Local Area Energy Plan

Bolton, Greater Manchester

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Context

Greater Manchester (GM) is committed to achieving carbon neutrality by 2038. To support this, it has a vision of each of its borough's transforming their infrastructure, homes and buildings to be part of a smarter local energy system. Recognising the climate emergency, national Net Zero* commitments and the need to translate the strategic vision to an implementable plan of action, Greater Manchester is supporting each borough in the development of a Local Area Energy Plan (LAEP).

This LAEP aims to define the extent of the transformation needed across each borough (including a focus on identifying first steps to progress),and provide a robust evidence base and plan to help engage businesses and citizens in accelerating towards the carbon neutral goal.

Local Area Energy Planning

Energy Systems Catapult (ESC) developed the concept of Local Area Energy Planning (LAEP) as a mechanism of applying a whole system approach to the planning and design of Net Zero Local Energy Systems.

The technologies and future trends considered and assessed for meeting Greater Manchester's carbon neutrality targets include: thermal insulation, heat pumps, district heating, electric resistive heating, hydrogen boilers, solar photovoltaics (PV), wind turbines, hydropower, electric vehicles (EVs), demand flexibility and energy storage

Scenarios for achieving Carbon Neutrality in Bolton

The two scenarios which have been more deeply analysed to inform this LAEP are:

- **Primary Scenario – Leading the Way:** this scenario focuses on meeting the carbon budget and carbon neutrality target by making use of **measures within Bolton's local control** where at all possible.
- **Secondary – An Alternative Future Local Energy Scenario:** this scenario assumes hydrogen for residential heating and non-domestic buildings becomes available in Bolton from 2030 onwards (aligned to HyNet Phase 3†), considering where it could be cost-effective to use hydrogen alongside the measures / technologies considered in the primary scenario. The quantity of hydrogen expected to be available under the HyNet plans would not be sufficient to allow all GM boroughs to pursue this option, therefore focus has been centred on prioritising where to target the use of hydrogen.

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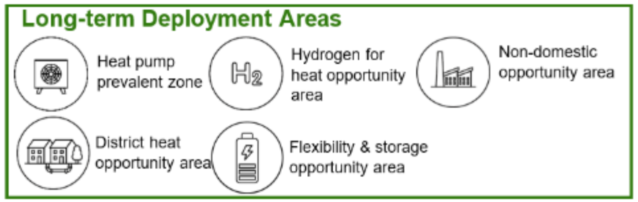
* Climate Change Act 2008 (2050 Target Amendment) Order 2019

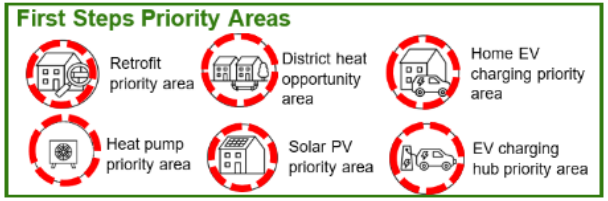
† HyNet North West is being delivered by a consortium of partners, each of which will lead a different part of the project. Progressive Energy is leading the development of the low carbon hydrogen production plant and the CO2 pipeline, while Cadent is leading development of the hydrogen pipeline

Local Priorities and Measures

Bolton has been geographically sub-divided into 8 zones for the purposes of assessment and to understand what is needed for decarbonisation at a more local level. The zones have been made along the 33-11kV substation boundaries, with each zone containing roughly equal numbers of dwellings.

This map shows the ‘First Steps Priority Areas’ and ‘Long Term Deployment Areas’ that have been identified for different areas within Bolton. This is based on a synthesis of the results from the two scenarios alongside other considerations such as network constraints.





1. INTRODUCTION

Context

Greater Manchester is committed to achieving carbon neutrality by 2038. To support this, it has a vision of each of its borough transforming their infrastructure, homes and buildings to be part of a smarter local energy system. Recognising the climate emergency, national Net Zero* commitments and the need to translate the strategic vision to an implementable plan of action, Greater Manchester is supporting each borough in the development of a Local Area Energy Plan. This aims to define the extent of the transformation needed across each borough (including a focus on identifying first steps to progress), provide a robust evidence based plan to help engage businesses and citizens in accelerating towards the carbon neutral goal.

Energy Systems Catapult developed the concept of Local Area Energy Planning (LAEP) as a mechanism of applying a whole system approach to the planning and design of Net Zero Local Energy Systems. Bury was one of the first Local Authorities in the country to work with Energy Systems Catapult, Electricity North West (ENWL) and Cadent in piloting a data-driven whole system approach in 2018. Since this initial pilot, Greater Manchester has launched its Five-Year Environment Plan, which includes a commitment to be carbon neutral† by 2038, and an accompanying science-based carbon budget. Alongside this, there have been significant updates to the supporting whole system modelling approach, including the latest technology attributes and costs, updated building data and network data, changes in EV uptake projections and more detail in options for decarbonising non-domestic buildings. The most significant update has been the addition of hydrogen in line with HyNet‡ projections, as an option that in certain scenarios can be used to decarbonise heat demand in domestic and non-domestic buildings. This is key as achieving carbon neutrality will require the transition of Bolton's heating systems from natural gas fired boilers to electrified heating systems, district heating networks or converting the gas network to hydrogen.

Modelling Approach

We have used the ESC-developed EnergyPath Networks tool to produce a series of future local energy scenarios for Bolton (these are discussed in the Technical Annex). This tool seeks to develop a full range of decarbonisation options for the local area and then use an optimisation approach to identify the combination that best meets the carbon ambitions in a cost-effective way across the whole system.

* Climate Change Act 2008 (2050 Target Amendment) Order 2019

† Carbon neutrality is defined by the Tyndall Institute's study for GM as below 0.6 Mt CO2/year across GM

‡ HyNet North West is being delivered by a consortium of partners, each of which will lead a different part of the project. Progressive Energy is leading the development of the low carbon hydrogen production plant and the CO2 pipeline, while Cadent is leading development of the hydrogen pipeline

For the impact of the energy system outside of the boundaries of Bolton, the national Energy System Modelling Environment (ESME) – an internationally peer-reviewed national whole energy system model – has been used to identify the lowest-cost decarbonisation scenarios for the UK energy system to then feed into the local modelling.

These national scenarios have been used to inform the development of a primary and secondary local scenario that illustrate two potential, but quite different, routes to achieve Greater Manchester's ambitions for carbon neutrality in Bolton. These explore the actions and investment needed in different areas of Bolton between now and 2038 to reduce its emissions. The scope of emissions in this plan covers those resulting from domestic, industrial and commercial consumption of electricity, gas and other fuels; home charging of personal electric cars; and process emissions from large industrial installations. Out-of-scope are emissions from agriculture, all usage of liquid fuels for transportation, and electricity use for vehicles other than personal cars.

It should be noted that techno-economic optimisations (i.e. the scenarios that have been considered and modelled) are imperfect. Many low carbon solutions have benefits and drawbacks that cannot be easily represented in modelling approaches. This appreciation has been used to shape the LAEP; however, as the LAEP is taken forward, new significant insight may result in a requirement to update this LAEP.

Scenarios for achieving Carbon Neutrality in Bolton

A core aspect of the analysis has been the consideration of resulting emissions from the gas and electricity required to serve domestic, commercial, industrial and public sector energy demands, including the impacts heating system and building fabric changes within the modelled scenarios, and how these relate to the GM carbon budget. This has strongly influenced the creation of this LAEP, recognising the need to cut emissions rapidly.

The two scenarios which have been more deeply analysed to inform this LAEP are:

- **Primary Scenario – GM Leading the Way:** this scenario focuses on meeting the carbon budget and carbon neutrality target by making use of **measures within Bolton's local control** where at all possible.
- **Secondary – An Alternative Future Local Energy Scenario:** this scenario assumes hydrogen for residential heating and non-domestic buildings becomes available in Bolton from 2030 onwards (aligned to HyNet Phase 3[*]), considering where it could be cost-effective to use hydrogen alongside the measures / technologies considered in the primary scenario. The quantity of hydrogen expected to be available under the HyNet plans would not be sufficient to allow all GM boroughs to pursue this option; therefore, focus has been centred on prioritising where to target the use of hydrogen[†].

[*] HyNet North West is being delivered by a consortium of partners, each of which will lead a different part of the project. Progressive Energy is leading the development of the low carbon hydrogen production plant and the CO2 pipeline, while Cadent is leading development of the hydrogen pipeline

[†] Cadent's Greater Manchester decarbonisation pathway report anticipates a proportion of homes being met by electric heat pumps out to 2038.

Once plans for all local authorities are complete, then total remaining emissions can be compared against the carbon neutrality target at a GM level; subsequent consideration will be required to determine how these remaining emissions are decarbonised. Of note, the scope of modelling completed does not include all the transport emissions included within the scope of the GM carbon budget, but these will be considered when the plans for all ten local authorities are analysed centrally at a GM level.

The modelled scenarios explore uncertainties, considering implications of different choices and behaviours by policy makers, businesses and individuals, the development and take up of technologies and the balance between different options, where they exist. Within the scenarios, the key technologies that are likely to be important in cost effective local system designs have been considered, as well as some that are more expensive but may have popular support. Technologies that consistently appear regardless of scenario and warrant prioritisation in preparing for transition; this approach has led to the identification of the priority and opportunity areas within this LAEP.

Conclusions from the scenario analysis have been used to develop this LAEP. This represents a point-in-time plan of intent, as the basis for Bolton taking important implementation steps over the next 5 years to engage industry and businesses, build momentum around a shared plan and support the identification and creation of opportunities for smarter local energy systems. Progressing this LAEP can help to realise the potential of a local energy market for GM and support meaningful action and progress on reducing emissions.

Both the primary and secondary scenarios make assumptions around changes to behaviour, advances in technology and innovation whilst recognising uncertainty in key areas such as the potential use of hydrogen for transport and heating in homes and buildings, as well as advances in energy storage and controls. While it is not a prescriptive plan to be followed exactly, it does provide a detailed spatial evidence base and supporting data that can be used to inform the planning and coordination of activity in Bolton over the coming years. Where hydrogen for building heating does become available (as per the secondary scenario), it is expected that all the components within the primary scenario (heat pumps, district heating, solar PV, EV charging, building fabric retrofit and flexibility and storage systems) will still be needed to decarbonise Bolton; any uncertainty is generally around the scale of deployment. Therefore, it is deemed low risk to demonstrate how to deploy these components and prepare for significant scale-up whilst assessing whether HyNet will be able to cost-effectively provide zero carbon hydrogen, across GM in-line with projections.

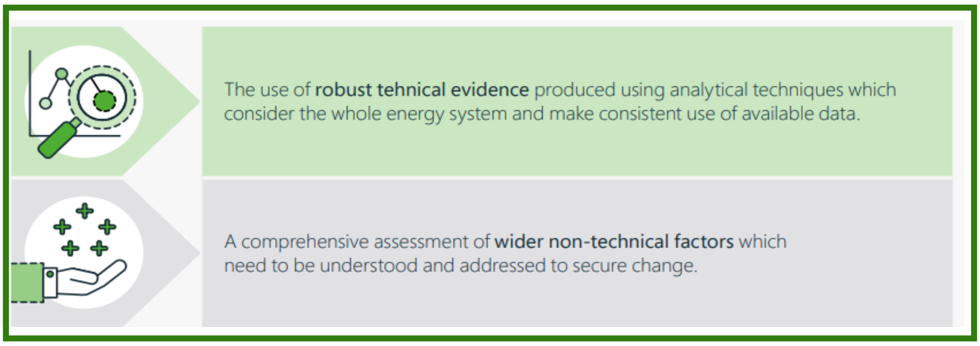
In addition, as the secondary scenario has a lower modelled cost (£8.2 bn compared to £8.5bn for the primary scenario), there is a need to make major decisions that consider the many associated advantages and disadvantages of each option; however, waiting until there is certainty would be too risky, reinforcing the need to commence demonstration in the identified priority areas. Furthermore, there may be a need to prioritize hydrogen supply in the region, therefore regional energy planning will be needed once the picture becomes clearer and all LAEPs for each GM borough are in place. Projects such as the Greenworks support this endeavor.

In summary, the scenarios have been developed in response to the science-based carbon budget for GM: defining a credible plan for Bolton, based on currently deployable technologies, to support an understanding of the actions, pace and scale of change as well as the investment needed. Insights from the scenarios that consider the role of hydrogen (in decarbonising domestic and non-domestic buildings), including aligning with the timeline for phase 3 of the HyNet project (which envisages low carbon hydrogen becoming available at scale from the early 2030s), have been used to set out heat decarbonisation priority areas. The scenarios also seek to understand the costs, benefits, uncertainties, opportunities and risks to decarbonisation by 2038 that a hydrogen-based approach would bring. Combining the insight from these scenarios informs the plan for Bolton.

This LAEP has also considered previous studies including the Decarbonisation Pathway for Greater Manchester study completed in 2020 by Navigant on behalf of Cadent Gas and Electricity North West* and is generally aligned to the latest guidance on Local Area Energy Planning developed with Ofgem, the ambitions of Greater Manchester and wider UK Net Zero commitments.

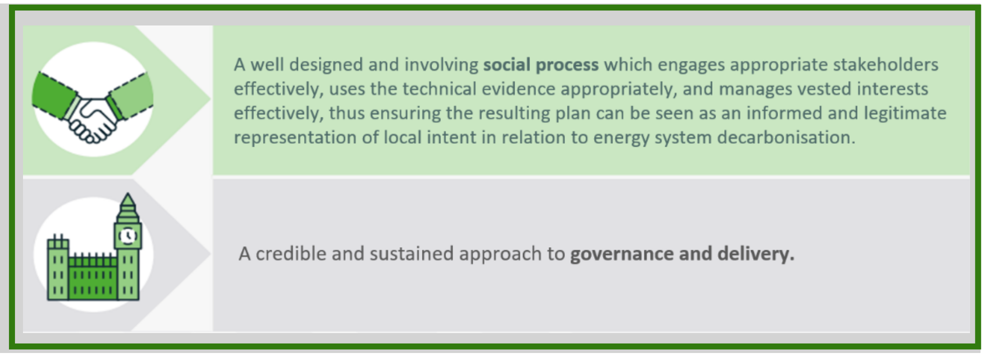
In accordance with the Ofgem LAEP Method†, which provides guidance and framework for LAEP done well, this plan has been developed through the use of robust technical evidence which considers the whole energy system for Bolton and consistent use of available data and assumptions.

It has also sought to consider wider non-technical factors which influence the deliverability, pace and scale of change required for decarbonisation.



The next steps of the development of the plan are expected to comprise wider stakeholder and public consultation on the plan to inform its further development, as well as the approach of both Greater Manchester and Bolton in its ongoing governance and delivery.

* Decarbonisation Pathway for Greater Manchester, Reaching carbon-neutrality in a balanced scenario by 2038, Navigant, July 2020
† From LAEP: The method https://es.catapult.org.uk/reports/local-area-energy-planning-the-method/



The approach differs from the Ofgem methodology where it has taken advantage of the data and engagement available at the Greater Manchester Combined Authority level, streamlining the approach and reducing the need for separate processes with each local authority.

Report Structure

The report is set out in the following structure. It summarises the key aspects of the plan and its supporting modelling and analysis and is presented in nine chapters, supported by an accompanying technical annex.

Chapter 1: (this chapter) sets out the context and the approach taken to modelling, developing the scenarios and supporting technical evidence and associated assumptions and limitations and relevant supporting information

Chapter 2: sets out the vision and primary scenario to carbon neutrality for Bolton, informed by the scenario analysis. The primary scenario demonstrates how Bolton could meet Greater Manchester's decarbonisation ambitions across each of its key areas by 2038 in a practical way. A series of first steps is also presented that focus on demonstration and scale-up of some of the key components that will be needed to decarbonise Bolton.

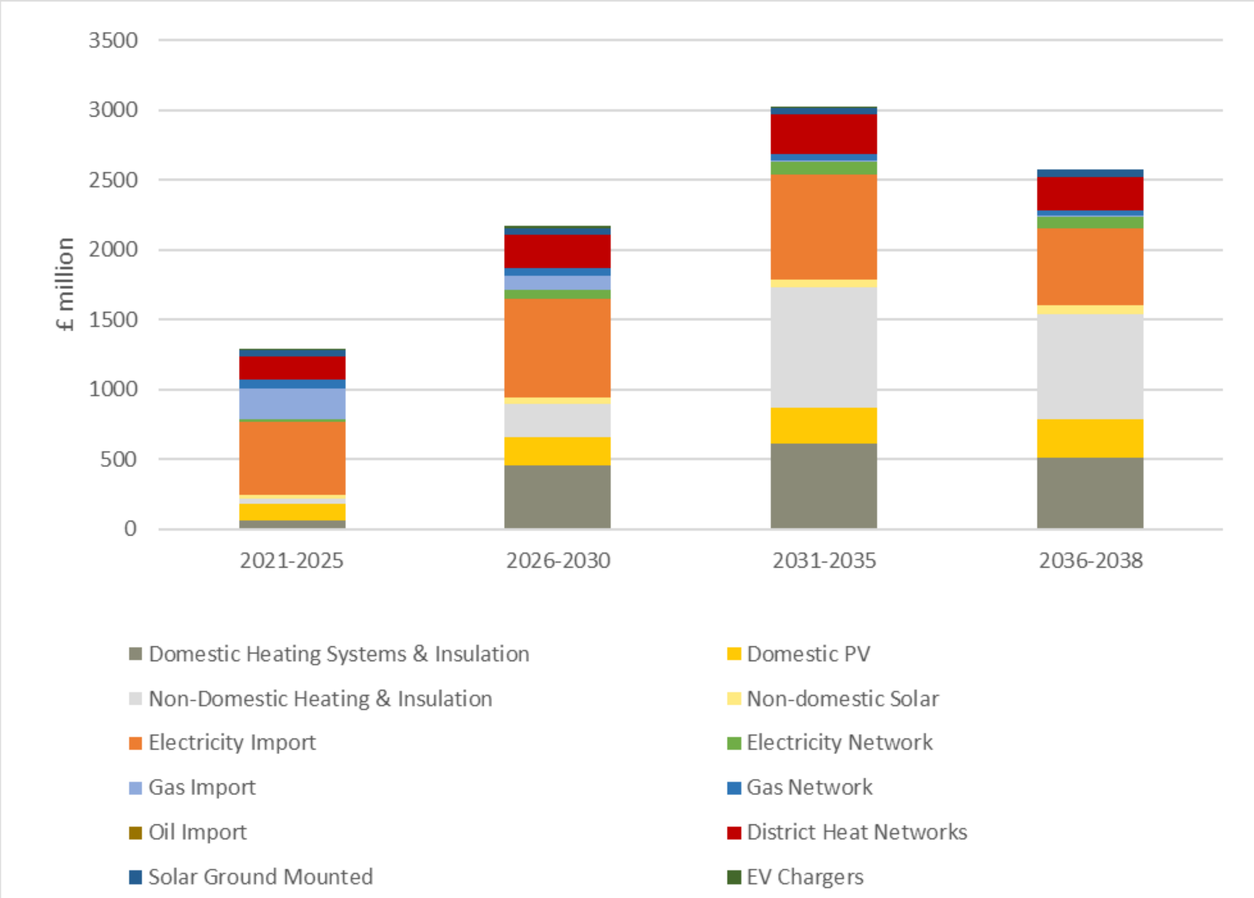
Chapters 3-7: set out some of the key aspects of the primary scenario and what this means in relation to implementation for Bolton including Fabric Retrofit (Chapter 3), Heating System Zones (Chapter 4), EV charging and infrastructure (Chapter 5), Local Energy Generation and Storage (Chapter 6), and Energy Networks including electricity, gas and heat (Chapter 7). They also consider key uncertainties and dependencies informed by the wider scenario analysis and specific areas of investigation

Chapter 8: sets out the estimated system costs and investment needed for implementation of the primary scenario. This includes definition of the total system costs between now and 2038 across different areas of Bolton, the capital investment at key time steps in infrastructure and key technologies within the scope of the analysis.

Chapter 9: summarises the key findings and recommended actions to support implementation and ongoing review and monitoring in the context of national and regional energy strategy, carbon budgets and associated policy and regulation.

This Local Area Energy Plan (LAEP) aims to support Bolton to transition to an affordable and decarbonised energy system and to support the delivery of Greater Manchester's (GM) commitment to carbon neutrality by 2038.

CapEx and Energy Costs Over Time



Decarbonising Bolton's local energy system by 2038 is achievable and expected to require capital investment of between £5.1 bn (secondary) and £6.2 bn (primary). This relies heavily on the assumptions of hydrogen price, which are very uncertain at this stage as well as the actual availability of hydrogen, of which the time frame is also very uncertain. Total energy costs including capital investments, operations and energy consumed is between £7.8 bn (secondary[*]) and £9 bn (primary) to 2038. The upper chart illustrates the breakdown of this expenditure over time for different components (for the primary scenario). The lower chart shows how implementing the transition reduces carbon emissions[†].

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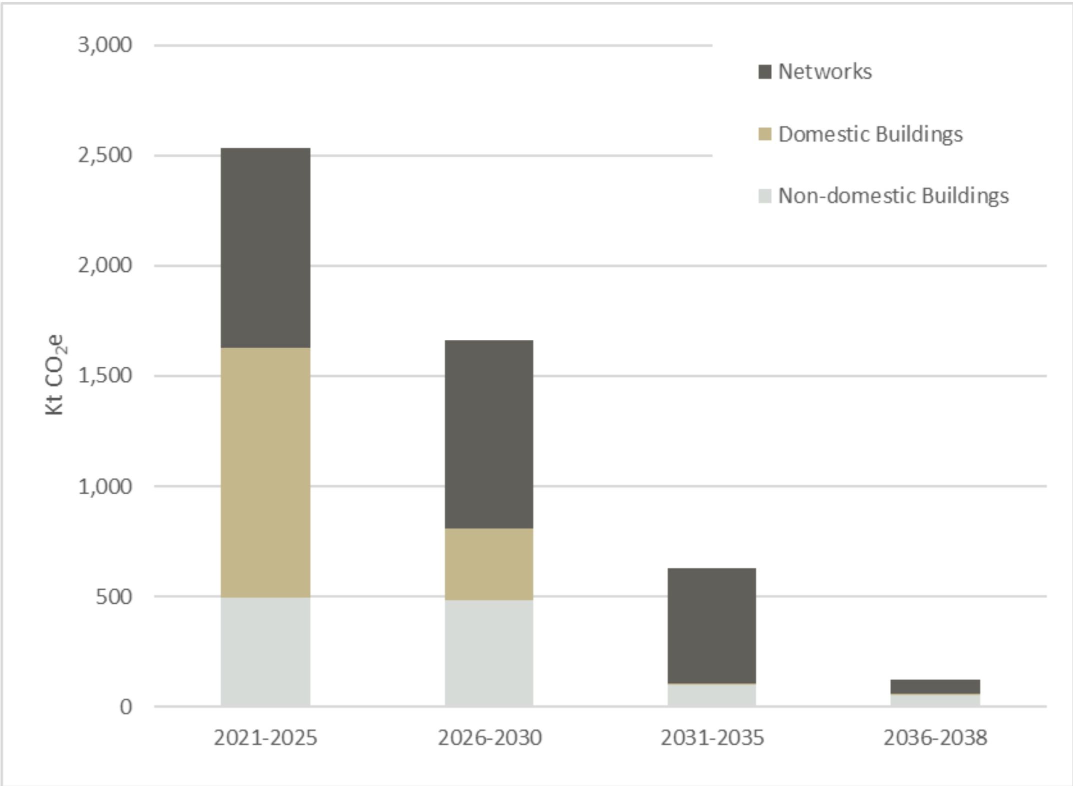
[*] Energy costs associated with hydrogen is very sensitive to actual hydrogen price, which is highly uncertain at this stage

[†] In-scope emissions are those resulting from domestic, industrial, and commercial consumption of electricity, gas & other fuels, electric vehicle charging and process emissions from large industrial installations. Out-of-scope are emissions from agriculture and existing liquid fuels for transportation.

With a variation (£1.2.bn) in total projected system cost between the two scenarios, progress on wider national energy planning and policy decisions would be needed, recognising the current uncertainty (regarding the UK's heat decarbonisation strategy) associated with selecting a preference. In addition, regional (Greater Manchester) collaboration, should be pursued to consider a GM wide approach, recognising that major decisions do not stop at a local authority boundary, for example, it may be preferential to prioritise the use of hydrogen in targeted areas of GM. Regional collaboration also provides the opportunity to ensure a complete LAEP process is undertaken, where key regional stakeholders (including Cadent and Electricity North West) should support the evaluation and decision making process.

CO2 Emissions Over Time



The cumulative emissions over the period 2021-2038 in the primary scenario are 4.9 Mt of CO_2e (from a range of 4.8 to 6.1 Mt across the scenarios assessed), of which 2.3 Mt is due to grid electricity consumption*.

How to Interpret this Vision

This transition will involve the greatest infrastructure change across Bolton and Greater Manchester for decades; key sections of this LAEP illustrate the scale of change and investment needed, based on a primary scenario. An alternative scenario (secondary),

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* Based on current forecasts for electricity grid decarbonisation. If the rate of grid decarbonisation accelerates in line with the UK's recent commitment in the Net Zero Strategy to reduce emissions by 80-85% by 2035, grid intensity could reach nearly zero emissions by 2035, eliminating most of the remaining emissions in this plan.

incorporating the use of hydrogen for heat, is also presented on page 18 (along with other variations within the appendix), where the supporting analysis indicates that hydrogen could have an important role in decarbonising Bolton. Unless explicitly stated otherwise, quoted values in this report will refer to the primary scenario. Given the significance of backing one view of the future (or scenario) now, the LAEP promotes a demonstration and scale-up approach over the coming years to 2025, before moving to full scale implementation. Therefore, this LAEP identifies several 'priority areas' to build capacity and test approaches, across different components, for working with Bolton's citizens and stakeholders. Insights from the alternative scenarios have been used to produce these priority areas. It is expected that this LAEP may need to be updated as lessons are learnt and uncertainties (such as UK policy regarding the decarbonisation of heat) become clearer.

Fabric Retrofit

As much as **71% of Bolton's dwellings receive insulation retrofit** in the plan: around **97,000** in the primary scenario, or 98,000 in the hydrogen focused secondary scenario. A greater number of these retrofits are deep retrofits in the secondary scenario (around 4000 more of Bolton's homes) to enable the earlier decarbonisation required to meet carbon budgets due to the late availability of low carbon hydrogen in 2030 relative to these targets. Fabric retrofit and solar PV are low regret measures to progress in the short-term.

Three heating options are explored to decarbonise buildings: electric heating (primarily heat pumps), hydrogen to replace natural gas, and district heat networks. For hydrogen to play a significant heat decarbonisation role, certainty would be required that hydrogen will be available to supply Bolton in a timeframe that supports the delivery of the GM carbon budget; this key decision point will need to be made c.2025, primarily based on the role hydrogen will play in providing heat to buildings. Alternatively, almost 103,000 heat pumps are deployed for most dwellings. District heating systems have been proposed in residential areas, with zone 4 and 5 receiving large amounts and some in zone 7. The heat network expands on the existing planned Bolton Town Centre Heat network, including more residents.

The combined cost of fabric retrofit and heating system replacement is £1.6 bn for homes, and £1.9 bn for non-domestic buildings. The delivery of any option presents comparable challenges and risks, resulting in the need to focus on the demonstration and scale-up approach advocated.

Energy Generation & Networks

To reduce emissions in line with the GM carbon budget, local energy generation would need to increase significantly, consisting predominantly of the installation of solar PV on much of the available roof space across all parts of Bolton (under all scenarios considered), providing up to 733 MWp of installed capacity, at a cost of £1 bn. Further work is required to understand how achievable and effective this substantial provision of electricity through rooftop solar PV is when taking into account wider system implications (p.62 providing some associated considerations).

Land in the area has been identified for opportunities to deploy up to 479 MWp ground mount solar PV for further CO_2 reduction. These solar farms will likely be connected into the transmission network; how this deployment of PV will impact the need for electricity network reinforcement will need to be explored as the modelling in this report is focussed on the effects of demand and generation change within the local distribution network.

Under the primary scenario, the electricity network would require capacity reinforcements of substations and underground feeders to accommodate electrification, at an estimated cost of £262m. A significant proportion of this is attributed to the peak demands of the large numbers of proposed heat pumps. Further work would be required, under this high electrification scenario, to determine the most cost-effective approach for providing this additional capacity.

EV Infrastructure

The transition to electric vehicles, with uptake increasing from around 5,000 electric and plug-in vehicles today to almost 118,000 by 2038, drives a demand for EV chargers to be installed across all areas. Around 46,000* domestic chargers would need to be installed (one for every home with potential for off-street parking) at a cost of £26m, along with multiple public charging stations (or hubs); areas where fewer car owning households have potential for off-street parking rely more on public charging hubs.

* Based on ESC in-house analysis of EV uptake. Quantities will need to be aligned with local planning policies as it relates to provision of chargers in new developments and existing dwellings.

Consumer Uptake

By the early 2030s all new cars and vans, and all boiler replacements in dwellings and other buildings in Bolton are low carbon; the vast majority of heating systems are either electrified or use hydrogen. Between 23,000 and 103,000 of Bolton's dwellings are fitted with a form of heat pump, and up to 102,000 boilers could be running from 100% hydrogen. By 2038, nearly 85% of cars are electric vehicles or plug-in hybrids, requiring the provision of ~46,000 electric vehicle charging points for homes with potential for off-street parking, as well as electric vehicle charging hubs for areas of terraced homes and destinations such as offices and shopping centres. By 2035 commercial and industrial activities in Bolton largely shift to using renewable electricity, district heating or hydrogen instead of fossil fuels; carbon capture may be required to reduce remaining emissions.

Low-carbon energy supplied to and generated in Bolton

The emissions intensity of UK electricity production is expected to fall by at least 65% from today's levels by 2035*. By then, offshore wind would contribute a significant source of renewable electricity generation nationally. Renewable electricity production in Bolton increases to contribute to the GM carbon budget, predominantly in the form of up to 733 MWp of rooftop solar PV, with opportunity for a further 479 MWp ground mounted solar PV across Bolton. Renewable generation (if the ground mounted PV potential is maximised), provides up to 1,277 GWh annually (50%), with 1,301 GWh (50%) of electricity supplied from the grid. This scale of solar PV is an ambitious aspiration and requires further detailed consideration; for example, from a network capacity perspective it may not be the optimal place to locate generation. However, with the 2038 target and GM carbon budget influence, solar PV could provide low carbon electricity earlier than the grid is expected to, assuming that significant deployment can be achieved.

The low carbon electricity is used in heating, industry and vehicle charging, approximately doubling electricity demand over the next 15 years. Total electricity consumption is expected to increase by 107% by 2038 in the primary scenario and by 73% by 2038 in the secondary scenario.

Low-carbon hydrogen is likely to be prioritised nationally for the hardest-to-decarbonise sectors such as shipping, heavy transport fuel and energy intensive industry, and therefore the quantity that will be available for building heating is uncertain. However, HyNet is a project which aims to pioneer low carbon hydrogen production, potentially making it available to buildings in the region by 2030. Greater Manchester has a carbon budget that requires immediate action to stay within, and so any delay to HyNet could make it too late to keep within the carbon budget. However, hydrogen may have a significant role to play in combination with other technologies. This has been explored in some of the further scenarios. The similarities across scenarios point to low regret opportunities for heating system options in each area of Bolton and areas where hydrogen deployment is most likely.

* Based on current forecasts for electricity grid decarbonisation. If the rate of grid decarbonisation accelerates in line with the UK's recent commitment to reduce emissions by 78% by 2035, grid intensity could reach nearly zero emissions by 2035, eliminating most of the remaining emissions in this plan.

Reducing demand for carbon-intensive fuels

Buildings will lose less energy thanks to a series of targeted fabric retrofit programmes, improving insulation and efficiency across Bolton. Fabric retrofit will prepare buildings for low carbon heating, whilst also making a notable contribution to staying within the carbon budget. By 2038, between 97,000 and 98,400 of Bolton's 139,000 dwellings are retrofitted in the plan (c 70%), of which there is a reasonably even split between basic fabric retrofit and deep retrofits. The option of deeper fabric retrofit has the potential to increase headroom in the carbon budget to give some flexibility for deferring decisions on heating systems.

In the hydrogen scenario, heat pump deployment reduces significantly from 102,000 in the primary scenario down to 23,000. This results in providing some of the basis for target areas for priority deployment of heat pumps; i.e. where it could still be cost-effective to use heat pumps when hydrogen is available.

Energy Networks

There is already in place a proposal for a heat network in Bolton, The Bolton Town Centre Heat Network which would connect several social housing buildings, some council and public sector assets and some private sector including planned development sites around the town centre. The proposed modelling has expanded this network to include a larger number of residential buildings, with some (c. 6%) non-residential buildings.

Annual electricity demand is forecasted to increase from 1,244 GWh to 2,578 GWh by 2038, due to electrified heat and electric vehicle charging. This requires an increase in electricity network capacity, with the greatest network reinforcement requirement in zone 3 and zone 4, though opportunities to consider using flexibility, storage (or other alternative measures) in place of grid reinforcements are highlighted in the provided opportunity areas (see map on p.25).

Depending on the conversion and roll-out of hydrogen for heat, gas networks remain in place in some areas to support some hard-to-decarbonise non-domestic buildings that may not be of the scale to have a dedicated hydrogen connection. However, should HyNet phase 3 be available, up to 102,000 homes could be supplied by hydrogen by 2038, at a 13.3% lower overall total system (CapEx and Opex inc. energy costs) cost[*] and very similar levels of emissions.

[*] Based on the Hynet projections

Investment

Bolton's transition requires a total energy system and building level investment of £6.2 bn (excluding energy costs). This unprecedented level of investment provides a once in a lifetime opportunity for Bolton. Urgent focus will be needed to determine how to maximise the local benefit from this opportunity, considering how to develop the local supply chains and skills needed to enable the transition and provide new, green, local jobs.

Local Opportunities

This LAEP provides a vision for a carbon neutral Bolton. How it is delivered will influence the local benefit to Bolton, in addition to job creation. For example, there will be opportunities for local/community initiatives to provide components of the future energy system.

Smart local energy systems could be used to provide EV charging hubs, renewable energy generation, communal or locally owned heat networks, energy storage systems, smart/flexible energy systems to avoid electricity network reinforcement or any combination of these or other measures. Greater Manchester is working with partners in developing a Local Energy Market to support the implementation of such solutions through new business models, customer propositions and a trading platform.

Local Impact and Risks

Without changes to national policy, wider energy market reforms or the introduction of new support mechanisms, household energy bills are forecasted to increase, predominantly as heating homes through electricity is more expensive than using gas. However, the proposed investments in building retrofit will help to mitigate this and consideration will be needed to target measures at homes with the most need. Consideration is also needed to determine how to fund an average household investment of £13,800 (CapEX) for the associated measures.

An electric or heat network focused heat transition, involving changes to building fabric and internal heating systems (e.g., changes to doors, windows, larger radiators, and improved controls) could be more disruptive to residents and it is not clear how this might compare with disruption associated with using hydrogen for home heating[*], where extensive fabric retrofit would also be required to provide emissions reductions aligned to the carbon budget. In either case, compelling consumer propositions would be needed to facilitate it. With extremely challenging rates of deployment, there is an urgent need to scale up and develop skills and supply chains. Moving to an electrified heating future also presents a risk of backing a technology 'winner' before national decisions are made on heat strategy. Targeting specific areas and housing types most likely to be suited to electric heating and demonstrating effectively clustered transitions in Bolton and GM more widely can build knowledge and evidence for policy decisions as well as industry supply chains, making meaningful progress on emissions reduction. Finally, there is a risk that the economic and social benefit may not be captured locally, therefore consideration of how to maximise the opportunity is essential.

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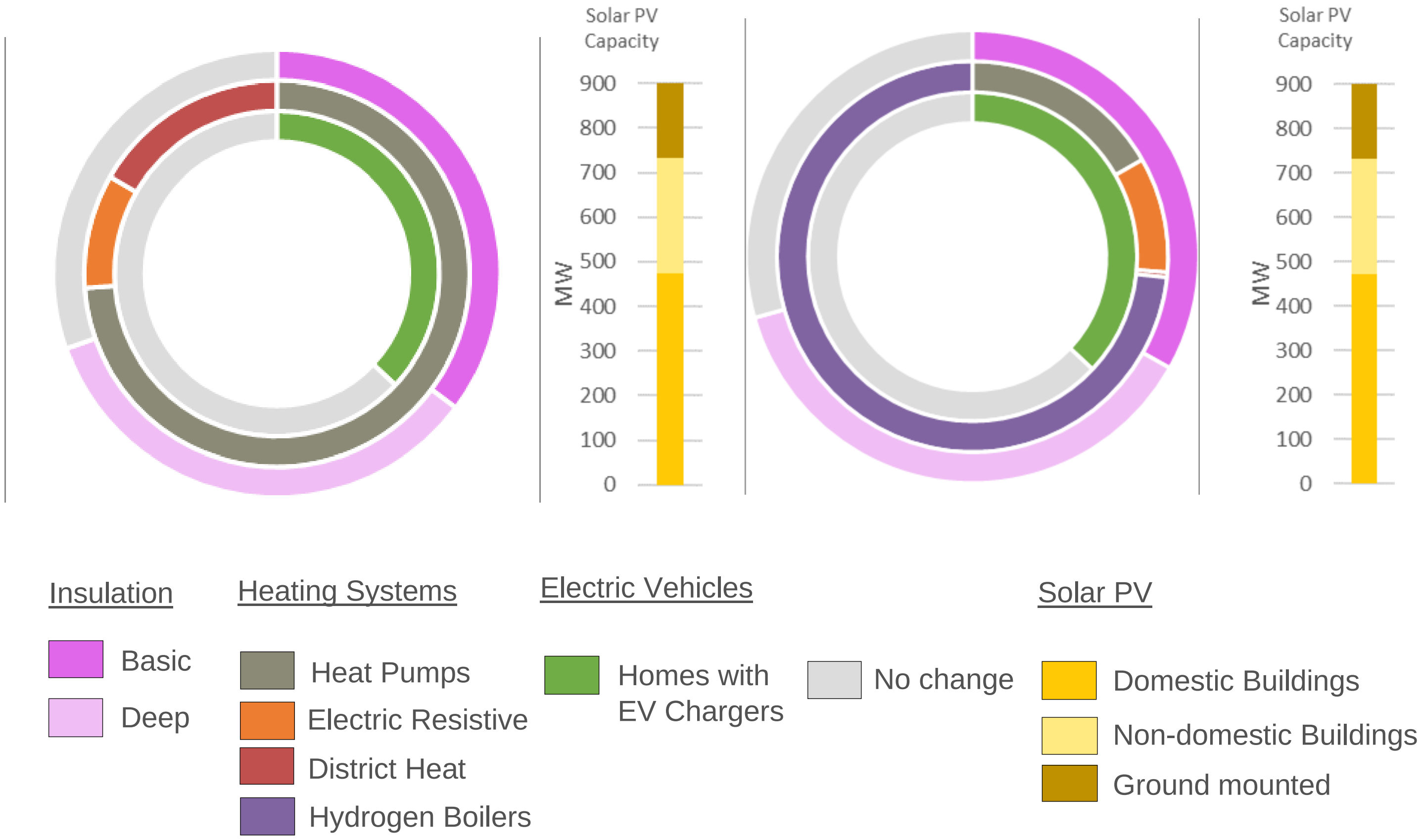
[*] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760508/hydrogen-logistics.pdf

What Bolton's transition to carbon neutral could look like

The charts below illustrate the scale of change needed to decarbonise Bolton in each scenario; the coloured portion of the rings indicating the proportion of homes that receive measures (the grey parts representing homes with no change). This is intended to illustrate the scale of measures and investment needed to the stakeholders who will support and deliver Bolton's transition.

