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To: Cllr Alasdair Ibbotson (Chair)

Councillors: Mike Allport, Mel Buckley, Geoff Collett, Steve Copple, Bill Crease, Ron Davies, Mared Eastwood, Ian Hodge, Simon Jones, Fran Lister and Allan Marshall

20 November 2024

Dear Sir/Madam

NOTICE OF REMOTE MEETING
CLIMATE CHANGE COMMITTEE
TUESDAY, 26TH NOVEMBER, 2024 at 10.00 AM

Yours faithfully

Steven Goodrum
Democratic Services Manager

The meeting will be live streamed onto the Council's website. The live streaming will stop when any confidential items are considered. A recording of the meeting will also be available, shortly after the meeting at https://flintshire.public-i.tv/core/portal/home

If you have any queries regarding this, please contact a member of the Democratic Services Team on 01352 702345.

AGENDA

1 APOLOGIES

Purpose: To receive any apologies.

2 DECLARATIONS OF INTEREST

Purpose: To receive any Declarations and advise Members accordingly.

3 MINUTES (Pages 3 - 6)

Purpose: To confirm as a correct record the minutes of the meeting held on 6 September 2024.

4 ACTION TRACKING (Pages 7 - 10)

Purpose: To consider the Action Tracking report for the Climate Change Committee.

5 TERMS OF REFERENCE FOR CLIMATE CHANGE COMMITTEE AS AMENDED (Pages 11 - 14)

Purpose: For Committee Members to note the amended Terms of Reference for the Committee as approved by Constitution & Democratic Services Committee on Wednesday, 6 November 2024.

6 DECARBONISATION OF SUPPLY CHAIN (Pages 15 - 18)

Purpose: An update from the Joint Procurement Business Partner - Decarbonisation

7 FLINTSHIRE LOCAL AREA ENERGY PLAN (Pages 19 - 368)

Purpose: To receive the finalised Local Area Energy Plan for Flintshire and recommend its endorsement by Cabinet

8 INQUIRIES UPDATE (Pages 369 - 380)

Purpose: To provide an update on the Committee Flood and Pensions Inquiries and discuss next steps

9 FORWARD WORK PROGRAMME ITEMS AND PURPOSES (Pages 381 - 382)

Purpose: To populate the Forward Work Programme for the Climate Change Committee.

Please note that there may be a 10 minute adjournment of this meeting if it lasts longer than two hours

CLIMATE CHANGE COMMITTEE
6 SEPTEMBER 2024

Minutes of the Climate Change Committee of Flintshire County Council held as a remote attendance meeting on Friday, 6 September 2024

PRESENT: Councillors:	**Councillor Alasdair Ibbotson (Chair)** Mike Allport, Mel Buckley, Geoff Collett, Steve Copple, Bill Crease, Ron Davies, Mared Eastwood, Ian Hodge, Simon Jones, Fran Lister and Allan Marshall
ALSO PRESENT:	Councillor Roz Mansell attended as an observer
IN ATTENDANCE:	Councillor David Healey (Cabinet Member for Climate Change and Economy), Programme Manager for Climate Change & Carbon Reduction, Dominic Scott - Drainage Policy and Strategy Specialist from Welsh Water (for item 12), Democratic Services Manager and Democratic Services Officer

11. DECLARATIONS OF INTEREST

None.

12. PUBLIC INQUIRY FLOODING - HEARING OF ORAL EVIDENCE WELSH WATER (Link to recording)

Following written evidence previously submitted to the Committee, Dominic Scott from Welsh Water was in attendance to respond to questions raised by Members. He agreed to look into specific issues raised by Councillors Geoff Collett, Fran Lister/Ron Davies, David Healey and Roz Mansell and would respond accordingly.

The Chair thanked Mr. Scott for his attendance and advised that a copy of the report relating to the Inquiry would be shared. Mr. Scott indicated that Committee Members were able to email him directly with any further issues on the matter.

13. MINUTES

RESOLVED:

That the minutes of the meeting held on 25 June 2024 be approved as a correct record.

14. ACTION TRACKING (Link to recording)

The Democratic Services Manager presented an update on progress with actions from previous meetings and noted that the third item from the March meeting had been closed.

On that basis, the recommendation was supported.

RESOLVED:

That the Committee notes the progress which has been made.

15. TERMS OF REFERENCE REVIEW (Link to recording)

The Programme Manager for Climate Change & Carbon Reduction presented a report on the updated Terms of Reference.

It was clarified that the Terms of Reference would need to be submitted to the Constitution and Democratic Services Committee prior to seeking formal adoption at full Council.

Councillor Allan Marshall agreed to email the Democratic Services Manager regarding formatting issues within the Constitution and would copy in the Chair of the Constitution and Democratic Services Committee.

Following discussion, additional primary objectives within the Terms of Reference were proposed by the Chair and Councillor David Healey. On that basis, the recommendation was supported.

RESOLVED:

That the amended Terms of Reference for the Climate Change Committee be approved, with the suggestion to incorporate additional primary objectives as follows:

- To work to ensure collective cross-portfolio responsibility on climate change, including advising and assisting other committees across the Council.
- To undertake work to mitigate the impact of climate change on residents, the Council and businesses.

16. CLIMATE CHANGE STRATEGY ACTION PLAN UPDATE (Link to recording)

The Programme Manager - Climate Change & Carbon Reduction presented a report on the current status of the programme’s action plans including areas of risk.

The recommendation was supported, recognising concerns about access to funding to support ongoing activities.

RESOLVED:

That the Committee notes current progress of the Climate Change Strategy Action Plans, areas of risk/vulnerability and actions to mitigate these risks.

17. CLIMATE RISK - EXTREME HEAT (Link to recording)

Councillor David Healey, Cabinet Member for Climate Change and Economy, presented a report on the impacts of extreme heat and sought approval of a recommendation to ensure appropriate consideration of those impacts within both local and regional climate risk and adaptation plans.

The Programme Manager - Climate Change & Carbon Reduction agreed to put forward points raised by Members:

- Communication with parents on mitigation measures to reduce the impact of extreme heat on school learners.
- A suggested ban on fires in rural areas during dry weather.
- Educating the public on effective solutions to tackle extreme heat in homes without the use of air conditioning.
- Consideration of heat reduction measures for new build homes.
- Potential use of community centres as cooling centres for elderly and vulnerable people during extreme hot weather.

The recommendations were supported.

RESOLVED:

(a) That the Committee supports the work to identify specific risks from the impact of extreme heat on the public and on services, both locally and regionally; and

(b) That the Committee supports the development of an action plan to mitigate the impact of the identified risks, both locally and regionally.

18. UPDATE ON INQUIRIES (LInk to recording)

As suggested by the Chair, it was agreed that Members who had served on the Committee during the Flood Inquiries would be invited to join the Committee at an informal meeting to discuss the evidence received, prior to preparation of a formal report.

A date for hearing oral evidence on the Pensions Inquiry would be scheduled.

19. FORWARD WORK PROGRAMME ITEMS AND PURPOSES (Link to recording)

The Committee received the current Forward Work Programme for consideration and agreed the following:

- November meeting - Update on fleet services and the ultra low emission vehicles (ULEV) transition plans.
- January meeting - Car Parking Strategy and feasibility study for installing solar roofs over car parks.
- November meeting - Council’s carbon footprint.

- To be scheduled - Mineworking heat generation opportunities within Flintshire and lead mining at Milwr tunnel.

The Chair gave a reminder of the expectation for Cabinet Members to attend to answer questions on reports covering their portfolio areas.

RESOLVED:

That subject to the above changes, the Forward Work Programme be agreed.

20. MEMBERS OF THE PRESS AND PUBLIC IN ATTENDANCE

None.

(The meeting started at 10am and ended at 12.10pm)

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Chair

Meetings of the Climate Change Committee are webcast and can be viewed by visiting the webcast library at http://flintshire.public-i.tv/core/portal/home

CLIMATE CHANGE COMMITTEE

Date of Meeting	Tuesday, 26 November 2024
Report Subject	Action Tracking
Report Author	Democratic Services Manager
Type of Report	Operational

EXECUTIVE SUMMARY

The report shows any outstanding actions from previous meetings of the Climate Change Committee and document the progress made in completing them.

Any outstanding actions will be reported back to the next meeting, and until they are completed.

RECOMMENDATIONS	
1	That the committee notes the progress which has been made.

REPORT DETAILS

1.00	**EXPLAINING THE ACTION TRACKING REPORT**
1.01	In previous meetings of Committees, requests for information, reports or actions have been made. These were included in the minutes as ‘action points’. ‘Matters Arising’ is not an item which can feature on an agenda.

1.02	This paper summarises those points and where appropriate provides an update on the actions resulting from them. The Action Tracking details are attached in appendix A.

2.00	**RESOURCE IMPLICATIONS**
2.01	The creation of the Action Tracking report increases workflow but should provide greater understanding and efficiency.

3.00	**CONSULTATIONS REQUIRED / CARRIED OUT**
3.01	In some cases, action owners have been contacted to provide an update on their actions.

4.00	**RISK MANAGEMENT**
4.01	Not applicable.

5.00	**APPENDICES**
5.01	Appendix A – Climate Change Committee Action Points

6.00	**LIST OF ACCESSIBLE BACKGROUND DOCUMENTS**
6.01	Minutes of previous meetings of the committee as identified in the report.

7.00	**CONTACT OFFICER DETAILS**
7.01	**Contact Officer:** Steven Goodrum, Democratic Services Manager **Telephone:** 01352 702320 **E-mail:** steven.goodrum@flintshire.gov.uk

8.00	**GLOSSARY OF TERMS**
8.01	None.

ACTION TRACKING FOR THE CLIMATE CHANGE COMMITTEE

Meeting Date	Agenda item	Action Required	Action Officer(s)	Action taken	Status
19.03.2024	4. Contingency Planning for extreme heat	In relation to assistance with a flood plan for the Broughton area, the Regional Manager agreed to provide contact details within her team along with those of Natural Resources Wales and Welsh Water / Dwr Cymru.	Manager of the Regional Emergency Planning Service	Update to be provided.	Open
	5. Audit Wales Assurance & Risk Assessment Report - Carbon reduction plan	A request was made for officers from the Capital Finance team to attend a future meeting to discuss the options available to deliver the Council's objectives in relation to carbon reduction.	Chief Officer (Planning, Environment and Economy)	To be scheduled on the Forward Work Plan	Open
	6. Commercial Carbon Offsets Report	To provide clarification to the Committee on opportunities to prioritise finances on non-profit carbon credits and the expected process for purchasing offsets	Climate Change Project Officer	Update to be provided.	Open
06.09.2024	8. Climate Risk - Extreme Heat	To clarify whether a fire ban can be implemented during prolonged periods of dry weather.	Programme Manager – Climate Change & Carbon Reduction	Update to be provided.	Open

9.16 THE CLIMATE CHANGE COMMITTEE

Composition

9.16.1 Membership

The Climate Change Committee is composed of 12 Members.
The Climate Change Committee is subject to the rules of political balance in the Local Government and Housing Act 1989.

9.16.2 Term of Office

It is important that members of the Committee are able to build up expertise and so there should be continuity of membership for a whole council term in so far as is possible.

9.16.3 Quorum

A meeting of the Climate Change Committee shall only be quorate when at least one third of the committee's members are attending the meeting.

9.16.4 Chairing the Committee

9.16.4.1 The Full Council will appoint the Chair of the Climate Change Committee at the Annual Meeting. The Climate Change Committee will elect its own vice chair.

9.16.4.2 The Chair and Vice Chair will serve from the first meeting after the Annual Meeting of Council (or the first meeting at which they were elected if later) until the end of the municipal year or until the member ceases to be a member of the committee or ceases to be a councillor (for whatever reason).

9.16.5 Role and Function

The primary objectives of the Climate Change Committee are to:

9.16.5.1 assist and advise the Council on how to become a net zero carbon emitter by December 2030 by overseeing the delivery of the Climate Change strategy and action plan;

9.16.5.2 consult with, and raise awareness amongst, the public, business and suppliers on steps that can be taken to reduce carbon emissions;

9.16.5.3 work to achieve collective cross-portfolio responsibility on climate change, including advising and assisting other committees across the Council;

9.16.5.4 To consider the economic, environmental and social challenges/risks arising from climate change for businesses, residents, suppliers and the Council;

It will have the following roles and functions to help the Council achieve those objectives:

9.16.5.5 To gather information on and model annual Council greenhouse gas emissions;

~~9.16.5.4 To consider the economic, environmental and social challenges/risks arising from climate change for businesses, residents, suppliers and the Council;~~

9.16.5.6 Reviewing, leading on and commenting on the Council Plan's Green Theme priorities and complementary priorities within other themes of the Council Plan;

9.16.5.7 To continue to develop, for approval by the Cabinet, the Climate Change Strategy and Action Plan with the aim of reducing the Council's net greenhouse gas emissions, the implementation of which it will continue to oversee;

9.16.5.8 To promote and support the use of renewable energy opportunities across the Council's estate and wider communities;

9.16.5.9 To support and promote Welsh Government's strategy to create a sustainable, circular economy in Flintshire;

9.16.5.10 To encourage local businesses in their efforts to reduce their carbon footprint and become more resource efficient.

9.16.5.11 To advise the Cabinet on:

9.16.5.12 steps it can take to limit the impact of the Council's services on the natural environment and supporting the wider communities of Flintshire to reduce their own carbon footprint;

9.16.5.13 the use, good management and protection of the Council's green spaces to deliver multiple benefits to the environment and its residents and visitors;

9.16.5.14 how to reduce the environmental impact of the Council's fleet by maximising the use of sustainable forms of transport;

9.16.5.15 how to ensure that the Council's retained housing stock meets the Welsh Housing Quality Standard developing plans for the de-carbonisation of council homes;

9.16.5.16 how to ensure that the Council's non-residential buildings and land supports and contributes to the Council's net zero carbon agenda and supports the aims and objectives within the Council's Climate Change Strategy

9.16.5.17 To review and make recommendations on procurement policy and practice to reduce greenhouse gas emissions from our suppliers;

9.16.5.18 To recommend to Council a policy for sustainable and long term energy usage in its capital projects;

9.16.5.19 To advise any other Committee on matters within the remit which might affect achievement of the aims within the Climate Change Strategy and Action Plan

9.16.6 Scope and Resources

9.16.6.1 The Climate Change Committee cannot make decisions which affect the Council's Budget or Policy Framework, but it may make recommendations to Cabinet for investment as part of the cycle for preparing the Medium Term Financial Strategy and/or Capital Programme

9.16.7 Work Programme

9.16.7.1 The Committee will prepare a forward work programme which will be reviewed and approved at each Committee meeting.

9.16.8 Rules of Procedure and Debate

9.16.8.1 The Council Procedure Rules at Section 4.10 of the Model Welsh Constitution will apply to the meetings of the Climate Change Committee Members.

Agenda Item 6

Cyngor sir ddinbych denbighshire County Council

CYNGOR Sir y Fflint Flintshire COUNTY COUNCIL

Procurement Decarbonisation

Procurement Shared Services – Driving forward low carbon procurement across Denbighshire & Flintshire County Councils

Roberta Bailey
Procurement Business Partner – Decarbonisation
November 2023

hyderus o ran anabledd CYFLOGWR
disability confident EMPLOYER

Supply Chain Decarbonisation

The Why:

- Welsh Gov't Net Zero Strategy - Net Zero by 2050
- Well-Being of Future Generations Act
- Denbighshire and Flintshire Climate Change Strategies for 2030
- Denbighshire Climate Emergency declared 2019
- Procurement Reform - Social Partnership Bill (New Public Contract Regulations and Social Partnership Bill) - Community Benefits
- Supply Chain emissions account for approximately 60 - 90% of reported emissions

The When:

- 2-year contract (ending Sept. 2025) to develop strategy to develop and implement reduction of Supply Chain carbon footprint. The process needs to be clear, appropriate, collaborative and effective.

What has happened over the past year?

- Introduction of Supply Chain decarbonisation and 2023 WLGA Toolkit to Service Areas.
- Creation of Supplier facing SC decarbonisation presentation shared with NWCF, D&P suppliers and at Meet the Buyer events.
- Trialling carbon calculator and rollout for move from spend-based to apportioned emissions reporting.
- Inclusion of requests for supplier Carbon Reduction Plans in all tenders.
- Participation in Climate Strategy Panel – Procurement Task & Finish Group, NW Decarbonisation Group and Procurement Task Group; connection with WLGA procurement and sustainability colleagues, providing input to Miller Research, Posterity Global, Business Wales, Carbon Trust; sharing of resources on Cyd website; liaising and sharing resources with NW LGAs and NHS Wales.
- Improvements to data coding to simplify reporting and encourage unified LGA approach.

Up Next:

- WRAP Sustainable Procurement Review: initiating December 2024, Report first quarter 2025
- Enhancement to WLGA Toolkit covering Social Care: Report and recommendation due 2025
- Transitioning from Spend Based to Apportioned/Contract specific emissions reporting: Carbon Trust working with WG. Report due Jan 2025, project completion March 2025.
- Service Area Emissions Communications
- Inclusion of new Net Zero clauses in contracting

- Challenges:
  - Contract Management
  - Data validity and responsibilities
  - SME onboarding
  - LGA alignment

Climate Change Committee

Date of Meeting	26th November 2024
Report Subject	Flintshire's Local Area Energy Plan
Cabinet Member	Collective Responsibility
Report Author	Chief Officer (Planning, Environment & Economy)
Type of Report	Operational

EXECUTIVE SUMMARY

Since the endorsement of the North Wales Energy Strategy and Action Plan and commencement of the Local Area Energy Planning (LAEP) in early 2023, the LAEP for Flintshire has now been finalised.

RECOMMENDATIONS	
1	That Cabinet endorses the attached Flintshire Local Area Energy Plan Main Report and Technical Report (Appendix 1 and 2), understanding that the LAEP actions assigned to Flintshire County Council are subject to securing and maintaining necessary funding.

REPORT DETAILS

1.00	**EXPLAINING THE REPORT**
1.08	**Local Area Energy Planning** Local Area Energy Planning (LAEP) is a data driven and whole energy system, evidence-based approach that sets out to identify the most effective route for the local area to contribute towards meeting the national net zero target, as well as meeting its local net zero target.
1.09	LAEP aims to: account for local and national conditions to achieve net zero; consider how cooperation with adjacent areas can bring success; and increase local stakeholder awareness to increase consent and facilitate credible commitments to achieve the plan.
1.10	LAEPs feed into regional energy strategies, which relate to national policies: Future Wales: the national plan 2040, Climate change targets, and National Energy Plan 2024.
1.11	The local energy system includes: whole building retrofit, local onshore renewables, decarbonisation of transport, deployment of heat pumps where appropriate, reinforced electricity distribution network, decarbonisation of industry and hydrogen networks.
1.12	On behalf of the Welsh Government, Ambition North Wales are managing a contract with consultants developing the LAEP for Flintshire, and the other north Wales counties. The LAEP was authored by The Carbon Trust and Arup, following an internationally recognised method, and was based on modelling, insights from data, and stakeholder plans and ideas, including through workshops. These workshops were attended by Council officers across portfolios, Members, Town & Community Councils, and external stakeholders. External stakeholders have included large local employers, large local energy providers, large local energy users, Deeside decarbonisation forum, transport providers, Distribution Network Operators, housing providers, and any community groups who are focussing on energy.
1.13	The plans will fall under the ownership of each local authority in Wales. They are aimed at being a guidance tool in how best to work towards a fully decarbonised energy system by 2050. All LAEPs will be aggregated to inform the development of the National Energy Plan by the end of the year. Local authorities are requested to endorse the Local Area Energy Plan through due process. The LAEP will be reviewed by Environment & Economy Overview & Scrutiny Committee, Corporate Resources Overview & Scrutiny Committee and Cabinet.

1.14	A Members’ Briefing was held on 21st November 2024, and provided an opportunity to increase understanding of and consider the details in the LAEP. With Ambition North Wales and other counties in Wales, a delivery/ monitoring mechanism to progress LAEP actions will be developed, including: • Agreeing on a governance structure • Aligning north Wales Regional Energy Strategy (+Action Plan) with the LAEPs • Identifying KPI’s • Regional Steering Group The LAEP is provisionally due to be reviewed in five years’ time, as we approach 2030 and the public sector net zero carbon target deadline.

2.00	**RESOURCE IMPLICATIONS**
2.01	The Flintshire LAEP includes high-level indicative costs. Actions identified in the plan are assigned to many organisations in the county and funding for actions is not expected to come only from the Council and the public sector. Where possible, the LAEP actions assigned to the Council align with the Climate Change Strategy and are subject to securing and maintaining necessary funding. Delivering the LAEP actions will be for a wide range of stakeholders and will be subject to sufficient political and financial support.
2.02	There will be the requirement for both capital and revenue resource in order to deliver on the LAEP. Specific projects will require full feasibility assessments and this would require additional staffing resource. Delivery of all projects and actions identified is subject to securing the necessary funding.

3.00	**IMPACT ASSESSMENT AND RISK MANAGEMENT**
3.01	There is a risk in terms of lack of capacity (people and/or funding) to deliver the actions allocated to the Council as lead. This could result in actions not being delivered, or delayed in delivery, and therefore outcomes in terms of decarbonising and futureproofing the energy system, not being realised. This risk can be mitigated by collaborating across the region to secure funding to support these actions. Ambition North Wales are working to increase resource capacity in order to support Councils with LAEP action delivery. Many of the actions within the LAEP are aligned with the Council’s Climate Change Strategy which will assist in likelihood of delivery, and robust, clear and transparent messaging must be used to manage expectations in terms of resource availability matching the Council’s ability to deliver.
3.02	**Ways of Working (Sustainable Development) Principles Impact**

Long-term	Positive: Decarbonisation of the Council's activities and services will require long term planning and a long term vision to ensure systems and services are fit for purpose as the climate changes as well as reducing the impact of harmful climate change through mitigation. Decarbonisation activities such as developing renewable energy will have long lasting impacts over tens to hundreds of years. These activities also contribute to the climate change targets set by Welsh Government particularly Wales generating 70% of its electricity demand from renewable energy by 2030 and becoming a net zero carbon nation by 2050.
Prevention	Positive: In order to avoid the harmful effects of climate change it is necessary for the Council to reduce its carbon emissions and increase the amount of carbon sequestered in its land assets. Carbon emissions caused by human activities are the main cause of climate change. Mitigating climate change will help to reduce impacts such as extreme weather causing flooding / extreme heat, loss of wildlife and habitats, increased pests and diseases, etc. Adapting to the impacts of climate change now will improve sustainability of our communities as the climate changes.
Integration	Positive: Becoming net zero carbon integrates with the following priorities under the Council Plan; Green Council, Ambitious Council and Supportive Council. It integrates with the public service board objectives in the Environment priority of the Wellbeing Plan as well as the Smart Access to Energy project in the North Wales Growth Deal. It also integrates with the Environment (Wales) Act 2016 and Welsh Government's decarbonisation of the public sector agenda.
Collaboration	Positive: The climate change programme offers multiple opportunities to work collaboratively both internally and externally – and this collaboration will determine the success of the programme. Collaboration with the following groups is needed to ensure decarbonisation is

	integrated into everything that the Council and the wider region does and plans for: - Welsh Government - Other public sector organisations such as local authorities, NRW, health boards, universities. - Private sector - Regional groups such as Ambition North Wales - Local Town and County Councillors - the local communities
Involvement	Positive: If decarbonisation is to succeed and harmful climate change is to be avoided then everyone at a professional and personal level will need to be involved

Well-being Goals Impact

Prosperous Wales	Positive: Reducing the Council’s carbon emissions should enable strategic investment in projects and ways of working that could deliver savings or generate new income streams, therefore supporting delivery of local services. It should also facilitate the development of the low carbon economy through infrastructure projects, land management etc which can support local businesses and communities.
Resilient Wales	Positive: Decarbonisation of the local energy sytem will promote resilience through actions such as: investment in renewable energy infrastructure which helps to reduce reliance on imports from across Europe and the World and the associated price fluctuations.
Healthier Wales	Positive: Decarbonisation of the energy system will provide clean, green energy that is not releasing emissions into the atmosphere via burning of fossil fuels.
More equal Wales	Neutral; No impact identified
Cohesive Wales	Neutral; No impact identified
Vibrant Wales	Neutral; No impact identified
Globally responsible Wales	Positive: Reducing the Council’s carbon emissions to net zero helps to mitigate climate change and therefore contributes to the achievement of Welsh Government, UK Government and international climate goals.

3.03	Not anticipated to be any negative anti-poverty, equalities or environmental impacts of the scheme.

3.04	**The Council's Well-being Objectives** Decarbonisation of the Council's activities will support the Green Council objective with a key impact of reducing carbon emissions mitigating climate change, for example, through the development of alternative and renewable energy production, promoting active travel, shifting to electric fleet vehicles, engaging with the supply chain and promoting a low carbon economy through the goods and services purchased. It can also contribute towards the success of other Council Wellbeing objectives such as 'An Ambitious Council' and 'A Caring Council' through providing local job creation and apprenticeships and therefore potentially reducing poverty through maximising residents' income and employability.

4.00	**CONSULTATIONS REQUIRED/CARRIED OUT**
4.01	The LAEP was created with stakeholders operating in Flintshire (geographical area). Identification and engagement of stakeholders eg in workshops, was a key part of the process of creating the LAEP. Details are included in the Technical Report (Appendix 2). Progress reports and draft versions have also been to Climate Change Committee, Environment & Economy Overview & Scrutiny Committee and Cabinet.

5.00	**APPENDICES**
5.01	1. LAEP Flintshire Main Report 2. LAEP Flintshire Technical Report

6.00	**LIST OF ACCESSIBLE BACKGROUND DOCUMENTS**
6.01	**1.** North Wales Energy Strategy (https://www.gov.wales/regional-energy-strategy-north-wales)

7.00	**CONTACT OFFICER DETAILS**
7.01	**Contact Officer: Alex Ellis – Programme Manager** **Telephone:** 01352 703110 **E-mail:** alex.ellis@flintshire.gov.uk

8.00 GLOSSARY OF TERMS

Anaerobic digestion – Processes biomass (plant material) into biogas (methane) that can be used for heating and/or generating electricity.

ANW – Ambition North Wales (formerly North Wales Economic Ambition Board).

Biomass boiler – Generates heat by burning wood-based fuel (eg. Logs, chippings) in a boiler.

Energy Component - This is a technology or component of the energy system – such as onshore wind, solar PV

Ground PV – Converts solar radiation into electricity using photo-voltaic cells mounted on the ground.

Heat pump – Uses a heat exchange system to take heat from air/ground and increases the temperature to heat buildings.

Hydro – Uses water falling between two reservoirs to turn turbines to generate electricity.

LAEP – Local Area Energy Plan

Onshore wind – Harnesses wind to turn a turbine to generate electricity on land.

Pathway - A pathway is how we get from the current energy system, to the most likely net zero end point. The pathway will consider what is needed from across the scenarios, the supply chain, number of installers etc. The propositions will make up the more certain part of the pathway, whereas the longer-term energy components will need further definition in the future.

Retrofit – Upgrading the performance of an existing building, such as installing more insulation or double glazing.

Scenario - A scenario is a set of assumptions for a particular end point (usually 2050) which are modelled in our optimisation model. We will model 5 different scenarios to see what is common across the scenarios and therefore “no regrets”, and what changes between the modelled scenarios.

WG – Welsh Government.

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Sponsors:

Delivery partners:

Flintshire

Local Area Energy Plan

Flintshire

2024

Mae’r ddogfen hon ar gael yn Gymraeg /
This document is also available in Welsh

Abbreviations

Acronym	Definition or meaning
ANW	Ambition North Wales.
CAPEX	Capital Expenditure.
CCGT	Combined Cycle Gas Turbine.
COP	Coefficient of Performance.
DESNZ	Department for Energy Security and Net Zero.
DFES	Distribution Future Energy Scenarios.
DNO	Distribution Network Operator.
EfW	Energy from Waste.
EPC	Energy performance certificate.
ESC	Energy Systems Catapult.
EV	Electric Vehicle.
FES	Future Energy Scenarios.
GDN	Gas Distribution Network.
GHG	Greenhouse Gas.
GIS	Geographic Information System.
HGV	Heavy Goods Vehicles.
LAEP	Local area energy planning or Local area energy plan.
LDP	Local Development Plan.
LGV	Light Goods Vehicles.
LSOA	Lower super output area, a small area classification in the UK designed to have a comparable population.
LULUCF	Land Use, Land Use Change and Forestry.
MSOA	Middle super output area, a medium-sized area classification in the UK designed to have a comparable population.
NAEI	National Atmospheric Emissions Inventory.
NGED	National Grid Electricity Distribution.
NZ	Net Zero.

Abbreviations

Acronym	Definition or meaning
REA	Renewable Energy Assessment.
REPD	Renewable Energy Planning Database.
RFI	Request for Information.
RIIO	Revenue = Incentives + Innovation + Outputs, a regulatory framework used by the UK energy regulator, Ofgem.
RSP	Regional Skills Partnership.
RTP	Regional Transport Plan.
SDP	Strategic Development Plan.
SMR	Steam Methane Reformation.
SPEN	SP Energy Networks.
SSE	Scottish and Southern Energy plc.
TfW	Transport for Wales.
WIMD	Welsh Index of Multiple Deprivation.
WWU	Wales and West Utilities.

Note: full definitions for terms used through the report are provided in the glossary at the end of the document.

Sponsors:

Delivery partners:

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Navigation to Sections
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Navigation within the report
Throughout this document, clicking on underlined text with take the reader to the page referred to.

This Local Area Energy Plan was prepared by Arup, Carbon Trust and Afallen on behalf of Flintshire County Council and co-ordinated across the region by Ambition North Wales. Energy Systems Catapult is the Technical Advisor for the LAEP Programme in Wales.

The Plan’s development was funded by the Welsh Government.

Local Area Energy Plan outline

This plan collates evidence to identify the most effective route for Flintshire to reach a net zero energy system

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Overview

As part of this project, two separate documents have been produced. This will ensure the content is accessible to a variety of audiences whilst also making it easier to find information relevant for the reader. These two documents are the:

1. **Local Area Energy Plan** *(this document)* contains the overarching plan, focusing on the Flintshire's area-wide local energy plan and actions.
2. **Technical Report** contains the graphs, charts, maps and supporting data for the results published in the Local Area Energy Plan. It also provides more detail about the approach to modelling and scenario analysis that we took. This report is available upon request.

Achieving the transformation that is needed for the energy system to reach net zero will not be easy and will need a collaborative approach. In this plan, the term "we" has therefore been used to refer to the range of people and organisations in Flintshire who will support the ambition we set out and take action. The Council and Ambition North Wales have taken facilitating roles in developing this LAEP, but we will not deliver the ambition it sets out alone. We have developed this Plan with input from a range of stakeholders, and we hope that you will be inspired by the actions that stakeholders have committed to, to take action to transform our energy system too.

	Local Area Energy Plan	**Technical Report**
Purpose	A compelling vision for a decarbonised energy system	Detailed methodology and analysis
Audience	General public, businesses, policy makers etc.	Local Authority, technical stakeholders (e.g. distribution network operators, energy managers, planners)

Figure 0.0.1: LAEP and support documents purpose and audience summary

Executive summary

Our vision for a net zero local energy system

The vision for Flintshire’s future local energy system is:

Flintshire County Council envisions a sustainable future with a net zero energy system that is affordable and promotes community health, wellbeing, and economic growth. We commit to a clean energy transition that fosters a resilient, inclusive, and prosperous community, ensuring a harmonious balance between environmental stewardship and social progress.

Flintshire’s **energy objectives** are collectively agreed and describe what needs to be done to create the enabling conditions needed to deliver this LAEP.

- Support a low-cost and affordable energy system through reducing energy demand and promoting energy efficiency.
- Optimise the use of local renewable energy sources within Flintshire, encouraging local ownership and community participation.
- Promote safe, healthy, and sustainable places to live, work and visit – helping to generate connected and resilient communities
- Create a resilient energy system capable of meeting future energy demands that reduces carbon emissions and protects and enhances Flintshire’s natural assets.
- Promote a low carbon economy, providing learning and skills for all to create a prosperous, thriving, resilient Flintshire.

Our **energy propositions** describe what needs to change between now and 2050 to decarbonise Flintshire’s local energy system and achieve net zero by 2050.

- **Scaling Zero Carbon Buildings**
- **Decarbonising Transport**
- **Increasing Local Renewable Generation**
- **Supporting Green Business**
- **Maturing Hydrogen**
- **Reinforcing and Transitioning Energy Networks**

Figure 0.0.2: LAEP priority energy proposition areas for Flintshire

Sponsors:

Delivery partners:

Executive summary

Flintshire’s energy propositions in more detail

Scaling Zero Carbon Buildings

Supporting and deploying energy efficiency measures across the county to reduce energy demand and costs.

Ensuring buildings are safe, healthy and low carbon in operation and design.

Low regret system components:

- Retrofit
- Heat pumps

Decarbonising Transport

Enabling the rollout of ultra low/zero carbon vehicles across the county and transitioning to a zero carbon council fleet.

Promoting active and sustainable travel within the region.

Low regret system components:

- EV chargers
- Active travel

Increasing Local Renewable Generation

Investigating opportunities for local and community ownership of renewables, providing low cost, clean energy to residents.

Low regret system components:

- Rooftop solar
- Ground-mounted solar

Supporting Green Business

Encouraging and supporting businesses to adopt low carbon measures and reduce energy costs.

Create an attractive environment for sustainable businesses to make base in Flintshire.

Low regret system components:

- Waste heat

Maturing Hydrogen in Industry

Exploring the potential for hydrogen within particular sectors and understand the infrastructure requirements for implementation.

Low regret system components:

- Innovation trials

Reinforcing and transitioning energy networks

Grid reinforcement will be required to accommodate the shift towards electric vehicles and heating.

Even in a low hydrogen scenario the gas grid will require repurposing for hydrogen within some applications.

Low regret system components:

- Flexibility and storage technologies

Figure 0.0.3: Summary of energy propositions

Cyngor Sir y Fflint Flintshire County Council

Sponsors:

Llywodraeth Cymru Welsh Government

Uchelgais Gogledd Cymru Ambition North Wales

Delivery partners:

ARUP

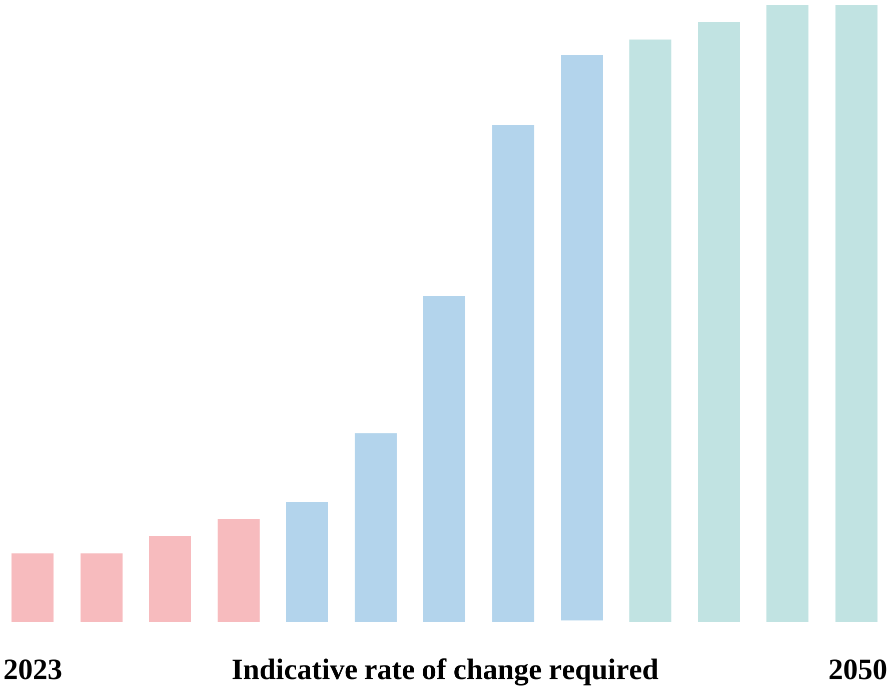
CARBON TRUST

Executive summary

Flintshire's local energy system will need to change significantly to achieve net zero by 2050

Flintshire's local energy system today

- **220** public EV charge points
- **700** heat pumps installed
- **13,000 (35%)** of all domestic properties EPC A-C
- **80MW** ground-mounted solar PV installed capacity
- **2,900** buildings with rooftop solar PV installed (12MW)
- **0 GWh/yr** of industrial hydrogen consumption



What Flintshire's net zero local energy system could look like in 2050

- **Up to 63,800** public EV charge points
- **Up to 95,300** heat pumps installed
- **Up to 37,200** of all domestic properties EPC A-C
- **645MW** ground-mounted solar PV installed capacity
- **99,700** buildings with rooftop solar PV capacity (400MW)
- **Up to 220 GWh/yr** of industrial hydrogen consumption

1 Between 2023 and 2030, we assume a slow but steady uptake of low carbon technologies due to factors such as limited awareness, higher capital costs, and the need for network reinforcement.

2 From 2030 onwards, we assume that deployment accelerates as technologies become more commercially attractive, awareness increases, supply chains develop, and they become more affordable.

3 From 2040 onwards, we assume that low carbon technologies are widely used and tend towards their maximum feasible adoption, which causes the deployment rate to stabilise.

Sponsors:

Delivery partners:

Executive summary

Achieving a net zero local energy system in 2050 aligns with the Well-being of Future Generations (Wales) Act 2015 and could lead to the following

Direct Impacts

Emissions reductions
22 times less GHG emissions than in 2023

Energy savings
1.4 times less heat used in buildings than in 2023

1.6 times less energy used for transport than in 2023

Wider Impacts

Energy security and reliability
Diversified local energy supply improves energy security

Air quality improvements
Reduced fossil fuel combustion from transport, heat and power improves air quality - up to £1,200m of cumulative savings by 2050

Net job creation
Emerging net zero industries attract investment and create high quality local jobs – up to 8,800 net jobs created by 2050

Affordability
Highly insulated homes reduce heat demand, improve affordability and reduce fuel poverty

National Well-being Goals

Wales' Well-being of Future Generations (Wales) Act 2015, well-being goals

Executive Summary
Flintshire's Plan on a page

To support transformation of the energy system, pilot projects may be useful. The map below highlights areas that could provide a useful focus for these pilots.

Figure 0.4 identifies zones with particularly favourable conditions for specific energy components, making them ideal locations for pilot studies. The summary boxes detail the location, opportunity type, potential capacity, required investment for each component, and total investment necessary for both energy component installation and electricity network infrastructure in each zone by 2030. Ranges have been calculated by taking the minimum and maximum results from each future energy scenarios modelled.

Point of Ayr

Opportunities:	Heat pumps	Rooftop PV
Potential:	0.6-1.0MW	1.0MW
Cost:	£0.4m-0.7m	£1.1m

Total opportunities cost: £3m-24m

Gronant
Opportunity: Insulation measures
Potential: 138-298 homes
Cost: £1.3m-23.1m
Total opportunities cost: £3m-24m

Greenfield
Opportunity: Insulation measures
Potential: 372-1,197 homes
Cost: £3.4m-63.4m
Total opportunities cost: £21m-79m

Trelawnyd
Opportunity: Heat pumps
Potential: 0.3-0.5MW
Cost: £0.2m-0.4m
Total opportunities cost: £3m-28m

Shotwick
Opportunity: EV chargers
Potential: 1.0MW
Cost: £0.9m
Total opportunities cost: £18m-22m

Caerwys
Opportunity: Rooftop PV
Potential: 1.1MW
Cost: £1.3m
Total opportunities cost: £9m-69m

Queensferry
Opportunity: EV chargers
Potential: 1.9MW
Cost: £1.6m
Total opportunities cost: £23m-66m

Leeswood
Opportunity: Ground PV
Potential: 35.2MW
Cost: £15.1m
Total opportunities cost: £31m-141m

Buckley
Opportunity: Ground PV
Potential: 75.2MW
Cost: £32.5m
Total opportunities cost: £68m-269m

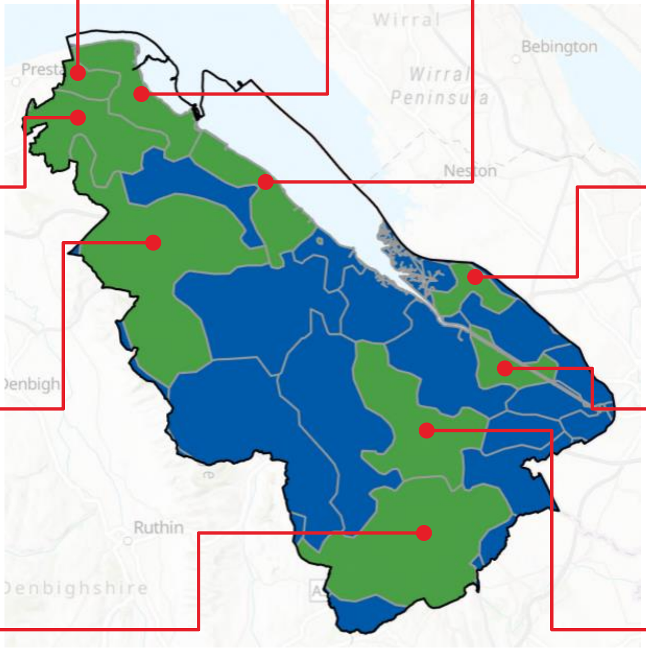


Figure 0.0.4: Flintshire's spatial representation of opportunities, including 2030 ambition and investment (million £) – in High and Low Demand scenarios. Zone boundaries are defined by primary substation service areas.

Executive summary

To deliver the LAEP, we have developed a series of actions and next steps that we'll need to take

Action routemap

Although the exact form of the decarbonised energy system in 2050 is uncertain, there are actions we can take now with relative certainty that will help us maintain the ability to meet our 2050 Net Zero ambition and capitalise on the opportunities that this transition will bring.

Our action routemap takes each energy proposition and outlines critical, enabling actions that we will take collectively alongside our stakeholders in the coming decade, with a particular focus on what we can achieve in the next 5-7 years.

The sequencing of activities in the routemap is highly dependent on the political, regulatory and strategic context it has been created in. Therefore, we expect it to evolve over time and be regularly updated to make sure it stays relevant. Flintshire's routemap can be found in Chapter 4: Action planning.

Next steps

Progressing energy propositions: For each prioritised proposition, we will undertake a series of development activities to progress towards delivery (such as feasibility studies, detailed technical and commercial development, business case, commercialisation and procurement).

Governance: Where possible, we will integrate oversight of LAEP delivery with existing governance structures. We will explore options to appoint a lead officer to guide the delivery of the actions in this plan.

Monitoring: We will work with regional and national partners to develop a monitoring framework which builds on existing processes and helps us understand the progress Flintshire is making towards its committed actions and ambitions set out in this plan.

Engagement & collaboration:
Many stakeholders with an interest and influence over the local energy system have come together to help shape this LAEP, and it is important that this collaboration continues as we deliver this plan. The development of this LAEP has brought those with interest and influence together.

Chapter 1: Introduction

1. Introduction

What is Local Area Energy Planning (LAEP)?

Overview

Definition of a LAEP

A LAEP sets out the changes required to transition an area's energy system to net zero carbon emissions against a specified time. By exploring a range of technologies and scenarios through whole energy system modelling and analysis, the most cost-effective preferred pathway to net zero can be identified. The process follows standardised guidance defined by ESC.

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

A LAEP results in an indicative costed spatial plan that identifies the change needed to the local energy system and built environment, detailing what changes are required, where, when and by whom. The level of detail in a LAEP is equivalent to an outline design or masterplan and is intended to identify core areas that require focus over the next 25 years. It proposes future sector-specific action plans that set out how each part of the area will be designed and built. Additional detailed design work will be required for identified specific actions, projects and programmes to progress to delivery.*

Vision of a LAEP

A LAEP defines a long-term vision for an area but should be updated approximately every 5 years (or when significant technological, policy or local changes occur) to ensure the long-term vision remains relevant. This LAEP sets out the start of Flintshire's net zero energy transition journey.

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

A note on the use of "we" throughout this report:

Achieving the transformation that is needed for the energy system to reach net zero will not be easy and will need a collaborative approach. In this plan, the term "we" has therefore been used to refer to the range of people and organisations across the Isle of Anglesey who will support the ambition set out and agreed in this plan. The Council and Ambition North Wales have taken facilitating roles in developing this LAEP but cannot deliver the ambition it sets out alone. This Plan has been developed with input from a range of stakeholders, and we all hope that you will be inspired by the actions that stakeholders have committed to, to take action to transform the island's energy system too.

1. Introduction

What is Local Area Energy Planning (LAEP)?

Overview

Scope of a LAEP

The UK government’s 2021 Net Zero Strategy[M02] estimates that **82% of the UK’s emissions are “within the scope of influence of local authorities.”**

The scope of a LAEP covers the current and projected future energy consumption and associated greenhouse gas (GHG) emissions, primarily focusing on an area’s built environment (all categories of domestic, non-domestic, and industrial buildings), energy used for road transport (excl. energy used in rail, aviation, and shipping), local renewable generation and the energy networks needed to support this consumption.

Elements included in a LAEP are:

- Electricity, heat and gas networks
- The future potential for hydrogen
- The built environment (industrial, residential, and commercial), its fabric and systems,
- Flexibility (in terms of shifting when demand is placed on the grid), and the storage and generation of energy,
- Providing energy to decarbonised transport (i.e., the electricity required for electric vehicle charging infrastructure).

Some GHG emissions sources are excluded from scope, because they are either not directly associated with the energy system (e.g. emissions from land, land use and forestry) or are produced from assets that are national (e.g. rail, aviation and shipping). More information on the boundary and scope can be found in Chapter 1: Introduction and the Technical Report (*Chapter 1*).

It identifies near-term actions and projects, providing stakeholders with a basis for taking forward activity and prioritising investments and action. Site-specific data is used where available, with remaining areas covered by the national dataset.

Benefits of a LAEP

A LAEP provides a long-term plan to deliver net zero. A benefit of LAEP is the ‘whole systems approach’, aligned to the Wellbeing of Future Generations Act[M06] “way of working” on integration. This provides consideration to the most cost-effective solutions to future energy system at the right time. For example, deploying different heat decarbonisation technologies to avoid a high-cost upgrade of the electricity network. By working closely with local stakeholders, incorporating their data, knowledge and plans, a LAEP is built on a common evidence base. The outputs can then be used reliably by stakeholders from Flintshire’s public service providers to network operators to community groups, knowing they are working towards a common goal built on strong foundations.

1. Introduction

The energy transition across Wales

Overview

The Welsh Government's "Net Zero Wales" plan[M03] establishes an increased level of ambition on decarbonisation, with a legally binding target to reach net zero emissions by 2050. It is the first national government to fund the roll out of LAEP to all its local authorities. The programme is being co-ordinated through a regional approach, where LAEPs are being developed for local authorities in mid Wales, South West Wales and in the North Wales and the Cardiff Capital Region. The rationale for taking this approach was because there are efficiencies on data collection and management, as well as reinforcing the links between the regional and local plans to maximise opportunities across LA areas and between regions. Several suppliers have been selected to produce the LAEPs for each region, as detailed in the map.

To contribute to the Welsh Government's commitment of producing a "National Energy Plan" in 2024, upon completion of the LAEP programme Energy Systems Catapult[M04] will aggregate the LAEPs into a national view. To support this task, they are working with the Welsh Government to create and import standardised LAEP outputs for aggregation into the DataMapWales platform[M05]. Energy Systems Catapult is also providing technical advisory support to the Welsh Government throughout the programme.

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

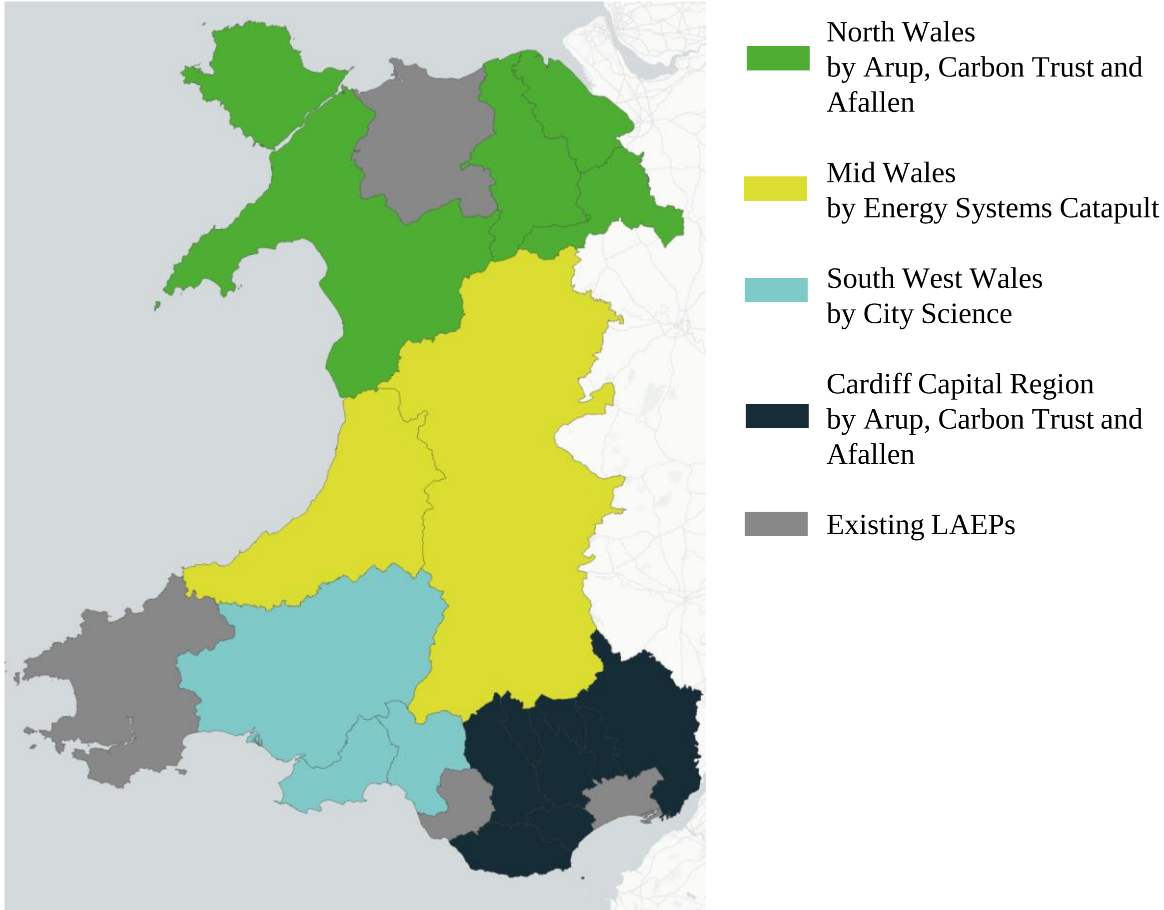


Figure 1.0.1: LAEP landscape across Wales

1. Introduction

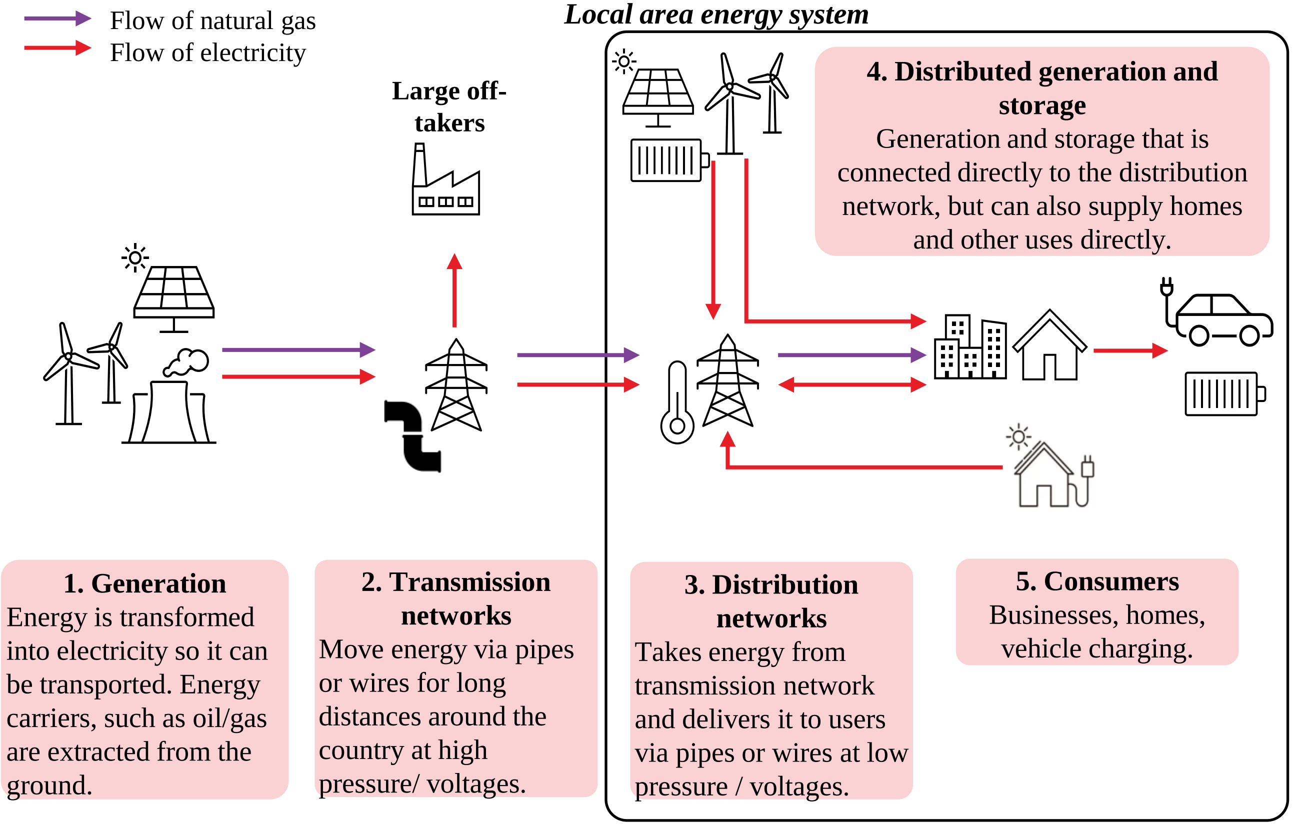
Boundary and scope

A LAEP considers energy use, supply and generation within the Flintshire boundary.

There are three core parts to the local energy system:

- **Infrastructure** – The physical assets associated with the energy system such as electricity substations.
- **Supply** – Generation (renewable and non-renewable), storage and distribution of energy to local consumers for use in homes, businesses, industry and transport.
- **Demand** – The use of energy driven by human activity e.g. petrol/diesel used in vehicles, gas burned for heat in homes. required for the energy system to operate.

The whole energy system across all sectors is considered in the planning process to ensure that the interactions and dependencies between generation and use of different energy sources are fully considered. This identifies where different systems can work together to improve the overall resilience and flexibility of the energy system.



4. Distributed generation and storage
Generation and storage that is connected directly to the distribution network, but can also supply homes and other uses directly.

1. Generation
Energy is transformed into electricity so it can be transported. Energy carriers, such as oil/gas are extracted from the ground.

2. Transmission networks
Move energy via pipes or wires for long distances around the country at high pressure/ voltages.

3. Distribution networks
Takes energy from transmission network and delivers it to users via pipes or wires at low pressure / voltages.

5. Consumers
Businesses, homes, vehicle charging.

Figure 1.0.2: Schematic of electricity and gas transmission and distribution network and the system boundary for LAEP

1. Introduction

Boundary and scope

Scope for the Welsh LAEPs

The diagram to the right indicate the parts of the local energy system which are in-scope for the LAEPs across Wales. This scope is defined by ESC's LAEP Guidance[M01].

