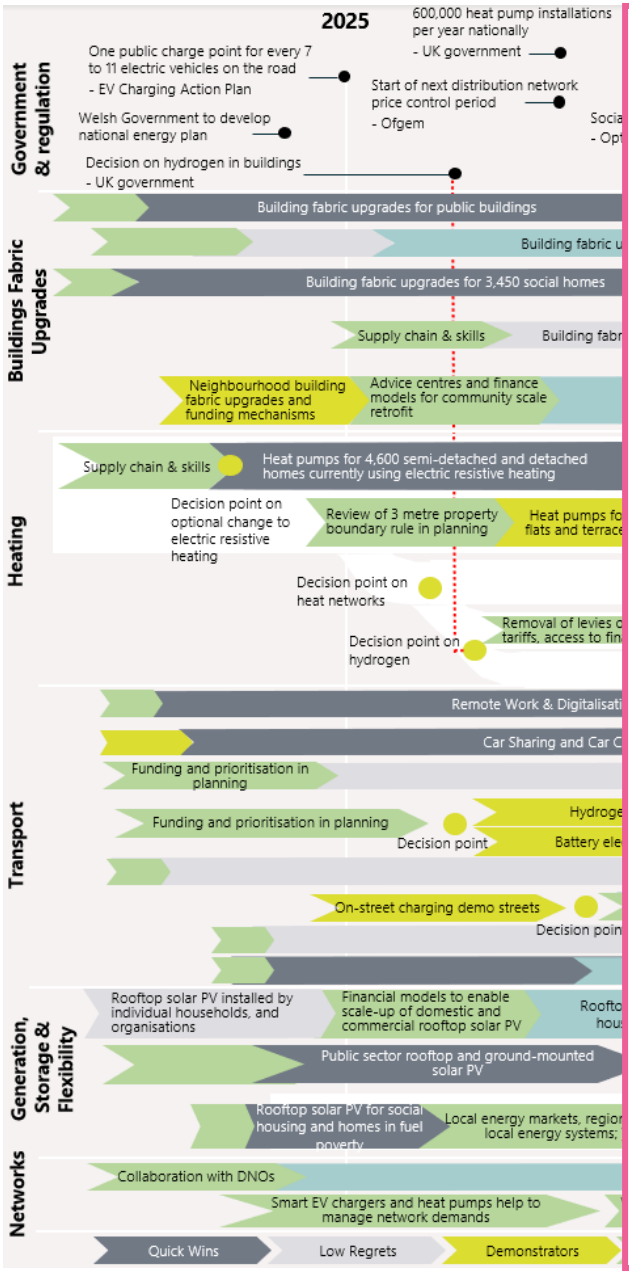


Map of the gas network in Ceredigion



Implementation:
Priority Projects

First Five Years



The first five years of the implementation process contains near-term components including quick wins, low regrets, enabling actions and some demonstrator projects.

Aligning these components with characteristics of the area such as network capacity with potential constraints, specific areas are highlighted as priority projects as listed below:

- Aberystwyth, Cardigan and Lampeter: retrofit packages for social housing
- Aberystwyth Central, Llanrhystud and Aberporth zones: retrofit packages for homes in fuel poverty
- Aberystwyth: district heat network
- Aberystwyth and Cardigan: shared ambient loop demonstrator for terraces
- New Quay zone: heat pumps for rural owner occupier homes and non-domestic buildings
- South Aberystwyth and Cardigan: public EV charge points
- Tregaron zone: smart local energy system demonstrator

The purpose of identifying specific outline priority projects is to provide stakeholders with projects that can immediately be implemented to make progress towards Net Zero. The following section specifies details of these near-term projects, including details such as locations and financial information. Energy Systems Catapult's "Net Zero Go" platform provides resources to help local authorities design and develop energy projects.

Project Implementation Workflow

This provides a conceptual framework on how projects could be taken forward (working on the basis that projects are progressed by the council); either for the identified projects, or for any other projects, recognising that delivering Net Zero will require progression of many thousands of projects. However, consideration will be needed to determine organisational role in net zero delivery, working with partners such as Growing Mid Wales and Welsh Government.

Energy Systems Catapult is well placed to help Ceredigion County Council, and other stakeholders to move from LAEP towards design and delivery.

Prioritise

The first stage recommends stakeholders work to prioritise the projects identified within the LAEP and commission desktop feasibility studies to assess their viability in meeting the regional aims and objectives. Prioritisation of the LAEP projects should be influenced by areas currently within stakeholders' direct control, for example social housing or land assets and public buildings owned by the council. Resources are available at Net Zero Go to assist with this.

Projects should then be assessed in line with regional targets to assess impact on fuel poverty, air quality, local economic growth plans, etc.

Prioritisation should also include understanding the role each tier of local and regional government wishes to play as decarbonisation projects are further developed. For example, they could work with partner organisations to assess their risk profiles, and desired roles in any future energy system before matching outcomes against different types of local energy business models. Prioritised projects should subsequently undergo desktop feasibility studies to assess their viability and to understand the low carbon interventions and renewable technologies required in further detail. This could include sizing commercial renewable technologies, assessing co-located storage options, consideration of network connection requirements and an initial outline business case.

Assess

In the next phase of energy project development, various options can be assessed with the aim of exploring investible delivery mechanisms. Dependent on project type, a partner organisation with experience of innovative business modelling can assess how technologies can be connected and delivered to residents in a way that matches the risk profile of each stakeholder and the role they wish to play. This could include assessing different types of smart energy tariffs that incorporate costs for retrofit for social housing, exploring ways for councils to invest into infrastructure projects while ensuring commercial revenues are secured or assessing business models where the councils are off-takers or customers.

Connect

Further consideration should be given to how technologies and projects can be connected together through Smart Local Energy Systems (SLES), which can aggregate to unlock private investment and create numerous co-benefits. Once a firm capital investment plan has been formed and initial sources of investment and funding have been identified, the design phase needs to firm up assumptions made during desktop feasibility.

This involves working with partner organisations with engineering expertise to assess spatial, planning and structural considerations. Connection costs should be fully understood, and a finalised capital investment plan produced.

Engage

Engagement is another key part of taking outline priority projects identified in the LAEPs forward. Key stakeholders need to be identified and consideration should be given to how residents are consulted and bought into the potential benefits of decarbonising dwellings and estates. A partner organisation with strong digital engagement experience and relationships with network operators can support this process.

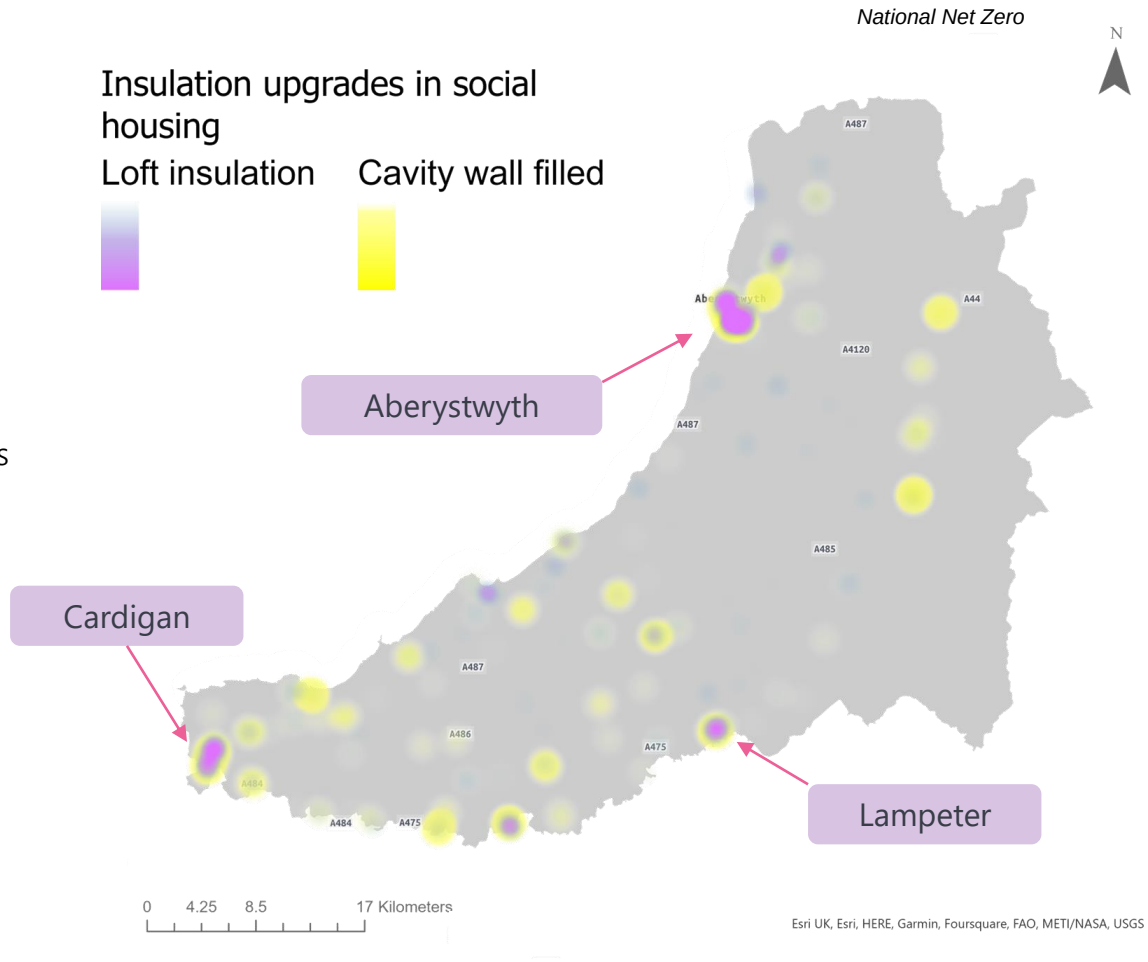
Social Housing Retrofit Packages

Several measures can be carried out together as a retrofit package for homes: insulation, rooftop solar PV and heat pump installation. This achieves the combined goals of bill reductions for residents, and decarbonisation of the housing authority's stock. Clusters of social housing with retrofit opportunities can be found in many of the towns and villages in Ceredigion.

Opportunities for loft and cavity wall insulation in social housing are highlighted as quick wins in the map, as these can give short payback on modest investment. Solid wall insulation and PV are further investments which deliver substantial bill reductions, and heat pumps can be installed as part of the same package of works to achieve decarbonisation.