System Changes by 2038 in Primary Scenario (left) and Secondary Scenario (right)



The primary scenario to 2038 is most suitable if uncertainty remains around converting the gas grid to zero carbon hydrogen (at an acceptable cost) by the mid to late 2020s. It is around this time that it would be deemed too late to rely on hydrogen for heat to meet the Greater Manchester science-based carbon budget, recognising the timescales needed to carry out widescale infrastructure and building investment and adaptation.

This secondary scenario illustrates an alternative future where hydrogen becomes widely available for heating and hot water in buildings from 2030, in accordance with the aspirations of HyNet phase 3. These graphs show some of the key differences in investment and installation between the primary and secondary scenarios. Total costs vary within 13.3% between the two scenarios – see section 8 for full cost details.

The availability of hydrogen for home heating in the secondary scenario does avoid some of the investment in electricity networks, investment for repurposing the gas network to distribute hydrogen is still needed. The need to invest in building retrofit is similar to the primary scenario, as both scenarios require large quantities of fabric retrofit measures to meet the carbon budget. Most of the cost savings are due to less expensive heating systems installed in buildings (hydrogen boilers rather than heat pumps), and lower energy costs compared to electricity. This energy cost saving is very sensitive to actual hydrogen price, which is highly uncertain at this stage.

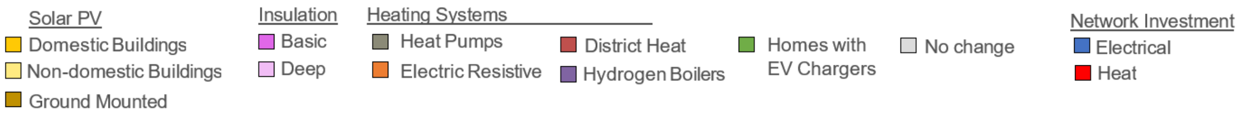
While the secondary scenario is found to cost less overall, the focus throughout this report is on the primary scenario. The understanding of the HyNet plans is that insufficient volumes of hydrogen would be produced in the timescale required for all of Greater Manchester to follow a hydrogen based decarbonisation pathway, so this LAEP assumes that available hydrogen is likely to be prioritised for boroughs with substantial industrial requirements[*] This assumption would need to be considered further with relevant stakeholders such as GMCA and Cadent. The secondary pathway is included for illustration of a future where progress on hydrogen occurs faster than expected, for example due to strong backing from national energy policy. Priority areas for hydrogen use within Bolton are also presented to give options for limited supply or later decisions in these areas. Further work with Cadent to understand realistic availability and timescales can help inform the scenario focus as this plan is updated going forward.

Both scenarios include a similar amount of roof and ground mounted solar PV, required in both cases to provide early emissions reduction to support the carbon budget. EV related aspects are consistent across both scenarios.

The primary scenario is broken down by zone on the following pages to give a detailed impression of the distribution of works and investment geographically.

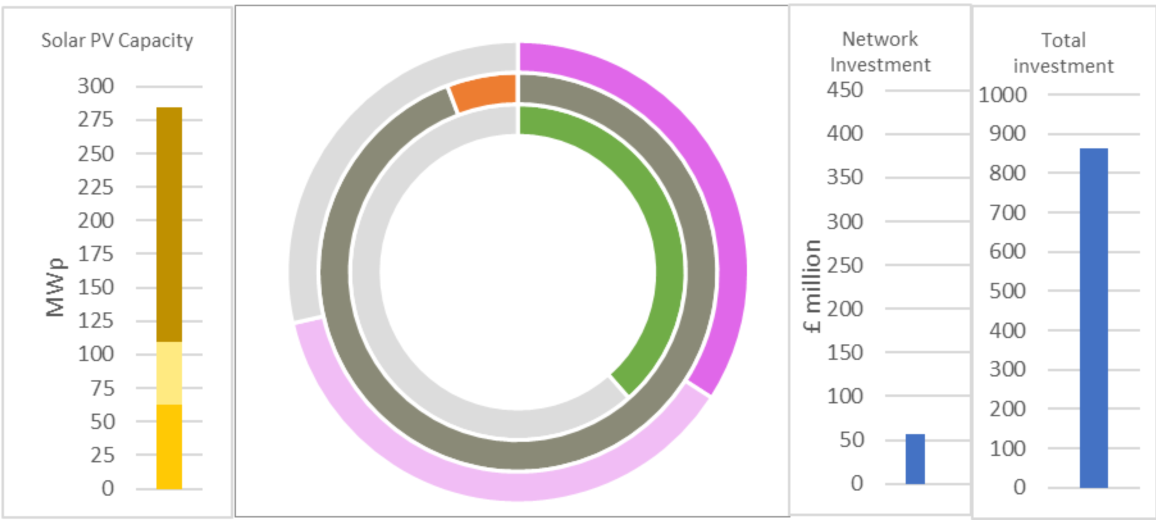
[*] Cadent's Greater Manchester decarbonisation pathway report anticipates a proportion of homes being met by electric heat pumps out to 2038 as well as a cluster-based approach of converting discrete sections of the gas network to 100% hydrogen starting with sections of the gas grid heavily relied on by industry.

2. THE VISION – BREAKDOWN OF PRIMARY SCENARIO BY ZONE

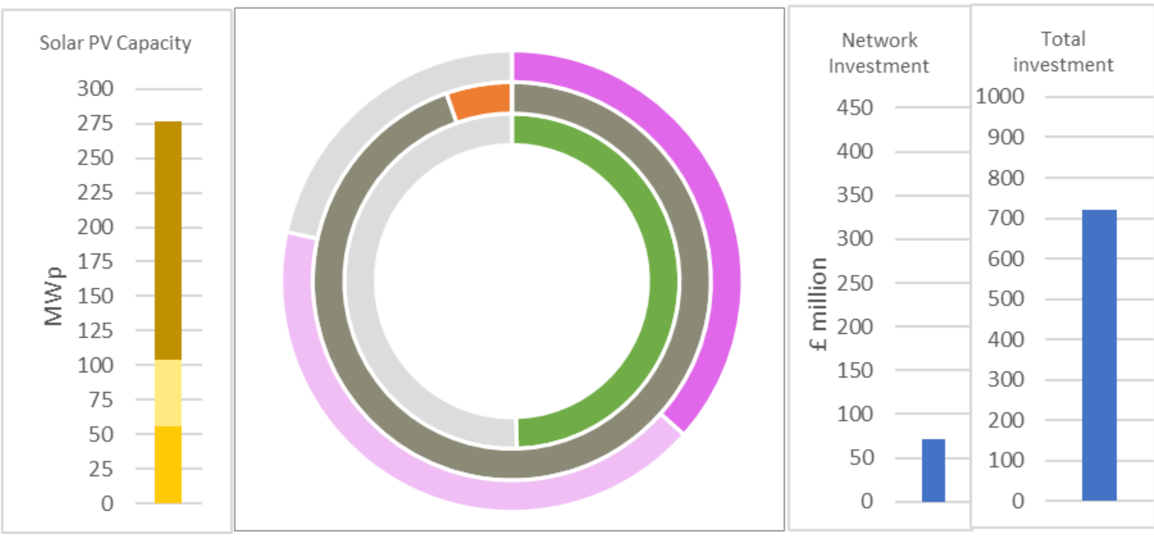


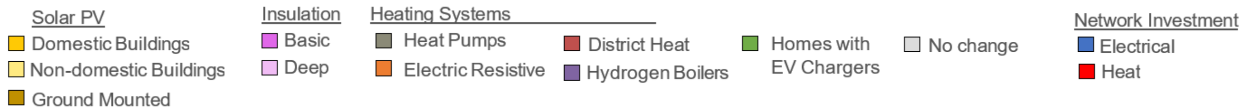
The coloured portion of the rings indicates the proportion of homes that receive measures (the grey parts representing homes with no change).

Zone 1

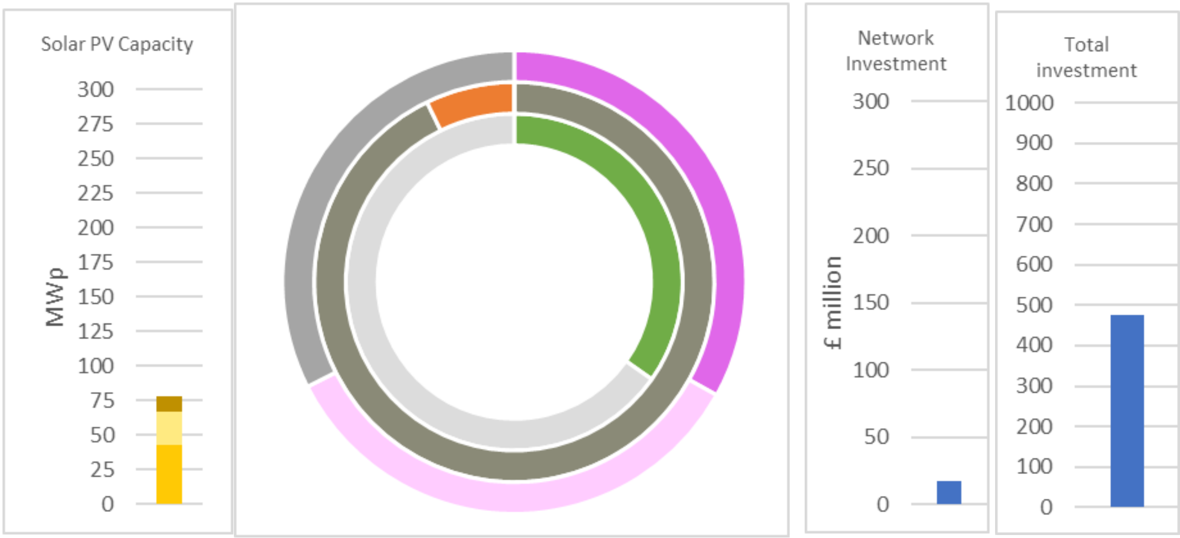


Zone 2

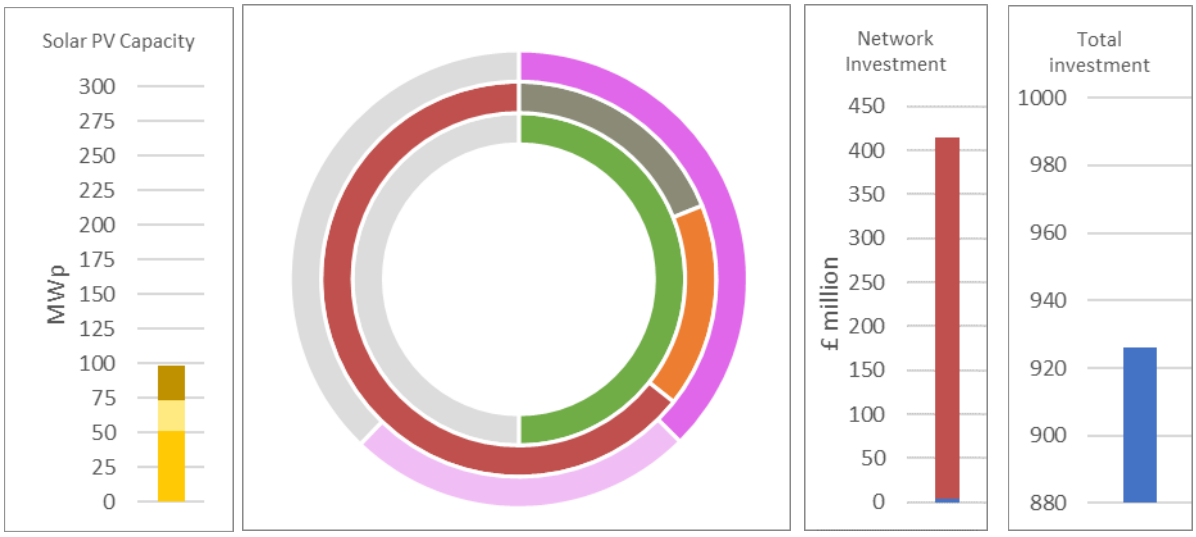




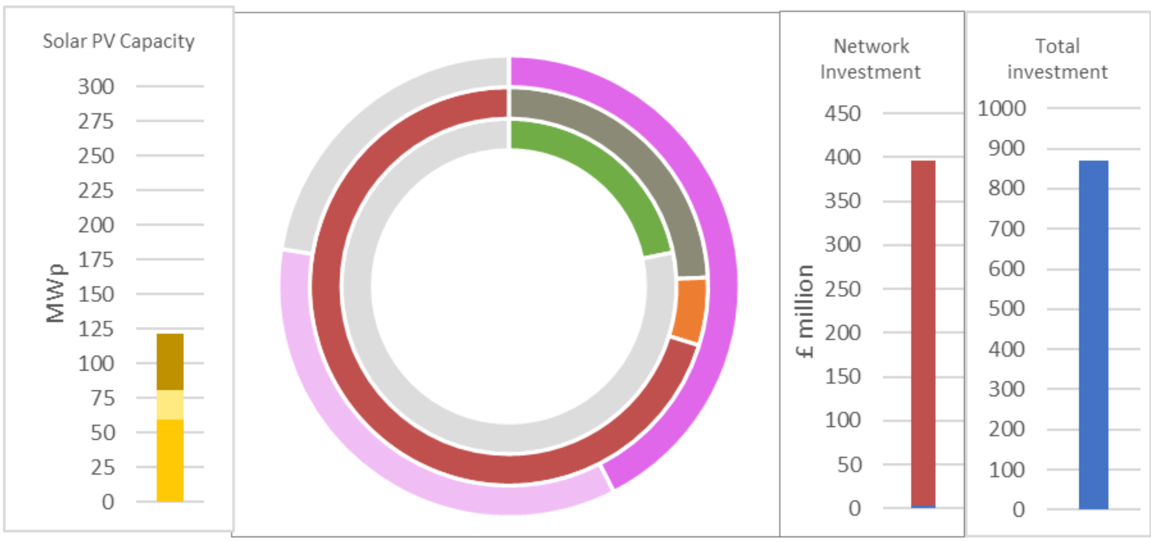
Cluster 3



Cluster 4



Cluster 5



Solar PV
Domestic Buildings
Non-domestic Buildings
Ground Mounted

Insulation
Basic
Deep

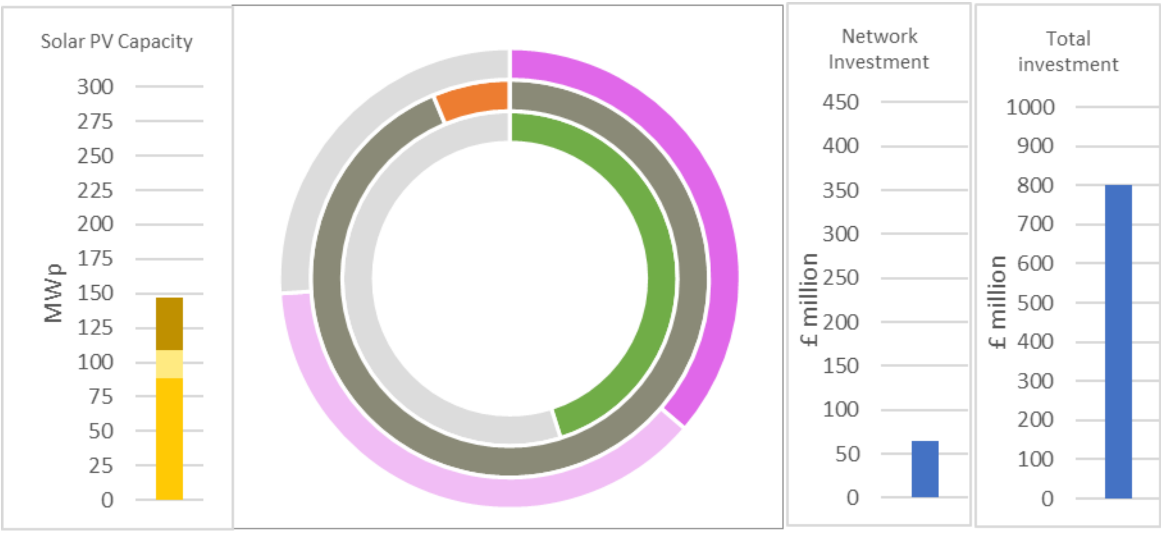
Heating Systems
Heat Pumps
Electric Resistive
District Heat
Hydrogen Boilers

Homes with EV Chargers

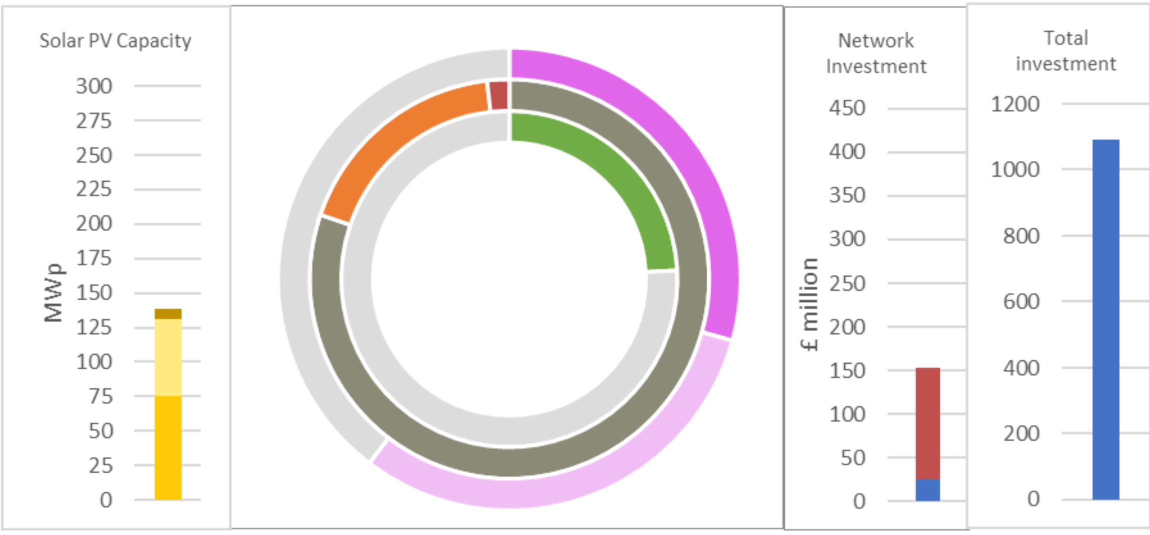
No change

Network Investment
Electrical
Heat

Cluster 6



Cluster 7



How to use this LAEP

The plan below illustrates the proposed activities to progress this LAEP in the near-term, based on a demonstration and scale-up approach, as well as focus areas for changes in the longer term. The red rings highlight priorities to test how to roll out Bolton's transition to carbon neutral and work with Bolton's citizens. Insights from these activities are expected to be evaluated, for example through demonstrating where proposed components of the LAEP are still the cost-effective option, before moving to widescale rollout. For example:

- How to roll out heating system and fabric retrofit change alongside renewable energy generation and EV charging infrastructure. Testing how best to combine these components and understand where a whole house retrofit approach may be beneficial

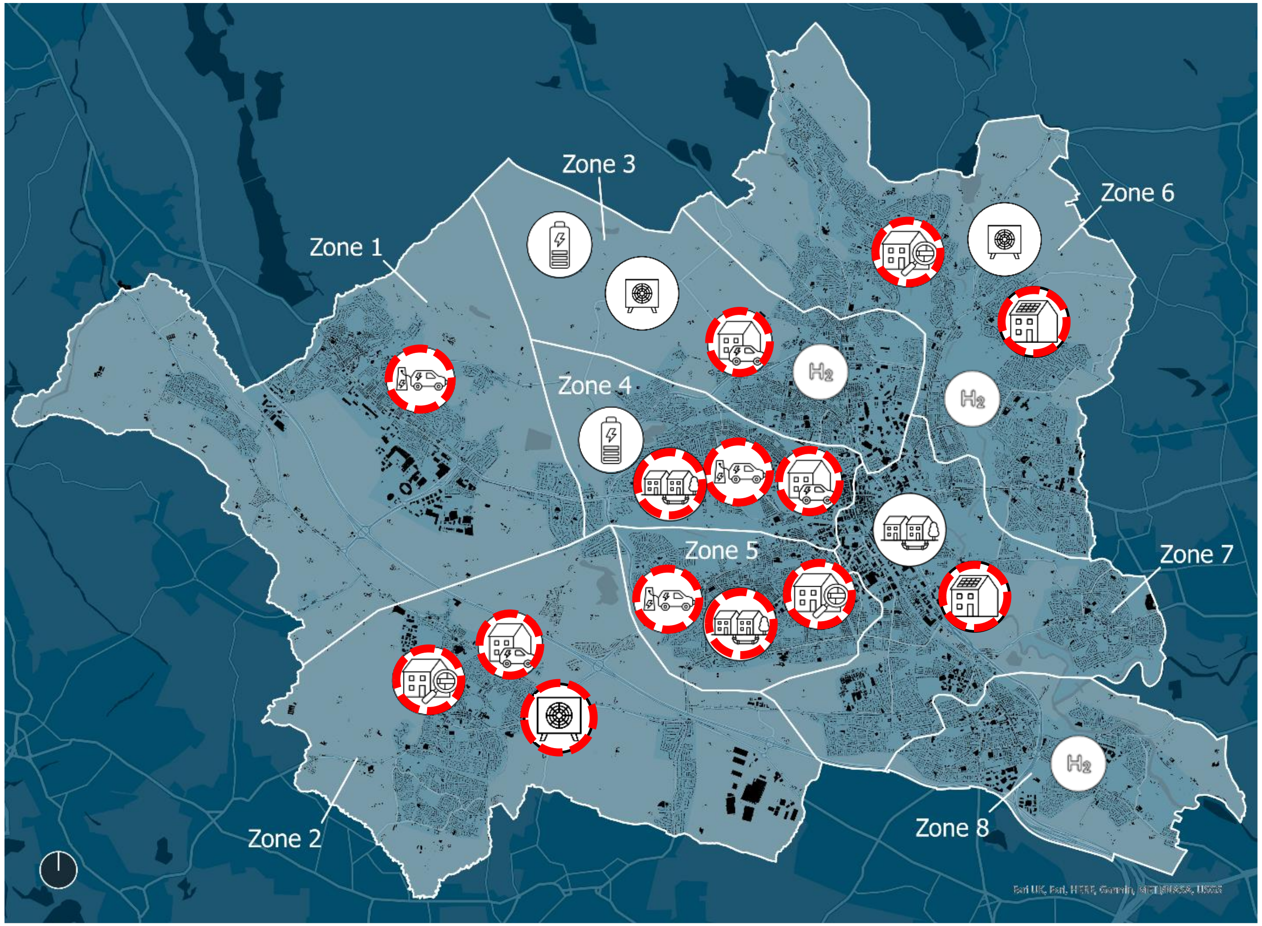
- How should additional electricity demand be provided in an area e.g. through network reinforcement or through providing alternative strategies

- How to engage with stakeholders and provide appealing customer propositions. Should activities be deployed at a neighbourhood level or dispersed across a wider area

- Taking account of evolving UK energy and heat policy

It is expected that Bolton Council will work with other key stakeholders, including GMCA, Cadent, ENWL and delivery partners to develop a detailed demonstration and delivery programme.

Demonstration and scale-up priority areas



Long-term Deployment Areas

- Heat pump prevalent zone
- Hydrogen for heat opportunity area
- Non-domestic opportunity area
- District heat opportunity area
- Flexibility & storage opportunity area

First Steps Priority Areas

- Retrofit priority area
- Solar PV priority area
- Home EV charging priority area
- Heat pump priority area
- EV charging hub priority area

The following priority areas highlight suggested areas to test specific components of this LAEP:

- Existing spare electrical network demand capacity in Zones 2 along with significant roll out of heat pumps in both scenarios is conducive to making early progress for heat pump deployment. This electrical capacity also allows for early deployment of home EV chargers.

- Modelling has also shown that ground source heat pumps could be cost-effective in detached homes, regardless of presence of low carbon hydrogen in the network.

- There are opportunities for developing district heat networks in Zones 4,5 and 7. This heat network aims to expand on the existing proposed Bolton Town Centre Heat network.

- Zones 2, 4 and 6 are prioritised for fabric retrofit deployment, predominantly due to high proportions of older semi-detached dwellings that would benefit from thermal improvement. Detached and terraced homes are also present in substantial quantities and see deployment of fabric retrofit. These zones differ in the make-up of building stock which are most prominent, allowing archetypal approaches to be pioneered and developed, e.g. for rows of terraces.

- Rooftop solar PV can be developed early in 2 priority areas with spare generation capacity in the electricity network, zone 6 and 7. Public EV charging is prioritised in zone 4 and 5 where demand is expected to be highest and existing car parks, public land and unoccupied buildings could be repurposed to provide EV charging hubs

Long term Deployment

- Flexibility and storage (combined with other components including heat pumps, solar PV and EV charge points) can be tested in zone 3 and zone 4, including a focus on evaluating whether alternative approaches to electricity network reinforcement provide benefit
- If hydrogen became widely available, most of the residential dwellings (apart from detached buildings) across all zones are proposed to move to low-carbon hydrogen, as well as 57% of non-domestic buildings.

To summarise, aspects of this LAEP present a vision (from many possible options), rather than a design, of how Bolton could move towards carbon neutrality by 2038. This is not meant to provide a forecast or recommendation on what Bolton's actual decarbonisation will be, where it is accepted that technologies, policy and expectations will evolve over the period of this vision.

The following themes set out both the rationale for how this vision has been produced, identifying several key considerations that will need to be thought about and integrated, alongside demonstration and scale-up activities, as plans to take this LAEP forward are developed. It is expected that insights from the demonstration activity and considerations of these themes will influence Bolton's actual transition.

Modelling Approach and GM Carbon Budget

The GM carbon budget and the modelling approach to develop this LAEP are the primary drivers for setting out this vision. The GM carbon budget requires an approximate 15% year-on-year emissions reduction. This stringent target drives the need for early decisions and significant action in early years rather than adoption of a 'wait and see' approach with more change in later years. Therefore, the cost-optimised modelling approach used has to identify measures from a wide range of options to provide the required short term carbon savings. This results in the identification of measures such as local generation and deep fabric retrofit, which can provide early emission savings. If there wasn't a carbon budget, or there were a later carbon neutrality target, different options would be identified, some of which may have provided a more cost effective (from a whole system perspective) transition or one that would be easier to roll out and less disruptive to building occupants.

There are risks and benefits associated with each of the options discussed and either of the scenarios presented. Because of these, Bolton's actual transition may result in a combination of the primary and secondary scenario. Before making any widescale and significant commitment to one option or technology over another, evaluation of multiple factors will be needed.

Evaluation

Demonstration of low-regrets and priority actions in the short term (3-5 years) feeds into key decisions in the plan. These decisions also require further evaluation of the following aspects, so that trade-offs between different options and their impacts on consumers are taken into account before moving from demonstration to large scale implementation, considering associated risks and benefits.

- Local generation is most effective at reducing carbon in the earlier years of the plan, while grid emissions are higher. This contributes to the near-term carbon budget, but is less critical for reaching long term targets as grid emissions fall. The large quantity of ground-mounted PV suggested in this plan will require assessment around feasibility, whole energy system integration and public acceptability.

- The timing (regarding the delivery) of HyNet compared to the rate of electricity grid decarbonisation

- The ability to scale-up and install options rapidly aligned to the carbon budget

- The practicality and cost of installing measures in dwellings and non-domestic buildings, for instance air source heat pumps in existing flats, or fabric retrofit of terrace houses

- The disruption associated with options – both within homes and at community level (e.g. traffic disruption from street works)

- Maintaining the gas network to supply sites (e.g. industrial) in areas that are expected to be heat pump or district heat prevalent

- How an electrified heat future would be paid for, recognising the greater in building investment required to move off-gas

- Coordination with other Greater Manchester local authorities in relation to energy network options

- Social and community benefits

- How to fund options and the preferences of investors

Consultation

Further consultation will be needed with key stakeholders, including GMCA, Cadent, ENWL and delivery partners to consider these considerations when developing demonstration and scale-up activity.

In addition, consultation with Bolton's citizens is essential to help understand attitudes towards Bolton's carbon neutrality transition; whilst also forming part of the evaluation process. This will help Bolton communicate with its citizens so that they both understand the transition and can help to inform plans to take forward this LAEP.

Citizen consultation will help to:

- communicate Bolton's intentions

- understand what people want and which options they are supportive of

- identify areas to focus demonstration and then wider roll-out activity

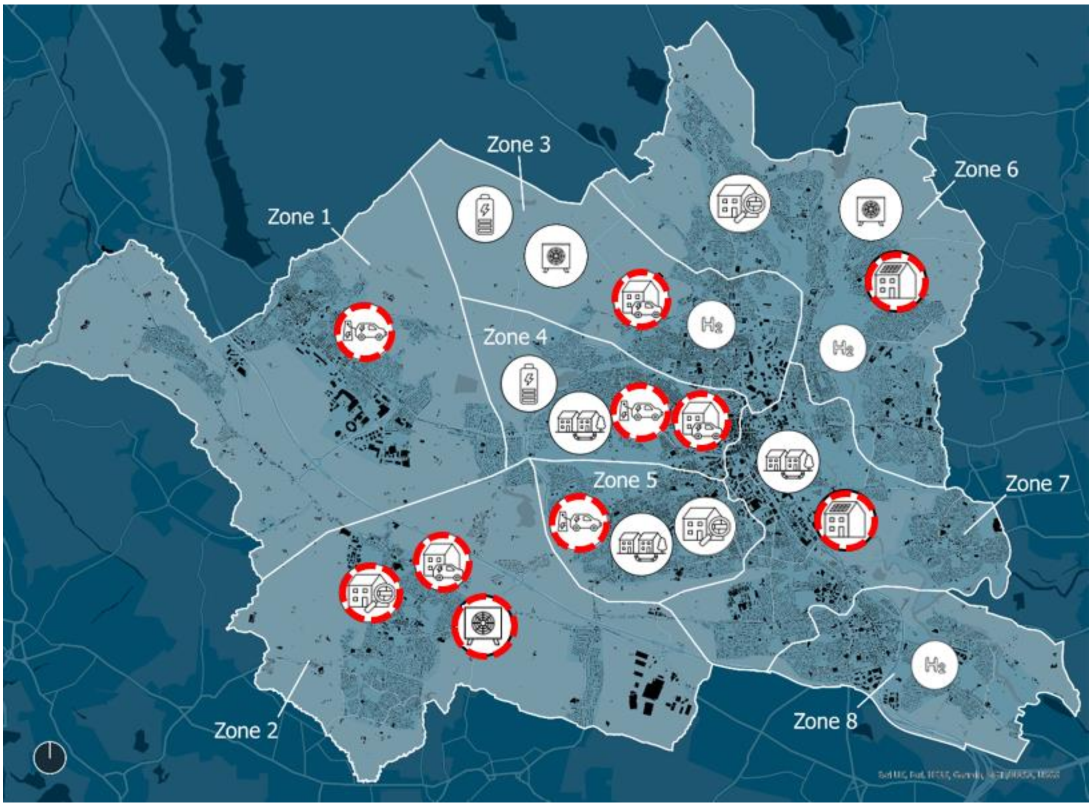
- provide confidence to the organisations that will be involved in the delivery of Bolton's transition that there is a demand for solutions, products and services

Vision to 2038

A significant portion of existing homes and buildings in Bolton will require retrofit, carrying out insulation in **at least 70% of dwellings** (around 97,000). This is true for both scenarios, whether electrification or hydrogen forms the bulk of the heating solution, so early focus and investment in fabric retrofit is a low regret step. Only a small percentage **more dwellings receive deep retrofits in the secondary (HyNet) scenario** (over 51,000, compared to circa 47,000 in the primary scenario). The reduction in energy usage through deep retrofit is prioritised to lower carbon emissions in the short term while waiting for the proposed supply of hydrogen through HyNet to become available. However, more basic insulation is proposed in the primary scenario (circa 49,000 vs 46,000)

However, regardless of the heating system used, additional level of fabric retrofit may be needed to address affordability issues; for example, the cost of hydrogen is expected to be higher compared to gas*. In the second scenario, a higher proportion of dwellings undergo deep retrofit (circa 51,000).

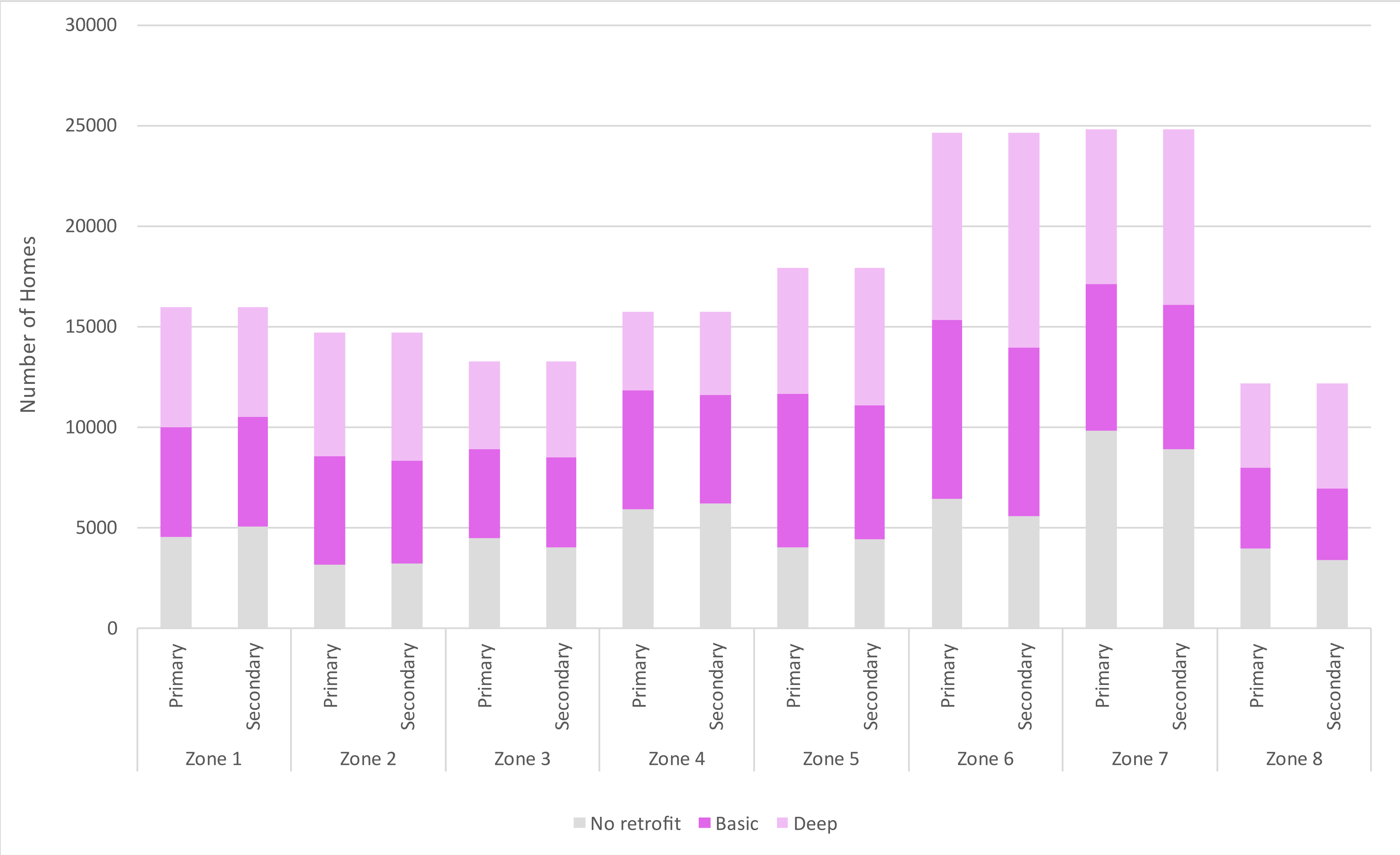
Fabric retrofit could be combined with other measures such as heating system replacement, PV installation and EV chargers to minimise number of visits required to homes, as in the "cost effective retrofit" option on page 38.



* Estimates vary - see for example projections for initial HyNet cost of hydrogen at around 150% uplift over natural gas https://HyNet.co.uk/wp-content/uploads/2021/06/14368_CADENT_PROJECT_REPORT_AMENDED_v22105.pdf [page 15]

Flats, which tend to have lower heat loss, show lower benefits from fabric retrofit, so are less of a focus area. However, further specific consideration will be needed at a building level to determine buildings that would benefit. For example, if a block of flats were to pursue a communal heating system, then the optimum balance between fabric improvement (to reduce heat loss and demand) and internal heating distribution systems would need to be specified, dependent on the heating system design strategy, recognising that a whole energy system approach will always be needed at a building level. Newer houses often already have better standards of insulation and fabric energy efficiency, but many will still need some treatment, unless built to the most recent building standards.

Overall, similar quantities of basic fabric retrofit have been selected in each zone for both the primary and secondary scenarios, as highlighted in the chart below, with only minor variation and greater deep retrofit within the secondary scenario.