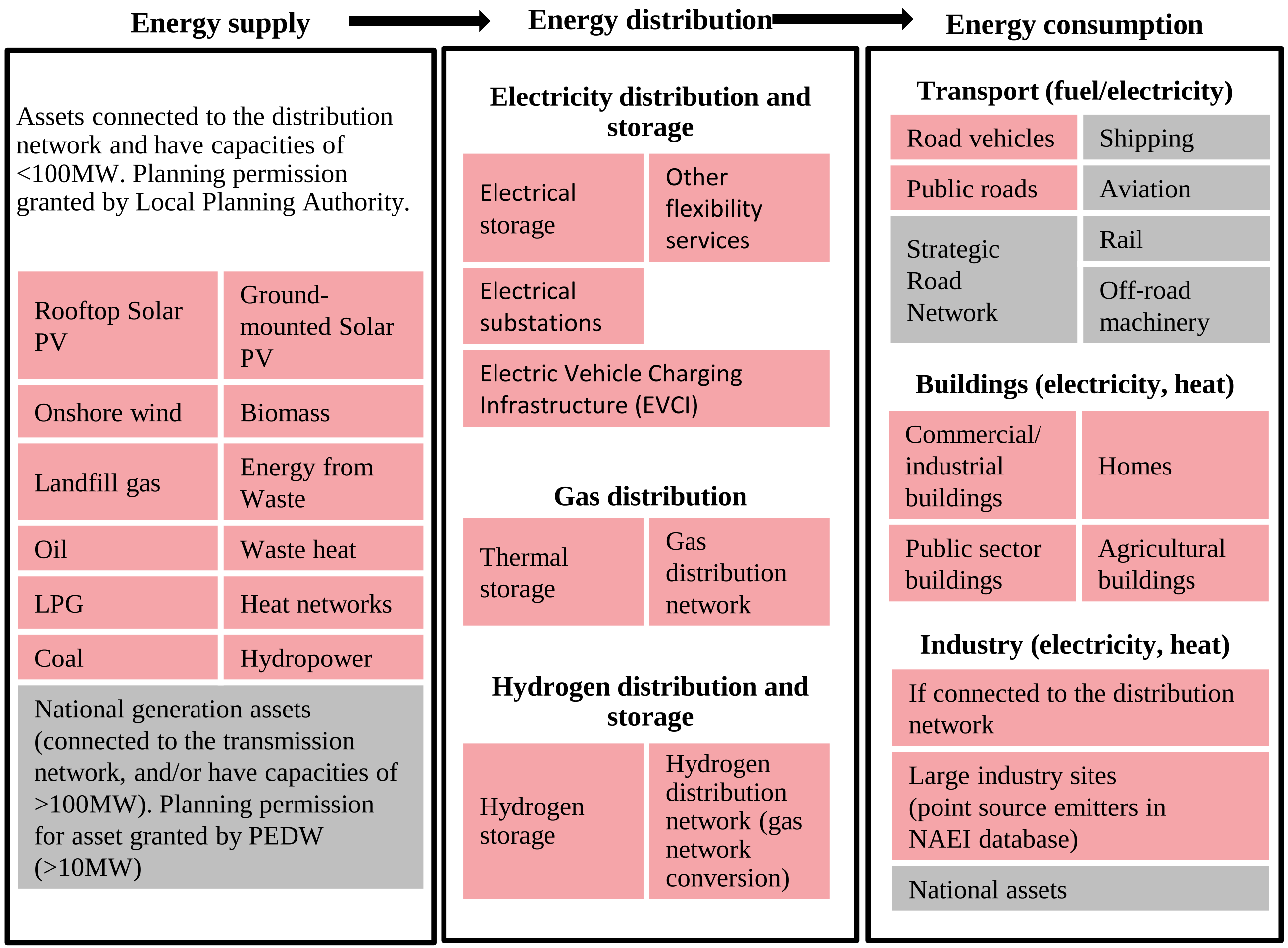
Geographic boundary

We used the geographic boundary for Flintshire to set the boundary for the LAEP, which meant that any energy generating assets, energy use and infrastructure in that boundary were considered for inclusion in the LAEP.

Exclusions from the LAEP

The following parts of the energy system within the Isle of Anglesey are excluded from the LAEP:

- Aspects of the energy system which are expected to be overseen by central government, or any non-energy sources of greenhouse gas (GHG) emissions occurring within the Local Authority's governing boundary (for example, GHG emissions from industrial processes, agricultural land use and livestock are excluded).
- Energy used for shipping, aviation and rail are excluded on the basis that they are not local uses of energy.
- Large electricity generators connected to the transmission network (such as offshore wind, grid scale batteries, hydrogen SMR) are considered national assets and excluded from the modelling, however these are likely to play an important role in Flintshire's decarbonisation journey.



Energy supply → **Energy distribution** → **Energy consumption**

Energy supply

Assets connected to the distribution network and have capacities of <100MW. Planning permission granted by Local Planning Authority.

Rooftop Solar PV	Ground-mounted Solar PV
Onshore wind	Biomass
Landfill gas	Energy from Waste
Oil	Waste heat
LPG	Heat networks
Coal	Hydropower

National generation assets (connected to the transmission network, and/or have capacities of >100MW). Planning permission for asset granted by PEDW (>10MW)

Energy distribution

Electricity distribution and storage

Electrical storage	Other flexibility services
Electrical substations	
Electric Vehicle Charging Infrastructure (EVCI)	

Gas distribution

Thermal storage	Gas distribution network

Hydrogen distribution and storage

Hydrogen storage	Hydrogen distribution network (gas network conversion)

Energy consumption

Transport (fuel/electricity)

Road vehicles	Shipping
Public roads	Aviation
Strategic Road Network	Rail
	Off-road machinery

Buildings (electricity, heat)

Commercial/ industrial buildings	Homes
Public sector buildings	Agricultural buildings

Industry (electricity, heat)

If connected to the distribution network

Large industry sites (point source emitters in NAEI database)

National assets

Figure 1.0.3: Schematic of the local system scope for LAEP

🟥 In scope of LAEP ⬜ Out of scope of LAEP

1. Introduction

Our vision for Flintshire's future local energy system

Future energy system vision and energy objectives

We have produced the following vision statement that underpins our ambition for the future net zero energy system in Flintshire:

Flintshire's vision

Flintshire County Council envisions a sustainable future with a net zero energy system that is affordable and promotes community health, wellbeing, and economic growth. We commit to a clean energy transition that fosters a resilient, inclusive, and prosperous community, ensuring a harmonious balance between environmental stewardship and social progress.

Finally, in shaping the LAEP for Flintshire, we established the following objectives. These objectives served as foundation elements that were considered when formulating recommended actions:

Energy objectives

1. Support a low-cost and affordable energy system through reducing energy demand and promoting energy efficiency.
2. Optimise the use of local renewable energy sources within Flintshire, encouraging local ownership and community participation.
3. Promote safe, healthy, and sustainable places to live, work and visit – helping to generate connected and resilient communities.
4. Create a resilient energy system capable of meeting future energy demands that reduces carbon emissions and protects and enhances Flintshire's natural assets.
5. Promote a low carbon economy, providing learning and skills for all to create a prosperous, thriving, resilient Flintshire.

1. Introduction

Navigating this report

LAEP contents

This LAEP presents a vision for a net zero local energy system in Flintshire, with a routemap to get there, including a set of recommended actions for Flintshire, whilst recognising the role of other key actors in government, the energy sector and across the community.

Plan structure

This plan is structured into three main topic areas:

Chapter 1 - Introduction – overview of what a LAEP is, and an introduction to Flintshire's vision and objectives for its LAEP.

Chapter 2 - The current energy system - description of Flintshire's existing energy system and relevant policies and objectives.

Chapter 3 - The future energy system - presentation of future scenarios for a net zero local energy system, including risks and "low regrets" measures, which are very likely to be part of the future energy system regardless of uncertainty around certain aspects of the future.

Chapter 4 - Action planning - a routemap and action plan for us to use to drive the local energy system transition in Flintshire, including what needs to happen and what we will do.

Chapter 5 - Next steps - outlines immediate next steps and what is needed to create an enabling environment for the delivery of this plan, and a net zero local energy system.

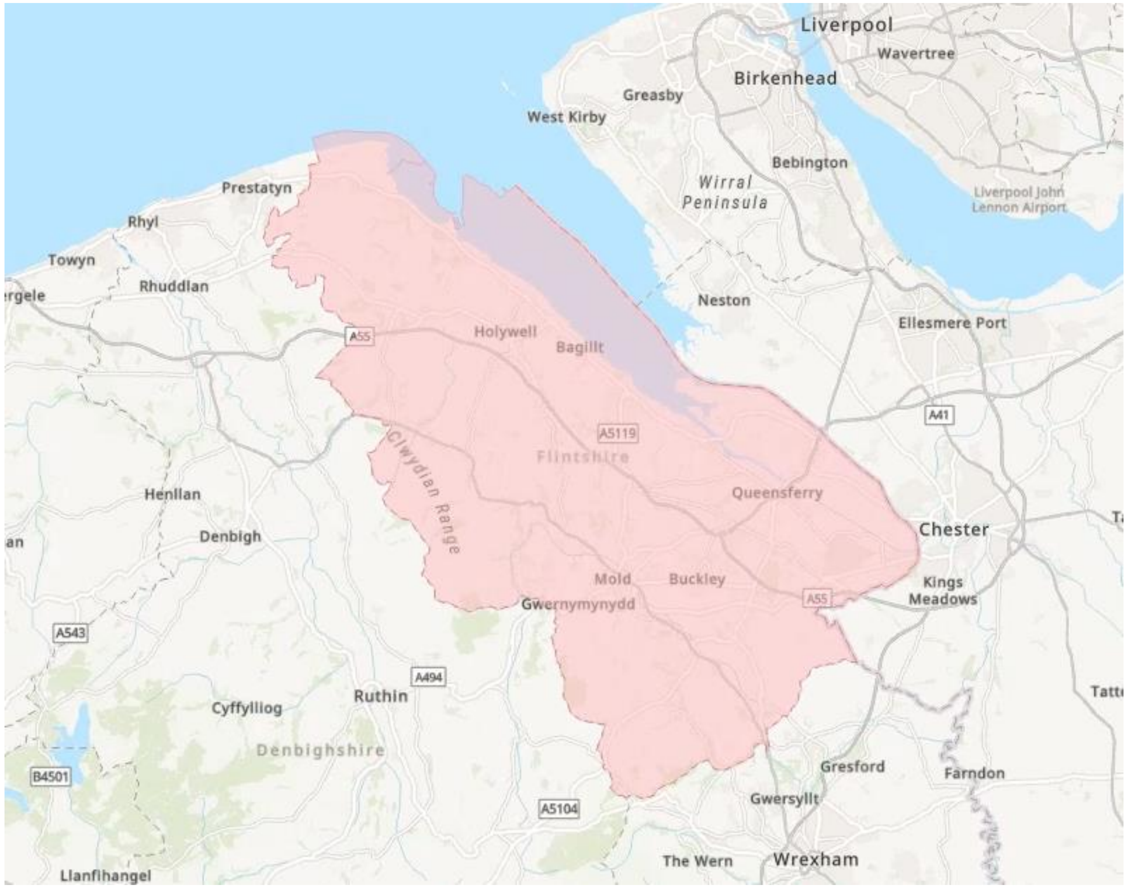


Figure 1.0.4: Geographic boundary for LAEP

Chapter 2: The current energy system

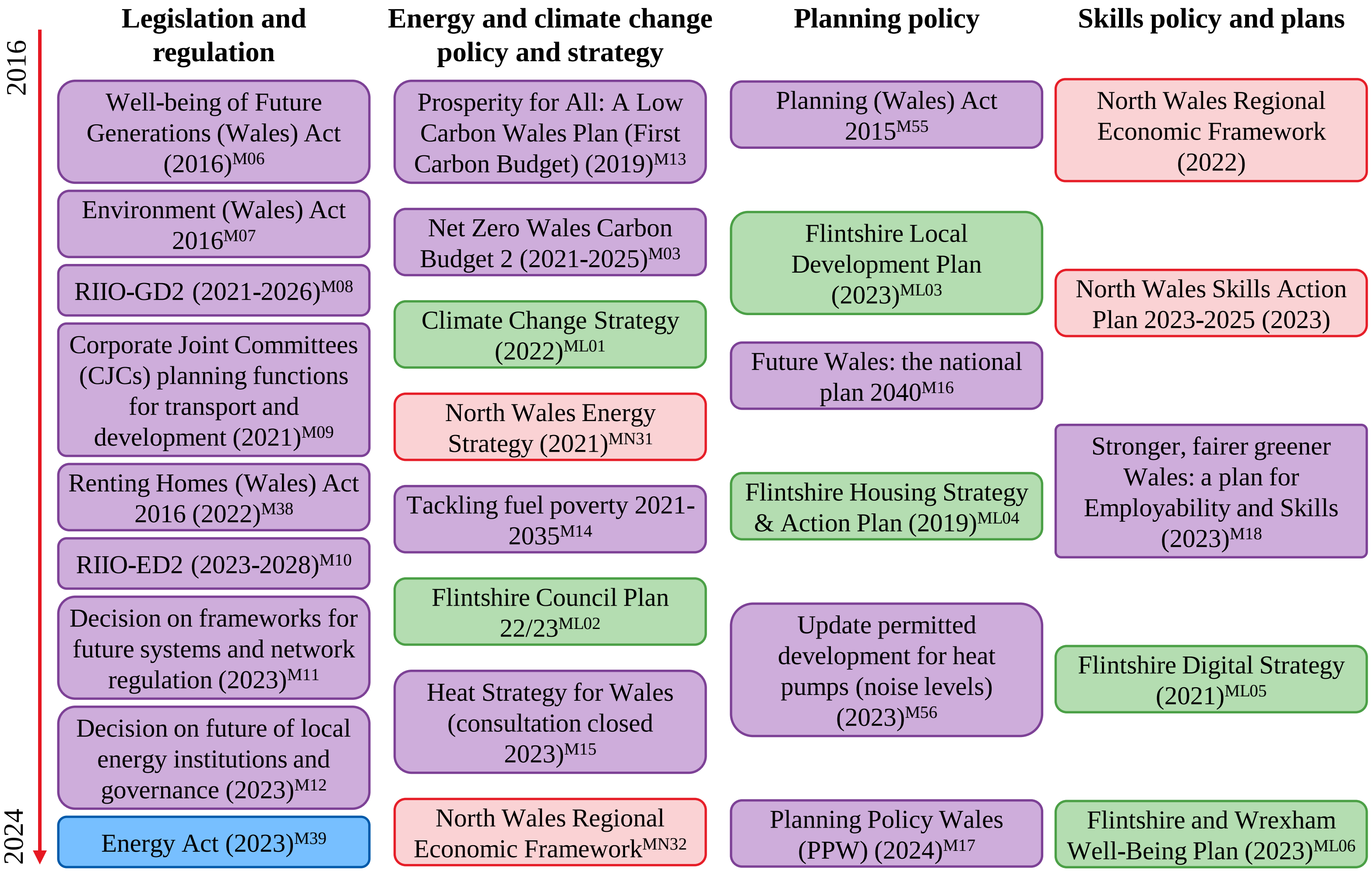
2. The current energy system

Policy and funding context

Net Zero Wales[M03] is the Welsh Government’s emissions reduction plan for the current carbon budget period between 2021-2025. This is a statutory document required by the Environment (Wales) Act[M07], which sets out policies and proposals to help Wales meet its carbon budget and be on track to meet its legally binding net zero target for 2050. The Well-Being of Future Generations (Wales) Act[M06] is in place to ensure that this transition fosters greater equality and positive outcomes for all.

There are a range of strategies and policies at Welsh and UK level that will influence how Wales transitions to a net zero energy system in the next 25-30 years. Devolved powers vary across the different parts of the energy system.

Using our own statutory powers, we, as a Local Authority, have also established plans and policies relating to decarbonising energy use across our own operations, and have started to look further to how we influence changes in our local communities through our place-making role.



2016 → 2024

Legislation and regulation

- 🟪 Well-being of Future Generations (Wales) Act (2016)[M06]
- 🟪 Environment (Wales) Act 2016[M07]
- 🟪 RIIO-GD2 (2021-2026)[M08]
- 🟪 Corporate Joint Committees (CJCs) planning functions for transport and development (2021)[M09]
- 🟪 Renting Homes (Wales) Act 2016 (2022)[M38]
- 🟪 RIIO-ED2 (2023-2028)[M10]
- 🟪 Decision on frameworks for future systems and network regulation (2023)[M11]
- 🟪 Decision on future of local energy institutions and governance (2023)[M12]
- 🟦 Energy Act (2023)[M39]

Energy and climate change policy and strategy

- 🟪 Prosperity for All: A Low Carbon Wales Plan (First Carbon Budget) (2019)[M13]
- 🟪 Net Zero Wales Carbon Budget 2 (2021-2025)[M03]
- 🟩 Climate Change Strategy (2022)[ML01]
- 🟥 North Wales Energy Strategy (2021)[MN31]
- 🟪 Tackling fuel poverty 2021-2035[M14]
- 🟩 Flintshire Council Plan 22/23[ML02]
- 🟪 Heat Strategy for Wales (consultation closed 2023)[M15]
- 🟥 North Wales Regional Economic Framework[MN32]

Planning policy

- 🟪 Planning (Wales) Act 2015[M55]
- 🟩 Flintshire Local Development Plan (2023)[ML03]
- 🟪 Future Wales: the national plan 2040[M16]
- 🟩 Flintshire Housing Strategy & Action Plan (2019)[ML04]
- 🟪 Update permitted development for heat pumps (noise levels) (2023)[M56]
- 🟪 Planning Policy Wales (PPW) (2024)[M17]

Skills policy and plans

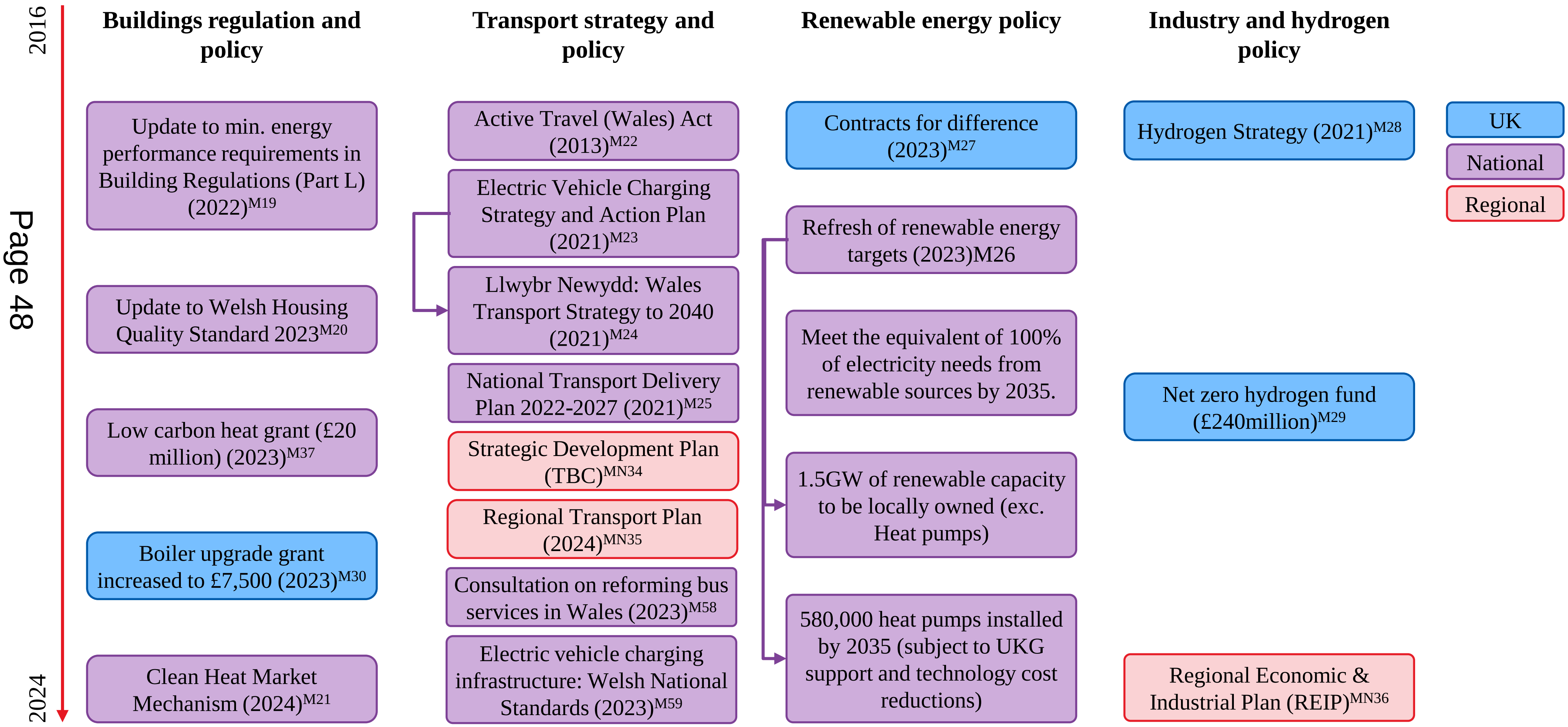
- 🟥 North Wales Regional Economic Framework (2022)
- 🟥 North Wales Skills Action Plan 2023-2025 (2023)
- 🟪 Stronger, fairer greener Wales: a plan for Employability and Skills (2023)[M18]
- 🟩 Flintshire Digital Strategy (2021)[ML05]
- 🟩 Flintshire and Wrexham Well-Being Plan (2023)[ML06]

Figure 2.0.1: Summary of cross-cutting regulation / policies at local, regional and national level

🟦 UK 🟪 National 🟥 Regional 🟩 Local

2. The current energy system

Policy and funding context



Buildings regulation and policy

- Update to min. energy performance requirements in Building Regulations (Part L) (2022)[M19]
- Update to Welsh Housing Quality Standard 2023[M20]
- Low carbon heat grant (£20 million) (2023)[M37]
- Boiler upgrade grant increased to £7,500 (2023)[M30]
- Clean Heat Market Mechanism (2024)[M21]

Transport strategy and policy

- Active Travel (Wales) Act (2013)[M22]
- Electric Vehicle Charging Strategy and Action Plan (2021)[M23]
- Llwybr Newydd: Wales Transport Strategy to 2040 (2021)[M24]
- National Transport Delivery Plan 2022-2027 (2021)[M25]
- Strategic Development Plan (TBC)[MN34]
- Regional Transport Plan (2024)[MN35]
- Consultation on reforming bus services in Wales (2023)[M58]
- Electric vehicle charging infrastructure: Welsh National Standards (2023)[M59]

Renewable energy policy

- Contracts for difference (2023)[M27]
- Refresh of renewable energy targets (2023)M26
- Meet the equivalent of 100% of electricity needs from renewable sources by 2035.
- 1.5GW of renewable capacity to be locally owned (exc. Heat pumps)
- 580,000 heat pumps installed by 2035 (subject to UKG support and technology cost reductions)

Industry and hydrogen policy

- Hydrogen Strategy (2021)[M28]
- Net zero hydrogen fund (£240million)[M29]
- Regional Economic & Industrial Plan (REIP)[MN36]

UK
National
Regional

Figure 2.0.2: Summary of sector-specific regulation / policy at local, national and regional level

2. The current energy system

Our collaborative approach to developing and delivering our LAEP

Stakeholder engagement approach

Delivering our LAEP calls for a collective effort from all types of organisations in and beyond the local authority boundary. The local energy system extends beyond Flintshire's influence which is why stakeholder engagement is the foundation for the development of our LAEP.

With the support of our delivery partners, we prioritised stakeholders based on their level of local knowledge of and / or influence over specific elements of the local energy system and their role in the development of the LAEP. The importance of recognising the involvement of regional stakeholders emerged early in the LAEP. They have a unique role, ensuring cohesion of action for specific element(s) of the energy system across neighbouring LAEPs in the same region and offering regional efficiencies where local objectives are aligned.

We engaged stakeholders at different stages of the development process to make sure stakeholders could help shape the plan and key development milestones. Regional steering groups were held for North Wales, attended by the regional and local authority leads, as well as bi-weekly meetings with the local authority leads. Two workshops were held regionally and involved primary stakeholders from across each local authority in North Wales. These workshops were used at stages where it was important to agree a way forwards that was appropriate for the region, as well as each local authority.

As part of the overarching programme, a national forum brought together all suppliers, local authority leads, the regional leads, Welsh Government and the Technical Advisor to share learnings and maintain a consistent approach across Wales. The suppliers and regional leads also had regular catch ups to share assumptions and challenges.

Please refer to the Technical Report (Chapter 2) for more detailed information on the methodology, analysis and engagement of stakeholders throughout the plan's development.

40+ Organisations engaged

90+ Hours of engagement

Sector	**Examples of stakeholders engaged**
Buildings	Housing developers
Transport	Transport providers
Renewable energy generation	Energy project developers Community energy groups, landowners
Industry and private sector	Local businesses, larger industrial players
Community engagement	Charities, social enterprise,
Networks	Distribution Network Operators, gas distribution networks
Public sector	Public services board, public service providers, Welsh Government, educational institutions

Figure 2.0.3: Summary of stakeholders engaged

ARUP

2. The current energy system

Flintshire's energy baseline

2. The current energy system

Overview

This section provides a detailed overview of the local energy system baseline, and describes the methodology and assumptions used to understand current energy infrastructure, what types of energy are used, what technologies are used to convert it from one form to another (e.g. heat) and how much is consumed.

Results presented reflect the energy baseline in Flintshire in 2023, apart from the transport (2019) and industry data (2019). Transport and industry datasets are the least likely to have changed in terms of electrification over the years 2019 to 2023, and transport is the most likely dataset to have changed due to COVID-19 with 2019 being the most representative year.

Some of the data collected that has locational characteristics is reported by "modelling zone". Figure 2.0.4 shows the geographic boundary of Flintshire (black line) which is also the boundary used for Flintshire's LAEP. The primary substation service areas that supply energy within the geographic boundary are shown with coloured blocks. Where primary substation service areas intersected one or more Local Authority boundaries, they were divided into smaller modelling zones. Most of the analysis, results, and maps in this report are presented in terms of these smaller modelling zones, which may also be called "substation zones" or simply "zones."

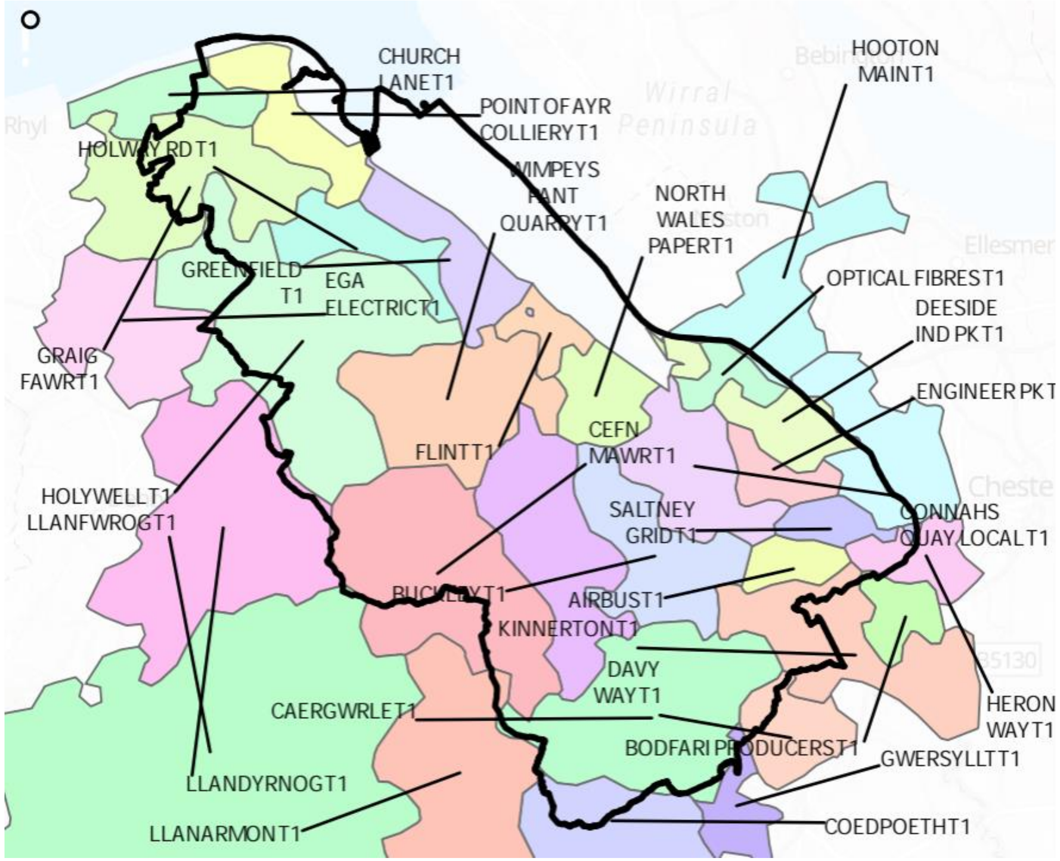


Figure 2.0.4: Geographic boundary of Flintshire used to define the boundary for this LAEP and the associated modelling zones within the LAEP boundary

2. The current energy system

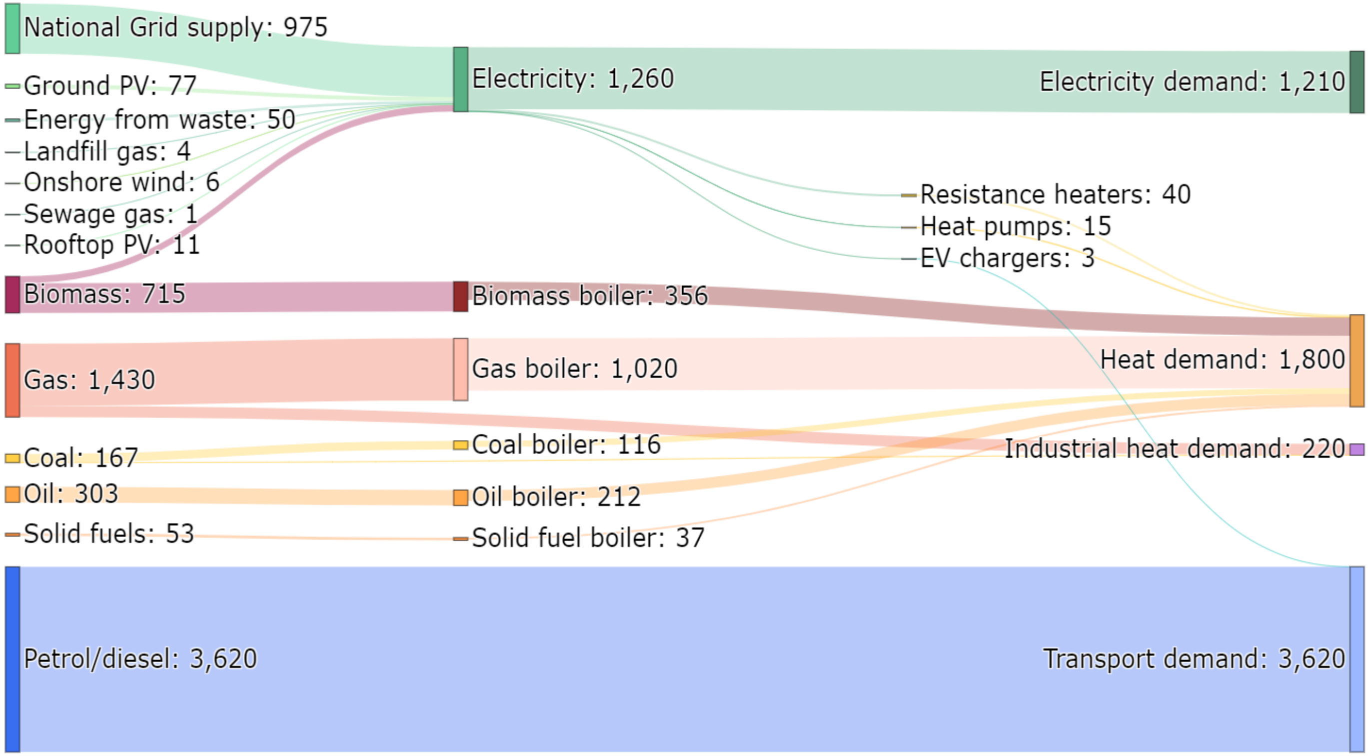
Overview

Sankey diagrams are a way of visualising energy transfer from energy sources to energy demands via energy vectors or conversion technologies.

They are read from left to right and show a snapshot of a scenario in time e.g., 2050

Energy transfers are drawn to scale and so are helpful to identify the size of each transfer and compare different scenarios.

The average Welsh home uses 3,300kWh/year of electricity, which is 0.003GWh for comparison with the scale on the Sankey. In terms of gas, a typical home uses 12,000kWh/year, which is 0.012GWh for comparison with scale on the Sankey[M40].



1. Where the energy comes from
This side represents the different **energy sources**, including generation technologies and imports from the national grid

2. How the energy is being converted

3. Where the energy is being used
This side represents the **final demands** for each energy vector: heat demand, electricity, demand, transport demand.

Figure 2.0.5: How to read a Sankey diagram (units are GWh/year)

2. Current energy system
Flintshire's energy baseline

Energy demand

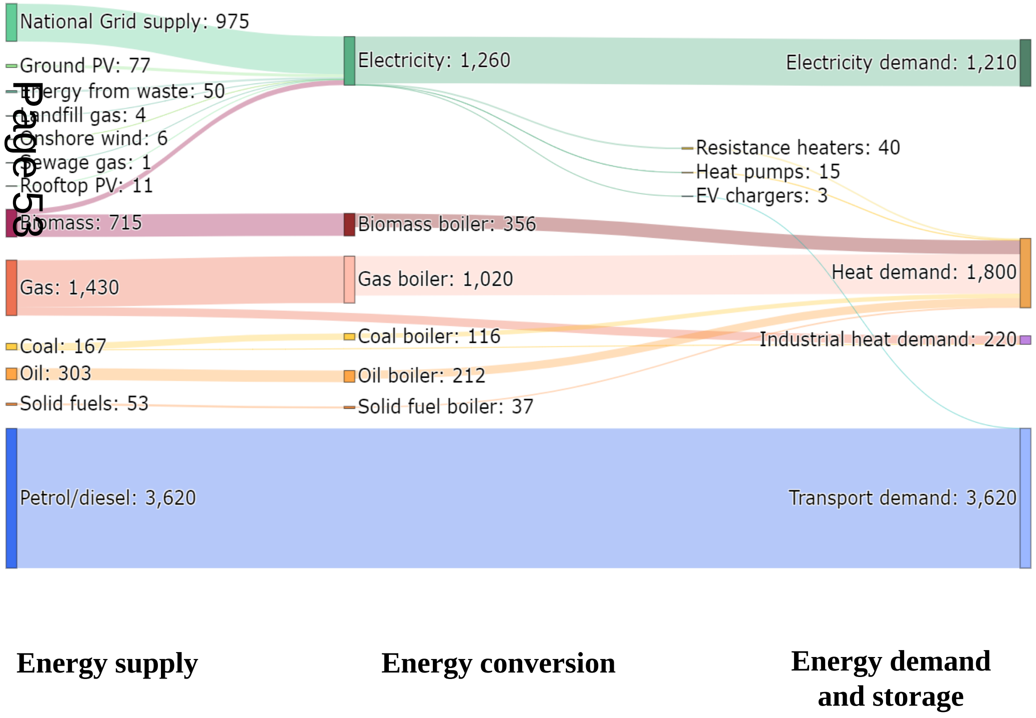


Figure 2.0.6: Sankey diagram showing energy input, conversion and output in Flintshire (GWh/year)

Industry

Around **61%** of total energy consumption in Flintshire is from the industrial and commercial sectors

The industry landscape is varied and expansive but key industries include paper manufacturing, food and drink, and vehicle manufacturing. Many of the largest consumers sit outside of the scope of this plan.

Electricity

18% of total energy demand is electricity

23% generated from renewable sources

The largest renewable source of electricity is ground-mounted **solar PV**, with Shotwick solar park the largest in the country at **72MW**

At the local level **no** electricity is generated through **fossil fuel** means

Transport

53% of total energy demand is from transport

The main source of transport emissions are HGVs, although car travel has the highest mileage

83% of households own a car[M65]

67% of fuel consumed is diesel

0.23% of vehicles are electric or plug in hybrid

Heat

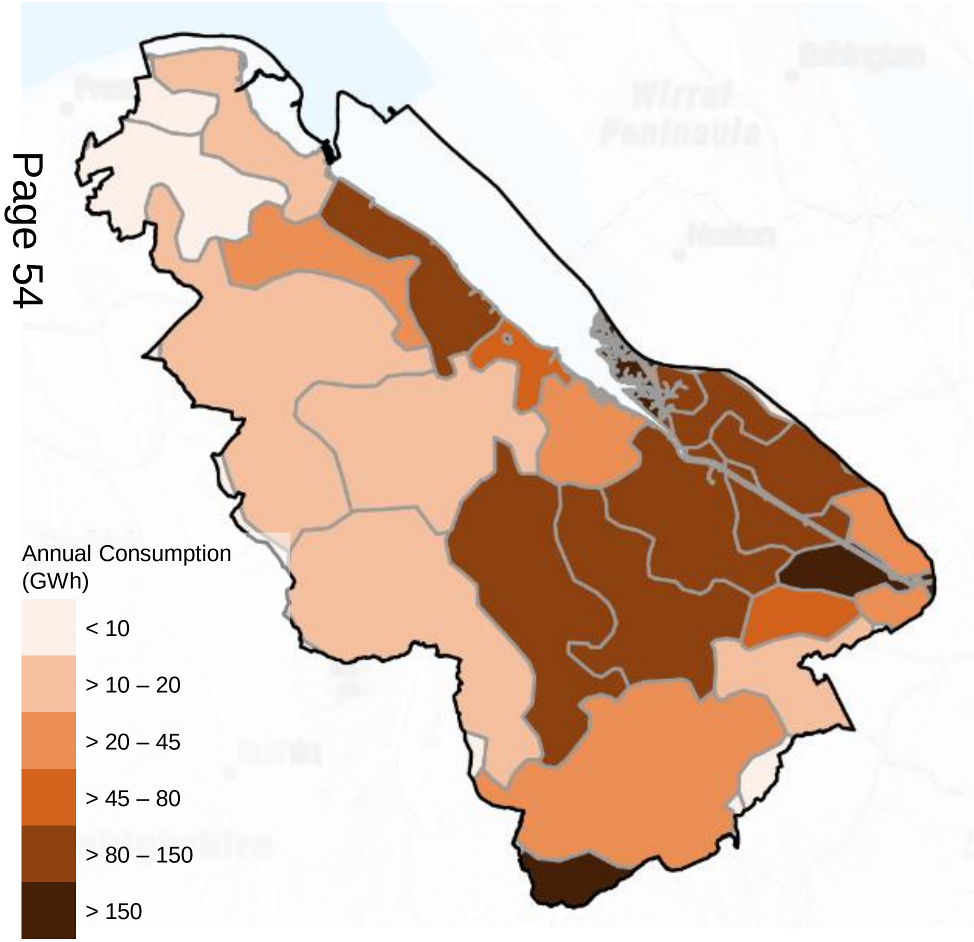
26% of total energy demand is from commercial and domestic heating

A significant proportion of biomass is used at the Shotton paper mill

The majority of heat demand is met through gas boilers, **82%** of properties have a gas grid connection, equivalent to the national average

42% of properties achieve an A-C EPC rating

Electricity demand in buildings (MWh per year)

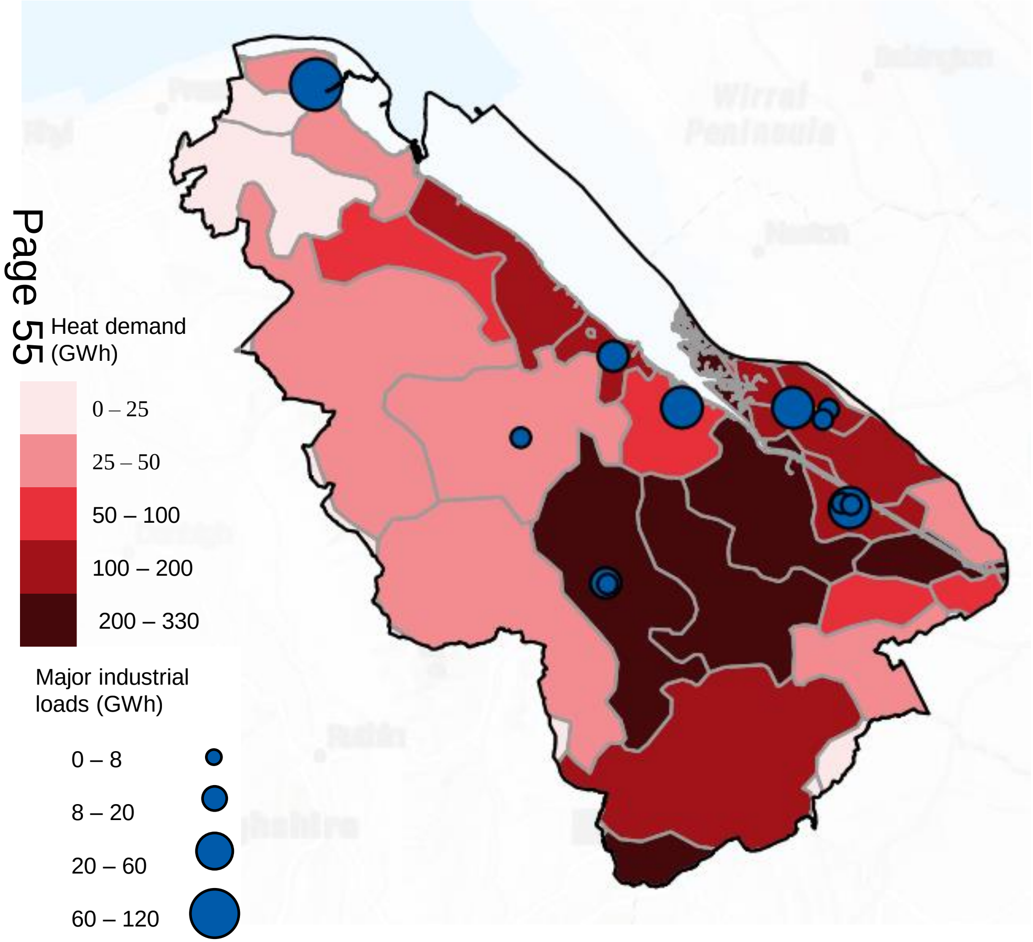


Electricity trends

Electricity consumption across Flintshire varies considerably from sub-station zone to sub-station zone, with some zones having over 100GWh/year difference in electricity consumption. The areas of higher consumption, understandably, correlate with areas of increased commercial, domestic and industrial density.

Figure 2.0.7: Electricity consumption (MWh/year) (domestic and non-domestic properties) by substation zone across Flintshire (2023). Data is based on meter level electricity consumption data

Heat demand in buildings and industry (MWh per year)



Building numbers

71,200 domestic buildings

4,000 non-domestic buildings

EPC ratings

On average, properties across Flintshire exhibit below average EPC ratings (35% of properties achieving A-C EPC rating compared with Wales-wide of 40%).

Insulation

26% with <100mm loft insulation, 12% with unfilled cavity walls.

Heating fuels

82% of homes are connected to the gas grid. Most homes that are not connected to the gas network use oil for heating (11% of all homes).

Gas consumption

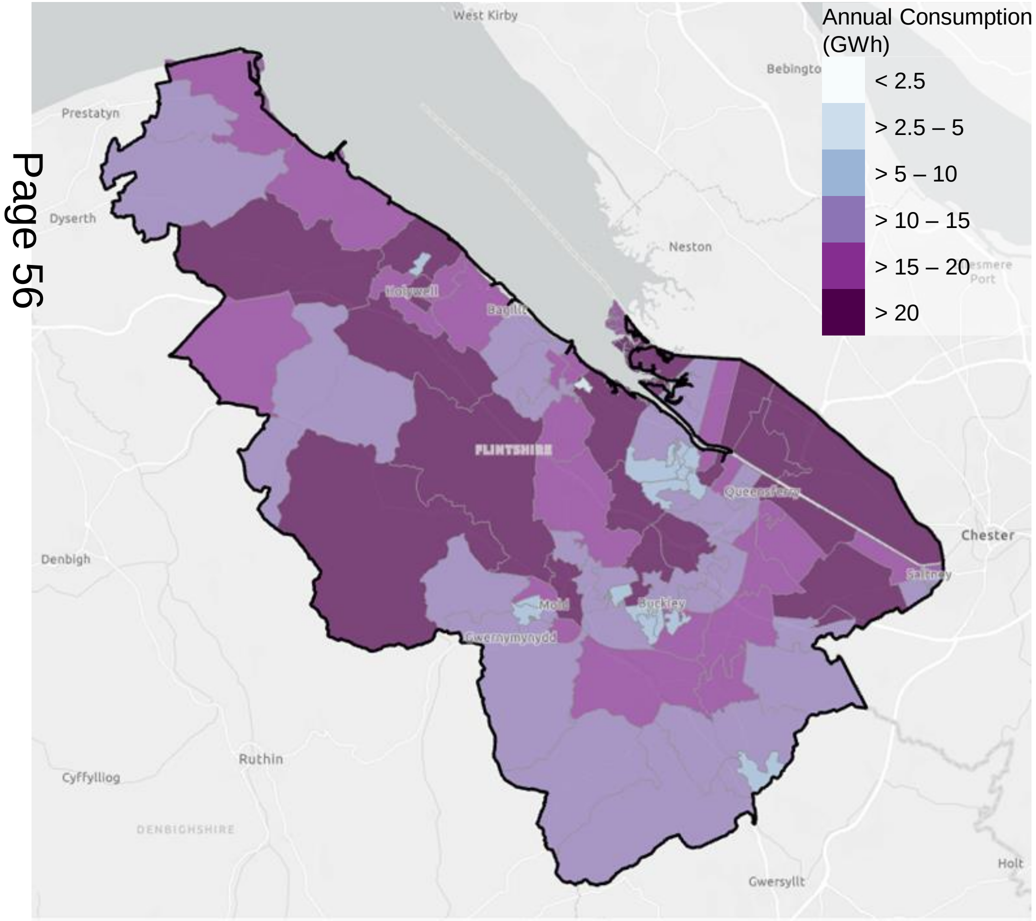
Areas of high and low gas consumption vary significantly across the local authority. The areas of greatest consumption align with more heavily populated areas in the centre of the county, where off-gas grids are less common and gas boilers are the predominant heating type.

Industry

There are numerous major point demands for gas and other fossil fuels, these are situated in the main industrial areas along the coastal parts of the county in Deeside, Connah's Quay, Flint, Greenfield and Tolacre.

Figure 2.0.8: Major industrial loads (2019) and heat demand (2023) by substation zone across Flintshire. The data is based on meter level gas consumption (MWh/year)

Transport energy demand



Transport trends

Transport related energy consumption varies across the local authority. Areas of higher energy consumption tend to align with the main thoroughfares of the A55 and A494 which intersect between Buckley and Deeside, as well as the more rural parts of the county, where car usage is more prevalent. Areas of lowest energy consumption tend to be in and around towns (Mold, Buckley, Deeside, Holywell, and Connah's Quay) where public transport and active travel can be a more viable option.

Number of EV chargers

Currently 53 listed on the National Chargepoint Registry (2023 data). [M43]

Car ownership

83% of households in the area own cars, with an average of 1.3 cars per household, which is above the national average. [M65]

Figure 2.0.9: Transport energy consumption (combined total across cars, light goods vehicles (LGV) and heavy goods vehicles (HGV) by LSOA, in 2019 as a baseline year

2. Current energy system
Flintshire’s energy baseline

Energy generation in 2023

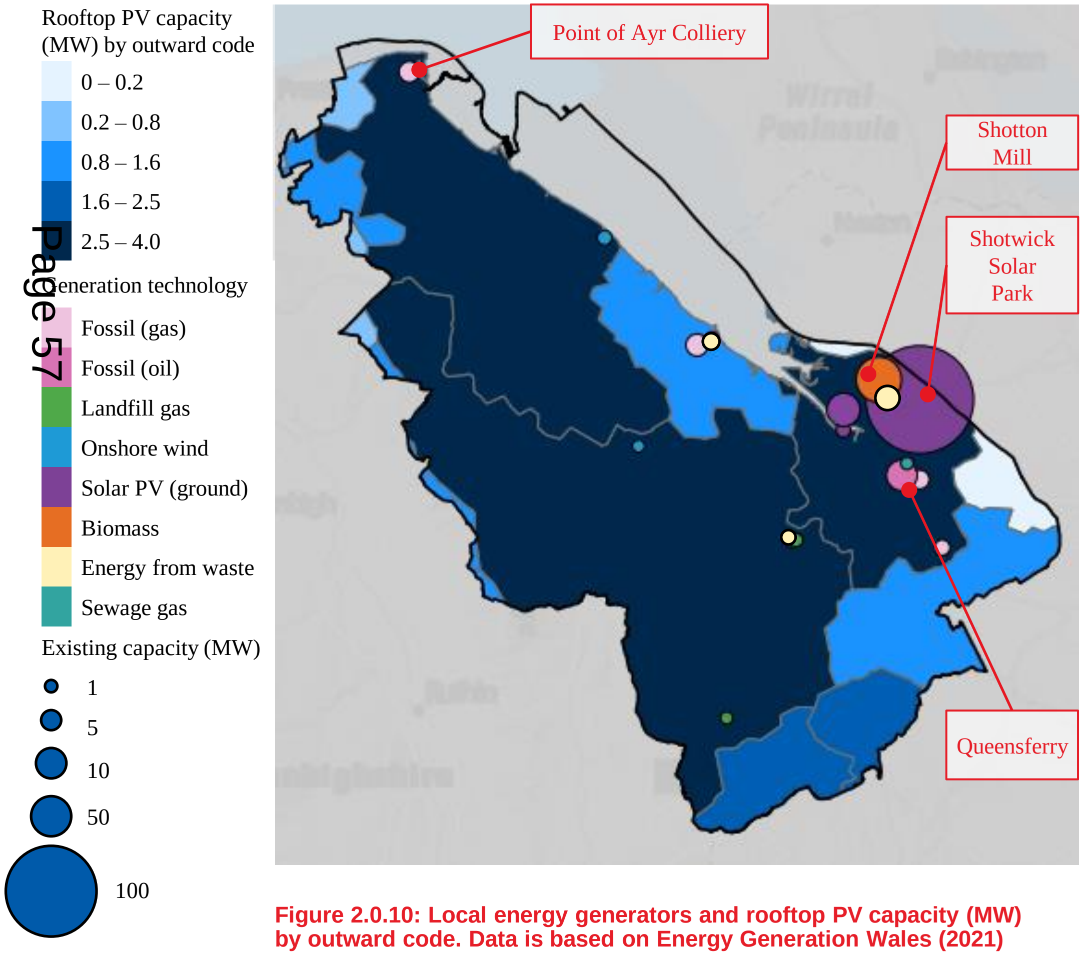


Figure 2.0.10: Local energy generators and rooftop PV capacity (MW) by outward code. Data is based on Energy Generation Wales (2021) and Renewable Energy Generation Database (2023)m (units in MW)

Electricity generation

There is **136MW** of renewable electricity generation capacity, across seven different generating technologies

Ground-mounted solar photovoltaics are the largest source of local electricity generation with a capacity of **80MW**, this includes Shotwick park the **country’s largest solar farm**

7% of electricity generation comes from rooftop solar PV across both domestic and non-domestic properties

20% of the electricity generation capacity is from fossil fuel sources (gas and oil), although these may not supply electricity in any given year

Heat generation

The majority of heat is generated through natural gas boilers (62% of heat across all sectors)

Flintshire’s large industrial presence provides ample waste heat that could be used for low heat processes or heating.

19% of heat supply comes from low carbon sources (electric or biomass)

2. Current energy system
Flintshire's energy baseline

Networks and infrastructure

Figures 2.10 and 2.11 display primary substation's supply and demand headroom across Flintshire, providing an insight to the network capacity in 2019. In this context, headroom is an indicative measure of primary substation's capacity. This metric offers an overview of the electricity network's capacity, highlighting areas where constraints may be present.

Generation headroom is relatively low across the local authority, with very little spare capacity in the largest towns and surrounding areas. There is greater demand headroom in heavily industrialised areas where the grid may be reinforced, and in areas of low population density where demand is low.

Although headroom offers valuable insights into the available 11kV network capacity, it is important to recognise that constraints can occur both upstream and downstream of primary substations. Fig 2.10 and 2.11 may not show the extent of networks constraints in Flintshire.

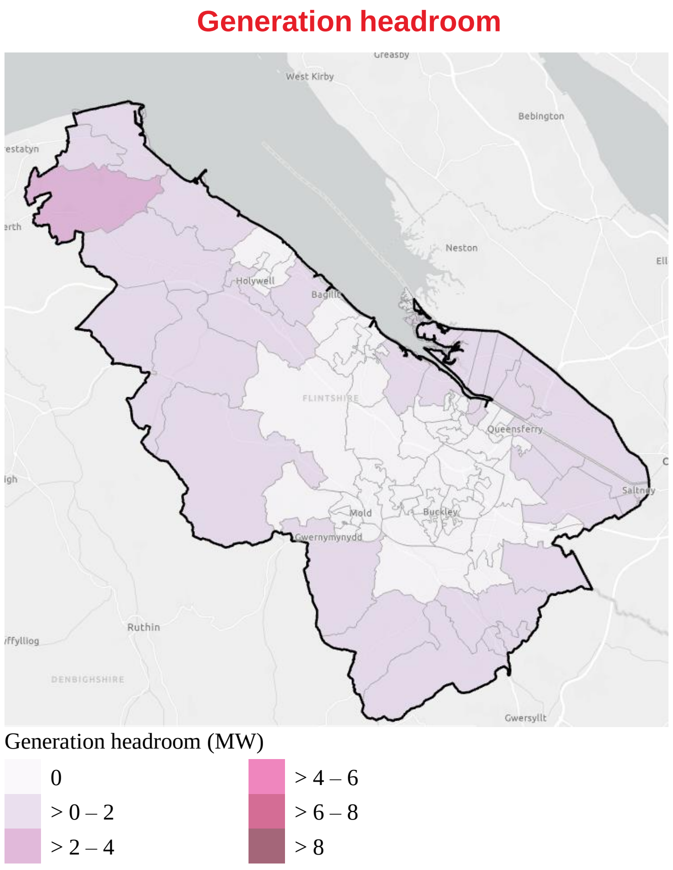


Figure 2.0.11: Electricity generation headroom

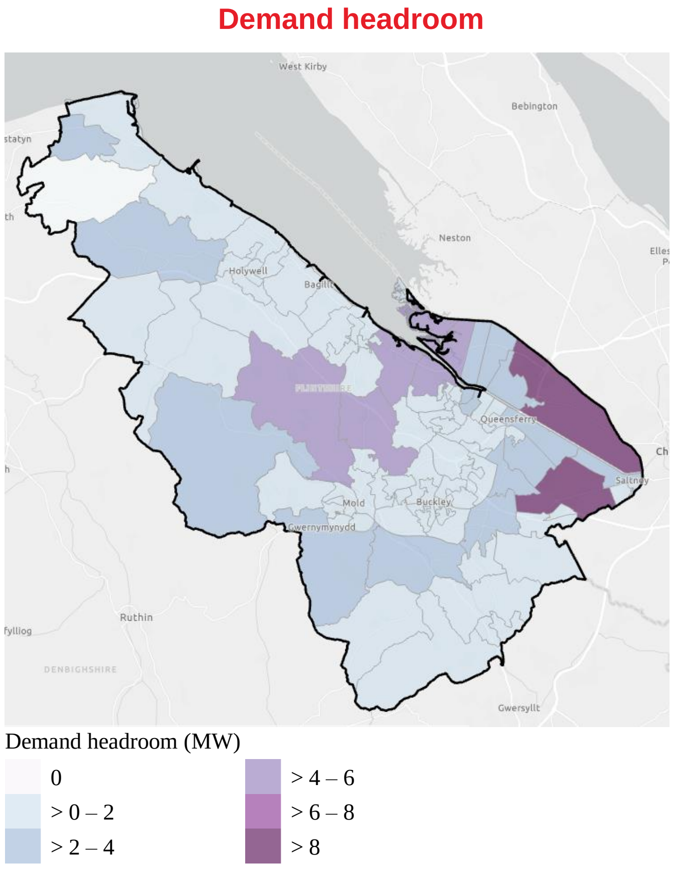


Figure 2.0.12: Electricity demand headroom

2. Current energy system
Flintshire’s energy baseline

Off gas grid properties

The highest proportion of properties off the gas grid are found in the more rural areas of the local authority, towards the west. In more densely populated areas of the local authority (i.e. where many of the larger towns are located) there is a much higher proportion of properties connected to the gas grid (80%+).

Where properties are not connected to the gas grid, heating oil is used as the primary means of heating and hot water generation. This is the case across the entirety of the local authority.

Off gas grid properties

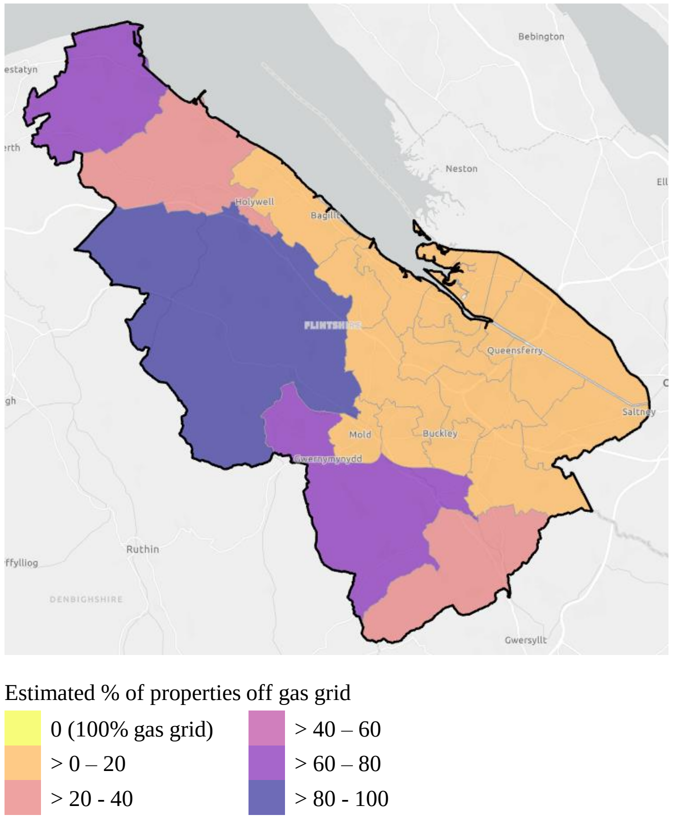


Figure 2.0.13: Percentage of properties that are not connected to the gas distribution network (2023)

Alternative heating

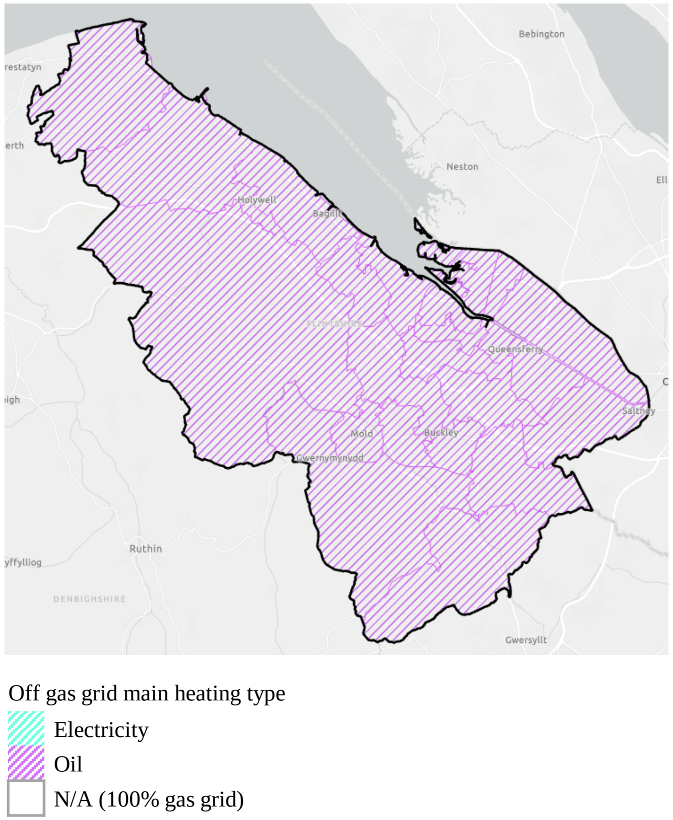


Figure 2.0.14: Main heating type for properties that are not connected to the gas distribution network, using 2019 as a baseline year

2. Current energy system

Flintshire’s energy baseline

Local environmental, social and economic factors that influence energy (2019 figures)

Area

Area: Flintshire has a total land area of 438km^2.