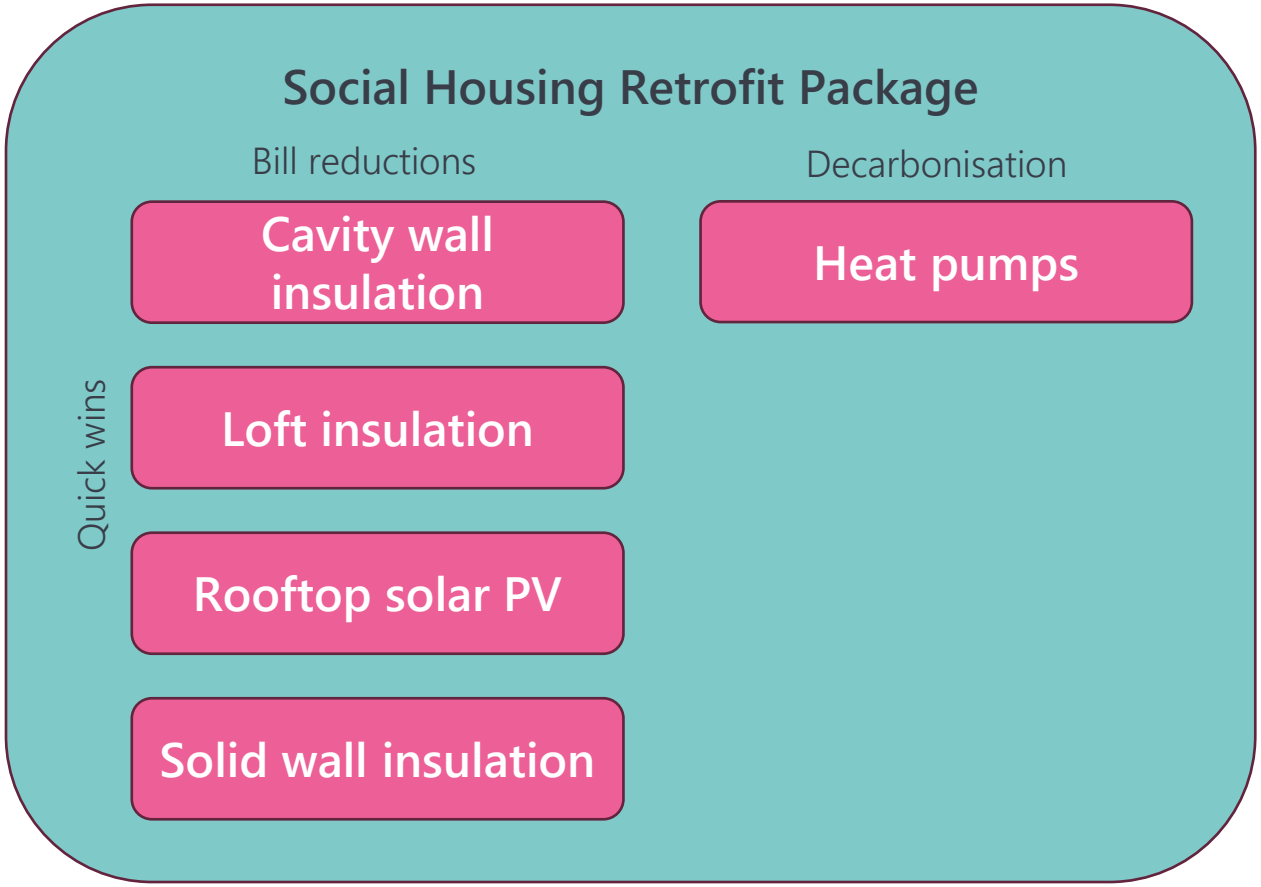
Around 24% of social houses receive upgraded loft insulation under National Net Zero, and 18% have their cavity walls filled. The map on the right highlights areas where groups of social houses receive these measures.

Solar PV and solid wall insulation will also deliver substantial bill reductions. Finally, including heat pumps in the retrofit package will decarbonise those homes as part of the intervention. Consideration could also be given to installing EV charging where appropriate as part of the package, to combine electrical works and facilitate decarbonisation of household transport.



	Loft	Cavity	Loft & Cavity
Number of Social Houses with insulation upgrades	900	700	200
As a proportion of all Social Houses	24%	18%	5%
As a proportion of all Homes	3%	2%	1%

Social Housing Retrofit Packages



Housing Retrofit – Fuel Poverty Focus Zone

Loft insulation upgrade by 2050

PV installed by 2050

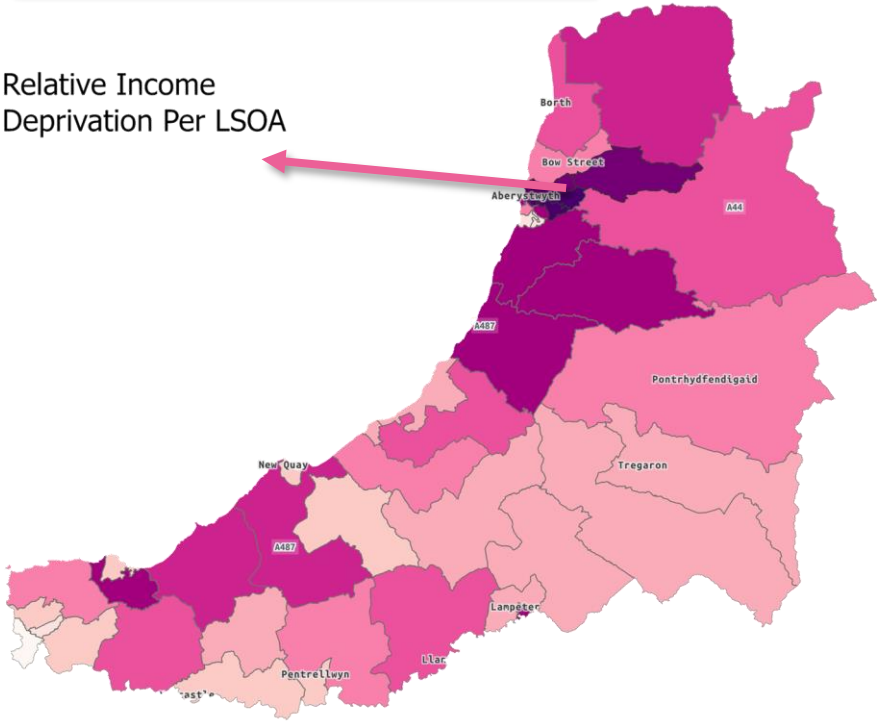
Cavity wall filled by 2050

National Net Zero
Housing estates in the east of Aberystwyth, centered around Penglais Road

Housing in areas of fuel poverty could be targeted for retrofit packages, similarly to social housing, although with a mixture of tenure types, reaching these homes will be less straightforward. Fuel poverty focus zones have been selected based on the data on relative income deprivation*, shown in the map below. The Aberystwyth Central, Llanrhystud and Aberporth zones have been prioritised, having the highest levels of income deprivation in Ceredigion.

The targeting of fuel-poor areas could build on the momentum of social housing retrofits, allowing for supply chains to ramp up and then expand into the private rental and private owned markets.

Relative Income Deprivation Per LSOA



Relative Income Deprivation Per LSOA

Lower Deprivation

Higher Deprivation

*Relative income deprivation has been used in lieu of fuel poverty data, which was not available, and may not correspond precisely with fuel poverty.

Aberystwyth Central Heat Network

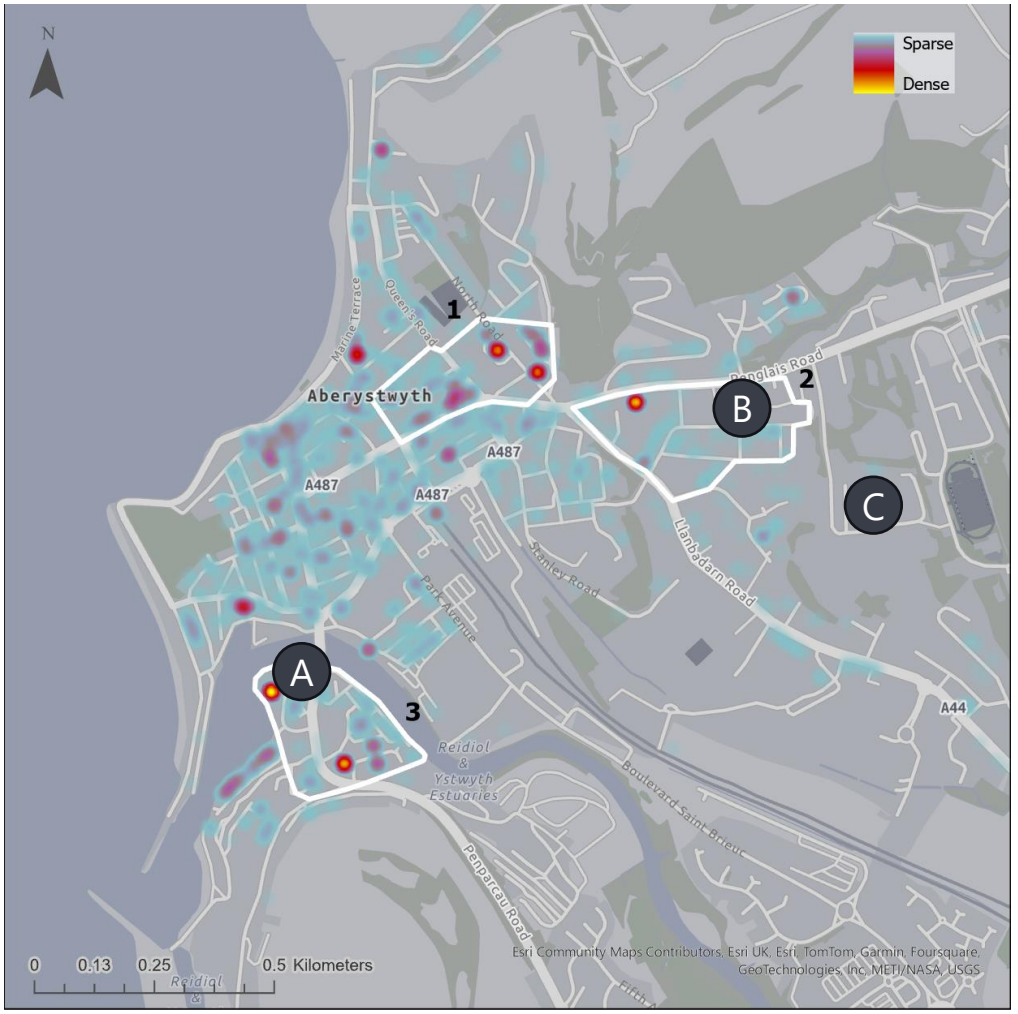
Within Aberystwyth, there are three areas (shown in the map) which stand out as suitable starting points for district heat network deployment, due to the higher heat demand density (a large amount of heat requirement in a small area).

From these starting points, networks could expand to serve significant numbers of terraced dwellings and low-rise flats – high density housing which can be more difficult to site heat pump equipment in – particularly between areas 1 & 2, as well as other types of dwellings and non-domestic buildings. In area 2, electric resistive heating is prevalent, which can mean more expensive and disruptive conversion of heating to plumbed systems, so the merits of district heating for areas like these will require separate consideration.

While heat networks are not always the most economic option for homes, once the case for a network has been established to serve non-domestic buildings in the area, it can be convenient for nearby homes to connect, avoiding the upfront costs and disruption of installing their own low carbon heating systems. The density of buildings in Aberystwyth could make siting individual heat pumps for each building impractical, in which case a heat network could be an enabler of heat decarbonisation here.

With both the river and sea being within reach of the town centre, a water-source heat pump could be considered in a heat network feasibility study.

The mixture of domestic and non-domestic buildings allows for more of a balanced load across the network at any given time. Heat network development projects should consider working with large public buildings such as Bronglais Hospital which have large demands for heat and may be both anchor loads and providers of heat for use in networks. Some examples of potential anchor loads are labelled on the map.



A. Aberystwyth Justice Centre

B. Bronglais Hospital

C. National Library of Wales

Aberystwyth Central Heat Network

The table shows the split of domestic and non-domestic properties and the peak demands. (Note: peaks are not additive as domestic and non-domestic peaks will not occur at the same time.)