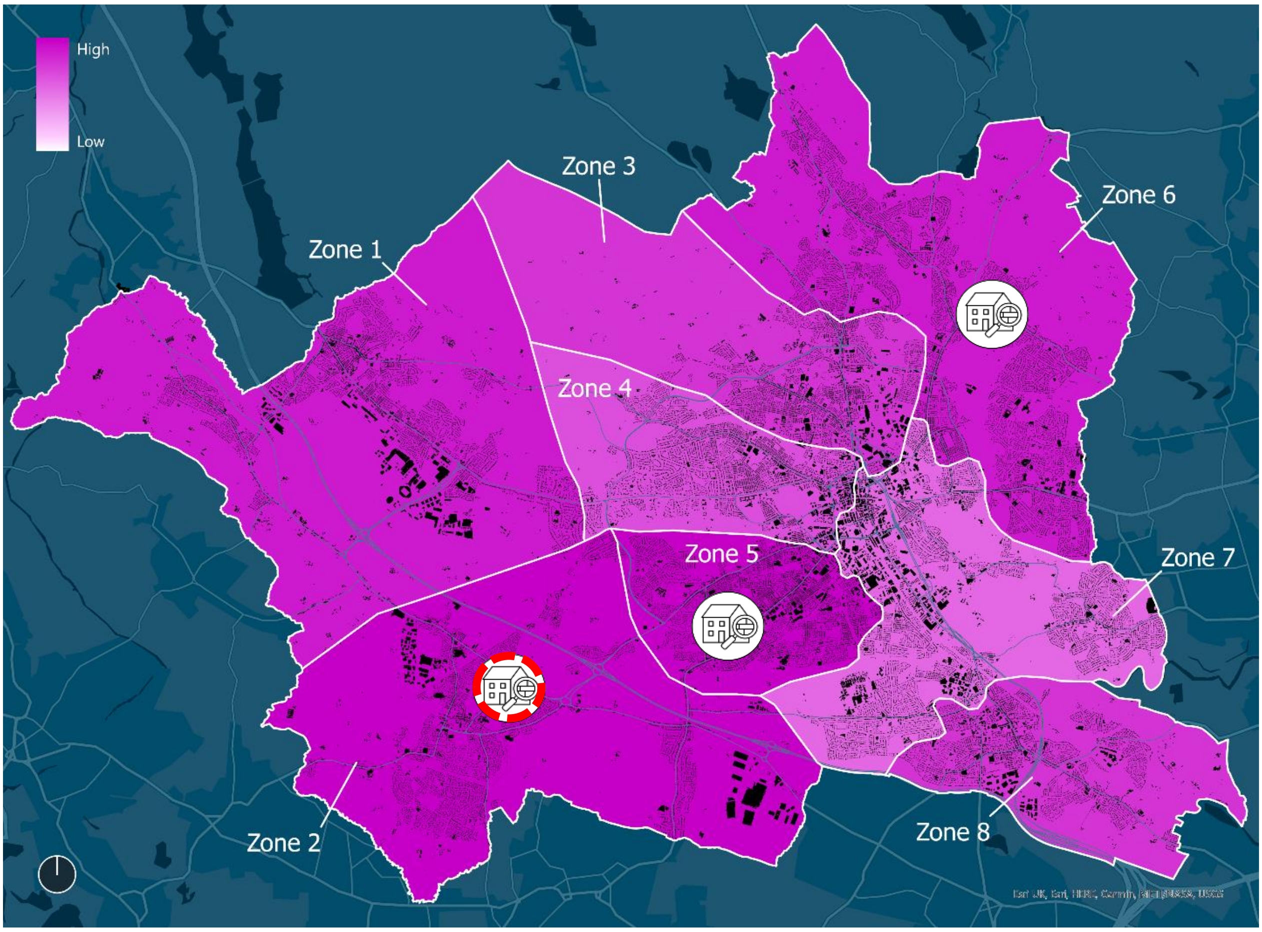


Retrofit across Bolton by 2038

First Steps – Priority Areas

Whilst large numbers of dwellings will need to be retrofitted to improve energy efficiency across all areas of Bolton, several retrofit priority zones have been identified.
The purpose of providing these priority zones is to highlight areas where demonstration and scale-up could be prioritised over the near-term (<5 years)*. The areas have been selected as they are regarded as low regret, are considered to be cost effective to receive fabric retrofit measures, regardless of the type of heating system (e.g. hydrogen or a heat pump) that is used to replace natural gas boilers.

Three priority retrofit zones have been highlighted for Bolton:



* Fabric retrofit measures have been identified following a whole energy system approach, considering the cost-effectiveness of fabric retrofit measures alongside other options to achieve carbon neutrality in Bolton. This does not mean that individual dwellings or buildings would not benefit from additional retrofit measures when considered on a case-by-case basis, particularly as part of a package of wider measures that could include heating system change and PV installation. During the development of any activity or plans to progress this LAEP, consideration will be needed to determine the optimum approach for deployment, when appraised alongside the approach for taking forward any of the other components of this LAEP. For example, in some cases a whole house retrofit may be beneficial, taking account of other GMCA activity, such as the Pathways to Healthy Net Zero Housing for Greater Manchester report and recommendations: https://democracy.greatermanchester-ca.gov.uk/documents/s13523/07%20Pathways%20to%20Healthy%20Net%20Zero%20Housing%20GM_Report.pdf

Zones 2, 5 and 6

These are areas in which a high proportion of homes (above 70%) receive insulation measures, with these zones also containing a large absolute number of proposed installs (at least 11,500), so the opportunity in these zones is significant.

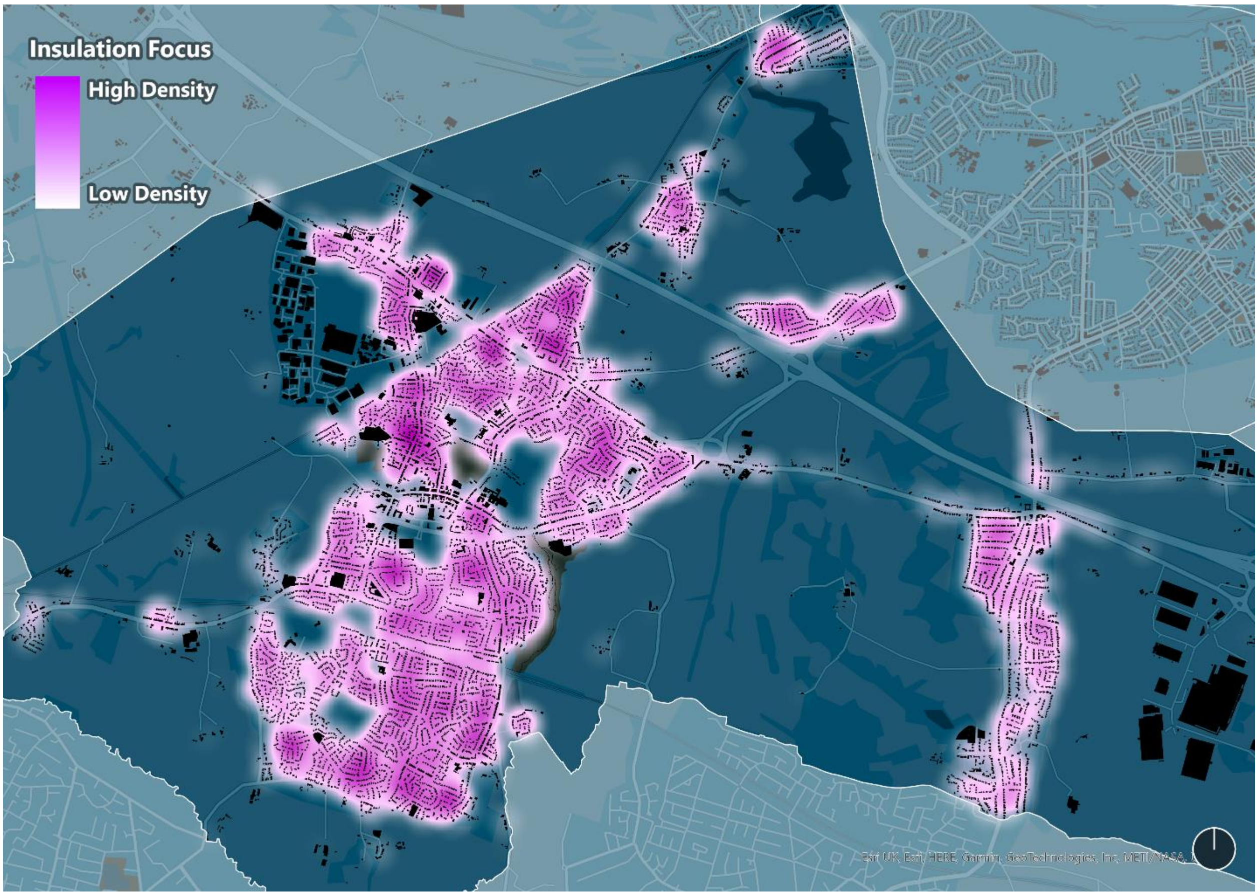
Across Bolton, all areas see at least 60% fabric retrofit. The proportions of flats, newbuilds or pre-1914 properties which are less economic to apply insulation to lead to lower insulation levels in these other zones (1, 3, 4, 7 and 8).
Whether or not a priority area based retrofit approach is pursued, it is essential that any delivery programme considers how to best integrate implementation with other dwelling related components to consider where a whole house retrofit approach would be required.

Fabric Retrofit Zones in Bolton by 2038

Zone 2 has a significant number of homes of which 78% (circa 11,500) receive fabric retrofit. 97% of terraced homes receive retrofit, followed by 88% of semi-detached homes. Around 52% of semi-detached homes receive deep retrofit, with similar percentages of terraced homes. The age of homes in zone 2 is spread through the years, with homes built after 1980 being the highest proportion but only by a small margin. Basic and deep retrofit is spread evenly across the ages, apart from pre-1914 homes, which predominately receive deep retrofits.

A similar amount of fabric retrofits are seen in the secondary scenario (11,400 vs 11,500) although with a greater proportion (43% vs 41%) of deep retrofits.

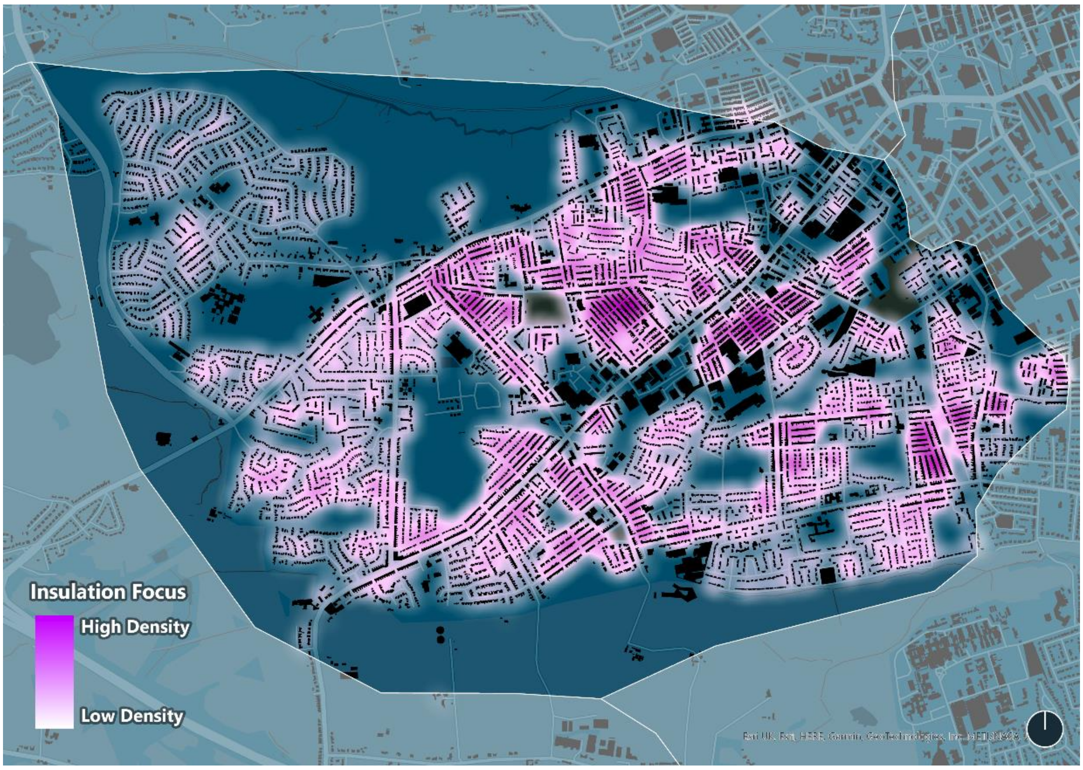
Fabric Retrofit Opportunity in Zone 2



Zone 5 is a much larger area (c. 18 ,000 dwellings) than Zone 2 (c. 14,700) but unlike Zone 2 which has a reasonably even split between detached, semi-detached, and terraced homes, zone 5 has premeditatedly terraced homes (around 50%), followed by semi-detached homes(around 22%).

In the secondary scenario, there is an overall reduction in the number of homes which see retrofit(18,000 vs 13,500), but see a small increase in deep retrofits (around 500).

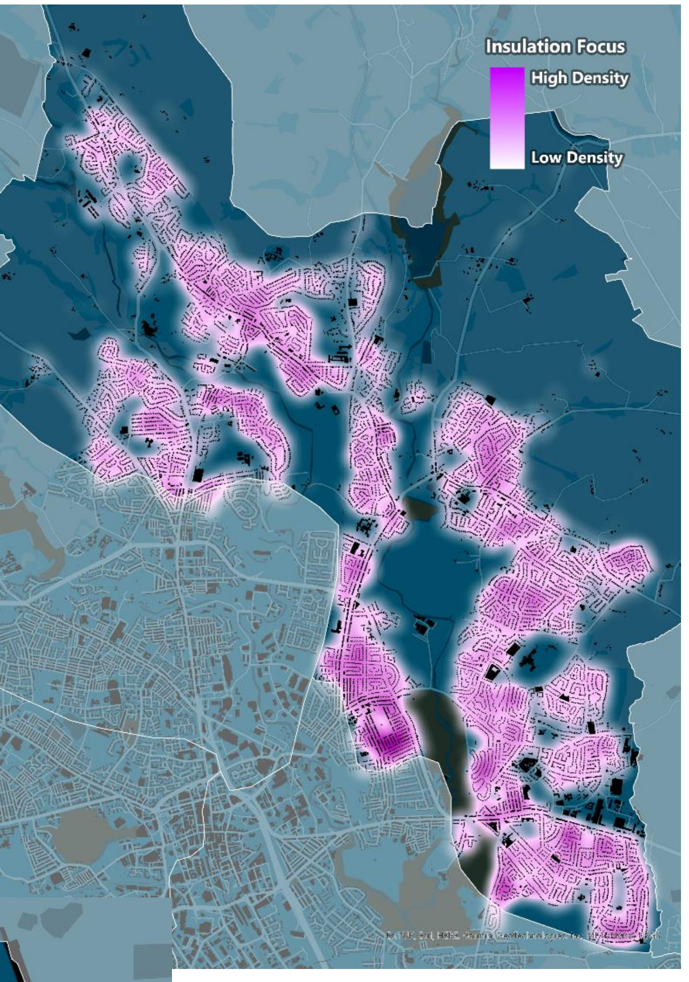
Fabric Retrofit Opportunity in Zone 5



Zone 6 is the largest area in Bolton with nearly 25,000 dwellings and is comprised predominantly of semi-detached dwellings (42%) with detached and terraced representing around 24% of dwellings each. Retrofit packages are spread in a similar fashion across the ages, with 18,200 homes receiving retrofit.

In the secondary scenario, around 1,400 more dwellings receive deep retrofit than in the primary scenario. The greatest increase is seen in the dwellings built between 1945-1964.

Fabric Retrofit Opportunity in Zone 6



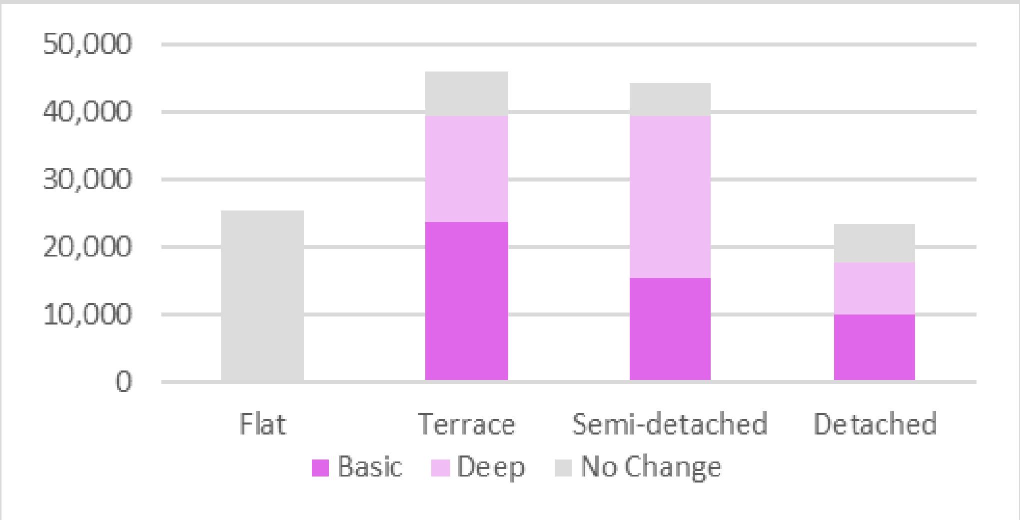
Fabric Retrofit Approach

Retrofit measures should be tailored for the individual dwelling, taking account of its type, age, construction, existing insulation and likely future heating system. For example, cavity wall insulation will only be applicable to dwellings that have suitable* cavities (usually post-1920 properties) that are not already filled. Narrow cavities, common in interwar houses, are likely to be unfilled, having been considered "hard to treat" during previous rounds of cavity treatment; targeting these dwelling (with an appropriate solution) types is a key focus for this LAEP.

The retrofit zones identified on the previous pages are designed to allow the coordinated targeting of interventions across Bolton in such a way that supports and aligns with Bolton's wider local energy system transformation.

There is uncertainty in the specific measures needed and most suitable for individual homes as exact details of the existing fabric efficiency of any given dwelling are not known. Survey work will be needed before any works are undertaken.

The distribution of the dwellings in Bolton expected to need retrofit measures by dwelling type is shown below. This represents around 70% (dependent on scenario) of the projected domestic building stock in Bolton of approximately 139,000 dwellings in 2038. This highlights both the scale of the challenge but also the opportunity for building and using local supply chains.



Fabric Retrofit in 2038 by Building Type

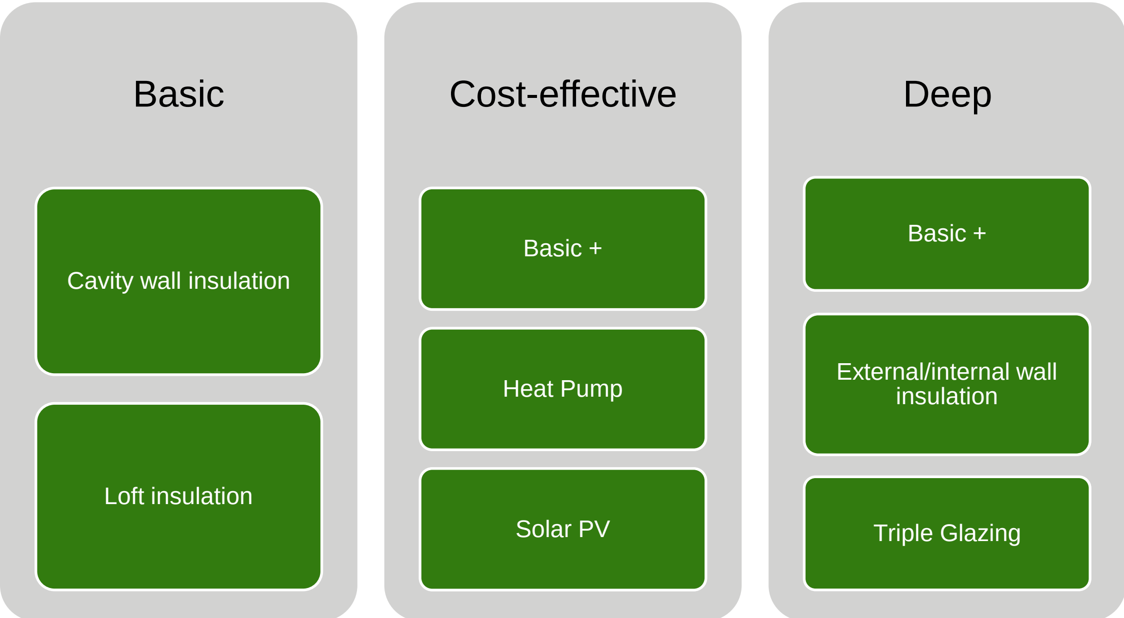
There are over 46,000 homes which receive basic insulation measures and over 47,000 receiving deep measures in both scenarios. Around 4,300 more dwellings will receive deep retrofit in the secondary scenario compared to the primary. Carrying out basic measures in earlier years would not preclude deeper measures being installed in homes in later years. Therefore, basic measures and the majority of deep measures are considered low regret across all scenarios and heating system selections. Due to the ages of housing targeted, a significant proportion of the cost-effective deep measures

* Consideration will be needed to identify a suitable approach for insulating inter-war cavity walls, noting cavity widths are generally smaller than more modern dwellings; considering aspects such as insulation type and damp prevention; where solid wall insulation may be needed on some dwellings with cavity walls

are based on adding triple glazing to dwellings with basic measures applied, rather than large volumes of external/internal wall insulation to pre-war period dwellings. This is based on the supporting optimisation led modeling, which identifies least-cost options to achieve the carbon targets. Further consideration would be needed to ascertain if individual homes could also benefit from further measures to reduce energy demand and subsequently energy usage costs, for example, considering socio-economic indicators.

Cost-Effective Deployment

The proposed approach centres on ensuring fabric retrofit measures are implemented in the vast majority of suitable homes in Bolton, which is found to be the most cost-effective approach for the whole system. However, deployment of measures should not be considered in isolation: integration with other components (such as heating system changes, PV installation and EV chargers) can help minimise disruption and offer cost savings, and so opportunities to develop cost-effective whole-house approaches will need to be considered during the development of any activity to take forward this LAEP. The range of different potential packages is illustrated in the diagram below*.



* The modelled packages align loosely with packages in the Pathways to Healthy Net Zero Housing for Greater Manchester, with some differences due to the modelling approach. The ‘deep’ package here is similar to the fabric measures in the ‘deep’ package in Pathways. The ‘basic’ package in this report is loosely comparable to the fabric measures in the ‘cost-effective’ package in the Pathways report, but generally does not include external/internal wall insulation. The cost-effective package illustrated here was not part of the modelling but may be a useful ‘real life’ approach for individual houses when wider factors are taken into account.

Rapid deployment of retrofit measures could be a relatively easy intervention in the near term, which is especially beneficial for staying within the carbon budget. The rate of deployment that is possible will depend on the development of a supply chain and business models; developing this in the next few years could allow for higher deployment rates in the medium term to support progress with decarbonisation where there may not yet be clarity on heating systems across all parts of Bolton.
In an electrified scenario, the number of dwellings expected to need deep retrofit would be even greater than in a hydrogen scenario. This is a pattern which hasn't been seen in other GM boroughs to date and is due to the greater quantity of larger detached and semi-detached homes present in Bolton. These homes require fabric retrofit to reduce heat demand and allow domestic heat pump capacity to meet the heat load of these homes. As heat pump technologies and products develop, the optimal choice between deep fabric retrofit or higher capacity heat pumps should be reviewed.

Deeper Retrofit

The approach described is based on finding the most cost-effective route for decarbonising Bolton overall, in line with the carbon budget. However, there may be strong reasons for additional retrofit work and so deeper and more extensive retrofit for individual dwellings is possible, with the potential to bring benefits including:

- Increased comfort and reduced running costs for individual households. This could also be important for some households to reduce fuel poverty and improve health and general quality of life
- Potential to reduce energy consumption and associated carbon emissions across Bolton more quickly. This would give greater headroom in the carbon budget, especially if carried out early in the plan, allowing strategic decisions to be made later (e.g. around the future of the gas grid). Or, to replace emissions savings that are currently proposed through other measures (e.g. the significant quantify of local electricity generation)

Supporting Low Carbon Heat

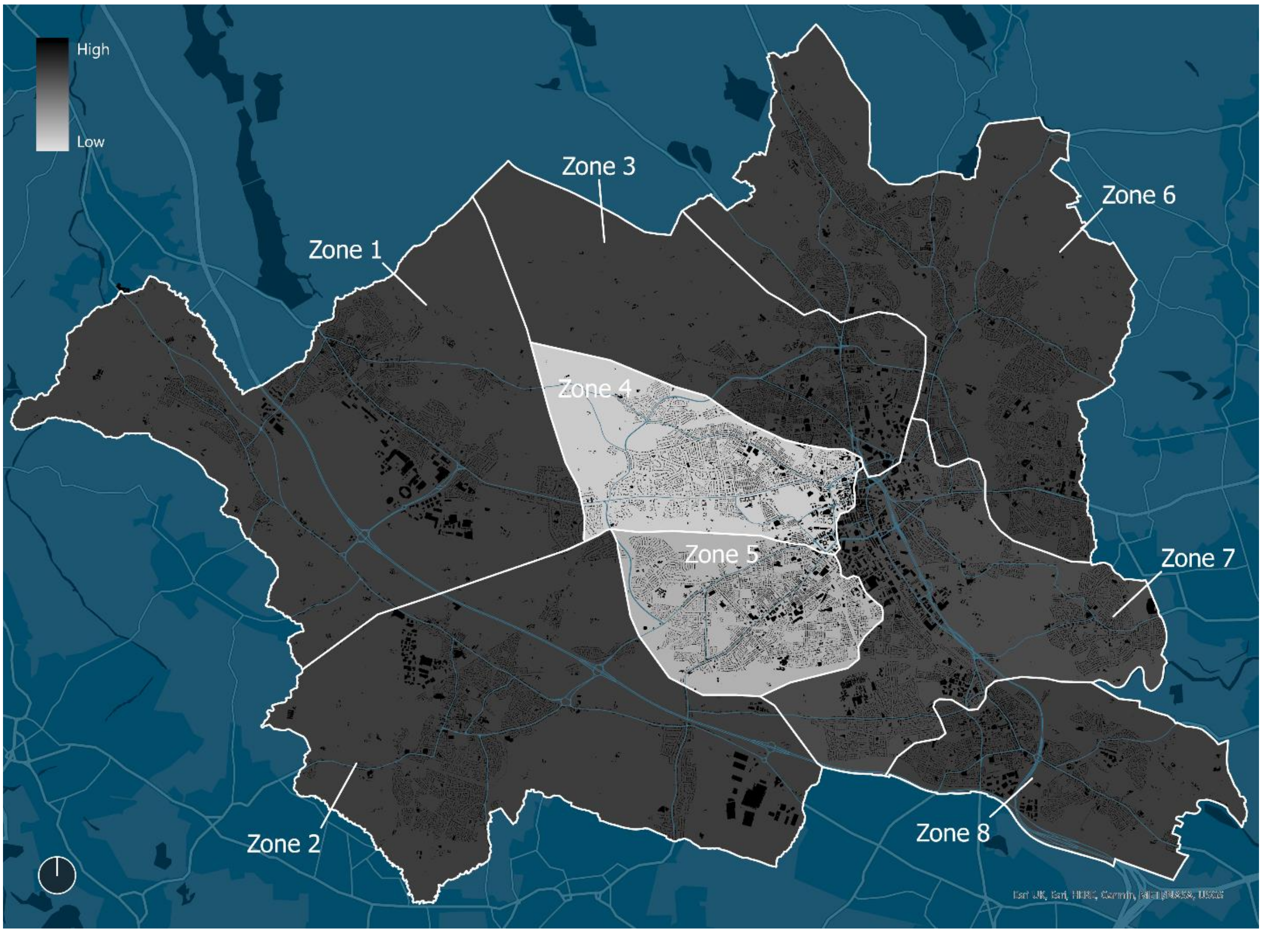
The improvement of building insulation supports the roll out of low carbon heat in several ways. Primarily, by reducing the heat demand, meaning that less powerful heating systems can be installed, reducing capital costs and by reducing energy costs associated with heating (compensating for a shift to a more expensive energy source (gas to electricity or hydrogen). Furthermore, reduced heat losses enable heat pumps and district heat networks to run at lower temperatures, improving their efficiency and running costs, and may also reduce the need for heating distribution system upgrades in homes.

It therefore makes sense to carry out retrofit either before or at the same time as heating system replacements to capture these benefits. Carrying out both activities at the same time would minimise the number of disruptions experienced by households, while insulating earlier would provide further emissions reductions compared to the modelled scenarios.

Vision to 2038

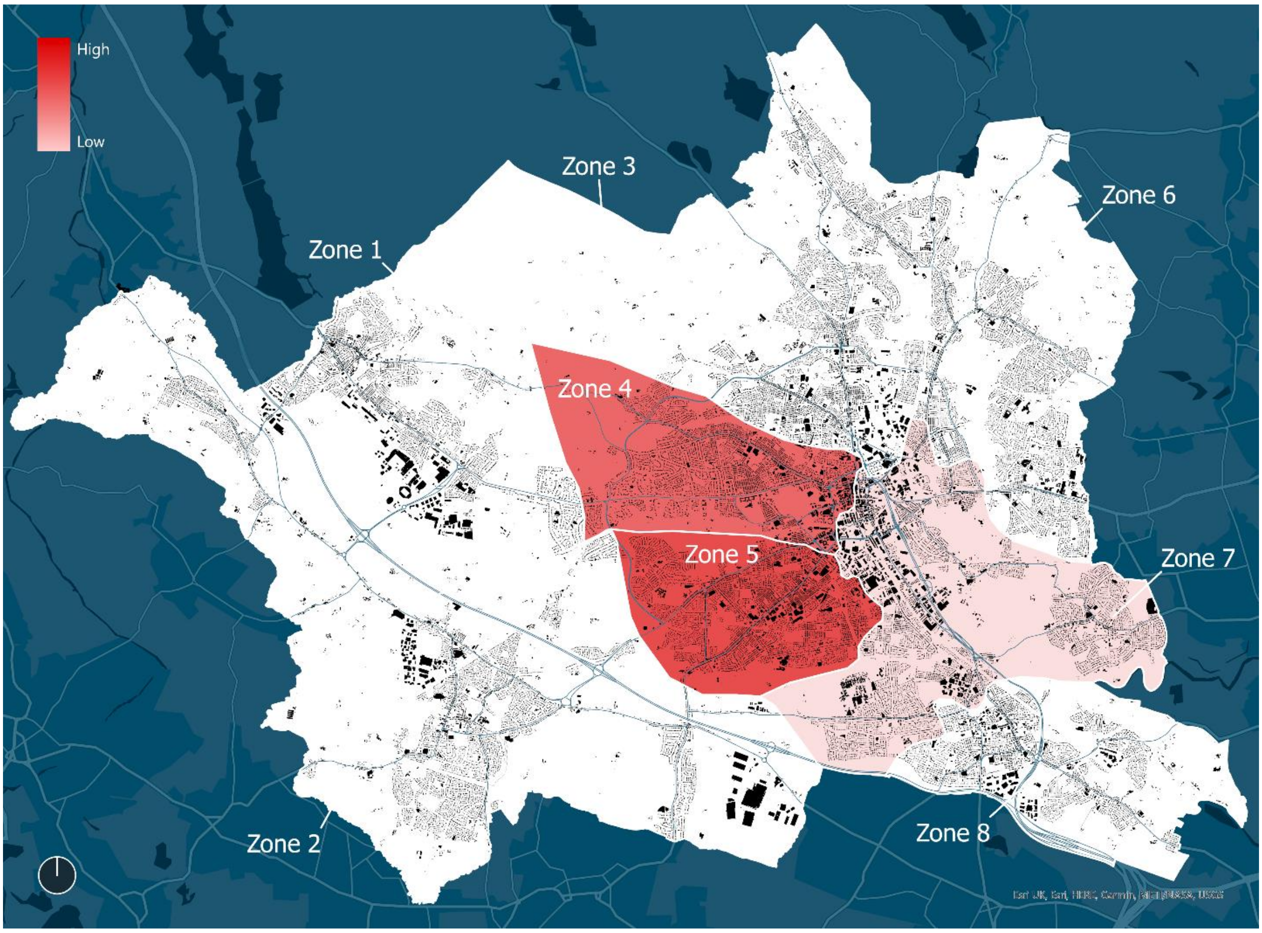
Building characteristics and existing network characteristics inform the low carbon heating system best suited to each building, and this causes patterns to emerge between the zones across Bolton. In the primary scenario, the decarbonisation of heat is primarily achieved through installation of electric heat pumps in existing and new homes, comprising approximately 103,000 domestic heat pump installations. These are the predominant heating system in all areas besides zones 4 and 5, where district heat takes precedence. Other electric systems are also present in less significant numbers. In the secondary scenario we see a large roll-out of hydrogen across all zones, making it the predominant heating system. See page 55.

Heat Zones for electric heating in Bolton by 2038 (Primary Scenario)



Heat Zones for District Heating Opportunities in Bolton by 2038 (Primary Scenario)

Within Bolton, zones 4 and 5 of existing residential areas were identified as being a priority to be served extensively by district heating over electrification or the use of hydrogen.

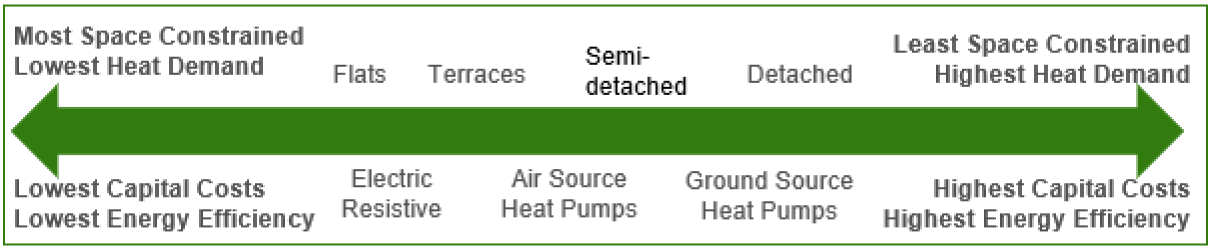


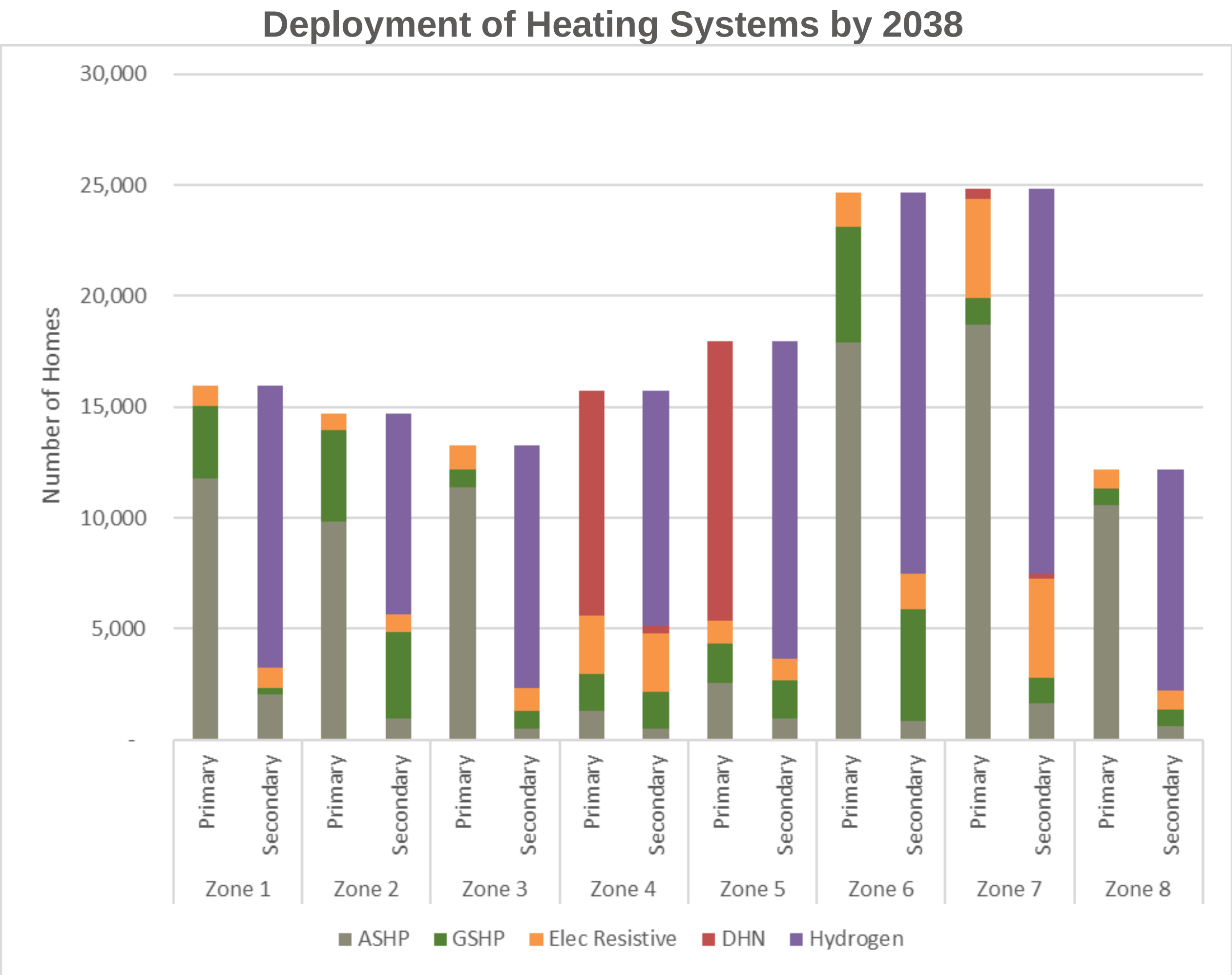
Even where hydrogen is available (as per the secondary scenario), least-regret effort in the near term is focussed on retrofit, priority electrification areas, and monitoring the development of hydrogen (at national and regional levels). The installation of hydrogen-ready boilers could provide optionality given the uncertainty, at minimal additional cost.

These forecasts are not definitive and represent a view of the future for each zone, to illustrate the scale of change required, it is expected that alternative solutions will be specified when exploring at a more detailed level, for example, there may be opportunities for communal / shared heating systems over the use of individual heat pumps.

Heating System Selection

Standalone electric heating systems are selected according to building characteristics as shown in the diagram below.