Enterprise: Flintshire is home to the Deeside enterprise zone, a 2,000 hectare area with the highest concentration of manufacturing jobs in the UK.

Population density: Around 80% of Flintshire’s population inhabits 20% of the county’s land.

Designated land: The County hosts over 23 Sites of Special Scientific Interest (SSSIs) and over 300 locally designated wildlife sites.

Socio-economic

Fuel poverty: 9% of households are regarded as being in fuel poverty, this compares to 12% for the Welsh national average.

Commuting: In general Flintshire sees more people commute out (38,100) of the county for work than commuting in (14,400). 73% of workers (133,000) in Flintshire also live in the county.

Employment: The largest sectors by level of employment in Flintshire are: ‘Production’, ‘Wholesale, retail, transport, hotels and food’ and ‘Public administration, defence, education and health’.

Industry & commerce: Industries that contribute substantially to the value of goods and services produced within Flintshire and Wrexham include transport manufacturing, health and social work, wholesale and retail trade, food and drink manufacturing.

Demographics

Population: Flintshire has a population of 155,000 and a density of 350 pers/km^2, the eleventh most densely populated local authority (out of twenty-two) in Wales.

Population change: The population has increased by 1.6% between 2011 and 2021 in Flintshire, compared to 1.4% nationally over the same period.

Age: Flintshire has a median age of 44, the proportion of the population over 19 years of age has increased from 76.2% to 78.2% between 2011 and 2021.

GHG Emissions

Emissions: Flintshire’s baseline year emissions for the region accounted for 7% of the national total and has an average emissions per capita of 10.6 tCO$_2$e/pers. This is greater than the national average of 7 tCO$_2$e/pers.

Sectoral emissions: The overwhelming majority of emissions arise from industry (56%), with the transport (23%) and domestic (15%) sectors contributing the next greatest proportion of emissions.

Emissions change: Emissions have decreased on average by just under 2% each year since 2005, this has been driven by decreases in almost all sectors but transport.

2. Current energy system

Flintshire's energy baseline

GHG Emissions

Figures 2.14 and 2.15 display the proportion of GHG emissions by different sectors for both Flintshire as a region (using the boundary considered within this LAEP) and for Flintshire County Council.

The Council's emissions have been taken from their 2018/19 baseline report and equal 46ktCO$_2$e for that year. Despite the Council's emissions only accounting for a small percentage (~4%) of the region's emissions, they still have a strong influence over emissions outside of their direct control and supply chain. The Council, amongst other local, regional, and national players, has the ability to influence emissions within the domestic, commercial, industrial and transport sectors of Flintshire as a region.

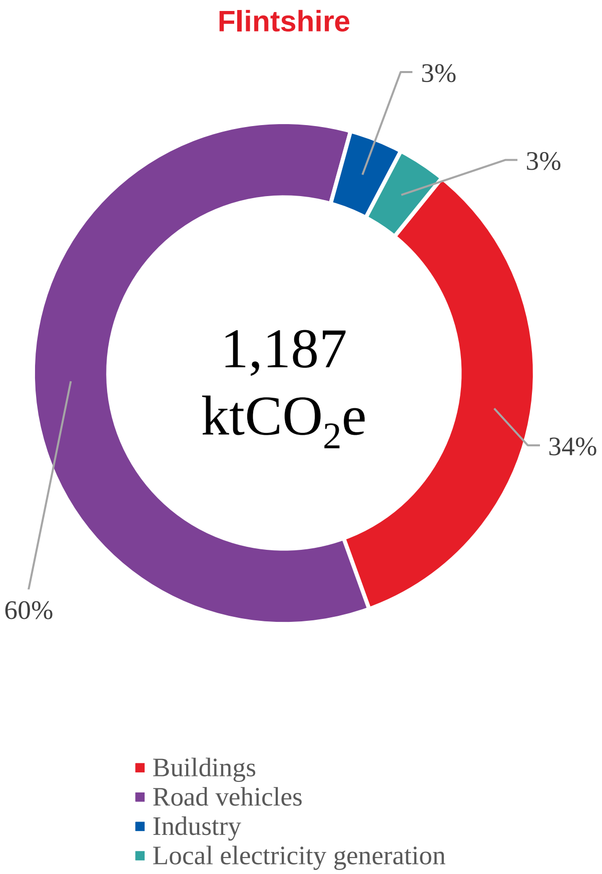


Figure 2.0.15: Doughnut of Flintshire's GHG emissions by sector for baseline years (2019 & 2023)

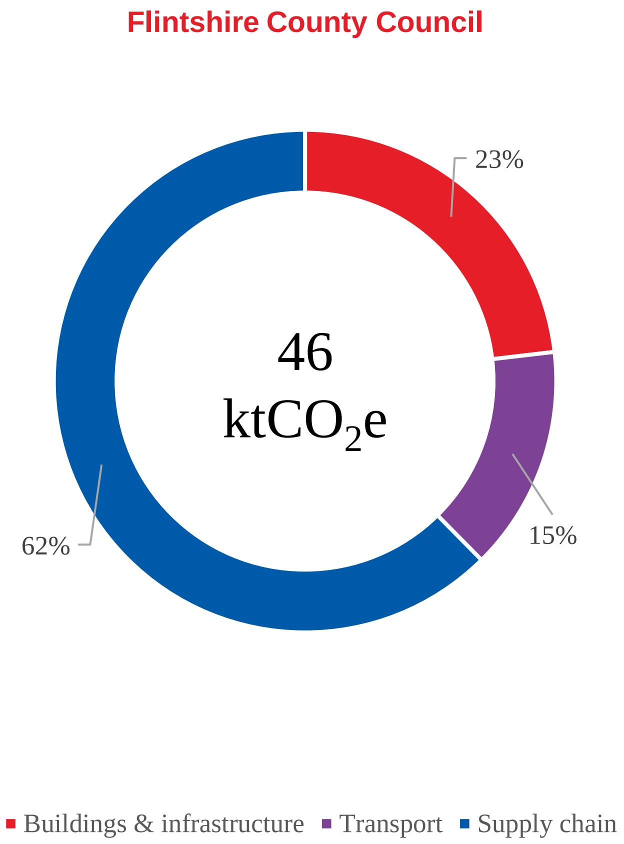


Figure 2.0.16: Doughnut of Flintshire County Council's GHG emissions for baseline financial year 2018/19

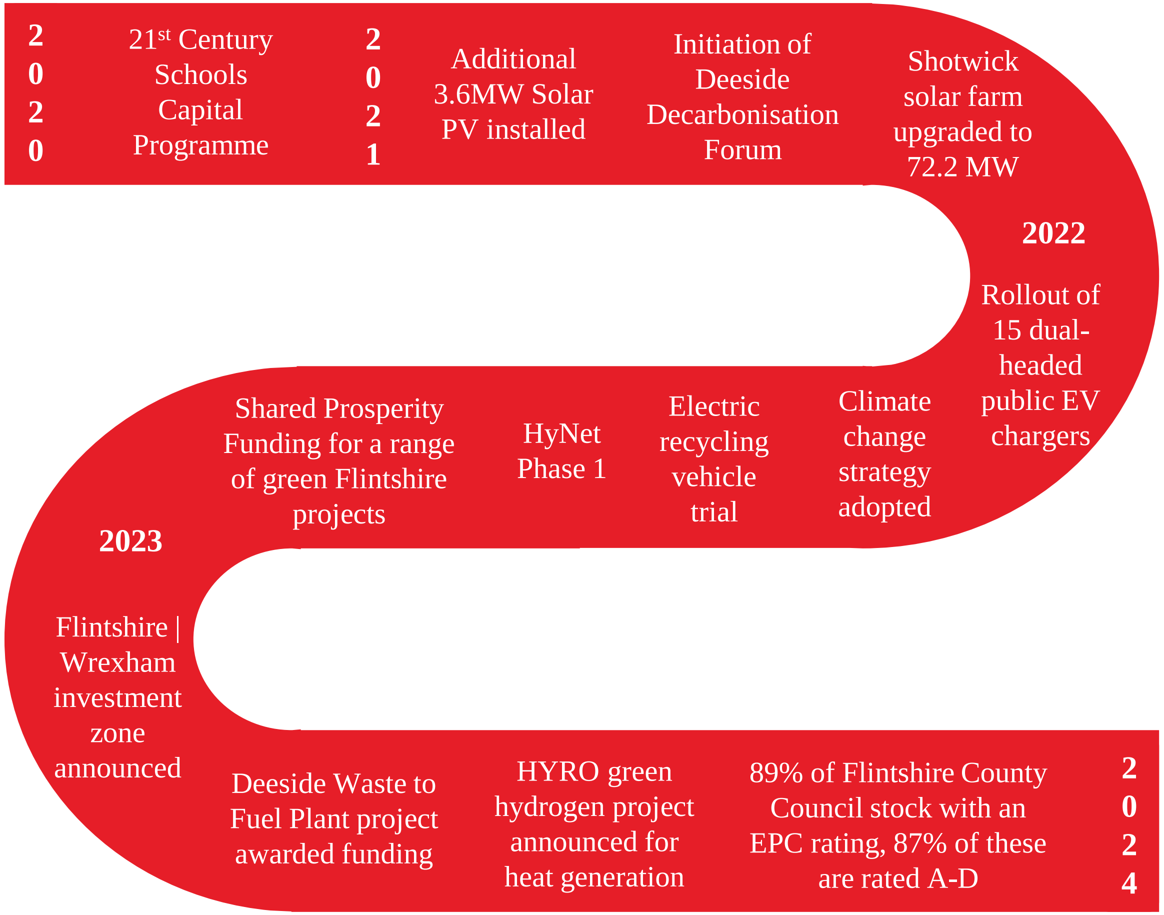
2. The current energy system

Progress to date

Since supporting Welsh Government’s climate declarations in 2019 and agreeing to develop a climate change strategy, Flintshire has worked to reduce its organisational carbon emissions, and to provide the means for the wider community to do the same, as we transition to a net zero energy system.

Flintshire County Council has made a lot of progress against the four themes of the climate change strategy with a handful of success stories to date listed below:

- Building and renovating fit for future schools through the 21st Century Schools Programme, with new school buildings funded through this programme required to be Net Zero Carbon.
- Replacement of the Council’s streetlighting with LED lamps which use significantly less electricity.
- Commitment made by the council for a net zero 2030 ambition, with a strategy and action plan created to deliver against the target.
- Developed and delivered active travel routes across the County.
- Through collaboration with regional partners and Welsh Government, the Council has managed the construction of an energy from waste facility, Parc Adfer, which will create electricity for 30,000 homes from waste that cannot be recycled. It will also help to prevent waste from going to landfill
- The construction of an additional two solar farms, with a combined generation capacity of 3.6MW, amounting in 4.8MW of total generation across four farms.



2020

21st Century Schools Capital Programme

2021

Additional 3.6MW Solar PV installed

Initiation of Deeside Decarbonisation Forum

Shotwick solar farm upgraded to 72.2 MW

2022

Rollout of 15 dual-headed public EV chargers

Climate change strategy adopted

Electric recycling vehicle trial

HyNet Phase 1

Shared Prosperity Funding for a range of green Flintshire projects

2023

Flintshire | Wrexham investment zone announced

Deeside Waste to Fuel Plant project awarded funding

HYRO green hydrogen project announced for heat generation

89% of Flintshire County Council stock with an EPC rating, 87% of these are rated A-D

2024

Figure 2.0.17: Summary of activities to date that have contributed to decarbonising the local energy system

Plans for the future

Renewable generation

Within the energy baseline, 23% of electricity generated within Flintshire is from renewable sources.

Building on the rollout of solar PV that has already taken place, there are further planning applications for even larger sources of generation, with a 30MW solar PV farm (Bretton Hall – YnNi Newydd) in the pipeline that would be community owned and partially sited in Flintshire.

The Coal Authority released a report in 2024 highlighting the opportunities for mine water heat within Flintshire. This has shown several potential sites that could provide low or zero carbon heat generation. The next step to fully understand the generation potential of these and potential off takers is now required. The timing of this report means it hasn’t been included within the future energy system analysis.

Reducing energy demand

There are plans to reduce energy demand across the local authority through retrofit measures available through 21st Century schools and ECO4 programmes.

There are larger scale projects too, such as the combined heat and power (CHP) facility at Shotton paper mill. The CHP facility can reach efficiency ratings in excess of 90%, in comparison of gas power stations, which in the UK range between 49% and 52%. In the future there are possibilities to use Hydrogen gas as a fuel source.

Reducing carbon

Beyond energy generation and demand reduction there are plans to remove or use lower carbon technologies within the energy system. One such example is the planned Carbon Capture and Storage at Padeswood cement site which intends to capture 800,000 tonnes of CO_2 a year, the equivalent of taking 320,000 cars off the road. The scheme will be an integral part of the HyNet industrial cluster, which could save up to 10 million tonnes of CO_2 per year. HyNet is a vast infrastructure project to produce, transport and store low carbon hydrogen across the North West of England and North Wales. Flintshire is likely to have a role to play providing hydrogen off takers in Deeside and helping to support the network of H_2 and CO_2 pipelines.

Another example is the HYRO project which plans to develop hydrogen electrolysers to provide green hydrogen for boilers and plant within the Kimberly-Clark paper manufacturing complex.

Chapter 3: The future energy system

3. The future energy system

Overview

Vision and objectives

Vision

Flintshire County Council envisions a sustainable future with a net-zero energy system that is affordable and promotes community health, well-being, and economic growth. We commit to a clean energy transition that fosters a resilient, inclusive, and prosperous community, ensuring a harmonious balance between environmental stewardship and social progress.

Objectives of the plan

We have worked with stakeholders to define the following objectives for our plan:

1. Support a low-cost and affordable energy system through reducing energy demand and promoting energy efficiency.
2. Optimise the use of local renewable energy sources within Flintshire, encouraging local ownership and community participation.
3. Promote safe, healthy, and sustainable places to live, work and visit – helping to generate connected and resilient communities.
4. Create a resilient energy system capable of meeting future energy demands that reduces carbon emissions and protects and enhances Flintshire's natural assets.
5. Promote a low carbon economy, providing learning and skills for all to create a prosperous, thriving, resilient Flintshire.

Understanding the future energy system

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

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

Scenario analysis

To inform our plan, we used scenario analysis to explore what a net zero future energy system could look like under different future outcomes, including considering the potential for reduction measures and potential energy sources. We modelled four future energy scenarios and modelled the most cost- and carbon-effective way to meet demand in each one. Through doing this, we were able to identify technologies that played a significant role in all the future scenarios modelled. These technologies represent low- and no-regrets options (meaning that they are likely to be most cost-effective and provide relatively large benefits) which are very likely to be important parts of the future energy system, regardless of the uncertainty of the future.

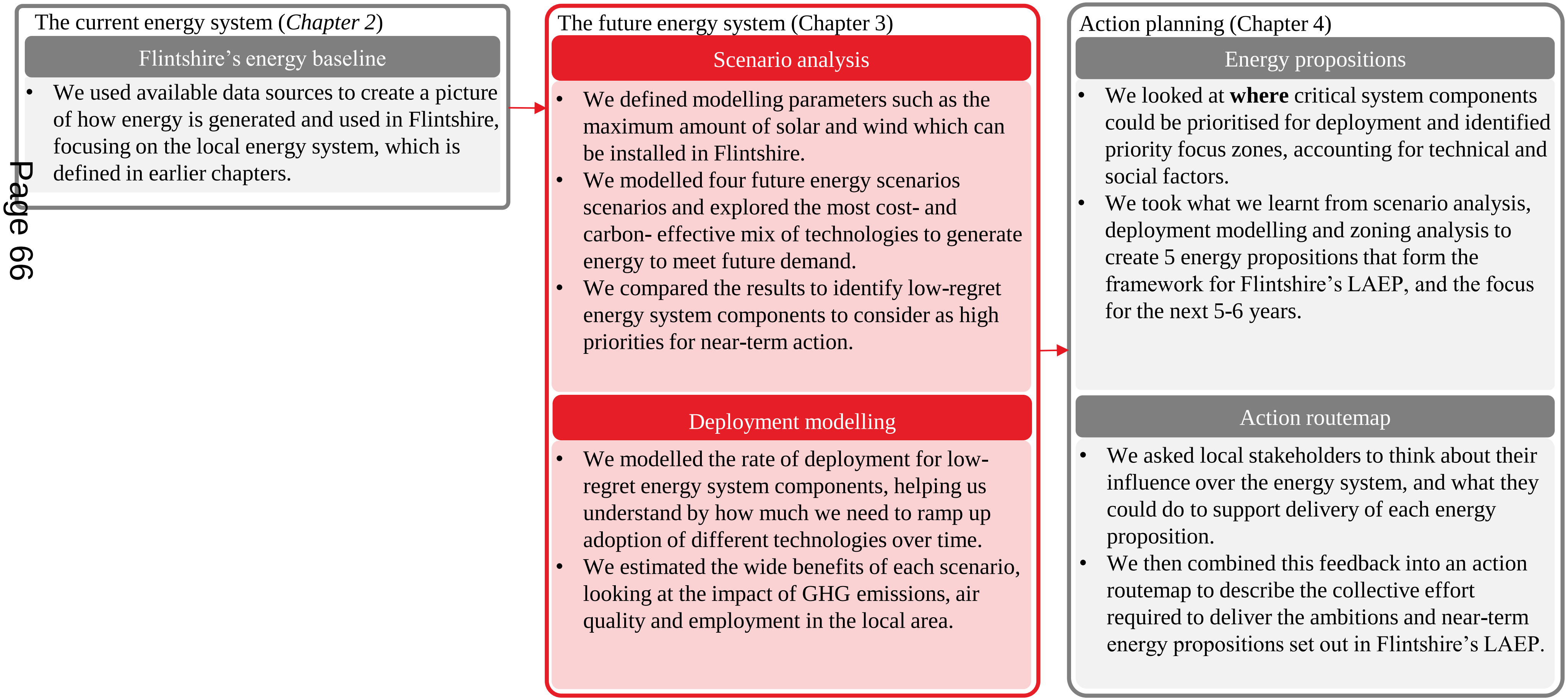
Deployment modelling

We looked at how aspects of each energy proposition might be deployed between now and 2050, creating deployment pathways. Deployment pathways indicate:

- the scale of change required over time,
- the sequencing of activity that needs to happen to achieve a net zero energy system.

Deployment pathways for different components were informed by broader plan objectives, local and regional strategic priorities, policies and national targets and using this context, helped us to define a suitable level of ambition, and bring all this evidence together into an action plan.

3. The future energy system
Overview



The current energy system (*Chapter 2*)

Flintshire's energy baseline

- We used available data sources to create a picture of how energy is generated and used in Flintshire, focusing on the local energy system, which is defined in earlier chapters.

The future energy system (Chapter 3)

Scenario analysis

- We defined modelling parameters such as the maximum amount of solar and wind which can be installed in Flintshire.
- We modelled four future energy scenarios scenarios and explored the most cost- and carbon- effective mix of technologies to generate energy to meet future demand.
- We compared the results to identify low-regret energy system components to consider as high priorities for near-term action.

Deployment modelling

- We modelled the rate of deployment for low-regret energy system components, helping us understand by how much we need to ramp up adoption of different technologies over time.
- We estimated the wide benefits of each scenario, looking at the impact of GHG emissions, air quality and employment in the local area.

Action planning (Chapter 4)

Energy propositions

- We looked at **where** critical system components could be prioritised for deployment and identified priority focus zones, accounting for technical and social factors.
- We took what we learnt from scenario analysis, deployment modelling and zoning analysis to create 5 energy propositions that form the framework for Flintshire's LAEP, and the focus for the next 5-6 years.

Action routemap

- We asked local stakeholders to think about their influence over the energy system, and what they could do to support delivery of each energy proposition.
- We then combined this feedback into an action routemap to describe the collective effort required to deliver the ambitions and near-term energy propositions set out in Flintshire's LAEP.

Figure 3.0.1: Summary of steps taken to produce the LAEP

3. The future energy system

Future energy scenarios and pathways

Summary of future energy scenarios

Do Nothing	• A scenario for comparison which considers committed activities and assumes that current and consulted upon policy goes forward and remains consistent. • This scenario provides a cost counterfactual. • There is no decarbonisation target for this scenario, and we do no use it in optimisation modelling.
National Net Zero	• Uses the lowest cost and carbon combination of technologies to meet Wales' 2050 net zero target. • Assumes a moderate level of energy demand reduction across the system. • Model is allowed to import and export to the electricity grid, this assumes that the electricity grid is decarbonised and reinforced to allow for the demands, likely to be a combination of offshore wind, hydrogen CCGT, grid level battery storage, nuclear (these are considered national assets and outside the scope of the LAEP)
Low Demand	• Considers the lowest future energy demand across different sectors. • Explores the impact of energy-reducing initiatives (home fabric improvements) and uptake of active travel and public transport use. • Model finds the lowest cost and carbon combination of technologies to meet predicted future energy demand. • Import and export of electricity as National Net Zero
High Demand	• Considers the highest future energy demand across sectors. • Model finds the lowest cost and carbon combination of technologies to meet predicted future energy demand. • Import and export of electricity as National Net Zero
High Hydrogen	• Considers the highest plausible future energy demand across different sectors. • Uses a cost- and carbon-optimal range of technologies to meet predicted future energy demand. • Considers hydrogen for heavy goods vehicles and industry. • The optimisation model was not forced to use hydrogen for undertaking any heating. Hydrogen was separately explored through hydrogen network modelling.

Figure 3.0.2: Summary of future energy scenarios

3. The future energy system

Scenario analysis

National Net Zero scenario

Figure 3.3 shows a potential future energy system for Flintshire. This system results from modelling to create the most cost and carbon optimal system. We have run a number of scenarios to support us in making decisions. The optimisation modelling informs the deployment modelling and the actions that go into the plans, but is not the "final plan" for the local authority area.

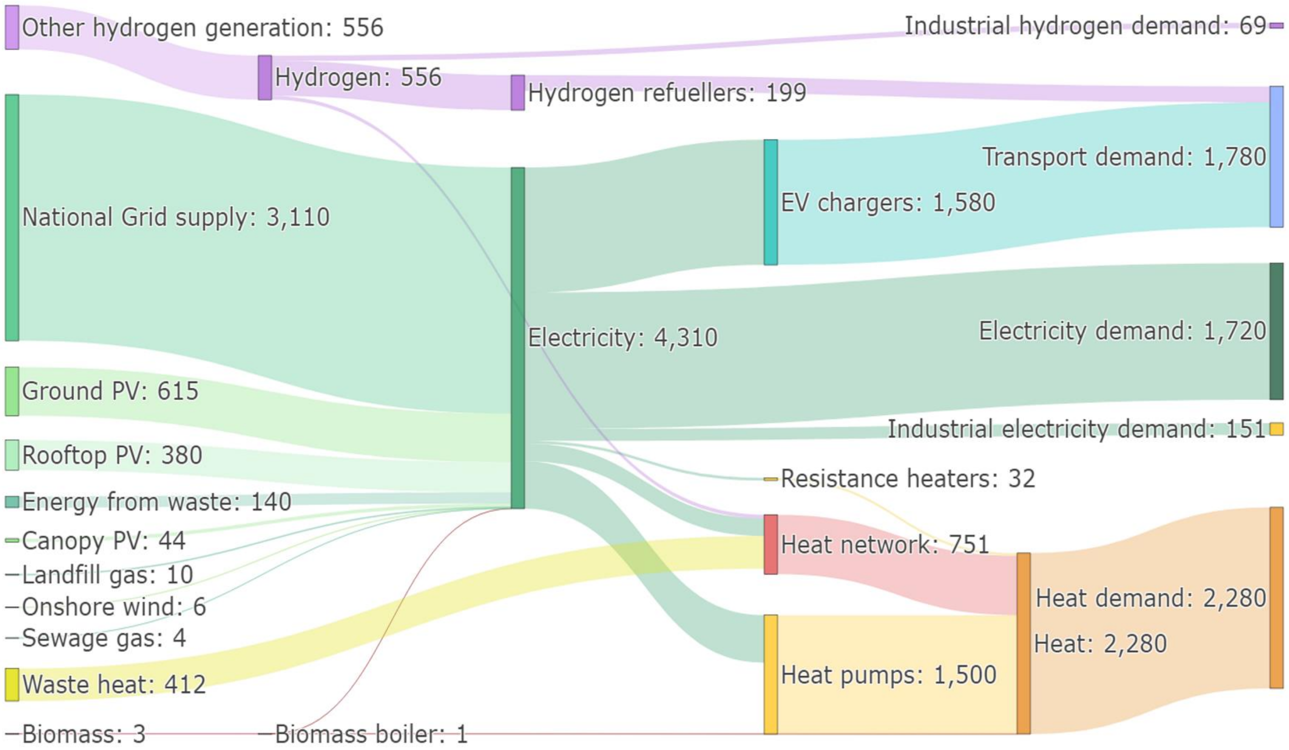
Hydrogen supply required for heavy transport and heavy transport

Electricity supply could be almost four times as great

Local renewables could provide 28% of electricity supply, compared to 23% in the baseline

Waste heat sources could supply a lot of heat in a future energy system via heat networks

Biomass supply reduces substantially as industrial processes switch to hydrogen or electricity for heat processes



Majority of transport demand could be met through electric vehicles (89%) and some hydrogen refuellers (11%) for heavier vehicles

Electricity demand could increase by over 40% by 2050

Heat demand could grow by almost 30% and be met by a predominant mix of heat pumps (66%) and waste heat (33%). This will all be met by 70% of the energy supply required for heat in 2019

Figure 3.0.3: A Sankey diagram for a potential future 2050 energy system (energy flows in GWh/year)

3. The future energy system
Scenario analysis

Energy system components

Figure 3.4 provides an overview of the variations in energy components observed in the optimisation modelling results across future energy scenarios, benchmarked against the baseline results.

Optimisation modelling shows ground-mounted and rooftop solar consistently increasing across all scenarios; contributing to meeting both Flintshire's energy demand but also exporting in times of surplus to the National Grid, and serving broader energy needs. In contrast, biomass generation sees a decline across all scenarios, likely due to a reduced dependency resulting from the enhanced output of solar and wind farms. Hydrogen is incorporated into the energy mix in all scenarios, sustaining Flintshire's industrial and transport demands.

Transport demand decarbonises, primarily due to the supply of electricity through EV charge points. Hydrogen also contributes to this demand, albeit to a lesser extent.

Heat demand is predominantly catered for by heat pumps, a trend that is consistent across all scenarios. While heat networks and other technologies contribute to this demand, their usage is comparatively less.

Energy system components	Baseline (GWh)	National Net Zero (GWh)	High Demand (GWh)	Low Demand (GWh)	High Hydrogen (GWh)
Ground-mounted PV	77	615 ↑			
Rooftop PV	11	380 ↑			
Onshore wind	6	6 →			
Sewage gas	1	4 ↑			
Biomass	715	3 ↓		2 ↓	3 ↓
Hydrogen import	0	556 ↑	553 ↑	555 ↑	1,850 ↑
Import from Grid	975	3,110 ↑	3,130 ↑	1,940 ↑	2,350 ↑
EV chargers	3	1,580 ↑	1,600 ↑	1,580 ↑	972 ↑
Hydrogen Refuellers	0	199 ↑	198 ↑	199 ↑	712 ↑
Heat pumps	15	1,500 ↑		507 ↑	1,500 ↑
Heat networks	0	751 ↑		747 ↑	751 ↑
Resistance heaters	40	32 ↓		13 ↓	32 ↓
Biomass boilers	356	1 ↓			

Figure 3.0.4: Comparison across the scenarios

3. The future energy system
Scenario analysis

Energy system components

Energy system components	Baseline (GWh)	National Net Zero (GWh)	High Demand (GWh)	Low Demand (GWh)	High Hydrogen (GWh)
Petrol/diesel	3,620	0 ↓			
Oil	303	0 ↓			
Coal	167	0 ↓			
Natural gas	1,430	0 ↓			
Solid fuels	53	0 ↓			
Energy from waste	50	140 ↑			
Export to National Grid	0	0 →	0 →	2 ↑	0 →

Figure 3.0.4 (continued): Comparison across the scenarios

3. The future energy system

Deployment modelling

Impact on energy demand

Figure 3.0.5 shows how the energy demand could change for each optimised scenario between 2023 and 2050.

All scenarios show a potential for an increase in total energy demand between 2023 and 2030 and then a reduction by 2050 (against both 2023 and 2030). Energy demand increases initially as a result of growth in housing and commercial property, before efficiency measures, and electrification of heat and transport take over and result in a peak in demand in the mid-2030s. Ultimately energy demand is only slightly lower in three of four scenarios by 2050.

The greatest reduction in total energy demand is understandably seen in the Low Demand scenario, primarily driven by improving building energy efficiency to achieve heat demands that are associated with homes with EPC A ratings.

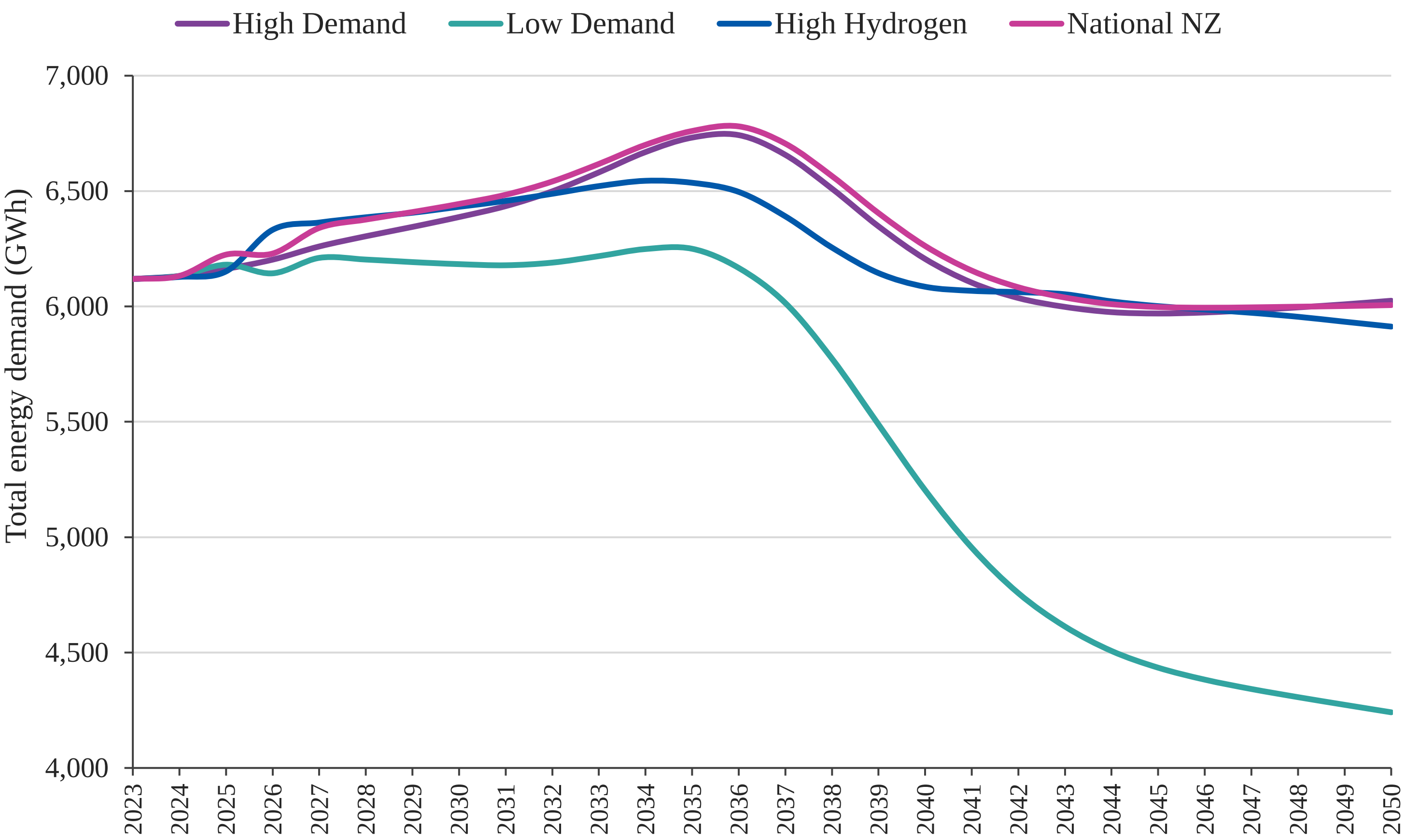


Figure 3.0.5: Change in total energy demand by scenario between 2023 and 2050 (GWh)

3. The future energy system

Deployment modelling

Impact on GHG emissions

Deployment modelling sets out the rate at which each energy component could be deployed in each optimisation scenario and the Do Nothing scenario. The Do Nothing scenario is based on current deployment rates and policy levers, whereas the other scenarios show trajectories that meet the optimisation models.

Figure 3.6 shows the gap in the carbon emissions between the Do Nothing scenario and the optimised scenarios. The optimised scenarios achieve a reduction in GHG emissions of at least 92% against 2023, while the Do Nothing achieves a 4% reduction.

Our deployment modelling provides additional evidence on the realism of delivering the changes suggested by the optimisation modelling. It helps us to determine the actions needed in the next five years to set us on the pathway to net zero in 2050. There are also bigger systemic changes that will be needed to achieve the scale of change set out in this plan.

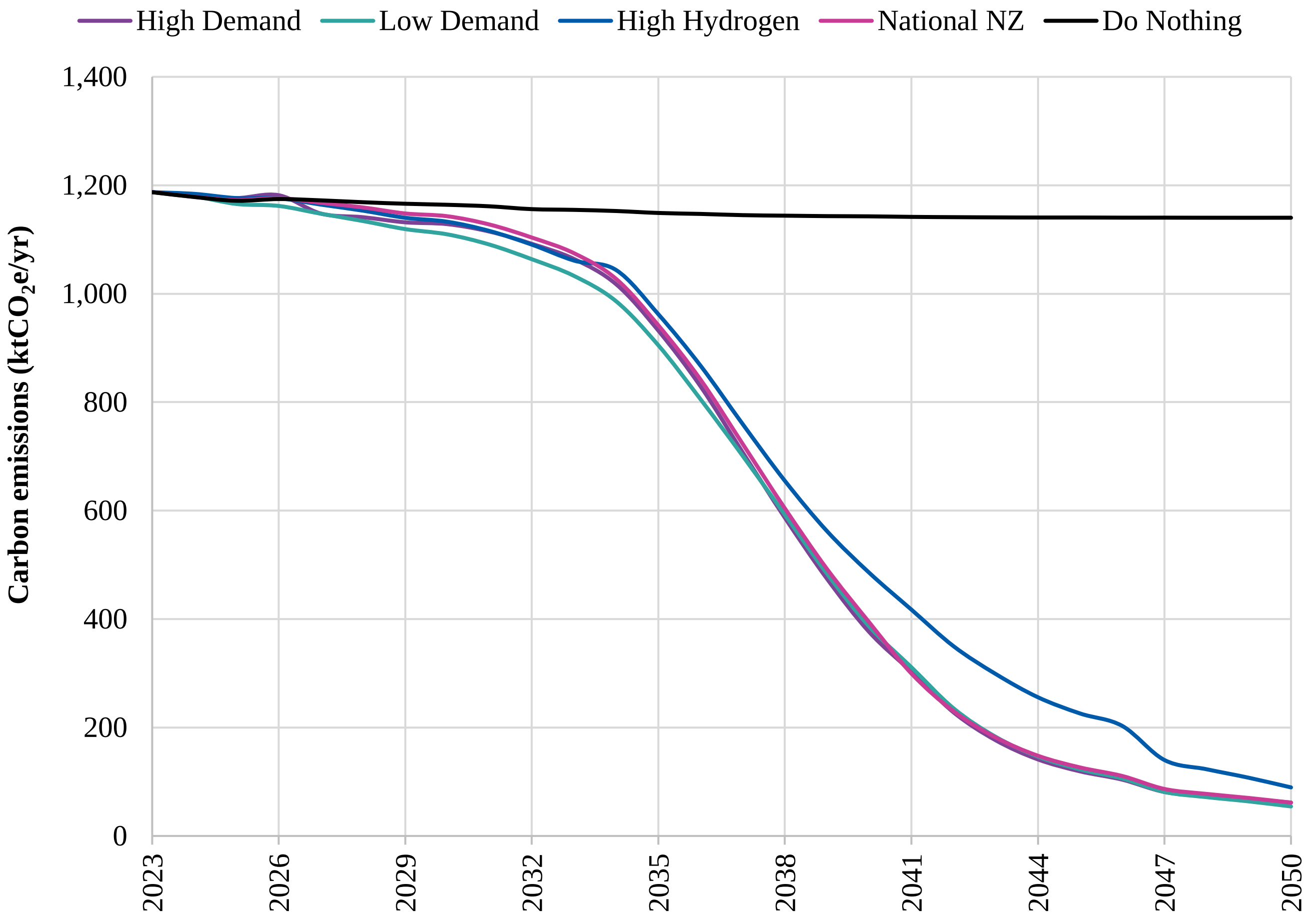


Figure 3.0.6: Carbon emissions (ktCO$_2$e/year) over time for each scenario

3. The future energy system

Deployment modelling

Impact on GHG emissions

The deployment modelling also shows how these pathways contribute to the Welsh Government emissions reduction targets. For Flintshire, Figure 3.7 shows that the 2023 baseline is a 30% reduction on the 1990 levels, all the pathways continue to underperform against the Welsh Government targets. All pathways also miss the net zero target in 2050, this is a result of residual emissions within the energy system. This is likely to always be expected to some extent as there will always like be hard to reduce emissions that arise from areas such as hydrogen production, or non-renewable electricity generation.

Scenario	2023	2030	2040	2050
High Demand	30%	34%	78%	96%
Low Demand	30%	35%	77%	97%
High Hydrogen	30%	34%	72%	95%
National Net Zero	30%	33%	77%	96%
Do Nothing	30%	32%	33%	33%
Welsh Government Targets	53%	63%	89%	100%

Table 3.0.1: GHG emissions from deployment against the Welsh Government emissions reduction targets

3. The future energy system
Deployment modelling

Socio-economic impacts

Reducing the amount of energy we use and using renewable energy sources for power generation can have wider environmental, social and economic benefits so it is important that they are fully understood to support decisions that impact the future of the energy system. For example, for every £1 invested in energy efficiency measures, the NHS can save £0.42 (amounting to annual savings of £1.4 billion in England alone)[M41].

Employment impacts

Investments in local energy systems can be expected to have employment benefits by providing local, skilled jobs. These will include direct jobs from construction and operational phases of the development as well as associated supply chain and multiplier effects[M42].

Impact on air quality

It can also impact the quality of the air which in turn impacts: human health, productivity, wellbeing and the environment, which is why it is so important to understand when planning future policy or programmes of work. Activity costs presented in Figure 3.8 show estimates for the impact of air pollution per unit of fuel consumed in each future energy scenario and estimates for the employment impacts associated with each future energy scenario, compared to the Do Nothing scenario

Metric	Do Nothing	National Net Zero	High Demand	Low Demand	High Hydrogen
Energy change (GWh, relative to 2023)	0	-113 (-2%)	-94 (-2%)	-1,878 (-31%)	-206 (-3%)
Change in GHG emissions (ktCO_2e, relative to 2023)	-47	-1,126	-1,125	-1,133	-1,097
Cumulative air quality activity costs between 2023-2050 (£m, *2022 prices*)	£0	£1,200	£1,177	£1,198	£1,170
Employment impacts between 2023-2050 relative to the Do Nothing scenario (net FTE)	0	7,178	7,194	7,325	8,760

Table 3.0.2: Summary of economic impacts for each scenario: employment impacts and air quality activity costs. Figures shown relate to the period 2023 – 2050. Air quality activity costs are presented using 2022 prices and are not discounted

3. The future energy system

Future energy scenarios and pathways

Summary of deployment

Our deployment model helps us to think about where we are now and where we need to get to, providing a starting point to frame the challenge and for more detailed analysis. We have included theoretical pathways which have a high degree of uncertainty as there are many variable factors and unknowns. The deployment modelling can't take into account every factor, some of the things that will impact deployment include:

1) Technological advance and innovation
2) Supply chains and how they develop
3) Large scale activity to decarbonise infrastructure at other levels: regional, UK and beyond.

*According to the National Charge Point Registry[M43] as of May 2023. Refers to individual charge points, and assuming 4kWp per charge point

**Assuming 4kWp per roof

***Renewable generation capacity is shown for technologies where current installed capacity is >5MW

Measure	2023	By 2030	By 2050
Number of homes retrofitted	13,00 homes with EPC A-C (35%)	Up to 25,000 homes retrofitted	Up to 61,100 homes retrofitted
Buildings with heat pumps installed (#)	700	Up to 14,600	Up to 95,300
EV charge points (#)*	220	Up to 8,430	Up to 63,840
Buildings with rooftop solar PV (#)**	2,900 (12 MW)	28,000 (112 MW)	99,700 (399 MW)
Ground-mounted solar PV capacity (MW)	80 MW	228 MW	645 MW
Other renewable capacity (MW)***	44 MW	73 MW	110 MW

Figure 3.0.7: Summary of deployment of various technologies between 2023, 2030 and 2050

4. Action planning

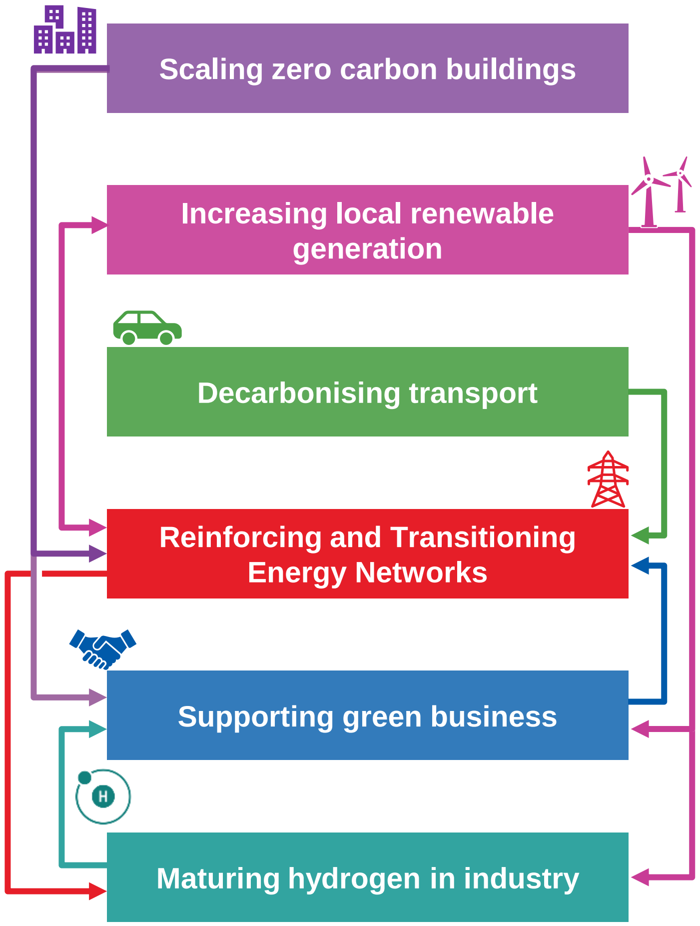
4. Action planning

Energy propositions

We shared what we learnt from exploring different energy futures and deployment pathways with our stakeholders and discussed with them what key drivers will be critical for the transition to net zero. We then considered their feedback, our strategic vision and objectives and agreed energy propositions to act as the framework for Flintshire's LAEP. There are numerous inter-dependencies and interactions between these propositions, as shown here, and this highlights the importance of a whole system approach with a co-ordinated programme of delivery to meet the net zero target by 2050. The following section describes each energy proposition in more detail, drawing together the evidence collected from baselining, scenario analysis and spatial modelling to propose priority areas to test critical, low-regrets system components that make up each energy proposition.

Vision

Flintshire County Council envisions a sustainable future with a net zero energy system that is affordable and promotes community health, well-being, and economic growth. We commit to a clean energy transition that fosters a resilient, inclusive, and prosperous community, ensuring a harmonious balance between environmental stewardship and social progress.



Scaling zero carbon buildings

Increasing local renewable generation

Decarbonising transport

Reinforcing and Transitioning Energy Networks

Supporting green business

Maturing hydrogen in industry

Retrofit is key to ensure heat pumps can operate efficiently at low supply temperatures

If located appropriately, local renewables can reduce required network reinforcements, otherwise could require more reinforcements

Electrolysers require electricity, from suitable electricity network

Hydrogen supports industrial decarbonisation

Reduction in demand minimises electricity requirements

EVs add electrical load onto network – network reinforcements required

Energy efficiency can reduce electricity demand and required reinforcements

Local renewable electricity required for electrolyser

Figure 4.0.1: Summary of energy propositions and their inter-dependencies

4. Action planning

Energy propositions

Energy propositions in more detail

Scaling zero carbon buildings

Supporting and deploying energy efficiency measures across the county to reduce energy demand and costs.

Ensuring buildings are safe, healthy and low carbon in operation and design.

Decarbonising transport

Enabling the rollout of ultra low/zero carbon vehicles across the county and transitioning to a zero carbon council fleet.

Promoting active and sustainable travel within the region.

Increasing local renewable generation

Investigating opportunities for local and community ownership of renewables, providing low cost, clean energy to residents.

Supporting future green business

Encouraging and supporting businesses to adopt low carbon measures and reduce energy costs.

Create an attractive environment for sustainable businesses to make base in Flintshire.

Maturing hydrogen in industry

Exploring the potential for hydrogen within particular sectors and understand the infrastructure requirements for implementation.

Reinforcing and Transitioning Energy Networks

Grid reinforcement will be required to accommodate the shift towards electric vehicles and heating.

Even in a low hydrogen scenario the gas grid will require repurposing for hydrogen within some applications.

Figure 4.0.2: Summary of propositions

Identifying priority focus zones and creating an action routemap

Although the exact form of the decarbonised energy system in 2050 is uncertain, there are actions we can take now with relative certainty that will help us maintain the ability to meet our 2050 Net Zero ambition and capitalise on the opportunities that this transition will bring.

Plan on a page

As a starting point, Flintshire's "plan on a page," shown in Figure 4.0.3 on the next page, indicates the location and scale of change that scenario modelling indicates for Flintshire be on a pathway to Net Zero by 2050. The map highlights five modelling zones identified as priority focus zones for the low-regret energy system components included in Flintshire's energy propositions: heat pumps, EV chargers, rooftop solar PV, ground-mounted solar PV, onshore wind, and insulation retrofits. To prioritise where each low-regret energy system component could be deployed, each modelling zone was ranked using two or more of the following considerations:

- **Off-gas homes** – prioritise zones with higher baseline proportion of off-gas housing. These homes will be the most challenging to transition to hydrogen and therefore are the most likely no-regrets targets for conversion to heat pumps.
- **Socioeconomics** - prioritise zones with higher baseline rates of deprivation (lower WIMD score).
- **Property ownership** - prioritise zones with the highest baseline percentage of social housing.
- **Substation generation headroom** – prioritise zones with the most baseline generation headroom available.
- **Listed buildings** – prioritise zones with the least number of currently listed buildings.
- **Domestic energy efficiency** – prioritise zones with the highest baseline percentage of homes with an EPC rating of D or below.
- **Built additional substation capacity** - prioritises zones where the least upgrades are required in the high demand scenario, since heat electrification is typically a major contributor to grid upgrade requirements (which may be back-logged by several years).
- **Built EV charging capacity** – prioritise zones with the most EV charging built in the high demand scenario.
- **Built additional capacity of each local generation technology** (rooftop PV, ground-mounted PV, or onshore wind) – prioritise zones where the most additional new capacity is built between the baseline and 2050 high demand scenario.

For more details on the methodology behind the "plan on a page", please see Chapter 4 of the Technical Report.

In the map (Figure 4.0.3 on the next page), green areas show modelling zones identified as priority focus zones, where the modelling indicates that conditions are most favourable to trial deployment of energy system components at pace and scale. Blue areas show "progress" zones where the conditions are less favourable in the near-term for delivery compared to the green zones, and where only tried and tested delivery models should be deployed. A consistent level of deployment will still be required in these zones to transform the local energy system at the pace indicated by the deployment analysis.

4. Action planning
Energy propositions

Plan on a page

To support transformation of the energy system, pilot projects may be useful. The map below highlights areas that could provide a useful focus for these pilots.

Figure 0.4 identifies zones with particularly favourable conditions for specific energy components, making them ideal locations for pilot studies. The summary boxes detail the location, opportunity type, potential capacity, required investment for each component, and total investment necessary for both energy component installation and electricity network infrastructure in each zone by 2030. Ranges have been calculated by taking the minimum and maximum results from each future energy scenarios modelled.

Point of Ayr

Opportunities:	Heat pumps	Rooftop PV
Potential:	95-165 units	1.0MW
Cost:	£0.4m-0.7m	£1.1m

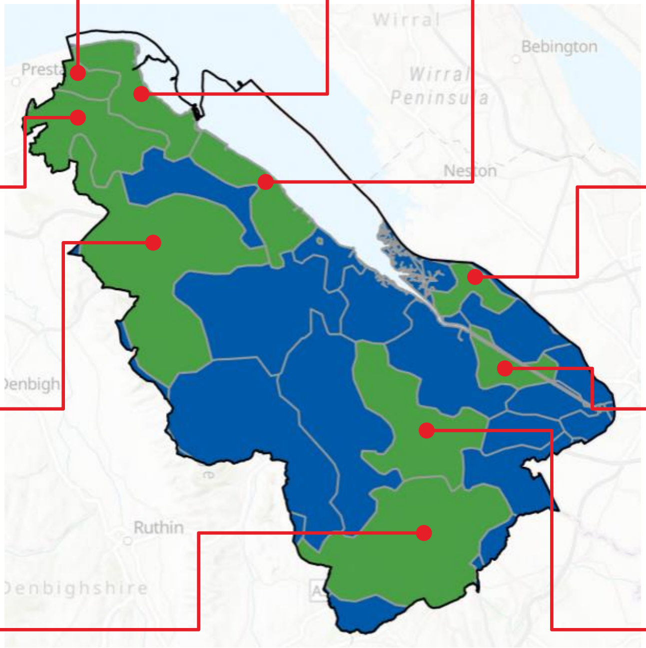
Total opportunities cost: £3m-24m

Gronant
Opportunity: Domestic retrofits
Potential: 138-298 homes
Cost: £1.3m-23.1m
Total opportunities cost: £3m-24m

Trelawnyd
Opportunity: Heat pumps
Potential: 47-80 units
Cost: £0.2m-0.4m
Total opportunities cost: £3m-28m

Caerwys
Opportunity: Rooftop PV
Potential: 1.1MW
Cost: £1.3m
Total opportunities cost: £9m-69m

Leeswood
Opportunity: Ground PV
Potential: 35.2MW
Cost: £15.1m
Total opportunities cost: £31m-141m



Greenfield
Opportunity: Domestic retrofits
Potential: 372-1,197 homes
Cost: £3.4m-63.4m
Total opportunities cost: £21m-79m

Shotwick
Opportunity: EV chargers
Potential: 261
Cost: £0.9m
Total opportunities cost: £18m-22m

Queensferry
Opportunity: EV chargers
Potential: 484
Cost: £1.6m
Total opportunities cost: £23m-66m

Buckley
Opportunity: Ground PV
Potential: 75.2MW
Cost: £32.5m
Total opportunities cost: £68m-269m

Figure 4.0.3: Flintshire's spatial representation of opportunities, including 2030 ambition and investment (million £) – in High and Low Demand scenarios. Zone boundaries are defined by primary substation service areas

Identifying priority focus zones and creating an action routemap

Action routemap

Our energy propositions describe where our priorities lie based on the evidence presented thus far. Our **action routemap** takes each energy proposition and outlines critical, enabling actions that we will take collectively alongside our stakeholders in the coming decade, with a particular focus on what we can achieve in the next 5-7 years. Our action routemap has been developed as a dynamic plan that recognises the influence that wider contextual changes at national and local level will have on the way we choose to transition to a net zero energy system, such as national regulation, policy and strategic plans. As a result, we expect to regularly review and update our routemap based on these dependencies.

Each action will require four key elements to be successful:

- Mobilising finance
- Strong and consistent policy frameworks
- Identifying delivery owners
- Community engagement

As Flintshire County Council, our role in delivering each energy proposition will vary. Some actions call for council action in the material delivery of programmes, whilst others require the council to act as the facilitator for market-driven change.

Through the LAEP process, we also identified that some of the actions are best delivered collaboratively through the regional partnership. This is because there are economies of scale, and it would be more efficient to have joined up and focused public resources. The regional actions will require detailed design work, to create projects and programmes, to progress them to implementation stage - with an initial focus on the tried and tested. The council will take an active role in supporting Ambition North Wales going forward.

Local ownership is a key focus throughout this plan, and where possible the action taken should leverage the progress made through the Welsh Government's recent Co-operation Agreement[M63] with Plaid Cymru, which includes key goals on tackling climate change in a way that maximises local benefits.

The following section provides further detail on each of the actions that we will undertake under each energy proposition, as well as our key asks of others. Due to the relative uncertainty of longer-term actions, we have chosen not to focus on detailed scoping of these in this report and instead, focus on actions we intend to deliver in the short-term, subject to appropriate support. For more details on the action plan, please see the Technical Report for further details.