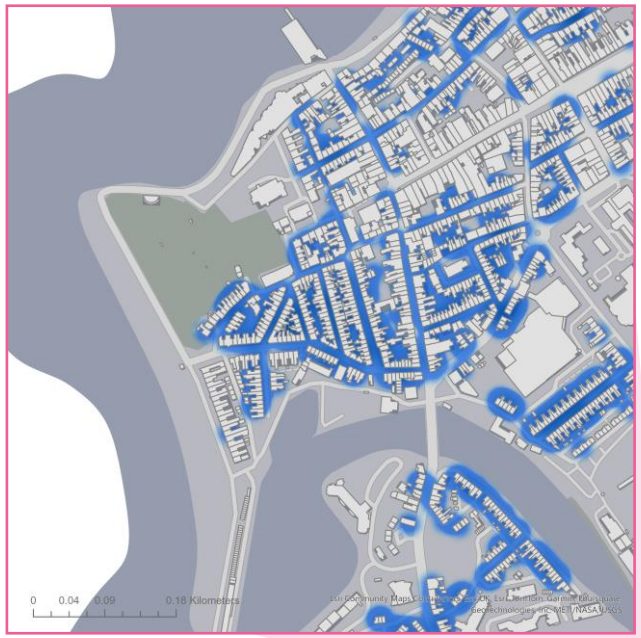
	Number of Domestic Dwellings	Number of Non-Domestic Properties	Domestic Peak Demand (MW)	Non-Domestic Peak Demand (MW)	Total Peak Demand (MW)
Area 1	191	27	0.32	0.14	0.42
Area 2	96	10	0.30	0.057	0.33
Area 3	119	45	0.17	0.086	0.23

Domestic Shared Ambient Loops

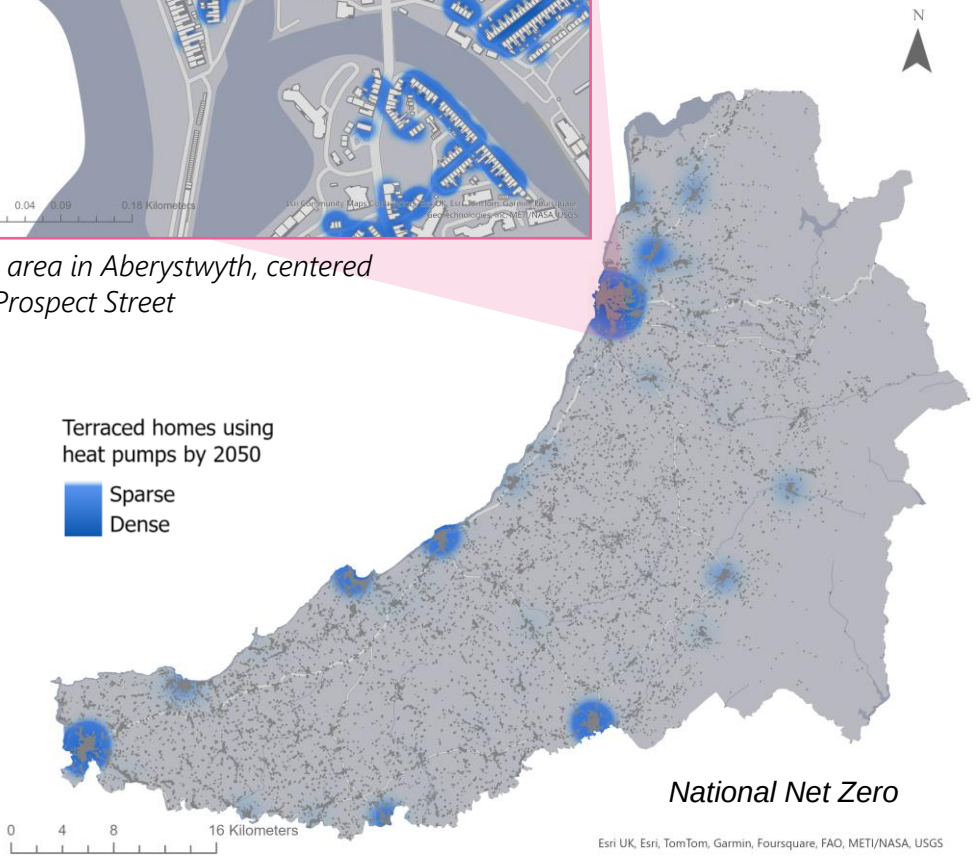
A middle ground between individual heat pumps for buildings and conventional heat networks, is shared ambient loops, also known as fifth generation heat networks. With this option, an underground collector loop extracts heat from the ground and serves multiple homes or buildings via shared pipework in the street. Each home has its own small indoor heat pump, avoiding the need to locate an outdoor unit for each home. This can be advantageous where planning, space and noise pose restrictions, such as in the case of flats, terraces, and historic buildings. Since the water in the communal pipework circulates at low temperature, these networks can be viable at lower building densities than conventional heat networks, which tend to be most suitable for dense urban areas like town centres. These ambient loops also provide efficient cooling, which could be beneficial for nearby offices, supermarkets, data centres and so on.

There are projects underway which treat the communal ground collector and pipework as a utility asset, which individual customers can connect to for a connection fee. This means that building owners avoid paying the high upfront costs of installing their own ground collectors, which could make the use of ground source heat pumps more accessible. The Heat Strategy for Wales (draft for consultation) expects a roughly 50/50 split between homes served by conventional heat networks and homes served by shared ambient loop systems.

Initial potential opportunities for shared ambient loop systems are concentrated in the larger towns in Ceredigion, for example in Aberystwyth and Cardigan as highlighted in the maps.



Example area in Aberystwyth, centered around Prospect Street



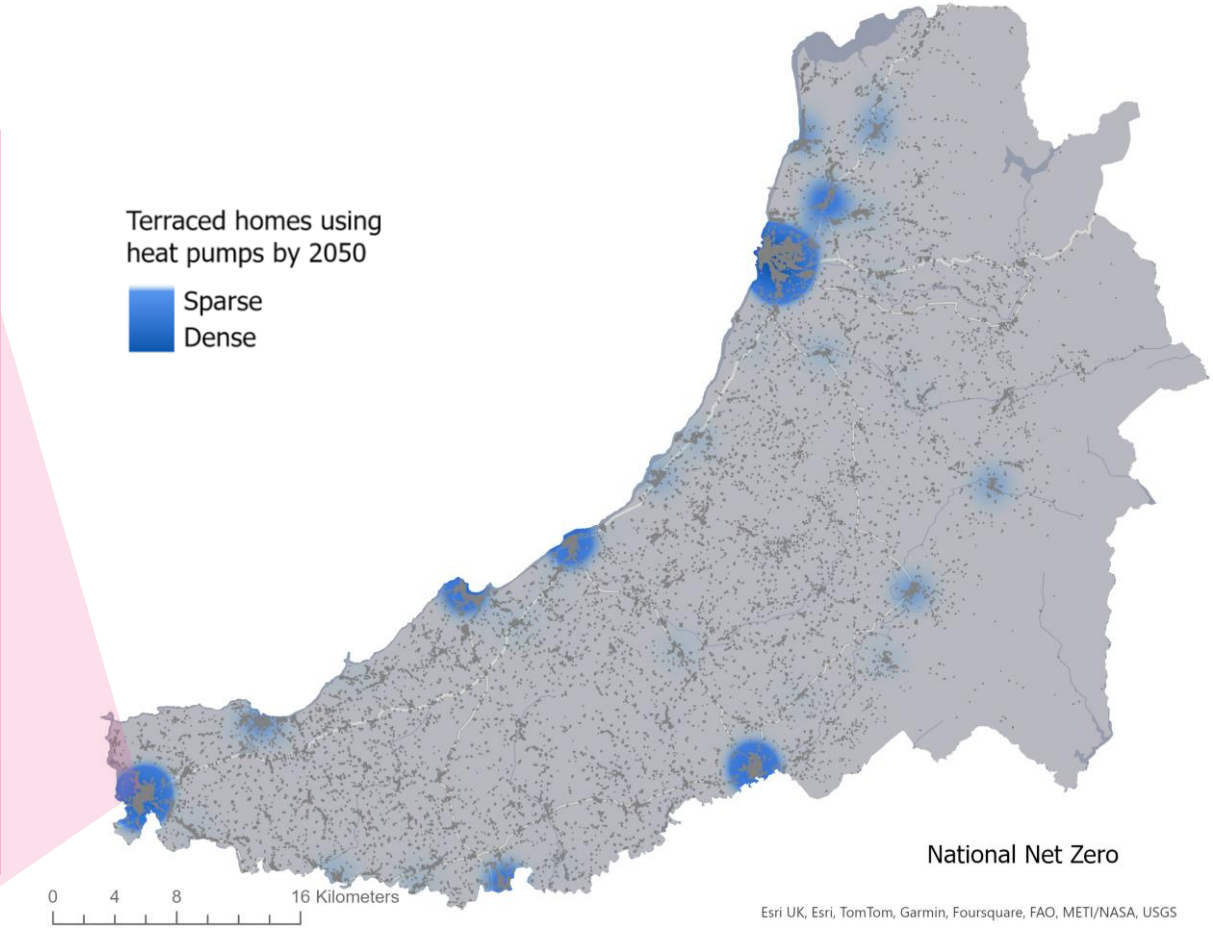
National Net Zero

Domestic Shared Ambient Loops

Neighbourhoods could be selected as demonstrator projects in the near term, to test this approach for wider scale-up.

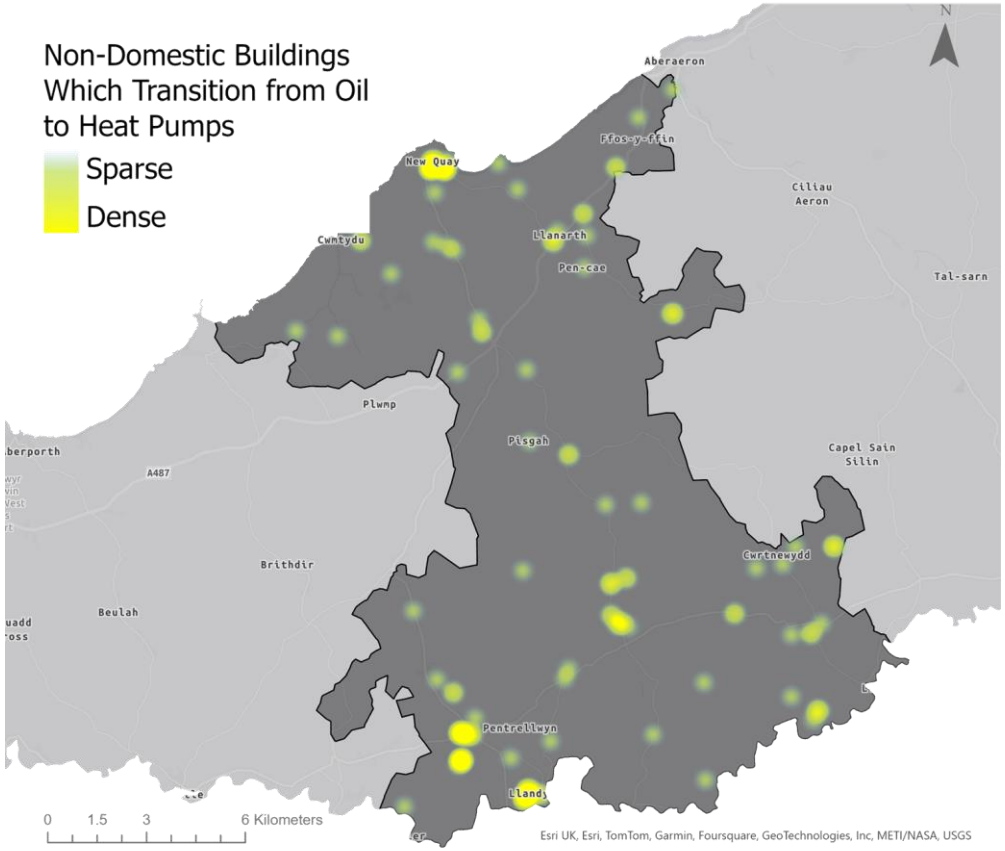
Neighbourhoods like these can also be targeted for demonstrator projects using individual air source heat pumps per home, identifying the barriers and enabling actions required to scale this solution up in dense areas. For example, the current requirement for heat pumps to be located 3 metres from the property boundary for permissive planning is more restrictive than in other parts of the UK, and will be an impediment for many terrace homes.