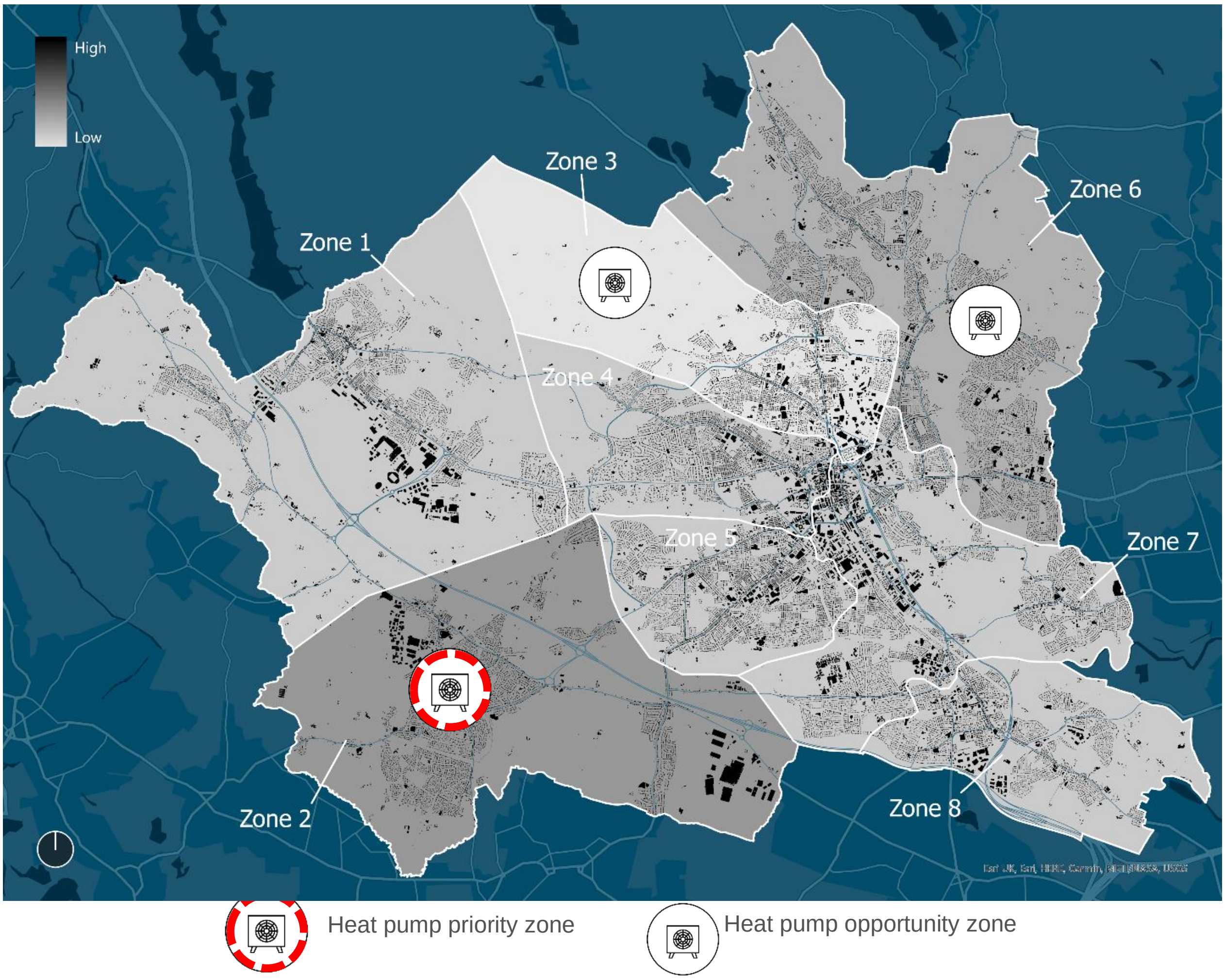
In the primary scenario, air source heat pumps are the most widely suited electric heating technology, though a proportion of homes in most areas were found to be suitable for ground source heat pumps, where greater outdoor space permits the installation of a ground collector, and larger properties may justify the higher upfront cost with greater savings in running costs. These properties would also be suitable for air source if preferred. The ASHP category includes high temperature, low temperature and hybrid types, according to the needs of individual buildings.

Heat pumps are a proven and mature renewable heating technology, capable of delivering deep emissions reductions today. They can be rolled out to individual households gradually, without the requirement for large scale area transitions and buy-in from multiple households that district heating and hydrogen require. Some disruption within the home is typically required for radiator replacements and the installation of a hot water cylinder in homes which do not have one already. These indoor space requirements, together with the need to manage disruption to the household and locating a space for the outdoor unit where it will not cause noise issues for neighbouring properties, must be considered in the design, and can make heat pumps unsuitable for some properties. These issues would be avoided with hydrogen boilers, which would be a like-for-like replacement for natural gas boilers.

Heat pumps perform best in homes with good levels of insulation, so building retrofit should be considered alongside heat pump installations to minimise disruption to dwelling occupants. This would also reduce overall cost by allowing smaller heat pumps to be used and fewer radiators to be upgraded due to reduced heat demand.

First Steps: Heat Pump Priority Areas

Heat Zones for electric heating in Bolton by 2038 (Secondary Scenario)



When hydrogen is available, the majority of heating systems transfer to hydrogen over electric based systems, in which heat pumps only play a small in decarbonising heating. In the map above, most of the areas have less than ~20% deployment of heat pumps, with only cluster 6 having 24% and cluster 2 having 33%.

Zone 2 has been identified as the priority zone for heat pumps. With the highest uptake of heat pumps in both scenarios, and plenty of available headroom in the electrical network, it’s the best option to prioritise heat pump deployment.

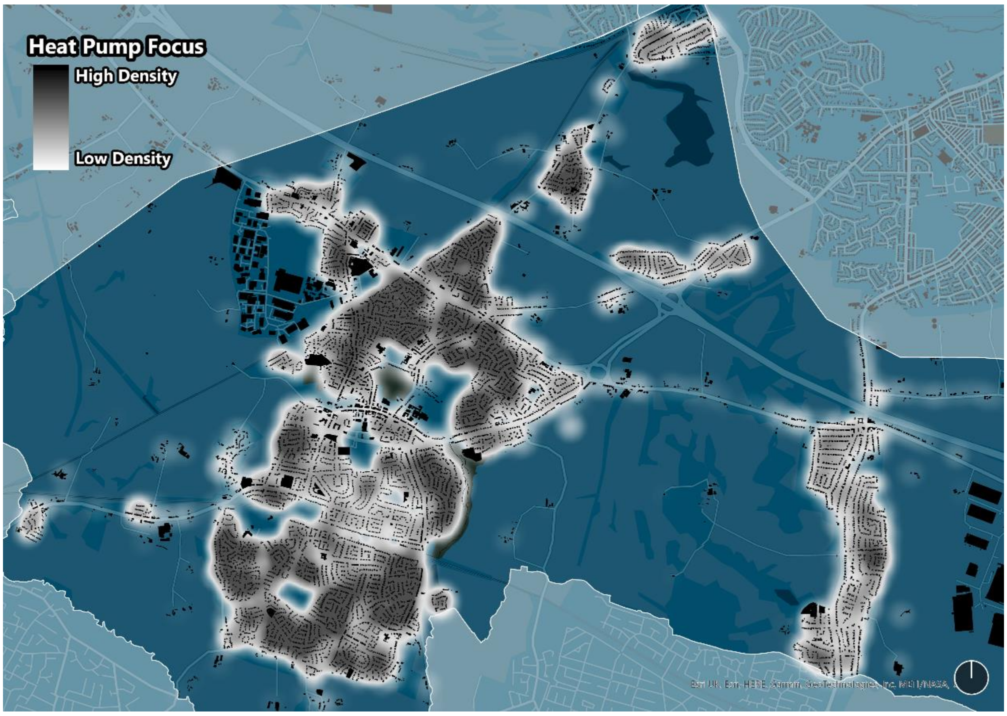
This can help establish supply chains, delivery approach and capacity, and strikes a balance between flexibility and early progress. It leaves the plan open to developments around the future of the gas network, conversion to hydrogen and the UK’s heat strategy, ahead of a mass programme of transition in places where the best option is less clear.

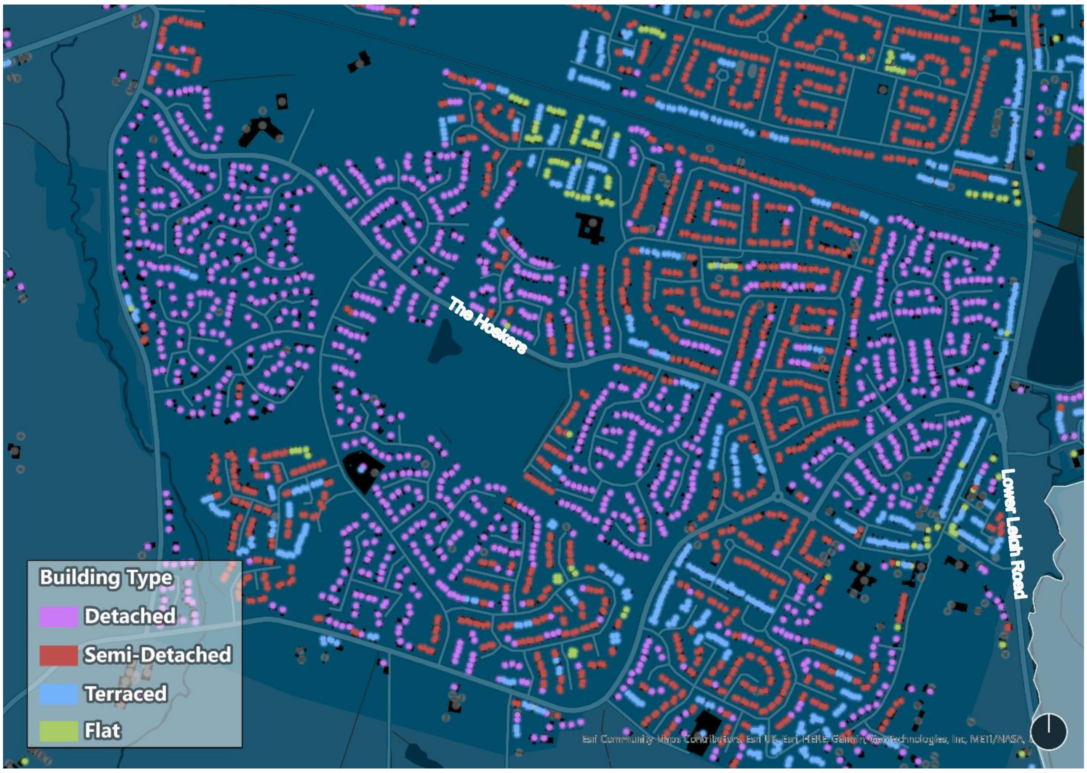
The heat pump priority map above illustrates suggested priority and opportunity areas for demonstration and scale-up activity. Consideration will be needed to develop a programme of works which aligns with other interventions to maximise delivery efficiency and minimise disruption to residents.

Zone 3 and 6 have been identified as further opportunity zones. These areas have a large deployment of heat pumps in the primary scenario and have ample headroom in the electrical networks to allow for action to be undertaken.

Priority Area

Zone 2 has been identified as a priority area due to its significant number of homes, with nearly 5000 semi-detached and detached properties and it's available headroom on the electricity network. Heat pumps remain a cost-effective heating system regardless of the availability hydrogen.

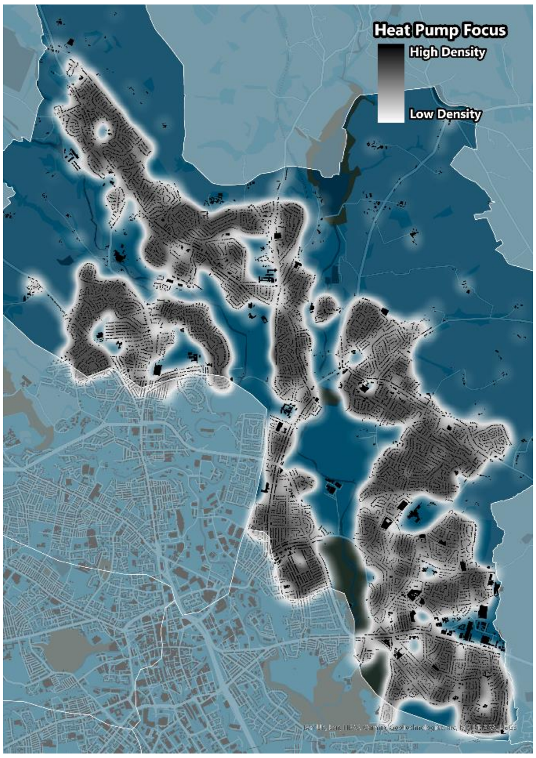




Opportunity Areas

Zone 3 has an opportunity to install a large number of heat pumps (c. 11,000). The zone has a mix of dwelling types, mostly semi-detached and terrace, of which nearly all move to air source heat pumps in the primary scenario. While there is limited headroom in the electricity network, there is still a sufficient amount to get started in the area. However, roll-out of heat-pumps is dependent on hydrogen availability, with only 11% of the properties converting to air source heat pumps in the hydrogen scenario, of which the majority are GSHP in detached homes.

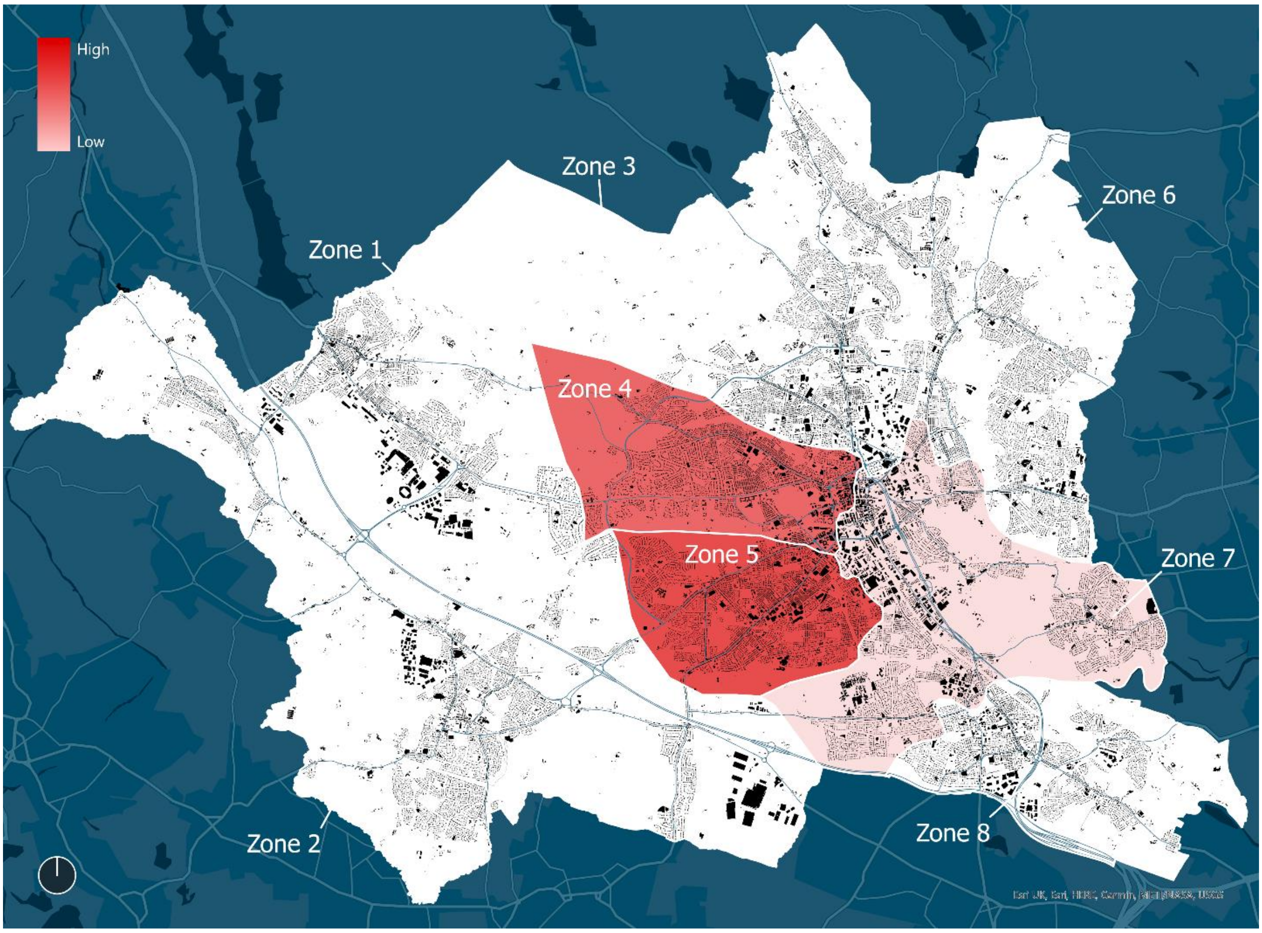
Zone 6 is an area with the largest number of dwellings. There is a proposed roll-out of nearly 23,000 heat pumps in the primary scenario, making it the largest in all of Bolton, across all dwelling types, apart from some flats, which retain electric resistive heating. Deployment of heat pumps in zone 6 is dependent on hydrogen availability. In the secondary scenario, when hydrogen is available, zone 6 still sees 24% of the housing stock transitioning to heat pumps, where 84% of those could use GSHPs in detached homes.



District Heat Networks

Heat supplied through underground pipes from a centralised energy centre tends to be most suitable for denser urban areas, particularly where there are large numbers of dwellings which are either too expensive or impractical (e.g. due to space limitations) to make suitable for heat pumps.

Heat networks can have the advantage of causing less disruption in dwellings during installation compared to some other options, though there are wider considerations such as disruption to roads during pipe laying, and space restrictions in town centres.



Three zones, 4,5 and 7 have been identified in Bolton which could benefit from district heat networks, connecting a total of 23,00 homes. All building types, apart from areas of clustered detached homes in these areas connect to the network, with detached homes potentially being more cost-effective to transition to heat pumps, including ground source heat pumps; although area specific consideration would be required if a district heat network is built in a specific area.

There are plans for a heat network in Bolton town centre, potentially supplying heat to several social housing blocks, comprised of flats and maisonettes, council and public sector buildings, and private assets including planned development sites in and around the town centre. Should a district heat network evolve in Zone 5, there is potential to expand the provision of district heating to Zones 4 and 7. The case for this is supported by the density of homes in the city centre.

In the primary scenario, there is a case for the majority of dwelling types in Zones 4 and 5 to transition to district heating, however, in the hydrogen dominated secondary scenario, the case for district heating systems diminishes as hydrogen is seen as a more cost-effective solution.

Zone 4 has over 10,000 homes that could connect to a heat network. As illustrated below, there are clusters of dwellings that are the most cost-effective, therefore several district heat networks may be needed that could form part of a wider network over time, all of which would require further investigation. In zone 4, the majority of terraced houses connect to the network, with semi-detached and flats connecting in similar numbers.

The map below shows potential sites in zone 4 for district heat network feasibility studies.

Zone 5 has over 12,000 homes connected to district heat networks in the primary scenario. Zone 5 is predominately terraced houses, of which a majority with a smaller percentage of flats and semi-detached homes, with the majority of them connected to the network.

The map below shows potential sites in zone 4 for district heat network feasibility studies

Hydrogen for Heating

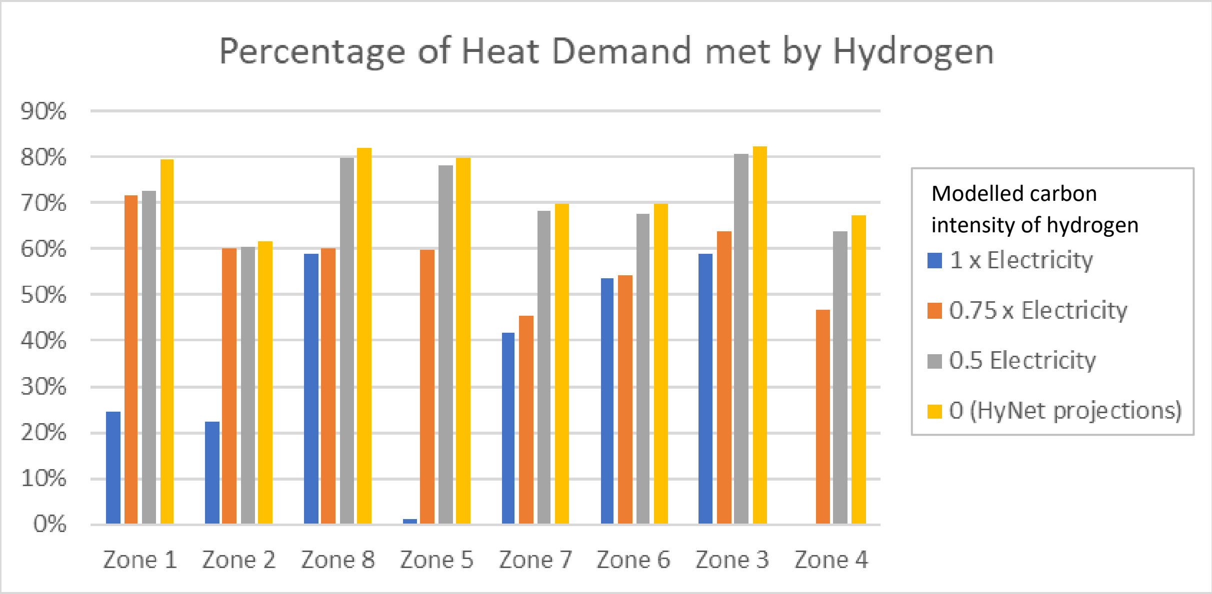
The representation of hydrogen in the analysis for this plan has been aligned with the proposals for HyNet in the North West of England, and the associated opportunities for the GMCA area.

The primary scenario reflects phases 1 and 2 of HyNet, where low carbon hydrogen may be available from 2025 onwards for the largest industrial sites in the region. It is not believed that any of these are likely to be in Bolton. The secondary scenario includes the possibility of HyNet phase 3, where low carbon hydrogen becomes available for homes and the full range of non-domestic buildings from the early 2030s onwards. This would require the repurposing of areas of gas grid to serve hydrogen to the buildings. Under this scenario it is found to be cost effective to provide hydrogen to domestic and non-domestic buildings in many areas of Bolton, resulting in a potential shift to hydrogen dominated heating. One of the key considerations being that the hydrogen based secondary scenario is assumed to be notably cheaper than the primary scenario (£9 bn compared to £7.8 bn); however, this is dependent on HyNet phase being delivered on time and at the cost and carbon projections provided by HyNet. Taking a wait-and-see approach is therefore deemed extremely risky when there is a 2038 carbon target; the scale-up and demonstration approach in the identified priority areas are therefore provided so that short to medium term activity can take place in areas of least regret.

A further scenario was also studied where hydrogen was tested as the only low carbon option (detailed in the appendix). Further analysis of both this and the secondary scenario showed that the total carbon emitted was very sensitive to the exact year that low carbon hydrogen became available in suitable quantities, which has a high level of uncertainty. Further detail is provided in Energy Networks section.

Under scenarios where HyNet phase 3 happens and low carbon hydrogen is available to the grid in the early 2030s, hydrogen heating displaces some of the electric and district heating. This would be across residential and industrial assets.

Illustration of Hydrogen Sensitivity Analysis for Carbon Intensity



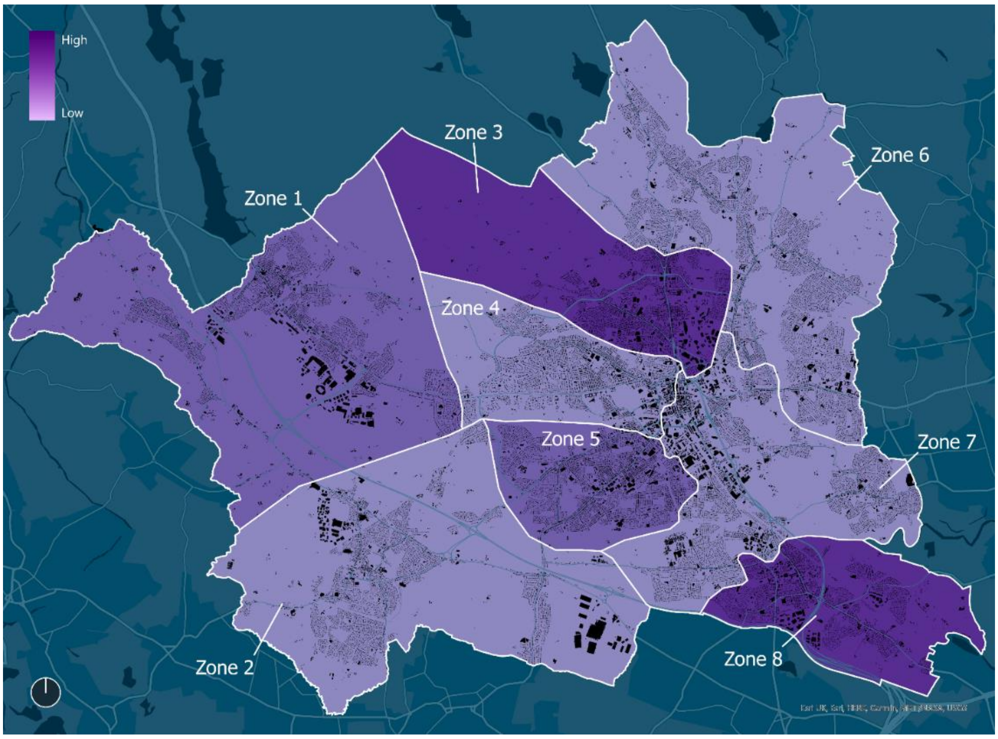
The graph illustrates a sensitivity analysis on the carbon intensity of hydrogen. As the carbon intensity is increased from the base assumption (from HyNet projections), the model continues to utilise hydrogen at large rates across the zones, until it drops off in certain zones when the carbon intensity matches that of electricity. This is a positive sign highlighting the efficacy of hydrogen as a heating source in all zones across Bolton.

Hydrogen for Heating - Opportunity areas

Non-domestic buildings serve a number of different functions, ranging from offices, educational facilities, retail, warehouses and factories (see the following section on non-domestic buildings). It is expected that some of these types of buildings may benefit from having access to hydrogen as the UK transitions away from natural gas. In particular, certain industrial processes may require high temperatures. A high level desk based study of such industrial facilities in Bolton has been conducted to highlight where these high temperature uses are likely to be, and we find no existing industry, however, there are potential sites which could have large heating loads.

The other possible building type to target is new builds due to be built at the point at which low carbon hydrogen is available. The exact timing of the buildings being complete and the hydrogen coming available is uncertain at this point, but if it can align then it provides a potential option for the buildings.

Given the consistent requirement of hydrogen when its available in all the zones, there are no real constraints that would prioritise hydrogen in one area or another. While there are sites with large heat loads, Bolton Hospital, Beaumont hospital and the University of Bolton would be great users of hydrogen given their heating requirements, however, no specific areas of significant industrial activity have been identified, which could benefit from the prioritization of hydrogen.
As per the sensitivity shown above, given the proposed roll-out of hydrogen in large amounts in zones 3,6 and 8 independent of the hydrogen price reaching parity with electricity prices, these zones are proposed as opportunity areas for hydrogen.



Colour shading shows number of homes identified as suitable for hydrogen heating

Most zones swing between being dominated by air source heat pumps or by hydrogen boilers between the primary and secondary scenarios, illustrating sensitivity to assumptions about the availability, cost and carbon content of hydrogen.

- In the secondary scenario, most of the dwellings will take on hydrogen, in all the zones will take on hydrogen.
- Flats are split evenly between electric resistive and hydrogen for heating. Detached homes have a large tendency to use ground source heat pumps. This makes sense given the potential space they might have

Zone	Prevalent heating system		Priority area
	Primary scenario	Secondary scenario	
1	Heat Pump	Hydrogen	
2	Heat Pump	Hydrogen	Heat Pump
3	Heat Pump	Hydrogen	(heat pump opportunity)
4	DHN	Hydrogen	
5	DHN	Hydrogen	
6	Heat Pump	Hydrogen with some heat pump	(heat pump opportunity)
7	Heat Pump	Hydrogen	
8	Heat Pump	Hydrogen	

Heat pump prevalent zone

Heat pump priority area

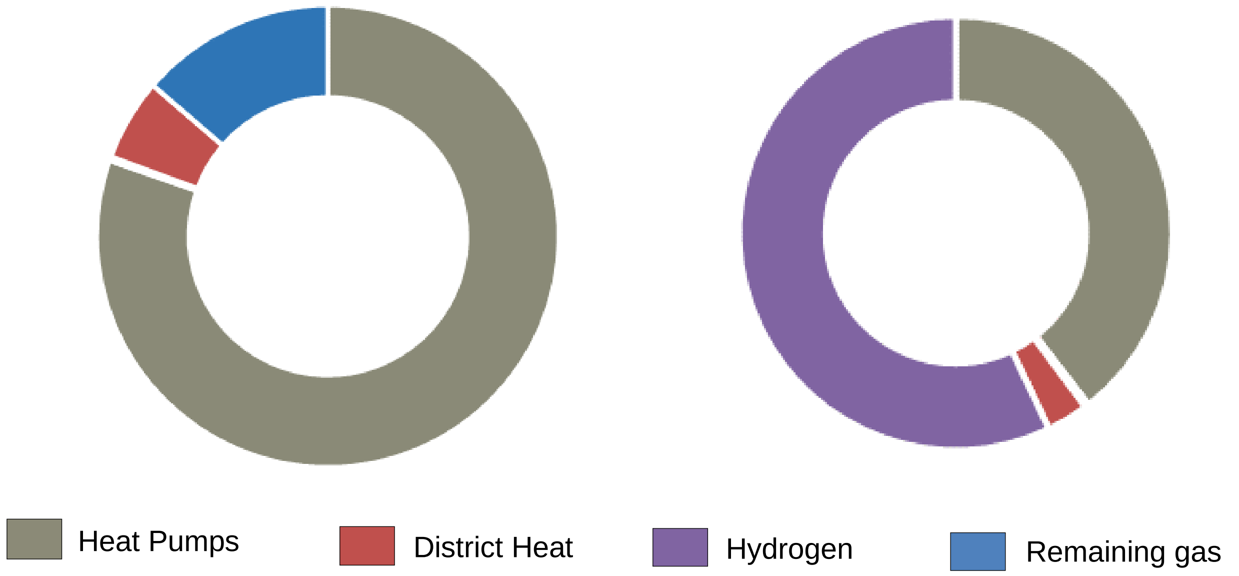
Hydrogen for heat opportunity area

District heat opportunity area

4. NON-DOMESTIC BUILDINGS

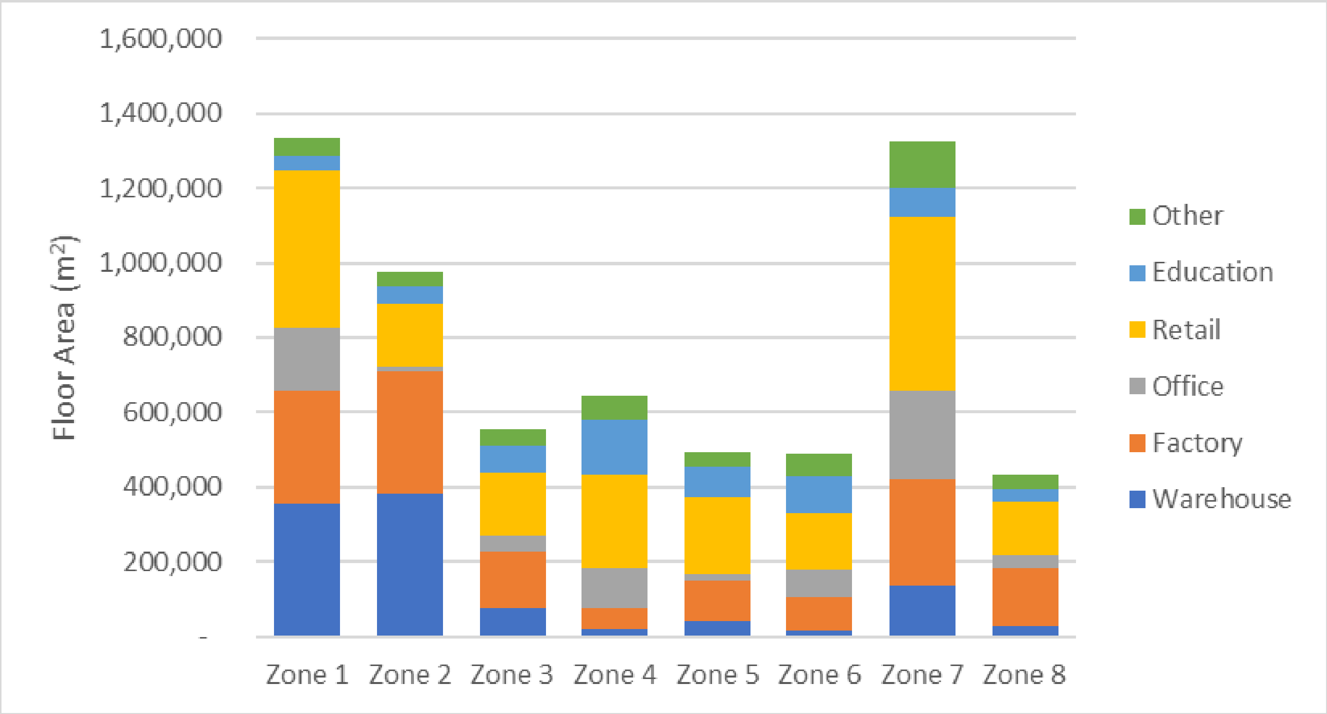
With the requirement to rapidly reduce CO_2 emissions in line with the GM carbon budget, the primary scenario is based on an individual heat pump transition for most Bolton's non-domestic buildings; however district heating may be suited to specific buildings, where more detailed analysis is needed that considers buildings at a more detailed level. The estimated combined investment (for improving the energy efficiency and installing heat pumps) is in the region of £1.9b. However, opportunity areas are also highlighted in section 4, where some non-domestic buildings in Bolton could be served by district heating.

Heating System Installations in Primary Scenario | **Heating System Installations in Secondary Scenario**



- The majority of Bolton's non-domestic buildings (80% by floor area) have been deemed able to transition to a heat pump option,
- 6% (by total floor area) has been deemed able to transition to district heat networks.
- A small proportion (14% by floor area) are deemed to be reliant on either gas or hydrogen for use in industrial processes
- Further area-specific and detailed consideration is required to identify the most appropriate non-domestic solutions.

Non-domestic Building Usage by Floor Area (m2)



Non-domestic Buildings Priority Area Selection

Each zone in Bolton has a diverse mix of non-domestic building type, with all zones covering all building types. Zones 1 and 2 have more warehouses and factory sites, but only by a small margin.

Retail sites and offices could move to heat pumps or heat networks, with warehouses and factories which continue to use gas, could benefit from conversion to hydrogen.

Vision to 2038

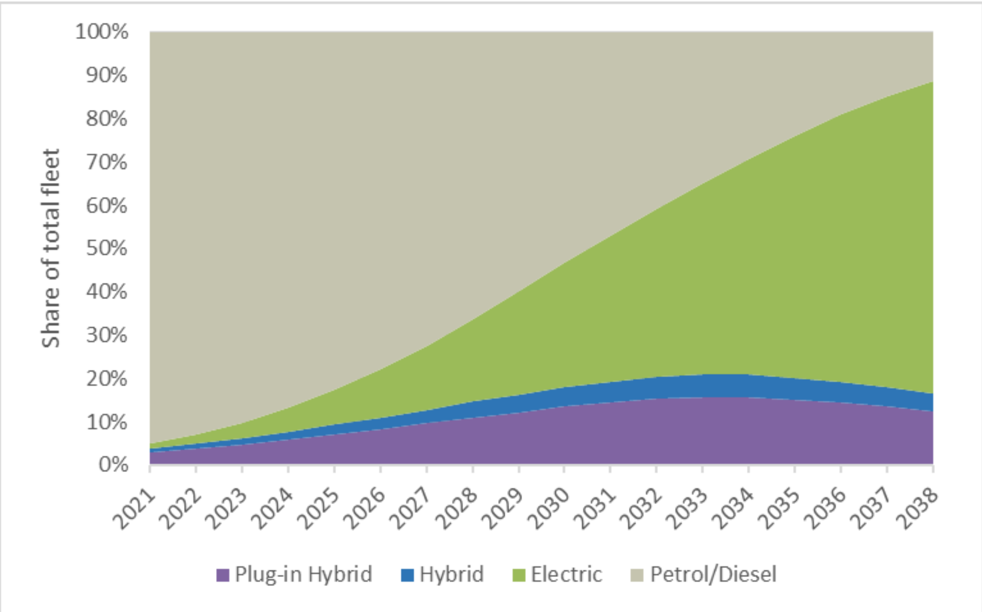
Electric Vehicle (EV) ownership is expected to grow significantly to support local decarbonisation targets and in alignment with national policy, which will see the phasing out of internal combustion engine vehicle sales by 2030 and hybrids by 2035.

Fully electric and plug-in hybrid vehicles (PHVs) in Bolton are expected to grow from around 5,000 today to almost 119,000 cars by 2038 – 85% of the total fleet. Charging infrastructure will need to be installed to encourage this transition and keep up with this demand, providing confidence that owners will be able to recharge when needed. A mixture of publicly accessible and private residential chargers will be required to provide this amenity.