4. Action planning

Routemap | short term actions

#	Lead	Scaling Zero Carbon Buildings	2024	2025	2026	2027	2028	2029	2030
1.1	FCC	Develop and implement programme of support for off-gas grid homes	■	■	■	■	■	■	■
1.2	FCC	Develop programme for retrofit of Council owned buildings	■	■					
1.3	FCC	Promote rollout of EPCs to all Flintshire residents	■	■					
1.4	FCC	Complete existing ECO4 and ORP 2 and 3 funding programmes	■						
1.5	FCC	Upskill Council planning and regeneration team staff on retrofit of 'heritage' buildings, and novel technologies (e.g. heat pumps and charging hubs)	■						
1.6	FCC	Develop emissions standards for operation and construction of Council new builds and retrofits	■						
1.7	FCC	Explore opportunities to engage with the supply chain to ensure they are adequately aware of the scale of change required for domestic retrofit	■	■					
1.8 B.1.8	WG	Apply lessons learnt from Optimised Retrofit Programme to retrofitting the privately rented and owner-occupied sectors through Welsh Zero Carbon Hwb.	■	■	■	■	■	■	■
1.9 B.2.1	WG	Using the learning from other information hubs to develop an information service that provides a trusted source of retrofit and energy efficiency information for consumers. Explore the potential of establishing an advice hub to support regional decarbonisation / low carbon energy initiatives.	■	■					
1.10 R1.4	Warm Wales	Work with Community Interest Companies (CIC) to provide a regional service of wrap around support for residents covering education, behaviour change, energy advice and support.	■	■	■	■	■		
1.11 3A	RSLs	Provide support and incentives for households to install energy efficiency measures and low-carbon heating systems, ensuring such support is targeted at those in fuel poverty and/or in most need.	■	■	■	■	■	■	■
1.12 3C	FCC; RSLs	Ensure PAS 2035 surveys and a clear plan for retrofit measures are prepared for individual social homes, in accordance with the Welsh Housing Quality Standard (WHQS)[M20].	■	■	■	■	■	■	■

FCC - Flintshire County Council; WG – Welsh Government; RSL – Registered Social Landlords

Sponsors: Delivery partners:

4. Action planning

Routemap | short term actions

#	Lead	Scaling Zero Carbon Buildings	2024	2025	2026	2027	2028	2029	2030
1.13 3D	WG; LAs	Review current support provision to tenants and landlords in the private-rented sector to ensure minimum energy efficiency standards are met. Review enforcement provisions to ensure minimum statutory standards within the sector are achieved.	▨	▨	▨				
1.14 5C	Business Wales / M-Sparc; North Wales Mersey Dee Business Council	Explore development of support mechanisms for small to medium-sized enterprises (SMEs) to encourage uptake of energy efficiency improvements to commercial buildings.	▨	▨	▨	▨	▨	▨	▨
1.15 B.1.7	WG	Work with local authorities and regional bodies to determine an approach to coordinated, street-by-street approach to retrofit and the mechanisms for delivery (e.g. governance, resource, finance, policy). Co-ordinate a retrofit plan for all housing tenures which expands on the Optimised Retrofit Programme.	▨	▨	▨	▨	▨	▨	▨
1.16 B.5.1 3E	WG; LAs	Identify specific local planning constraints (e.g. permitted developments i.e. 3 metre rule for heat pumps, permissive planning for listed buildings, new build regulations) limiting progress to net zero and delivering the LAEPs and work with Welsh Government to resolve these.	▨	▨	▨	▨	▨	▨	▨
1.17 B.5.2	WG	Consider tighter building regulations to support delivery of net zero ready buildings including a consultation on Part L regulations in 2024	▨	▨					
1.18 B.1.2 3B	WG	Develop and agree an approach and delivery plan for tackling owner-occupied retrofit. Review existing and explore new potential financial mechanisms to support owner-occupiers and building owners seeking to undertake energy efficiency retrofit works.	▨	▨					
1.19 E.4.1	WG	Identify procurement frameworks for renewable technologies which consider local and ethical sourcing of goods and services. Develop national procurement framework, learning from previous ECO 4 roll out and the Optimised Retrofit Programme, to deliver street-by-street retrofit.	▨	▨					

FCC - Flintshire County Council; WG – Welsh Government; LA – Local Authority; RSL – Registered Social Landlords

4. Action planning

Routemap | short term actions

#	Lead	Decarbonising Transport	2024	2025	2026	2027	2028	2029	2030
2.1	FCC	Apply pressure to Welsh Government for greater direction for on street EV charging	🟩	🟩					
2.2	FCC	Explore EV charging technologies for kerbline properties where no off-street options are available	🟩	🟩	🟩				
2.3	FCC	Understand charging facilities potential within town centre regeneration and place making plans, explore SPF and ORCS funding	🟩	🟩	🟩				
2.4	FCC	Ensure commitment to high speed broadband connections for everyone in Flintshire	🟩	🟩					
2.5	FCC	Lobby for investment in the rail infrastructure to improve service frequency and reduce travel time	🟩	🟩	🟩				
2.6	FCC	Further develop active travel networks and principles, keeping in mind impacts of equalities act	🟩	🟩					
2.7	FCC	Develop plans for last mile sustainable mobility requirements within the scope of new and improved stations in the North Wales metro programme	🟩	🟩	🟩				
2.8	FCC	Provide public finance options and national standards for EV charging infrastructure.	🟩	🟩	🟩				
2.9	FCC	Release pilot EV charge point locator and costing tool for EV charge points.	🟩	🟩	🟩				
2.10 4C	ANW; WGES	Collaborate on opportunities to decarbonise the public sector fleet, public service vehicles, and commercial and industrial fleets and the co-ordination of associated infrastructure design and development across local authority boundaries.	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2.11 4D	ANW; North Wales Corporate Joint Committee; TfW; SPEN	Work together to deliver the most appropriate electric vehicle public charging infrastructure across the region, aligning with national work being undertaken through Transport for Wales.	🟩	🟩					

FCC - Flintshire County Council; WG – Welsh Government; LA – Local Authority; ANW – Ambition North Wales; TfW – Transport for Wales; SPEN – SP Energy Networks; WGES – Welsh Government Energy Service

4. Action planning

Routemap | short term actions

#	Lead	Decarbonising Transport	2024	2025	2026	2027	2028	2029	2030
2.12 4F	ANW	Support greater awareness raising of UK Government funding for development of electric vehicle charging infrastructure such as the on-street residential charging scheme.	🟩	🟩	🟩	🟩	🟩		
2.13 4G	ANW; WGES	Continue to support organisations such as local community car clubs to deliver community-oriented, low-carbon transport infrastructure and services.	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2.14 R4.1	North Wales Corporate Joint Committee	Establish a Regional Transport Officer's Group that provides a forum for collaboration and alignment between local and national government in addition to Transport for Wales.	🟩	🟩					
2.15 R4.2	North Wales Corporate Joint Committee	Explore opportunities around bus franchising across the region.	🟩	🟩	🟩				
2.16 R4.3	North Wales Corporate Joint Committee	Produce the first Regional Transport Plan (RTP) in line with that Welsh Government statutory guidance.	🟩	🟩					
2.17 T.2.4	WG	Develop a national procurement framework for EV infrastructure	🟩						

FCC - Flintshire County Council; WG – Welsh Government; LA – Local Authority; ANW – Ambition North Wales; TfW – Transport for Wales; WGES – Welsh Government Energy Service

4. Action planning

Routemap | short term actions

#	Lead	Increasing Local Renewable Generation	2024	2025	2026	2027	2028	2029	2030
3.1	FCC	Promote community energy schemes	▨	▨					
3.2	FCC	Continue to rollout renewables in line with REAs, land assessments and constraints mapping	▨	▨	▨	▨	▨	▨	▨
3.3	FCC	Facilitate rooftop solar PV uptake in owner-occupied dwellings through knowledge sharing and signposting	▨	▨	▨	▨			
3.4	FCC	Understand local potential for solar carports	▨	▨	▨				
3.5	FCC	Support SMEs with rooftop solar installation for reducing energy costs by highlighting energy savings, local installers and potential costs	▨	▨	▨	▨			
3.6	FCC	Further explore possibilities for geothermal energy generation within old coal fields, this can build on the work that has been undertaken by the Coal Authority.	▨	▨	▨	▨			
3.7 G	ANW	Explore the development of an investment prospectus for renewable developments currently in the pipeline.	▨	▨					
3.8 2A	Ynni Cymru; ANW	Engage with Welsh Government to identify and build on opportunities that Ynni Cymru could provide to North Wales.	▨	▨	▨	▨	▨	▨	▨
3.9 2B	ANW	Explore how to improve communication of available funding sources for the development and delivery of a range of low-carbon power generation projects (e.g. onshore and offshore wind, solar PV, nuclear, and tidal and marine energy).	▨	▨					
3.10 2D	Ynni Cymru; ANW	Support workstreams in increasing local ownership of energy projects to be delivered in line with proposed guidance on local and shared ownership in Wales.	▨	▨	▨	▨	▨	▨	▨
3.11 2E	ANW	Explore the potential of establishing an advice hub to support regional decarbonisation / low carbon energy initiatives.	▨	▨	▨				

FCC - Flintshire County Council; WG – Welsh Government; LA – Local Authority; ANW – Ambition North Wales

Sponsors: *Delivery partners:*

4. Action planning

Routemap | short term actions

#	Lead	Increasing Local Renewable Generation	2024	2025	2026	2027	2028	2029	2030
3.12 2F	ANW	Maximise opportunities for public procurement to support the acceleration of renewable energy generation and secure local economic and social value. - Ensure that public procurement strengthens local supply chains / local jobs (social value). - Ask the supply chain to deliver against public sector carbon ambitions through procurement frameworks.	▨	▨	▨	▨	▨	▨	▨
3.13 2G	ANW	Maximise opportunities for community benefits funds from energy infrastructure projects (on the distribution network) to support local and regional decarbonisation initiatives, recognising the need to target those communities and areas most impacted by such developments.	▨	▨	▨	▨	▨	▨	▨
3.14 R2.1	ANW	Explore the opportunities that Power Purchasing Agreements could provide to energy generation across the region.	▨	▨	▨				
3.15 R2.2	ANW; WGES	Continue to explore the opportunities presented by solar canopies in car parking spaces and the enablers to scale the technology across the region.	▨	▨	▨	▨			
3.16 RN.4.1	WG; Trydan Gwyrdd Cymru	Identify and explore opportunities for the development of renewables on public sector owned land	▨	▨	▨	▨	▨	▨	▨

FCC - Flintshire County Council; WG – Welsh Government; LA – Local Authority; ANW – Ambition North Wales; WGES – Welsh Government Energy Service

4. Action planning

Routemap | short term actions

#	Lead	Supporting green business	2024	2025	2026	2027	2028	2029	2030
4.1	FCC	Promote work undertaken by AMRC where appropriate	▨	▨	▨				
4.2	FCC	Continue to support Deeside Decarbonisation Forum and signpost funding opportunities	▨	▨	▨	▨	▨	▨	▨
4.3	FCC	Understand potential for redevelopment plan of Mostyn dock, undertake opportunities mapping	▨	▨	▨				
4.4	FCC	Understand how sustainability can be worked in to Flintshire's digital strategy and potential for data supported decarbonisation	▨	▨					
4.5	FCC	Look to undertake heat mapping exercise and understand heat network potential	▨	▨	▨				
4.6	FCC	Support SMEs to develop plans to decarbonise and signpost to funding opportunities	▨	▨	▨	▨	▨	▨	▨
4.7	FCC	Continue to support town centre place making investment and signpost funding opportunities available to businesses and social enterprises	▨	▨	▨	▨	▨	▨	▨

FCC - Flintshire County Council; WG – Welsh Government; LA – Local Authority; ANW – Ambition North Wales

Sponsors:

Delivery partners:

4. Action planning

Routemap | short term actions

#	Lead	Maturing hydrogen in industry	2024	2025	2026	2027	2028	2029	2030
5.1	FCC	Plan for and be aware of upcoming hydrogen project funding opportunities	🟦	🟦	🟦				
5.2	FCC	Develop local strategy to understand local need, requirements, challenges, and opportunities for hydrogen	🟦	🟦	🟦				
5.3	FCC	Look to support research into hydrogen co-challenges for local businesses	🟦	🟦	🟦	🟦			
5.4 [illegible]	ANW	Support the emerging hydrogen economy, taking account of proposed hydrogen projects across the region.	🟦	🟦	🟦	🟦	🟦	🟦	🟦
5.5 N.4.4	WG; NRW	Publish a Welsh Government carbon intensity standard for hydrogen production based on that of UK Government. This standard can be used as a basis for future permitting by Natural Resources Wales.	🟦	🟦					
5.6	WWU	Publish findings from North Wales Conceptual Plan for hydrogen infrastructure.	🟦	🟦					
5.7 N.3.5	WWU	Make the network hydrogen ready. Deliver programme to convert remainder of gas network not covered by the REPEX programme to enable a 100% hydrogen conversion, WWUs sustainability strategy from 2023 identifies a desire to complete this between 2035-2040.	🟦	🟦	🟦	🟦	🟦	🟦	🟦 to 2040 >
5.8 N.4.4	WWU	Develop hydrogen and bio-methane projects.	🟦	🟦	🟦	🟦	🟦	🟦	🟦 to 2050 >
5.9 N.4.5	WWU	Develop a more detailed understanding of potential hydrogen transport demand and incorporate this demand within existing network demands. This action will be supported by WWU's innovation project HyDrive.	🟦	🟦					

FCC - Flintshire County Council; WG – Welsh Government; LA – Local Authority; ANW – Ambition North Wales; NRW - Natural Resources Wales; WWU – Wales and West Utilities

4. Action planning

Routemap | short term actions

#	Lead	Reinforcing and Transitioning Energy Networks	2024	2025	2026	2027	2028	2029	2030
6.1 N.1.2	SPEN; WWU	Hold regular engagement meetings between FCC, SPEN and WWU	▨	▨	▨	▨	▨	▨	Ongoing basis
6.2 N.2.2 N.3.3	FCC; SPEN	FCC and SPEN to work collaboratively to understand future demands (electricity) and use this to influence ED3 Planning and investment from OFGEM.	▨	▨	▨				
6.3 N.2.1	SPEN	Inform local authorities about available data resources by providing access to the DFES report and the resulting NDP (Network Development Plan) via SPEN's Open Data Portal as well as other datasets such as heat maps, network infrastructure & usage. Requests for additional, bespoke reports can also be made via the portal.	▨	▨	▨	▨	▨	▨	▨
6.4 N.2.3	SPEN	Use all relevant outputs from the LAEPs to inform SPEN's DFES (Distribution Future Energy Scenario) Report, in turn SPEN will share the trends and highlights from the DFES with individual LAs.	▨	▨					
6.5 N.2.4	SPEN	Provide low carbon technology (LCT) optioneering services to Local Authorities to support them with site optioneering (cost and timescale) for EV charging, heat pump rollout and renewable generation infrastructure planning.				▨	▨	▨	
6.6 N.2.5	SPEN; WWU	Co-ordinate Net Zero clinics for Local Authorities to discuss decarbonisation of heat, transport and renewables strategies, and willingly contribute to workshops organised by the Local Authorities for local small-medium enterprises (SMEs).	▨	▨	▨	▨	▨	▨	Ongoing basis
6.7 N.2.6	SPEN; WWU	Discuss and agree any strategic optimisation opportunities with each Local Authority to continue progressing decarbonisation and economic growth plans.	▨	▨	▨	▨	▨	▨	Ongoing basis
6.8 N.1.3	SPEN; WWU	Plan a method to consolidate the pipelines for all energy-related projects across the electricity and gas/hydrogen networks. This will consolidate all actions planned by electricity and gas/hydrogen networks within an area into one common database. As a starting point, set up ongoing engagement meetings with DataMapWales, NGED SPEN, and WWU to coordinate if and how DataMap Wales may be an appropriate platform to consolidate this information.	▨	▨	▨	▨	▨	▨	Ongoing basis

FCC - Flintshire County Council; WG – Welsh Government; LA – Local Authority; ANW – Ambition North Wales; SPEN – SP Energy Networks; WWU – Wales and West Utilities

4. Action planning

Routemap | short term actions

#	Lead	Reinforcing and Transitioning Energy Networks	2024	2025	2026	2027	2028	2029	2030
6.9 N.3.1	WWU	Highlight gas infrastructure opportunities. Support Local Authorities in exploring new opportunities to develop the existing gas networks in advance of 100% transition to existing hydrogen network.	▨	▨	▨	▨	▨	▨	▨ Ongoing basis
6.10 N.3.2	WWU	Include new projects from the LAEP in strategic planning process.	▨	▨	▨	▨			
6.11 N.3.4	WG	Share LAEP outputs on DataMapWales, plan how to keep this data up to date and relevant	▨	▨					
6.12	SPEN	Raise awareness of SPEN's Flexibility Service procurement to support a smarter system.	▨	▨					
6.13 N.2.7	SPEN	SPEN is already looking at industrial decarbonisation through their partnership in the NEW-ID (North East Wales Industrial Decarbonisation) Project. Any opportunities/benefits identified as part of work on this project will be shared with the affected Local Authorities, including Flintshire .	▨	▨	▨	▨	▨	▨	▨
6.14	WG; Coal Authority; WWU	Explore opportunities for partnership delivery of district heating and cooling networks, using waste heat sources such as mine water.	▨	▨	▨	▨			
6.15 5B	ANW; DDF	Understand the role that micro-grids and other innovative solutions can play in existing industrial clusters such as those in Deeside and Flintshire.	▨	▨	▨	▨	▨		
6.16 R5.1	North Wales Corporate Joint Committee; DDF	Explore and recognise opportunities that will be made available from the Flintshire/Wrexham investment zone.	▨	▨	▨	▨	▨		

FCC - Flintshire County Council; WG – Welsh Government; ANW – Ambition North Wales; SPEN – SP Energy Networks; WWU – Wales and West Utilities; DDF – Deeside Decarbonisation Forum

4. Action planning

Routemap | short term actions

#	Lead	Enabling actions	2024	2025	2026	2027	2028	2029	2030
7.1 A	ANW	Ensure effective alignment between local, regional and national energy strategies, plans and initiatives.	▨	▨	▨	▨	▨	▨	▨
7.2 D	ANW	Provide regional support in the delivery of commitments made in the Climate Action Wales public engagement strategy (July 2023) to help citizens take action to reduce demand, improve energy efficiency and use energy in a way which supports our vision	▨	▨	▨	▨	▨	▨	▨
7.3 I1.3 F	ANW; Ynni Cymru; WG	Continue to explore and support opportunities for smart local energy systems in the region. Using outputs from the LAEP, map smart local energy system opportunities and identify feasibility/demonstrator projects through engagement with key stakeholders including community energy groups and general public.	▨	▨	▨	▨	▨	▨	▨
7.4 R1.1	WG; Ofgem; National Grid ESO	Ensure alignment between the scope and function of the new Regional Energy Strategic Planners (RESPs) with Ofgem's policy design. Consultation of the policy design will be published in the summer of 2024 with the RESPs in operation by late 2025/early 2026	▨	▨	▨				
7.5 R1.2	North Wales Corporate Joint Committee	North Wales Corporate Joint Committee to support the Race to Zero campaign and provide oversight on carbon emissions across the region	▨	▨	▨	▨	▨	▨	▨
7.6 E3.1 C	RSP; WG	Lead on developing the skills requirements identified in the Regional Skills Partnership's (RSP's) Green Skills Report and Welsh Government's Net Zero Skills Action Plan. Map and identify skills and labour needs and gaps up to 2050 for retrofit and low carbon new builds; renewable deployment; decarbonised transport and business / industry decarbonisation.	▨	▨	▨	▨	▨	▨	▨
7.7 E3.2	WG	Review and develop educational programmes to meet skills needed	▨	▨	▨	▨	▨	▨	▨
7.8 E3.3	WG	Develop a communication strategy to educate, promote skills, training and the need for a supply chain	▨	▨	▨	▨	▨	▨	▨

FCC - Flintshire County Council; WG – Welsh Government; LA – Local Authority; ANW – Ambition North Wales; WGES – Welsh Government Energy Service; RSP – Regional Skills Partnerships

Sponsors:

Delivery partners:

4. Action planning

Routemap | short term actions

#	Lead	Enabling actions	2024	2025	2026	2027	2028	2029	2030
7.9 R1.5	ANW; WGES	Work with Welsh Government to create a governance structure and performance management framework for the LAEPs to facilitate monitoring of progress and performance of the LAEPs across the Region.	▨	▨					
7.10 E2.2	WG	Using the outputs from the LAEPs and REPs, create a national plan which covers the gaps such as national and regional assets.	▨						
7.11 R1.3	North Wales Corporate Joint Committee	Develop the first regional Strategic Development Plan (SDP). Include policies in the plan that support low carbon building practices and low carbon new builds.	▨	▨	▨	▨	▨		
7.12 H	Bangor University / M-Sparc; Wrexham University; ANW	Strengthen the link between research, development and innovation with regards to current and emerging technology and the Energy Strategy priorities.	▨	▨	▨	▨	▨	▨	▨

FCC - Flintshire County Council; WG – Welsh Government; LA – Local Authority; ANW – Ambition North Wales; WGES – Welsh Government Energy Service

4. Action planning

Routemap | short term

National Targets	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Up to 1GW of electrolytic hydrogen secured (2025) [UK][M44]	■						
Decision on hydrogen to heat buildings (2026) [UK][M45]		■					
Up to 10GW hydrogen capacity in UK (50% electrolytic) [UK][M44]	Progressing towards 2030						■
Up to 50GW of offshore wind capacity including up to 5GW of innovative floating wind (2030) [UK] [M44]	Progressing towards 2030						■
Future Homes Standard consultation suggests all space heating and hot water demand be met through low carbon sources in new builds (2025)[M46]		■					
All new social homes built to Welsh Development Quality Requirements 2021 without fossil fuel heating (from 2025)[M47]		■					
All existing social homes to have a plan for minimising environmental impact and improving energy performance (2027) [Wales][M48]		■					
-37% GHG emissions by 2025 (rel. to 1990) [Wales][M49]		■					
-63% GHG emissions by 2030 (rel. 1990) [Wales][M49]	Progressing towards 2030						■
Meet the equivalent of 100% of electricity needs from renewable sources by 2035 [Wales][M26]	Progressing towards 2035						
1.5GW of renewable capacity to be locally owned (exc. Heat pumps) (2035) [Wales][M26]	Progressing towards 2035						
580,000 heat pumps to be installed in Wales by 2035, contingent on scaled up support from the UK Government and reductions in the cost of technology (2035) [Wales][M26]	Progressing towards 2035						
Minimum EPC E to rent out any property (from 2023 onwards) and EPC C from 2030 [UK][M51]	■						■
1 public charge point for every 7 to 11 electric vehicles (2025) [Wales][M52]		■					
Rapid charging available every 20 miles on the strategic trunk road (2025) [Wales][M52]		■					
£220 million committed through Active Travel Fund (2022-2025) [Wales]		■					
-10% car miles travelled/person (2030) [Wales][M03]	Progressing towards 2030						■
80% new cars and 70% new vans sold to be zero emissions[x] (2030) (ZEV mandate) [UK][M53]	Progressing towards 2030						■
100% new cars and vans sold to be zero emissions (2035) (ZEV mandate) [UK][M53]	Progressing towards 2035						
Net zero public sector by 2030 [Wales][M54]	Progressing towards 2030						■

5. Next steps

5. Next steps

Enabling conditions for success

Through the LAEP development process, we identified that broadly, each action requires four key elements to be successful. These are:

- Actions to mobilise finance
- A strong and consistent policy framework
- Accountable delivery owners and
- A community engagement element

Progressing energy propositions

We, as a county want to make sure that there is a well-defined governance structure for managing the delivery of the LAEP. As an area-wide plan it is the responsibility of all who live and operate in the area to support its delivery, and the chosen governance framework will need to reflect this. We, as a Council, will seek to bring the delivery of our LAEP into alignment with our plans for delivering our Climate Change Strategy and other plans where activities are mutually beneficial for addressing the climate emergency and meeting our climate change targets.

The council is currently strengthening its governance arrangements to support delivery of its Action Plan to Net Zero Carbon. Currently the climate change strategy programme is monitored by Climate Change Committee is made up of representatives from each political party. The Committee is supported by Officer Groups for each theme with representation from each of the stakeholder portfolios. Progress reports will be received by the Environment & Economy Scrutiny Committee to deliver further development of the plan. Scrutiny of the programme is also available from Internal Audit as appropriate.

Roles and responsibilities

The Council's role in each action will vary. Some actions call for Council action in the delivery of programmes, whilst other actions involve the Council as a convener, or co-ordinator between multiple organisations.

As a Council, we will decarbonise assets within our direct control, such as council buildings and the council transport fleet. Further, we will drive and influence the decarbonisation of the wider area through our role as:

Planning Authority:

- Preparing planning policies and allocating land in our Local Development Plan
- Development management – taking decisions on planning applications submitted to the local planning authority for development; as well as preparing Local Impact Assessments for schemes which are determined by the Infrastructure Planning Commission

Place-maker:

- Acting at a council wide level to achieve a low carbon economy.
- Taking forward wider community action and communicating the need to increase the uptake of renewable energy.

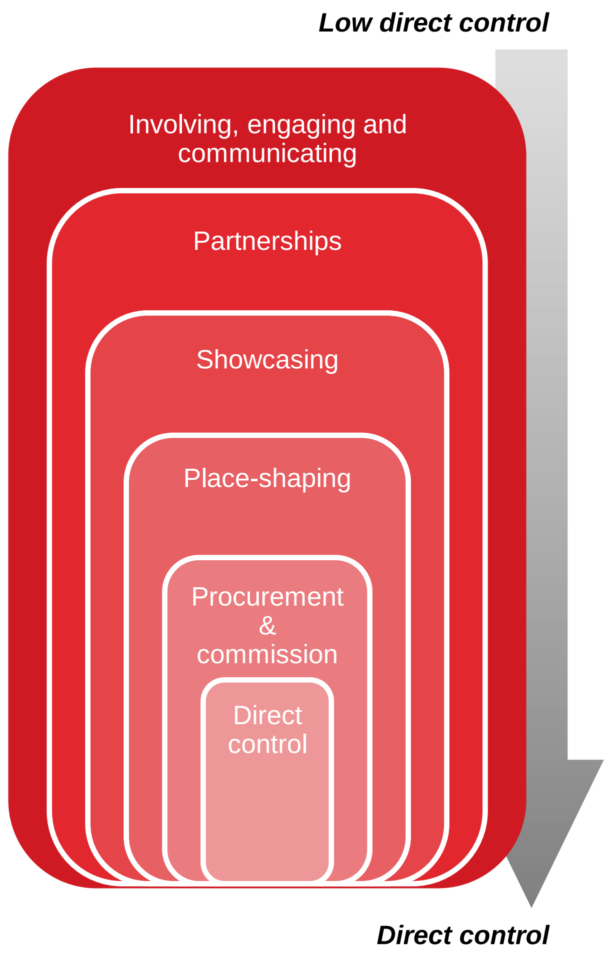


Figure 5.0.1: A local Council's roles and level of influence

5. Next steps

Enabling conditions for success

For this delivery of the LAEP and our own Climate Change Strategy to be successful, we will require a collective, co-ordinated effort from many different stakeholders, which means closer collaboration between the Council and our partners, and building relationships with key stakeholders that hold influence over different parts of the energy system. We will leverage our existing partnerships to do this, such as the Public Sector Board (PSB), Public Sector Decarbonisation Group and others.

Regional perspective

Developing this LAEP in close collaboration with other local authorities in Wales recognises that a consistent, co-ordinated plan for creating a net zero energy system in North Wales can bring wider economic and social benefits and capitalise on the unique potential in each local area. This regional approach to energy planning recognises the environmental, economic and social dependencies between different local areas and energy systems. Ambition North Wales, a regional representative in national discussions on energy, as well as responsible for co-ordinating North Wales' Energy Action Plan and managing the North Wales Growth Deal, recognises its critical role in endorsing this way of working, and how it might support this approach where it is most effective. Ambition North Wales plans to:

- Act as a regional resource to support local authorities to deliver their LAEPs.
- Ensure effective alignment between each LAEP, North Wales Regional Energy Strategy and the emerging National Energy Plan.
- Develop the skills requirements identified in the Regional Skills Partnership's Green Skills Report and Welsh Government's Net Zero Skills Action Plan.
- Encourage, facilitate and support a joined-up approach to delivering local actions that are common across the region to be efficient, effective and consistent (e.g. cross-border collaboration on funding applications).
- Facilitate engagement between local authorities and regional stakeholders e.g. continue to facilitate forums like the Regional Steering Group, where updates and support can be shared regionally between local authorities, networks and other local and regional stakeholders.
- Provide regional support in the delivery of commitments made in the Climate Action Wales public engagement strategy (published July 2023) to help citizens take action to reduce demand, improve energy efficiency and use energy in a way which supports our vision.

5. Next steps
Enabling conditions for success

National perspective

Welsh Government has committed to achieving net zero emissions in Wales by 2050 and recognises that a significant part of this will depend on transforming the energy system to enable the reduction and decarbonisation of energy generation and use in Wales. As such, it committed to providing the resource and funding for each Local Authority to develop a Local Area Energy Plan (LAEP). Having Local Area Energy Plans (LAEP) for every Local Authority in Wales provides an opportunity for Welsh Government to aggregate the findings into a national energy plan that is coherent with local energy priorities and needs and identifies large-scale opportunities to accelerate the transition at pace and scale. Welsh Government is well-placed to:

- Develop a national energy plan using the outputs of the LAEPs and four Regional Energy Strategies which covers aspects of the energy system that Welsh Government could influence (e.g. national assets, rebalancing energy costs etc.) [E2.2]
- Utilise the findings from LAEP to influence national energy infrastructure planning to support local energy ambitions
- Understand what policy and/or institutional support might be needed to empower Local Authorities and regional public bodies to drive energy innovation at a local level.
- Work with local and regional bodies to establish an effective local-national governance framework to enable co-ordinated decision-making and monitoring.
- Scale-up local energy plans to identify gaps to enable us to plan for a system that is flexible and smart – matching local renewable energy generation with energy demand

5. Next steps

Enabling conditions for success

Finance

For those actions that relate directly to our statutory duties as a local council and align with our immediate priorities, we will develop an investment plan to support the delivery of a Local Authority programme of works to enable the delivery of the LAEP. This may be from usual capital markets or through more innovative financing mechanisms such as community municipal investments, Pay as you Save or net-metering. Innovative finance options to be explored for individual energy consumers such as green mortgages.

For actions that are best delivered by other local, regional or national organisations, partnering and engaging with these organisations will be critical for discussing Flintshire's ambitions and how to make them investable.

Monitoring and review

This plan sets out key actions that will be taken by various stakeholders across Flintshire for the first five years to set the local area on a journey to achieve a net zero energy system. The plan needs to be flexible to adapt to changes in the future.

We will work with regional and national partners to develop a monitoring framework which builds on existing data and processes and helps us understand the progress Flintshire is making towards its committed actions and ambitions set out in this plan.

We will make use of publicly available datasets such as the Energy Performance Certificate Register[ML19], the Micro Generation Certification Scheme[ML20], the Renewable Energy Planning Database[M62] and publications such as Renewable Generation in Wales report[M61].

We will also track GHG emissions reduction, building on our existing submissions to Welsh Government for Public Sector Reporting as a starting point. We recognise that available data will lag a few years behind.

Our action routemap has been developed as a dynamic plan that recognises the influence that wider contextual changes at national and local level will have on the way we choose to transition to a net zero energy system, such as national regulation, policy and strategic plans. As a result, we expect to regularly review and update our routemap based on these dependencies.

The whole plan will be updated at least every five years to take account of key factors, including policy changes at a UK and Welsh Government level, changes in costs and the effectiveness of technologies.

Appendices

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Glossary of terms

Term	Definition or meaning
Action	The process of doing something – a specific action assigned to a responsible person preferably with a date to be completed.
Anaerobic Digestion	Processes biomass (plant material) into biogas (methane) that can be used for heating and generating electricity.
Baseline	The baseline is the data showing the current energy system, containing the 2019 data sets provided by the LA and publicly available data.
Batteries	Devices that store electrical energy to be used at a later time.
Biomass boiler	A boiler which burns wood-based fuel (e.g. logs, pellets, chippings) to generate heat and electricity.
Carbon Capture and Storage (CCS)	The process of capturing and then storing carbon emissions before they enter the atmosphere.
Certainties	A fact that is definitely true or an event that is definitely going to take place. In terms of a local energy system, certainties include funded projects, etc.
Demand	Local energy demand that the local energy system needs to meet.
Demand headroom	The difference between the electrical capacity of a substation, and the electricity demand at the substation at the time of peak demand.
Deployment modelling	A model investigating rates by which to deploy specific technologies between the baseline year and 2050 to achieve the end state developed by the optimisation model for each scenario. The model considers broader plan objectives and local, regional, and national strategic priorities, policies, and targets to help us to define a suitable level of ambition and inform an action plan.
Dispatchable energy generation	Energy generation that can turn on and off (i.e. isn’t controlled by the weather) – this is likely to be gas turbines of some sort.

Glossary of terms

Term	Definition or meaning
Distribution network	Takes energy from transmission network and delivers it to users via pipes or wires at low pressure / voltages.
Electricity network	Interconnected infrastructure which consists of power stations, electrical substations, distribution lines and transmission lines. The network delivers electricity from the producers to consumers.
Electrolyser	A piece of equipment that uses electricity to split water into hydrogen and oxygen.
Energy Proposition	A proposition is an energy component with a scale and a timescale. For instance, X MW of wind turbine to be built in 5 years, 10,000 buildings to retrofit with XX by 2030, or a pilot project such as hydrogen storage innovation. These are typically near term, low regrets energy components that are needed in future energy systems (it is likely that these appear in all scenarios).
Energy System Component	A term used to describe anything that can have a direct impact on energy demand and/or the way energy is supplied. E.g. installing retrofit measures can reduce overall heating demand, increasing solar PV capacity can change the supply mix and the way that the energy system operates.
Focus zone	A modelling zone which has been identified as an area in which to target near-term installation, upgrade, retrofit, or other activities related to a specific energy system component.
Generation	Local generation – size below 100MW.
Generation headroom	Generation headroom in a local authority's electricity distribution network refers to the remaining primary substation capacity at the time of peak generation, crucial for maintaining a stable and reliable power supply to meet the community's needs
Grid electricity	Electricity that is supplied by the electricity network.
Grid substation	The physical equipment comprising a substation with a 132kV-33kV transformer(s) connecting the grid-level, extra high voltage electricity lines to the primary-level, high voltage electricity lines. The grid substation facilitates connection with the national grid.
Heat network	A distribution system of insulated pipes that takes heat from a central source and delivers it to a number of domestic or non-domestic buildings.
Heat pump	A piece of equipment that uses a heat exchange system to take heat from air, ground or water and increases the temperature to heat buildings.

Glossary of terms

Term	Definition or meaning
Hydrogen	A flammable gas that can be burned, like natural gas, to generate heat or power vehicles. The by-product is water only, no carbon.
Infrastructure	Local energy distribution infrastructure, includes storage assets if these are at grid level.
Landfill gas	Gases such as methane that are produced by micro-organisms in a landfill site that can be used as a source of energy.
Lever	We use the term policy levers to refer to the 'governing instruments' (Kooiman, 2003) which the state has at its disposal to direct, manage and shape change in public services.
Local energy system	The distribution level energy system, excludes the transmission and national assets.
Longer-term options	The likely outcome of these is less certain and dependent upon actions and decisions being made that are not under our control, e.g. a national policy or the capability / availability of a technology.
Major industrial load	The power demand of industrial sites in the 2019 NAEI Point Sources data are large enough to be classified as major industrial loads. Sites that aren't included in this database are likely too small to have a significant impact on the energy system singlehandedly.
Methane reformation	Process of producing hydrogen by heating methane from natural gas and steam, usually with a catalyst. Produces carbon dioxide as a by product.
Modelling zone	A specified area in our modelling which is the smallest level of granularity for analysis. The zones are used through energy modelling, deployment modelling, and mapping. Zones were created by intersecting the Local Authority boundary with the primary substation service area boundary, as described in the "Methodology - electricity and gas network infrastructure" section of the Technical Report. *May also be called "zone" or "substation zone" in the reports.*
National Asset	National infrastructure (can be supply or demand and the accompanying transmission / distribution infrastructure) – defined as over 100MW, unless it produces heat which can only be used locally this is generally excluded from LAEP particularly the modelling.

Glossary of terms

Term	Definition or meaning
National grid	A generic term used in the reports referring to the electricity network serving Wales, including both the transmission and distribution networks and facilitating the flow of electricity between neighbouring areas or regions. *May also be called generically "grid" in the reports.*
National Net Zero	The National Net Zero modelled in the LAEP. Details of assumptions are in the methodology section.
Natural Heritage	This includes features which are of ecological, geological, geomorphological, hydrological or visual amenity importance within the landscape, and which form an essential part of the functioning of the natural environment and natural assets.
Net Zero	Net zero when used in this LAEP is the energy net zero as it does not include all emissions, only energy emissions.
No regrets/ low regrets	Options which are common to all scenarios, cost-effective, provide relatively large benefits, and are very likely to be important parts of the future energy system, regardless of future uncertainty.
Optimisation modelling	Modelling to create the most cost and carbon optimal system.
Option	A term used to describe ways that a particular objective can be achieved. In the context of this LAEP, an option could be deploying a particular energy system component
Outward code	The first part of a postcode i.e. BS1.
Pathway	A pathway is how we get from the current energy system, to the most likely net zero end point. The pathway will consider what is needed from across the scenarios, the supply chain, number of installers etc. The propositions will make up the more certain part of the pathway, whereas the longer-term energy components will need further definition in the future.
Primary substation	The physical equipment comprising a substation with a 33kV-11kV transformer(s) connecting the primary-level, high voltage electricity lines to the consumer-level, low voltage electricity lines.
Primary substation service area	The area bounding the buildings or other electricity demands which are served by a primary substation (or, in ANW, a group of primary substations acting together to serve one area).

Glossary of terms

Term	Definition or meaning
Programme	A series of projects, usually with a theme, that is run collectively.
Project	Strategic scale projects being implemented or planned for implementation in the local energy system that will significantly affect local demand or local supply.
Resistance heating/ heater	Generate heat by passing electrical currents through wires.
Scenario	A scenario is a set of assumptions for a particular end point (usually 2050) which are modelled in our optimisation model. We modelled 5 different scenarios to see what was common across the scenarios and therefore is a "no regrets" measure, and what changed between the modelled scenarios.
Solar PV	Convert solar radiation into electricity using photovoltaic (PV) cells.
Strategic objective	Strategic objectives are purpose statements that help create an overall vision and set goals and measurable steps to achieve the desired outcome. A strategic objective is most effective when it is quantifiable either by statistical results or observable data. Strategic objectives further the vision, align goals and drive decisions that impact change.
Strategic options	Strategic options are longer-term changes to demand, generation and infrastructure that will lead onto decarbonisation of the local energy system - and the key variables that determine scenarios.
Substation upgrades	Interventions at an existing primary substation designed to increase the capacity of the substation, such as upgrading an existing primary substation or installing a new primary substation. *May also be called 'substation interventions' in the reports.*
Supply	Energy supply options – this is how energy is delivered from the point of source – so a supply option would be solar PV.
Supply/generation headroom	The difference between the electrical capacity of a substation, and the power being supplied to the substation at a given time.
Transmission network	Move energy via pipes or wires for long distances around the country at high pressure/ voltages.
Uncertainties	Uncertainty results from lack of information or from disagreement about what is known or even knowable.
Wind power	Harnessing the kinetic energy of wind to turn a turbine to generate electricity.

Units of measure

Unit	Definition or meaning
°C	Degree(s) Celsius – a unit of temperature on the Celsius scale.
GWh	Gigawatt hour(s) – a unit of energy representing 1 billion watt-hours.
$kgCO_2e$	Kilogram(s) of carbon dioxide equivalents – a unit of measurement for greenhouse gas warming potential, expressing the equivalent weight of carbon dioxide with the same global warming potential.
$ktCO_2e$	Kilotonne(s) of carbon dioxide equivalents - a unit of measurement for greenhouse gas warming potential, expressing the equivalent weight of carbon dioxide with the same global warming potential. Represents 1 million kgCO2e.
kV	Kilovolt(s) – a unit of potential energy of a unit charge in a point of a circuit relative to a reference (ground) representing 1000 volts.
kW	Kilowatt(s) – a metric unit of power measuring rate of energy consumption or production representing 1000 watts.
kWh	Kilowatt hour(s) - a unit of energy representing 1000 watt-hours.
kWp	Peak kilowatt(s) – the maximum power rating possible produced by an energy generation source (i.e., amount of power produced in ideal generation conditions).
MW	Megawatt(s) – a metric unit of power measuring rate of energy consumption or production representing 1 million watts.
MWe	Megawatt(s) electric – a unit of electric power output from a generation source representing 1 million watts electric.
MWth	Megawatt(s) thermal – a unit of thermal power output from a generation source representing 1 million watts thermal.
MWh	Megawatt hour(s) - a unit of energy representing 1 million watt-hours.
tCO_2 per capita	Tonne(s) of carbon dioxide per capita – a unit of mass of carbon dioxide emitted per member of a population per year. Represents 1000 $kgCO_2$ per capita.

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Flintshire

Local Area Energy Plan (LAEP)

Technical Report

Abbreviations

Acronym	Definition or meaning
ANW	Ambition North Wales.
BEIS	Business, Energy and Industrial Strategy.
CAPEX	Capital Expenditure.
CCGT	Combined Cycle Gas Turbine.
CCR	Cardiff Capital Region.
COP	Coefficient of Performance.
DESNZ	Department for Energy Security and Net Zero.
DFES	Distribution Future Energy Scenarios.
DfT	Department for Transport.
DNO	Distribution Network Operator.
EfW	Energy from Waste.
EPC	Energy performance certificate.
ESC	Energy Systems Catapult.
EV	Electric Vehicle.

Acronym	Definition or meaning
GHG	Greenhouse Gas.
HGV	Heavy Goods Vehicles.
LAEP	Local area energy planning or Local area energy plan.
LGV	Light Goods Vehicles.
LSOA	Lower super output area, a small area classification in the UK designed to have a comparable population.
LULUCF	Land Use, Land Use Change and Forestry.
MSOA	Middle super output area, a medium-sized area classification in the UK designed to have a comparable population.
NAEI	National Atmospheric Emissions Inventory.
NGED	National Grid Electricity Distribution.
NZ	Net Zero.
NWTM	North Wales Transport Model.
OPEX	Operational Expenditure.
RFI	Request for Information.

Abbreviations

Acronym	Definition or meaning
RIIO	Revenue = Incentives + Innovation + Outputs, a regulatory framework used by the UK energy regulator, Ofgem.
SDP	Strategic Development Plan.
SMR	Steam Methane Reformation.
SPEN	SP Energy Networks.
SSE	Scottish and Southern Energy plc.
TfW	Transport for Wales.
WWU	Wales and West Utilities.

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Contents

This report was prepared by Arup, Carbon Trust and Afallen on behalf of Flintshire County Council and co-ordinated across the region by Ambition North Wales. Energy Systems Catapult is the Technical Advisor for the LAEP Programme in Wales.

This report’s development was funded by the Welsh Government.

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Technical report

Chapter 1: Introduction (stage 1)

Introduction to Technical Report

Flintshire’s Local Area Energy Plan (LAEP) provides an evidence-based plan of action that identifies the most effective route to a net zero local energy system for an area. This LAEP has been developed by bringing local organisations and groups together to discuss the evidence created as part of the development process and collectively agree on the best way forward to achieve this objective.

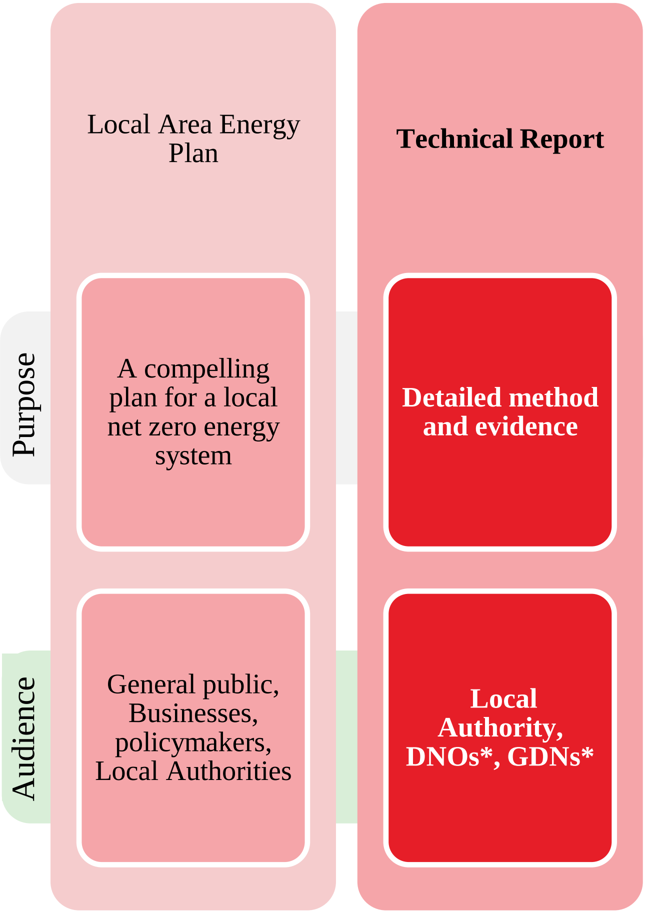
Applying this approach, a LAEP puts local needs and views at the centre of the planning process, and helps creates a co-ordinated, place-based plan that avoids the duplication of efforts, aims to save money, and realises additional social benefits that might otherwise have been over-looked.

The LAEP has been divided into two separate documents to make the content accessible to a variety of audiences and to make it easier for readers to find what they are looking for:

This is the **Technical Report**, which contains the graphs, charts, maps and supporting data for the results published in the LAEP. It also provides more detail about the approach to the modelling and scenario analyses that we completed.

The **Local Area Energy Plan** focuses on Flintshire’s local energy strategy and action plan.

The report is structured so that it follows the seven-staged development process outlined in ESC’s LAEP Guidance[T01]. It includes additional supporting information related to stages 1-5, which are categorised into the introduction (Stage 1-2), the current energy system (Stage 3) and the future energy system (Stages 4-7). The table overleaf summarises what is included in this report and the Local Area Energy Plan in more detail.



	Local Area Energy Plan	**Technical Report**
Purpose	A compelling plan for a local net zero energy system	**Detailed method and evidence**
Audience	General public, Businesses, policymakers, Local Authorities	**Local Authority, DNOs*, GDNs***

Figure 1.1.1: Summary of LAEP reports’ purpose and audience. *DNO – electricity distribution network operator, GDN – gas distribution network operator

1. Introduction

Summary of content in Local Area Energy Plan and Technical Report

	Stage	Included in the Technical Report	Included in the Local Area Energy Plan
Introduction	**1**	• Overview of LAEP programme • Process of preparing to create LAEP, identifying resources, appointing lead organisation and agreeing roles.	• Overview of LAEP programme
	2	• Summary of stakeholder identification process • Overview of stakeholder engagement plan	• Summary of stakeholder engagement
The current local energy system	**3**	• Data sources used to inform the energy system baseline • Detailed definition of the system boundary and scope of assessment • Assumptions used to define the energy system baseline • Additional analysis not included in Local Area Energy Plan • Local, regional and national policy review	• Summary of energy system baseline • Summary of local, regional and national policy drivers for LAEP
The future local energy system	**4**	• Modelling approach for scenario analysis • Assumptions applied: cost, network dependencies • Sensitivity analysis results • Comparing scenarios and defining energy propositions	• Description of scenarios • Summary of key outputs and aspects of scenarios such as cost, emissions savings, energy savings and impact on networks • Defining energy propositions
	5	• Modelling approach for deployment model • Illustration of focus zones for each energy proposition across buildings, industry, transport and renewable generation • Describing deployment rates for different technologies related to each energy proposition across buildings, industry, transport and renewable generation • Opportunities with neighbouring local areas / regional	• Summary of deployment pathways for each scenario and setting level of ambition • Illustration of key focus zones for each energy proposition across buildings, industry, transport and renewable generation, with an indication of deployment from deployment modelling
Action Plan	**6 - 7**	• Analysis and evidence to support implementation for each energy proposition	• Action plan routemap • Details of near-term actions • Details of enabling actions, such as upskilling, funding

Table 1.1.1: Summary of content in Local Area Energy Plan and Technical Report

1. Introduction

The energy transition across Wales

The Welsh Government's "Net Zero Wales" plan[T02] establishes an increased level of ambition on decarbonisation, with a legally binding target to reach net zero emissions by 2050. It is the first national government to fund the roll-out of LAEP to all its local authorities. The programme is being co-ordinated through a regional approach, where LAEPs are being developed for local authorities in Mid Wales, South West Wales, North Wales and the Cardiff Capital Region. Several suppliers have been selected to produce the LAEPs for each region, as detailed in the map.

To contribute to the Welsh Government's commitment of producing a "National Energy Plan" in 2024, upon completion of the LAEP programme Energy Systems Catapult[T03] will aggregate the LAEPs into a national view. To support this task, they are working with the Welsh Government to create and import standardised LAEP outputs for aggregation into the DataMapWales platform[T04]. The Catapult is also providing technical advisory support to the Welsh Government throughout the programme.

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

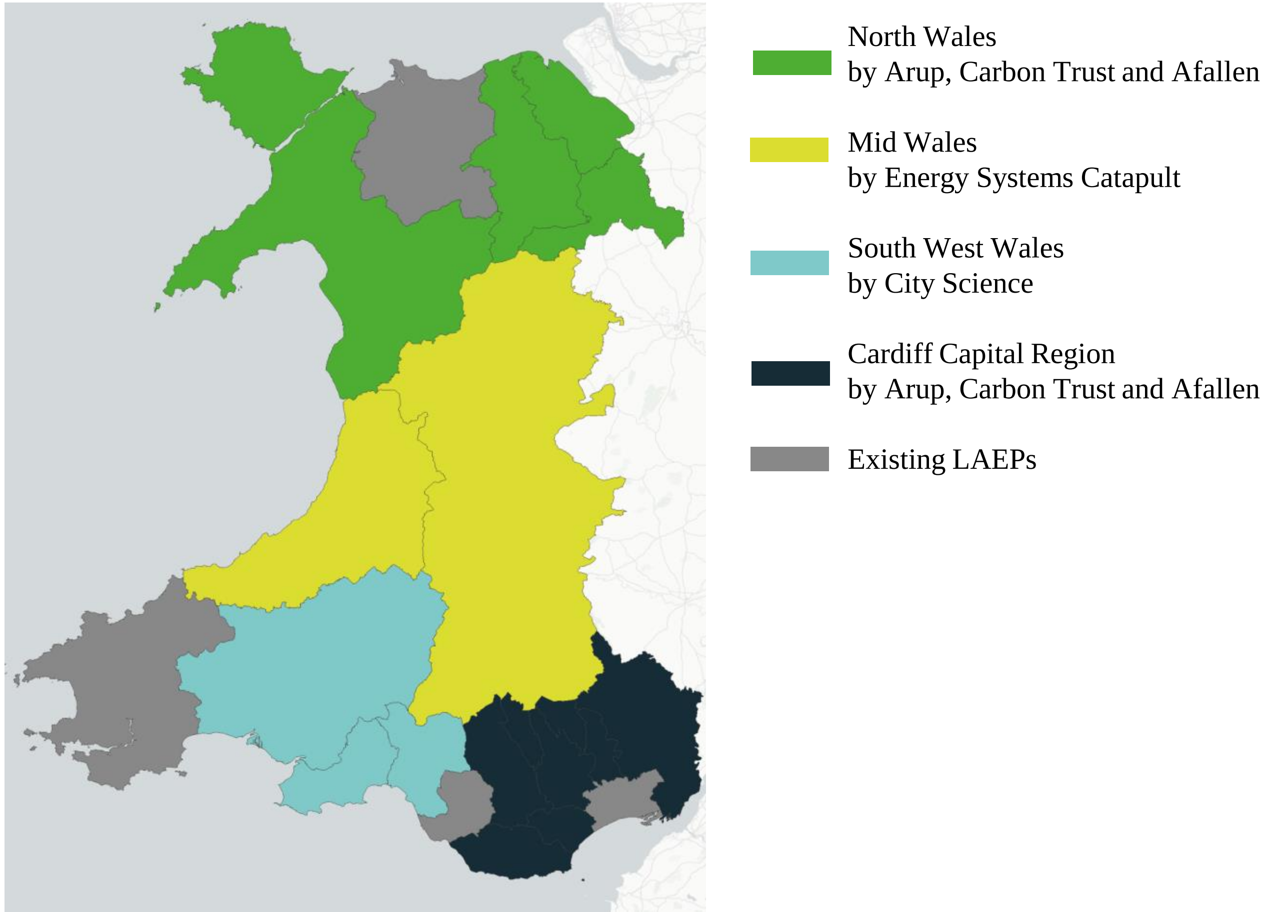


Figure 1.1.2: Progress made in the development of LAEPs across Wales

The local energy system

A LAEP considers energy use, supply and generation within the council boundary.

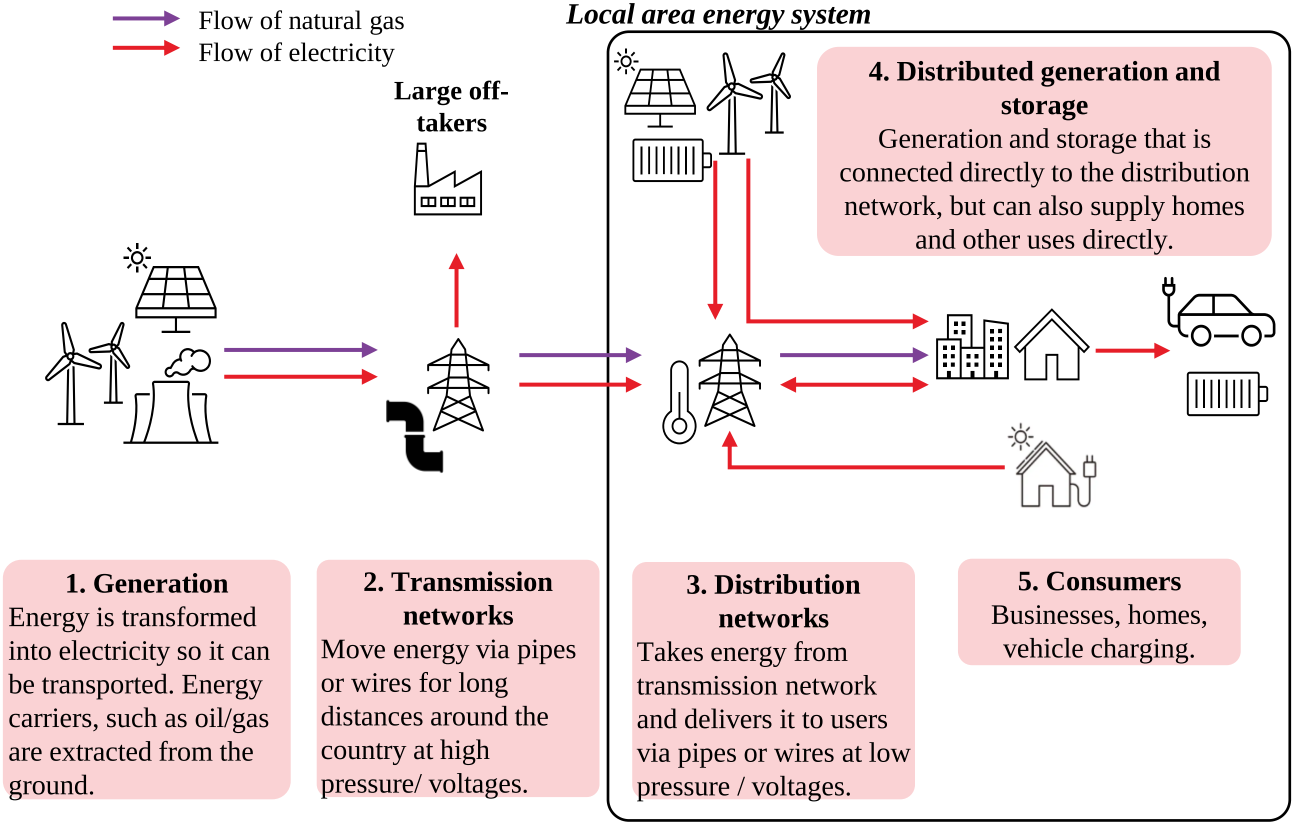
There are three core parts to the local energy system:

Infrastructure – The physical assets associated with the energy system such as electricity substations.

Supply – Generation (renewable and non-renewable), storage and distribution of energy to local consumers for use in homes, businesses, industry and transport.

Demand – The use of energy driven by human activity e.g. petrol/diesel used in vehicles, gas burned for heat in homes is required for the energy system to operate.

Fuel for transport, heat and power in buildings and heat and power for industrial processes and other energy needs are considered together in the planning process to ensure that the interactions and dependencies between the generation and use of different energy sources across different sectors are fully considered. This can also help to identify where different systems can work better together to improve the overall resilience and flexibility of the energy system.



4. Distributed generation and storage
Generation and storage that is connected directly to the distribution network, but can also supply homes and other uses directly.

1. Generation
Energy is transformed into electricity so it can be transported. Energy carriers, such as oil/gas are extracted from the ground.

2. Transmission networks
Move energy via pipes or wires for long distances around the country at high pressure/ voltages.

3. Distribution networks
Takes energy from transmission network and delivers it to users via pipes or wires at low pressure / voltages.

5. Consumers
Businesses, homes, vehicle charging.

Figure 1.1.3: Illustration of transmission and distribution of gas and electricity from supply to consumer, and what parts of this system are included in the system boundary for LAEP

1. Introduction

The local energy system

Boundary

The LAEP is a plan to support the transition of the local energy system to net zero, and therefore requires an understanding of the emissions produced by the local energy system as well as energy supply, use and infrastructure. To do this, the geographic boundary was used to set the boundary of the study, which meant that any energy generating assets, energy use and infrastructure in that boundary was considered for inclusion in the LAEP.

Scope

The scope of the LAEP was then determined based on ESC's LAEP Guidance[T03]. The Guidance states that certain energy assets should be considered national rather than local, where the asset serves the wider energy needs of the UK. Considering this, electricity connection at lower voltages (132kV / 33kV / 11kV) was defined as "local" and included in the modelling for the LAEP. Any assets connected at higher voltages (400kV / 275kV) or with capacities > 100 MW were considered "national" and excluded from the modelling unless otherwise specified. This includes, for example, Connah's Quay Power Station.

If local government has control over the siting of generation/production and associated infrastructure (e.g. through the planning process) then it is local energy production. When permitting for siting and construction is controlled by national organisations (e.g. for offshore wind) then it is national energy production. Energy generation should be considered local where the key input to energy production is a local resource. Energy generation where the key resource comes from outside the local area (e.g., imported biomass) should be considered part of the national energy system.

Like the above, any demand connected to the transmission network is excluded, as we are focused on the local distribution network.

The scope of the LAEP also excludes energy use in shipping, aviation, exports, military transport, and oil refineries because they are considered national decarbonisation challenges and should be addressed by central Government.

Emissions

Emissions from sources that are not related to the energy system are excluded. This includes emissions from land use, land use change and forestry, industrial processes and waste and wastewater treatment processes. Please refer to Appendix B1 for a summary of emissions in scope.