Example area in Cardigan, centered around Feidrfair Road



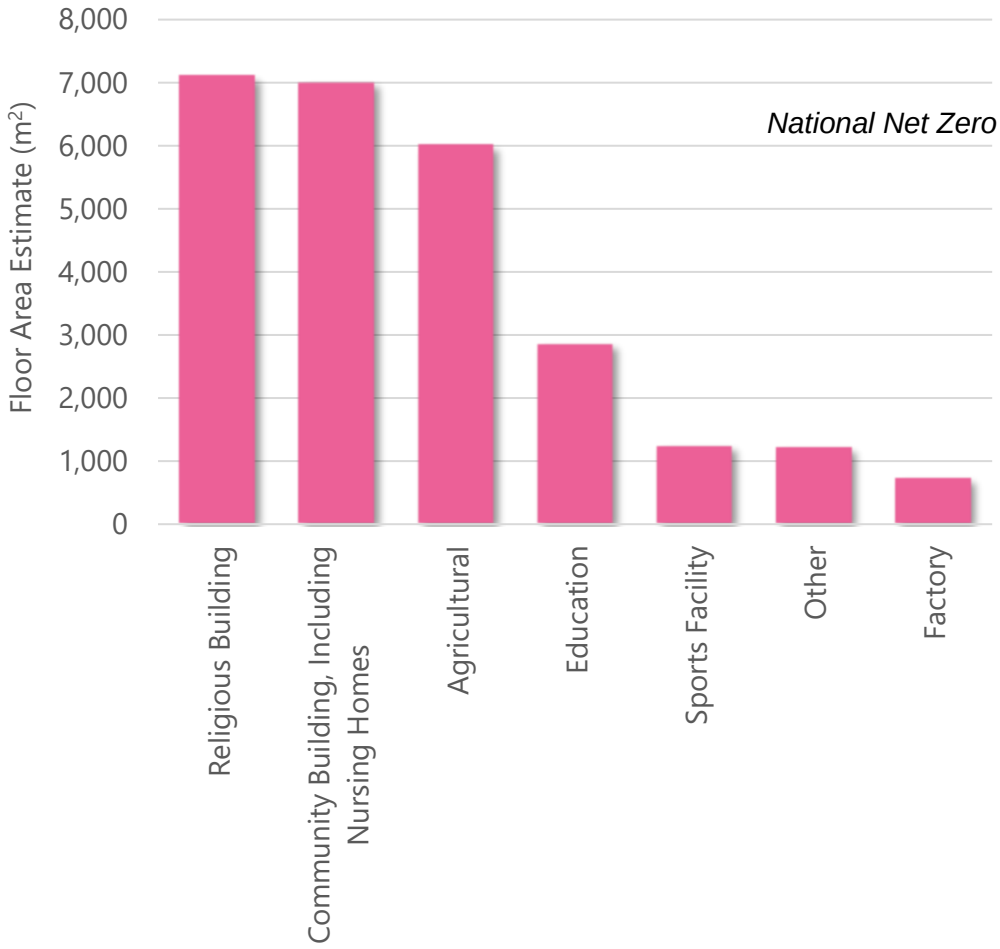
Non-Domestic Heat Pumps in the New Quay Zone

The New Quay zone contains a sizeable share of non-domestic buildings which could transition to heat pumps from oil – approximately 26,400 m^2 of floor space. This zone also benefits from spare capacity in the electricity network. For these reasons, it can be prioritised for supporting businesses in exploring electrification options.



National Net Zero

Non-Domestic Buildings Which Transition From Oil to Heat Pumps in the New Quay Zone by 2050

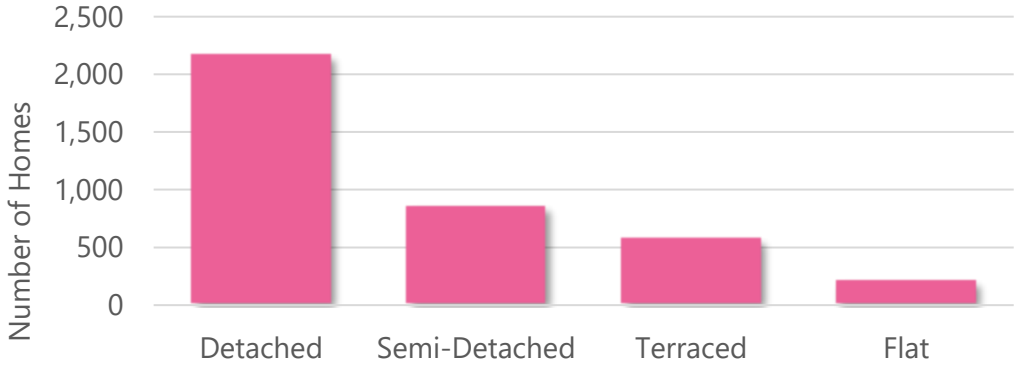


Supporting Rural Owner-Occupiers in the New Quay Zone to Install Heat Pumps

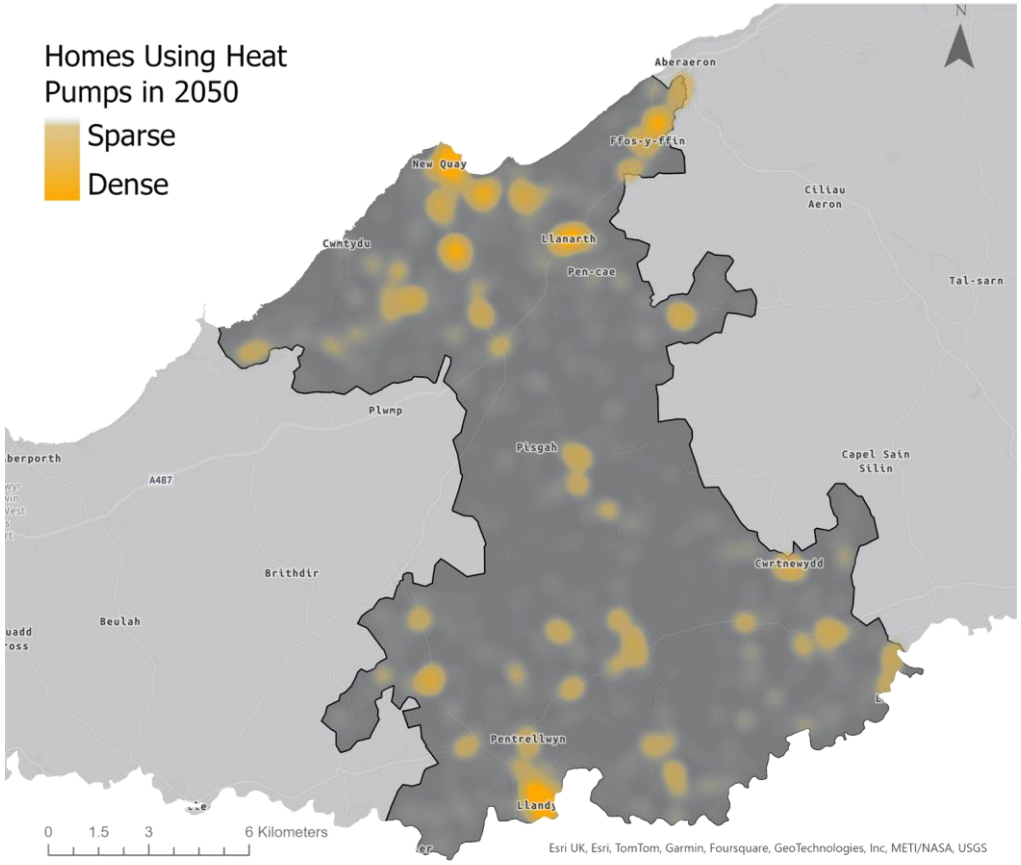
A high prevalence of rural owner-occupied homes transitioning from oil heating to heat pumps in the New Quay zone, combined with spare capacity in the electricity network, points to an opportunity in this zone to support and encourage this demographic to retrofit their homes with fabric efficiency upgrades and heat pumps. By selecting an area to begin the transition early, understanding can be built around the barriers and enablers faced by this type of household, with learnings taken forward into the scale-up phase.

In this zone, there are approximately 2,500 owner-occupier homes using oil boilers, and 680 using electric resistive heating (including storage heaters). Transitioning from oil to heat pumps brings the advantage of no longer needing to order oil deliveries, with a major carbon reduction, while the transition from electric resistive heating can bring sizeable reductions in running costs. In some cases, air-to-air heat pumps could be an effective choice for homes transitioning from electric resistive, as it can be installed without full central heating plumbing, avoiding the associated cost and disruption.

Homes in the New Quay Zone Using Heat Pumps in 2050 in the National Net Zero scenario



National Net Zero scenario

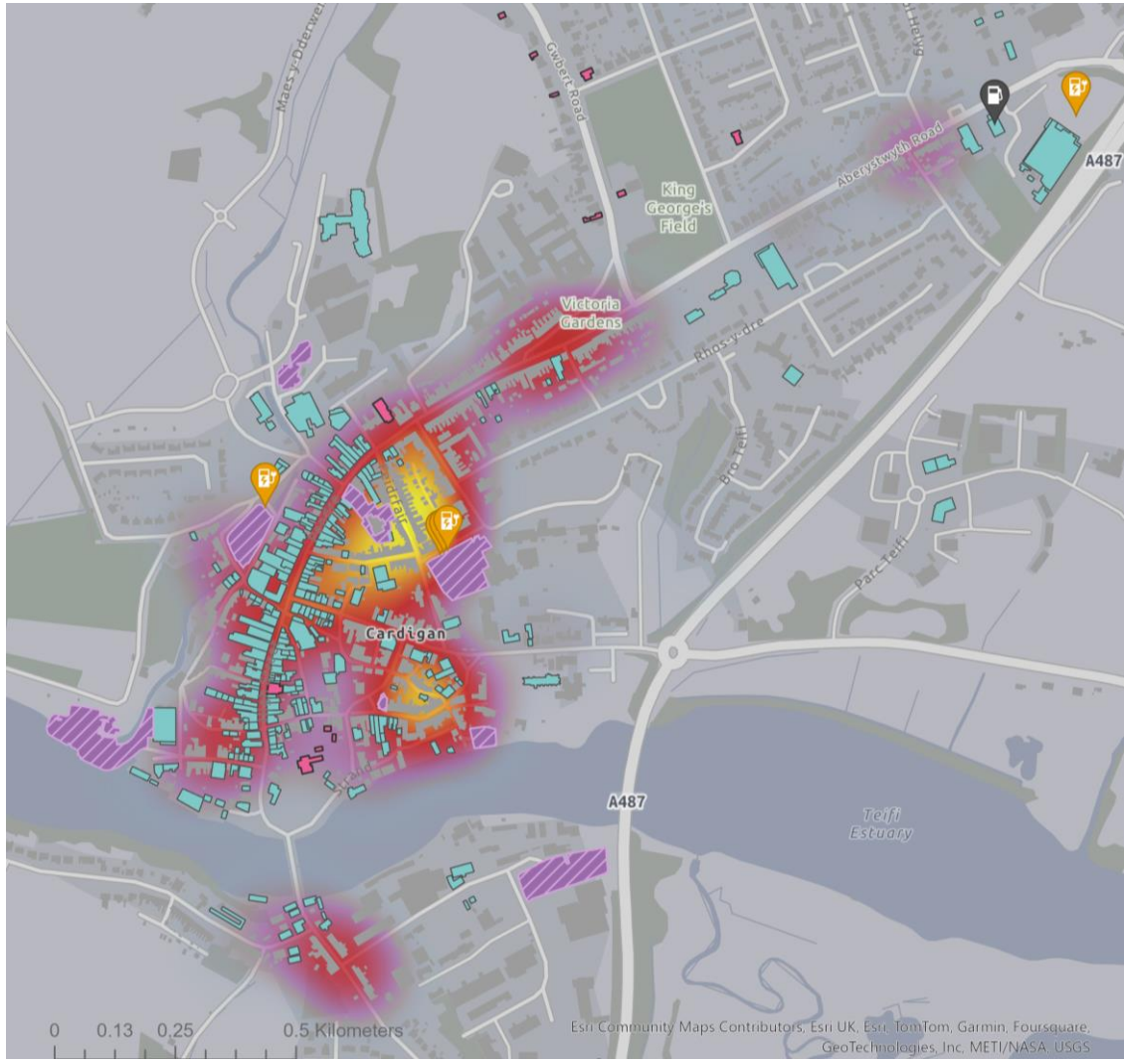


National Net Zero

Public EV Chargers

Like in Aberystwyth, Cardigan is expected to need a high number of public chargers. This is due to the level of buildings without access to off-street parking and due to the retail and tourist nature of the town. In this zone there are expected to be around 70 fast chargers and 5 rapid chargers by 2050 in the National Net Zero scenario.