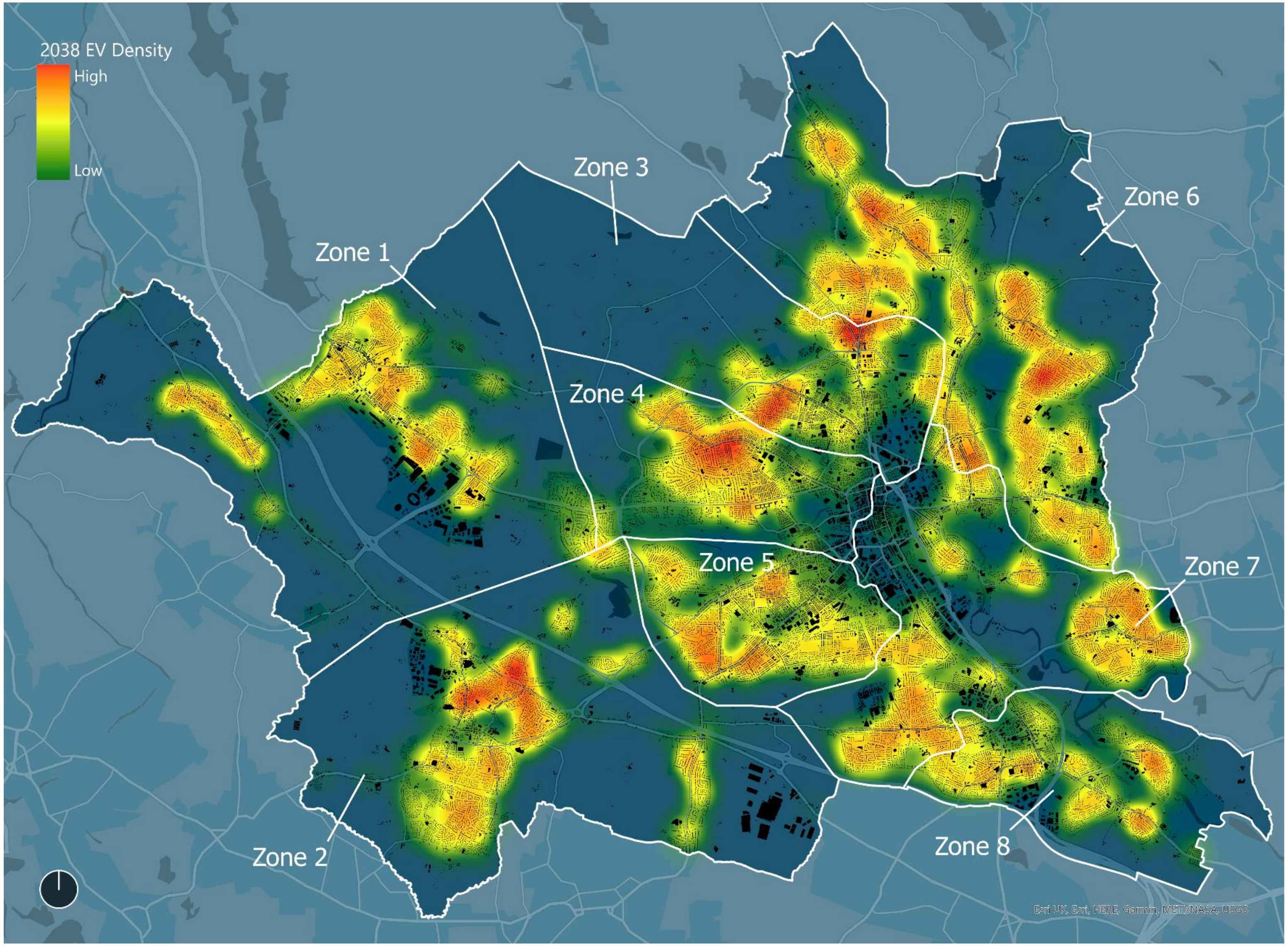
Greater Manchester's Transport Strategy 2040 sets out an ambition that no more than 50% of daily trips (across all modes) will be made by car in 2040, down from 61% today. In light of an expected overall growth in trips, the strategy sets out that meeting this target would mean a reduction of car trips from the current 3.7m per day to 3.4m. However, this still represents a significant demand for EV charging, estimated to increase to 362 GWh per year in Bolton by 2038.

Since EV transition, supported by publicly accessible and home chargers, is a consistent result across all scenarios, all moves to make first steps in charger deployment can be considered low regret.

Projected Vehicle Mix Over Time



"Heat map" showing density of EV uptake by 2038 across Bolton



Publicly Accessible EV Charge Points

Charge points will be a mixture of at-home and at-destination (such as workplaces and shopping centres). Transport for Greater Manchester (TFGM) is developing plans for the expansion of the existing network of publicly accessible charge points, to help overcome the inability to charge an EV at home, as experienced by many GM residents, to aid an accelerated transition to EV; aspects of this have been incorporated in this plan.

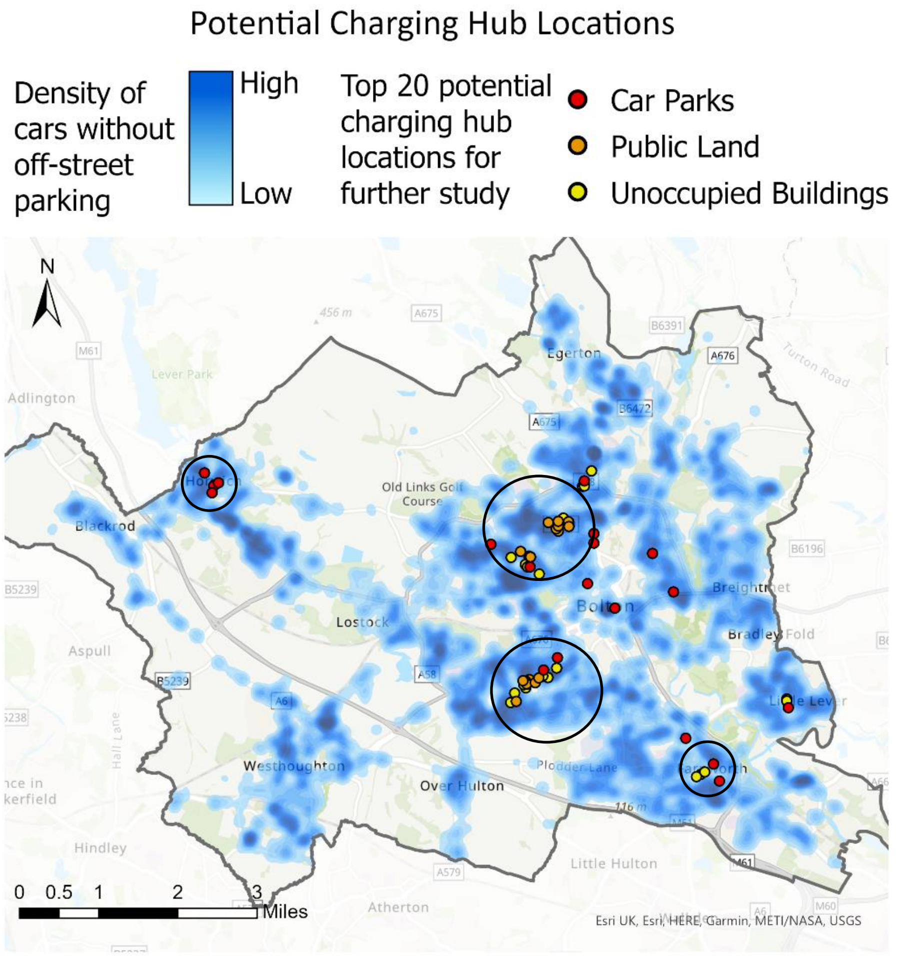
At-home charging for dwellings that have off-street parking is a solution which is well developed, but for dwellings without that potential, other solutions will be needed. One solution may be public charging hubs located in residential areas with limited potential for off-street parking. Other alternatives include developing an EV car club offer and expanding levels of workplace and destination charging provision.

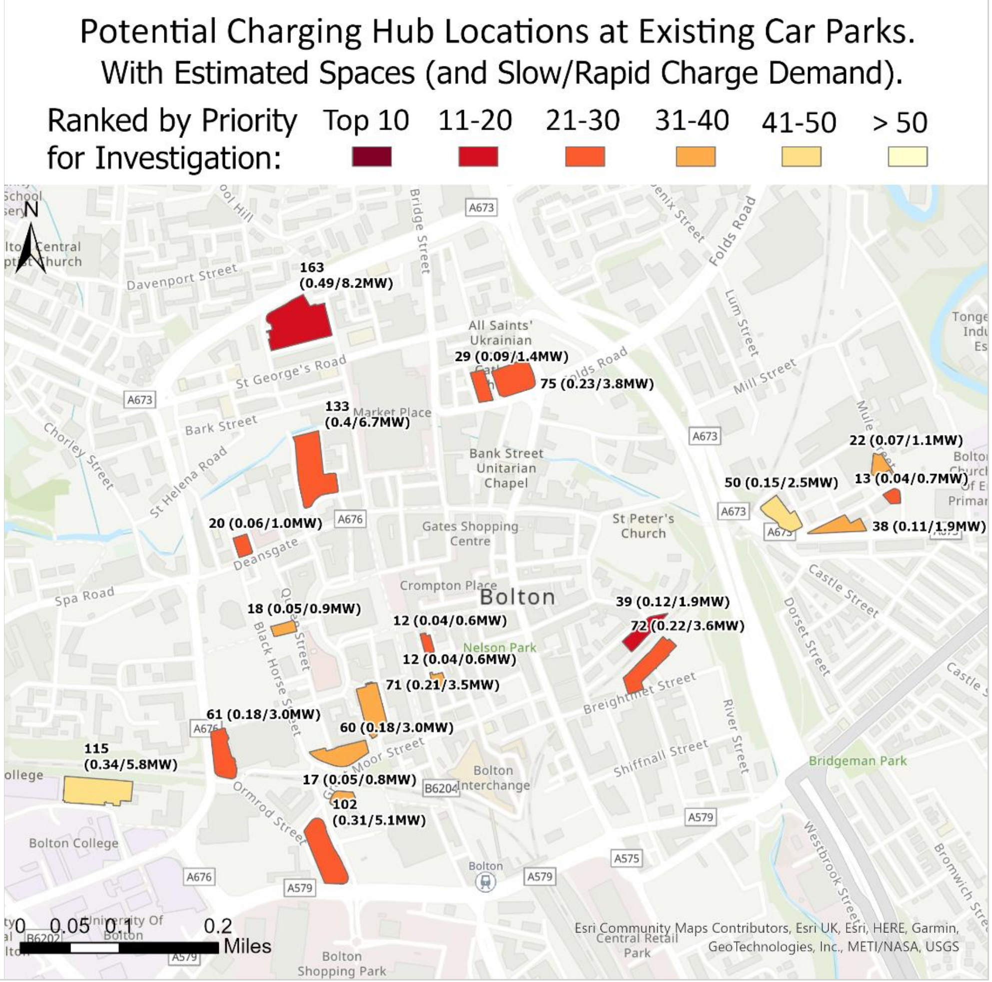
The maps shown on the following page identify potential prioritised charging hub locations, based on dwellings without potential for off-street parking and projected EV use. Further consideration will be needed, working with TFGM to identify and develop public/hub charge points across Bolton[*].

Home Charge Points

Homes with potential for off-street parking are considered able to install private chargers. EV ownership is projected to significantly outstrip the number of homes with off-street parking, and every home with off-street parking sees a charger installed, amounting to over **46,000 home chargers**. The installation of these chargers could be coordinated with other home interventions, such as PV installation, heating system replacement and insulation, to minimise disruption experienced by households, and avoid multiple changes to wiring. Opportunities should also be explored for smart system integration between these different technologies.

* It is also recognised that EV charging provision should not be considered in isolation from other transport related decarbonisation plans. Bolton will need to work with GMCA, TFGM and other relevant stakeholders to ensure a joined up transport decarbonisation approach is developed and implemented. As well as aligning with local planning policies as it relates to provision of chargers in new developments and existing dwellings





As discussed, these maps highlight areas by proposed density/priority. These locations have been taken forward as the proposed 'EV charging hub priority areas in the Demonstration and Scale up Priority Areas aspect of this LAEP. Other public/hub charge points will be needed in other areas across Bolton; supporting data will be provided in the accompanying detailed and granular data set.

Vision to 2038

The shift to electricity for heating and transport increases the importance of using low carbon electricity sources. Although the electricity grid will need to reach almost zero carbon by 2050 for the UK to meet its net zero commitments, with very low or even negative levels of emissions anticipated as early as 2035, Bolton will need to shift to zero carbon electricity earlier than the nation as a whole in order to stay within the carbon budget. This will mean generating much more zero carbon energy locally. All modelled scenarios found increases in locally generated renewable energy, primarily through solar PV.

This would require significant investment and transformation of land which may have other beneficial uses. In the context of an electricity grid which is already rapidly decarbonising, the relative merit of large-scale solar PV rollout should be considered. Additionally, analysis of matching supply and demand should be conducted to determine the optimal configuration of local renewable assets versus grid supplied electricity (taking a whole energy systems approach), alongside demand side response, flexibility, and energy storage; these aspects are discussed further on p.75 where potential priority areas are highlighted to consider further assessment.

This local generation is particularly beneficial in staying within the carbon budget in the early years, while grid emissions are still relatively high. Consequently, early deployment is key to reaping the benefits of renewable generation, although it is recognised that deploying such large volumes of local generation in such timescales would be extremely challenging. If some of the capacity can't be deployed until later years, the carbon benefit will be diminished as the generation displaces cleaner grid electricity. Reassessment of the cost-benefit of such deployment would then be advisable.

Rooftop Solar and Batteries

Building rooftops are used to meet a portion of energy requirements.
Every modelled scenario utilised all suitable rooftop space (generally South East to South West), resulting in approximately 733 MWp rooftop PV capacity installed by 2038, yielding 872 GWh of energy annually. In other words, all buildings with suitable roofs are low regrets opportunities to install solar PV, meaning there is plenty of flexibility around the approach for this.

As an indication, the map on the following page highlights homes in a sample area which are suited to both rooftop PV and EV chargers. Combining the installation of these two measures would mean that the design of electrical works (such as cable routing) will integrate the needs of both measures, reducing disruption and potentially reducing overall cost. This opportunity could also be taken to create additional electrical capacity for future heat pump power supplies.

Alongside rooftop PV, there is an opportunity to install home battery energy storage systems. These can store generated energy for times when there is no generation and potentially provide flexibility services to the electricity network; new market incentives which value flexibility may boost the economic case for domestic batteries going forward.

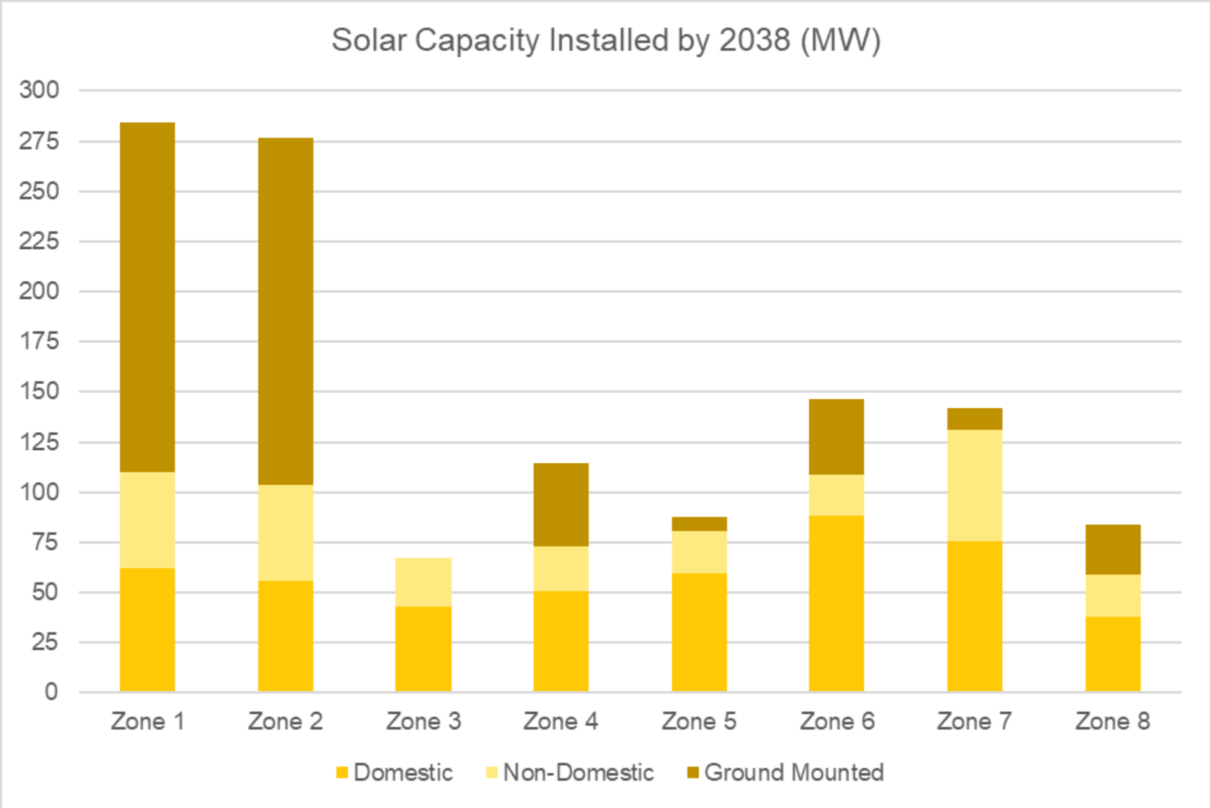
Density of dwellings with both rooftop PV and EVs, by 2038 in Bolton

Large Scale Solar PV* Wind and Hydroelectric

A study to determine the areas of land in Bolton suitable for ground mounted solar PV, small-scale hydroelectric and wind turbines (including land not owned by the council) was carried out, accounting for factors such as flood zones, protected natural spaces and habitats, infrastructure, agricultural quality of land and future developments. This study found substantial opportunities for solar and only very limited hydro developments, but none for wind. Forty two potential sites for ground mounted solar PV were identified (see map below), covering a total of up to 782 hectares. Such large-scale deployment of solar on the land would clearly require careful consideration around feasibility and public acceptability. If the full extent of solar capacity in this plan could not be deployed in practice, the largest impact would be on near-term carbon budget, whereas beyond 2035, the National Grid emissions are expected to be very low, so local generation becomes less critical to reaching low emissions.

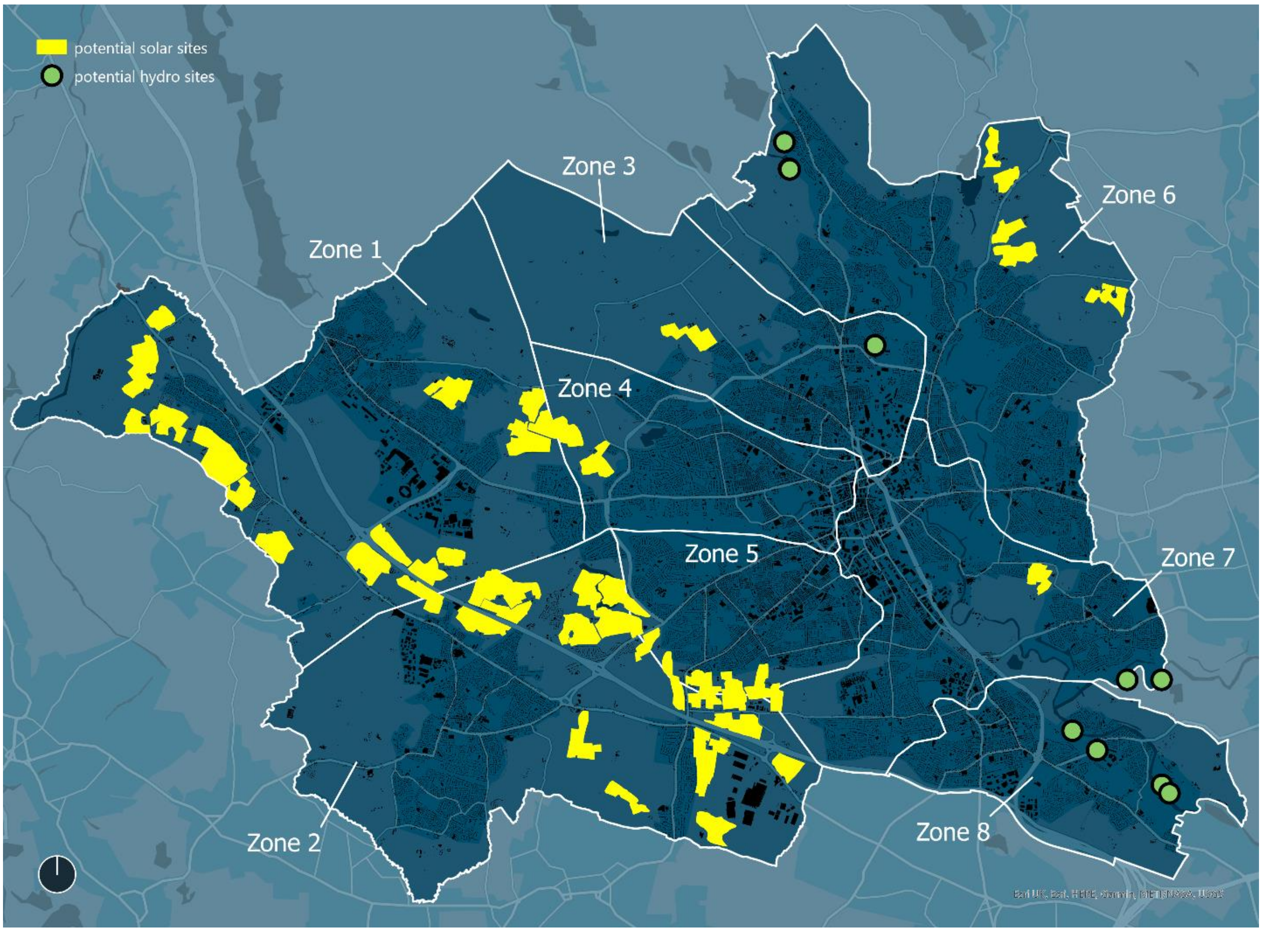
* Opportunities for local energy generation have been identified following a high level screening study in support of this LAEP. Further assessment will be required to consider renewable energy generation opportunities in detail. Screening has been carried out through assessing constraints surrounding location/land suitability e.g. considering aspects such as proposed development, protected areas, land classification, flood risk and available resource (e.g. wind speed and solar irradiance). Impact of large-scale renewables on grid constraints and potential curtailment requirements have not been assessed and will need consideration to ensure optimal integration.

A total of 479 MWp of PV capacity could be deployed on this land, yielding 399 GWh of energy per year. Potential for ten hydro sites was also identified in Bolton with generation capacity of 1,800kW, yielding 6,100 MWh per year.



Of the 733 MW of rooftop PV, 260 MW is provided on non-domestic building roof space. Alongside domestic solar and ground mounted arrays, this could serve up to 50% of Bolton's annual electricity demand. Time of electricity demand and generation and their impact on the electricity network should be considered alongside the practicalities of rolling out this amount of rooftop PV.

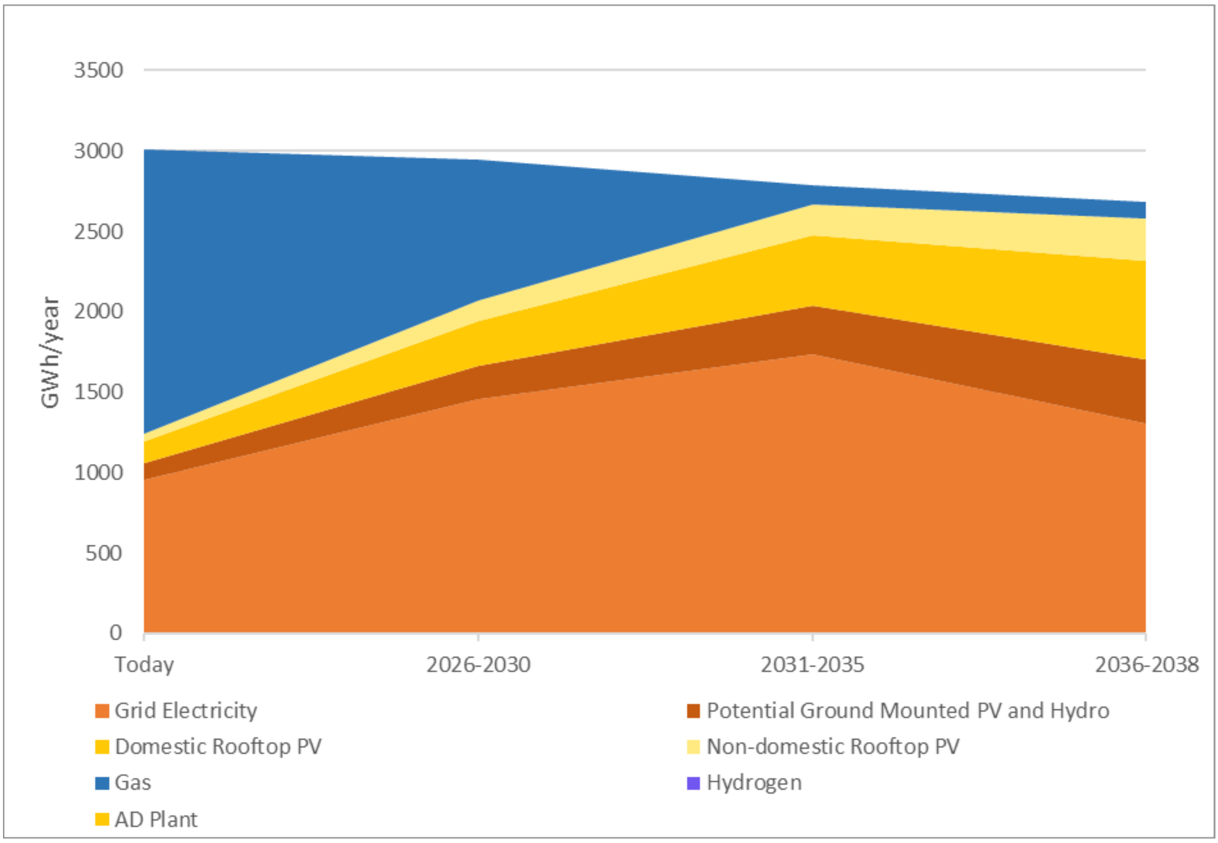
Potential sites for large scale solar PV, wind and hydroelectric in Bolton



Energy Supply and Demand

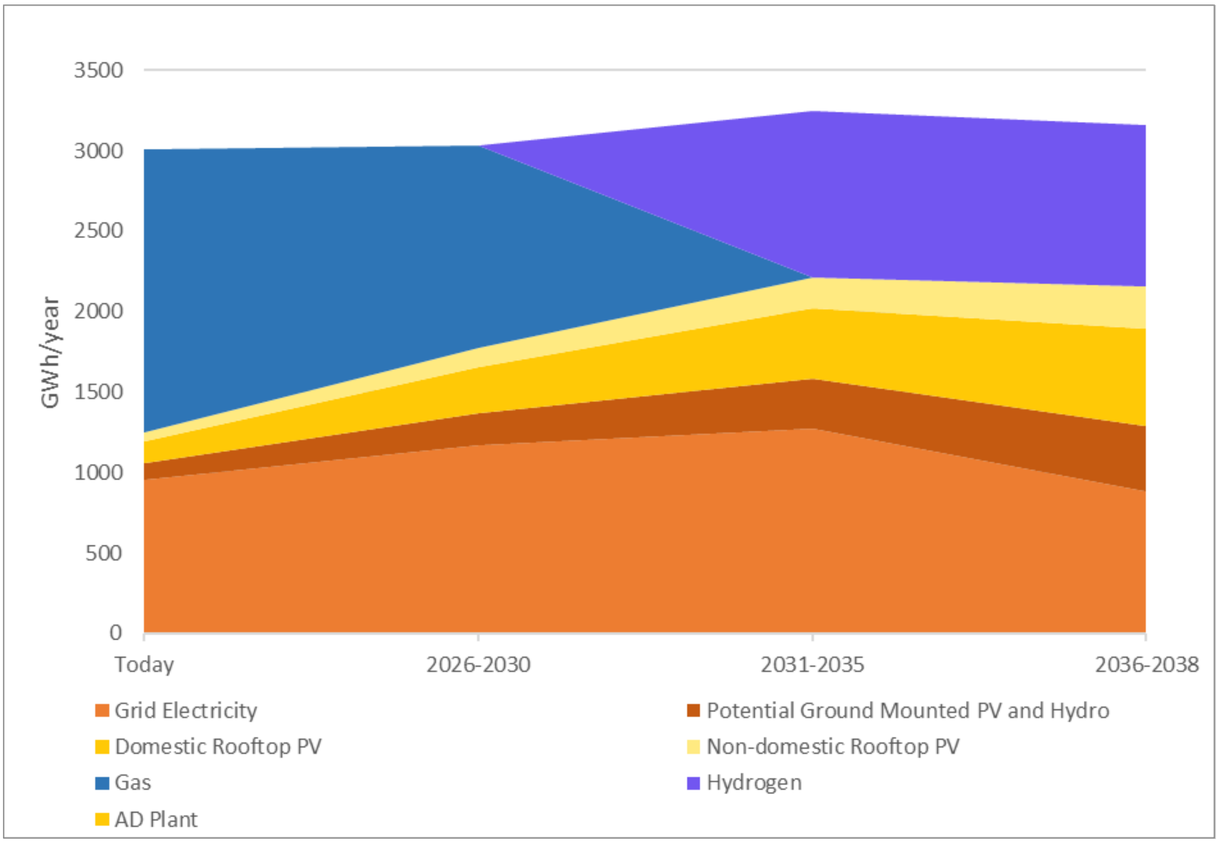
The overall trend in the energy balance is an increase in the consumption of electricity to replace fossil fuels, with a shift towards some of that electricity being generated by local renewables. This is a transformation in the way energy is used, meaning the energy system must evolve rapidly. This is explored in the next section: Energy Networks. The increase in energy produced and consumed locally offers the potential to explore local energy market arrangements.

Changes in Energy Supply in Primary Scenario



Changes in Energy Supply in Secondary Scenario

Figures shown exclude petrol and diesel fuel consumed for transport. The overall reduction in energy consumption due to increased efficiency is therefore greater than shown, since the reduction in transport fuel consumption is not shown here, whereas the new electrical consumption by vehicles is shown (and also in the chart above). Overall, electric vehicles use substantially less energy than petrol or diesel vehicles.



Vision to 2038

Energy networks are the backbone of Greater Manchester's carbon neutral future; the large-scale changes in the way we use energy described in the previous sections will require our networks to adapt and evolve in significant ways. For Bolton to reach carbon neutrality, major changes to the existing gas and electricity networks will be required, as well as the development of new networks including district heat and potentially hydrogen networks to meet future demand without the carbon emissions.

The electrification of heat and transport is likely to drive a major shift towards greater dependency on the electricity network. Greater demand for electricity will require investment in generation capacity and storage and distribution network infrastructure upgrades.

In the primary scenario, to decarbonise Bolton by 2038, gas demand is reduced to a small residual level due to its use in some non-domestic and industrial applications which are more difficult to electrify.

This section of the report provides an overview of the impact on each of the energy networks of the primary plan as well as insight from the other modelled scenarios and other key considerations given the uncertainties.

The primary scenario sees gas consumption reducing from c. 1,765 GWh per year currently down to around 115 GWh by the early 2030s, and lower still in the secondary scenario where hydrogen can replace many remaining uses of gas.

There is uncertainty currently about the role of hydrogen to replace heating, including when and where it may be available, in what quantities, the associated carbon emissions, and the cost compared to other solutions

The modelled scenarios considered the possible role of hydrogen for heating aligned to the development of HyNet infrastructure (secondary scenario), serving businesses and dwellings throughout Bolton.

All scenarios show that some gas or hydrogen remains in use by 2038, largely to support hard-to-decarbonise non-domestic premises, including high-temperature process heat for industry; although the proportion is significantly greater in the scenarios that consider HyNet phase 3 as an option. If hydrogen does not become available to support decarbonisation of these uses, alternatives may need to be considered to achieve the carbon target and budget, such as carbon capture and storage technologies.

Capacity Requirements for 2038: High Voltage

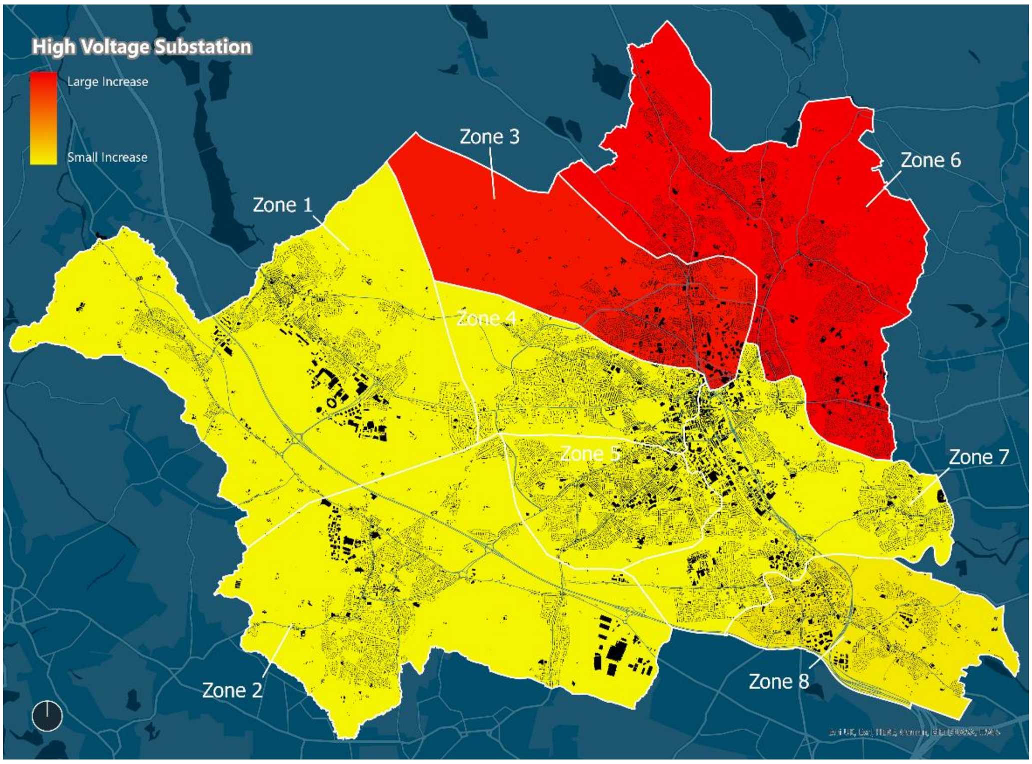
The local electricity distribution network operated under license by Electricity North West supplies electricity to the majority of dwellings and industry in Bolton today. Modelling indicates the capacity that would be required to meet all projected demand growth through conventional investment, but some of this demand could instead be accommodated through alternative investments, such as flexibility and storage. Hence the physical capacity increase required could be less than shown here. Areas with large increases in required capacity present opportunities for innovation and smart technology. Smart EV chargers and smart heat pump controls could make demand flexible, while storage technologies and vehicle-to-grid could help meet peaks in demand locally and provide other grid services.

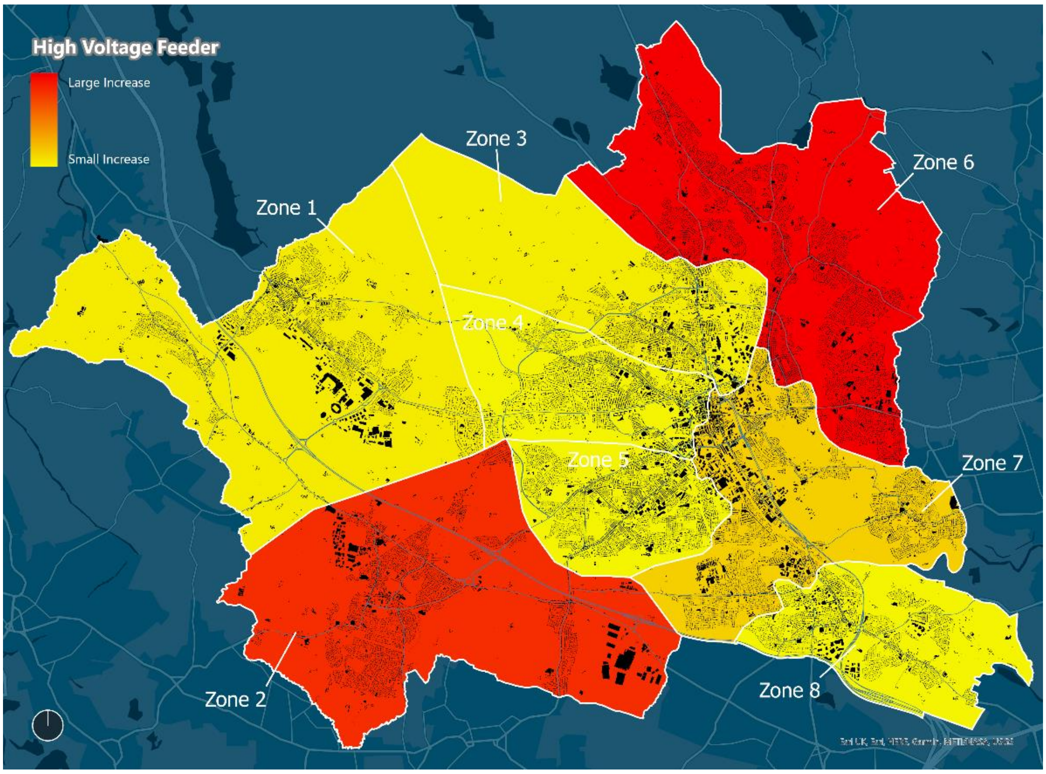
The modelled capacity requirements at high and low voltage levels are shown in the following maps and tables. The distribution of these impacts is determined by a combination of factors, such as electric vehicle ownership, potential for off-street parking and existing spare capacity in the current electricity infrastructure. For example, a zone may see a large increase in demand for home EV chargers, but not require large capacity increase because it currently has significant spare capacity. The difference in capacity requirement increase is evident between the primary scenario where heat is mostly electrified, and the secondary scenario where heating is mostly provided by hydrogen.