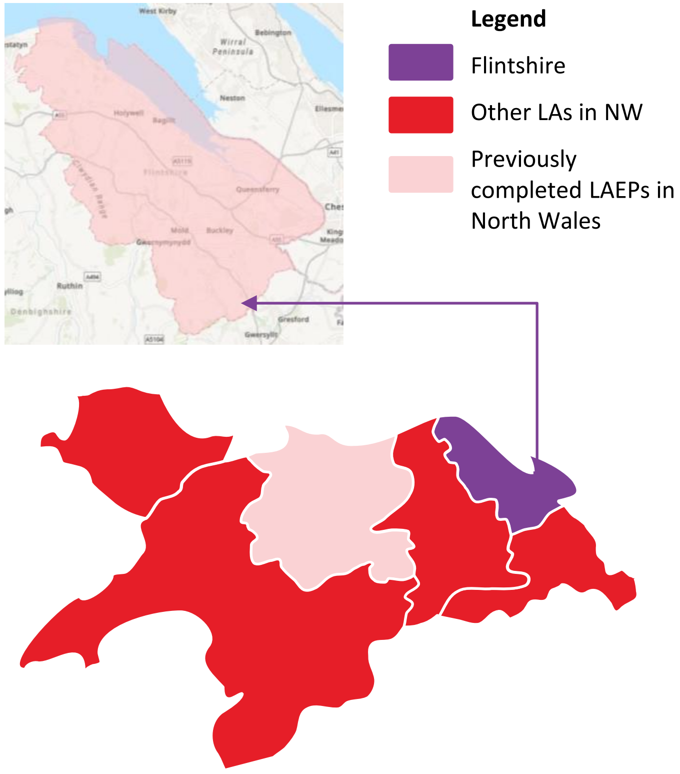


Figure 1.1.4 Location of the North Wales economic region (red) and the LAEP system boundary for Flintshire (purple)

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Chapter 2: Stakeholder engagement (stage 2)

2. Stakeholder engagement

Stakeholder identification process

This section provides a detailed overview of the stakeholder identification and prioritisation process. It describes the methodology and definitions used to understand and identify the stakeholders relevant to a local authorities.

1. Stakeholder definitions and roles

Specific definitions and roles are included in the introduction (see Table 2.0.0 overleaf). Our approach was particularly guided by the imperative to involve a broad cohort of secondary stakeholders with specific local knowledge, experience and / or influence over the local energy system within the local authority area. As LAEP is a whole systems approach at the local authority level, so we needed individuals from a broad range of stakeholder organisations with the appropriate level of local expertise and local knowledge. To avoid stakeholder fatigue and to ensure we addressed regional synergies we created the additional regional secondary stakeholder group described in the introduction.

2.Stakeholder identification and mapping

A pre-developed stakeholder mapping tool was provided to each local authority to collect stakeholder data, both for organisations and appropriate target individuals. These were reviewed with the LAEP programme teams so that their wider knowledge of the local energy system and potential stakeholders could be used to jointly iterate and continuously improve the final stakeholder map. The mapping tool was then used to allocate identified stakeholders to either a primary or secondary stakeholder role based on a scoring schema that reflected their respective knowledge and influence of the local energy system.

3. Stakeholder engagement planning

We reviewed the scored stakeholder lists with each Local Authority and ANW and using the results from the analysis completed in stage 3, we ensured that where possible, stakeholders that represented key components of the local energy system were considered, for example, where industry is a key component, stakeholders were identified.

4. Limitations and mitigation

Some limitations applied to our stakeholder mapping, and we undertook mitigations to address them as far as possible:

1. Knowledge within the local authority team of the local energy system and participants with high levels of local knowledge and / or local influence. Mitigated through iterative reviews of the developing stakeholder mapping and inclusion of the wider programme team's local knowledge and experience of stakeholders across all relevant sectors in each local authority.
2. Sufficient data and information on stakeholder organisations was needed to identify appropriate individual(s). Mitigated by networking with participants, continuous improvement, promotion of LAEPs locally.

2. Stakeholder engagement

Stakeholder identification process

Stakeholder group	Organisations	Role in LAEP development	Method of engagement
Primary stakeholders	Local Authority officers, council member(s), energy network operators i.e. Distribution Network Operators, (DNOs) and Gas Distribution Networks (GDNs).	Responsible for the creation of the LAEP, as well as having executive decision-making powers. Contribute existing and future policies and programmes relevant to the LAEP.	Steering groups, workshops, bi-weekly meetings, emails, 121 interviews
Secondary local stakeholders	Other local government organisations, major energy users, organisations with influence over and / or local knowledge of specific energy system components (e.g. developers, housing associations), community energy organisations, local organisations active in net zero and decarbonisation, transport sector organisations	Responsible for shaping the direction and actions collectively agreed in the LAEP. Contribute advice and guidance to the LAEP programme given influence over and / or local knowledge of specific element(s) of the local energy system, e.g. share details of existing programmes and projects.	Interactive workshops
Secondary regional stakeholders	Transmission network operators, transport providers, housing associations, growth deal organisations, landowners, national parks, further education, public bodies or national organisations (e.g. TfW) with a regional influence, trade organisations.	Responsible for shaping the actions and considering opportunities to deliver at scale across local authority boundaries by providing advice and guidance given regional influence and / or knowledge of specific elements of the regional energy system.	Interactive workshops
Technical advisors for LAEP	Energy Systems Catapult (ESC).	Ensuring a consistent approach is taken to the development of LAEPs in Wales.	Monthly meetings and invited to attend all workshops

Table 2.1.1: Overview of engagement activity for identified stakeholder groups

2. Stakeholder engagement

Overview of stakeholder engagement plan

This section describes the methodology used to engage with primary and secondary (local and regional) stakeholders throughout the programme.

1. Contract meetings

As part of the overarching programme, a national forum brought together all suppliers, local authority leads, the regional leads, Welsh Government and the Technical Advisor to share learnings and maintain a consistent approach across Wales. The suppliers and regional leads also had regular catch ups to share assumptions and challenges.

We held regional steering groups for Cardiff Capital region/North Wales, attended by the regional and local authority leads, as well as bi-weekly meetings with the local authority leads.

2. Interactive, online workshops

Interactive online workshops were used as the primary means of engaging with both primary and secondary stakeholders. The benefits of using them included: reduced time commitments for participants ensuring attendance was maximised, the interactivity of workshops allows participants to contribute dynamically, e.g. verbally, chat, Miro boards, enabling a broader data collection via these interactive tools, and the ability to cost effectively deliver multiple workshops. As well as enabling local workshops to be delivered the use of virtual workshops meant regional stakeholder workshops were easier to convene.

3. Approach to workshops

The purpose of each of the interactive workshops were tailored to the objectives of respective stage of the LAEP. Agendas were constructed to deliver the purpose(s), see Table 2.0.1 overleaf. For each agenda item a clear aim was set that supported achievement of one or more of the workshop's purpose. Using the research question(s) and / or outcome needed to achieve the aim presentation material, exercises, facilitation material and appropriate means of data collection were created.

4. Workshop data collection, analysis and synthesis

Appropriate means of data collection were used to ensure a complete and accurate record of participants responses was made. These included:

- Workshop recordings
- Chat transcripts
- Workshop exercises requiring inputs in response key research questions best presented and facilitated visually used Miro boards
- Post-workshop emails and follow-up interviews

Analysis, evaluation and synthesis of data was undertaken to achieve the workshop outcomes. Examples include: identification of comments relating to missing data in material presented, evaluation and synthesis of the data to identify key themes emerging from a synthesis of collected data.

5. Limitations and mitigation

Some limitations applied to our methodology, and we undertook mitigations to address them as much as possible:

Potential risk of a lack of structure to the data collection given the open discursive nature of workshops. Mitigated through clear workshop briefings, purpose(s), agenda and sound facilitation to ensure participants had a range of opportunities to contribute and group discussions remained focussed on the research questions.

Potential risk participants have a personal preference for text based or commercial reason for not contributing comments in an open forum. These were mitigated through the use of chat, and facilitation introducing chat comments on participants behalf, and the opportunity to contribute for an extended period after the workshop by email.

2. Stakeholder engagement

🟪 Regional
🟥 Local

Overview of stakeholder engagement plan

LAEP stages>>	1	2	3	4	5	6	7
Objectives / Purposes	Governance set-up. Identify relevant regional policy and strategic drivers for work and create objectives Review stakeholder mapping	Review constituents of the local energy system Review the local energy system baseline. Review potential scenarios	Agree regional scenarios to be used in the LAEP modelling Identify local scenarios for each LA Review regionally consistent assumptions for LAEP modelling	Review potential futures for the local energy system Determine 'low regrets' near-term propositions Understand local barriers and enablers	Review near-term, low regrets propositions Share deployment pathways to net zero. Identify local and regional actions and responsibilities	Identify opportunities for regional collaboration and focus from local discussions.	Launch of LAEP report
Key outputs	Objectives for the LAEP Stakeholder mapping refined	Set local strategic energy objectives, local policy drivers.	Agree four future energy scenarios, as well as a reference “do-nothing” scenario.	Identify low-regrets, near term energy propositions.	Agree collective action to address barriers to delivering energy propositions locally	Agree regional actions and responsibilities to support the delivery of the local propositions	Final comments
Technical advisor	🟪	🟥	🟪	🟥	🟥	🟪	🟥
Primary	🟪	🟥	🟪	🟥	🟥	🟪	🟥
Regional	🟪		🟪			🟪	
Secondary		🟥		🟥	🟥		🟥

Table 2.1.2: Groups of stakeholders engaged at each stage of the LAEP process

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Chapter 3: The current energy system (stage 3)

Methodology

3. The current energy system

Methodology overview

This section provides a detailed overview of the energy system baseline, and describes the methodology and assumptions used to understand current energy infrastructure, what types of energy are used, what technologies are used to convert it from one form to another (e.g. heat) and how much is consumed.

1. Data collection

We compiled energy consumption data and the capacities for existing energy generators across Flintshire from local and regional sources, prioritising the highest level of granularity possible. We circulated a Request for Information (RFI) to the Local Authority to gather council-owned datasets and policy documents to inform the broader context for renewable energy in the area. Sectoral datasets were sourced through other organisations such as Transport for Wales (TfW), distribution network operator (DNO) and the gas distribution network operators (GDN) where relevant. Publicly available data sources and existing databases were also used where appropriate. The resulting dataset comprised of six core modules; buildings, transport, industry, renewable energy, heat networks, and energy supply infrastructure. Detailed methodologies for each of these modules are outlined overleaf.

We collected baseline data for 2023 to include the most up to date data for housing stock and renewable generation installations. The exception to 2023 datasets was for transport (2019 for North Wales) and industry data (2019). Transport and industry datasets are the least likely to have changed in terms of electrification over the years 2019 to 2023, and transport is the most likely dataset to have changed due to COVID-19.

2. Data validation

The calculated results were cross-referenced with existing datasets to evaluate their accuracy. This validation process was essential to understand any discrepancies between datasets and ensure the overall precision of our reporting. The Department for Energy Security and Net Zero's (DESNZ) (formerly BEIS) sub-national total final energy consumption dataset[T05] formed the main source of validation, with other datasets also considered for other emission sources.

3. Data analysis

Maps were generated to present spatial information related to the current energy system to support analysis.

1. **Context:** maps showing socioeconomic and energy efficiency data.
2. **Demand:** maps showing electricity, heat/gas and transport demand data.
3. **Infrastructure:** maps showing primary substation demand headroom, generation head and the proportion of properties that are not connected to the gas.
4. **Supply:** maps showing energy generators.

Methodology – electricity and gas network infrastructure

Electricity

Capacity data was combined with the corresponding primary substation service area, assigning primary substation capacity and headroom to each service area.

Each 11kV cable was mapped to a primary substation, and then to a Local Authority boundary. Where primary substation service areas intersected one or more Local Authority boundaries, they were divided into smaller modelling zones at the boundary. The capacity of the primary substation was then distributed proportionally among its constituent modelling zones based on the modelling zone's area as a fraction of the primary substation service area.

In some cases, these primary substation did not have corresponding capacity and/or headroom. For modelling purposes, they were assigned an unlimited capacity.

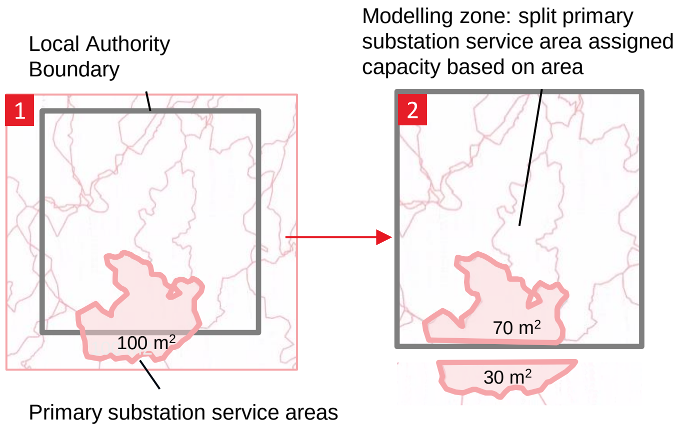
For five small areas in the North Wales region, there was no data provided. These areas with data gaps were referred to as modelling zones, with an unlimited capacity for modelling purposes.

Exclusions

This piece of analysis only considers the distribution network, as the transmission network is considered a national asset and therefore out of scope of the LAEP.

Gas

We used the percentage of off-gas homes derived EPC data[T07] to understand the extents of the existing natural gas service area. The EPC data contains address-level statistics for around 60% of homes, including information on heating type. The percentage of off-gas homes in the current system is the proportion of domestic EPC records that are not heated by natural gas. To extrapolate the on- or off-gas designation to buildings without an EPC rating, we created building archetypes and extrapolated the statistics using a nearest-neighbour extrapolation method.



*Note: areas shown here are theoretical values.

Figure 3.1.1: Process of mapping primary substation service areas to the local authority boundary

Data input	Data source	Data type	Data quality
Primary substation service areas and headroom	SPEN Open Data Portal[T06]	Primary	Five small areas in the north Wales region were not included within any SPEN substation zones.
Off-gas grid homes	EPC data[T07]	Primary	Heating-type data available for ~60% of homes

Table 3.1.1: Electricity and gas network infrastructure – data sources

3. The current energy system

Methodology – electricity and gas network infrastructure

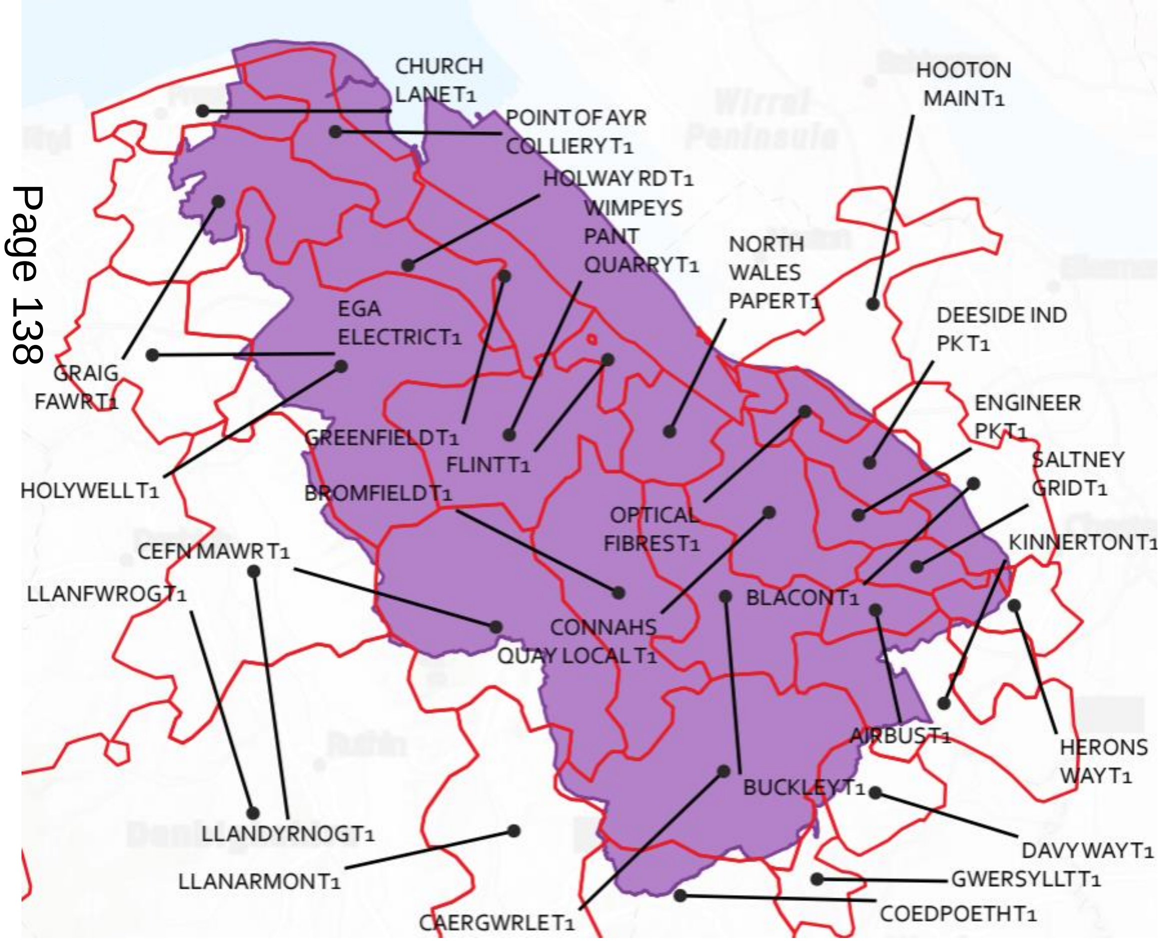


Figure 3.1.2: Map of substation zones in Flintshire

Figure 3.1.2 shows the geographic boundary of Flintshire county borough (purple) which is also the boundary used for Flintshire’s LAEP. The primary substation service areas that supply energy within the geographic boundary are shown in red. Where primary substation service areas intersected one or more Local Authority boundaries, they were divided into smaller modelling zones. Most of the analysis, results, and maps in this report are presented in terms of these smaller modelling zones, which may also be called “substation zones” or simply “zones.”

Key

🟥 ANW substation zones

🟪 Local Authority

Methodology – buildings energy demand

Carbon Trust has a well-established address-level database that uses a “bottom-up” approach for both domestic and non-domestic properties. The Carbon Trust’s address-level model enables a more accurate assessment of building-level energy demand and provides a detailed platform for assessing decarbonisation measures and scenarios.

We created an address-level database for this assessment by combining energy performance certificate (EPC) and council data with Ordnance Survey (OS) AddressBase[T08].

For properties with no EPC record, we extrapolated insulation statistics at the postcode level. See Appendix B3.

Where possible, we supplemented this database with council-supplied data to improve the accuracy of energy consumption statistics.

Data input	Data source	Data type	Data quality
Address-level attribute data (property type, insulation, construction age, heating fuel etc.)	Domestic & non-domestic EPC, display energy certificates (DEC)[T07]	Primary	Approximately 60% of building stock covered. Attributes extrapolated to remaining buildings based on closest neighbours. Last updated April 2023.
Outline polygons for buildings (GIS mapping)	OS AddressBase Plus[T08]	Primary	Quality assured by GeoPlace and contains the most extensive and accurate information available. Last updated April 2023.
Gas and electricity consumption data	Council-supplied data	Primary	Council-owned stock only.
Domestic heat and electricity demand profiles	Profiling tool commissioned by NGED and developed by Hildebrand[T09]	Secondary	Uses data from approximately 10,000 smart meters from across the UK categorised by archetype to estimate average electricity and heat demand profiles.
Non-domestic heat, electricity and cooling profiles	CIBSE non-domestic electricity and gas benchmarks[T10] and Arup’s normalised profiles	Secondary	Building profiles used have been tested against other buildings of the same type.

Table 3.1.2: Baseline data sources (buildings)

Methodology – buildings energy demand

We categorised all domestic and non-domestic properties into a numbered list of archetypes based on the following parameters:

- Property type and built form (e.g. Detached house, top floor flat)
- Construction age (before/after 1930)
- Level of insulation
- Prevalence of building type in Wales

An archetype is assigned the median or most common attributes of all properties in the archetype category. E.g. the median attributes for archetype 1 are cavity wall (filled); insulated loft; uninsulated solid floor; 38kWh/m^2 electricity demand; and 114kWh/m^2 annual heat demand.

Data validation

We generated building profiles at the archetype level and aggregated to Local Authority area to compare the annual consumption with DESNZ's sub-national energy consumption statistics[T05].

Differences are expected between this dataset and this approach due to the difference in scope, boundary, technology efficiencies, occupancy and consumer behaviour. The DESNZ's sub-national statistics[T05] are therefore used to sense check our results and scale the fuel consumption where the difference is high Consumption taken from DESNZ's statistics[T05] is 13% lower per domestic address than the bottom-up generated profiles for electricity. One possible reason for the difference is occupancy – the bottom-up method assumes all properties are occupied, which is important for sizing a 2050 electricity network.

For non-domestic consumption, one limitation of the archetype approach is that it does not capture the range of ways floor area can be used in each archetype. See Appendix B3 for a detailed list of energy benchmarks.

Flintshire	% diff
Domestic electricity demand difference	-13%
Domestic heat demand difference*	-16%
Non-domestic electricity demand difference	80%
Non-domestic heat demand difference	89%
Un-occupancy (Census 2021)[T11]	5%
% non-domestic properties with no archetype	56%

Table 3.1.3: Demand differences between sub-national energy consumption statistics and building profiles. *Sub-national statistics reports gas consumption which was used as a proxy for heat demand

No.	Description
1	Detached - after 1930 - medium/high efficiency
2	Detached - low efficiency
3	Terrace - medium efficiency
4	Terrace - before 1930 - low efficiency
5	Semi-detached - after 1930 - low efficiency
6	Semi-detached - after 1930 - high efficiency
7	Semi-detached - before 1930 - low efficiency
8	Semi-detached - before 1930 - high efficiency
9	Flat (any floor) - high efficiency
10	Top floor flat - low efficiency
11	Bottom floor flat - low efficiency
12	Office
13	Retail
14	Hotel/Hostel
15	Leisure/Sports Facility
16	Schools, nurseries And Seasonal Public Buildings
17	Museums/Gallery/Library/Theatre/Hall
18	Health Centre/Clinic
19	Care Home
20	Emergency Services, Local Gov Services, Law, Military
21	Hospital
22	Warehouse
23	Restaurant/Bar/Café
24	Religious building
25	Transport Hub/Station
26	University Campus
27	Other non-domestic

Table 3.1.4: Summary of building archetypes used

Methodology – transport energy demand

Here we explain the approach taken to assess the transport demand baseline. The outputs of this baselining are regional mileage demand maps and the transport values in the baseline Sankey diagrams per local authority.

We used data from Transport for Wales (TfW) transport models[T12] to estimate annual road mileage data between different parts of a local area. TfW's data provided the number of trips between two different 'travel zones' (defined by TfW) on an average day according to vehicle type. In this data, a trip is defined by the transport zone where a vehicle's journey starts and the transport zone where it ends; therefore vehicles which pass through a transport zone without stopping are not counted. We estimated the route distance to be 130% longer than the distance between each area's centre point. This 'route indirectness' factor was based on Arup work from a previous local area energy plan in Wales. We then scaled up that daily mileage value to an annual mileage value.

We then geospatially mapped these annual mileage values from the TfW travel zones to substation zones. We summed over vehicle types to produce the map shown on the right in Figure 3.0.2.

We also estimated the energy consumption in kWh associated with these mileage values using vehicle type-specific kWh/mile factors, derived from external sources of miles per gallon provided in Table 3.1.3: baseline data sources (transport). The sum of this over a local authority resulted in the transport demand value for the baseline.

Exclusions

Note that trips by rail are not included. Rail is considered a national asset.

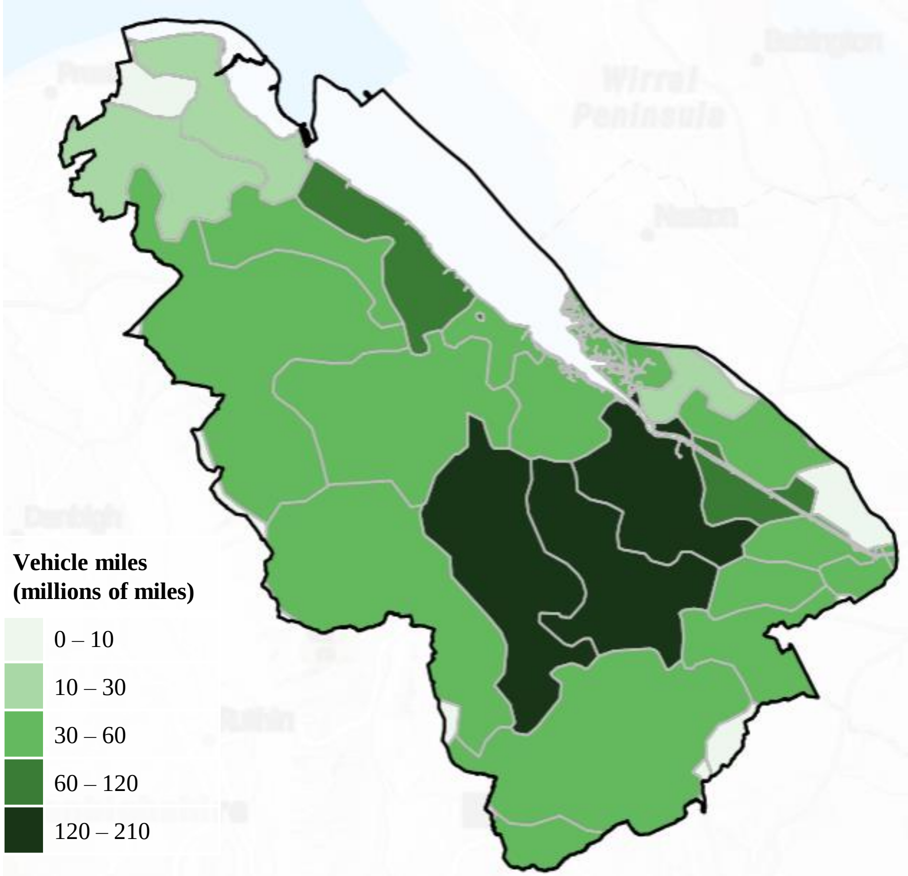


Figure 3.1.3: Estimated annual mileage (million miles / year) for all vehicles in Flintshire by substation zone (2019)

Methodology – transport energy demand

Data validation

We compared our baseline results against two datasets: our mileage values were compared against the Department for Transport (DfT) road traffic statistics[T13], and the energy consumption values were compared against the DESNZ sub-national road transport fuel consumption statistics[T14].

The mileage comparison is on the right, which compares total mileage of all vehicles. We found our estimates to be broadly consistent with the DfT dataset – in some cases above and in some cases below, meaning the differences are likely due to differing levels of route directness in different local authorities.

The TfW dataset was used for our analysis because it was prepared on a zonal basis for each Local Authority, which provided more detail compared to the DfT road traffic statistics which were prepared by Local Authority area.

Please see the energy consumption comparison on the next page.

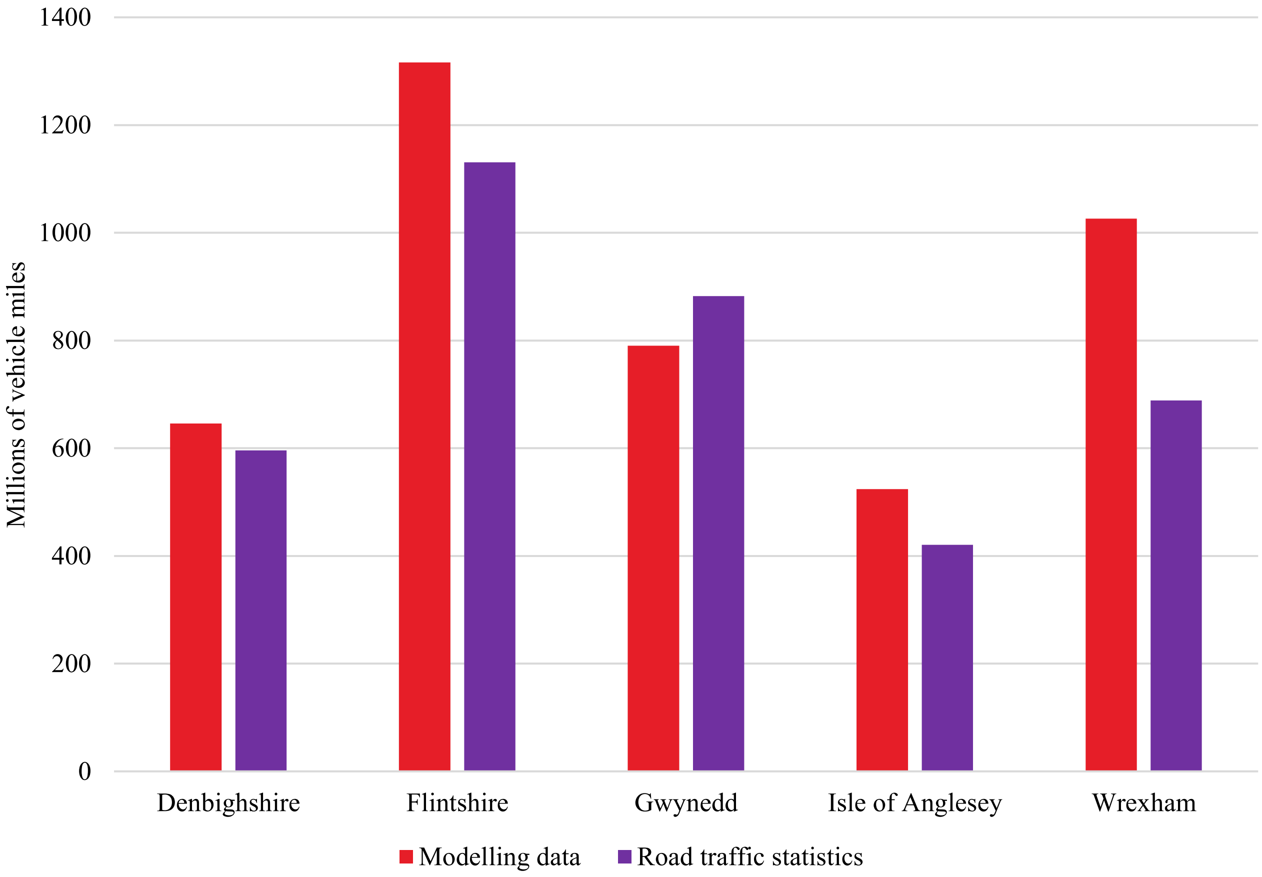


Figure 3.1.4: Comparison of modelling data to DfT road traffic statistics[T13]

Methodology – transport energy demand

The energy consumption comparison is on the right, showing the total energy consumption as estimated by our method and by the DESNZ sub-national fuel consumption statistics[T14]. Our estimates were found to be very consistent with the DESNZ dataset.

Mapping of local electric vehicle charge points

In the baseline maps, we mapped local charge points according to the postcodes supplied in the National Chargepoint Registry[T15] and, where provided, local authority records. For Flintshire's baseline, we used information from the National Chargepoint Registry[T15] so that it was consistent with data sources used across Wales for reporting and have specified any differences in the following sections where they apply. It was decided that any data provided by Flintshire County Council wasn't included in Figure 3.0.4 because it is not clear if (or how many) chargers are duplicated with the mapped National Chargepoint Registry[T15] data.

Exclusions

Note that trips by rail and therefore energy demand from rail transport is not in scope and excluded from the energy baseline. Rail is considered a national asset. Journeys made by off-road vehicles are also excluded.

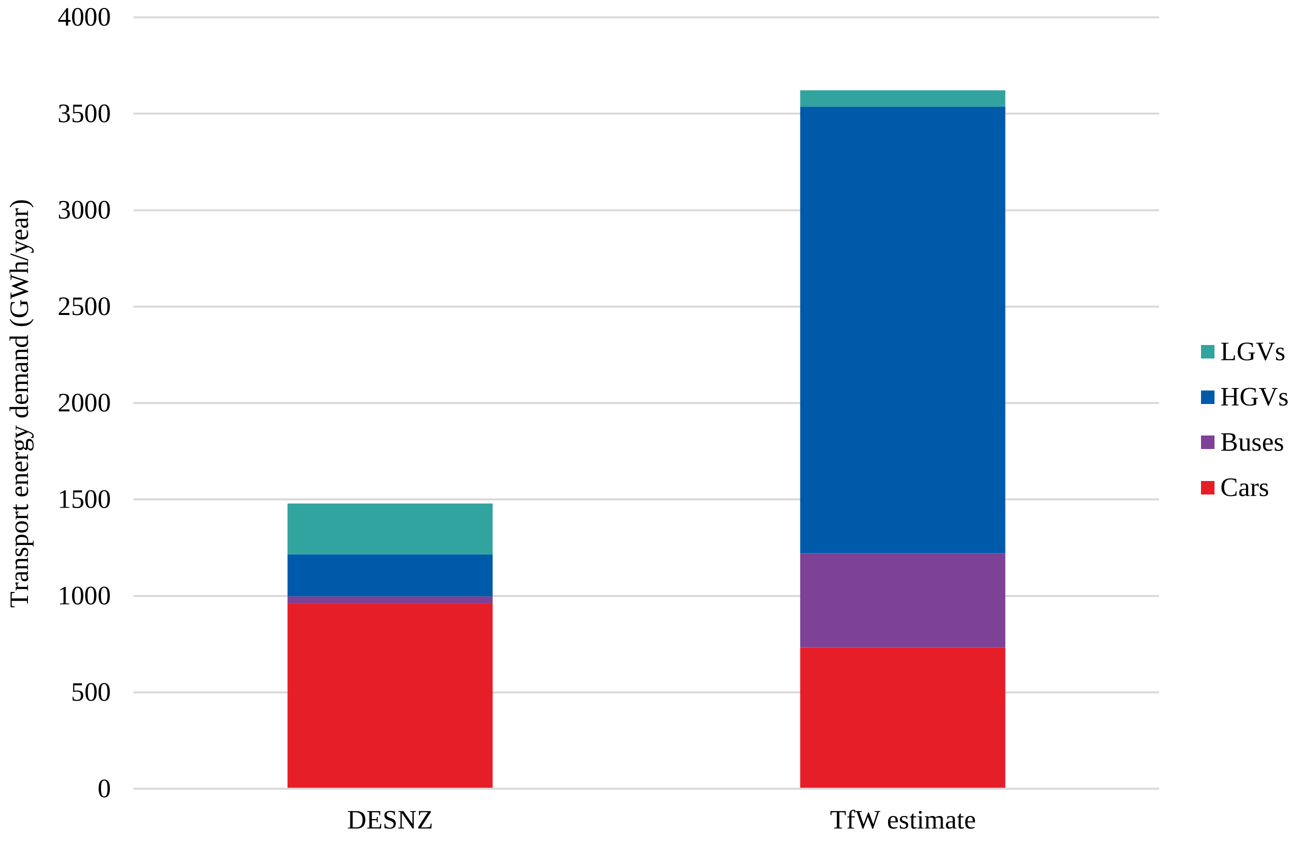


Figure 3.1.5: Annual transport energy consumption; our analysis based on TfW data compared to DESNZ sub-national fuel consumption statistics

Methodology – transport energy demand

Data input	Data source	Data type	Data quality
Demand tables	North Wales Transport Model (NWTM)[TN12]	Primary	Total number of trips between zones for a typical 24-hour period only. Trip distances not available
Miles per gallon values for cars and LGVs	Env0103: Average new car fuel consumption: Great Britain. Assumes average age of 10 years for cars and 9.3 years for LGVs[T16].	Secondary	"Obtained under consistent, carefully controlled laboratory conditions and do not reflect external factors"
Miles per gallon values for HGVs	Env0104: Average heavy goods vehicle fuel consumption: Great Britain. Assumes average age of 11 years[T17].	Secondary	"Obtained under consistent, carefully controlled laboratory conditions and do not reflect external factors"
Miles per gallon values for buses	Transport for London press release (2014)[T18]	Secondary	Does not differentiate between diesel and petrol. Data source is a press release based on London buses; not UK-wide dataset. The miles per gallon value may differ significantly between driving in London and driving in less urban parts of Wales.
Number of diesel vehicles and total number of vehicles	Vehicle licensing statistics data tables (veh0105)[T19]	Secondary	All non-diesel vehicles assumed to be petrol
Postcodes of charge points	National Chargepoint Registry (NCR)[T15]	Primary	Relies on updates by contributors

Table 3.1.5: Baseline data sources (transport)

Methodology – industry energy demand

We identified industrial demands in each Local Authority using the large point sources database from the National Atmospheric Emissions Inventory (NAEI)[T20]. This includes spatial coordinates for each point source that could be used to locate industrial sites.

The NAEI database also contains information on the emissions generated by each site. For this baseline analysis, we only considered carbon dioxide emissions.

To estimate the energy from emissions at each industrial site, we divided emissions by the appropriate carbon emissions factor[T21.]

We sent industry stakeholders an RFI to obtain primary data for the site's annual electricity and gas consumption, to validate calculated industrial energy demands.

Where industrial organisations with large energy demands in Flintshire did not respond to this information request, we used the NAEI emissions to provide a proxy for the energy used by the site. When calculating energy demand, we only considered carbon emissions in the conversion from carbon emissions to energy demand.

Data validation

There was no information on the industrial sites at other sources for cross-referencing.

Exclusions

We omitted national assets connected to the transmission network, as well as assets that did not have any available data.

Data input	Data source	Data type	Data quality
Point source data	NAEI, 2020[T20]	Primary	Only carbon emissions were considered. Other emission types were excluded.

Table 3.1.6: Baseline data sources (industry)

Methodology – local energy generation

We mapped generators identified in the renewable energy planning database (REPD)[T22] to modelling zones in geographic information systems (GIS) using address or postcode.

Data validation

We cross-checked data against the energy generation in Wales (EGW)[T23] 2021 report to capture any operational generators that were not captured in renewable energy planning database (REPD[T22] or SPEN's embedded capacity registers (ECR))[TN24]. This was the latest report available at the time of developing the baseline.

As the EGW dataset[T23] includes ground-mounted generators connected to the transmission network, we cross-checked any additional generators identified in EGW against the transmission embedded capacity register (TEC)[T25] to ensure only generators connected to the distribution network were captured.

Exclusions

Offshore wind generators were not captured. Generators with capacities exceeding 100MW were not captured. Generators that did not include an electricity capacity or postcode/address were not included.

Data input	Data source	Data type	Data quality
Installed renewable electricity capacity (MWe) for ground-mounted solar PV, commercial rooftop solar PV, onshore wind, hydropower, biomass, anaerobic digestion, landfill gas, sewage gas, energy from waste, natural gas, oil.	REPD (January 2023)[T22] ECR (April 2023)[TN24] EGW (2021)[T23] Council-supplied data (where available)	Primary	Distribution-connected generators only. REPD: Renewable generators greater than 150kW*, UK wide, updated quarterly. ECRs: Generators or storage greater than or equal to 1MW, DNO supply area, updated monthly. EGW: Generators connected to distribution or transmission network, Wales-wide, updated annually.
Thermal generator installed capacity (MWth)	EGW (2021)[T23]	Secondary	Generators listed by outward code (first half of postcode) as no full postcode available.
Domestic rooftop solar PV	EGW (2021)[T23] Council-supplied data (where available)	Secondary	Rooftop solar PV data was compiled using feed-in-tariff registers and other micro-generator databases. Generators listed by outward code as no full postcode available.

**the minimum threshold for installed capacity was 1MW until 2021, at which point it was lowered to 150kW. This means that projects below 1MW that were going through the planning system before 2021 may not be represented in the REPD.*

Table 3.1.7: Baseline data sources (local energy generation)

Methodology – Greenhouse gas (GHG) emissions

Generation-based emission factors are factors that measure greenhouse gas (GHG) emissions (in CO_2 equivalent) per unit of electricity generated. These were used in this analysis by multiplying the fuel feedstock for each technology in the scope of modelling, with the relevant emission factor.

GHG emission factors and their relevant sources are presented in Table 3.0.7. Each emission factor is a 2023 estimation except for electricity, where a projection was used to reflect grid decarbonisation.

Exclusions

Emissions associated with the extraction, transportation and distribution of the fuel sources are not considered. Lifecycle emissions of generation facilities are also excluded. Renewable energy generators that generate electricity with no intermediary (e.g. solar PV, wind etc.) are modelled as having no associated GHG emissions

Technology	Value	Units	Source
Biomass	0.0119	$kgCO_2e/kWh$	DESNZ, 2023 (Average of 4 biomass fuels: wood logs, wood chips, wood pellets, grass/straw)[T21]
Coal	0.3226	$kgCO_2e/kWh$	DESNZ, 2023 (Coal - Industrial, Gross CV)[T21]
Diesel	0.2391	$kgCO_2e/kWh$	DESNZ, 2023 (Liquid fuels - Diesel (average biofuel blend), Gross CV)[T21]
Electricity grid	0.045	$kgCO_2e/kWh$	National Grid FES 2023 (averaged scenario, without BECCS). Also includes projection to 2050. [T26]
Landfill gas	0.0002	$kgCO_2e/kWh$	DESNZ, 2023 (Biogas - Landfill gas)[T21]
Natural gas	0.1843	$kgCO_2e/kWh$	DESNZ, 2023 (Gaseous fuels - natural gas, Gross CV)[T21]
Oil/LPG	0.2413	$kgCO_2e/kWh$	DESNZ, 2023 (Average of LPG and Fuel Oil, Gross CV)[T21]
Organic matter	0.0002	$kgCO_2e/kWh$	DESNZ, 2023 (Biogas - Biogas)[T21]
Petrol	0.2217	$kgCO_2e/kWh$	DESNZ, 2023 (Liquid fuels - Petrol (average biofuel blend), Gross CV)[T21]
Sewage gas	0.0002	$kgCO_2e/kWh$	DESNZ, 2023 (Biogas - Biogas)[T21]
Waste incineration	0.038	$kgCO_2e/kWh$	Tolvik, 2021 [T26]

Table 3.1.8: Baseline emission factors (local energy generation)

Sponsors:

Delivery partners:

Technical report

Chapter 3: The current energy system (stage 3)

Analysis

3. The current energy system

Analysis - local context

Flintshire, located in the northeast corner of Wales, serves as a key gateway to North Wales from Northwest England. It stands out with a robust industrial sector, notably in advanced manufacturing, setting it apart from other areas in Wales and the UK. The region is recognised nationally for its employment opportunities and economic significance in Wales, with broader importance to the Northwest sub-region.

Diverse towns, villages, employment parks, and picturesque landscapes define Flintshire. Its unique blend of culture and language is evident across various regions. While two-thirds of its population resides near the border, the rest of the county remains rural, hosting diverse landscapes and habitats.

The county's rich heritage, including conservation areas and listed buildings, contributes to its appeal. The natural and built environment serves as a primary asset, pivotal for conservation efforts, attracting investments, promoting tourism, and ensuring sustainability for residents and businesses.

Most of Flintshire's population resides in the east and along the coast, forming key towns like Buckley, Flint, Holywell, Saltney, and Mold. The Deeside area, particularly the Deeside Industrial Park, acts as a growth hub and a major economic driver, housing key employers such as Airbus UK and Toyota. Flintshire plays a pivotal role in the regional economy, contributing high-value manufacturing employment and demonstrating a positive economic outlook despite global challenges.

Flintshire has excellent transport links to the rest of North Wales and Northwestern England being at the intersection of the A55 and A494. Improving rail links through the North Wales Metro programme is increasing sustainable travel options in the region, with new or improved stations at Greenfield, Shotton and Deeside and enhanced rail frequency along the line.

Flintshire has a strong base in renewable energy production, hosting the largest solar park in the UK. This and other solar farms support some of the vast industrial energy demand in the region. Future developments in renewables will focus on solar PV due to the local constraints on wind energy from flight paths and the Clwydian range and Dee Valley area of outstanding natural beauty (AONB).

Climate change poses various risks, including flooding along the Dee Estuary and River Dee, impacting landscapes, habitats, and community well-being

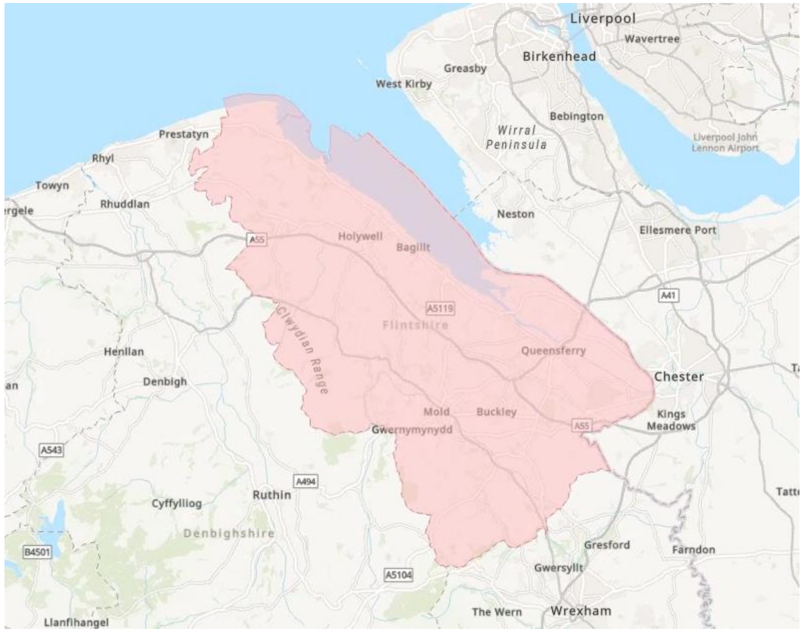


Figure 3.2.1: Map showing the boundary of Flintshire

Analysis – socio-economic context

A household is regarded as being in fuel poverty if they are unable to keep their home warm at a reasonable cost. In Wales, this is measured as any household that would have to spend more than 10% of their income on maintaining a satisfactory heating regime.

In 2021, 9% of households in Flintshire were identified to be in fuel poverty in comparison to 14% of households across Wales[T27]. Across Wales, households living in the private-rented sector were more likely to be fuel poor compared to owner-occupiers or those in social housing. These figures are expected to increase to around 45% in 2022[T27], largely driven by the impacts of the pandemic.

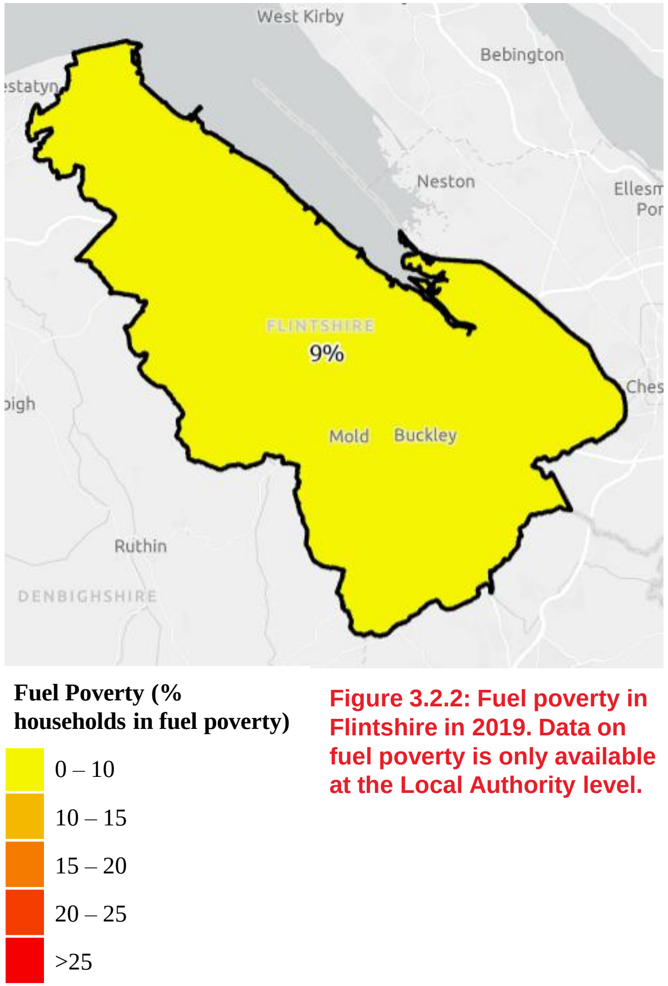


Figure 3.2.2: Fuel poverty in Flintshire in 2019. Data on fuel poverty is only available at the Local Authority level.

The Welsh Index of Multiple Deprivation 2019 (WIMD) is the official measure of deprivation in small areas in Wales. It is a relative measure of concentrations of deprivation at the small area level. Deprivation refers to wider problems caused by a lack of resources and opportunities. The most deprived small area in Flintshire in WIMD 2019 was Shotton and Garden City[T28].

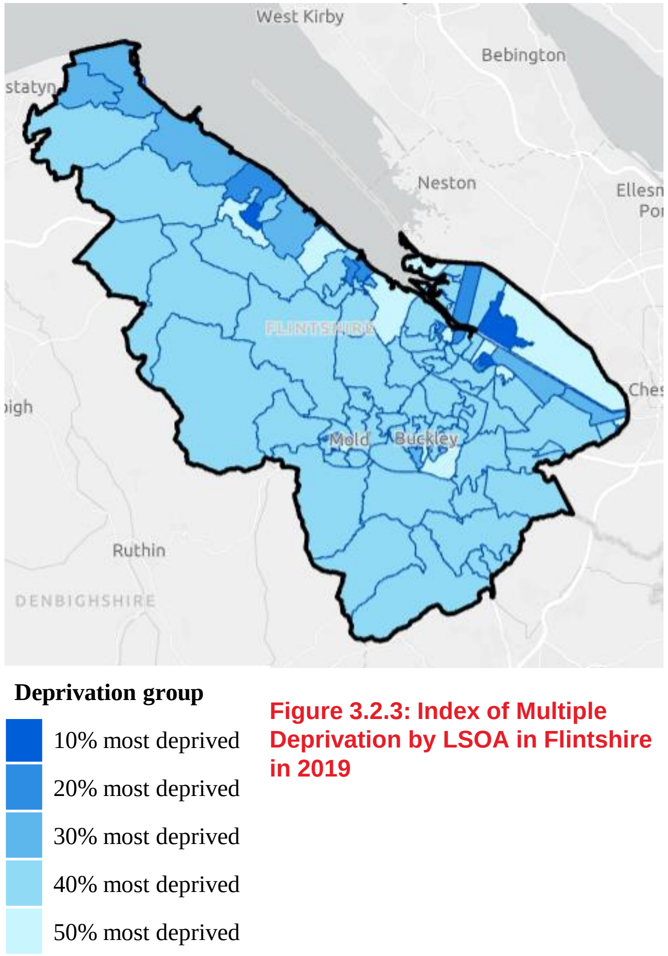


Figure 3.2.3: Index of Multiple Deprivation by LSOA in Flintshire in 2019

3. The current energy system

Analysis – greenhouse gas (GHG) emissions by sector

The figures presented here are emissions produced by the local energy system, as defined in Chapter 2: The current energy system.

The emissions shown in Figure 3.2.4 include:

Buildings: emissions from heating and electricity use from all buildings

Transport: emissions from road vehicles including cars, vans, lorries, and buses. Trains are not included.

Energy: emissions from electricity plants fired by fossil fuel

Industry: emissions from the large industry sites identified from the NAEI emissions dataset

Greenhouse gas (GHG) emissions in Flintshire in 2023 were 1,187ktCO_2e. GHG emissions per capita were 7.6tCO_2e per capita..

The largest contributors were:

- Road vehicles (60%)
  - 52% of total GHG emissions are from the use of diesel in road vehicles
- Energy used in buildings (34%)
  - 29% of total GHG emissions are from the use of natural gas in buildings.

Flintshire's CO_2e emissions are reducing over time.

NB: The emissions in Figures 3.2.4 and 3.2.5 exclude emissions from waste and land use, land use change and forestry (LULUCF).

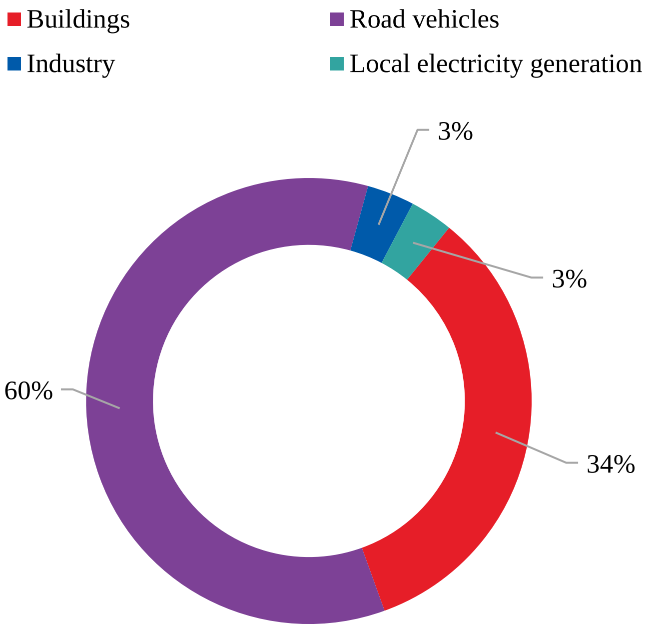


Figure 3.2.4: CO_2 emissions by sector in 2023, excluding LULUCF

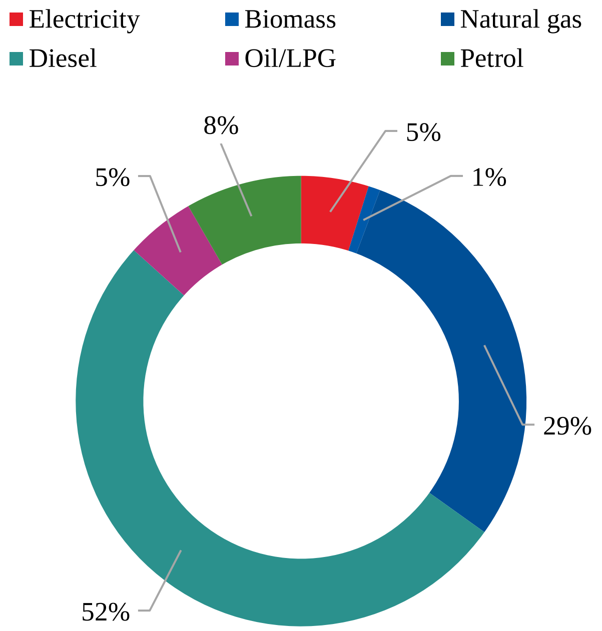
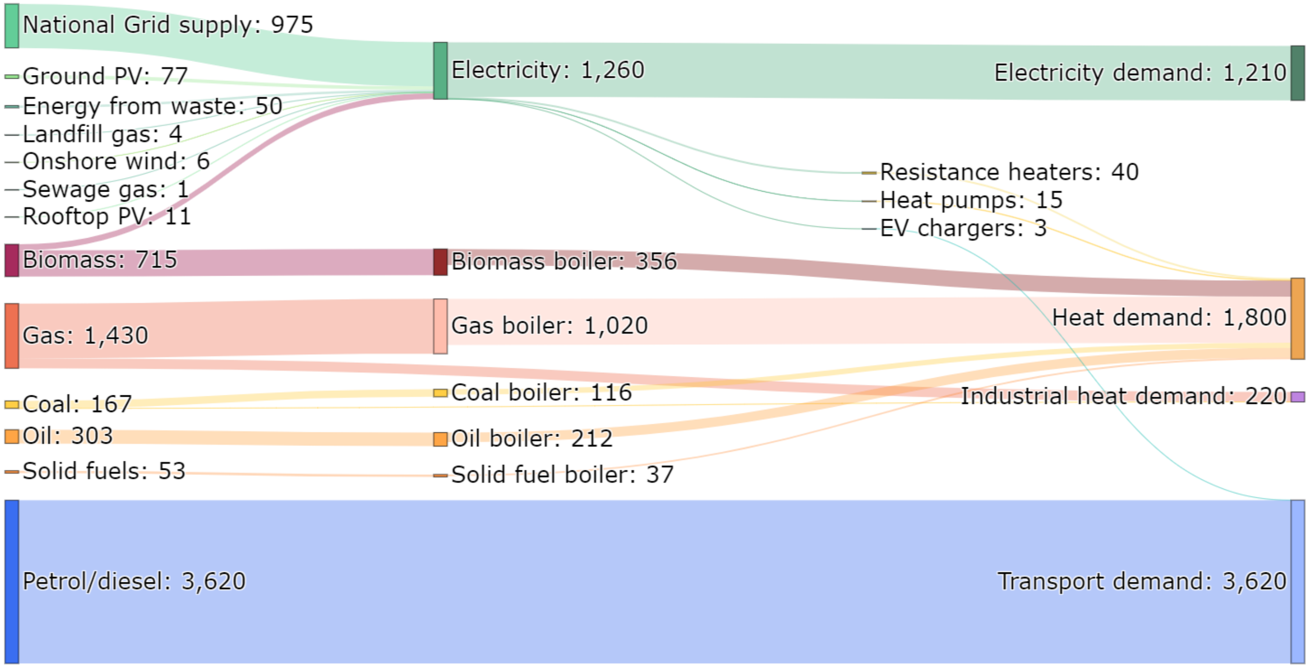


Figure 3.2.5: CO_2 emissions by fuel in 2023, excluding LULUCF

How to read a Sankey diagram

This section provides a detailed overview of the local energy system baseline, and describes the methodology and assumptions used to understand current energy infrastructure, what types of energy are used, what technologies are used to convert it from the form to another (e.g. heat) and how much is consumed. The Sankey diagrams are a way of visualising energy transfer from energy sources to energy demands via energy vectors or conversion technologies. They are read from left to right and show a snapshot of a scenario in time e.g., 2050. Energy transfers are drawn to scale and so are helpful to identify the size of each transfer and compare different scenarios. This page and the following, reflect the energy baseline in Flintshire in 2023, apart from the transport (2019) and industry data (2019). Transport and industry datasets are the least likely to have changed in terms of electrification over the years 2019 to 2023, and transport is the most likely dataset to have changed due to COVID-19.



1. Where the energy comes from
This side represents the different **energy sources**, including generation technologies and imports from the national grid

2. How the energy is being converted

3. Where the energy is being used
This side represents the **final demands** for each energy vector: heat demand, electricity, demand, transport demand.

Figure 3.2.6: How to read a Sankey diagram (units are in GWh/year)

3. The current local energy system

Analysis – annual energy flows

The baseline analysis for Flintshire provides insight into the existing energy system in 2023.