Amenities Today



In the south of Cardigan there is a large amount of retail but also plenty of car parks. Therefore, this could be a good location for extra fast and rapid charge points to serve consumers in this area. This could be a quick win in council-owned car parks.

There are quite a few areas in Cardigan where homes don't have access to off-street parking, meaning on-street chargers could be installed for these users. Alternatively, given the number of car parks in the area, slow overnight charging could be provided in the car parks which may reduce street clutter on roads with small pavements.

There are existing fast EV chargers in three car parks in the south of Cardigan, but only a small number compared to how many may be needed by 2050.

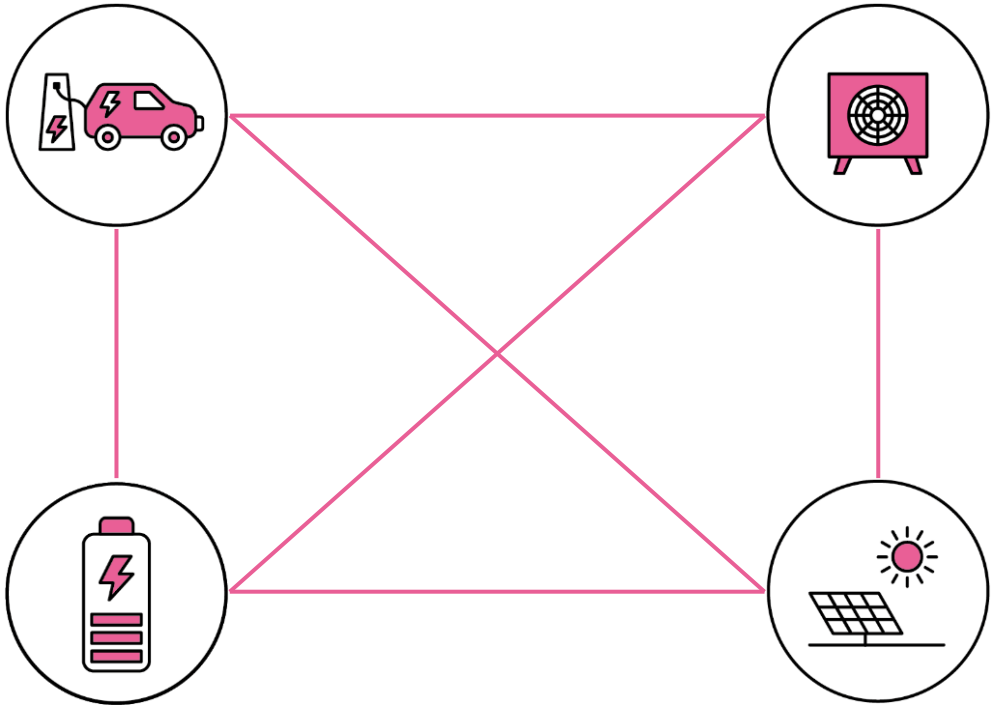
In the north of Cardigan there is a residential area where most dwellings are expected to have potential for off-street parking. Therefore, in this area it is expected that most homes would have home EV chargers installed.

Given this zone has some current network capacity available, this could be an area for a quick rollout of chargers.

While the Aberystwyth zone is also highlighted for a large requirement for public EV charging, the Llanrhystud zone to the south is likely to require less network capacity upgrade, and so could accommodate early deployment of public chargers. Since some of Aberystwyth crosses into the Llanrhystud network zone, this southern part of the town could also be prioritised for early roll-out.

Smart Local Energy System Demonstrator

Smart local energy systems (SLES) can co-ordinate local energy sources, storage and demand to make better use of assets and reduce investment required. By linking local renewable generation with new low-carbon technologies, it may be possible to offer lower energy prices to those uses, improving the incentive to make the transition to electrification. Infrastructure civil works can be co-ordinated across different elements of the SLES, avoiding inefficiencies such as multiple rounds of roadworks for electricity, gas and heat networks.



SLES can package different types of investment needed to reach zero carbon in the area, to improve the attractiveness to investors. Energy service companies could reduce the burden of complexity and upfront cost for households and businesses, by providing packaged services for a subscription fee. This could include elements such as building fabric efficiency retrofits, heat pump installation, supply of local renewable energy, maintenance and performance guarantees.

Areas which show significant potential to host renewable generation and electrification of heating and transport, but which are likely to be limited by network capacity, would be prime candidates for SLES demonstrator projects, such as in the Tregaron zone. Theses could explore the potential for SLES to reduce the need for network capacity investment, while bringing community benefits discussed above.

Today's regulatory environment limits the possibilities of fully realising the potential of SLES. Regulatory reform is needed to unlock the full potential for SLES to benefit local communities.

For more information on SLES, see
https://iuk.ktnuk.org/programme/smart-local-energy-systems/

Implementation:
Costs & Benefits

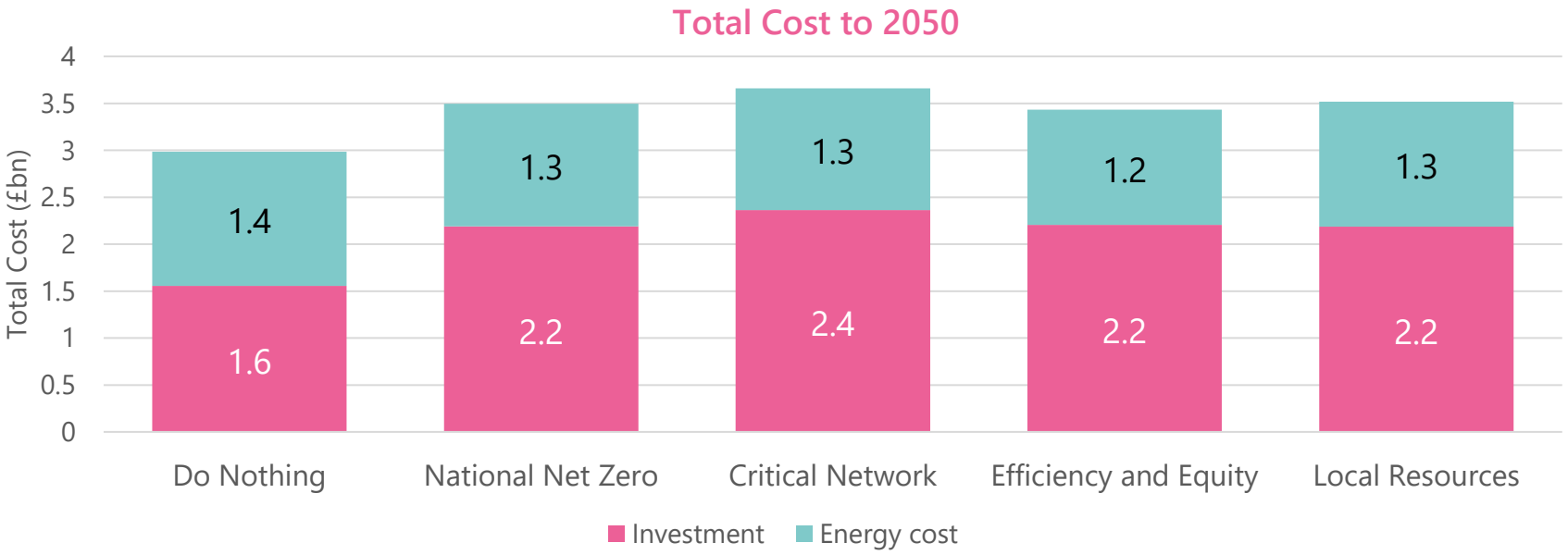
Cost Summary

Whilst there is a significant cost associated with the Do Nothing scenario – to maintain existing infrastructure, upgrade infrastructure where required by new developments, and to pay for energy imports – all decarbonisation scenarios are higher cost. The range to deliver is between £2,985m from the Do Nothing scenario to £3,661m for the Critical Network scenario.

Efficiency and Equity has the lowest overall costs of the four decarbonisation scenarios. This is reflective of the reduced demand in this scenario (for example from less private vehicle mileage) minimising the network upgrades and energy imports required. Conversely, the Critical Network scenario is the most expensive – it requires a lot of investment in the hydrogen network and hydrogen import costs, and it also spends the most on building district heat networks. Avoided investment in electricity network upgrades does not save money overall, since the actions required to compensate for this lack of network capacity are likely to be more expensive than the network upgrades themselves.

These costs are broken down by category and year of investment in the following pages. Note that the below costs are discounted using a discount rate of 3.5%, whereas costs included in the next pages are not discounted to allow fair assessment of the relative size of costs in different years.

All costs shown throughout this plan have had discounting applied in accordance with HM Treasury's *Green Book*, unless otherwise stated. Discounting is a financial process which aims to determine the "present value of future cash flows", or in other words: calculating what monies spent or earned in the future would be worth today. Discounting reflects the "time value of money" – one pound is worth more today than a pound in, say, one year's time as money is subject to inflation and has the ability to earn interest. A discount rate is applied to financial inflows or outflows – this generally reflects what it costs to borrow money or is a defined rate such as 3.5% as suggested in the *Green Book* (this is used in the financial evaluation of UK Government projects).



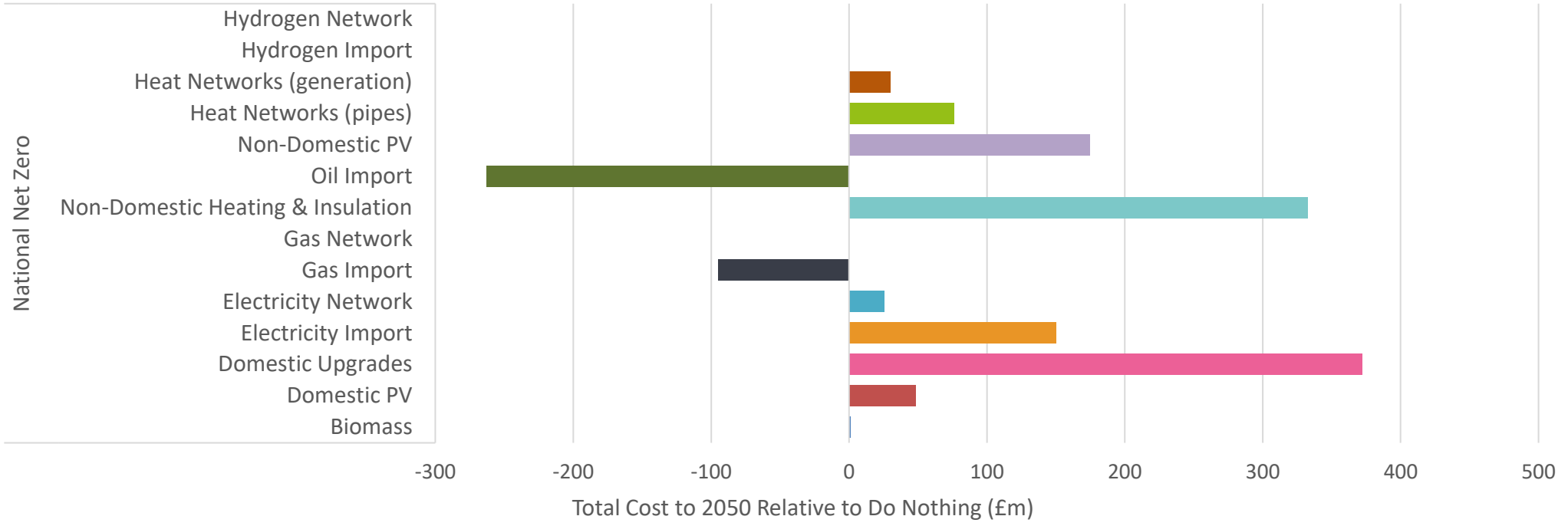
Further technical information for the cost breakdown can be found within the appendix.