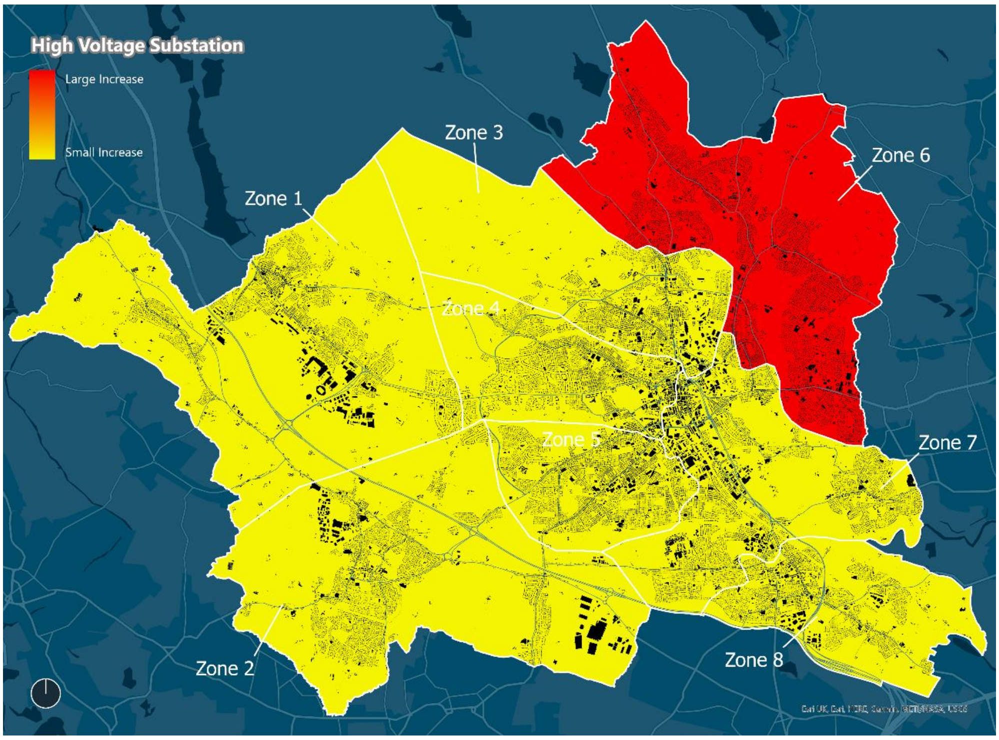
	High Voltage Feeder Capacity (MW)			High Voltage Substation Capacity (MW)		
Zone	2020	2038		2020	2038	
		Primary Scenario	Secondary Scenario		Primary Scenario	Secondary Scenario
Zone 1	76	83	76	85	85	85
Zone 2	55	145	55	63	63	63
Zone 3	45	48	45	38	145	38
Zone 4	50	50	50	48	48	48
Zone 5	49	49	49	43	43	43
Zone 6	57	172	59	49	203	203
Zone 7	81	106	81	86	86	86
Zone 8	44	44	44	34	39	34

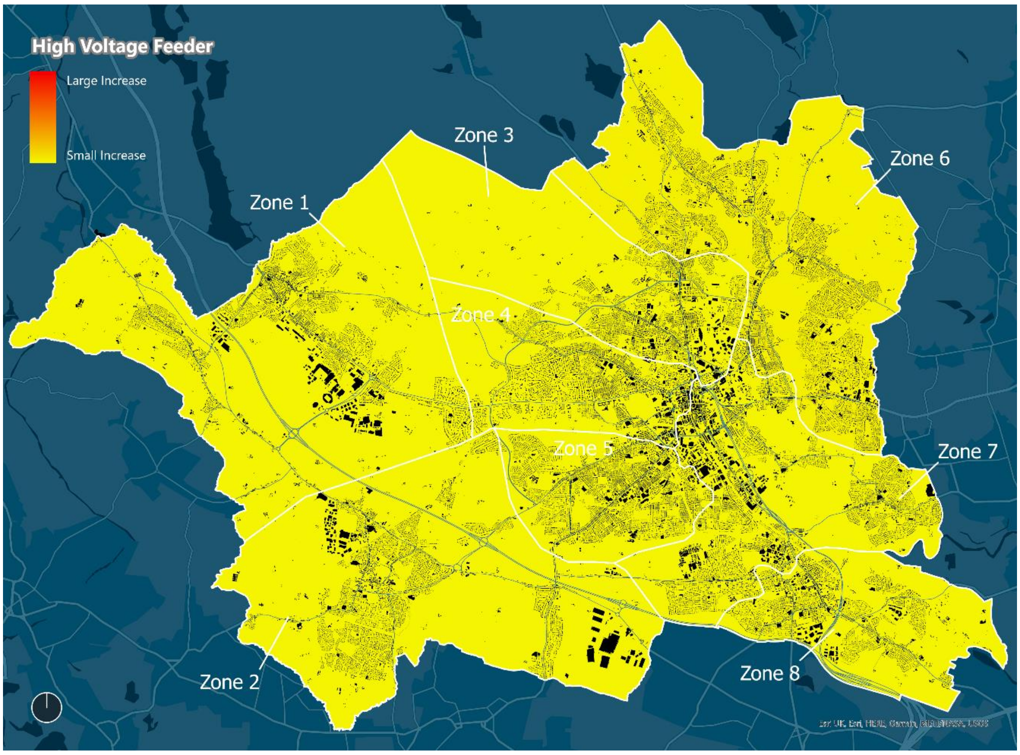
The following maps show the expected increase in capacity required to different parts of the electricity to support the increase in demand (primarily from heat pumps and EVs) as well as increased generation (primarily from PV). Darker colours indicate a greater increase.

Primary Scenario






High Voltage Substation
Large Increase
Small Increase
Zone 1
Zone 2
Zone 3
Zone 4
Zone 5
Zone 6
Zone 7
Zone 8


High Voltage Feeder
Large Increase
Small Increase
Zone 1
Zone 2
Zone 3
Zone 4
Zone 5
Zone 6
Zone 7
Zone 8

Capacity Requirements for 2038: Low Voltage

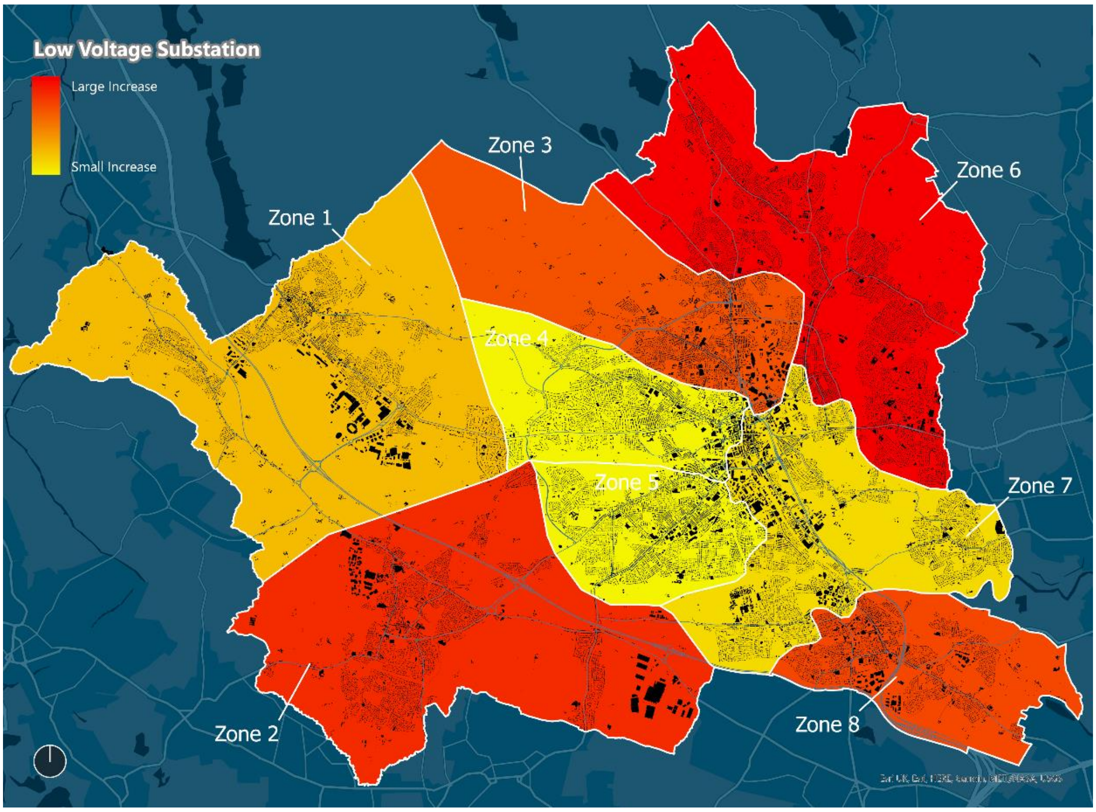
Low voltage feeders are the underground cables serving individual buildings, often located under pavements, so upgrades to these can involve extensive street works. High voltage feeders on the other hand, only run to substations which typically serve multiple streets, so require less extensive works. They are typically laid in ducts under roads. Substations are located on designated plots of land, with exclusive access for the DNO.

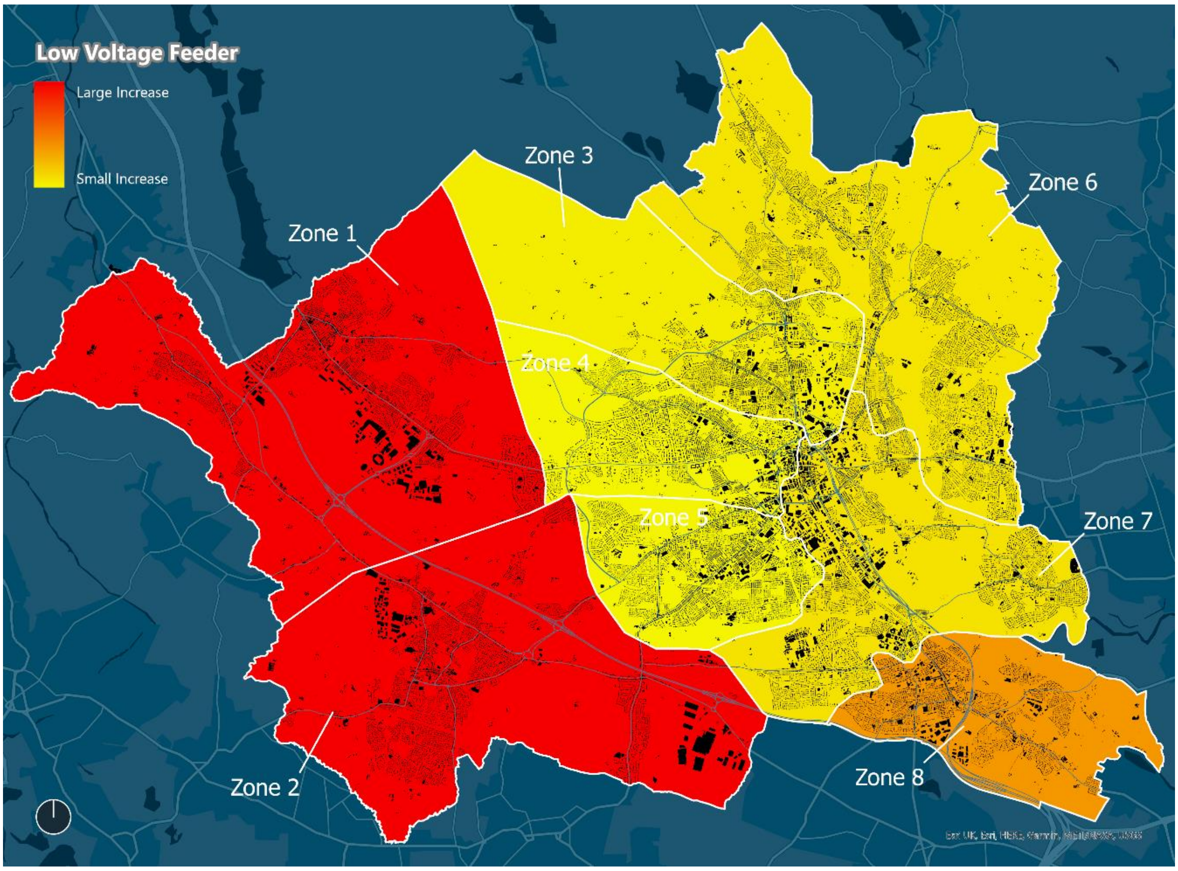
	Low Voltage Feeder Capacity (MW)			Low Voltage Substation Capacity (MW)		
Zone	2020	2038		2020	2038	
		Primary Scenario	Secondary Scenario		Primary Scenario	Secondary Scenario
Zone 1	43	140	57	55	145	145
Zone 2	43	140	57	42	283	283
Zone 3	47	50	33	35	199	35
Zone 4	40	40	40	40	40	40
Zone 5	35	35	35	36	36	36
Zone 6	97	110	60	45	361	361
Zone 7	77	91	77	78	138	78
Zone 8	32	59	32	31	187	31

Capacity increase is notably high in some areas, corresponding with high levels of heat electrification (zones 2 & 6) where the network must be sized for demand on the coldest day of the year, when heat pump efficiency is also lower. These areas could be a focus for the use of smart, flexible heat pumps or storage to reduce the capacity needed.

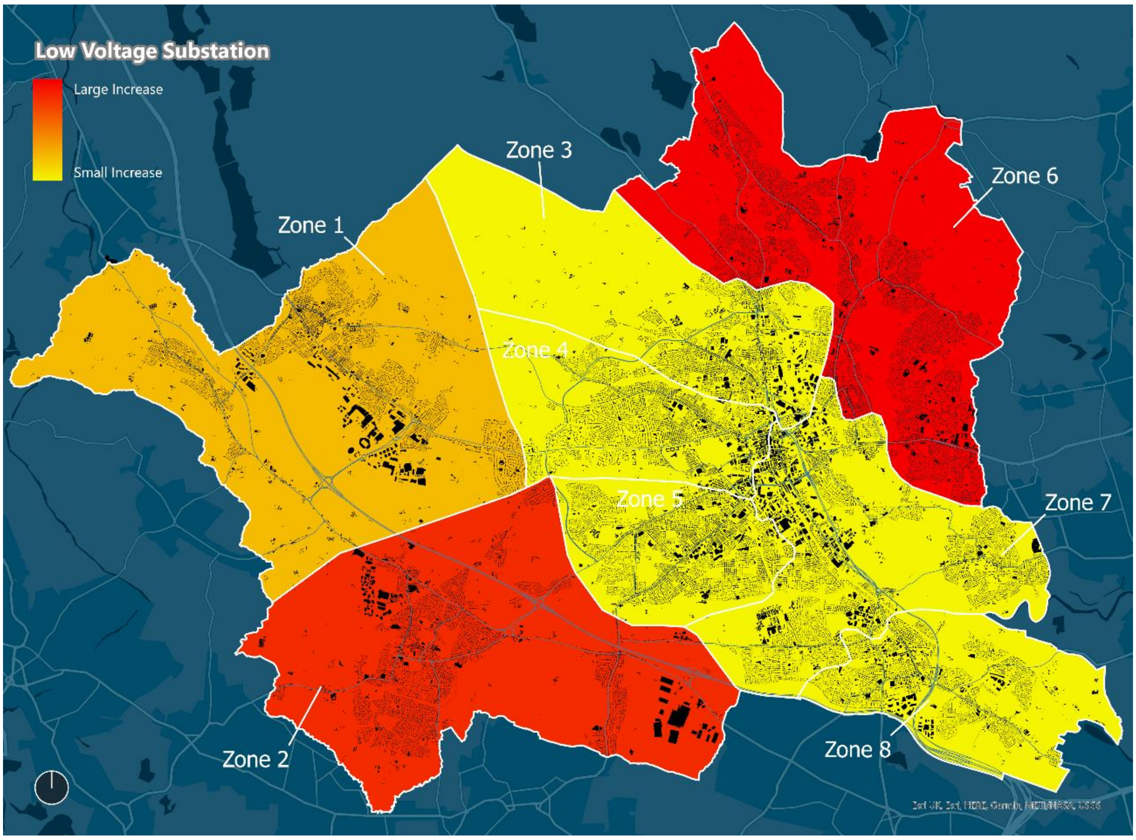
As stated throughout this LAEP, the intention of this work is to highlight the potential change in electrical demand, **not identify the most appropriate and cost-effective solution for providing additional capacity**. More detailed electrical network design and planning work would be required to identify the most appropriate solution.

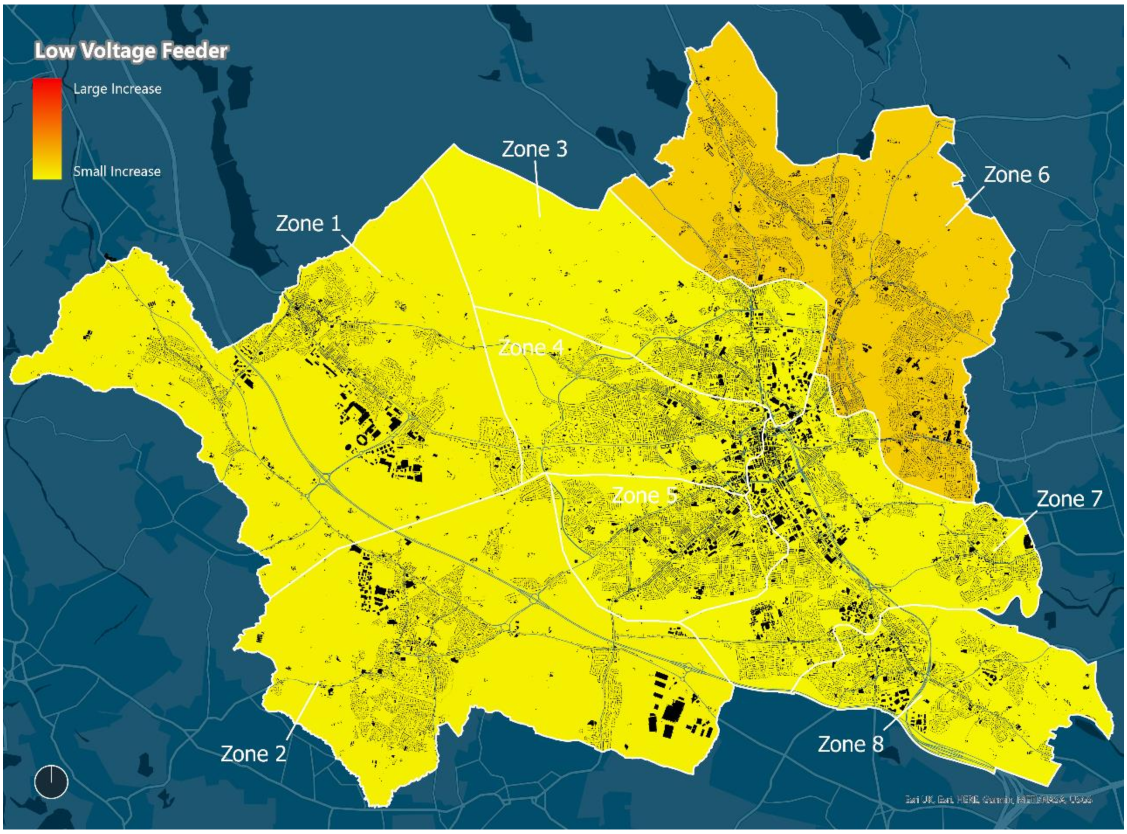
Primary Scenario





Secondary Scenario





Present Day Capacity and First Steps

Examining present network capacity gives some indication of where deployment of low carbon technologies could be prioritised without immediately running into network constraints.

Zone 2 for example, has the greatest capacity headroom for demand, with Zone 5 & 8 also having significant demand headroom. This suggests that roll out of heat pumps and EV chargers could begin here before network upgrades are eventually required to reach the total numbers in the plan.

In contrast, Zones 3 & 4 have very little spare capacity. This suggests that the need for infrastructure reinforcement to deliver the full plan should be assessed early to ensure that it doesn't delay progress. Local flexibility, storage and generation could be trialled to overcome demand constraints. Although it's worth noting that peak network demand typically occurs on winter evenings, when solar generation is negligible, and electrification of heat is likely to compound this.

	Demand			Generation	
Zone	**Headroom (MW)**	**Heat pump installs**	**Households with EV chargers**	**Headroom (MW)**	**Solar PV installs (MW)**
Zone 1	15	15,041	6,147	56.6	110
Zone 2	56.8	13,935	7,292	73.1	104
Zone 3	9	12,205	4,240	8.1	67
Zone 4	0	2,977	3,903	0	73
Zone 5	38.1	4,359	6,005	16.1	81
Zone 6	18	23,102	11,121	16.2	109
Zone 7	10.4	19,918	3,214	40.2	131
Zone 8	27.2	11,306	3,807	46.7	59

Demand headroom is non-firm headroom at the primary substation for the zone. Generation headroom is the inverter-based headroom at the primary substation for the zone, which is most relevant for considering solar PV. All figures from ENW's heat map tool
https://www.enwl.co.uk/get-connected/network-information/heatmap-tool/

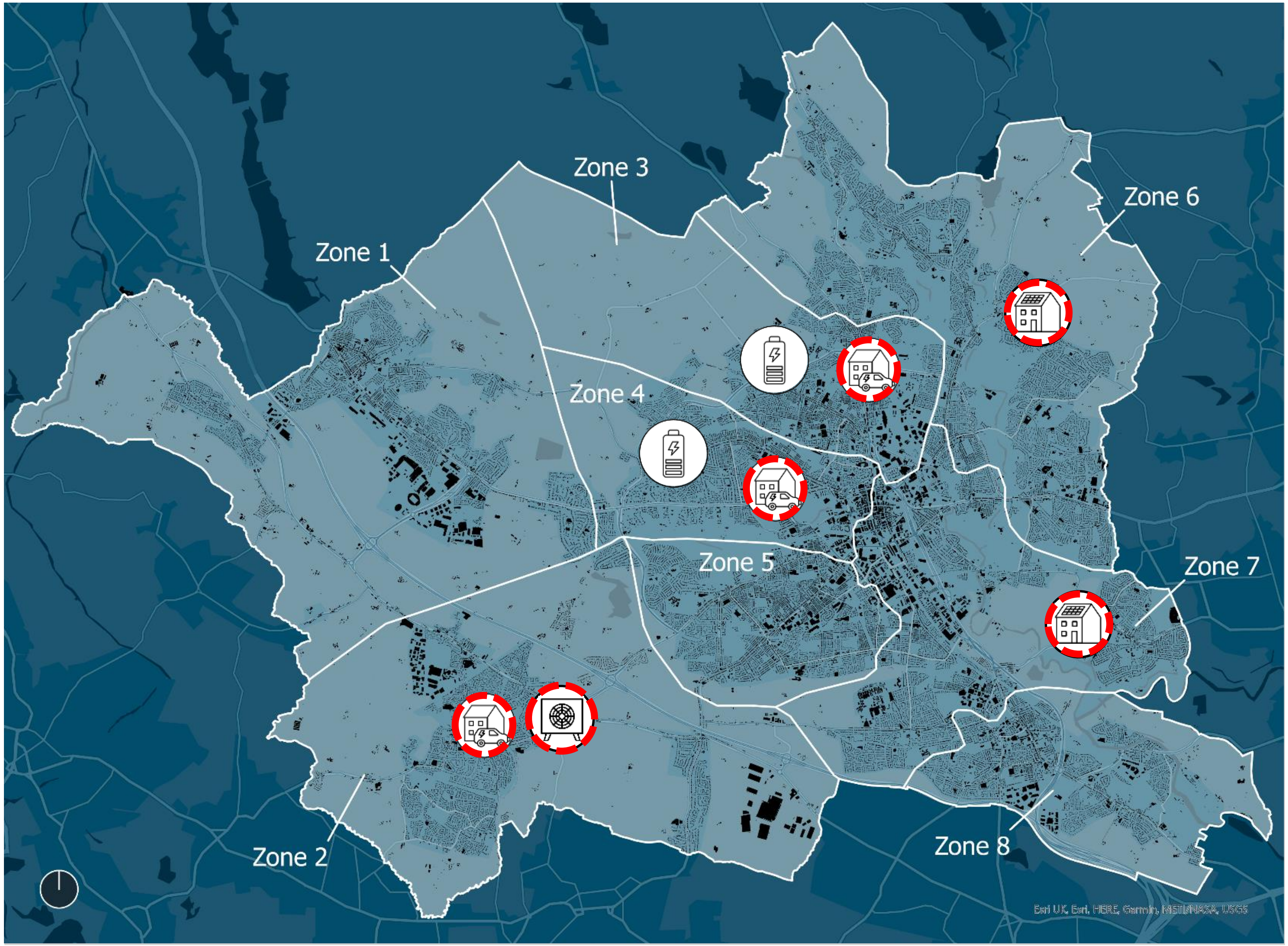
For solar PV, half of the zones (1, 2, 7 & 8) have a large generation headroom. The other four areas could run into limitations earlier without network upgrades.

EV charging priority area

Heat pump priority area

Solar PV priority area

Flexibility and storage opportunity area



Gas Network Today

The gas network operated under license by Cadent supplies gas to the majority of dwellings in Bolton today, predominantly for heating and hot water but also cooking. It also supports a range of non-domestic and industrial local energy demands. The current total gas consumption across Bolton is around 1,837 GWh.

To deliver Bolton and GM's carbon budget and target, it is expected that the vast majority of dwellings will no longer use natural gas by the early 2030s to stay within the carbon budget. Most non-domestic buildings will also transition away from gas.

Future of Gas and Hydrogen for Heat

The primary scenario for Bolton sees the majority of dwellings converting their heating systems to either be

- connected to a district heat network or, more commonly,
- converted to electric heating, predominantly in the form of different types of heat pumps depending on different factors such as location, energy efficiency and house type.

This would necessitate phased disconnection of homes from the gas network as they are converted to electric or district heating, which would need coordination. However, the secondary scenario sees the majority of buildings supplied by hydrogen, meaning they would remain connected to a repurposed gas network. Around £89m of investment would be required for this network conversion. Of Bolton’s approximately 1,395 km of gas pipework, around 78% is already made of polyethylene, suggesting that much of the network could already by suitable for carrying hydrogen.

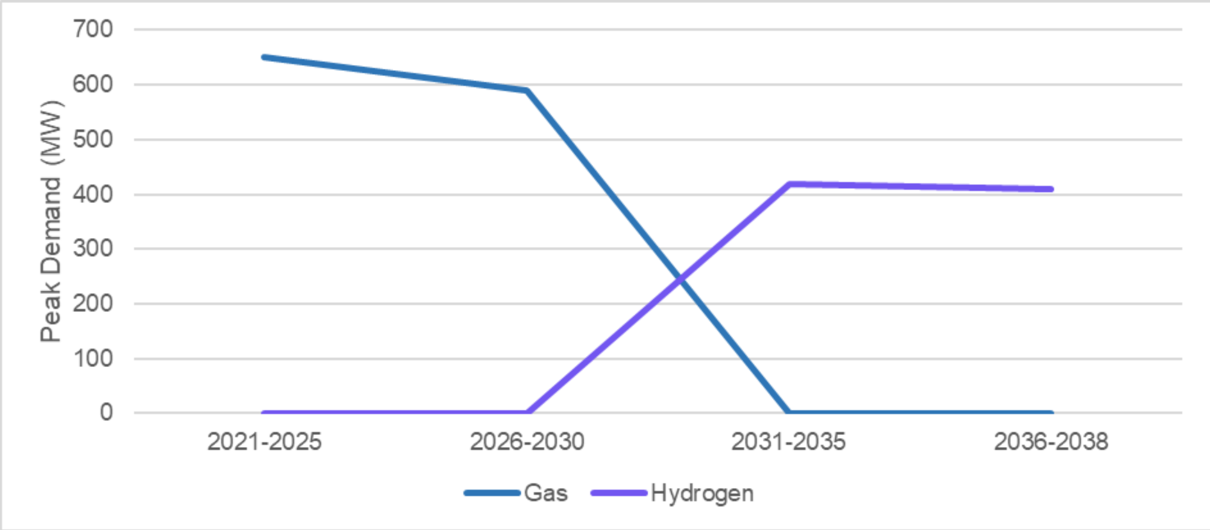
Hybrid heating (air source heat pump/gas boiler hybrid) is an option in certain circumstances and could provide a valuable transition technology to manage uncertainty around the role of the gas network in domestic heating through the 2020s, and to manage demands on the electricity network. Around 600 dwellings may be suited for this technology (even when the wider whole energy system balancing aspect isn’t considered): generally larger properties where a hybrid solution may become more cost effective than an air source heat pump alone, but where a ground source heat pump is unsuitable due to exterior space and access requirements; this could provide an opportunity to understand the role of hybrid systems.

Even in the electrification scenario, gas networks may need to be retained for longer in areas where hybrids are a useful transition option due to property types.

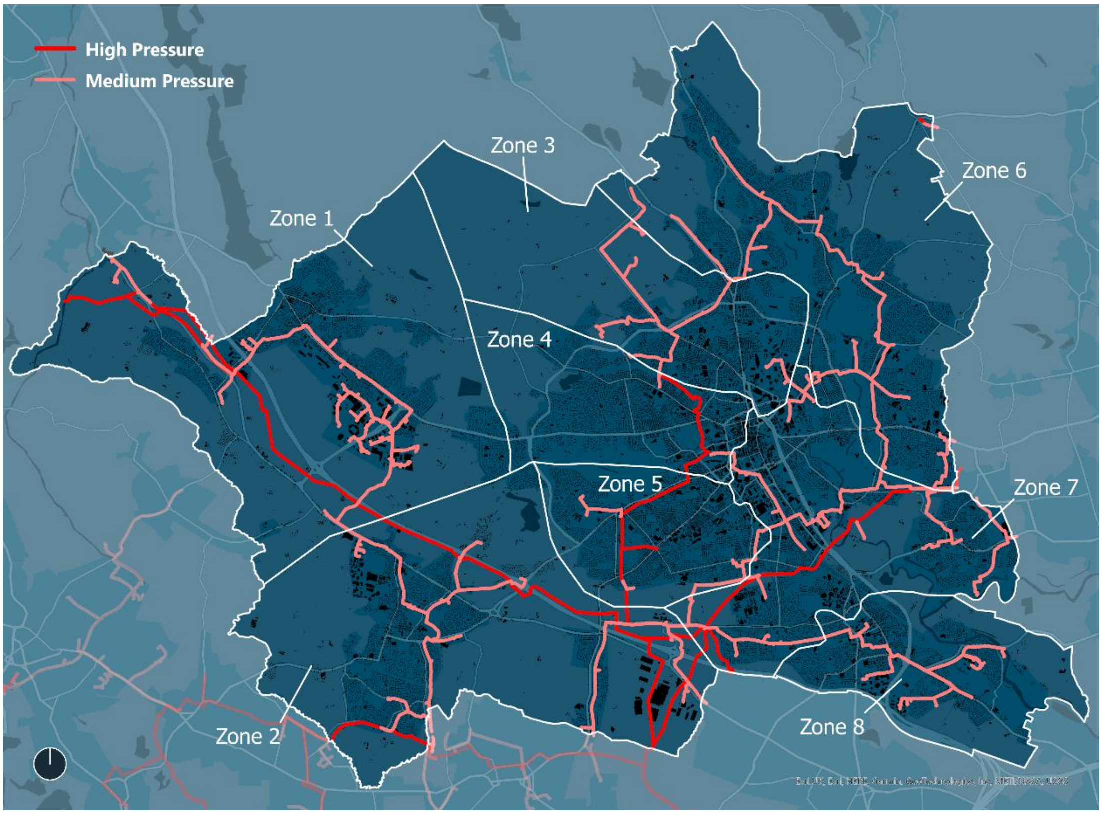
There are a small number of non-domestic properties that are harder to electrify, particularly with industrial uses that require high temperature process heat; these will remain on the gas network under the primary scenario and use hydrogen where possible in the secondary. Most non-domestic gas use can be electrified.

Equitable solutions for dealing with the ongoing gas network maintenance costs for remaining customers will need to be explored for the scenario where usage falls to very low levels. These properties may also be well suited to using hydrogen for heat under a scenario where hydrogen becomes available.

Usage of Gas Network under HyNet Scenario in Bolton



Current Gas Network in Bolton



District heating could supply in the region of 17% (23,000) of Bolton's dwellings. The role of district heating is diminished in the secondary scenario where hydrogen meets much of the demand, although in practice district heating could be supplied by hydrogen boilers in the energy centres, meaning that investment in the heat networks would remain a relatively low regrets option if hydrogen for heating materialised. By centralising the hydrogen boilers, the need to replace gas pipework in streets and buildings to make them compatible with hydrogen would be reduced.

District heat networks have been identified in previous heat network studies, focusing on residential areas in zones 4,5 and 7. In the proposed modelling, the original heat network has been expanded out to include more residential dwellings, with only a small percentage (6%) of non-residential buildings

Heat Network Opportunity Area	Approximate Peak Heat Generation Capacity (MWp)	Approximate Network length (km)
Zone 4	1.9	4.8
Zone 5	1.8	5.1

There are two main opportunity areas for district heating zones, providing opportunities to develop networks, in the region of 10 km of heat network for an investment of £254m*.

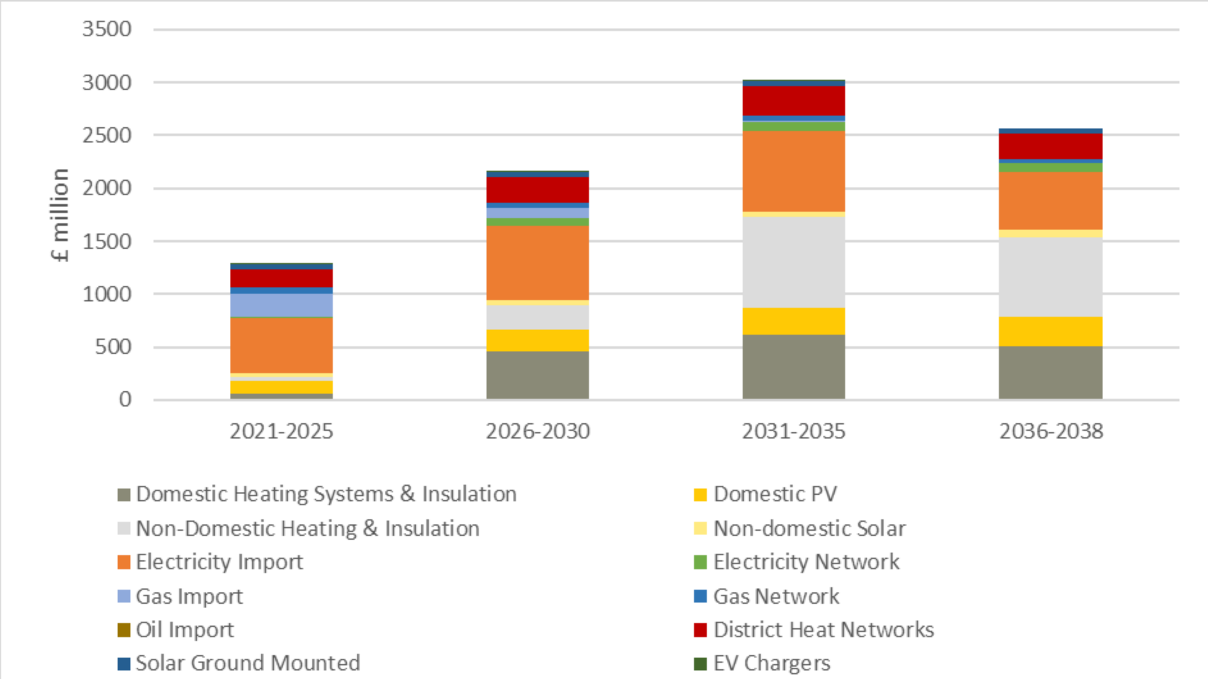
Heat generation is assumed to be primarily based on large scale heat pumps, with of 3.7 MWp of heat delivered from heat pumps. However, opportunities to make use of any waste heat sources should be explored, as these could improve the cost and carbon credentials of a district heat scheme further

* District heating network (I.e. pipework) cost only.

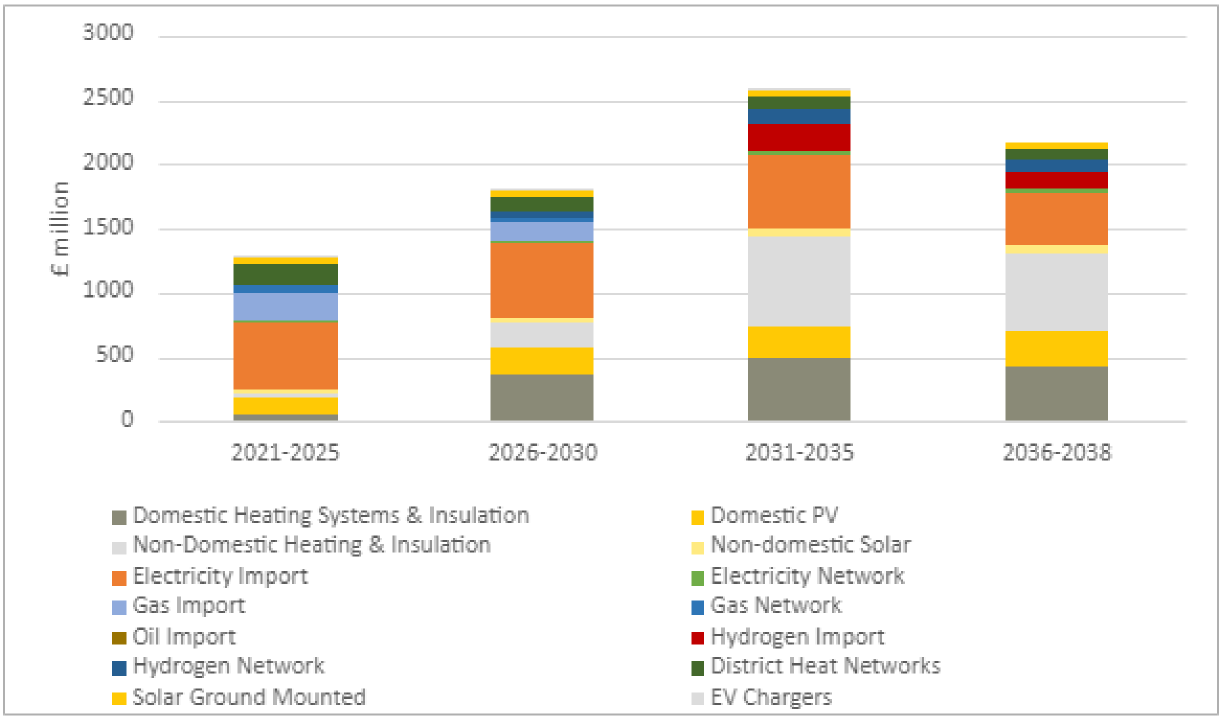
Total cost (including energy consumption)

The primary scenario is based on a total energy system spend of £9.0 bn (compared with £7.8 bn in the secondary scenario). The cost is attributed to investment in energy networks, in buildings (for components such as fabric retrofit, heating system change and roof mounted PV) and for energy consumed. The charts below illustrate the split between these components. Notably, a significant proportion of this cost would have been spent without accounting for decarbonisation; noting that money is spent every day on maintaining existing energy systems, replacing old or failed systems (e.g. gas boilers in dwellings), improving energy efficiency and paying gas and electricity bills. This LAEP sets out an approach for redirecting some of that business-as-usual expenditure, boosted with additional investment, to the areas needed to achieve the carbon neutral target. For example, energy costs are re-directed to electricity use in place of natural gas.