Most of the **electricity** within the system is supplied by the National Grid, accounting for 77% of total electricity consumed.

Ground PV, onshore wind and energy from waste generated, on average, 77GWh, 6GWh and 50GWh in 2019 respectively.

Almost all electricity was used to fulfil electricity demand from buildings and industry (i.e. not heat or transport).

Heating comprises the second largest component of energy demand, accounting for 29% of total energy across Flintshire. Due to the moderately high penetration of the gas network in Flintshire, most properties (82%) have heating delivered by gas. 1,430GWh is supplied to the system to meet demand. The remaining heat demand is met by other fuels such as oil, biomass, coal and solid fuels.

Almost all **vehicles** in Flintshire have internal combustion engines (ICEs), with relatively low uptake of electric vehicles (EVs).

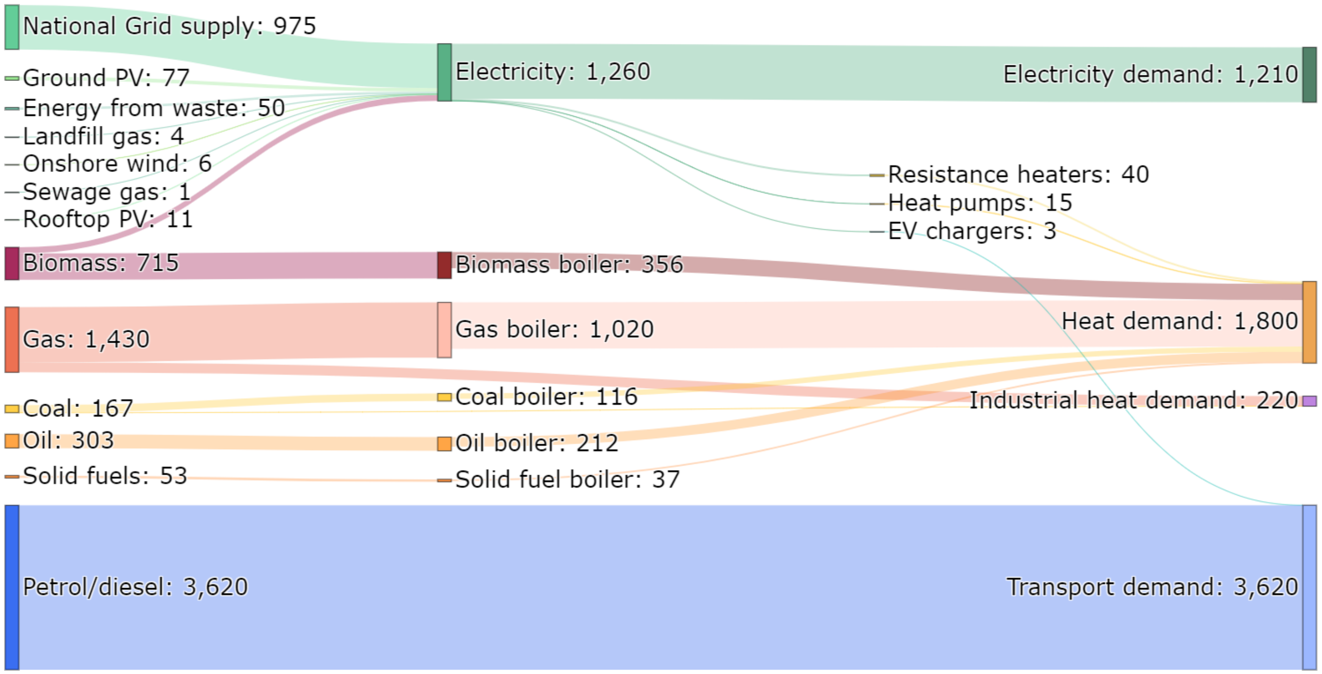


Figure 3.2.7: baseline Sankey diagram, representing energy flows in Flintshire in GWh/year (2023)

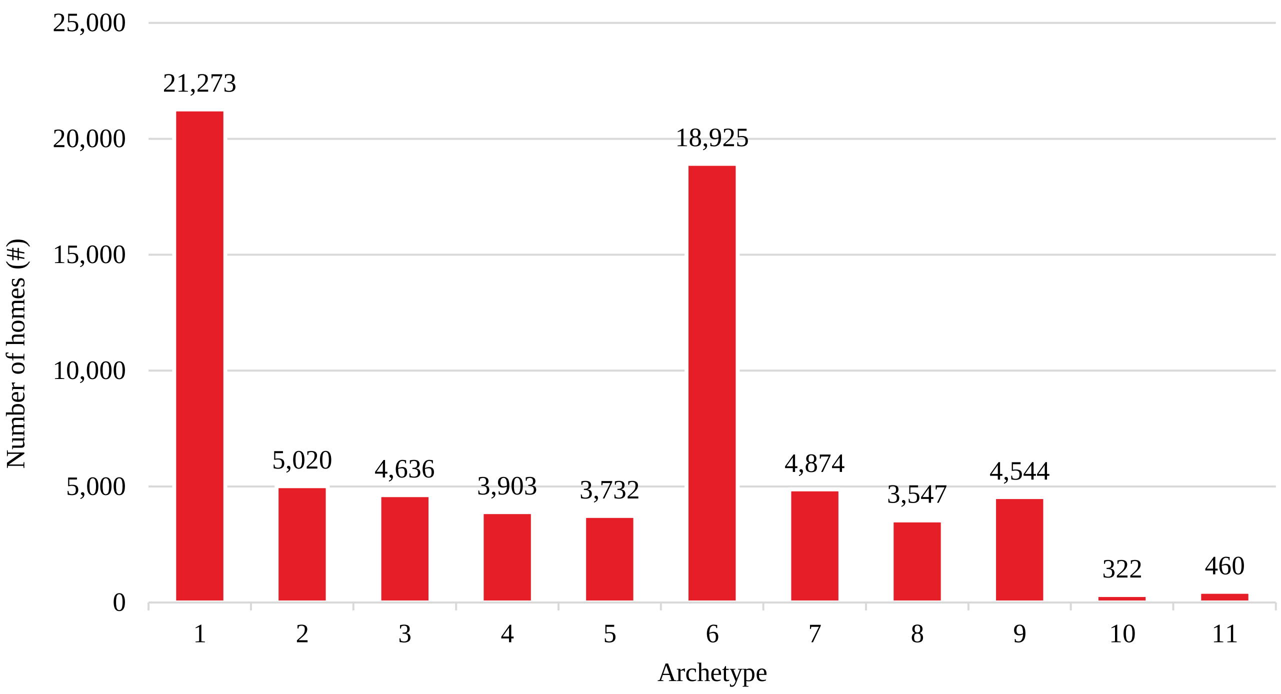
Analysis – buildings energy demand

Heat in buildings constituted 29% of total energy demand in 2023 and domestic heating was responsible for 49% of total heat demand from buildings.

In total, there were 71,236 domestic properties. 81% of homes were semi-detached or detached. Unoccupied homes in Flintshire accounted for 5% of the total stock, this is below the Welsh average of 7%[T11].

82% of homes were connected to the gas grid. This figure was equal to the regional average for Wales[T29], of 82%. Homes that are not connected to the gas network mostly use oil, and to a lesser extent LPG, electricity or a combination for heating.

The energy efficiency of Flintshire's housing stock varies considerably. On average, properties here exhibit below average levels of insulation, influencing their overall energy performance. These distinctions are shown in the EPC ratings, with 42% of properties achieving A-C ratings, above the Welsh average of 40%.



No.	Description	No.	Description
1	Detached - after 1930 - medium/high efficiency	7	Semi-detached - before 1930 - low efficiency
2	Detached - low efficiency	8	Semi-detached - before 1930 - high efficiency
3	Terrace - medium efficiency	9	Flat - high efficiency
4	Terrace - before 1930 - low efficiency	10	Top floor flat - low efficiency
5	Semi-detached - after 1930 - low efficiency	11	Bottom floor flat - low efficiency
6	Semi-detached - after 1930 - high efficiency		

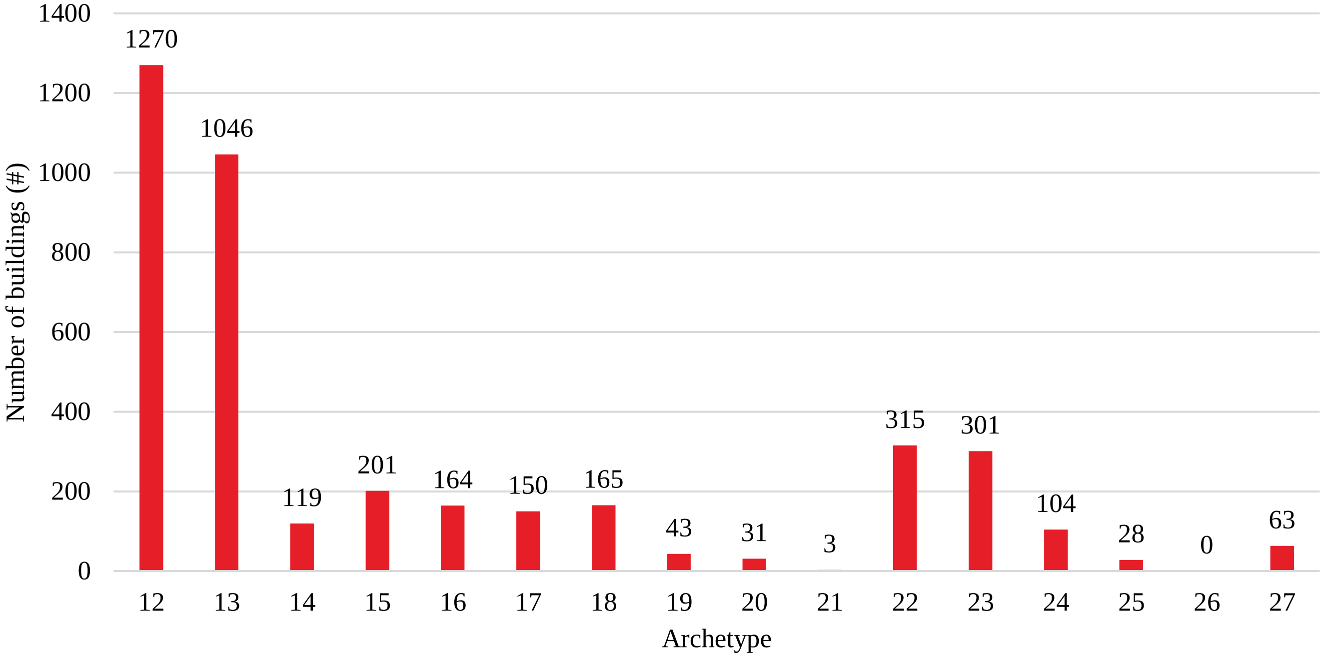
Figure 3.2.8: Distribution of domestic properties by archetype

3. The current energy system

Analysis – buildings energy demand

51% of heat demand in buildings was for non-domestic properties in 2023.

There were a total of 4,003 non-domestic properties with offices being the predominant type, accounting for 32% of non-domestic buildings. 26% of non-domestic properties are used for retail.



No.	Description	No.	Description
12	Office	20	Emergency services, local gov services, law, military
13	Retail	21	Hospital
14	Hotel/hostel	22	Warehouse
15	Leisure/sports facility	23	Restaurant/bar/café
16	Schools, nurseries and seasonal public buildings	24	Religious building
17	Museums/gallery/library/theatre/hall	25	Transport hub/station
18	Health centre/clinic	26	University campus
19	Care home	27	Other non-domestic

Figure 3.2.9: Distribution of non-domestic properties by archetype

Analysis – monthly buildings energy demand profile

Energy demand has been presented on an annual basis in this report, but it’s important to recognise that demand for different sources of energy varies on a monthly and daily basis, and this can influence how we design a net zero local energy system to meet demand. For example, Figure 3.1.9 shows monthly electricity and heat demand. Heat demand is much higher in the colder months compared to the summer months, and electricity demand stays relatively consistent across each month. These trends will influence what technologies or energy sources are best suited to deploy for consistent demands and others that are less predictable and similarly, what types of energy supply might be available all the time (dispatchable) compared to those that are not (intermittent).

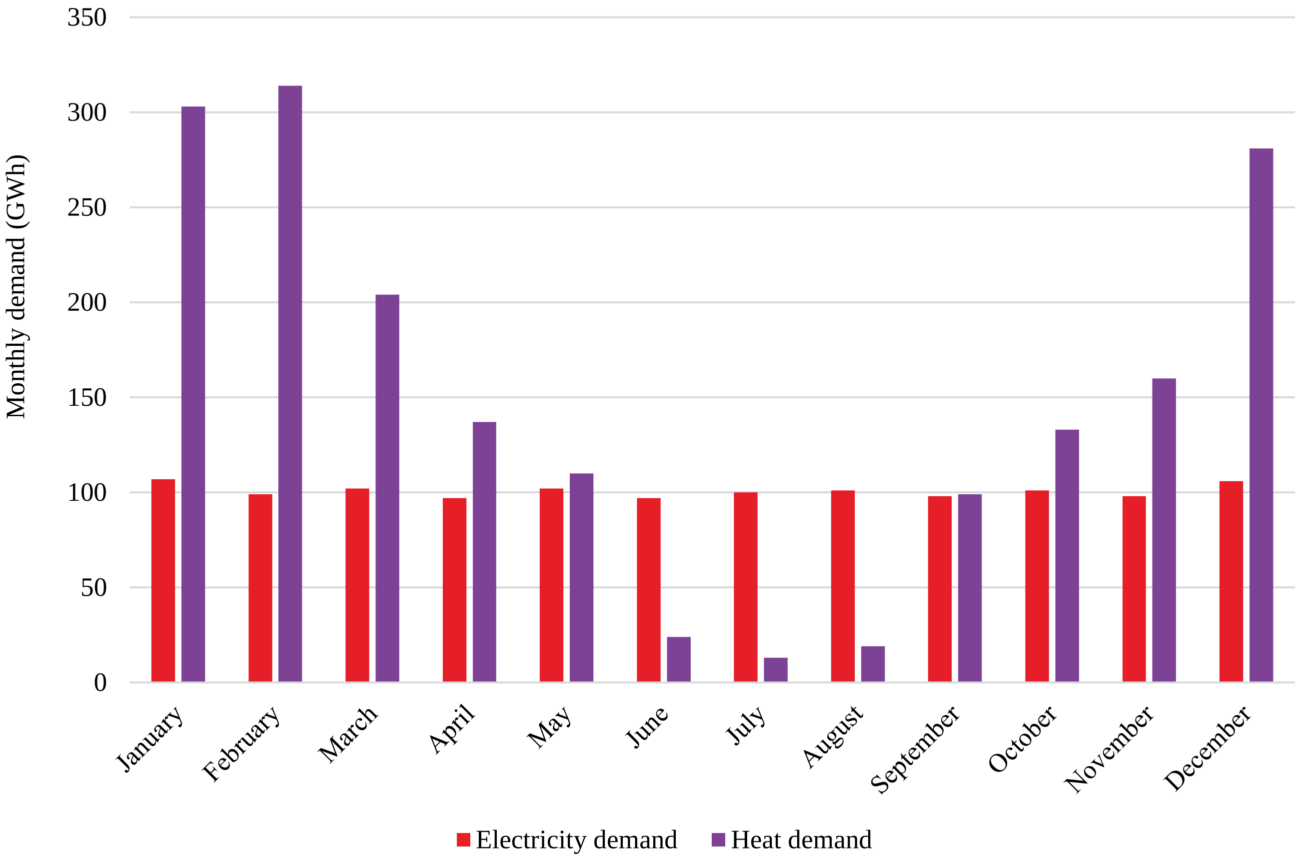
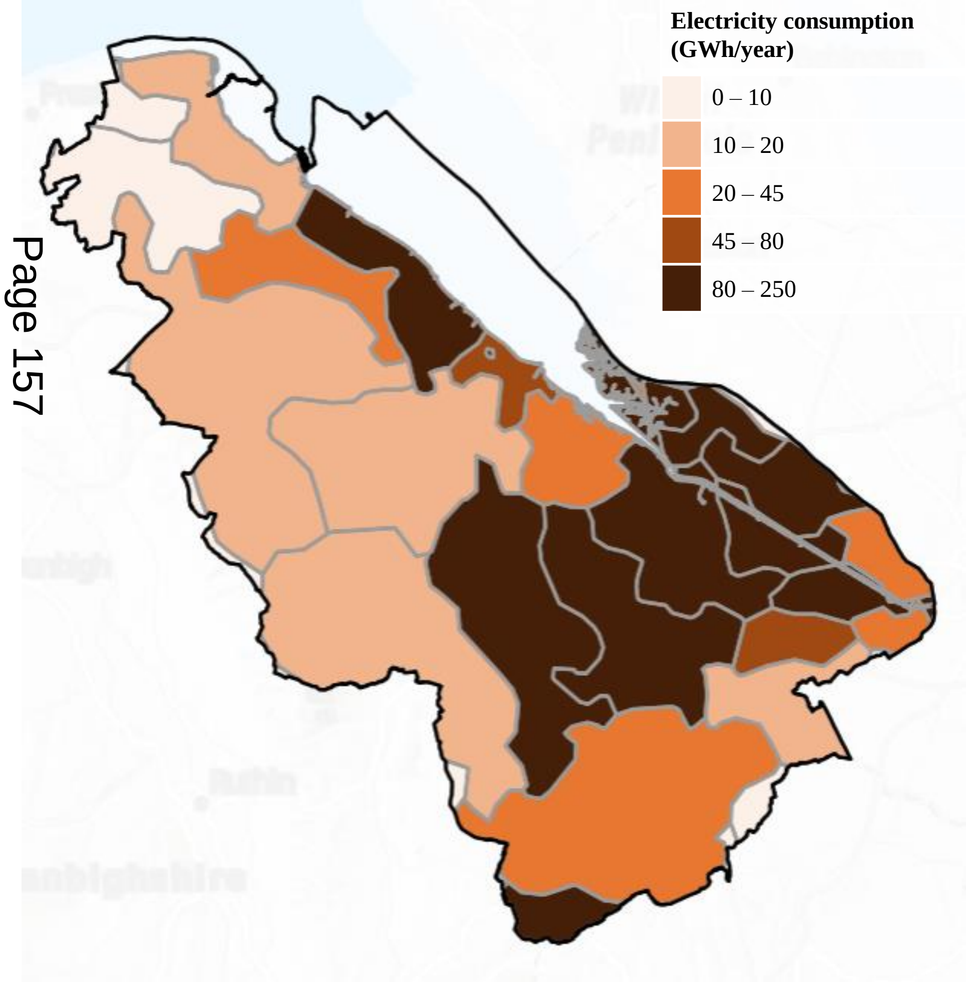


Figure 3.2.10: Monthly buildings energy profile for Flintshire (2023)

Analysis – electricity demand from buildings (GWh/year)



Electricity consumption (total domestic and non-domestic) varied across the area in 2023, except for areas where industrial clusters or larger towns are located (e.g. Deeside, Buckley and Mold) areas with lower population density like Caerwys had lower electricity demands.

Figure 3.2.11: Electricity consumption (GWh/year) (domestic and non-domestic properties) by substation zone across Flintshire (2023). Data is based on meter level electricity consumption data

Analysis – heat demand in buildings and industrial energy demand

Heat demand is generally higher in more densely populated locations like Deeside, Mold, and Buckley. These locations are also where most homes and businesses are located, and therefore the higher gas and heat demand.

The industrial landscape in Flintshire is a pivotal component of its economic framework, encompassing a diverse range of sectors and activities.

Emissions from industrial activities significantly contribute to Flintshire's carbon footprint, totalling 40 ktCO$_2$e in 2023^{T49}. Detailed analysis and data on emissions from industries are integral to understanding the environmental impact and sustainability challenges posed by this sector.

Flintshire hosts a diverse array of industries that play a fundamental role in its economic vitality. These industries encompass manufacturing, technology, agriculture, and services, each contributing uniquely to the region's economic fabric. The nature of industrial sites in Flintshire varies, with a mix of fragmented sites and industrial clusters.

Across Flintshire, several key industrial sites serve as economic anchors and employment hubs. These sites are strategically located and encompass various sectors, including paper, printing and publishing; chemicals; food and drink; and vehicles. Highlighting these industrial centres provides insight into their significance in driving local economic growth and job opportunities. The largest sectors and companies are highlighted below and in Figure 3.2.18.

Mechanical Engineering

- J Reid Trading Ltd (natural gas)

Vehicles

- Toyota motor manufacturing UK Ltd (Coal)

Paper, Printing and Publishing Industries

- Kimberly-Clark Ltd (natural gas)
- UPM-Kymmene (UK) Ltd (natural gas)
- Essity UK Ltd (natural gas)

Other Mineral Industries

- Knauf Insulation Ltd (natural gas)
- Tarmac Trading Ltd (natural gas)

Chemical Industry

- Synthite Ltd (natural gas)
- TS Resins Ltd (natural gas)

Food, Drink and Tobacco Industry

- Farmers Boy Ltd (natural gas)

Minor Power Producers.

- Culvery Power Ltd (natural gas)

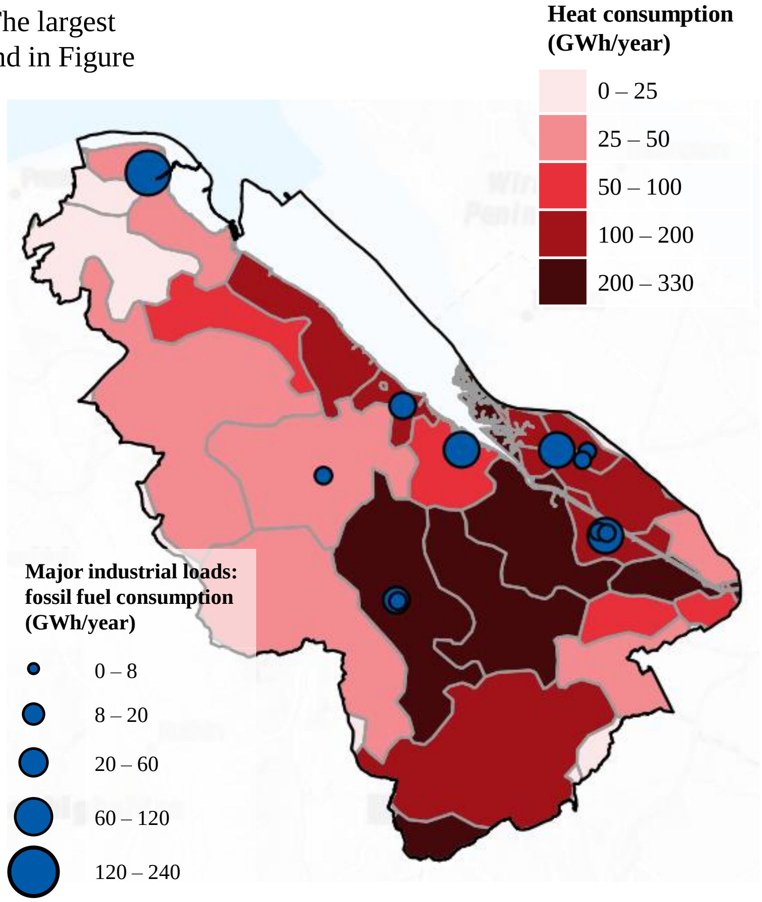


Figure 3.2.12: Major industrial loads (2019) and heat demand (2023) by substation zone across Flintshire. The data is based on meter level gas consumption (MWh/year)

Analysis – buildings energy efficiency

The energy efficiency of Flintshire's housing stock varies considerably. On average, properties have below average levels of insulation (e.g. 26% of homes have <100mm loft insulation and 12% had unfilled cavity walls), influencing their overall energy performance. These distinctions are shown in the EPC ratings, with only 35% of properties achieving A-C ratings, relatively high compared to other local authorities in North Wales. There are a higher proportion of homes on the fringes of Flint, Buckley and with EPC A-C ratings. And there are a lower proportion of homes with EPC A-C ratings in and around the Clwydian Range and Dee Valley National Landscape.

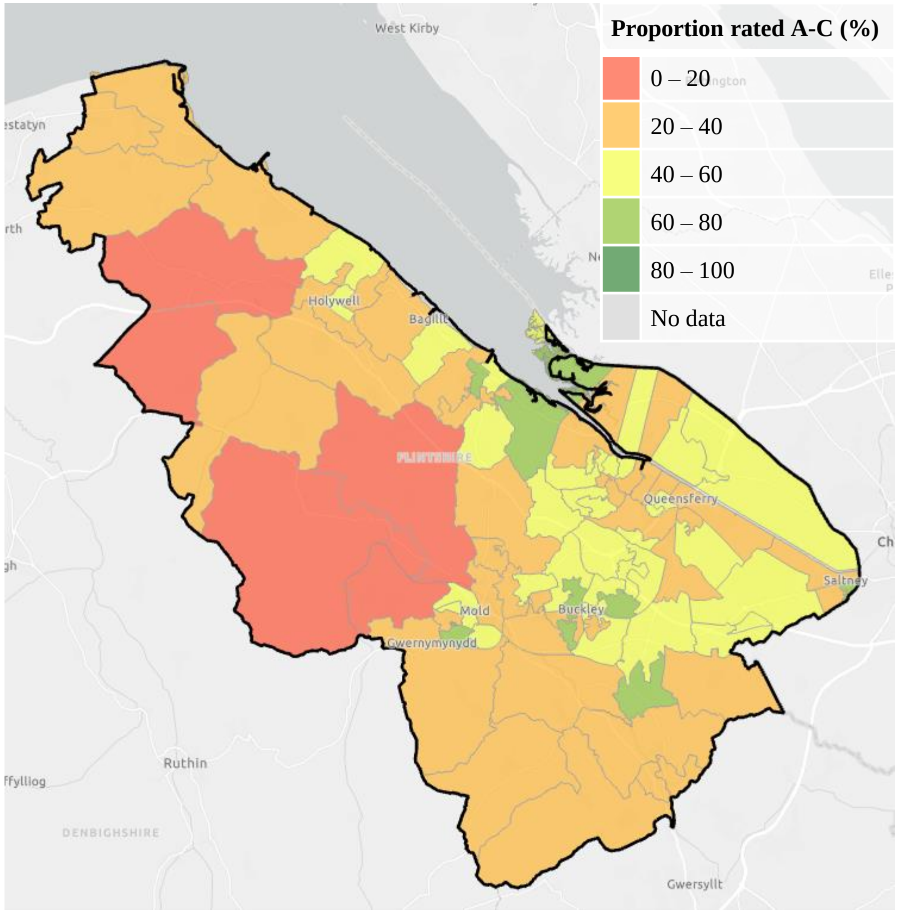


Figure 3.2.13: Proportion of domestic homes by EPC rating in Flintshire by LSOA. (2023)

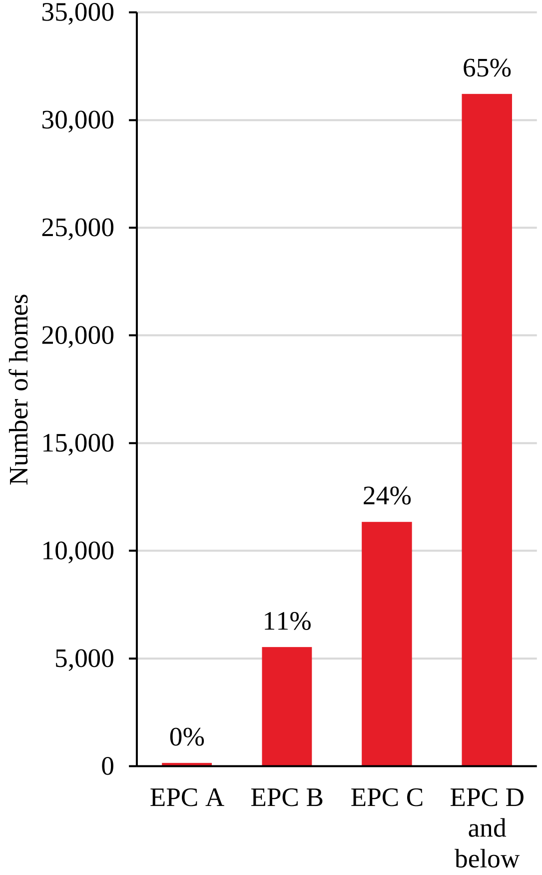


Figure 3.2.14: Energy efficiency of domestic properties across Denbighshire, rated EPC A-C and EPC D and below (2023)

Analysis – transport energy demand

In 2023, transport Flintshire contributed 710 ktCO$_2$e to the total emissions, accounting for 60% of the overall emissions. The primary sources of these emissions stem from private car usage and HGVs, highlighting the need for sustainable transportation solutions.

Flintshire’s proximity to major transportation corridors makes it an attractive hub for businesses in these sectors. This has a significant impact on local employment, fostering economic growth and job opportunities.

HGVs are the main source of transport emissions accounting for over 60% despite only accounting for 29% of mileage due to their higher emissions intensity (gCO2e/km).

In Flintshire, 0.23% of vehicles are electric or hybrid[T40], slightly behind the Wales-wide average of 0.26%[T40]. Flintshire displays a distinctive pattern of car ownership when compared to the national average. 83% of households in the area own cars, with an average of 1.3 cars per household, which is above the national average[T41].

Flintshire County Council has invested in enhancing public transport infrastructure, including the trial of electric buses; improvements to the North Wales metro; development of cycleways; and park and ride schemes aiming to offer residents efficient and sustainable commuting alternatives, reducing reliance on private vehicles.

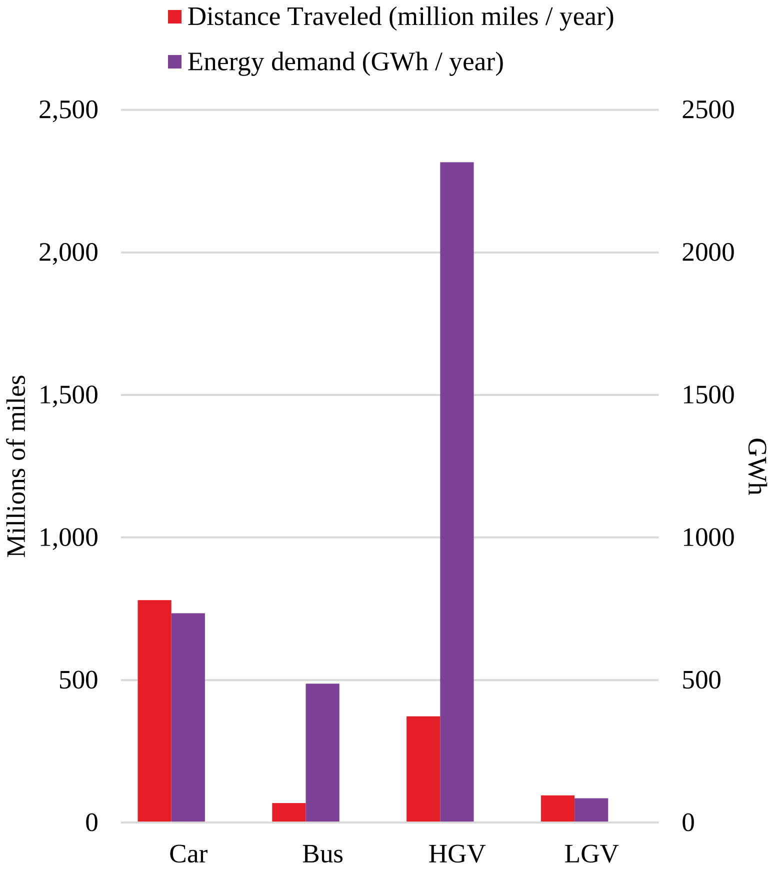


Figure 3.2.15: Total mileage (million miles / year) by vehicle type (2019)

3. The current energy system

Analysis – transport energy demand

Flintshire's transport landscape varies significantly, influenced by its combination of larger towns along the coast and main roads, and rural areas. More rural regions in the west of the local authority see a reliance on private vehicles due to limited public transport options, longer travel distances to essential services, and the practical necessity of cars. In contrast, more densely populated areas such as Mold, Flint or Deeside feature more robust public transport networks, with residents having the option of buses, cycle networks and trains for daily commuting.

According to the National Chargepoint Registry, there were 53 EV charge points in Flintshire in May 2023[T15]. These points are distributed in areas with high EV concentration and along major transportation routes to facilitate convenient charging for residents and visitors.

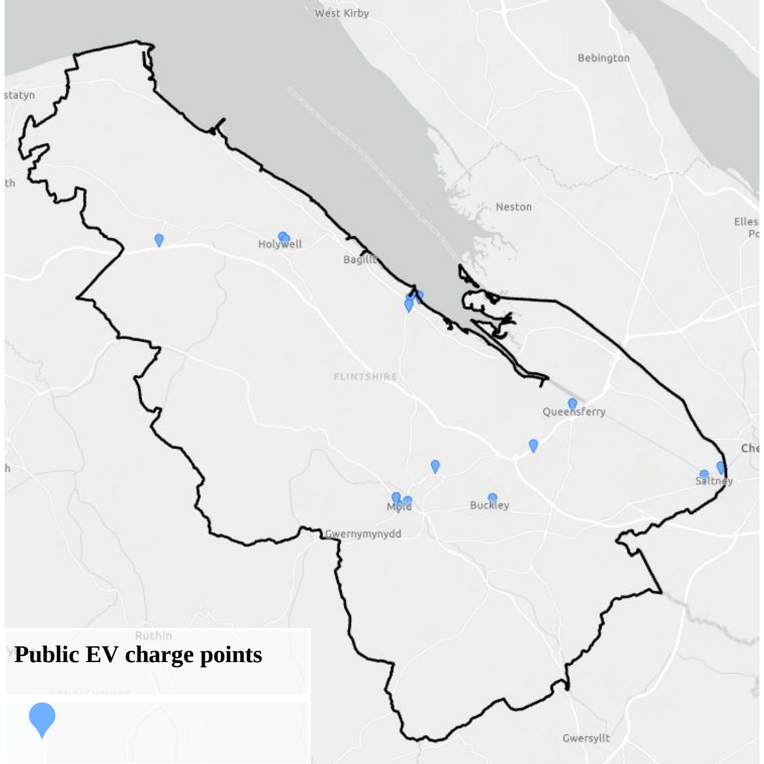


Figure 3.2.16: Public EV chargepoints registered on the National Chargepoint Registry[T16] across Flintshire (date extracted: May 2023)

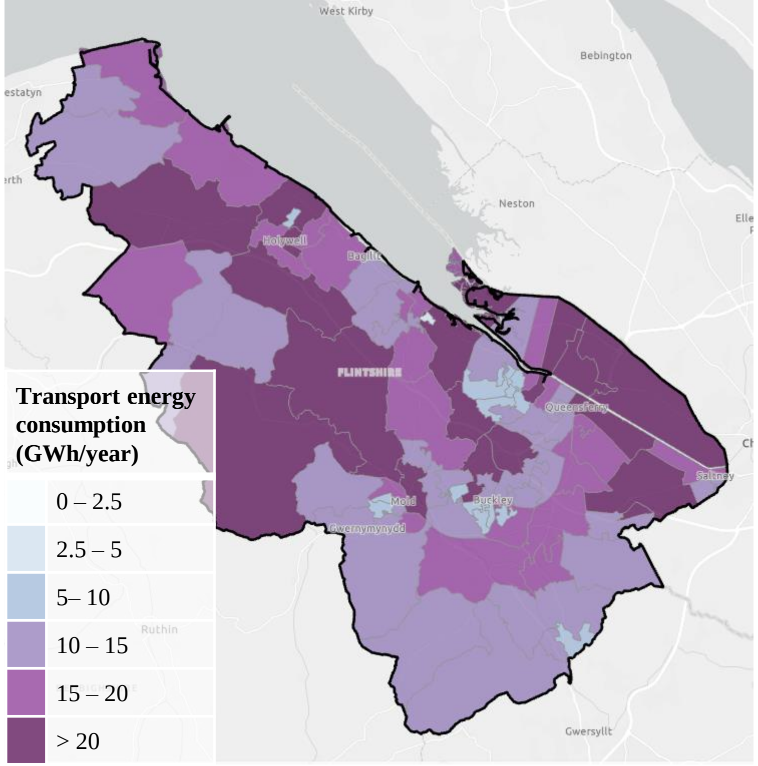


Figure 3.2.17: transport energy consumption (combined total across cars, light goods vehicles (LGV) and heavy goods vehicles (HGV) by LSOA (2019)

3. The current energy system

Analysis – electricity generation in 2023

Currently, Flintshire has the potential to generate a total of 171MW electricity annually. This electricity generation capacity plays a pivotal role in meeting the energy demands of the region's residents, businesses, and industries. Assets over 100MW are not in scope of this LAEP because these are considered national assets.

Onshore wind power: is a prominent renewable energy source harnessed within Flintshire. The region boasts a total 1.8MW of electricity generated annually from wind turbines. Wind energy continues to grow as a reliable and sustainable power source, contributing significantly to reducing carbon emissions. Given local flight zones and areas of outstanding natural beauty, growth of onshore wind within Flintshire is limited.

Solar power: also plays a vital role in the local energy mix. Flintshire harnesses 91.6MW electricity annually from solar panels on rooftops and dedicated solar farms. Solar PV is employed widely in industrial areas for direct use, and this is expected to expand significantly.

In addition to wind and solar, Flintshire utilises various other renewable generation sources, including biomass, energy from waste and biogas facilities. These sources further diversify the energy mix, ensuring reliability and sustainability. To manage increases in renewables and alleviate issues associated with intermittency, several grid-scale battery projects are planned within industrial zones.

In addition to these renewable sources of generation Flintshire generates 35.5MW electricity from non-renewable sources, including gas, and oil. It is anticipated that fossil fuel energy generation will continue to grow as it is a key, cheap resource within industrial zones at the moment.

While Flintshire is a significant contributor to its electricity needs through local generation, it also imports a portion of its electricity to meet the overall demand, totalling 975GWh in 2023. This import ensures a reliable and continuous supply of power.

See overleaf for a map of existing electricity generation in Flintshire.

Analysis – electricity generation (ground-mounted)

Rooftop solar PV

As of 2023, there was a total of 11.6MW of rooftop solar PV capacity across Flintshire, roughly equivalent 4% of buildings (if we estimate that there are 75,200 buildings and rooftop solar PV systems are on average, 4kWp).

This map shows where these systems are located. Across Flintshire, the density of rooftop solar PV per substation is roughly consistent, with an average of 2.5-4.0MW connected at each substation. There is a slightly lower capacity in the areas around Flint, Greenfield and Broughton.

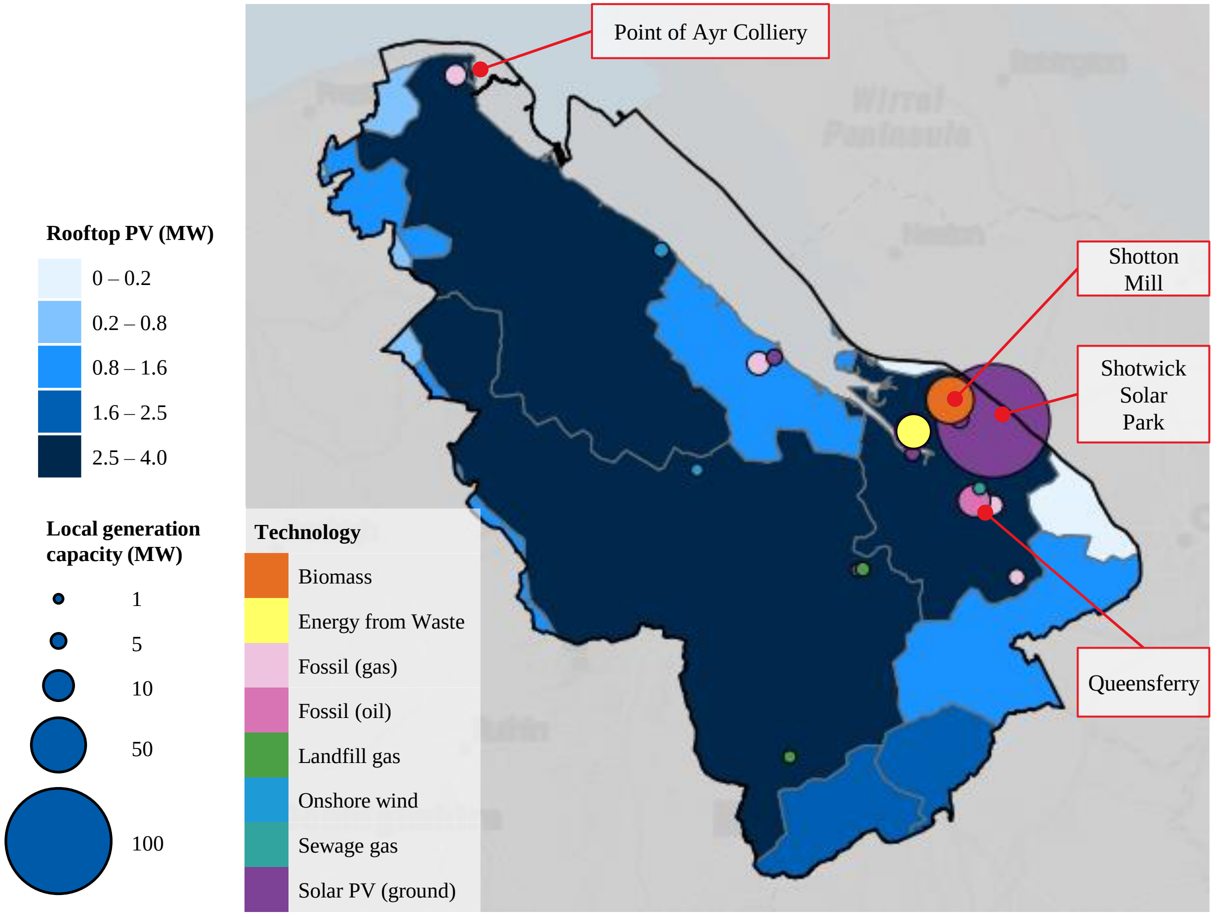


Figure 3.2.16 Local energy generators. Data is based on Energy Generation Wales (2019) and Renewable Energy Generation Database (2019)

Analysis – electricity distribution network

Generation and demand headroom in a Local Authority's electricity distribution network refers to the remaining primary substation capacity at the time of peak generation or demand, crucial for maintaining a stable and reliable power supply to meet the community's needs.

Presently, Flintshire faces challenges due to existing grid limitations, which often lead to delays in new connections and substantial associated expenses. These constraints impact the ability to develop new energy sources and infrastructure, highlighting the need for grid upgrades and enhancements.

To illustrate, the maps in Figures 3.1.19 and 3.1.20 show demand and generation headroom at primary substations in Flintshire. Note that substation and LSAO boundaries do not typically align, and the headroom has been distributed proportionally among LSOAs by area

Demand headroom varies across the region significantly with greater room towards the east of the local authority just outside the heavily industrialised areas.

Generation headroom is minimal across most of the county, with some slightly higher capacity in the northwest.

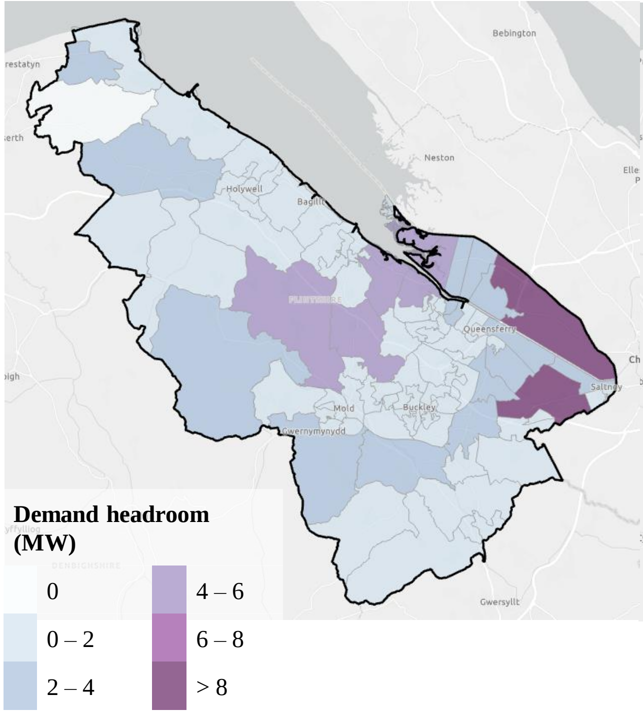


Figure 3.2.17: Electricity demand headroom

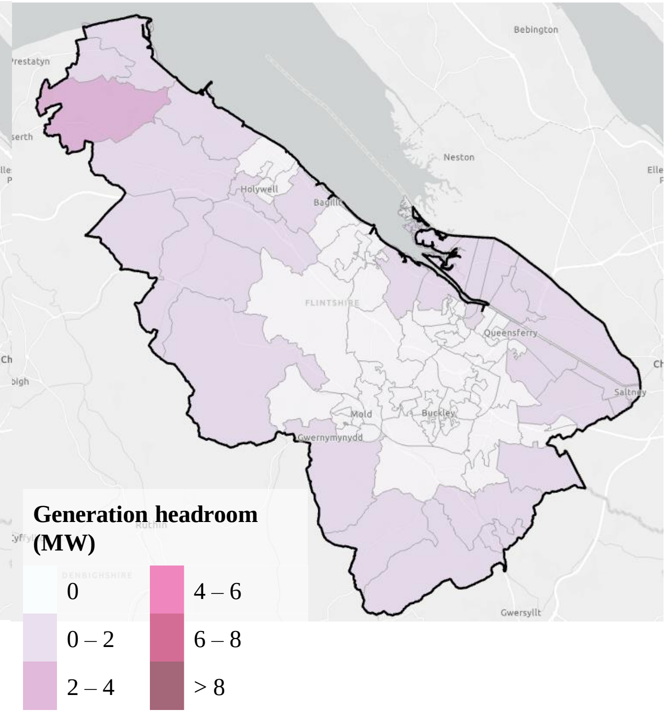


Figure 3.2.18: Electricity generation headroom

Analysis – Off-gas grid buildings (domestic only) shows extent of gas distribution network

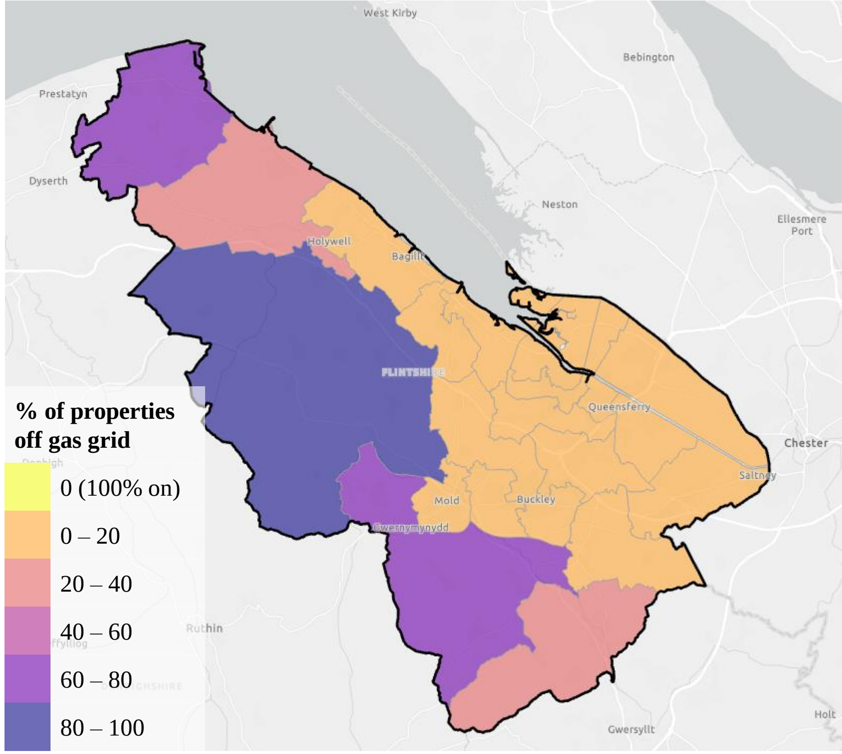


Figure 3.2.19: % of properties that are not connected to the gas distribution network across Flintshire (2023)

18% of properties are not connected to the gas network. This is most prominent in the west and northwest of Flintshire.

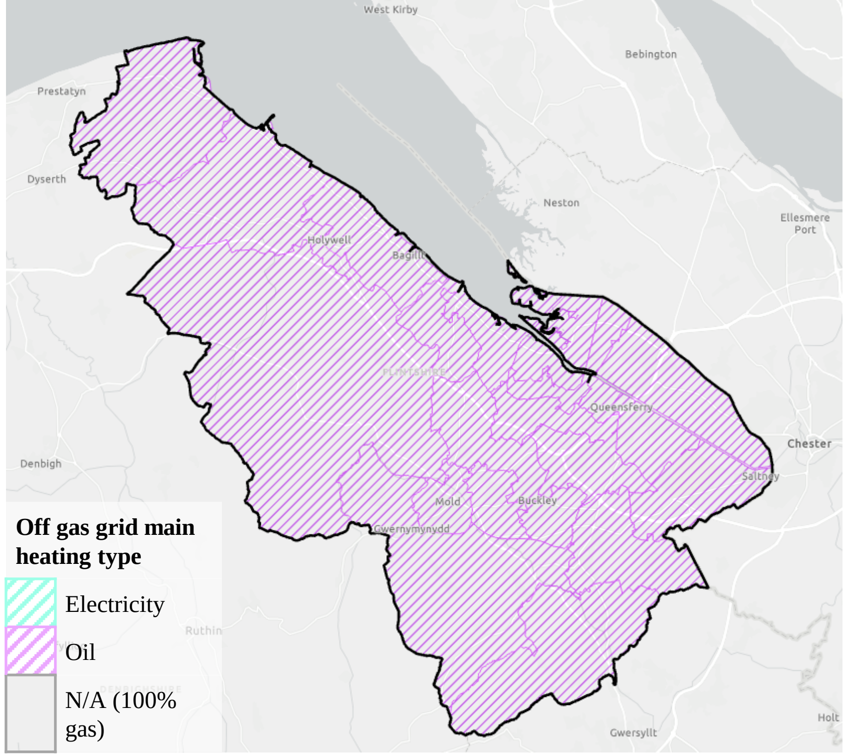


Figure 3.2.20: Main heating type of domestic buildings that are not connected to the gas distribution network across Flintshire (2023)

11% of properties use oil or LPG for heating. There are a small proportion of homes that use direct electric heating (2%). The remainder use biomass, other solid fuels (e.g. coal) or a combination of different fuels.

CYNGOR Sir y Fflint
Flintshire
COUNTY COUNCIL

Sponsors:

Llywodraeth Cymru
Welsh Government

Uchelgais Gogledd Cymru
Ambition North Wales

Delivery partners:

ARUP

CARBON TRUST

Technical report

Chapter 4: The future energy system (stages 4-5)

4. The future energy system

Methodology overview

This section is structured as follows:

Scenario analysis

This section presents an overview of the future energy scenarios chosen and how they were agreed with stakeholders. It describes our scenario modelling methodology, including data sources and assumptions and the criteria used to optimise each future energy scenario. We then discuss the key findings from scenario analysis in more detail, exploring the energy system components that constitute each proposed future energy system and what similarities and differences there are between scenarios, and the impact this has on network infrastructure requirements and energy needs.

Deployment modelling

Scenario analysis highlighted energy system components that played a role in all future energy scenarios and could therefore be defined as "low-regret, near-term" energy system components to focus on for deployment. We created a deployment model to understand the deployment profiles for these components, accounting for broader local and regional strategic objectives and national targets that had been discussed in stakeholder workshops. This is described in more detail in this section and in Appendix B7. The outputs helped define the scale of change required to achieve net zero energy system, and to set a level of ambition from which the action plan could be based.

Chapter 4: Future energy system

Scenario analysis

- We defined modelling parameters such as the maximum amount of solar and wind which can be installed in Flintshire.
- We modelled four future energy scenarios scenarios and explored the most cost- and carbon- effective mix of technologies to generate energy to meet future demand.
- We compared the results to identify low-regret energy system components to consider as high priorities for near-term action.

Deployment modelling

- We modelled the rate of deployment for low-regret energy system components, helping us understand by how much we need to ramp up adoption of different technologies over time.
- We estimated the wide benefits of each scenario, looking at the impact of GHG emissions, air quality and employment in the local area.

Chapter 5: Action planning

4. The future energy system
Scenario analysis

Methodology - overview

The process of creating scenarios involves considering different versions of possible futures. Some of these may seem unlikely or even surprising, yet they could still be possible. Other scenarios explore the possible outcomes of choices the world already appears to be making. By exploring multiple scenarios, we can reveal patterns in supply trends, energy sources and renewable technologies that play a part in multiple energy futures and use this to inform the Flintshire's investment decisions and prioritisation when planning for the energy transition.

Scenario analysis is used to explore how different assumptions about the future can impact how a particular desired outcome is achieved. The future for Flintshire County Council's local energy system consists of many different dependencies, making it challenging to predict how it might look in the future. Therefore, we used scenarios to explore how different potential energy futures might influence how a net zero local energy system is achieved. It's important to note that at this stage of LAEP we are not trying to define a preferred future energy system but evaluating a range of potential future energy systems. This identifies certain technologies or demand reduction interventions that are prevalent in multiple energy futures, and those that only appear in one or two, helping us to determine the uncertainty and risk associated with deploying certain technologies or interventions to make informed decisions on a suitable, credible approach to achieving a net zero energy system.

This analysis was presented to stakeholders to support a decision about what ***energy propositions*** Flintshire might focus on as "low-regret, near-term energy propositions" and those that have a higher risk and uncertainty associated with them based on the modelling results. This information was then taken forwards for further consideration alongside broader plan objectives and local and regional strategic priorities to inform Flintshire's routemap and Action Plan.

As part of this analysis, we also tested different sensitivities to understand the impact of uncertainty and certain modelling parameters on the scenario outcomes. The findings are reported in the following section.

What future energy scenarios were chosen?

Using the outcomes of Workshop 2 (Strategic options and priorities workshop), future energy scenarios and their associated assumptions were agreed with the primary stakeholders, ANW representatives and the LAEP technical advisor. To allow for the comparison of results at the national and regional levels, two of the five scenarios were chosen to be tested across all Welsh Local Authorities, and two scenarios were chosen to be tested in all Local Authorities within the region. See Figure 4.0.0 for a description of each scenario and its scope. The final scenario was agreed by Flintshire County Council and was informed by Flintshire County Council's existing principles, strategic objectives and energy priorities.

4. The future energy system

Scenario analysis

Methodology - overview

Do nothing	• A scenario for comparison which considers committed activities, and assumes that current and consulted upon policy goes forward and remains consistent. • This scenario provides a cost counterfactual. • There is no decarbonisation target for this scenario, and we do not use it in optimisation modelling.
National net zero	• Uses the lowest cost and carbon combination of technologies to meet Wales’ 2050 net zero target. • Assumes a moderate level of energy demand reduction across the system. • Model is allowed to import and export to the electricity grid, this assumes that the electricity grid is decarbonised and reinforced to allow for the demands, likely to be a combination of offshore wind, hydrogen CCGT, grid-level battery storage, nuclear (these are considered as national assets and outside the scope of the LAEP).
Low demand	• Considers the lowest future energy demand across different sectors. • Explores the impact of energy-reducing initiatives (home fabric improvements) and uptake of active travel and public transport use. • Model finds the lowest cost and carbon combination of technologies to meet predicted future energy demand. • Import and export of electricity as National Net Zero
High demand	• Considers the highest future energy demand across sectors. • Model finds the lowest cost and carbon combination of technologies to meet predicted future energy demand. • Import and export of electricity as National Net Zero
High Hydrogen	• Considers the highest plausible future energy demand across sectors. • Uses a cost- and carbon-optimal range of technologies to meet predicted future energy demand. • Explores hydrogen as a possibility within high temperature industrial processes. • Considers hydrogen for heavy goods vehicles. • Explores the possibility and impact of hydrogen generation and imports.

Figure 4.1.1: Summary of future energy scenarios

Methodology – modelling parameters

We developed a set of modelling parameters that describe certain characteristics of the future local energy system and how different factors could affect it in the future in each scenario. We set parameters for:

Technologies considered: we identified a list of viable technologies for the model to consider in the optimised future energy scenarios. These technologies were reviewed by primary stakeholders to ensure that they accurately reflected technologies the local area were likely to consider in the future based on the political context. For each technology, we collected key information defining costs, deployment and relationships with other technologies.

Capital and operational costs: we considered costs associated with capital and the operation of the asset over its lifetime as the main parameter for the model to optimise.

Emission factors: emissions factors associated with the operation of the asset over its lifetime were given a weighted cost and considered as part of the optimisation.

We translated the assumptions associated with each future energy scenario into Calliope[T30], an open-source, linear programming tool which was used to solve for the most cost- and carbon-effective future energy system in each scenario.

The methodology used to define these parameters is described in the following section.

Future energy demand profiles: we estimated future energy demand profiles by applying the assumptions made about how energy demand for different energy resources might change in each scenario. See the following pages for more details.

Maximum and minimum capacities for renewable technologies: we used maximum theoretical capacities to make sure the optimisation of supply reflected real-world constraints such as available land. Where there was a project pipeline and/or installed capacity, these were assumed to be built as a minimum capacity.

Geographic boundary: the geographic boundary specified what future energy demand should be included in any given future energy scenario. With each substation being used as the locational points for the model to solve.

Time: we modelled the future local energy system by building an annual profile divided into 8,760 hourly periods. We ran models using 1-hr, 3-hr or 24-hr time periods, to better understand the sensitivities of the results on the time resolution chosen. Where the model was large (i.e. has a lot of substations), we could not always run an hourly model, but over the 150 model runs undertaken on this project we are confident of the impact of the timestep on the model outputs.