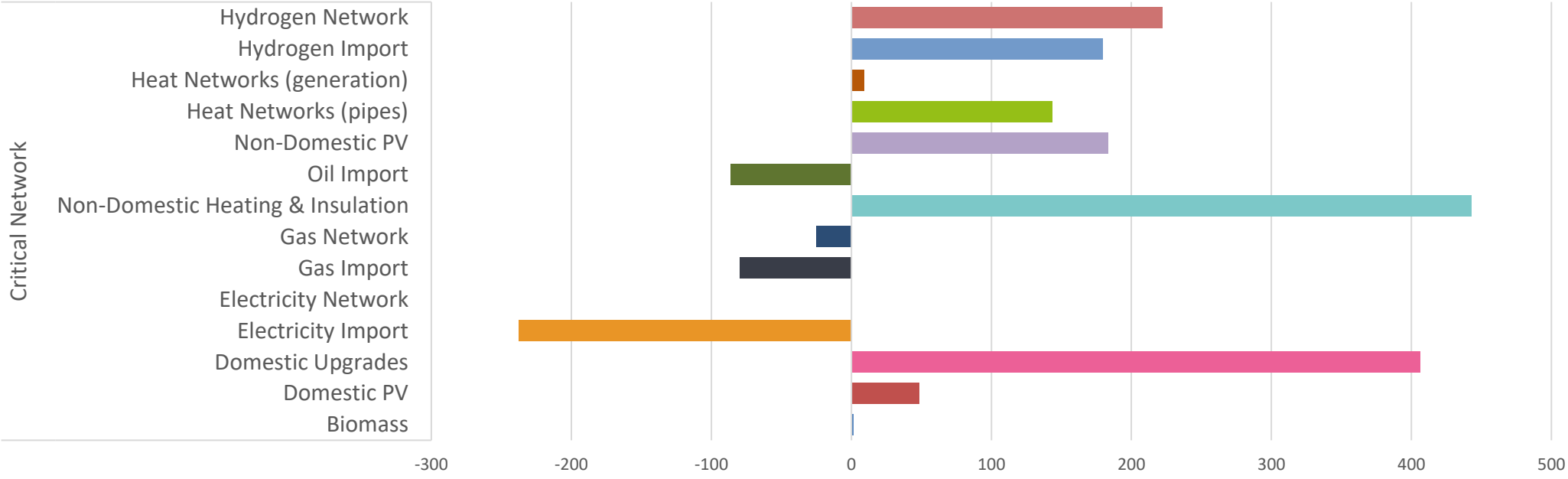
Cost Breakdown Relative To “Do Nothing”

The below chart shows scenario costs split into more granular categories. In this case all costs are relative to the corresponding cost incurred in the ‘Do Nothing’ scenario.

The National Net Zero scenario saves a significant amount of money over the baseline ‘Do Nothing’ spend on oil import (£263m) and gas import (£95m). All other categories require the same or greater investment, particularly so for building upgrades and heating system installations (domestic and non-domestic) and PV installations.

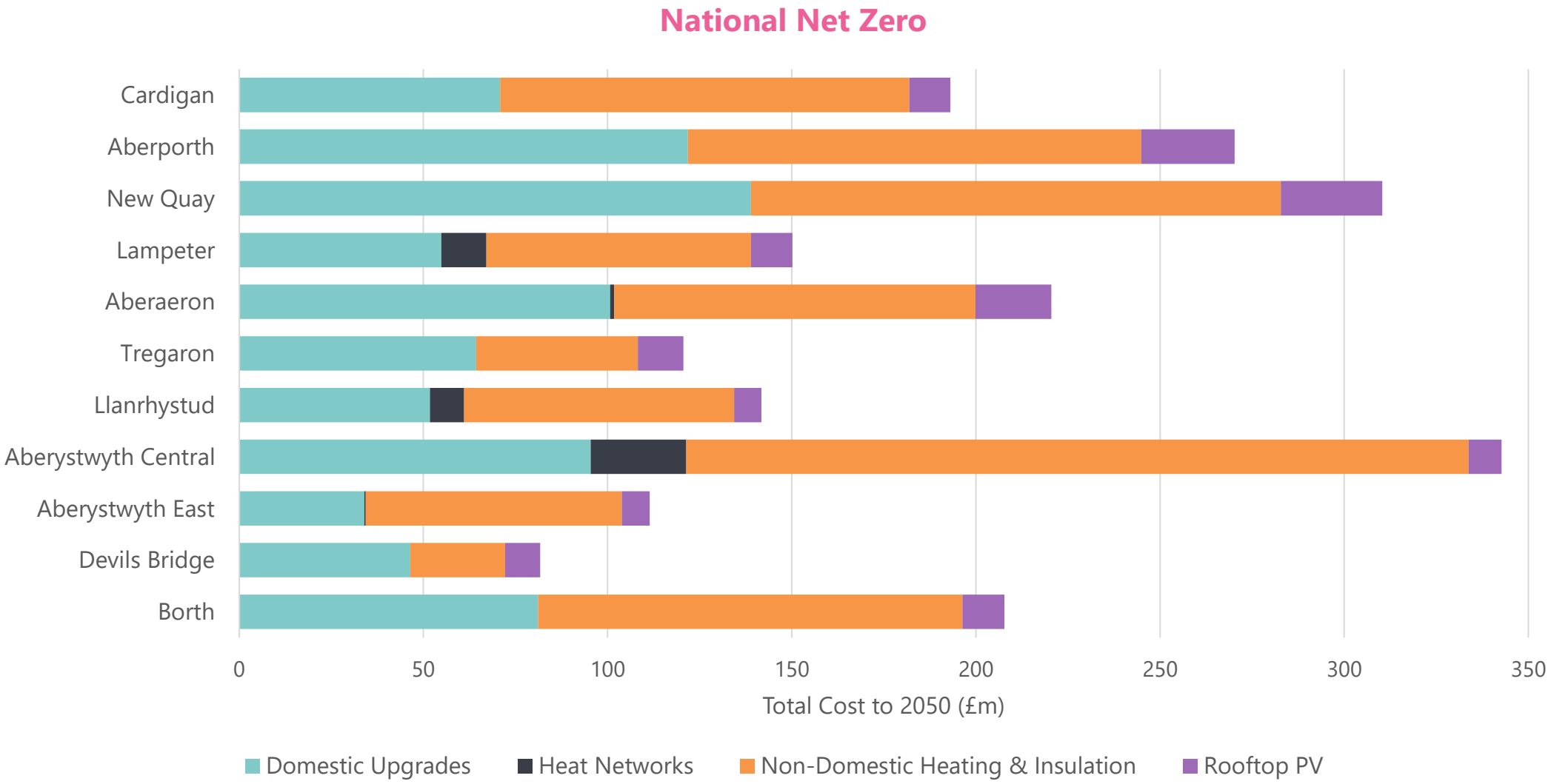
This is broadly also true of the Critical Network scenario, with the difference that the emphasis on reducing electricity network upgrades means that this scenario saves £237.5m on electricity import costs over the baseline. In order to achieve this, it incurs cost in importing hydrogen to the area, converting the gas network to hydrogen and creating district heat networks. More investment is also required in non-domestic heating and insulation and domestic insulation measures.





Cost Breakdown by Zone

The below chart shows the cost breakdown split per zone area. In this case all costs are relative to the corresponding cost incurred in the National Net Zero scenario.



Deployment Breakdown

This table provides a complete view of the quantity of solutions deployed across Ceredigion's energy system to reach Net Zero by 2050, categorised by technology (based on the National Net Zero scenario).

Zone	Fabric Efficiency Upgrades for Homes*	Heat Pumps for Homes	Heat Network Connections for Homes	Rooftop Solar PV for Homes	Heat Pumps for Non-Domestic Building (m^2 floor area)	Non-Domestic Buildings Connected to Heat Networks (m^2 floor area)	Home or On-Street EV Chargers	Rooftop Solar PV for Non-Domestic Buildings (MW)	Public EV Chargers	Electricity Substation Capacity Increase (MW)
Borth	3,790	2,640		1,120	65,830		2,600	14	100	4
Devils Bridge	1,870	1,365		690	29,010		2,060	11	70	4
Aberystwyth East	1,960	1,650		390	97,900		700	12	30	2
Aberystwyth Central	5,180	2,830	910	730	292,010	99,660	1,680	13	215	26
Llanrhystud	2,960	2,360	290	790	35,490	25,390	1,590	9	160	3
Tregaron	2,480	1,890		1,010	59,510		1,780	14	30	18
Aberaeron	4,060	3,120	30	1,420	111,030		2,750	30	80	25
Lampeter	2,540	1,990	260	830	69,660	59,060	1,220	16	45	12
New Quay	5,630	4,560		2,130	123,400		3,300	38	60	29
Aberporth	4,920	4,110		2,060	124,620		4,290	31	75	31
Cardigan	3,510	3,100		1,180	157,770		1,100	14	75	9

*includes end-of-life window replacements

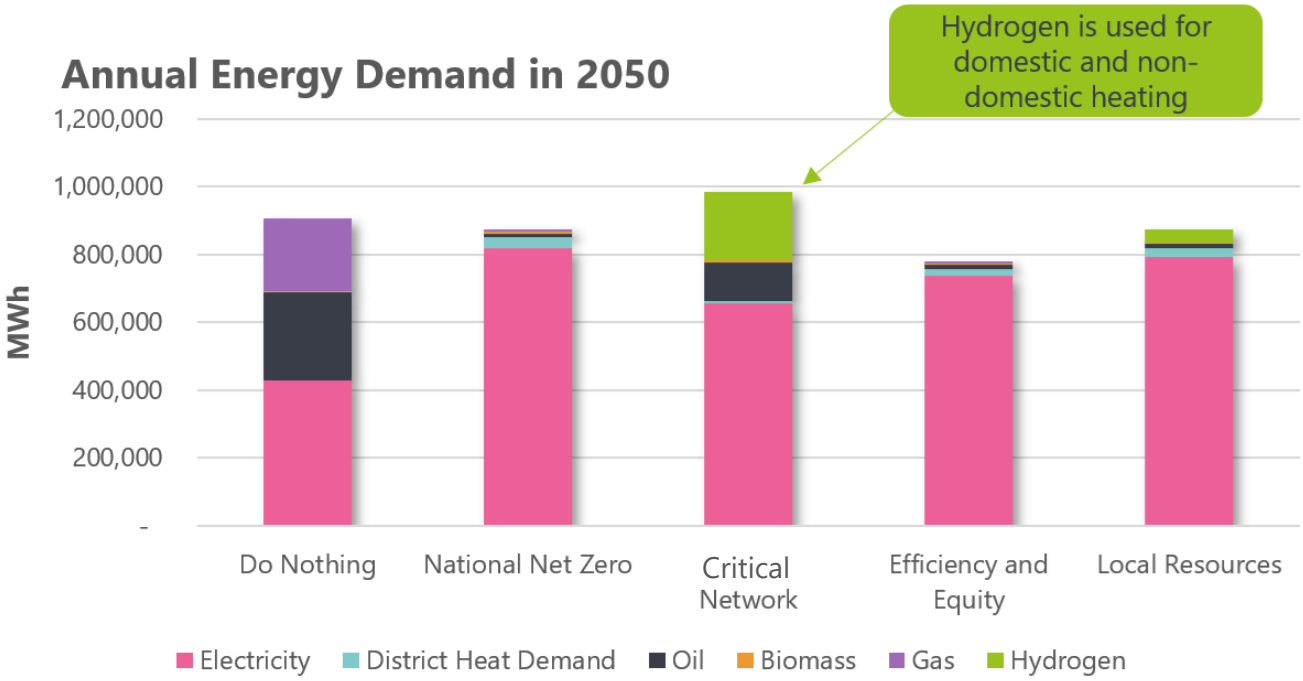
Household Bill Savings

Indicative household energy bill savings are shown in the table below, based on figures from the Energy Saving Trust website. The headline household saving shown in the executive summary is based on a home topping up loft insulation, installing external wall insulation and solar PV, and switching to an EV. This is a common combination of actions for homes across Ceredigion, however other combinations with larger and smaller savings are also seen. At present energy prices, switching from fossil fuel boilers to heat pumps does not have a large impact on bills.