Primary Scenario



Secondary Scenario



Investment (exclusive of energy consumption)

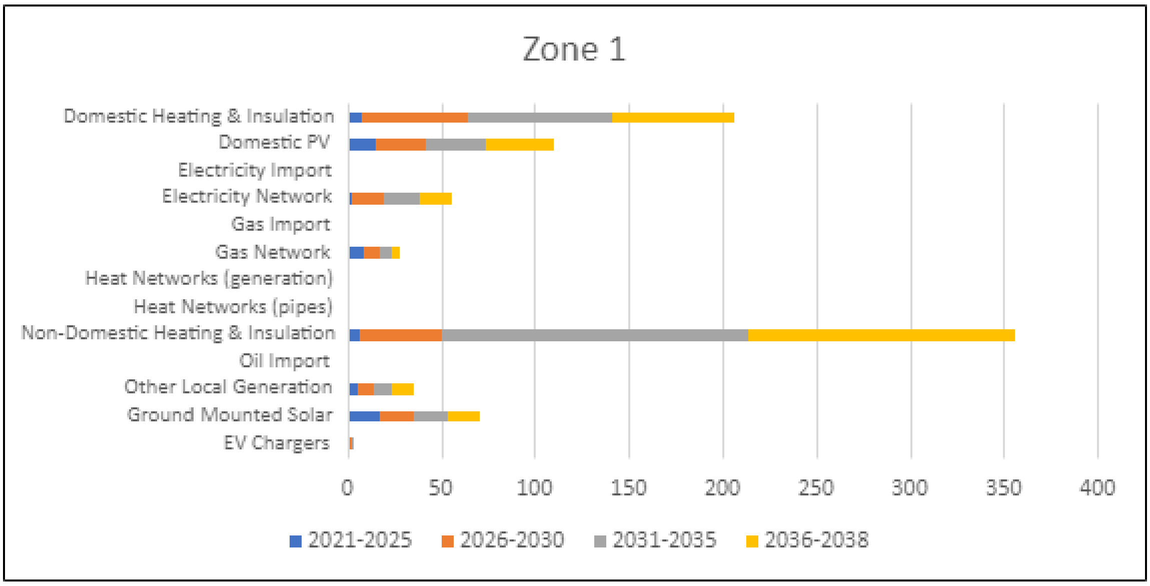
The tables below illustrate the total investment needed in the energy system to deliver the plan, equating to a total of £6.2 bn for the primary scenario and £5.1 bn for the secondary, with the charts on the following page breaking this down by technology. Again, a significant proportion of this investment will be required without working towards carbon neutrality, for example expenditure on replacement gas boilers is instead targeted at low carbon heating systems.

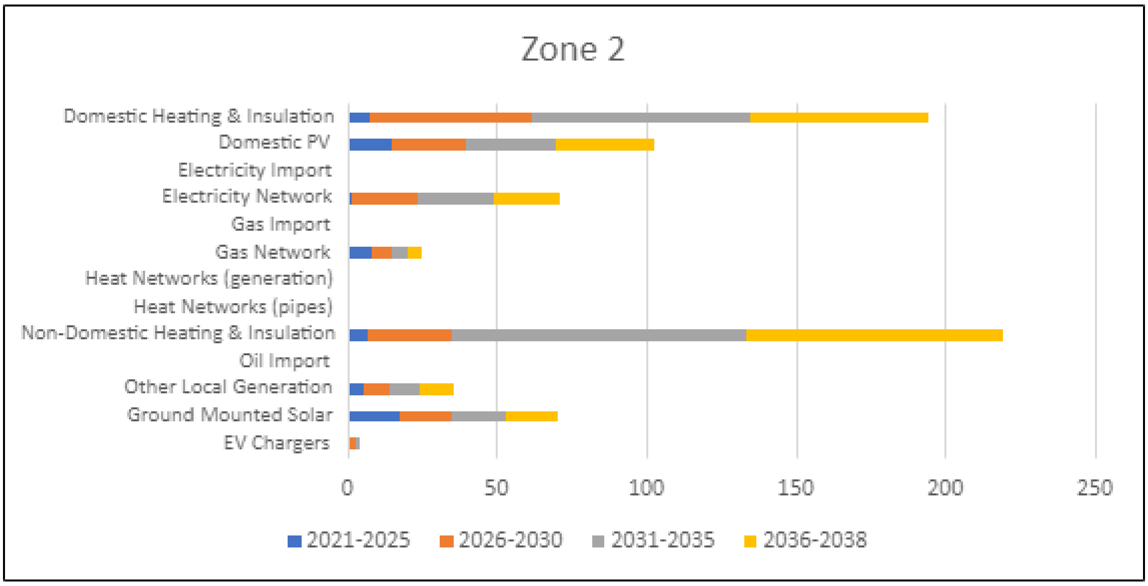
Zone	Total Investment (£m)	
	Primary Scenario	Secondary Scenario
Zone 1	867	772
Zone 2	723	602
Zone 3	477	408
Zone 4	928	699
Zone 5	871	603
Zone 6	809	695
Zone 7	1,094	940
Zone 8	411	347

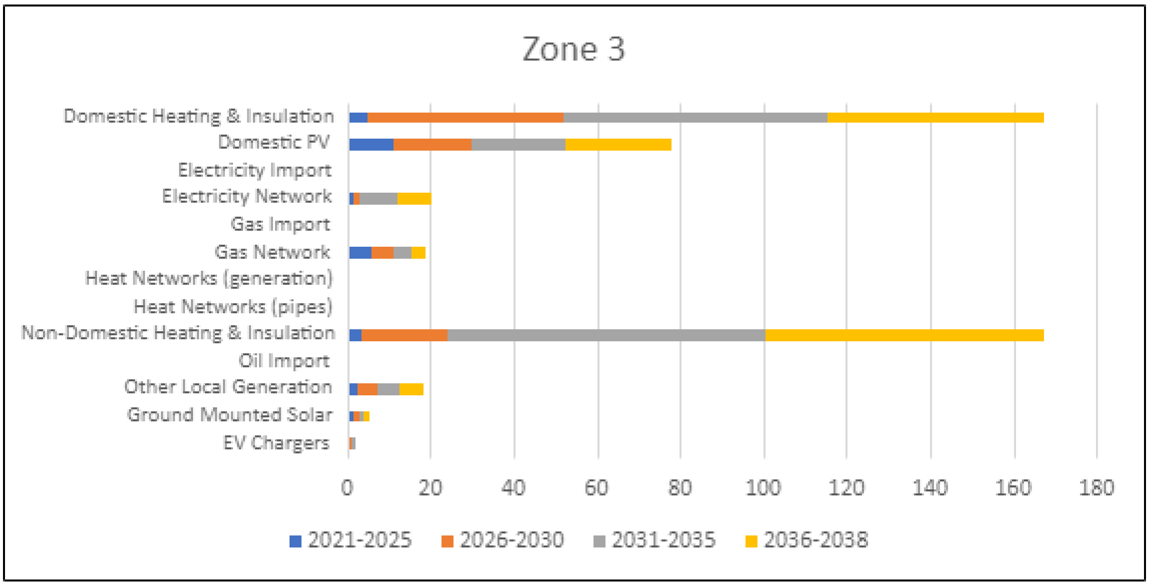
Investment type	Total Investment (£m)	
	Primary Scenario	Secondary Scenario
Domestic Heating Systems & Insulation	1,642	1,346
Domestic Solar	855	855
Domestic EV Chargers	26	26
Non-domestic Heating Systems & Insulation	1,881	1,535
Non-domestic Solar	195	195
Large Scale Ground-mounted Solar	197	197
Electricity Network	262	95
District Heat Network*	932	470
Gas Network	190	89
Hydrogen Network	-	259

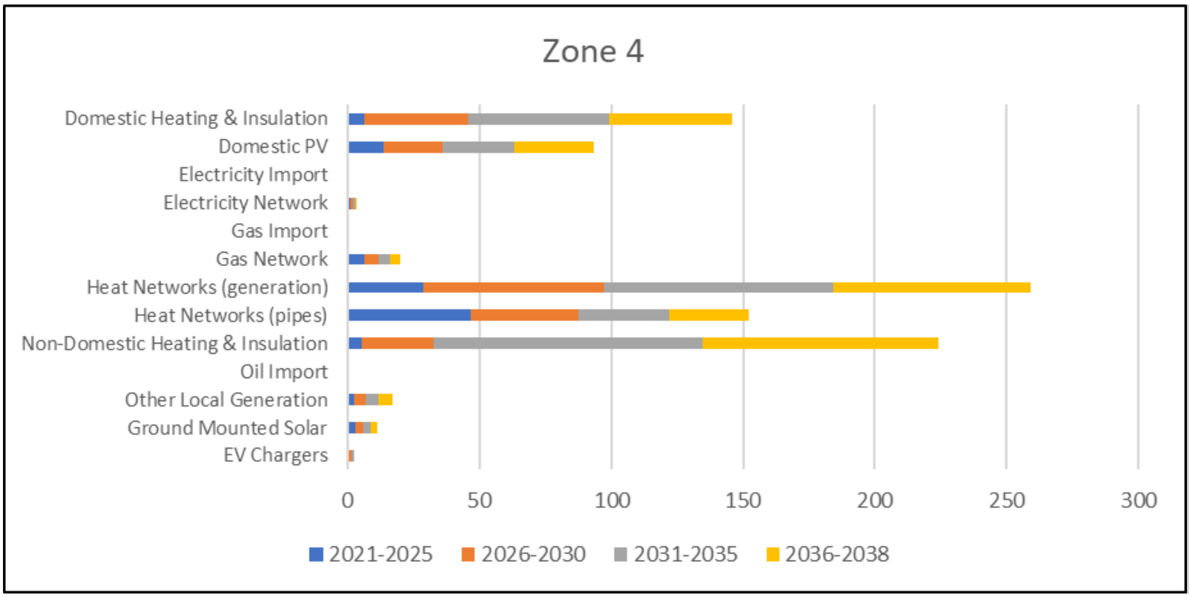
* While existing work has shown the potential for district heat networks in Bolton, further work needs to be undertaken to understand the full opportunity.

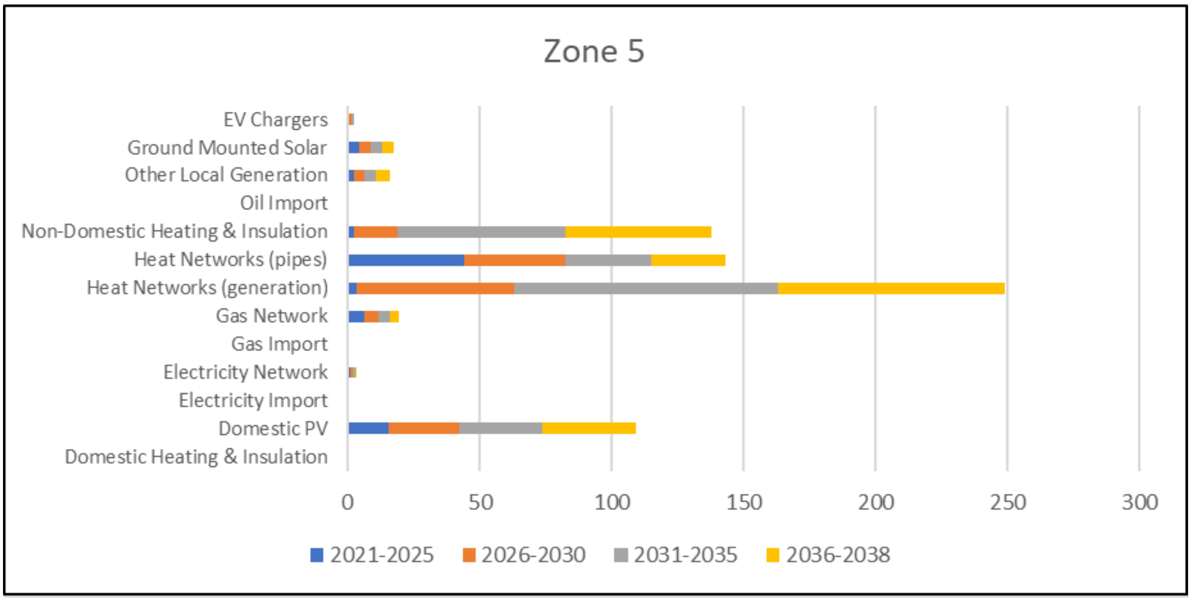
Investment in Bolton's energy system (£m) by time period across each area

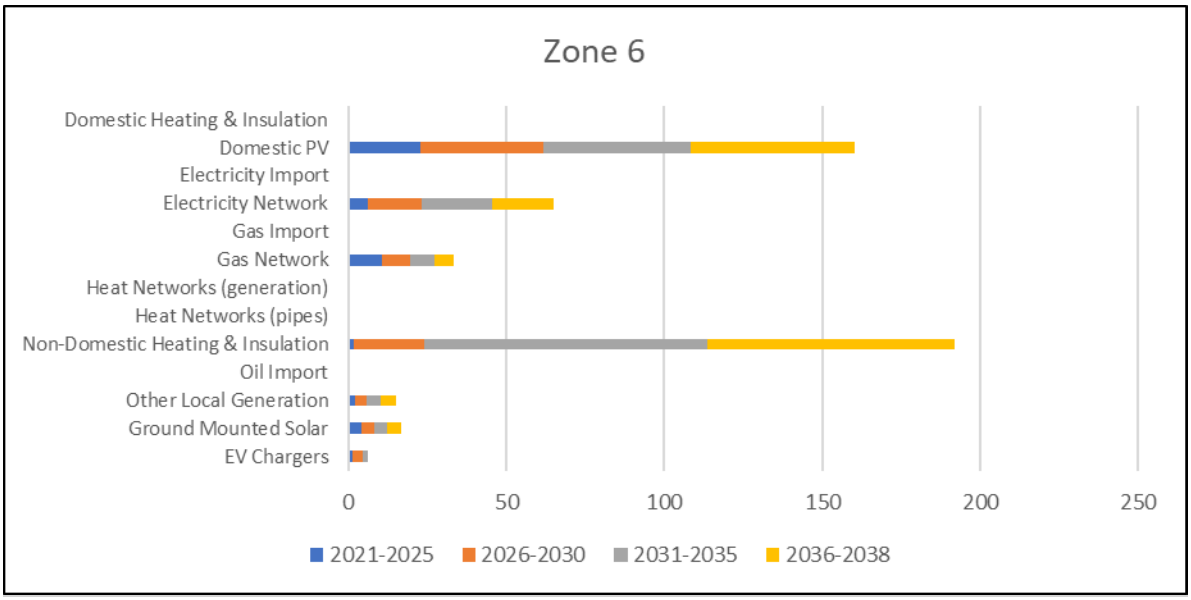


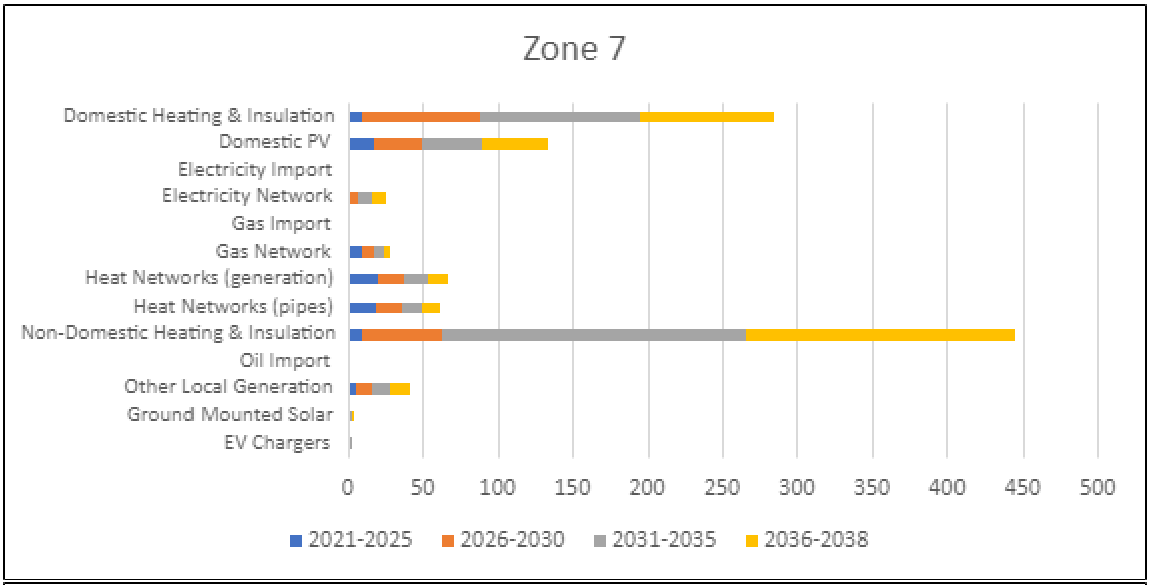




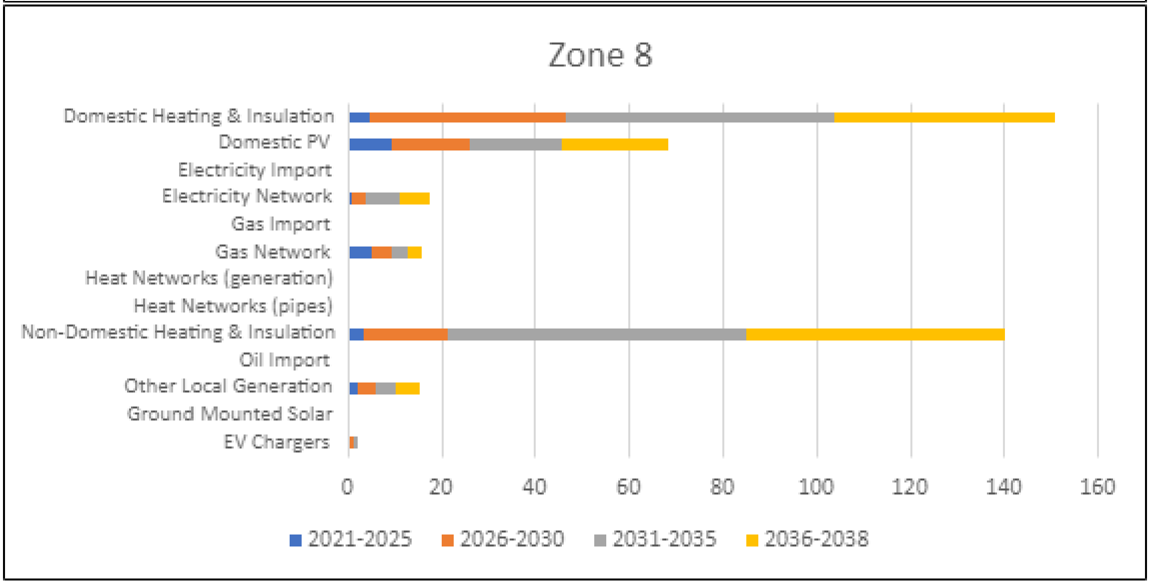

Zone 4
Domestic Heating & Insulation
Domestic PV
Electricity Import
Electricity Network
Gas Import
Gas Network
Heat Networks (generation)
Heat Networks (pipes)
Non-Domestic Heating & Insulation
Oil Import
Other Local Generation
Ground Mounted Solar
EV Chargers
0
50
100
150
200
250
300
2021-2025
2026-2030
2031-2035
2036-2038


Zone 5
EV Chargers
Ground Mounted Solar
Other Local Generation
Oil Import
Non-Domestic Heating & Insulation
Heat Networks (pipes)
Heat Networks (generation)
Gas Network
Gas Import
Electricity Network
Electricity Import
Domestic PV
Domestic Heating & Insulation
0
50
100
150
200
250
300
2021-2025
2026-2030
2031-2035
2036-2038


Zone 6
Domestic Heating & Insulation
Domestic PV
Electricity Import
Electricity Network
Gas Import
Gas Network
Heat Networks (generation)
Heat Networks (pipes)
Non-Domestic Heating & Insulation
Oil Import
Other Local Generation
Ground Mounted Solar
EV Chargers
0
50
100
150
200
250
2021-2025
2026-2030
2031-2035
2036-2038



Zone 7
Domestic Heating & Insulation
Domestic PV
Electricity Import
Electricity Network
Gas Import
Gas Network
Heat Networks (generation)
Heat Networks (pipes)
Non-Domestic Heating & Insulation
Oil Import
Other Local Generation
Ground Mounted Solar
EV Chargers
0 50 100 150 200 250 300 350 400 450 500
2021-2025
2026-2030
2031-2035
2036-2038



Zone 8
Domestic Heating & Insulation
Domestic PV
Electricity Import
Electricity Network
Gas Import
Gas Network
Heat Networks (generation)
Heat Networks (pipes)
Non-Domestic Heating & Insulation
Oil Import
Other Local Generation
Ground Mounted Solar
EV Chargers
0 20 40 60 80 100 120 140 160
2021-2025
2026-2030
2031-2035
2036-2038

9. SUMMARY AND CONCLUSIONS

There are less than twenty years until 2038, the date by which Greater Manchester aims to be carbon neutral, and less than thirty years until 2050, the latest date by which the UK must reach Net Zero emissions*.

The technologies and infrastructure that make up the energy system typically last for decades, whilst the development, planning, design, delivery and operation of new energy infrastructure can have lead-times of five to ten years.

Whilst there is some flexibility to meet carbon neutrality in different ways depending on societal changes and technology innovation, there is an urgency for Bolton and Greater Manchester to prepare to start the transition now and over the next few years, focusing on low regret activities, building capacity and supply chains, etc. The key decision point of how to decarbonise heat will need to be made c.2025, primarily based on the role hydrogen will play in providing heat to buildings. The longer the delay in making this decision, the more unrealistic it would be to achieve the 2038 carbon neutral target.

Future Local Energy System in Bolton

All the scenarios investigated involve strong contributions from core activities and technologies and also identified a number of key opportunities and uncertainties. This have been categorised into four key areas:

1. **Reducing energy demand in Bolton**
2. **Increasing Uptake of Low Carbon Solutions in Bolton**
3. **Increasing local low carbon electricity production and storage**
4. **The future role of the gas grid in Bolton**

1. Reduced energy demand in Bolton: Reducing emissions, energy use and energy costs through making buildings more energy efficient has been shown to play an important role in all of the scenarios considered. In the primary scenario this means basic fabric retrofit of approximately 49,000 homes and deep retrofit of a further 48,000 homes requiring £681m of investment. Many of these homes can receive a cost-effective retrofit package, combining heating system replacements, solar PV and EV charger installations. Across all scenarios extensive fabric retrofit of existing homes is prominent both in cost-effectively reducing emissions in the near term, but also enabling the future installation of low carbon heating systems. It is important to note that new demands from transport, buildings and industry (moderated by improving energy efficiency) mean electricity demand increases in Bolton from 1,244 GWh of electricity consumed per year to 2,578 GWh by 2038.

2. Increasing uptake of low-carbon solutions in Bolton: By the early 2030s all new cars, vans and heating system replacements in homes and businesses must be low carbon. In the primary scenario in the 2020's the majority of this shift is to battery electric vehicles (BEVs) and electric heat pumps along with development of heat

* On 12 June 2019 the Government laid the draft Climate Change Act 2008 (2050 Target Amendment) Order 2019 to amend the Climate Change Act 2008 by introducing a target for at least a 100% reduction of greenhouse gas emissions (compared to 1990 levels) in the UK by 2050

networks, that are primarily served by large scale heat pumps providing the heat generation. EV charging comprises a combination of domestic charge points (c.46,000) and public EV charging hubs, targeted at priority locations. Industry in Bolton must either adopt technologies that use zero carbon electricity or hydrogen instead of fossil fuels or install carbon capture and storage technologies.

3. Increasing production of local low carbon electricity and its storage in Bolton: Increasing electricity demand and reducing costs of generation from renewable sources sees an increase in local renewable energy production in Bolton. In the primary scenario 733 MWp of roof mounted solar PV capacity is installed.

Deploying the maximum potential for rooftop and ground mounted solar PV would produce up to 1,271 GWh per annum of local, low carbon electricity, a significant contribution to Bolton's forecasted annual consumption of 2,578 GWh. A key consideration for progressing and implementing this LAEP will be to determine how best to deploy solar PV systems alongside other components, such as heat pumps and EV charge points that could be provided as an integrated solution.

Due to geographical constraints on other renewable technologies and the significant available roof and ground space for solar PV, this energy which is tied to the times of the rising and setting of the sun contributes to a large extent of electrical demand in Bolton. This solution would need consideration as to how this energy could distributed to meet demand and matched with its time of use. Flexibility and storage as well as opportunities to trade this energy between with in a Local Energy Market could be explored.

4. The Future role of the Gas grid in Bolton: The role of hydrogen for heating is uncertain. Whilst there are many activities underway across the sector to develop a potential hydrogen supply, at a suitable scale, there is currently no guaranteed commitment for this to be considered a reliable means of supporting the decarbonisation of Bolton. Greater Manchester's ambition of carbon neutrality by 2038 creates significant pressures regarding the deliverability of 100% hydrogen heating to all homes in Bolton. In the primary scenario, in the 2020's, increasing numbers of homes start to switch from gas to electric heating solutions and the majority of existing off-gas and new homes are heated using electricity by 2038. Bolton should not rule out the potential for hydrogen heating, however, neither should it plan for it with certainty. The secondary scenario found that the same level of emission reduction could be achieved using predominantly hydrogen for heating (4.9 Mt CO_2 generated through to 2038) with a reduced total system cost (£7.8 bn compared to £9 bn for the primary scenario); however, these results are sensitive to the carbon intensity and cost of hydrogen, which are highly uncertain at this stage. A hydrogen heat-based future could also be more appealing to Bolton's citizens, being potentially less disruptive. Therefore, the presented heat decarbonisation demonstration and scale-up priority areas have generally been identified in areas where it would not to be cost-effective to utilise hydrogen for heat even if available.

Key Findings

Achieving carbon neutrality by 2038 in Bolton in support of Greater Manchester's commitment across the Combined Authority area is estimated to represent total energy related costs of between £7.8bn and £9bn across both scenarios

The primary plan for Bolton:

- Will require capital investment of £6.2bn (excluding energy costs) in less than 20 years. This investment is broken down with an approximate spend of £1.4 bn on energy networks, £1.6 bn on Bolton's dwellings, £1.9 bn on Bolton's non-domestic buildings. This has the potential to build local supply chains and create jobs for the future as part of a green industrial revolution for Bolton
- By 2038 the local electricity network in Bolton could supply as many as 46,000 domestic EV charge points distributed across the local area and numerous EV community charging hubs, spread out across the region.
- Approximately 103,000 homes could have heat pumps with 100% of homes being electrified for heating. This means that in the 2020's new homes will need to be electrically, or hybrid heated, connected to a heat network or at minimum be hydrogen ready. The majority of existing off-gas grid homes in Bolton will need to shift to a combination of electric and hybrid solutions
- If hydrogen were to become widely available earlier than anticipated, it could be supplied to approximately 102,000 homes, as well as non-domestic buildings, allowing hydrogen boilers to replace gas boilers for heating and hot water, as well as providing low carbon fuel for high temperature industrial applications. This would mean much of the gas network would be retained and repurposed by 2038.
- The gas network will continue in the immediate term to meet the majority of heating demands of homes and buildings although new connections will start to decline in the 2020s as new development favours electric or district heating solutions.
- The majority of homes with suitable characteristics will have solar panels and many of those could also have electrical (battery) and thermal storage systems

The Scale of the Challenge

- The following table details both modelled and assumed representative numbers. These are provided for illustrative purposes only, intended to demonstrate the scale of implementation, take-up, investment, and deployment needed, by time period, of specific components for Bolton to achieve carbon neutrality.

Local Energy System Aspects	Key Metrics	Value in 2038 Primary Scenario	Value in 2038 Secondary Scenario
Local Energy Consumption	Local energy consumption (excluding transport fuels, GWh/yr)	2,681	3,160
	Number of dwellings	139,294	139,294
	Non-domestic buildings (m^2)	6,245,988	6,245,988
GHG Emissions	Greenhouse gas emissions (ktCO2e/yr)	41	14
Local Energy Demand Reduction	Basic domestic retrofit measures installed (no of homes)	49,066	46,226
	Deep domestic retrofit measures (no of homes)	47,821	52,184
Local Electrification	Petrol & diesel vehicles on the road (No of vehicles)	15,798	15,798
	Pure electric vehicles on the road (No of vehicles)	101,266	101,266
	Hybrids (including plug-in) on the road (No of vehicles)	23,139	23,139
	Domestic EV charge points installed (No)	45,729	45,729
	Heat pumps installed (No of homes)	102,843	23,312
	Rooftop solar PV generation capacity installed (MWp)	733	733
	Ground-mounted PV generation capacity potential (MWp)	479	479
Local Heat Networks	Domestic heat network connections	23,161	588
Capital Investment***	Buildings and energy system (£m)	9,047	7,847

It must be recognised that achieving carbon neutrality by 2038 is hugely ambitious and challenging and will require major local policy interventions, investment by government and industry and both technology and business innovation.

A key challenge for Greater Manchester and Bolton over the next five years is to build collective and coordinated action such that long-term investment in low carbon infrastructure is made in the 2020’s and investment scale-up and mass market deployment of low carbon technologies is achieved through the 2030’s.

Achieving this will require action in the 2020s to act as the catalyst for change and to ensure supporting infrastructure is invested in as the backbone of a zero-carbon energy system for Bolton. It will require systematic changes in consumer and business behaviours, Bolton's local energy networks, the use of energy in its buildings and the ways people move around.

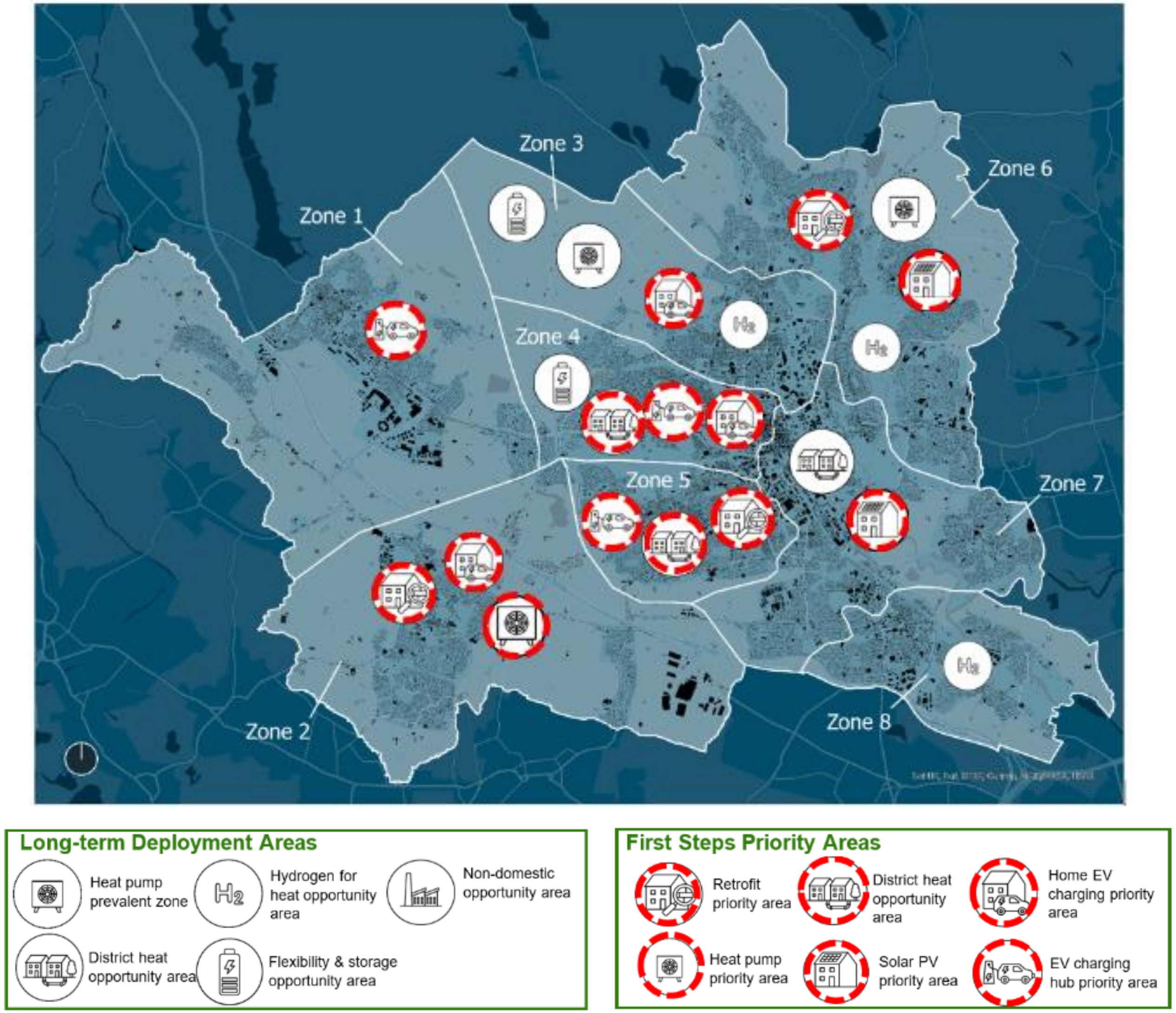
This LAEP provides Bolton with both:

- An overall vision that illustrates the scale of change needed, through to 2038, to work towards carbon neutrality (based on the primary scenario)
- And importantly, the identification of priority areas to both demonstrate and test how to roll out the measures that will be needed to decarbonise Bolton, whilst building the capacity needed for wide-scale deployment

The priority areas are summarised in the following map. This illustrates suggested areas and components for Bolton Council to work with GMCA and other key stakeholders to develop a detailed, area specific*, action plan and delivery programme.

* In addition to this LAEP, Bolton Council and GMCA are being provided with a more detailed and granular data set that can be used to identify potential target areas for demonstration and scale up activity. This data set identifies interventions and technology options at a neighbourhood level.

Demonstration and scale-up priority areas



Next Steps

Using the insights within this LAEP and in the identified priority areas, Bolton Council will need to work with GMCA to determine how to take forward this LAEP. Suggested key next steps include:

- Determine approach for wider stakeholder collaboration, engagement, and consultation; utilising outcomes to refine target priority areas and to support the creation of a detailed action plan and delivery programme

- Determine approach for governance and tracking progress; incorporating mechanism for evaluating impact of interventions aligned to GM's carbon budget

- Develop process for evaluating actual intervention and technology options for implementation, in order to understand trade-offs between options*

- Work with ENWL to consider and prioritise potential demonstration and scale up of electricity-based components aligned to ENWL activity

- Work with Cadent regarding commitment and delivery of HyNet to Bolton, integrating Cadent plans and activity with this LAEP

- Work with both ENWL and Cadent to develop a whole energy system energy network planning approach for taking forward this LAEP

- Work with GMCA to establish process for cross border LAEP reconciliation and interaction with a wider GMCA approach

- Build understanding and evidence around practical approaches to challenging or novel building modifications, such as fabric retrofit of terrace rows, or installation of air source heat pumps to existing flats.

- Conduct further heat network feasibility analysis for the opportunity areas identified

- Determine approach for procurement and working with energy and technology suppliers and service providers, including considering relationship with developing local skills and supply chain

* For example: considering hydrogen, heat pump and hybrid systems and associated risks and benefits e.g. consumer demands and disruption; evaluating providing greater levels of dwelling retrofit e.g. to target reducing dwelling energy consumption costs

- Work with government and other key stakeholders to establish policy and funding mechanisms
- Establish programme of works and detailed plans for demonstration and scale up activity, including testing how to successfully provide new technologies, products, and services to Bolton's citizens
- Determine approach for ensuring the integration of components and activity so that measures are not considered in isolation

Wider LEM Project Partners

GMCA Greater Manchester Combined Authority
bruntwood
ovo energy
Carbon Co-op
HITACHI Inspire the Next
DAIKIN
CORNWALL INSIGHT CREATING CLARITY
GrahamOakes Community & Municipal Energy
Cadent Your Gas Network
regen transforming energy
electricity north west
Northwards Housing North Manchester's Council Homes

This report was prepared by Energy Systems Catapult on behalf of Greater Manchester Combined Authority. Support on renewable energy generation opportunities and engineering feasibility review was provided by Buro Happold.

Local knowledge, data, direction and guidance were provided by Bolton Council and Greater Manchester Combined Authority.

Information relating to existing energy networks, and wider input to the development of this Plan were provided by the electricity distribution network operator Electricity North West and gas distribution network operator Cadent.

The following stakeholders also provided input during the development of this Plan: Department of Business, Energy and Industrial Strategy, Ofgem and Innovate UK.

About the GM LEM project

This report was produced as part of the Greater Manchester Local Energy Market (GM LEM) project, which forms a key part of Greater Manchester Combined Authority's plans for decarbonisation, set out in the 5 Year Environment Plan, complemented by the Smart Energy Plan. Together these enable Greater Manchester to work towards the target for a zero-carbon emissions city region by 2038. The GM LEM project is an ambitious integrated, whole system energy vision that addresses how energy is generated, traded, transported, supplied, and used across the city region. Co-ordinated by the Greater Manchester Combined Authority (GMCA), it brings together a diverse array of partners from the private, public and third sectors, including commercial and legal advisors, service design consultants, financial and regulatory specialists and the energy, technology, and systems resources. The two-year project is funded by Innovate UK.

About Local Area Energy Planning

Energy is a core part of national and local economies and infrastructure. Decarbonisation of the UK will require significant changes to energy systems, yet every local area is unique and the changes needed to decarbonise will be specific to each area. Energy Systems Catapult (ESC) pioneered a new whole system approach to Local Area Energy Planning (LAEP) with pilots in three different local areas of the UK – Newcastle, Bury in Greater Manchester and Bridgend in Wales. ESC has since worked with others to evolve this approach, including with Ofgem and Centre for Sustainable Energy to define a method for LAEP* 'done well', which we have sought to follow in the creation of this Bolton LAEP, within the constraints of the GM LEM† project. In this project the ESC's EnergyPath Networks toolkit has been used to perform the local analysis.

About Energy Systems Catapult

* https://es.catapult.org.uk/reports/local-area-energy-planning-the-method/
† https://es.catapult.org.uk/reports/local-area-energy-planning/

ESC was set up to accelerate the transformation of the UK's energy system and ensure UK businesses and consumers capture the opportunities of clean growth. ESC is an independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia and research. We take a whole systems view of the energy sector, helping us to identify and address innovation priorities and market barriers, in order to decarbonise the energy system at the lowest cost. We work with innovators from companies of all sizes to develop, test and scale their ideas. We also collaborate with industry, academia and government to overcome the systemic barriers of the current energy market to help unleash the potential of new products, services and value chains required to achieve the UK's clean growth ambitions as set out in the Industrial Strategy.