4. The future energy system

Scenario analysis

Methodology – optimisation

Once the modelling parameters had been set, we then used the Calliope model to optimise the future supply profiles using the “objective functions” of cost and carbon emissions. This instructs the Calliope model to search for the future supply profile that minimises cost and carbon emissions across the hypothetical year of supply and consumption in 2050 for each scenario. The results suggest the most cost- and carbon-optimised generation profile using a mix of low-carbon technologies that could be used to meet the future energy demand profiles estimated in each future energy scenario.

We reviewed the scenarios alongside primary stakeholders and, in some cases, the assumptions were updated based on local preferences. The main adjustments requested were to the maximum theoretical capacities for renewable energy generation, which is discussed in more detail in later sections.

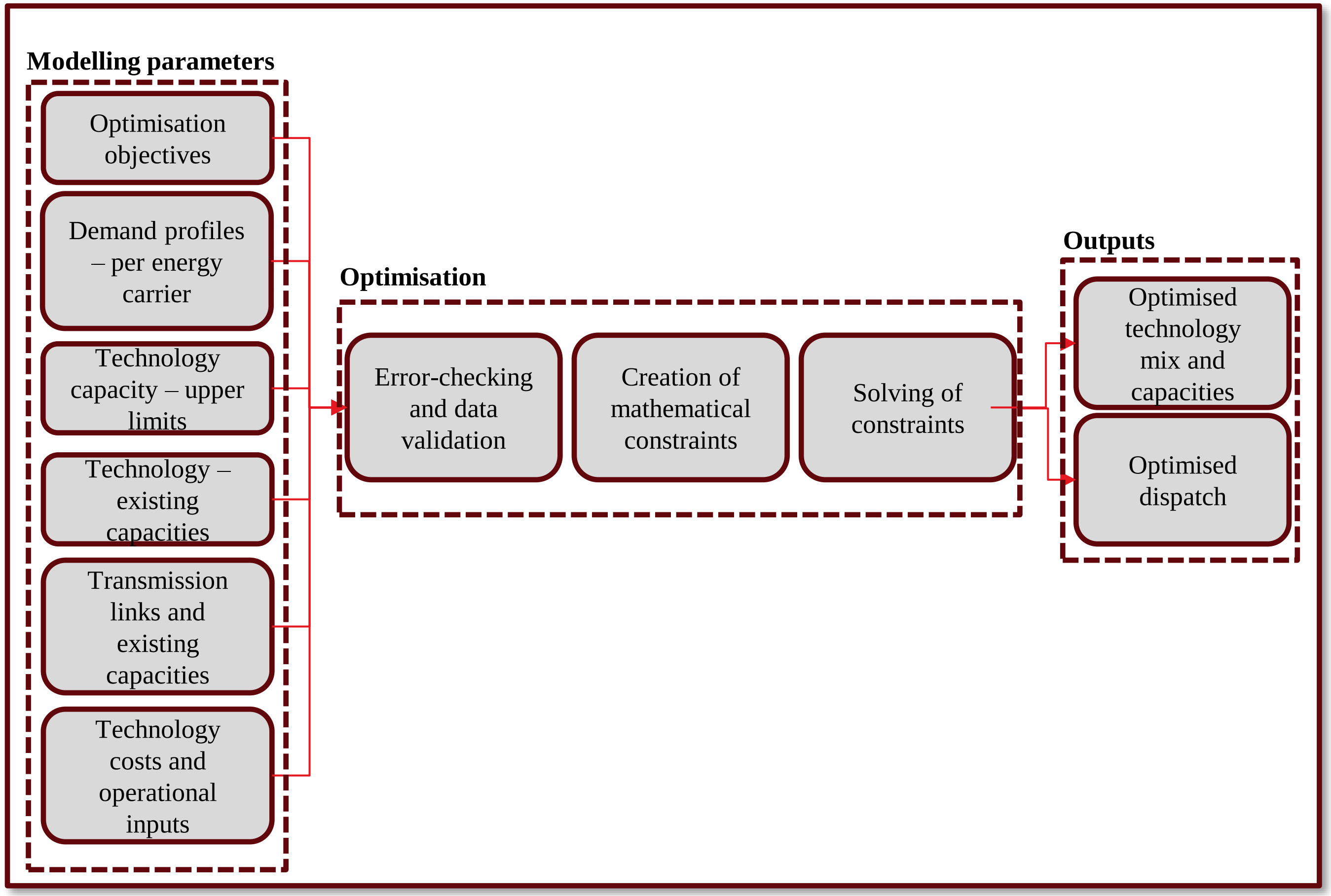


Figure 4.1.2: Optimisation modelling input data and desired outputs

Methodology - technologies considered

The scope of technologies included in the energy system model are broadly categorised as supply, demand, conversion, transmission, storage.

Figure 4.0.2 overleaf shows the technologies and carriers (energy vectors) that were modelled for Flintshire’s LAEP.

For each technology we collected key information defining costs, GHG emissions, deployment and relationships with other technologies. The key parameters collected are summarised in Table 4.0.0 (see Appendix B7 for more details). Alongside the baseline information collated on demands, existing energy assets and potential renewable locations and capacities, this information was loaded into a database. Automated python scripting was used to handle this data and transform it into formatted model inputs in preparation for running the model. This approach ensuring efficiency and consistency, and minimised opportunities for manual errors.

There are challenges to projecting out many of the technological data parameters, and some will carry greater confidence than others. Novel technologies, for example, might have a wider spread of potential costs in 2050 depending on the source consulted. For quality assurance purposes, sources of costs and details of any data transformations taken to normalise all units were stored alongside their values in the database.

Technology data parameters
Technology costs • Capex (£/kW capacity) • Opex (£/kWh output)
Technology emissions • Operational carbon emissions (tCO_2e/kWh)
Technology fundamental parameters • Efficiencies where applicable (%) • Technology lifetime (years)
Technology constraints • Maximum renewable energy technology capacity, where applicable (kW) • Minimum renewable energy technology capacity, from baseline assessment (kW) • Minimum connection capacities between modes for transmission technologies

Table 4.1.1: Technology parameters

Sponsors:

Delivery partners:

4. The future energy system

Scenario analysis

Methodology - technologies considered

Energy Supply

Energy Imports:

	Electricity import	🟦
	Hydrogen import	🟪
	Heat networks	🟥
	Biomass import	🟩

Local electricity generation:

	Ground PV	🟦
	Rooftop PV	🟦
	Onshore wind	🟦
	Canopy PV	🟦
	Anaerobic digestion	🟦
	Sewage gas	🟦
	Hydroelectricity	🟦
	Energy from waste	🟦
	Landfill gas	🟦

Conversion

Heat generation:

🟦	Heat pump	🟥
🟩	Biomass boiler (elec)	🟥
🟦	Resistance heating	🟥

Electricity generation:

🟪	Hydrogen CCGT	🟦
🟩	Biomass boiler (heat)	🟦

Hydrogen generation:

🟦	Electrolyser	🟪
	Methane reformation	🟪

Transport:

🟦	Electric car charging	▣
🟪	Hydrogen refuelling	▣

Transmission

Energy transmission:

🟦	Electricity network	🟦
🟪	Hydrogen network	🟪
🟥	Heat network	🟥

Storage

Energy storage:

🟦	Battery storage	🟦
🟪	Hydrogen storage	🟪
🟥	Heat storage	🟥

Demand

Energy demands:

🟦	Electricity demand	
🟪	Hydrogen demand	
🟥	Heat demand	
▣	Transport demand	

Key:

	Technology	

^ Input Output ^

🟦	Electricity
🟪	Hydrogen
🟥	Heat
🟩	Biomass
▣	Transport

Figure 4.1.3: Technologies included in optimisation modelling

Methodology - future energy demand for buildings

We produced two scenarios for the buildings sector – high and low demand. The high demand scenario represents the most cost-optimal route to upgrade all buildings to the insulation associated with the current EPC C rating. Similarly, the low demand scenario represents a high-cost route to upgrade all buildings to the insulation associated with the current EPC A rating. The national net zero scenario aligns with the more pragmatic high demand scenario. The local scenario also matches the high demand scenario.

To produce the scenarios, we chose packages of retrofit measures for each of the 27 archetypes in each scenario. The retrofits are summarised in Table 4.0.1 for domestic buildings and in Table 4.0.2 (overleaf) for non-domestic buildings (see Appendix B3 for more detail). Electricity and heat profiles, generated at the archetype level, were reduced in line with RdSAP-modelled changes to building thermal properties and aggregated to modelling zones.

The rate of installations in the near-term considers the targets and initiatives of the Welsh authorities, as well as the major housing associations operating across Wales.

		High demand	Low demand
	Other scenarios this applies to	**National net zero, High hydrogen, High demand**	**Low demand**
DOMESTIC	**Electricity demand**	No change from baseline	5% reduction from smart appliances
	Heat demand	Cost-optimal fabric measures applied to upgrade all buildings below EPC C with insulation measures associated with an EPC C-rated property. 18,300 domestic retrofits will be required.	All buildings below EPC A upgraded with insulation measures associated with an EPC A-rated property. 61,100 domestic retrofits will be required.
	New development build rate	LDP housing targets extrapolated to 2050. 19% increase in number of homes from 2023 to 2050	Average historic build rate applied to 2050. 10% increase in number of homes from 2023 to 2050
	New development energy efficiency	2025 building regulation standard	Net Zero buildings with solar PV and battery storage
	Weather profile	4 days with temperature profiles equivalent to the 'Beast from the East' (extreme weather event in 2018 with -7°C lowest temp) (Appendix B7)	2 days with Beast from the East (-7°C lowest temp) temperature profiles
	Interventions for retrofit considered	See Appendix B7 for details on measures Options dependent on archetype	**High demand interventions**, plus additional measures. See Appendix B7 for more details on measure applied Options dependent on archetype

Table 4.1.2: Assumptions for domestic buildings in each future energy scenario

Methodology - future energy demand for buildings (continued)

To upgrade buildings to EPC C, the most cost-effective combination of measures was selected e.g., prioritising loft and cavity wall insulations. Appendix B7 describes the types of retrofits and sources of retrofit costs.

For the domestic profiles, SAP modelling was consolidated with smart meter data in the network planner profiling tool developed by Hildebrand which improves the accuracy of profiles by factoring in diversity.

New developments were also added to the 2050 energy system by projecting housing and commercial growth in line with LDP targets for high demand, and historic rates of growth for the low demand scenario.

New domestic and commercial growth were spatially mapped based on the location of existing domestic and commercial properties. Large new developments (>500 homes) were mapped separately to their precise substations.

Limitations

The number of insulation retrofits required is based on the insulation in the current building stock. This method is limited by the coverage of EPC (approx. 60% of buildings) and the archetype approach of grouping similar buildings that may have slightly different levels of insulation.

EPC rating is correlated, but not representative of the efficiency of a building. Therefore, the number of properties receiving retrofit measures does not necessarily correspond to the number of properties below EPC A or EPC C.

The model limits non-domestic archetypes to one profile for each scenario. Energy density ranges is a limitation for all archetypes but particularly for non-domestic archetypes which can vary massively.

		High Demand	Low Demand
	Other scenarios this applies to	**National Net Zero, High hydrogen, High demand**	**Low demand**
NON-DOMESTIC	**Electricity demand**	No change from baseline	5% reduction from smart appliances
	Heat demand	Cost-optimal fabric measures applied to upgrade all buildings with a rating of EPC C and below with insulation measures associated with EPC C-rated properties.	All buildings below EPC A upgraded with insulation measures associated with EC A-rated properties.
	Employment site allocation	LDP employment land allocations/jobs projection (proxy) extrapolated to 2050. 51% increase in commercial floorspace from 2023 to 2050.	LDP employment land allocations/jobs projection (proxy) extrapolated to 2050. -20% decrease in commercial floorspace from 2023 to 2050.
	Weather profile	4 days with temperature profiles equivalent to the 'Beast from the East' (extreme weather event in 2018 with -7°C lowest temp)	2 days with Beast from the East (-7°C lowest temp) temperature profiles
	Interventions for retrofit considered	**Same as domestic**, plus MEV/MVHR ventilation	**Same as domestic**, plus MEV/MVHR ventilation

Table 4.1.3: Assumptions for non-domestic buildings in each future energy scenario

4. The future energy system
Scenario analysis

Methodology – future energy demand for transport

The methodology used here closely aligns with the baseline methodology. The key difference is that the output was a year-long hourly demand profile in kWh.

Like the baseline analysis, we used the North Wales Transport Model (NWTM)[T12] to determine transport demand across Flintshire. These models provided the number of trips between two different transport zones (defined by TfW) on an average day. In this data, a trip is defined by the transport zone where a vehicle's journey starts and the transport zone where it ends. Therefore, vehicles which pass through a transport zone without stopping are not counted. We estimated the route distance to be 130% longer than the distance between each area’s centre point. This ‘route indirectness’ factor was based on Arup work from a previous local area energy plan in Wales. We then scaled up that daily mileage value to an annual mileage value and geospatially mapped these values to substation zones.

To determine the proportion of vehicles that converted to either electric or hydrogen, we applied proportions from National Grid’s “Leading the Way” 2050 future energy scenario (FES)[T31] percentages to the annual mileage for the baseline. Refer to Table 4.0.3 for electric and hydrogen vehicle percentages per vehicle type.

Then, we applied growth factors for each vehicle type to the baseline annual mileage data obtained from the NWTM to account for modal shifts. The selection of growth factors varied based on the specific scenario considered. Table 4.0.4 presents the growth factors applied to each scenario.

Finally, we applied a transport profile to the annual mileage figure, resulting in an hourly demand profile over the course of the year. This profile was then converted into an hourly demand in kWh using the miles per kWh values specific to different vehicle types.

	High demand, Low demand		High hydrogen	
Vehicle type	**Electric (mileage)**	**Hydrogen (mileage)**	**Electric (mileage)**	**Hydrogen (mileage)**
Cars	100%	0%	94%	6%
Buses	85%	15%	70%	30%
Vans	100%	0%	83%	17%
Heavy Goods Vehicles	86%	14%	45%	55%

Table 4.1.4: Assumptions for vehicle fuel type in each future energy scenario

Methodology – future energy demand for transport (continued)

	High demand	Low demand	High hydrogen
Scenario application	High demand	National net zero, low demand,	High hydrogen
Fuels of vehicles	National Grid's FES (2022) - Leading the Way	National Grid's FES (2022) - Leading the Way	National Grid's FES (2022) – System Transformation
Transport energy demand	Mileage for: Cars – 8% increase Buses – 5% decrease HGVs: 6% increase LGVs: 15% increase All the above changes are from National Grid's FES (2022) - Falling Short scenario.	Mileage for: Cars – 13% decrease from Llwybr Newydd adjusted by LA-specific car dependency factor. The car-dependency factor was developed to reflect that rural areas may achieve less than the nationwide target while urban areas may achieve more. Buses – Increases in proportion with the reduction in car journeys, scaled by the bus share of sustainable transport options and greater average bus occupancy compared to cars. HGVs - Increase by 6% (National FES)(2022) - Leading the Way) LGVs – Increase by 15% (National Grid's FES (2022) - Leading the Way)	Mileage for: Cars - <1% increase Buses - <1% decrease HGVs: 6% increase LGVs: 15% increase All the above changes are from National Grid's (FES) (2022) - System Transformation scenario.

Table 4.1.5: Assumptions for future transport energy demand in each future energy scenario

Methodology– future energy demand for industry

The 2020 NAEI (National Atmospheric Emission Inventory) Point Sources database[T20] was used as the primary source. The sites within this dataset were subsequently categorised as using high-grade heat or low-grade heat processes.

For industries using high-grade heat processes, we identified their link to chemical processes. Where this data was accessible, we determined the proportion of emissions attributed to these chemical processes. These emissions were excluded from our calculations as they are deemed out of scope, and unavoidable.

In cases where quantifiable data for non-process operational emissions was made available, we assumed that all such emissions would transition from gas to electricity by 2050, while operational emissions associated with processes would transition from gas to hydrogen by 2050. In cases where quantifiable data for non-process operational emissions was not accessible, we assumed that operational processes accounted for the entirety of the site's emissions, resulting in a complete transition to hydrogen.

For industries using low-grade heat, the only variation in the methodology was the assumption that all operational emissions (process and non-process) would shift from gas to electricity, rather than hydrogen.

Accordingly, we calculated the expected consumption of kilowatt-hours (kWh) of electricity and hydrogen by each site in the year 2050, assuming no growth in emissions. Note that this reflects total fuel consumption, rather than heat or electricity demand at the site Any efficiency improvements were offset by considerations related to growth. This annual value was converted into an hourly timeseries using Arup's industrial usage profiles.

Limitations

Companies that owned the industrial sites in Flintshire were sent an RFI, requesting the sites annual electricity and gas consumption and expected change in fuel consumption for 2050. This was not provided, therefore these assumptions need verification with the owners.

Methodology – maximum potential capacities for renewable generation

The maximum theoretical amount of renewable resource (onshore wind, ground-mounted PV, and rooftop PV) was included in the energy model as the sum of the baseline capacity (discussed previously in Chapter 3) and the 2050 renewable resource (discussed below) for each technology.

2050 renewable resource – onshore wind and ground-mounted PV

The maximum available resource (upper limit of renewable generation capacity) was calculated using local authority-specific renewable and low carbon energy assessments (RLCEA) and/or local development plans (LDP). These areas are shown in Figure 4.0.3. A full breakdown of sources and associated shapefiles used during the mapping exercise is presented in Appendix B5.

Overlapping areas were calculated to ensure capacities were not double-counted.

Where insufficient data was available to estimate solar and wind resources, a Welsh-wide study completed by Arup in 2019[T47], which ultimately fed into the Future Wales: the national plan 2040[T32], was used.

Following the mapping of available resource areas, wind and solar capacity factors (MW/area) were used to estimate available capacity (MW) at the LA- and substation-level.

2050 renewable resource – rooftop PV

Maximum available new resource for rooftop PV capacity was estimated using roof-area at the LA- and substation-level. Further information can be found in Appendix B5.

Pipeline projects

Pipeline projects were compiled using the REPD[T23] and ECR[TN24] datasets. Where relevant, Local Authority projects which have had planning permission granted (not necessarily an accepted grid connection) were included in the dataset.

We did not directly include the capacity of the pipeline projects in the energy modelling process, as the pipeline capacities did not influence either the minimum or maximum capacities allowed in the energy models. However, the pipeline projects were included in the deployment modelling process.

Seasonality and daily fluctuations

To capture fluctuations in solar and wind power, hourly resource profiles were used for wind speed[T45] and solar irradiance[T46]. Both profiles were based on conditions at the centre of a local authority. For wind speed, the hourly profile was based on a height of 80 metres and used the MERRA-2 atmospheric model. For solar irradiance, the hourly profile assumed an optimal slope and azimuth, and used the PVGIS-SARAH2 radiation database.

Methodology – maximum potential capacities for renewable generation

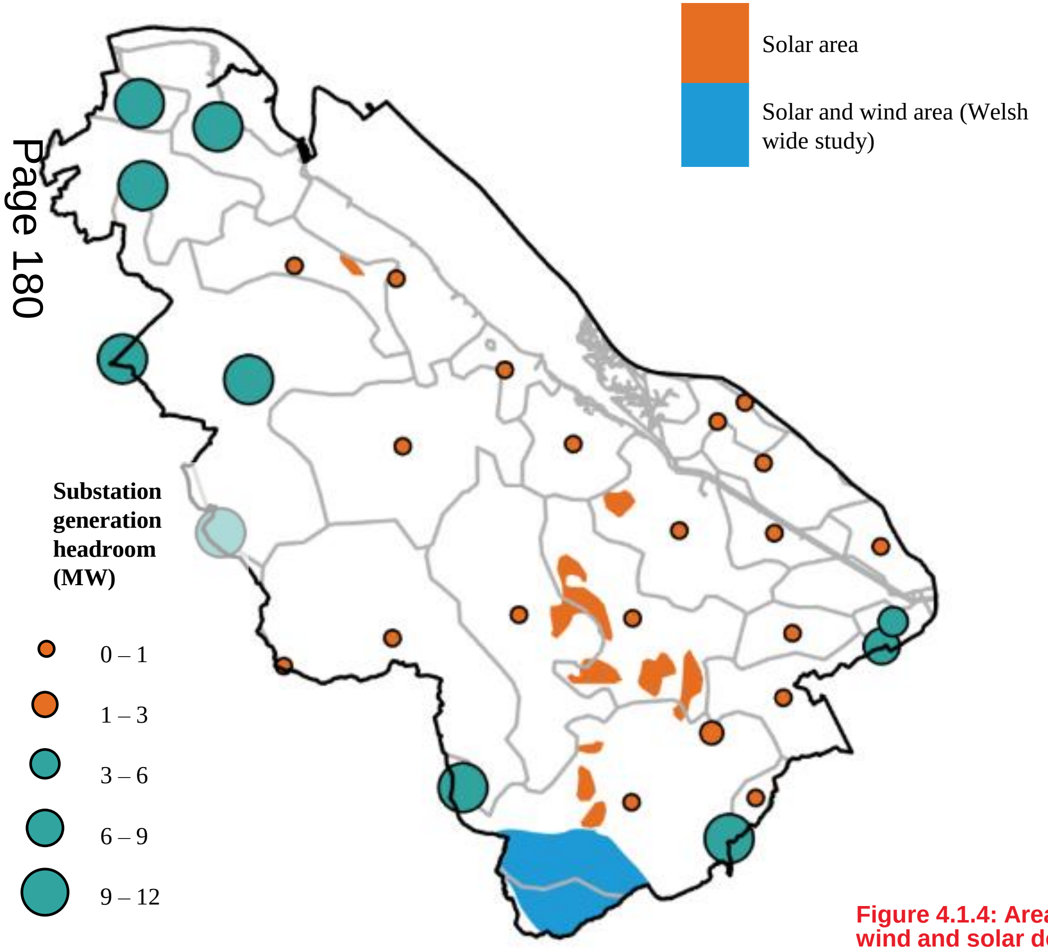


Figure 4.1.4: Areas suitable for wind and solar development

Figure 4.1.4 shows the location of different land packages that could be suitable for ground-mounted solar PV, onshore wind or both, and the generation capacity that is available in each substation zone. This overlay helps to highlight the locations where there is renewable potential and where there is available capacity, which would make conditions more favourable for development. This is discussed in more detail in Chapter 5: action planning, where we introduce the different “priority focus zones” across Flintshire that are ranked highly based on defined criteria for different low carbon technologies, including ground-mounted solar PV and onshore wind.

	Maximum theoretical capacity (MW)	Equivalent land area (km^2)
Ground-mounted solar PV	565	10.6
Onshore wind	2	0.2

Methodology – electricity infrastructure

The electricity distribution network was structured into three distinct levels:

1. Grid-level: This level operated at an extra high voltage of 132kV.
2. Primary-level: This level operated at a high voltage of 33kV.
3. Consumer-level: This level operated at a low voltage of 11kV.

To transition between these levels, two types of transformers were used; grid transformers (located at grid substations) and primary transformers (located at primary substations). Figure 4.0.4 illustrates the flow of electricity between these substations in the model.

Each modelling zone was connected to a primary substation and grid substation, as well as a pseudo-substation.

Primary substation

Each modelling zone was part of a primary substation service area. The capacity of the primary substation[x] was split proportionally between its modelling zones by area. For modelling purposes, the portion of the primary substation capacity allocated to a zone was located at the zone centroid.

Grid substation

To facilitate grid import, each zone was connected to a grid substation, either directly or via other primary substations, via the following:

1. We plotted the locations of grid substations. For each primary substation service area which had a grid substation physically located within it, each constituent zone was allocated a grid substation in the model.
2. Modelling zones were interconnected with other zones that shared the same grid substation.
3. Finally, any zone not yet connected to a grid substation directly was linked to the closest connected zone, based on the Pythagorean distance between their centroids.

Pseudo-substation

We assigned each modelling zone an additional pseudo-substation, a theoretical primary substation with unlimited capacity. In conjunction with costs per kW (rules of thumb provided by the DNOs; real-world costs are likely to differ depending on the network), this enabled capacity expansion (with associated cost considerations) when required.

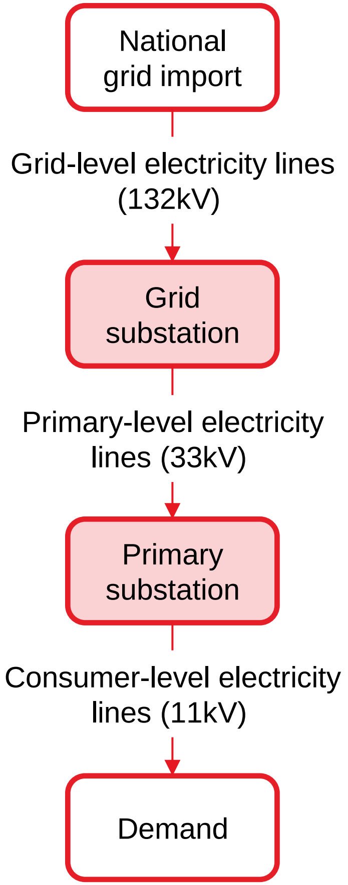


Figure 4.1.5: Modelled electricity flow for each zone

4. The future energy system
Scenario analysis

Methodology – gas infrastructure

We assumed that in all future energy scenarios for 2050, there is no longer a demand for gas, coal and other fossil fuels, as this demand has been replaced by renewable forms of energy. Gas blending was also excluded because we modelled the 2050 scenario, and we assumed the network will be fully hydrogen at this point.

Hydrogen demand is modelled at the same level of granularity as other supply technologies and therefore "modelling zones" align to the substation zones used to model electricity infrastructure and supply.

We set assumptions about future hydrogen demand (for combustion) which has been described in earlier sections. There is a high level of uncertainty around where hydrogen will be produced and how it will be supplied in 2050, and as a result, is left undefined in the future energy scenarios. This means that any hydrogen demand can be met by hydrogen from electrolysis within the system or from a "hydrogen import" which could be blue or green hydrogen either within or external from the LA using the existing gas network.

We calculated the conversion of the baseline gas flow rates into hydrogen capacity.

We then established modelling zones by mapping PRI nodes with specific zones, allowing for the allocation of import and export activities based on the pipes entering and exiting each modelling zone. We used optimisation modelling to find the most cost and carbon-effective way to meet this future demand.

Exclusions

We excluded decommissioning of the gas networks from our modelling. While decommissioning will play a large role in the total cost of the hydrogen transition - current estimates for the average cost in Great Britain suggest a magnitude of £1k/household[T33] to £2.3k/household[T34]- it is still an area of great cost uncertainty[T33], especially since the data available is not specific to Flintshire or Wales.

	Low hydrogen	**High hydrogen**
Scenario application	National net zero, Low demand, High demand	High hydrogen
Industry	High-grade heat met by hydrogen (low-grade heat met by electricity)	High- and low-grade heat met by hydrogen
Transport	Proportion of vans and HGVs use hydrogen	Proportion of vans and HGVs use hydrogen
Domestic / commercial heat	Hydrogen not considered for domestic/commercial heat	Hydrogen not considered for domestic/commercial heat

Table 4..1.6: Summary of assumptions related to hydrogen demand applied to future energy scenarios

4. The future energy system
Scenario analysis

Methodology – heat networks

What are heat networks?

Heat networks are one of the options for supplying heat to buildings in The future local energy system. Heat networks supply heat to buildings through hot water pipes buried in the ground from a centralised heat source. Centralised heat sources in decarbonised heat networks may be heat pumps (boosting heat from sources like air, ground, water, or waste heat), or hydrogen boilers.

Heat networks offer benefits such as reducing electricity infrastructure requirements and costs by enabling use of higher temperature heat sources at specific locations, which increase heat pump co-efficient of performance (COP), and offering large thermal stores, which can shift the timing of heat pump usage. Large centralised plants in heat networks can also offer economies of scale. However, networks can be very complex projects to deliver, and network pipework is highly expensive to build, meaning that they require high heat demand density to offer lower cost heating than alternatives like decentralised heat pumps.

How were heat networks modelled?

To determine which buildings should be supplied by heat networks rather than decentralised heat pumps in a future, optimised energy system, Arup used its proprietary HeatNet tool to assess where networks could offer a lower levelised cost of heat (LCoH) than decentralised heat pumps. The tool builds a digital representation of the local road network and uses a specialised algorithm to evaluate the combination of pipework routes and connected heat loads that maximises the amount of connected demand while minimising pipework length and maintaining a LCoH lower than the value for decentralised ASHPs. The LCoH is evaluated through a built-in discounted cashflow model. See Appendix B7 for the model's techno-economic inputs.

We integrated the HeatNet results into the wider analysis by allowing the heat networks to displace the equivalent capacity of heat pumps selected by the Calliope optimisation at each substation. This was carried through capacities and energy analysis but was not carried through to grid upgrade requirements. Thus, the grid upgrade requirements presented herein can be seen as a worst-case scenario, as heat networks (often able to use higher-temperature heat sources and consequently often more efficient than decentralised heat pumps) may lighten the electrical demand.

Methodology – heat networks

Mapping heat sources

To capture the full potential of heat networks, location-specific waste heat sources, their temperature and their supply potential were mapped across Flintshire for including in the model. Figure 4.0.5 shows the waste heat sources identified in Flintshire. This includes waste heat generated by national assets, since the waste heat is a locally available resource. In addition to these sources, hydrogen boilers were made available to the model at industrial sites expected to transition to hydrogen in the future, and unlimited 'location agnostic' heat pumps (i.e. plant that can be installed largely regardless of location – like ASHPs) with lower COPs were made available without requiring networks to route to specific locations.

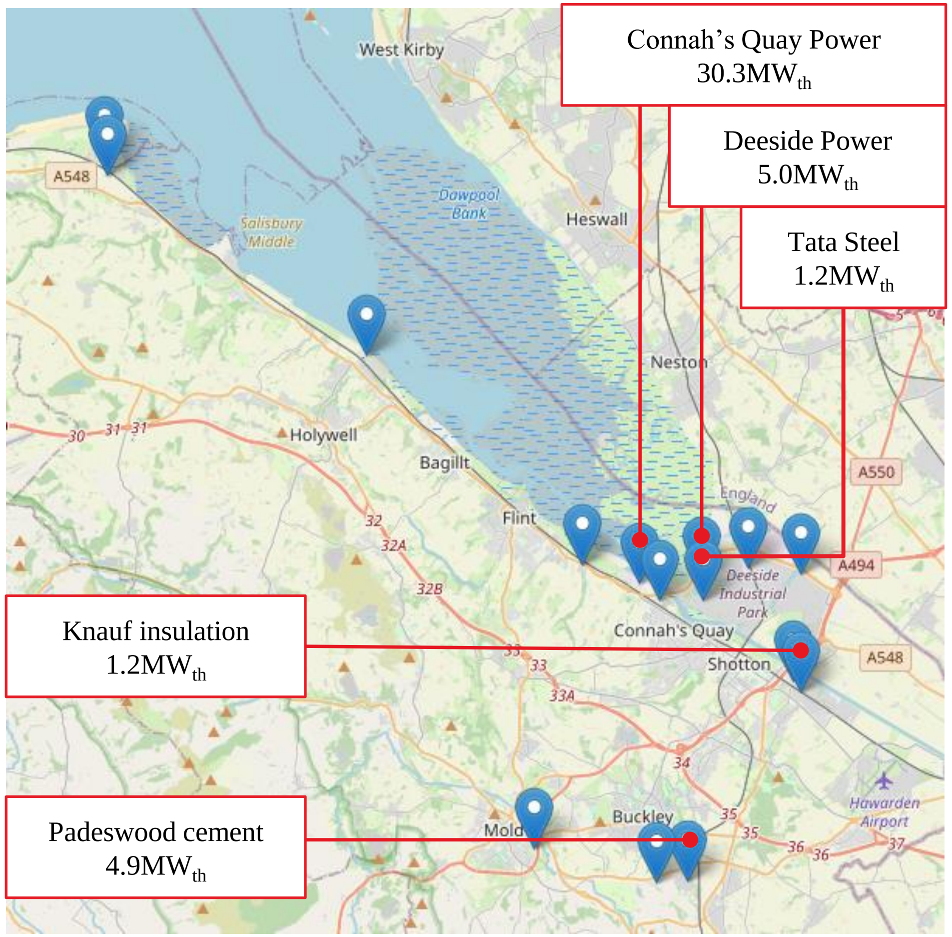


Figure 4.1.6: Heat sources identified, with top five sites named and capturable heat output noted in MW

Sponsors:

Delivery partners:

Technical report

Chapter 4: The future energy system (stages 4-5)

Analysis

4. The future energy system

Analysis

National Net Zero scenario – annual energy flows (GWh, 2050)

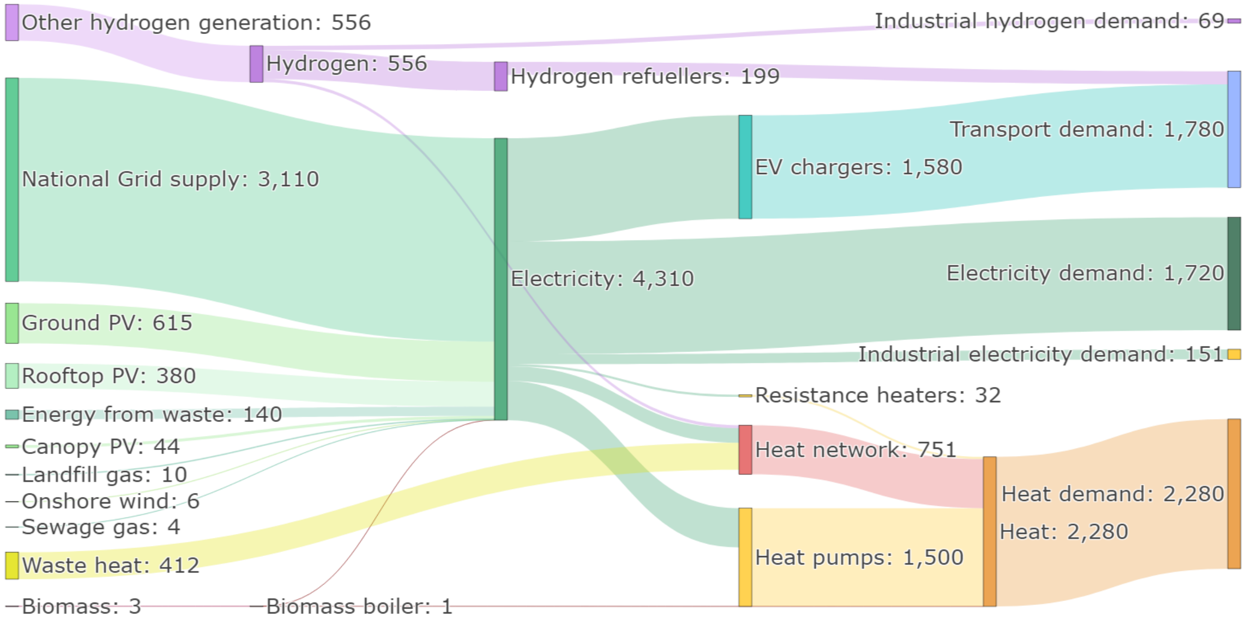
Figure 4.1.0 is an output from our modelling and shows a potential future energy system for Flintshire under the National Net Zero scenario. This energy system results from modelling to create the most cost and carbon optimal system. We ran the model for four scenarios to support our decision making. This optimisation modelling informs the deployment pathways as well as the action plan. The National Net Zero scenario (shown below) aligns with trends in both the High and Low Demand scenarios, as shown in the comparison presented in Figure 4.0.0. Note that this Sankey diagram does <u>not</u> present the final plan for Flintshire's future energy system.

Hydrogen generation /import expected to be required for some transport and industry demand

Electricity supply from the national grid could increase threefold as electricity becomes the primary vector for heat and transport demand

Local renewable generation could provide 28% of electricity, driven by growth of all forms of solar PV and energy from waste

Waste heat is a by-product of industrial processes



Some industrial heat processes are expected to be met through hydrogen use

The transport sector could be almost fully electrified, with some contribution from hydrogen refuellers

Heat demand could grow 25%+ and be met entirely through heat pumps and waste heat delivered through heat networks. ~50% less input energy supply is required (compared to 2019) to provide the increased amount of heat demand in 2050

Figure 4.2.1: Annotated Sankey diagram showing energy flows under the National Net Zero scenario (GWh in 2050)

Low Demand scenario – annual energy flows (GWh, 2050)

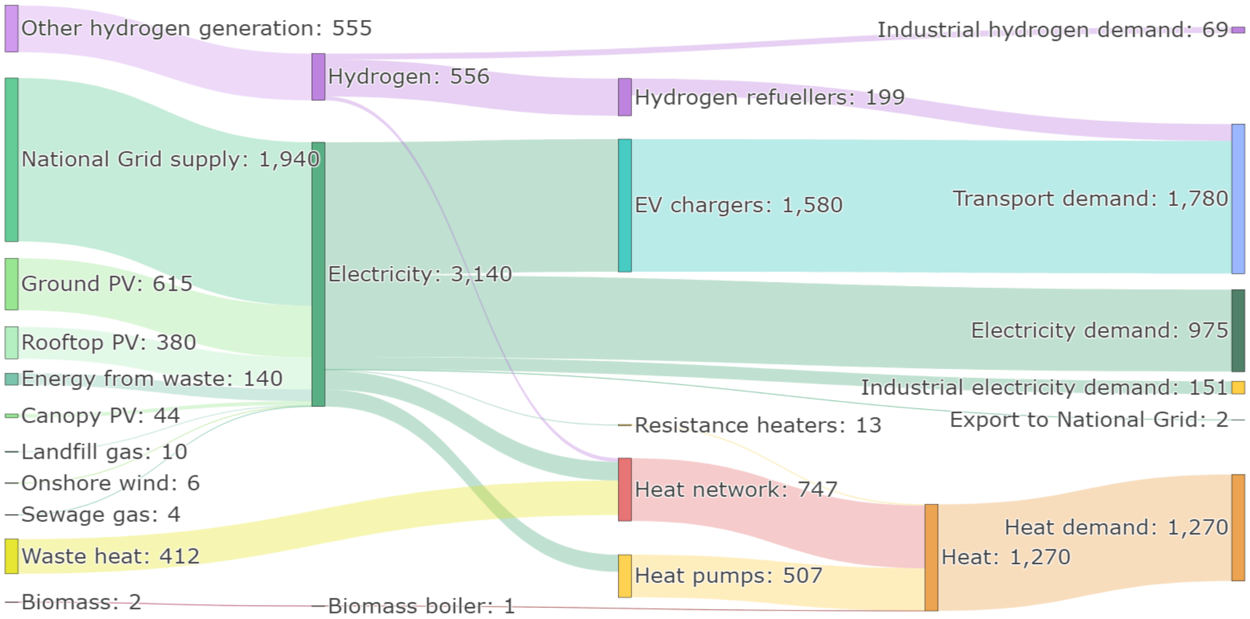
Figure 4.1.1 is an output from our modelling and shows a potential future energy system for Flintshire under the Low Demand scenario. This energy system results from modelling to create the most cost and carbon optimal system. We ran the model for four scenarios to support our decision making. This optimisation modelling informs the deployment pathways as well as the action plan. Note that this Sankey diagram does not present the final plan for Flintshire's future energy system.

Hydrogen generation /import expected to be required for some transport and industry demand

Electricity supply from the national grid could double as electricity becomes the primary vector for heat and transport demand

Local renewable generation could provide 38% of electricity, driven by growth of all forms of solar PV and energy from waste

Waste heat is a by-product of industrial processes



Some industrial heat processes are expected to be met through hydrogen use

The transport sector could be almost fully electrified, with some contribution from hydrogen refuellers

Heat demand could shrink by ~30% and be met entirely through heat pumps and waste heat delivered through heat networks. ~70% less input energy supply is required (compared to 2019) to provide the amount of heat demand in 2050

Figure 4.2.2: Annotated Sankey diagram showing energy flows under the Low Demand scenario (GWh in 2050)

4. The future energy system

Analysis

High Demand scenario – annual energy flows (GWh, 2050)

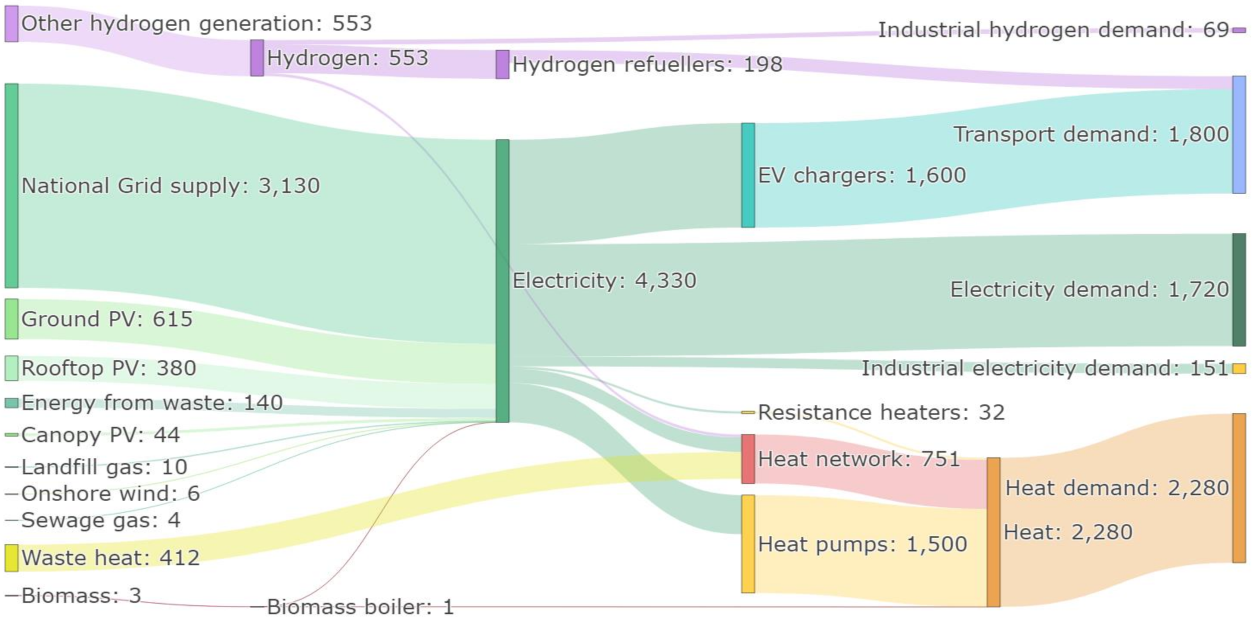
Figure 4.1.2 is an output from our modelling and shows a potential future energy system for Flintshire under the High Demand scenario. This energy system results from modelling to create the most cost and carbon optimal system. We ran the model for four scenarios to support our decision making. This optimisation modelling informs the deployment pathways as well as the action plan. Note that this Sankey diagram does not present the final plan for Flintshire's future energy system.

Hydrogen generation /import expected to be required for some transport and industry demand

Electricity supply from the national grid could increase threefold as electricity becomes the primary vector for heat and transport demand

Local renewable generation could provide 28% of electricity, driven by growth of all forms of solar PV and energy from waste

Waste heat is a by-product of industrial processes



Some industrial heat processes are expected to be met through hydrogen use

The transport sector could be almost fully electrified, with some contribution from hydrogen refuellers

Heat demand could grow 25%+ and be met entirely through heat pumps and waste heat delivered through heat networks. ~50% less input energy supply is required (compared to 2019) to provide the increased amount of heat demand in 2050

Figure 4.2.3: Annotated Sankey diagram showing energy flows under the High Demand scenario (GWh in 2050)

4. The future energy system
Analysis

High Hydrogen scenario – annual energy flows (GWh, 2050)

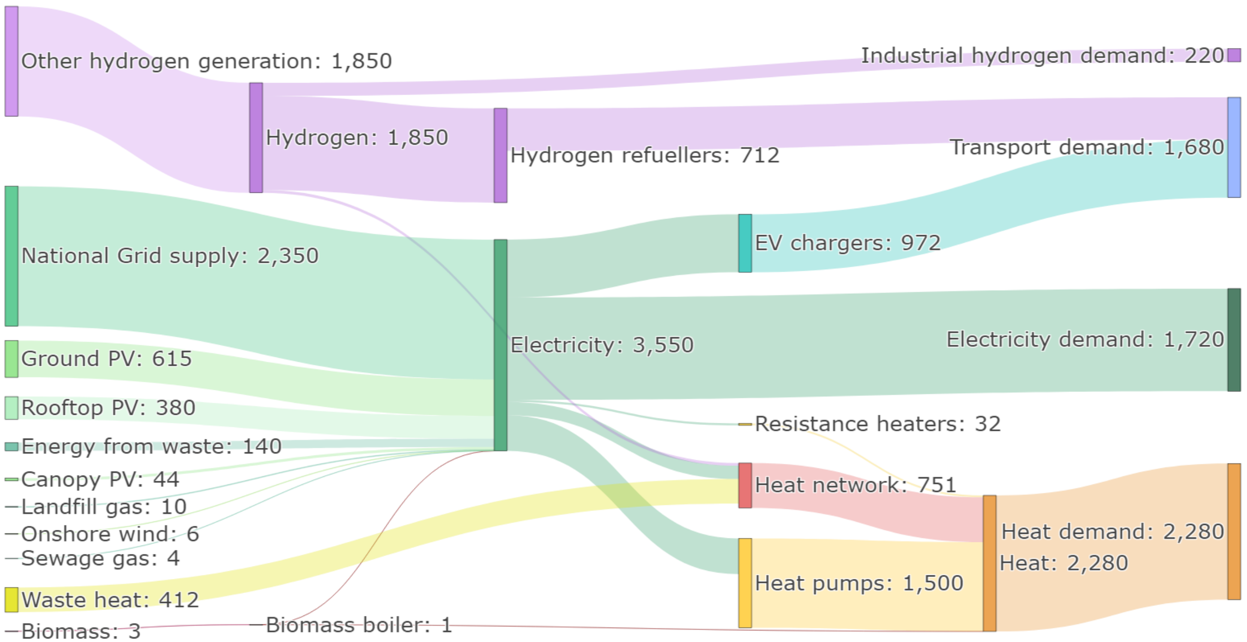
Figure 4.1.3 is an output from our modelling and shows a potential future energy system for Flintshire under the High Hydrogen scenario. This energy system results from modelling to create the most cost and carbon optimal system. We ran the model for four scenarios to support our decision making. This optimisation modelling informs the deployment pathways as well as the action plan. The High Hydrogen scenario (shown below) aligns with trends in the High Demand scenarios, as shown in the comparison presented in Figure 4.0.0. Note that this Sankey diagram does <u>not</u> present the final plan for Flintshire's future energy system.

Hydrogen generation/ import expected to increase significantly with a 3-4 times amount of supply than in any other scenario.

Electricity supply from the national grid could double as electricity becomes the primary vector for heat

Local renewable generation could provide 34% of electricity, driven by growth of all forms of solar PV and energy from waste

Waste heat is a by-product of industrial processes



Both industry and transport expected have a greater demand met through hydrogen supply. 42% of transport demand met through hydrogen refuellers.

The transport sector is likely to be electrified for passenger vehicles and LGVs

Heat demand could grow 25%+ and be met entirely through heat pumps and waste heat delivered through heat networks. ~50% less input energy supply is required (compared to 2019) to provide the increased amount of heat demand in 2050

Figure 4.2.4: Annotated Sankey diagram showing energy flows under the High Hydrogen scenario (GWh in 2050)

Comparing future energy scenarios

Table 4.1.0 provides an overview of the variations in energy components observed in the optimisation modelling results across future energy scenarios, benchmarked against the baseline results.

Optimisation modelling shows ground-mounted, rooftop solar and onshore wind generation consistently increasing across all scenarios; contributing to meeting both Flintshire's energy demand but also exporting in times of surplus to the National Grid, and serving broader energy needs. In contrast, biomass generation sees a decline across all scenarios, likely due to a reduced dependency resulting from the enhanced output of solar and wind farms. Hydrogen is incorporated into the energy mix in all scenarios, sustaining Flintshire's industrial and transport demands.

Transport demand decarbonises, primarily due to the supply of electricity through EV charge points. Hydrogen also contributes to this demand, albeit to a lesser extent.

Heat demand is predominantly catered for by heat pumps, a trend that is consistent across all scenarios. While heat networks and other technologies contribute to this demand, their usage is comparatively less.

Energy system components	Baseline (GWh)	National Net Zero (GWh)	High Demand (GWh)	Low Demand (GWh)	High Hydrogen (GWh)
Ground-mounted PV	77	615 ↑			
Rooftop PV	11	380 ↑			
Onshore wind	6	6 →			
Sewage gas	1	4 ↑			
Biomass	715	3 ↓		2 ↓	3 ↓
Hydrogen import	0	556 ↑	553 ↑	555 ↑	1,850 ↑
Import from Grid	975	3,110 ↑	3,130 ↑	1,940 ↑	2,350 ↑
EV chargers	3	1,580 ↑	1,600 ↑	1,580 ↑	972 ↑
Refuellers	0	199 ↑	198 ↑	199 ↑	712 ↑
Heat pumps	15	1,500 ↑		507 ↑	1,500 ↑
Heat networks	0	751 ↑		747 ↑	751 ↑
Resistance heaters	40	32 ↓		13 ↓	32 ↓
Biomass boilers	356	1 ↓			

Table 4.2.1: Comparison across the scenarios

4. The future energy system

Analysis

Electricity generation and consumption

Figure 4.2.5 shows monthly averages for one year for optimised generation and consumption of electricity to show what balancing could look like in the High Demand scenario.

A future electrical energy system will look somewhat different from today. On the consumption side there will be much greater demand for electricity for transport, ancillary demand and industry. As heat pumps become the primary heat source, heat demand will require electrical energy and this introduces an element of seasonality to the consumption profile - 13GWh in July vs 154GWh in January.

The seasonal electricity consumption profile will be directly out of phase with increased local renewable generation provided by solar PV (fewer sunshine hours in the winter). As such, the winter months will require a much greater proportion of electricity imported from the national grid – 418GWh in January vs 151GWh in July.

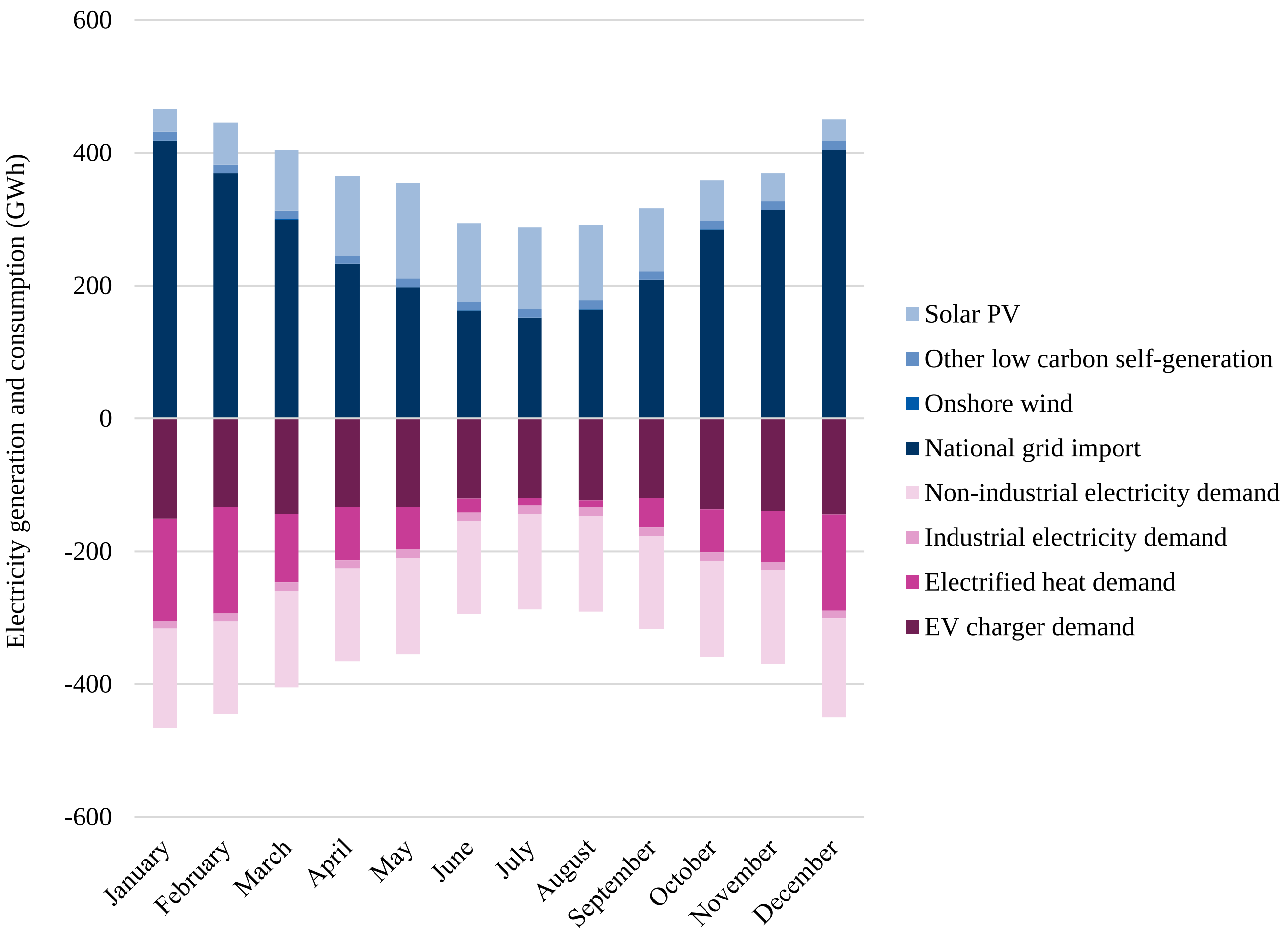


Figure 4.2.5: Monthly electricity generation and consumption in the High Demand scenario

4. The future energy system
Analysis

Comparing future energy scenarios - Buildings

Figure 4.2.6 shows the different technologies that are deployed to meet heat demand in homes and commercial properties in 2050, compared to 2023. In 2023, gas boilers and oil/LPG boilers were the most common heating technology installed. In all scenarios, all gas boilers have been replaced by heat pumps with a small number of resistance heaters. Heating systems are generally set up with thermal stores which can help to reduce peak demand by storing heat when there is less demand on the electricity grid and release it when there is high demand. Storage also reduces GHG emissions and costs by making sure energy is used when it’s cheaper and when there is a higher proportion of renewables on the grid. This result is likely due to the high efficiency of heat pumps (generates on average, 3kWh of heat for every 1kWh of electricity used) compared to other technologies, and a lower capital cost.

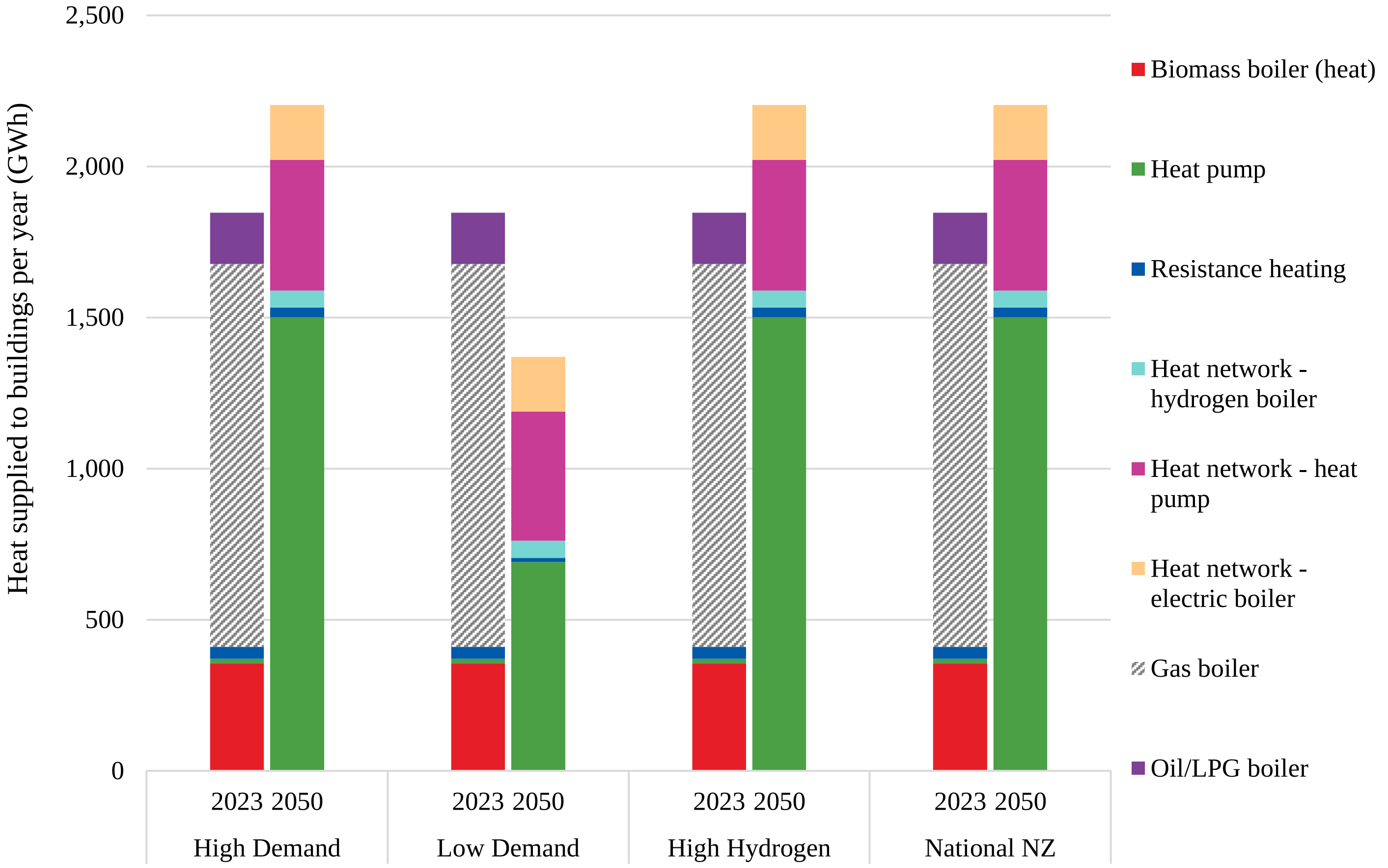


Figure 4.2.6: Proportion of heat supplied to buildings by technology in 2050 for each scenario

Comparing future energy scenarios - Buildings

Table 4.2.2 shows the total number of energy efficiency measures completed between 2023 and 2050 and their relative proportions in each scenario. In the High Demand scenario, our approach considers the most cost-effective package of retrofit measures for each archetype to reach heat loss measurements associated with an EPC C-rated home or building. This means that in the High Demand scenario, cavity wall, loft, and sometimes floor insulation is fitted, but more expensive measures such as solid wall insulation and triple glazing are not. In the Low Demand scenario, all practical measures are installed where possible regardless of cost, which is why we see deployment of solid wall insulation and triple glazing, as well as an increase in the deployment of floor insulation measures.