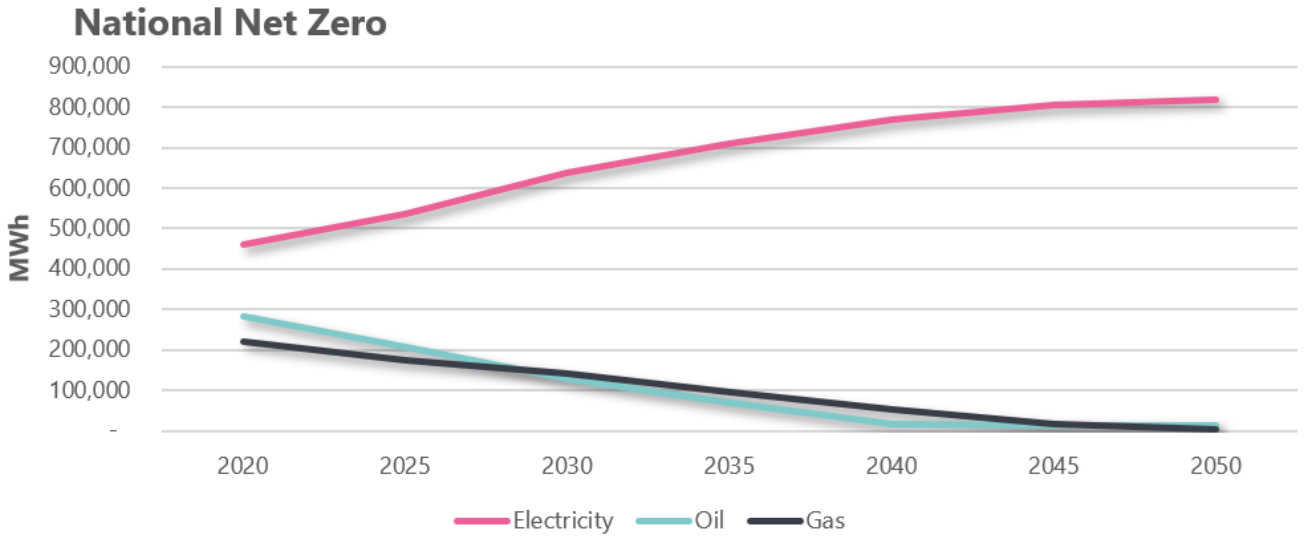
Note that these savings are a snapshot of today's policy and market conditions, which are likely to change over the course of this plan. For example, a portion of the saving from switching to EVs is due to avoided fuel duty. This source of government revenue is likely to be recovered from EV users in other ways once EVs become more common, such as through road usage pricing.

Action	Typical Annual Saving	Based on
Top up loft insulation	**£25**	Semi-detached house
Insulate loft from uninsulated	£270	Semi-detached house
Add cavity wall insulation	£280	Semi-detached house
Add external wall insulation to solid wall	**£380**	Semi-detached house
Install rooftop solar PV	**£415**	Home in afternoons (mid value in potential savings), with SEG
Switch to electric car	**£540**	Driving 6,600 miles per year, switching from diesel, charging at home

Change in Energy Demand



The transition described in this LAEP involves a shift in energy consumption in buildings from oil and gas towards electricity, as well as an overall reduction in demand due to efficiency. A similar shift in transport happens as well, though the transport fuel is not shown here. Only the electricity consumption by electric vehicles is shown, so a greater overall energy saving takes place than is apparent, as electric vehicles use much less energy than petrol and diesel vehicles. These charts show the shift in consumption by energy source across the scenarios.



Implementation:
Deliverability

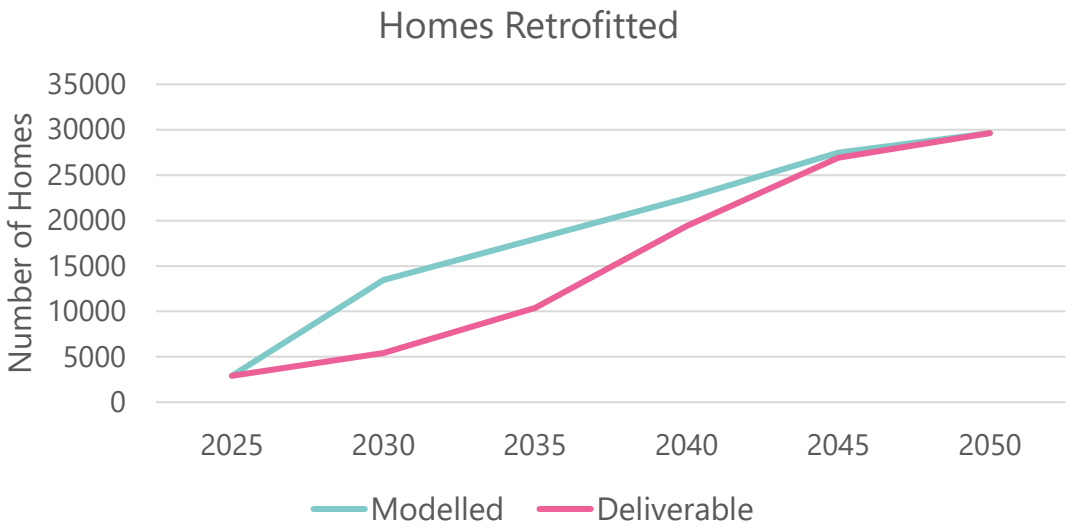
The following pages on delivery during implementation highlight examples of subjects that will need to be considered when taking this LAEP forward

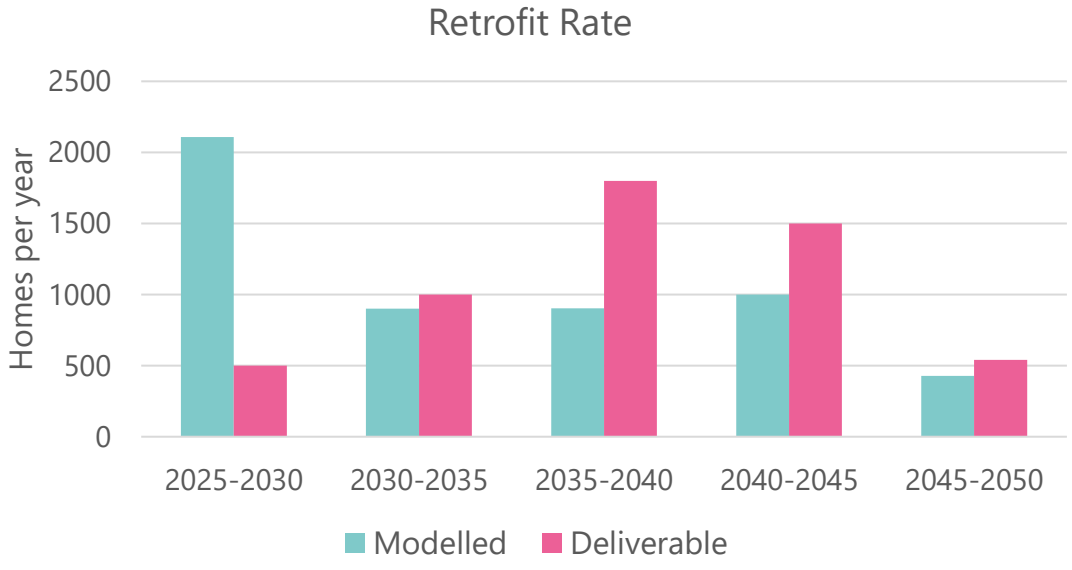
Rates of Technology Deployment

To reach the 2030 interim carbon target (63% reduction on 1990 baseline), installation of low carbon technologies would need to occur extremely rapidly in the near-term. The lower graph shows that to meet the 2030 target, homes would need to be retrofitted with fabric efficiency upgrades, heat pumps and solar PV at a rate of approximately 4,400 homes per year on average, over the period 2025-2030.

This scale and pace of change in the next five years is deemed very unlikely to be deliverable due to the requirement to scale up a skilled workforce and supply chain that quickly. Network capacity, economic incentives, permissive policy and public acceptance would also be key challenges. This suggests that it would not be possible to decarbonise Ceredigion at the rate required to meet the 2030 interim carbon target.

The 'Deliverable' pathway in the graphs shows a more evenly-distributed (though still highly ambitious) deployment profile, which allows for a ramp-up of supply chain and resident participation over the period to 2050. It would meet the 2050 Net Zero target but miss the interim 2030 target.

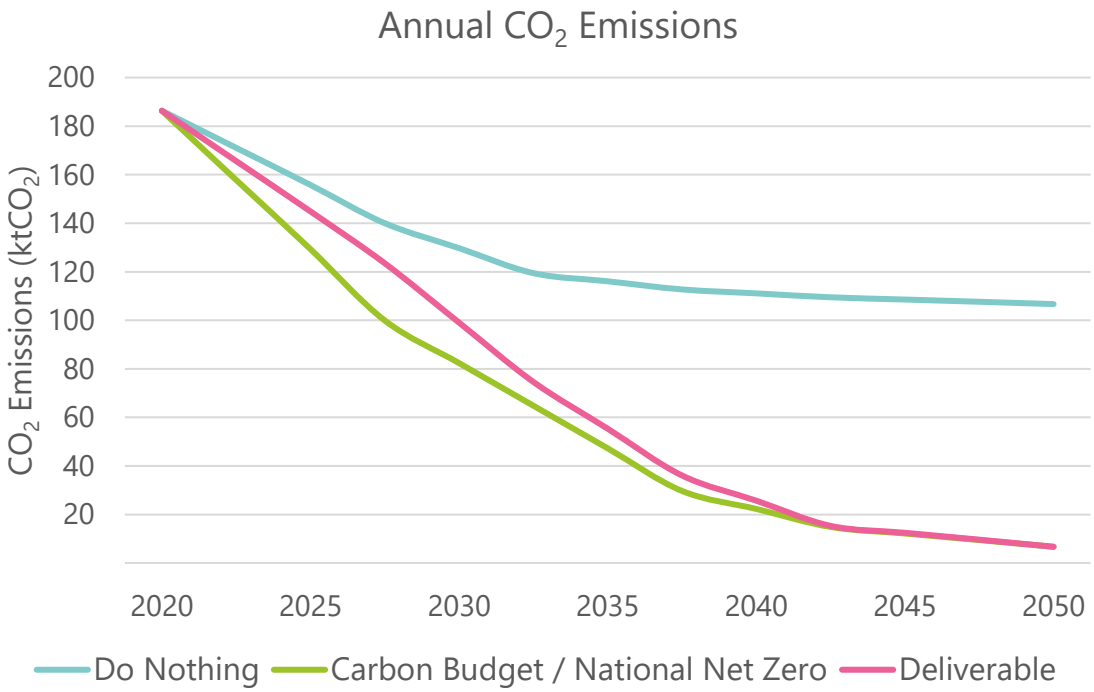




Rates of Technology Deployment

This chart shows the impact of the more gradual ramp up in delivery rate on the carbon targets and budgets. The green line shows the carbon emissions trajectory required to meet the interim targets, whereas the red line shows the slower reduction in emissions resulting from more gradual ramp-up. While this more deliverable trajectory still meets the Net Zero target by 2050, it misses the interim 2030 target. It results in a total of 201 kilotonnes additional CO_2e released against the target-compliant trajectory.

This raises an important policy discussion around the deliverability of the 2030 target, and whether emissions savings elsewhere could be able to compensate for the time required to scale-up the delivery of the energy system transition.



Annual $ktCO_2$	2020	2025	2030	2035	2040	2045	2050
Do Nothing	190	160	130	120	110	110	110
Carbon Budget / National Net Zero	190	130	80	50	20	10	0
Deliverable	190	140	100	60	30	10	0

Implementation: Next Steps

Taking LAEP Forward

This section considers some of the practical steps which should be taken to begin the delivery stage of this LAEP. Further consideration will be needed to develop an approach to monitoring the progress of delivery, which may be best to carry out at a regional or national level. Some example of metrics which could be used to track progress are given on the right.