About Buro Happold

Buro Happold is an international, integrated consultancy of engineers, consultants and advisers. Operating in 26 locations worldwide, with 55 partners and over 1,900 employees; for over 40 years we have built a world-class reputation for delivering creative, value led solutions for an ever challenging world.

Document control:

Project name	GM LEM: WP2 Local Area Energy Planning – Bolton
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Status	Approved: Contains reviewed and approved content.
Restrictions	Open

Review and approval:

	Name	Position
Author	Tian Coulsting and Usman Farooq	Systems Integration Consultant Local Energy Area Planning Consultant
Reviewer	Richard Leach	Local & Site Energy Transition Manager
Approver	Rebecca Stafford	Senior Manager

Revision history:

Date	Version	Comments
14/02/22	0.1	Initial draft for initial review
09/05/22	0.2	Working draft for initial client consultation
16/05/22	0.3	Response top Bolton comments; amendment to present day capacity table
20/06/22	1.0	**Client Issue**

GREATER MANCHESTER
LOCAL ENERGY MARKET
DOING THINGS DIFFERENTLY FOR THE ENVIRONMENT

Technical Annex

The technical annex summarises aspects of the evidence base that has been used to develop this LAEP; based on scenario based whole energy system modelling and analysis

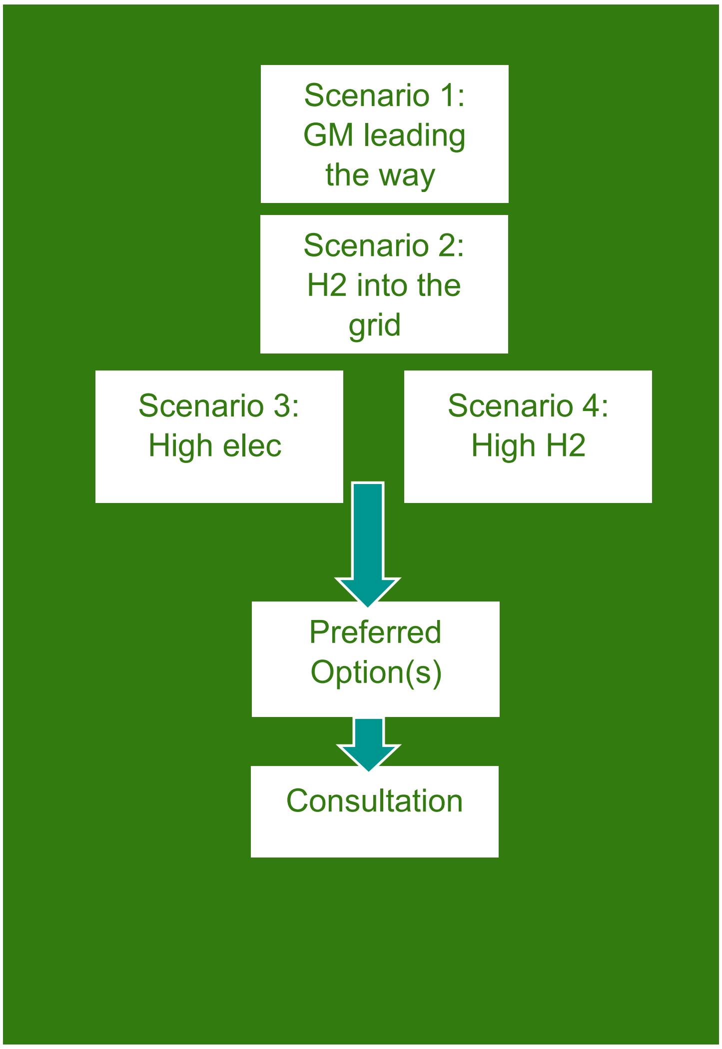
A variety of energy system scenarios are possible to deliver Greater Manchester and Bolton’s future energy vision. It is not practical to consider every possible configuration of Bolton 's local energy system in a limited number of scenarios, therefore four main scenarios have been considered; these represent the prominent cost-effective options that could materialise.

The scenarios are not predictions or forecasts of the most probable outcomes. They represent plausible and affordable futures based on available information and have been used to inform a plan for Bolton. The decarbonisation of any local energy system will require considerable co-ordination, planning and investment as well as consumer and social engagement.

The scenarios have been developed through frequent engagement with GMCA, as well as consulting with a wider group of stakeholders including Cadent and Electricity Northwest. Further consultation and engagement with Bolton residents is proposed as part of the wider Greater Manchester Local Energy Market project and will continue to inform the development and refinement of the LAEP for Bolton and other districts

A brief description of the different scenarios developed and used to inform the plan is given here, with modelling outputs from the scenarios provided in the following pages.

Importantly, each future local energy scenario for Bolton has been developed to reach carbon neutrality by 2038, aligned to Greater Manchester’s decarbonisation ambition and to also act as counterfactuals and alternative futures for Bolton. These scenarios are constructed using location specific information on Bolton's existing energy networks, buildings, local constraints and resources in combination with data on technology performance and costs and modelled using ESC's EnergyPath Networks modelling toolkit.



Modelled scenarios and plan development

These scenarios provide an understanding of pace and scale of activity needed, costs and investment needed for local implementation in support of decarbonisation goals and the commonality and variation of measures across the different future local energy scenarios. The scenarios help to explore choices around how to reach carbon neutrality using different technologies and known solutions where they exist.

Scenario 1 – Leading the Way: this scenario focuses on meeting the carbon budget and target by making use of **proven measures within Bolton's local control** where at all possible.

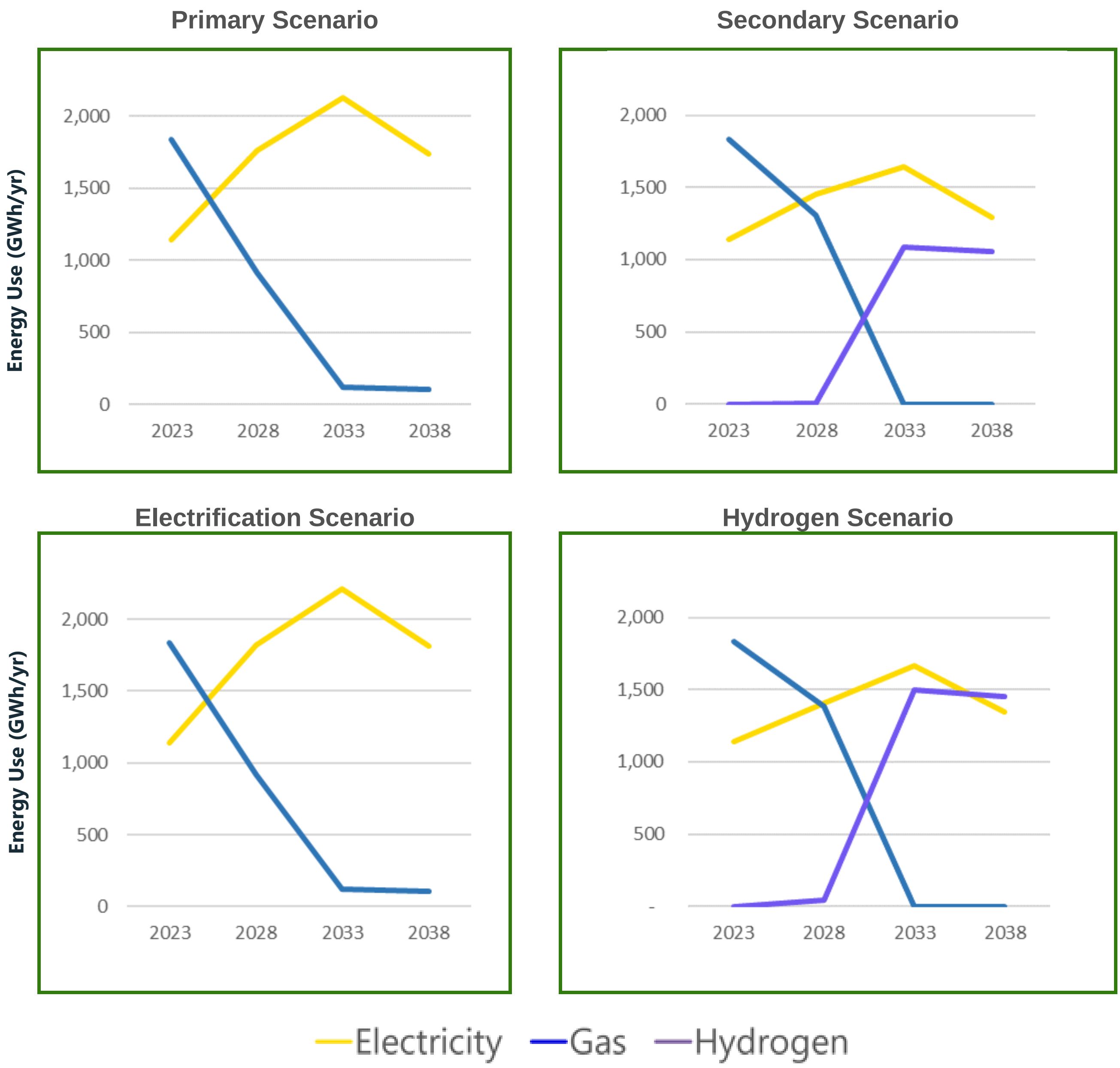
Scenario 2 – An Alternative Future Local Energy Scenario:
we have assumed hydrogen options for residential heating and non-domestic buildings become available in Bolton from 2030 onwards, aligned to HyNet Phase 3 and the repurposing of the gas grid to hydrogen is an option

Scenario 3 – High Electrification: we have assumed the only low carbon options for buildings heating and hot water demand are electric based. This includes energy centres feeding local heat networks

Scenario 4 – High Hydrogen - we have assumed the only available low carbon options for buildings' heating and hot water demand are hydrogen based from 2031 onwards

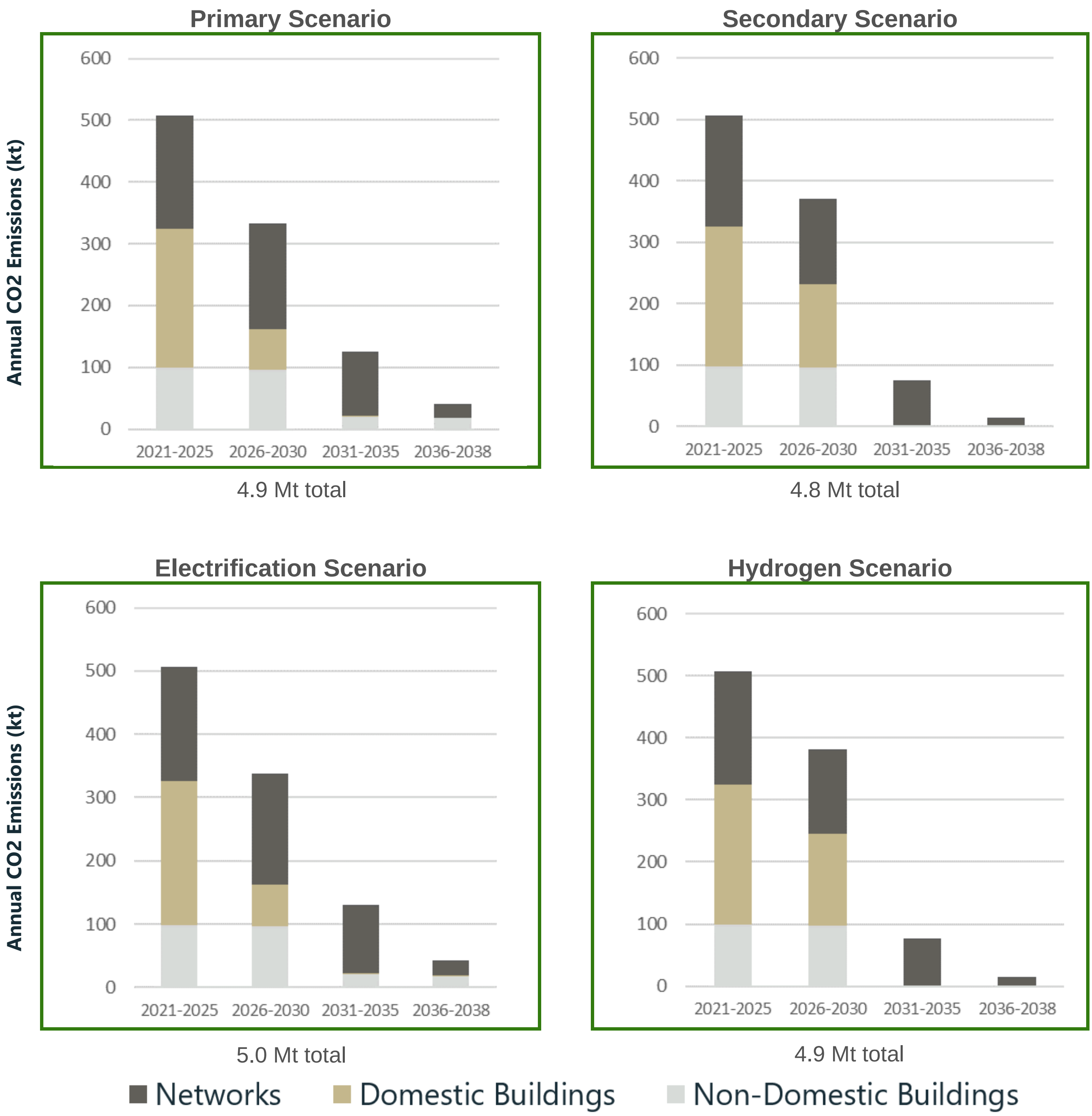
Scenarios 3 and 4 provide context and evidence for what would happen if either hydrogen or electrification were pursued as the sole solution for the decarbonisation of homes and buildings in Bolton. Whilst this is considered to have a number of practical limitations to feasible implementation by 2038, these were considered useful as comparative scenarios.

ENERGY CONSUMPTION



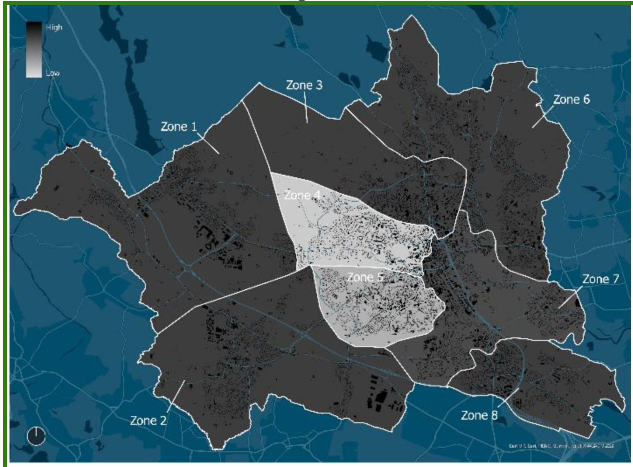
Figures shown exclude petrol and diesel fuel consumed for transport. The overall reduction in energy consumption due to increased efficiency is therefore greater than shown, due to the reduction in transport fuel consumption.

EMISSIONS

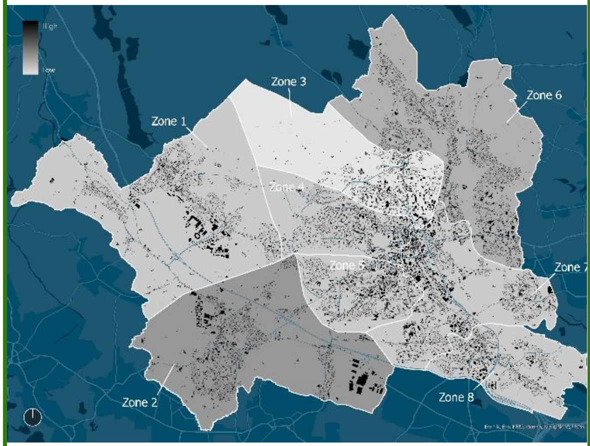

Primary Scenario
Secondary Scenario
Annual CO2 Emissions (kt)
600
500
400
300
200
100
0
2021-2025
2026-2030
2031-2035
2036-2038
4.9 Mt total
4.8 Mt total
Electrification Scenario
Hydrogen Scenario
5.0 Mt total
4.9 Mt total
Networks
Domestic Buildings
Non-Domestic Buildings

HEATING ZONING OPTIONS: HEAT PUMP DEPLOYMENT BY 2038

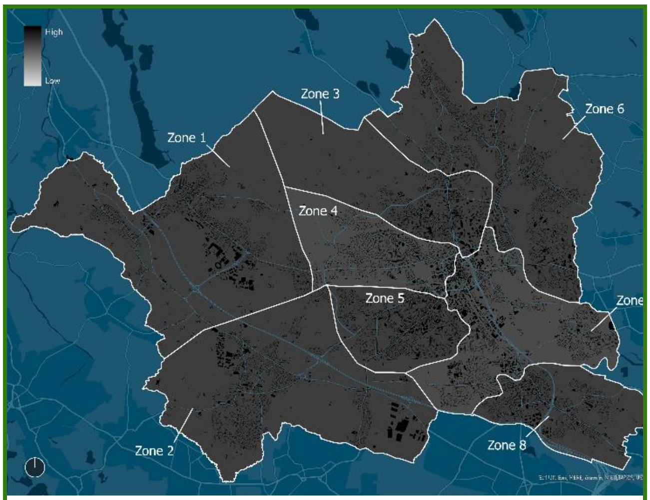
Primary Scenario



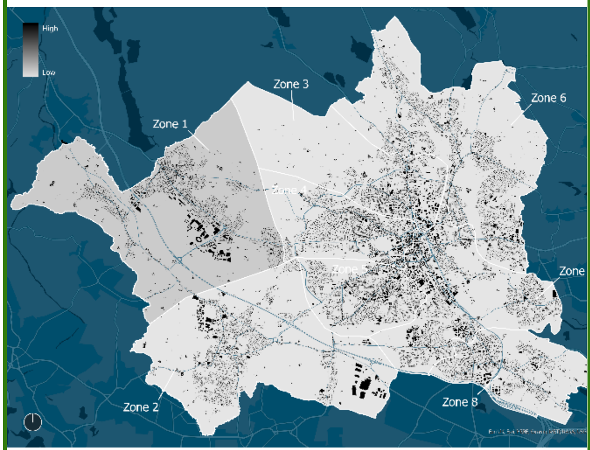
Secondary Scenario



Electrification Scenario

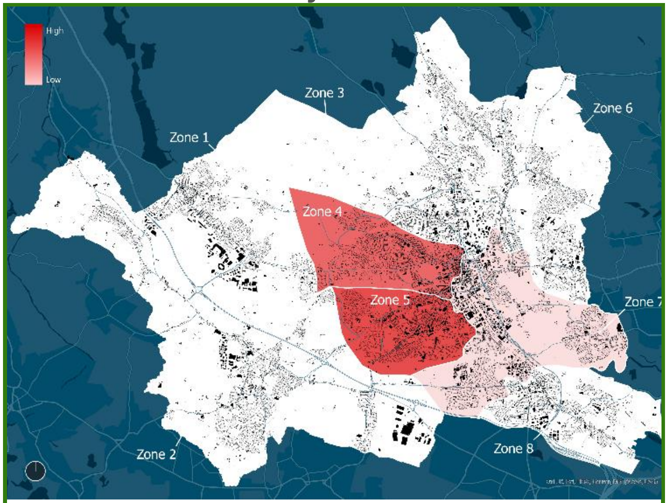


Hydrogen Scenario

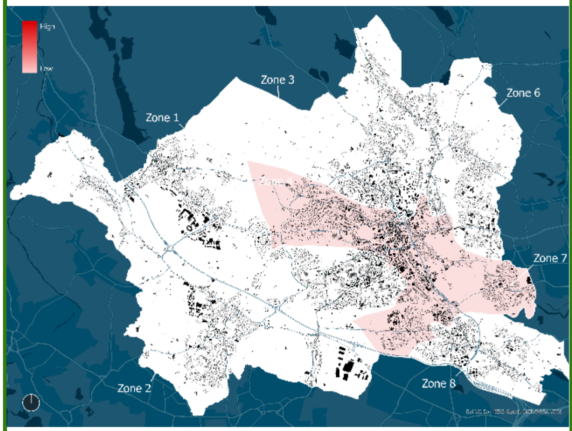


HEATING ZONING OPTIONS: DISTRICT HEATING CONNECTIONS BY 2038

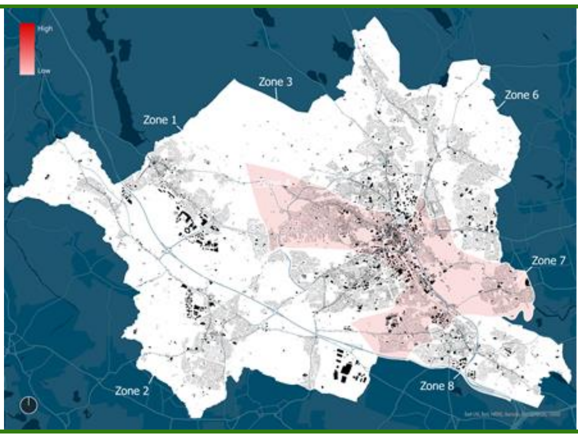
Primary Scenario



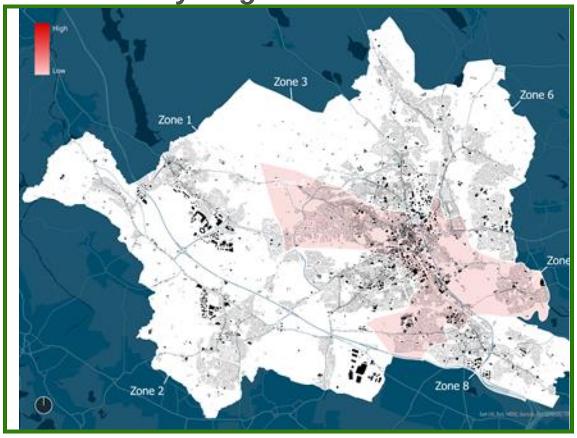
Secondary Scenario



Electrification Scenario

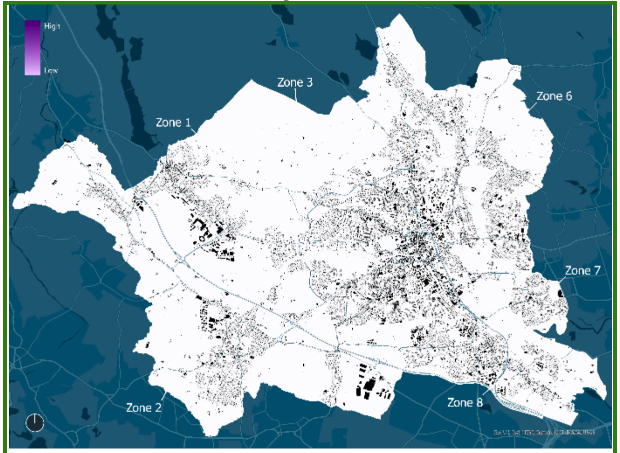


Hydrogen Scenario

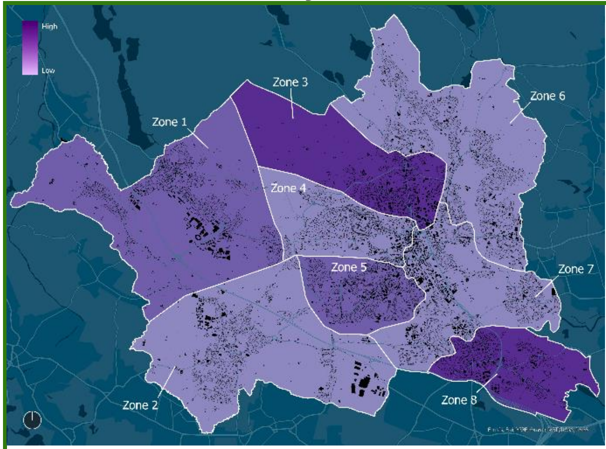


HEATING ZONING OPTIONS: HYDROGEN BOILER DEPLOYMENT BY 2038

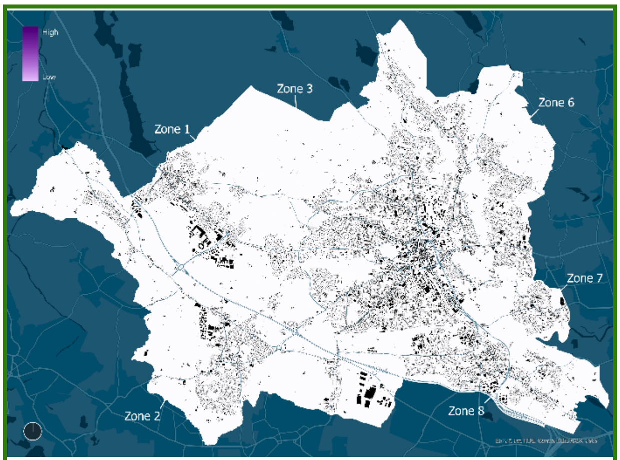
Primary Scenario



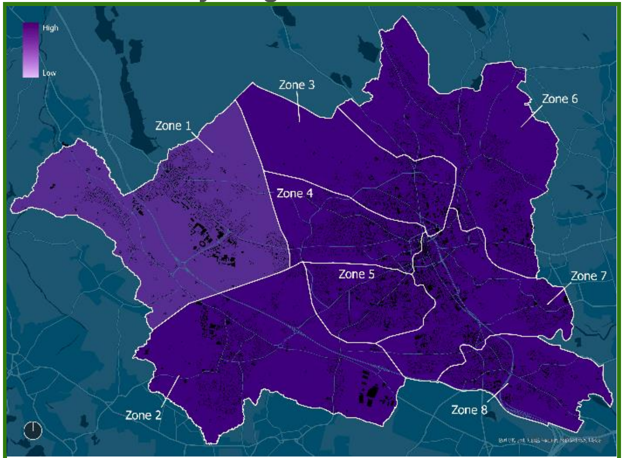
Secondary Scenario



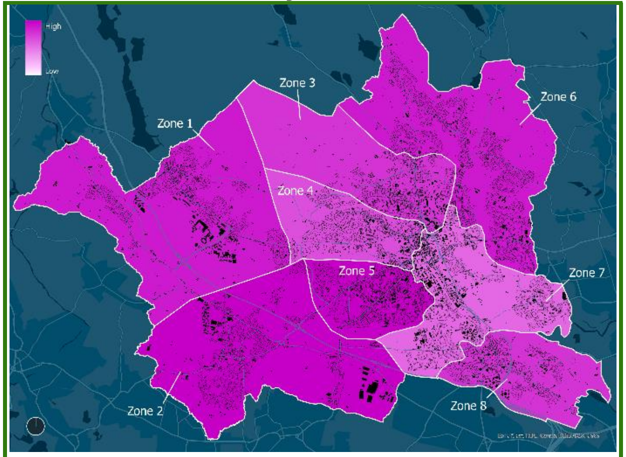
Electrification Scenario



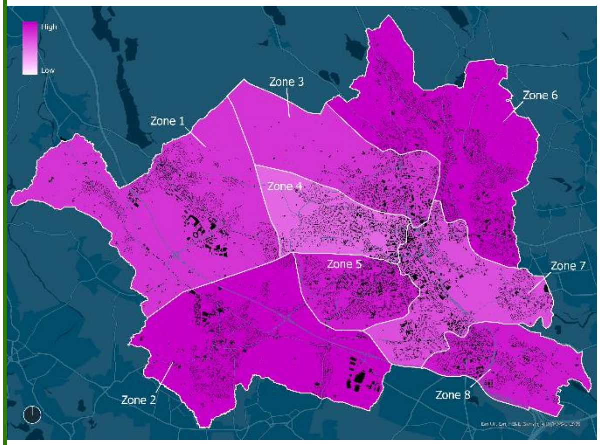
Hydrogen Scenario



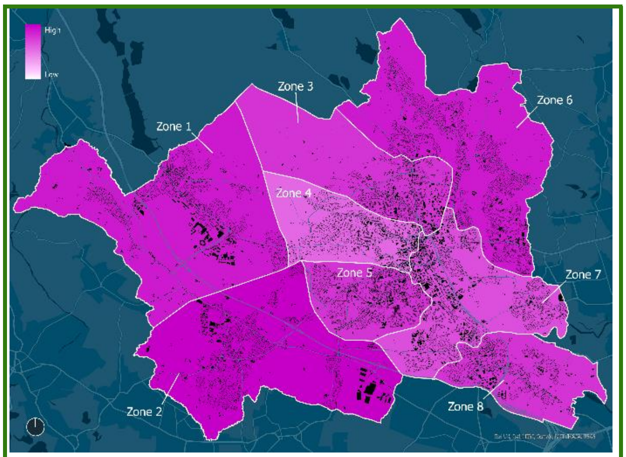
Primary Scenario



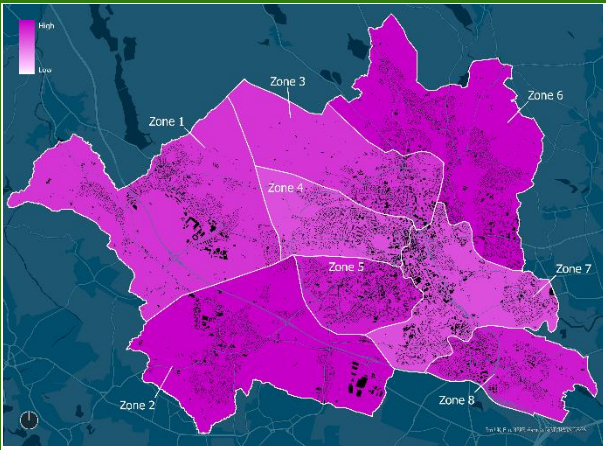
Secondary Scenario



Electrification Scenario

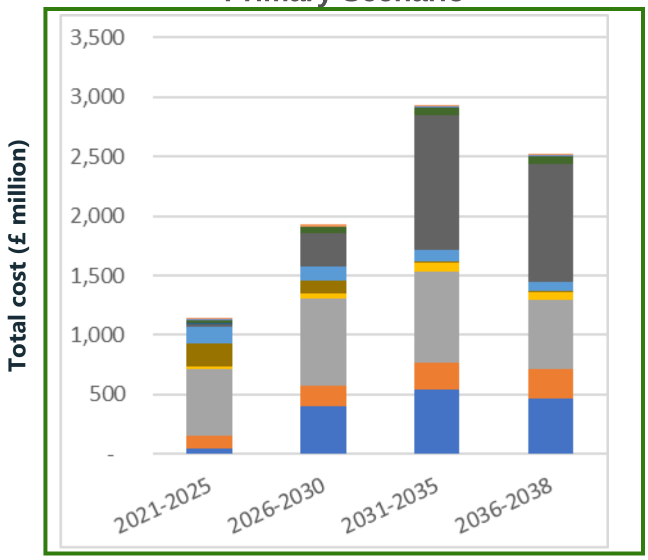


Hydrogen Scenario



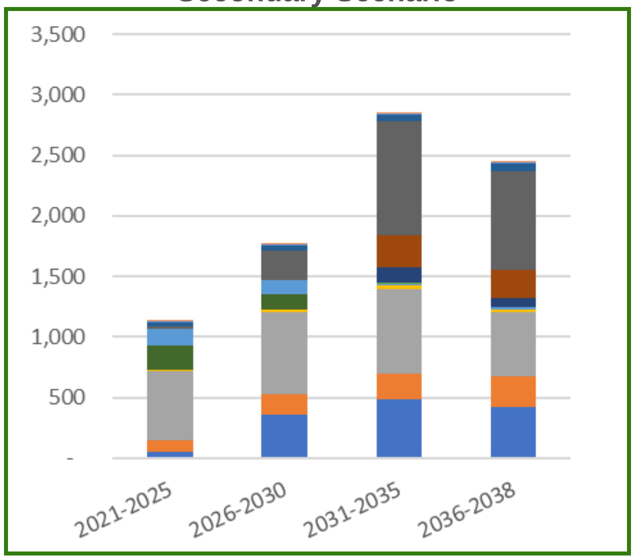
SYSTEM COST

Primary Scenario



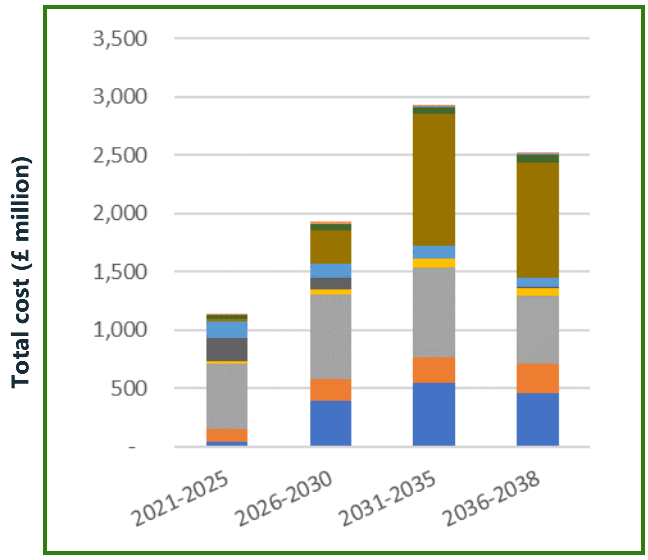
£7.3 bn total

Secondary Scenario



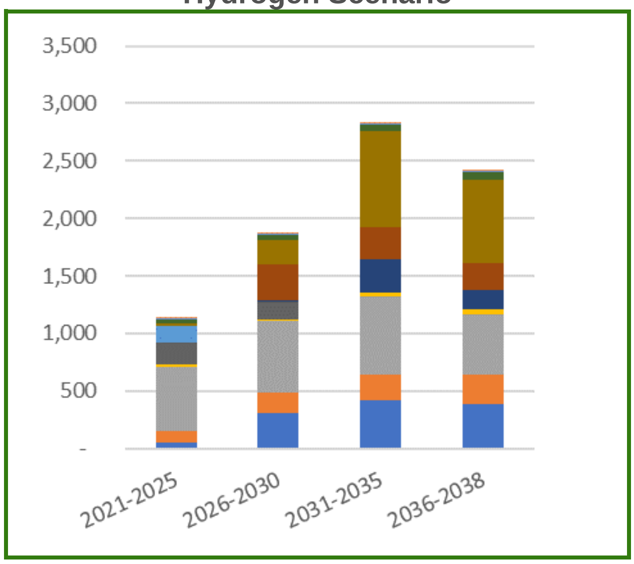
£6.3 bn total

Electrification Scenario



£6.8 bn total

Hydrogen Scenario



£6.5 bn total

- Domestic Heating Systems & Insulation
- Domestic PV
- Electricity Import
- Electricity Network
- Gas Import
- Gas Network
- Heat Networks
- Hydrogen Import
- Hydrogen Network
- Non-Domestic Heating & Insulation
- Oil Import
- Other Local Generation
- Solar Ground Mounted
- EV Chargers

GREATER MANCHESTER LOCAL ENERGY MARKET

DOING THINGS DIFFERENTLY FOR THE ENVIRONMENT

Data Sources Annex

The data sources annex summarises the consistent baseline data used by the ESC used to develop this LAEP.

Domestic

- **Ordnance Survey AddressBase Premium, MasterMap Topography, Highways**
  - Shows location, footprint and classification of buildings, plus road layout for network modelling.
  - Latest data obtained December 2020 for buildings and roads.
- **GMCA Accelerating Retrofit Domestic Buildings Dataset**
  - Detailed attributes of all domestic properties in GM produced by Parity Projects, using EPCs and filling gaps with other data.
- **Energy Performance Certificates (EPCs)***
  - ESC-built address matching algorithm to match housing attributes from EPCs
  - Informs building-level attributes – e.g. current heating system, levels of insulation.
- **Listed Buildings** – Historic England† as a potential constraint on retrofit

Non-Domestic

- **Ordnance Survey MasterMap Topography**
  - Provides status and classification of building (e.g. office, retail).
  - Informs building size and height.
- **OpenStreetMap** has not been chosen due to inconsistent national coverage compared with Ordnance Survey.
- **Non-domestic Energy Performance Certificates (EPC) and Display Energy Certificates (DEC)††††††††** to provide further building attributes and demands.
- **GMCA Public Sector Decarbonisation Scheme (PSDS)** to provide further demand data for significant public sector buildings and funded interventions in specific buildings
- **GMCA "Go Neutral"** provides further demand data for public buildings.
- Energy benchmarks (kWh/m^2) developed in conjunction with Arup

Future Building Stock

- **GMCA Existing Land Supply Sites**
  - For domestic, number given split by house/apartment, with planned construction date.
  - For non-domestic, type given (office, retail, industry/warehouse) with planned construction date.

- **GMCA Spatial Framework Allocation Sites**
  - Usage as above.
  - In total over 3,000 sites provided

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* https://epc.opendatacommunities.org/
Note: details of Green Homes Grant (GHG) and Local Authority Delivery (LAD) projects provided separately by Local Authorities where relevant

† https://historicengland.org.uk/listing/the-list/data-downloads/

Networks

- Relationships & NDAs with Electricity North West (ENWL) & Cadent
- **ENWL** (Electricity Distribution Network Operator)
    - Substation locations and capacities (for 11kV-400V upwards)
    - Typical component costs, combined in packages to generate reinforcement costs for different network assets.
- **Cadent** (Gas Distribution Network Operator)
    - Mapping of pipes including material, size and pressure.

Local Generation

- **Renewable Energy Planning Database***
    - Current planned and operational renewable energy installations (above 150kw)
- **Feed-in-tariff install reports†**
    - Current levels of domestic PV by postcode
- **GMCA "Unlocking Clean Energy in Greater Manchester" project**
    - Details of various solar PV, hydro-electric generation, battery storage and electric vehicle (EV) charging projects.
- **ENWL Embedded Capacity Register‡**
    - Identify registered generation assets within the region.

Electric Vehicles

- **Zap-Map§**
    - Location and speed of public chargepoints.
    - **National Chargepoint Registry (NCR)**** has not been used since its data is included within Zap-Map's national database.
- **Future domestic EV uptake**
    - ESC in-house analysis on the expected uptake of EVs on the network.
- **GMCA Transport for Greater Manchester (TfGM) list of potential EV charging sites**
    - Work carried out by Arup to determine 60+ locations, number of connections and charge speed across GM.

* https://www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract
† https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-installation-report-31-december-2020
‡ https://www.enwl.co.uk/get-connected/network-information/embedded-capacity-register
§ https://www.zap-map.com/
** https://www.gov.uk/guidance/find-and-use-data-on-public-electric-vehicle-chargepoints