Actions identified throughout the LAEP and through stakeholder engagement are summarised on the following tables. These actions are not exhaustive and should be updated as a live document as part of moving forward with the plan. Please note the actions below are yet to be agreed with all stakeholders and many will be subject to funding and resourcing.

- Proportion of innovation and demonstration projects funded
- Total funding secured against LAEP recommendations
- Innovation and demonstration projects completed
- Emissions
- Number of solutions deployed
- Policy & regulation milestones reviewed for impact on LAEP pathway
- Decisions made against key decision points
- Levels of fuel poverty

Category	Action	Who?	When?
Overarching	Form a LAEP delivery group across council departments, local business and other local stakeholders, appointing points of contact for each party, and arranging regular forums.	Lead: GMW and LAs	Short-term
Overarching	Map resource gaps to LAEP delivery locally and regionally.	Lead: GMW and LAs	Short-term
Overarching	Work with regions and local authorities on an approach to monitoring the delivery of the LAEP.	Lead: Welsh Government, GMW, LAs	Short to medium-term
Overarching	Engage with UK government over the importance of rebalancing energy costs (e.g. electricity-to-gas price ratio) to support the electrification of different sectors.	Lead: Welsh Government	Short to medium-term
Overarching	Engage with Ofgem and UK government over the importance of ensuring the costs associated with district heat networks and the potential decommissioning of gas networks is done fairly.	Lead: Welsh Government Support: DNOs, Ofgem, UK Government	Short to medium-term
Overarching	Following the publication of the Heat Strategy, understand the role that hydrogen will play for heating and work with the gas networks to understand the next steps.	Lead: Welsh Government Support: DNOs	Short-term
Overarching	Identify specific local planning constraints (e.g. permitted developments i.e. 3 metre rule for heat pumps, permissive planning for listed buildings, new build regulations) limiting progress to net zero and delivering the LAEPs and work with Welsh Government to resolve these.	Lead: GMW and LAs Support: Welsh Government	Long-term

Category	Action	Who?	When?
Overarching	Work with local authorities and regional bodies to determine an approach to coordinated, street-by-street approach to retrofit and the mechanisms for delivery (e.g. governance, resource, finance, policy). See the priority projects "Fuel Poverty Focus Zone", "Supporting Rural Owner-Occupiers in the New Quay Zone to Install Heat Pumps", and "Non-Domestic Heat Pumps in the New Quay Zone".	Lead: Welsh Government Support: LAs and GMW	Short-term
Overarching	Aggregate procurement across the LAEP where possible to benefit from economies of scale.	Lead: GMW and LAs	Short to medium-term
Overarching	Align energy projects with social value procurement process (e.g. look beyond the financial cost of a contract to consider how the services they commission and procure can improve the economic, social and environmental wellbeing of an area).	Lead: GMW and LAs	Medium to long-term
Overarching	Use Masters students' dissertation projects to understand what influences behavioural change in relation to low carbon activities in Mid Wales. Use outputs to identify potential pilot projects.	Lead: Aberystwyth University Support: GMW, Hywel Dda University Health Board, TfW	Short to medium-term
Overarching	Work with adjoining regions across Wales to develop strategic energy planning.	Lead: GMW and LAs Support: WGES	Phased approach: Short to long-term
Electricity grid	Businesses and public sector organisations to engage early, individually or collectively, with the DNOs about future plans for low carbon technologies (e.g. renewable electricity generation, electric vehicle charging points, heat pumps).	Lead: Businesses and public sector organisations Support: GMW	Phased approach: Short to long-term
Electricity grid	Use the provided details of planned future domestic and non-domestic projects (generation and demand) to inform business planning (e.g. strategic project register and/or DFES process).	Lead: DNOs Support: GMW	Phased approach: Short to long-term
Electricity grid	Raise awareness of the need for businesses to engage with the DNOs about future plans for low carbon technologies (e.g. renewable electricity generation, electric vehicle charging points, heat pumps).	Lead: DNOs Support: GMW	Short to long-term
Electricity grid	Clarify the role of the Regional Energy Strategic Planners and how different stakeholders (e.g. local authorities, community energy groups) will engage them.	Lead: National Energy System Operator	Short to medium-term

Category	Action	Who?	When?
Buildings	Work with Welsh Government to understand the readiness of current supply chain for the scale of retrofit on the horizon and prepare accordingly.	Lead: Welsh Government, RSP, LAs, GMW	Short to medium-term
Buildings	Co-ordinate a retrofit plan for all housing tenures which expands on the Optimised Retrofit Programme. See Social Housing Retrofit Packages priority project.	Lead: Welsh Government Support: RSLs, private landlords	Short-term
Buildings	Identify funding opportunities to develop an Aberystwyth district heat network following the completed feasibility study. See Aberystwyth Central Heat Network priority project.	Lead: Aberystwyth university, Hywel Dda University Health Board, Ceredigion County Council Support: Ceredigion PSB, Welsh Gov	Short to medium-term
Buildings	Review existing feasibility study for Lampeter district heat network to identify if it needs to be updated.	Lead: TBC Support: Ceredigion PSB, Welsh Gov	Medium term
Buildings	Commission feasibility studies and demonstrators on shared ground loops for flats and terraces (e.g. Cardigan, around Feidrfair Road and Aberystwyth, around Prospect Street). See Domestic Shared Ambient Loops priority project.	TBC	Short-term
Buildings	If needed, develop national procurement framework, learning from previous ECO 4 roll out and the Optimised Retrofit Programme, to deliver street-by-street retrofit.	Lead: Welsh Government Support: LAs	Short to medium-term
Buildings	Apply lessons learnt from Optimised Retrofit Programme to retrofitting the privately rented and owner-occupied sectors through Welsh Zero Carbon Hwb.	Lead: Welsh Government Support: RSLs	Short to medium-term

Category	Action	Who?	When?
SLES / community energy	Using outputs from the LAEP, map smart local energy system opportunities. Following mapping exercise, identify feasibility/demonstrator projects through engagement with key stakeholders including community energy groups and general public.	Lead: GMW, LA, DNOs Support: Ynni Cymru, WGES, Community Energy Wales	Short-term
SLES / community energy	Hold stakeholder events to bring together public, private and third sector to discuss collaborative decarbonisation projects.	Lead: GMW	Short-term
SLES / community energy	Develop private and third sector decarbonisation projects (e.g. buildings retrofit, low carbon heating, renewable electricity generation) ahead of new rounds of funding becoming available.	Lead: Businesses and third sector Note potential collaboration with public sector.	Short to medium-term
SLES / community energy	Develop public sector decarbonisation projects (e.g. buildings retrofit, low carbon heating, renewable electricity generation) ahead of new rounds of funding becoming available.	Lead: Public sector Note potential collaboration with private sector and third sector.	Short to medium-term
SLES / community energy	Apply lessons learnt from other local authorities which have worked with community energy organisations on renewable energy projects (e.g. overcoming procurement challenges). Explore local / shared ownership models.	Lead: GMW, LA	Short-term
SLES / community energy	Explore options to enable smart local energy systems through power purchase agreement or local energy markets	Lead: GMW, LA	Short to medium-term
SLES / community energy	Work collaboratively to unlock barriers facing community energy organisations (e.g. finance, resource).	Lead: GMW, LA Support: Community energy organisations, Community Energy Wales, WGES, Ynni Cymru	Short to medium-term
Large-scale renewable energy	Engage with communities to explore options for strategic use of community benefit funds (e.g. community hubs) to provide regular income for communities to invest in projects locally (e.g. fabric upgrades).	Lead: LA	Short to medium-term
Large-scale renewable energy	Explore opportunities for local authorities to invest in large-scale renewable energy projects (i.e. full ownership or shared ownership).	Lead: LA	Medium-term

Category	Action	Who?	When?
Skills	Use the outputs of the LAEP to inform the Net Zero Wales Skills Plan and link to the ongoing mapping work of Wales Retrofit Supply Chain.	Lead: Welsh Government Support: GMW, RSP	Short to medium-term
Skills	Use the outputs of the LAEP to inform the Regional Skills Partnership's work plan to address skills gap in Mid Wales.	Lead: GMW, RSP Support: Training providers, Welsh Government	Short to medium-term
Skills	Determine what rate of retrofit is achievable with current local trade capacity, and whether the 2030 carbon target can be met.	Lead: GMW, RSP Support: Welsh Government	Short to medium-term
Skills	Increase the net zero skills training provision with support from Welsh Government.	Lead: Training providers Support: Welsh Gov, RSP, DNOs	Medium-term
Skills	Communicate the career opportunities of the energy transition to young people	Lead: Training providers Support: Welsh Gov, RSP	Medium-term
Transport	Work with Regional Transport Lead to embed the findings of the LAEPs around public transport and active travel infrastructure into the Regional Transport Plan and Local Transport Plans. Identify gaps in LAEP modelling where more detail is needed.	Lead: GMW and LAs	Short to medium-term
Transport	Determine an approach to permit installation of residential on-street vehicle charging (e.g. gullies in pavement).	Lead: Welsh Government, TfW Support: LAs, GMW	Short-term
Transport	Publish EV charge point procurement framework.	Lead: Welsh Government, TfW Support: LAs, GMW	Short-term
Transport	Review LAEPs outputs against local EV strategies.	Lead: GMW and LAs	Short-term
Transport	Identify further locations for EV charging infrastructure best suited for public investment.	Lead: LAs Support: Charge point operators	Short to medium-term
Transport	Identify further locations for EV charging infrastructure best suited for private investment (e.g. commercial freight routes).	Lead: TfW, businesses Support: Charge point operators, LAs, GMW	Short to medium-term
Transport	Install public and residential charging hubs for electric vehicles. See Public EV Chargers in Cardigan priority project.	Lead: LAs Support: Welsh Government, WGES	Short to medium-term
Transport	Explore public transport demonstrator projects (e.g. hydrogen and battery electric buses).	Lead: LAs, GMW, TfW Support: Welsh Government, WGES	Long-term
Transport	Explore commercial and agricultural transport demonstrator projects (e.g. hydrogen / battery agricultural vehicles, HGVs).	Lead: Welsh Government, GMW, TfW, Businesses	Medium to long-term

Category	Action	Who?	When?
Industry, commercial and agricultural sectors	Develop a more detailed understanding of agricultural energy use, and investigate options to decarbonise (e.g. biogas from agricultural waste to fuel agricultural machinery).	Lead: GMW Support: Farmers unions	Medium to long-term
Industry, commercial and agricultural sectors	Bring stakeholders together to discuss innovative decarbonisation solutions, particularly targeting those with high temperature processes.	Lead: GMW and LAs Support: Farmers unions, businesses	Medium to long-term
Financial / technical support	Develop additional financial and technical decarbonisation support (e.g. for homeowners who are not eligible for existing schemes).	Lead: Welsh Government	Short to long-term (phased approach)
Financial / technical support	Raise awareness of the funding opportunities available for businesses, particularly focusing communication on those using oil for heating. Highlight funding gaps to Welsh and UK Government.	Lead: GMW and LAs	Short to medium-term
Financial / technical support	Raise awareness of the funding opportunities available to homeowners (e.g. Boiler Upgrade Scheme) to decarbonise particularly focusing communication on those using oil for heating.	Lead: GMW and LAs	Short to medium-term
Financial / technical support	Capacity building to de-mystify the net zero transition within the Local Authority.	Lead: LA	Medium to long-term
Financial / technical support	Through Climate Action Wales, continue to develop a communication strategy to de-mystify the net zero transition to businesses, landlords and homeowners (e.g. raise awareness of heat pumps).	Lead: Welsh Government	Short to long-term (phased approach)
Financial / technical support	Explore options to fund regional / local trusted decarbonisation advice (financial and technical) to homeowners and businesses.	Lead: GMW and LAs	Medium to long-term
Financial / technical support	Explore 'energy as a service' as an alternative to building owners paying for upgrades upfront.	Lead: Welsh Government	Short to medium-term
Financial / technical support	Raise awareness of industry accreditation for low carbon energy technology installations (e.g. MCS, TrustMark).	Lead: Welsh Government Support: LAs and GMW	Medium to long-term

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