Metric	Unit	Baseline	High demand	Low demand
Existing homes	#	71,236		
Domestic - cavity Wall insulation	#		3,732	3,732
	% of total homes		5%	5%
Domestic - floor insulation	#		5,480	56,952
	% of total homes		8%	80%
Domestic - roof insulation	#		12,831	12,831
	% of total homes		18%	18.%
Domestic - solid wall insulation	#			14,579
	% of total homes		0%	20%
Domestic - triple glazing	#			61,128
	% of total homes		0%	86%

Table 4.2.2: Proportion of homes with insulation measures

4. The future local energy system

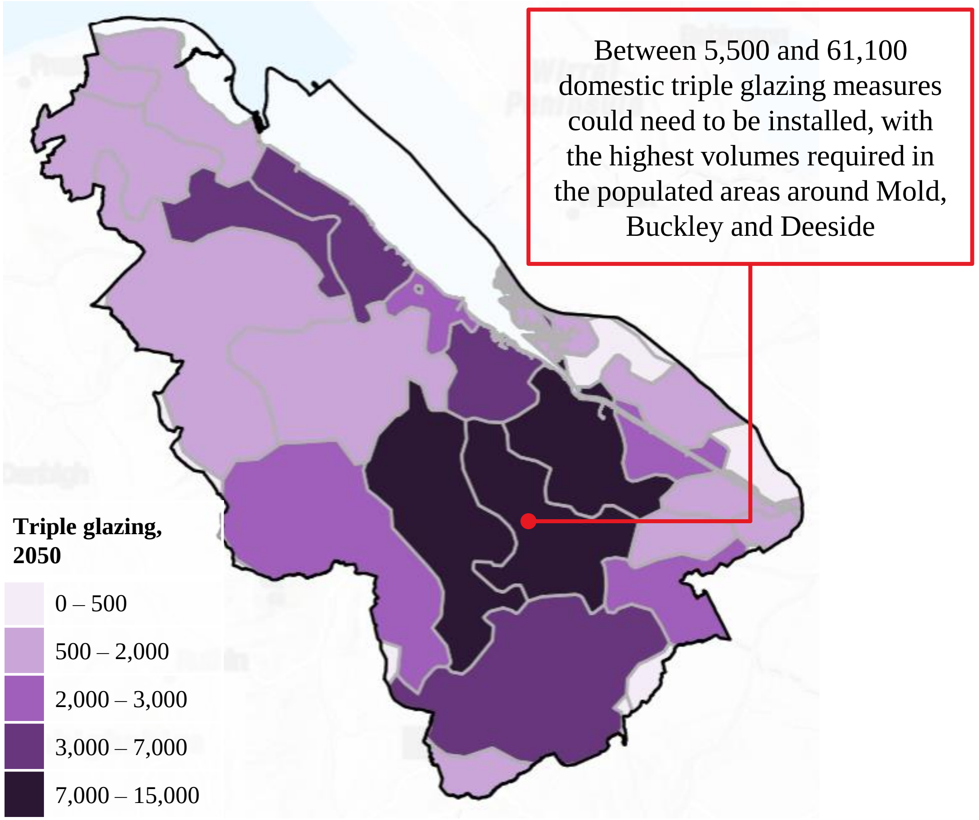
Analysis

Comparing future energy scenarios - Buildings

The following five maps (overleaf) show where insulation measures (cavity wall, solid wall, floor, loft and triple glazing) could be deployed in the Low Demand scenario, aggregated to substation zone. The measures deployed depend on how technically viable it is to deploy each one in different housing archetypes. Scenario modelling explores what deployment of these measures looks like in 2050, in two scenarios:

High Demand: Cost-optimal fabric measures applied to upgrade all buildings with a rating of EPC C and below with insulation measures associated with EPC C ratings.

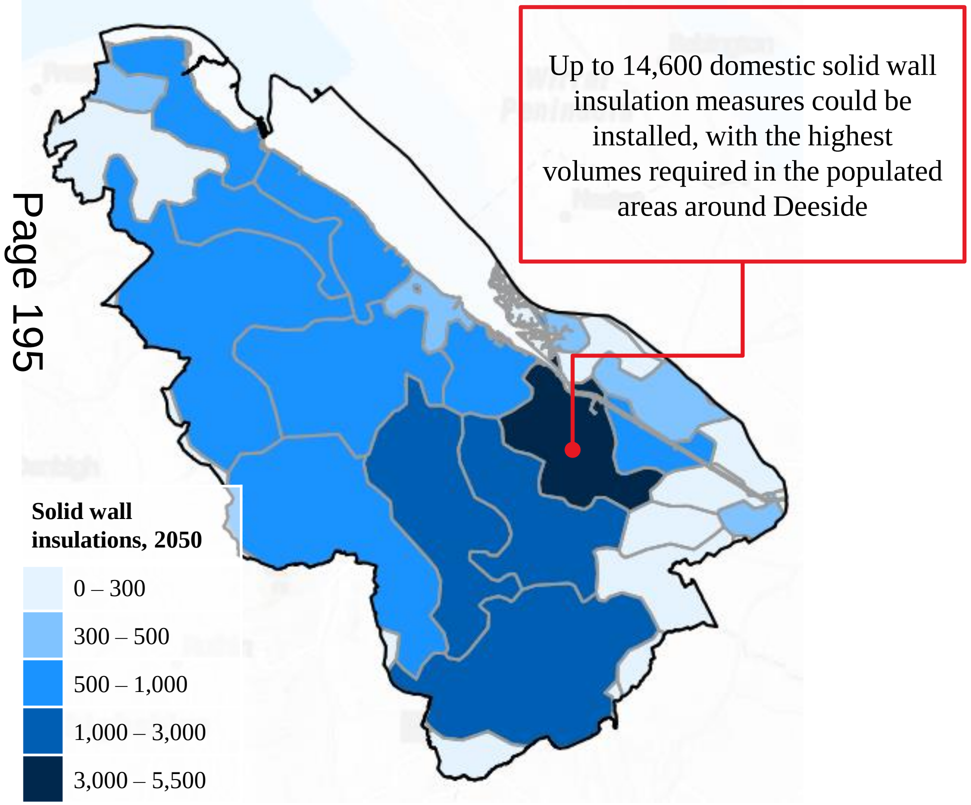
Low Demand: best practice insulation upgrades to improve the heat loss value to the typical efficiency of an EPC C/A.



Between 5,500 and 61,100 domestic triple glazing measures could need to be installed, with the highest volumes required in the populated areas around Mold, Buckley and Deeside

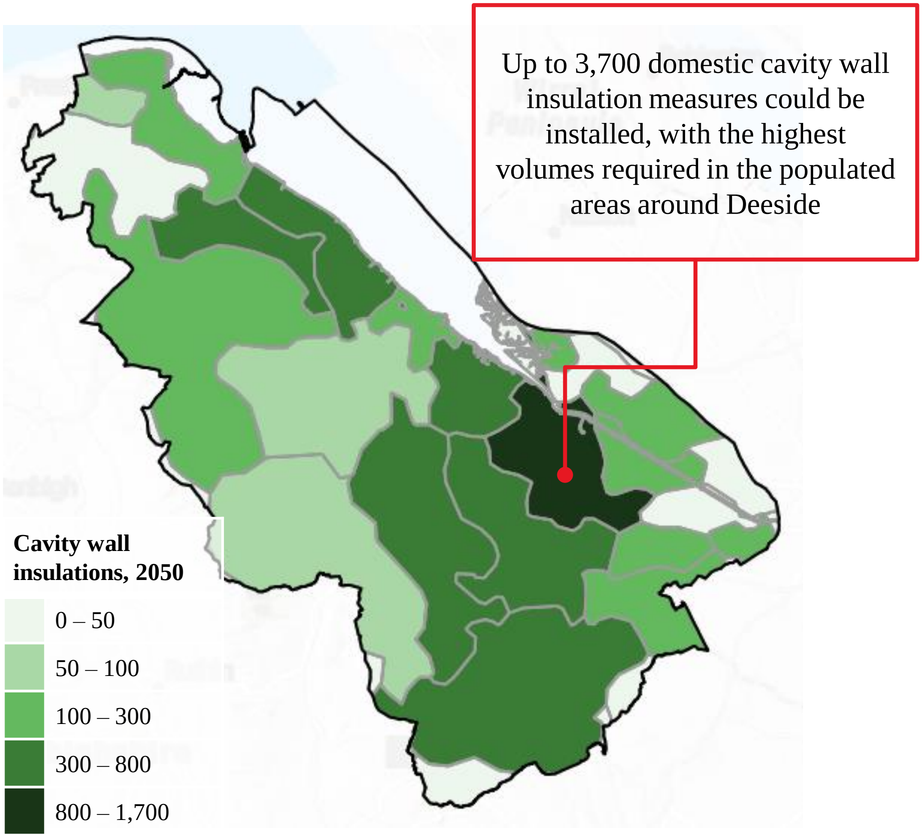
Figure 4.2.7: Map showing the number of additional triple glazing fittings completed by 2050 by substation zone in the Low Demand scenario

Comparing future energy scenarios - Buildings



Up to 14,600 domestic solid wall insulation measures could be installed, with the highest volumes required in the populated areas around Deeside

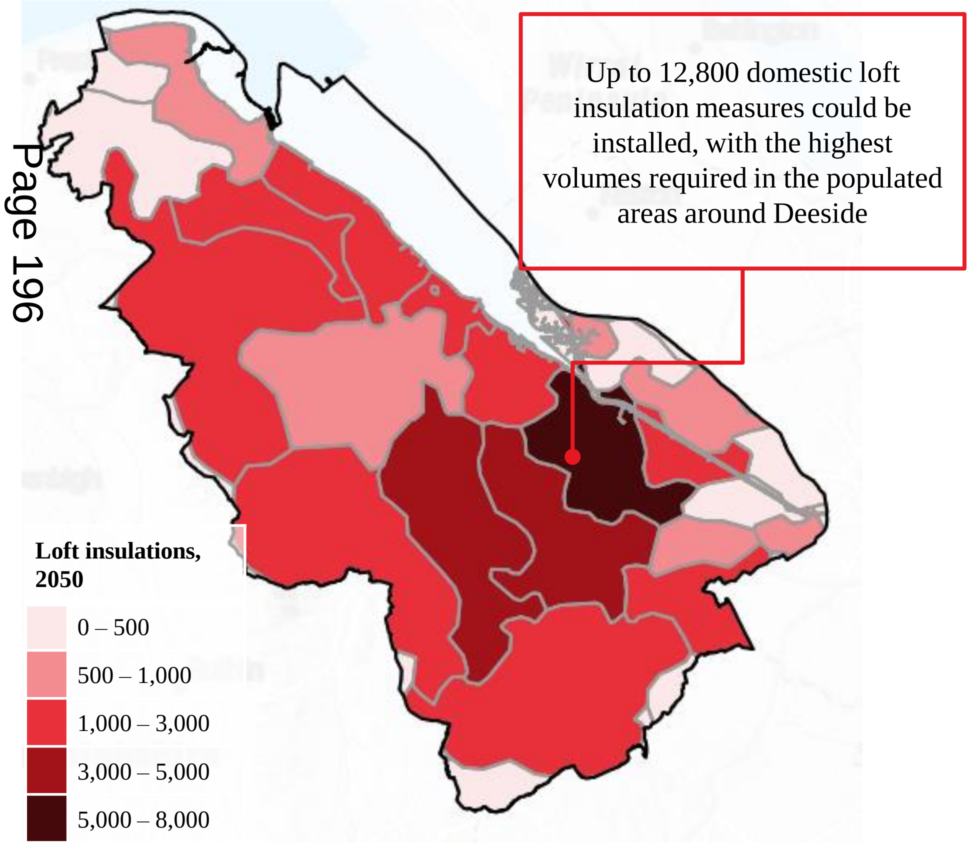
Figure 4.2.8: Map showing the number of solid wall insulation measures fitted by 2050 by substation zone in the Low Demand scenario



Up to 3,700 domestic cavity wall insulation measures could be installed, with the highest volumes required in the populated areas around Deeside

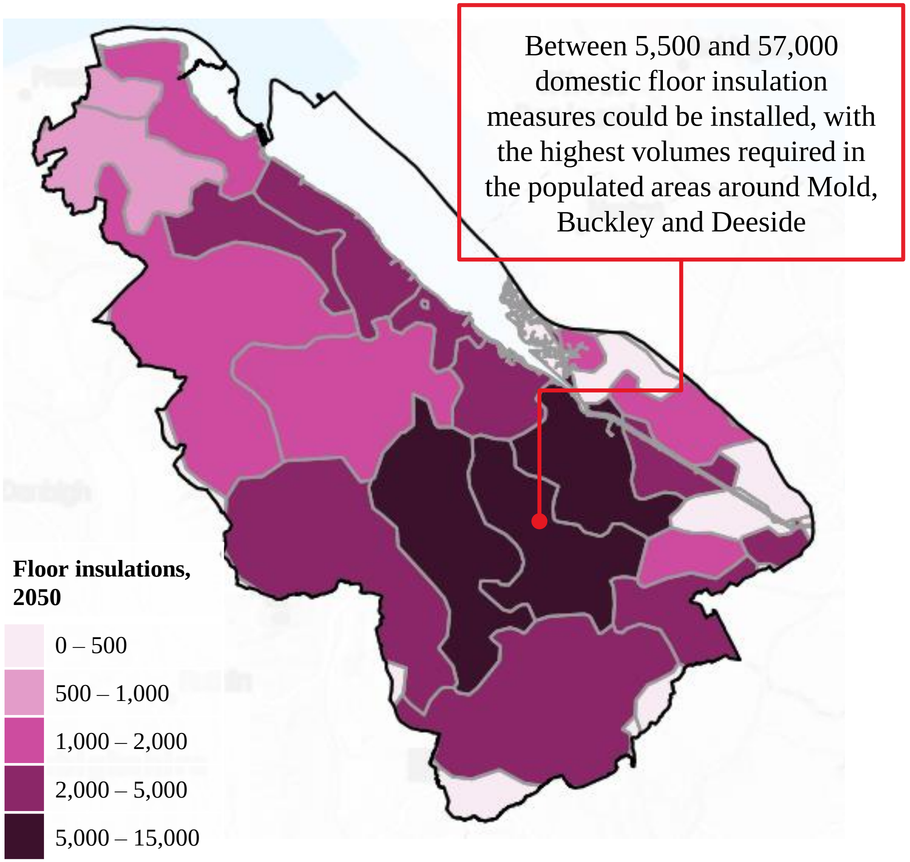
Figure 4.2.9: Map showing the number of additional cavity wall insulation measures fitted by 2050 by substation zone in the Low Demand scenario

Comparing future energy scenarios - Buildings



Up to 12,800 domestic loft insulation measures could be installed, with the highest volumes required in the populated areas around Deeside

Figure 4.2.10: Map showing the number of additional loft insulation measures fitted by 2050 by substation zone in the Low Demand scenario



Between 5,500 and 57,000 domestic floor insulation measures could be installed, with the highest volumes required in the populated areas around Mold, Buckley and Deeside

Figure 4.2.11: Map showing the number of additional floor insulation measures fitted by 2050 by substation zone in the Low Demand scenario

Comparing future energy scenarios - Heat networks

This section will analyse potential heat networks in the LA, under high demand scenario.

Potential heat network opportunity areas have been identified where heat networks may be able to deliver heating at lower cost than individual air source heat pumps (ASHPs).

Unsurprisingly, there are numerous potential waste heat providers across the county. These have been highlighted with the blue markings in Figure 4.1.12, and align with the industry and commercial hotspots. This essentially forms a linear network stretching from Saltney in the South to Greenfield in the North with a branch covering the Deeside industrial zone and a separate branch catering for Buckley and Mold. Potential offtakers have been highlighted in yellow, orange and red (depending on the size off the heat offtaker). The offtakers are a mix of commercial, public sector and domestic buildings.

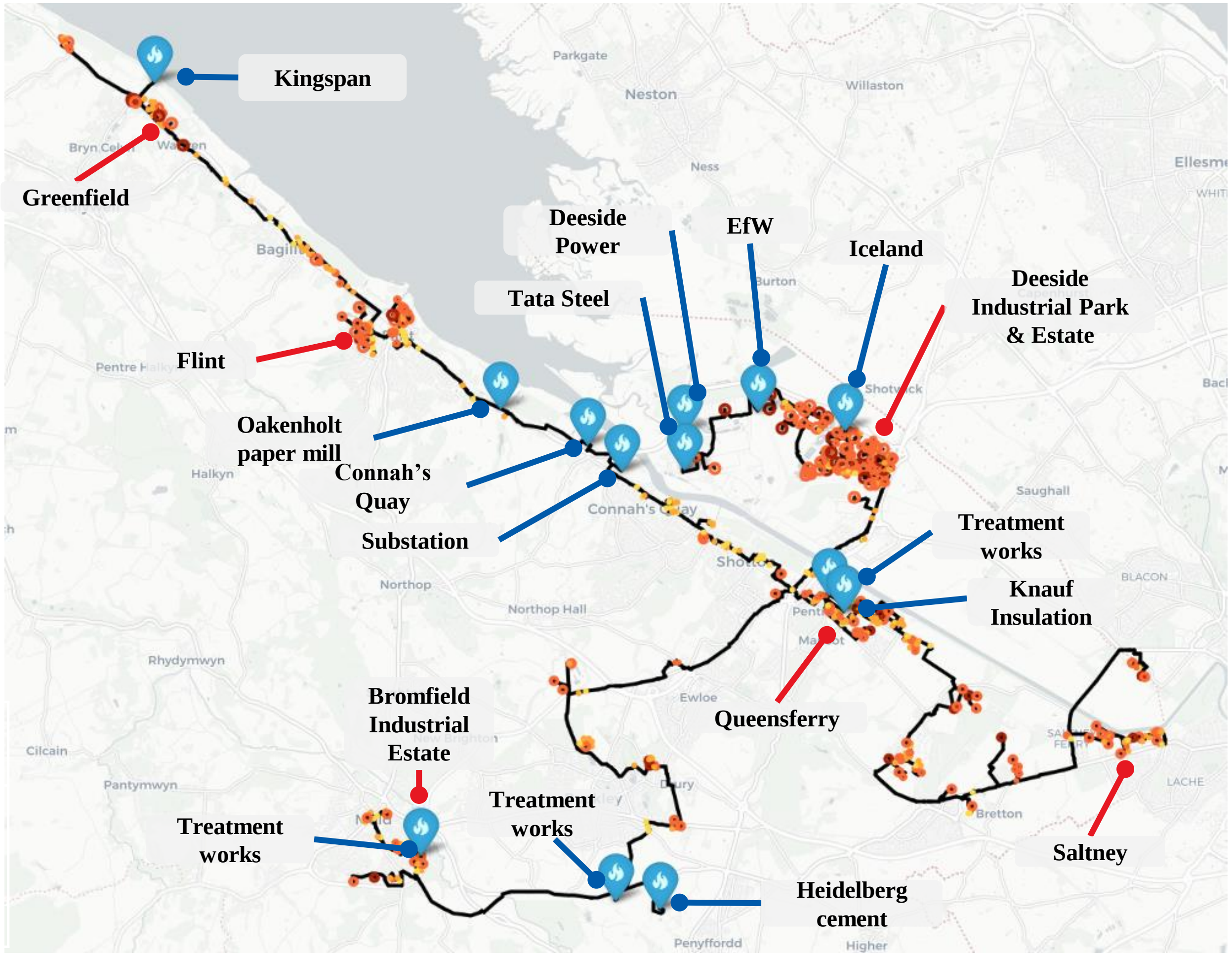


Figure 4.2.12: Map of identified zones for heat network potential in a high demand scenario

Comparing future energy scenarios - Transport

Figure 4.1.12 shows the total number of vehicle miles covered in one year by vehicle type and scenario.

- Car mileage could decrease by 1% in the Low demand scenario and increases by 6% in the High demand scenario based on National Grid's Future Energy Scenarios. This reflects the assumption that people choose to take public transport or use active travel where possible, rather than using their car for all journeys taken.
- Across the three scenarios, 71-88% of mileage is covered by electric vehicles and 12-29% by hydrogen vehicles. These are mostly hydrogen HGVs and buses.
- There are several factors that could influence a greater uptake of hydrogen HGVs:
  - Hydrogen refuelling can be done in 3-8 minutes, compared to at least 60 minutes needed for rapid charging, or overnight for standard charging.
  - Hydrogen HGVs are projected to have up to 50% range advantage over battery electric models (800km against 1,200km).
  - If the uptake of hydrogen HGVs is driven by wider factors such as their range and ease of recharging, and hydrogen becomes widespread in the future, then a significant proportion of HGVs could be powered by hydrogen.

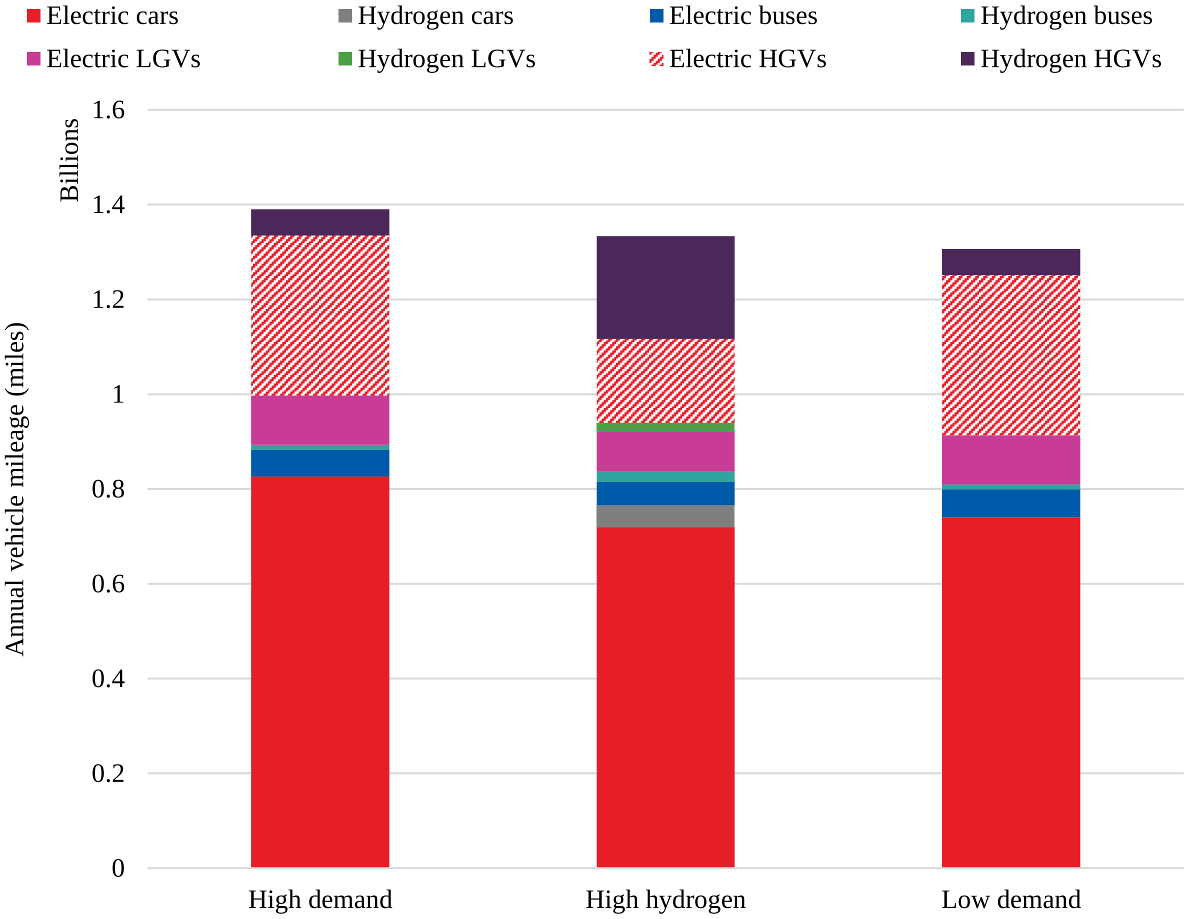


Figure 4.2.13: Total annual vehicle miles by scenario and vehicle type

4. The future energy system

Analysis

Comparing future energy scenarios - Onshore renewables (electricity generators)

Our modelling points to an extensive build out of ground solar PV and rooftop solar PV as the most cost- and carbon- effective way to meet projected energy demands. Across all scenarios, all the land identified as potentially suitable for ground PV was used.

Onshore wind is limited within Flintshire due to restrictions from flight paths over the county, as well as areas of outstanding natural beauty. We, therefore, don't see a build out at all of onshore wind from the current baseline levels.

Solar carports, batteries and energy from waste pick up the small remainder of potential 2050 energy generation.

We see a reduction in the number of different generation technologies being deployed as fossil fuel powered generators are phased out.

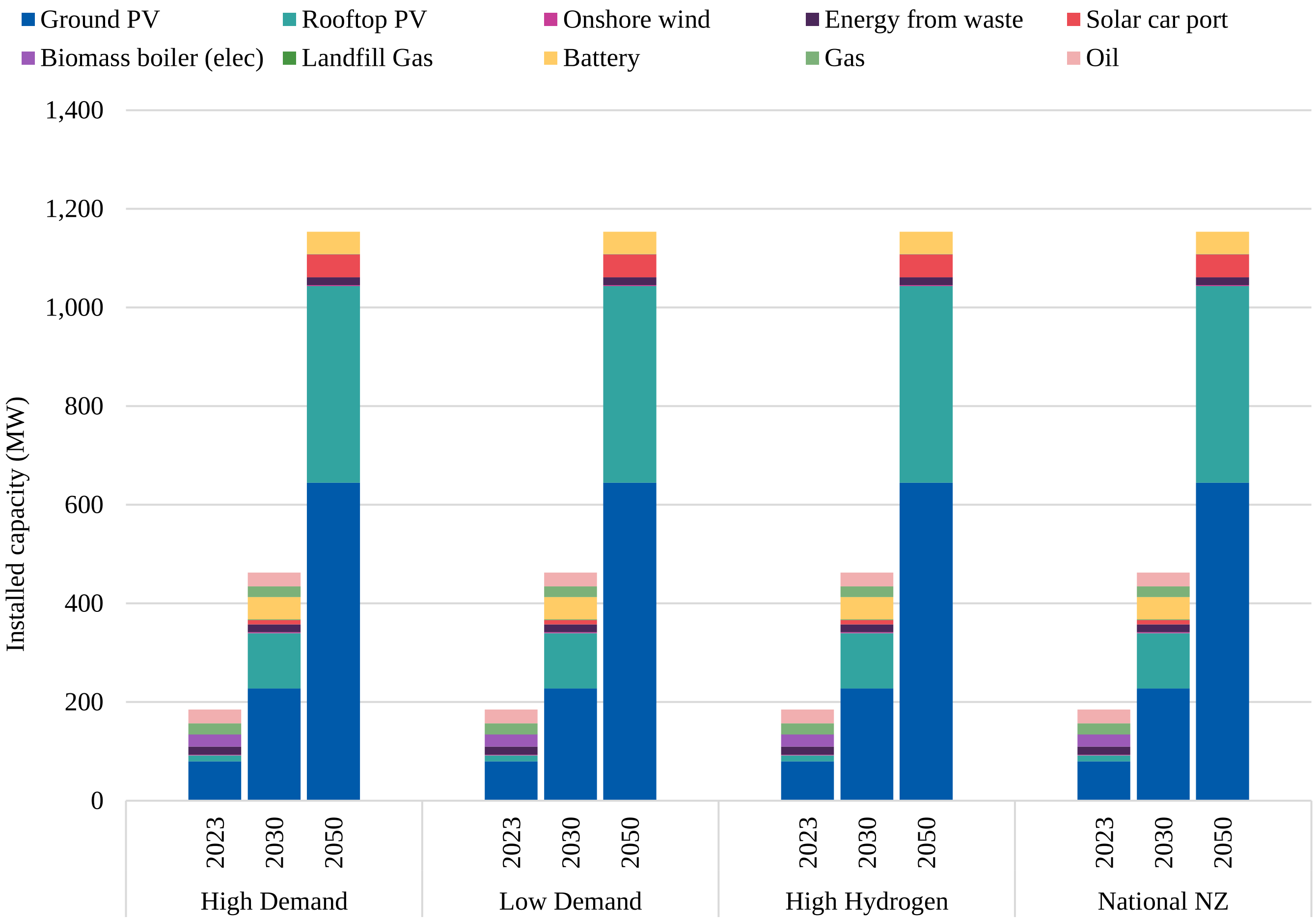


Figure 4.2.14: future capacity of onshore renewables in each scenario

4. The future energy system
Analysis

Comparing future energy scenarios - Onshore renewables (electricity generators)

Table 4.1.2 details the maximum theoretical capacity of various generating technologies, taking into account land type and other constraints. Also shown, is the percentage of the theoretical maximum that the modelling suggests needs to be built in order to cover the 2050 energy demands.

It is anticipated that all technologies will either need to be built out to their theoretical maximum or be retired.

In practice, we know that achieving the levels of deployment indicated in the scenarios is ambitious and is beyond the rates of deployment we see today. This is further explored in the renewable energy proposition in Chapter 5: Action planning.

Renewable technology	Baseline capacity (MW) (2023)	Total theoretical capacity across scenarios in 2050 (MW)	Additional capacity indicated across scenarios (MW)	Percentage of total maximum theoretical capacity across scenarios (%)
Ground-mounted solar PV	80	565	645	100%
Rooftop solar PV	12	387	399	100%
Onshore wind	2	2	2	100%
Canopy Solar PV	0	46	46	100%
Biomass boiler (elec)	0	25	25	100%
Energy from waste	16	16	0	100%
Battery	0	45	45	100%
Sewage gas	0.2	0	-	n/a
Landfill gas	1	0	-	n/a

Table 4.2.3: Existing and maximum future capacity of onshore renewables

Comparing future energy scenarios - electricity infrastructure - upgrades

The model optimises each future energy system by considering the most cost- and carbon-optimal supply profile to meet demand in each substation zone, solving this problem for three hour intervals over the course of one year. In some cases, the marginal cost of upgrading and connecting an additional unit of capacity to the substation is less than the marginal cost of installing an additional unit of battery or thermal storage capacity to reduce peak demand enough that the upgrade wouldn't be needed. Figure 4.1.14 shows the degree of upgrades required in the High Demand scenario, which explores a future scenario where electricity demand is high because of limited rollout of demand reduction measures and consumer behaviour changes.

28 of the 30 primary substations across Flintshire are likely to require some form of upgrade. The level of upgrade could vary from 0.5MW at some substations to over 90MW at others. 80% of the upgrade in capacity across all 30 primary substations, will be needed from the following 11 primary substations:

1. Connah's Quay (91 MW)
2. Buckley (63 MW)
3. Greenfield (50 MW)
4. Bromfield (43 MW)
5. Deeside Industrial Park (43 MW)
6. Queenferry (38 MW)
7. Flint (30 MW)
8. Caergwrle (25 MW)
9. Shotwick (21 MW)
10. North Wales Paper (20 MW)
11. Holway Road (19 MW)

This modelling considers up to the primary substation; there will be further upgrades required to the 11kV network out from the substations which is not included within the modelling.

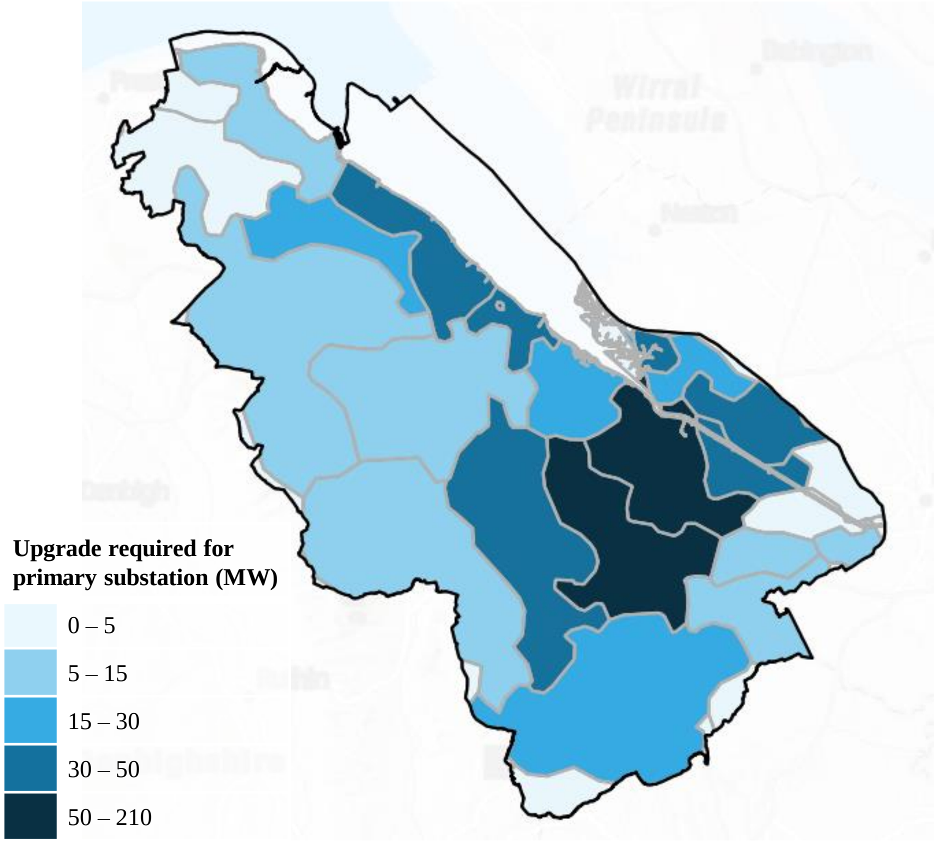


Figure 4.2.15: Map of electricity network upgrades in the high demand scenarios

4. The future energy system
Analysis

Uncertainties and limitations

There are numerous uncertainties that may impact the future local energy system between now and 2050. These uncertainties could influence the CAPEX, OPEX, and carbon emissions associated with delivering the future local energy system.

It is important to acknowledge these uncertainties in the LAEP to ensure that it is adaptable, and resilient to any negative impacts uncertainties could lead to.

This analysis also highlights how the modelling associated with the LAEP are not designed to be used in isolation, and should be combined with other evidence, as they cannot cover all potential future outcomes.

Table 4.1.3 (overleaf) summarises the impact of key sensitivities and uncertainties on the future energy system scenarios.

4. The future energy system

Analysis

Uncertainties and limitations

Uncertainty	GHG emissions	CAPEX	OPEX	Other notes
Lower uptake / roll-out of renewables	↑	↓	↑	If there is a lower roll out of solar or wind, the model maximises other renewables up to their maximum capacities and then imports electricity from the national grid.
Lower uptake / roll-out of retrofits	↑	↓	↑	Higher consumer bills and more capex spent on deploying heat pumps, likely to result in poor consumer perception.
Lower uptake / roll-out of heat pumps	↑	↓	?	More chance of hydrogen scenario. OPEX changes would depend on future costs of electricity, gas (and potentially hydrogen).
Lower uptake / roll-out of demand side management	↑	↑	↑	Higher energy infrastructure costs. Greater cost to consumers..
Lower uptake of EVs	↑	↓	?	OPEX changes would depend on future costs of diesel/petrol and electricity.
Higher uptake of hydrogen	↓	?	↑	Higher uptake of hydrogen could facilitate a faster transition to net zero, with less pressure on the electricity network.
Increased grid electricity import prices	?	?	↑	Likely to drive more demand side management in area– if this occurs, carbon emissions and infrastructure investments would reduce. However, increase grid electricity prices might also slow down electrification and decarbonisation.
Reduced gas prices	↑	?	↓	Less people switch to heat pumps, more chance of hydrogen scenario CAPEX impact would depend on cost of heat pumps vs hydrogen boilers.
Increased CAPEX for electrical reinforcement	↑	↑	↑	Could slow down electrification, with impact on overall GHG emissions. Could increase cost of electricity for consumers.
More extreme weather	?	↑	↑	More extreme cold days mean higher heat pump capacities would be required. More hot summer days could lead to increased cooling, with increase in OPEX. Overall emissions remain similar if annual average temperatures are unvaried.

Table 4.2.4: Impact of key sensitivities on the future local energy system

4. The future energy system

Analysis

Trends from optimisation model runs

Having run over 150 models across multiple Local Authority areas, we observed several trends. Where it has not been possible to undertake modelling at a 1-hour timestep, we can estimate what the expected impact would be. We have also observed how the system changes when we remove the electricity import. The diagram in Figure 4.1.15 demonstrates what we have found over the multiple model runs that we have undertaken.

What does the model always do?

- Maximises onshore renewables (solar PV and wind
- Chooses heat pumps as the dominant heating technology
- Chooses to meet 10% of transport demand using hydrogen, and 90% with electricity
- Imports electricity to meet demand where renewable energy generation is not available
- Export surplus electricity generated

How does the timestep influence the system?

- If we use a more granular time resolution for modelling (e.g. 24-hour to 1-hour timesteps):
  - The size of the electricity system increases
  - Thermal storage increases
  - The model sometimes chooses to add battery storage

What does the model do if electricity imports are restricted?

- Increases any renewables that haven’t already reached their theoretical maximum capacity
- Builds hydrogen CCGT to meet electricity demand when renewable energy generation is not available
- Prioritises electrolysers to generate hydrogen but sometimes chooses a combination of electrolysers and hydrogen imports to meet hydrogen demand.

Figure 4.2.16: Trends from optimisation model runs

Sponsors:

Delivery partners:

Technical report

Chapter 4: The future energy system (stages 4-5)

Deployment modelling

4. The future energy system
Deployment modelling

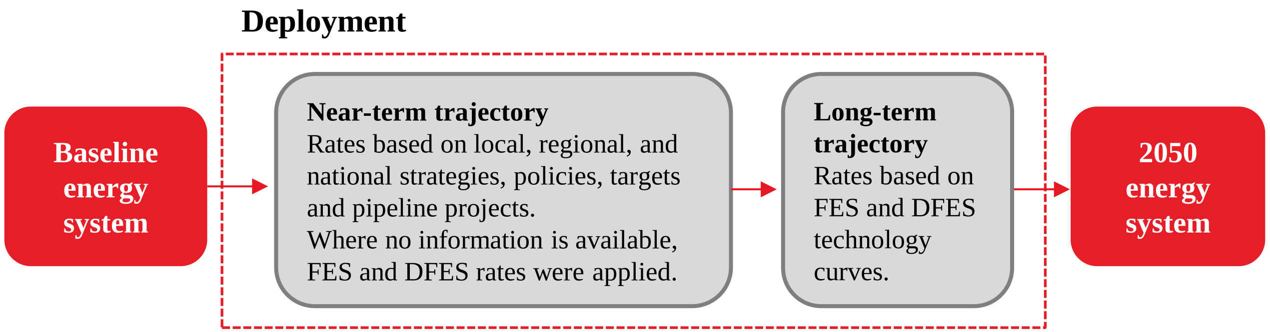
Methodology

We developed a deployment model to determine the rate at which specific technologies could be deployed between the baseline year and 2050. Exploring how quickly different solutions could be deployed and comparing this to the pace of change required helps us gauge what is achievable and what else is needed to facilitate the changes required. The model can also help us break down the changes required into appropriate time periods and provides a way to monitor progress.

The deployment pathways for each energy system component describes the technological changes required over time. From this, we were able to compare how GHG emissions would change over time against national emissions reduction targets and indicate the capital investment requirements between the baseline year and 2050.

Figure 4.2.0 shows how assumptions were applied to near-term and long-term deployment trajectories. Near-term indicates the period for which local and national policy can be applied which is generally 2023-2030 but can vary depending on technology.

Table 4.2.0 summarises the data sources used to inform deployment rates for different technologies that were assessed in our optimisation modelling. A full list of technologies deployed, their metrics, and relevant policies can be found in Appendix B7.



Deployment

Baseline energy system

Near-term trajectory
Rates based on local, regional, and national strategies, policies, targets and pipeline projects.
Where no information is available, FES and DFES rates were applied.

Long-term trajectory
Rates based on FES and DFES technology curves.

2050 energy system

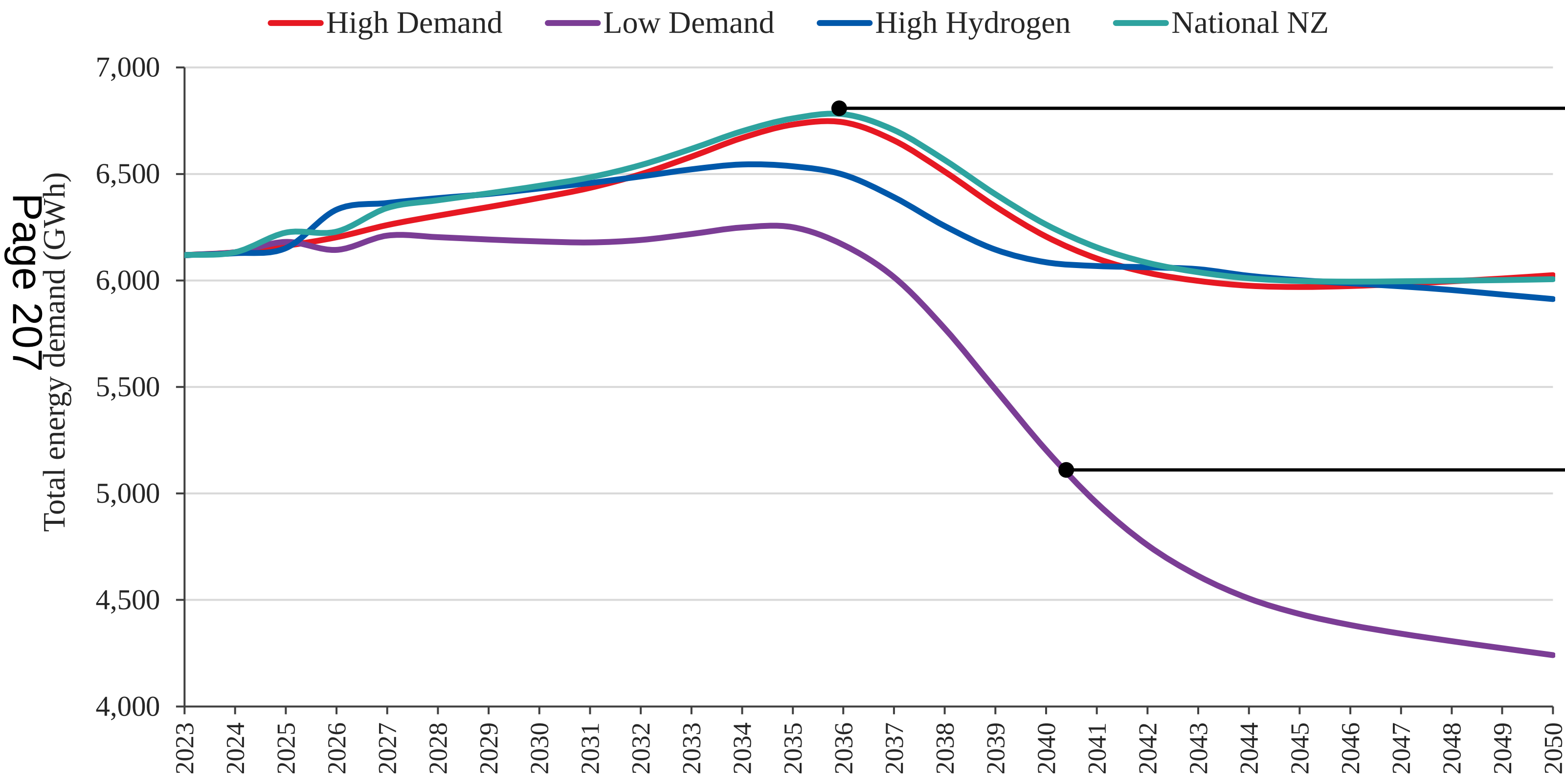
Figure 4.2.0: Deployment model overview of assumptions used to determine rates

Data source	Description
National Grid's Future Energy Scenarios (FES)[T31]	FES are a range of forecasted net zero technology trajectories to 2050 for the electricity system in Great Britain. They consider national policies and ambitions for an extensive list of supply and demand technologies at the distribution level.
Distribution Future Energy Scenarios (DFES)[TN34]	DFES projects the FES technologies at a more granular resolution (primary and secondary substation zones).
National policies and ambitions review	A review of national strategies to do with the energy system was carried out to support the deployment modelling. E.g. no new gas boilers or fossil vehicles by 2035.
Local authority strategies and plans e.g. local development plans (LDP)	A review of local strategies and plans was carried out to support the deployment modelling. E.g. transport strategies containing a target number of chargepoints for an area.
Stakeholder engagement	Information captured in Welsh LAEP programme workshops.

Table 4.3.1: Summary of data sources used to inform deployment modelling

4. The future energy system
Deployment modelling

Impact on total energy demand (GWh)



Energy demand increases initially as a result of growth in housing and commercial property, before efficiency measures, and electrification of heat and transport take over and result in a peak in demand in the mid-2030s. Ultimately energy demand is only slightly lower in three of four scenarios by 2050.

Total energy demand decreases to much lower levels in the Low Demand scenario, primarily driven by improving building energy efficiency to achieve heat demands that are associated with homes with EPC A ratings

Figure 4.3.1: Change in total energy demand by scenario (GWh)

4. The future energy system
Deployment modelling

Energy demand from buildings (GWh)

Buildings energy demand increases overall because the evidence assumes an increase in the number of homes and commercial buildings between now and 2050. However, the average heat demand decreases from approximately 13,000 to 11,000 kWh_{heat}/home and commercial buildings 100 to 77 kWh_{heat}/m^2.

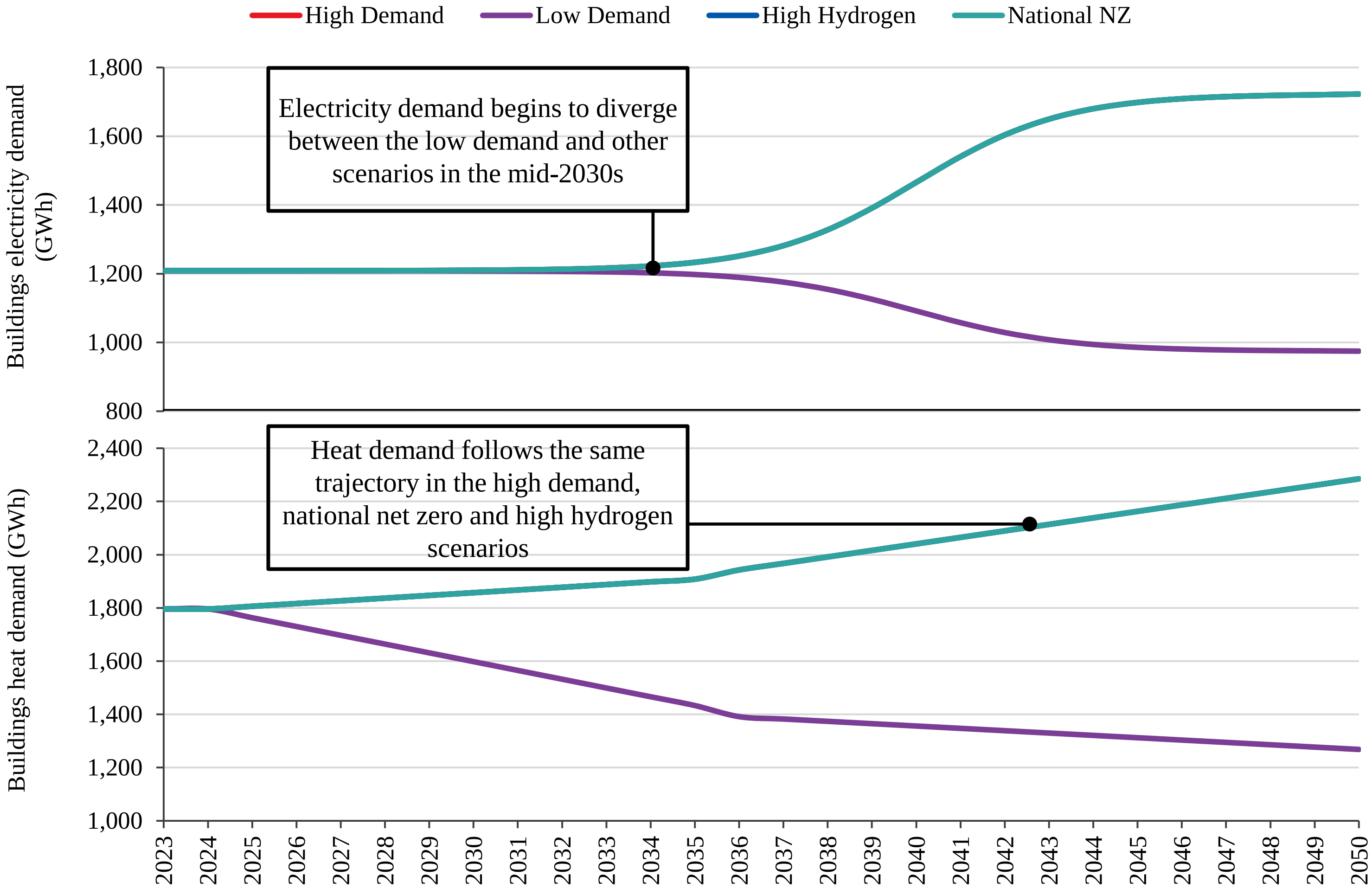


Figure 4.3.2: Projected electricity and heat demand for buildings in each scenario

4. The future energy system
Deployment modelling

Energy demand from transport (GWh)

The high demand scenario sees the greatest switching to electric vehicles early on, and therefore the greatest reduction in energy demand.
However, as the levels of vehicle electrification increases in the low demand and national net zero scenarios the energy demand trajectories begin to align.
The high hydrogen scenario ultimately sees the greatest reduction in energy demand thanks to the greater efficiencies of hydrogen fuelled HGVs compared to electric.

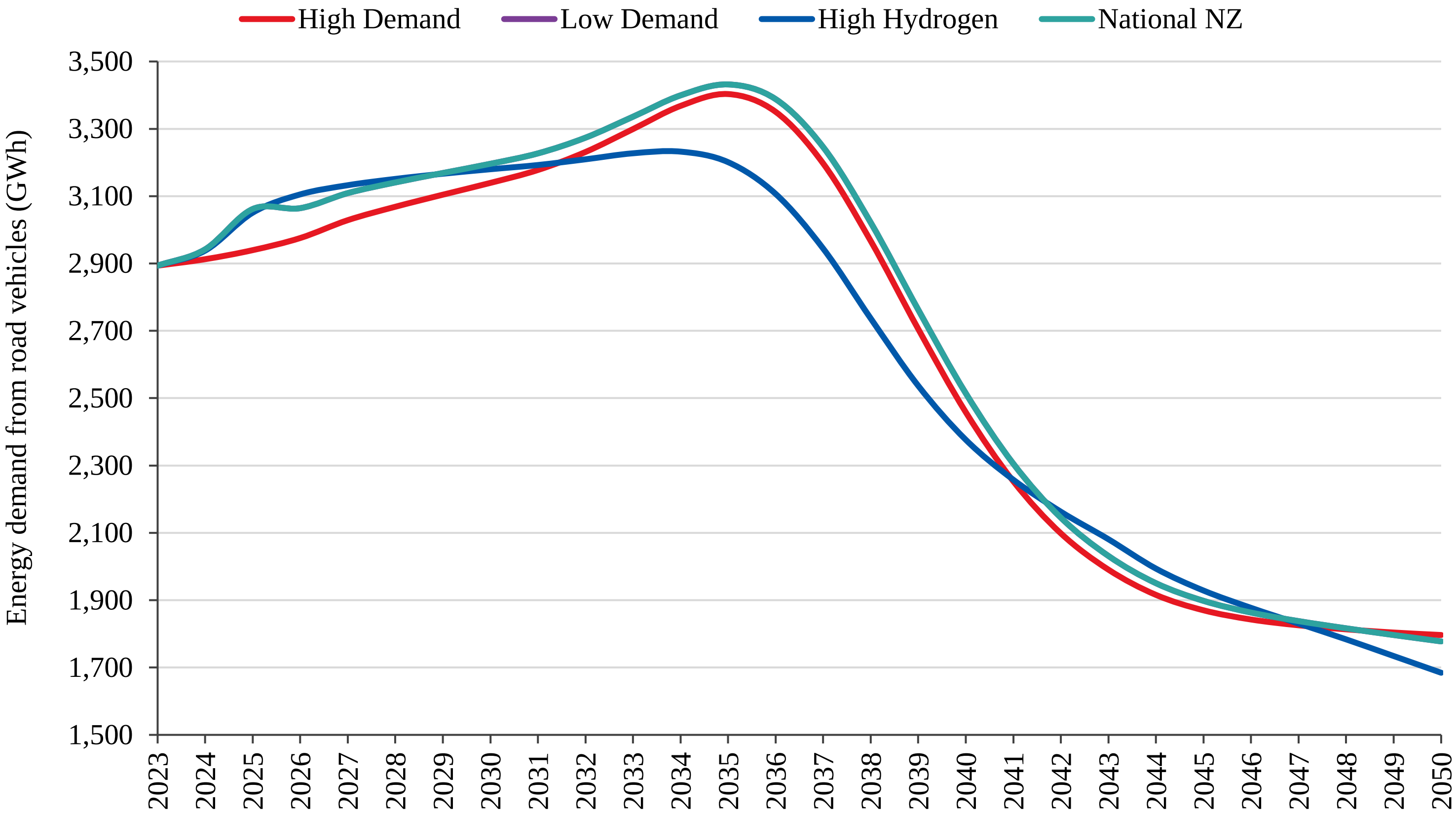


Figure 4.3.3: Projected energy demand from road vehicles by scenario

4. The future energy system
Deployment modelling

Summary of deployment for low-regret energy system components

Our deployment model helps us to think about where we are now and where we need to get to, providing a starting point to frame the challenge and for more detailed analysis. We have included theoretical pathways which have a high degree of uncertainty as there are many variable factors and unknowns. The deployment modelling can't take into account every factor, some of the things that will impact deployment include:

1) Technological advance and innovation
2) Supply chains and how they develop
3) Large scale activity to decarbonise infrastructure at other levels: regional, UK and beyond.

*According to the National Charge Point Registry[M43] as of May 2023. Refers to individual charge points, and assuming 4kWp per charge point

**Assuming 4kWp per roof

***Renewable generation capacity is shown for technologies where current installed capacity is >5MW

Measure	2023	By 2030	By 2050
Additional homes with insulation measures (#)	13,00 homes with EPC A-C (35%)	Up to 25,000 homes retrofitted	Up to 61,100 homes retrofitted
Buildings with heat pumps installed (#)	700	Up to 14,600	Up to 95,300
EV charge points (#)*	220	Up to 8,430	Up to 63,840
Buildings with rooftop solar PV (#)**	2,900 (12 MW)	28,000 (112 MW)	99,700 (399 MW)
Ground-mounted solar PV capacity (MW)	80 MW	228 MW	645 MW
Other renewable capacity (MW)***	44 MW	73 MW	110 MW

Table 4.3.2: Summary of deployment of various technologies between 2023, 2030 and 2050

Impact on GHG emissions

Figure 4.2.4 compares projected GHG emissions for each future energy scenario (see Chapter 4. The future energy system (methodology) for a description of scenarios). The “Do Nothing” scenario assumes that Flintshire continues operating as it is today, with no further action beyond what is already current mandatory UK and Wales GHG emission reduction targets. However, this does not reach the net zero target. Any change can largely be attributed to the forecasted decarbonisation of the electricity grid. By considering external factors such as committed policy and other decision points, the deployment pathways for each scenario help us to prioritise actions that we might deliver in the next five years. It also highlights the systemic changes that will be needed to achieve the scale and pace of change that is indicated.

Scenario	2030	2040	2050
Welsh Gov targets	-63%	-89%	-100%
National Net Zero	-33%	-77%	-96%
High Demand	-34%	-78%	-96%
High Hydrogen	-34%	-72%	-95%
Low Demand	-35%	-77%	-97%
Do Nothing	-32%	-33%	-33%

Table 4.3.3: % GHG emissions reduction for each scenario compared to the Welsh Government emissions reduction targets

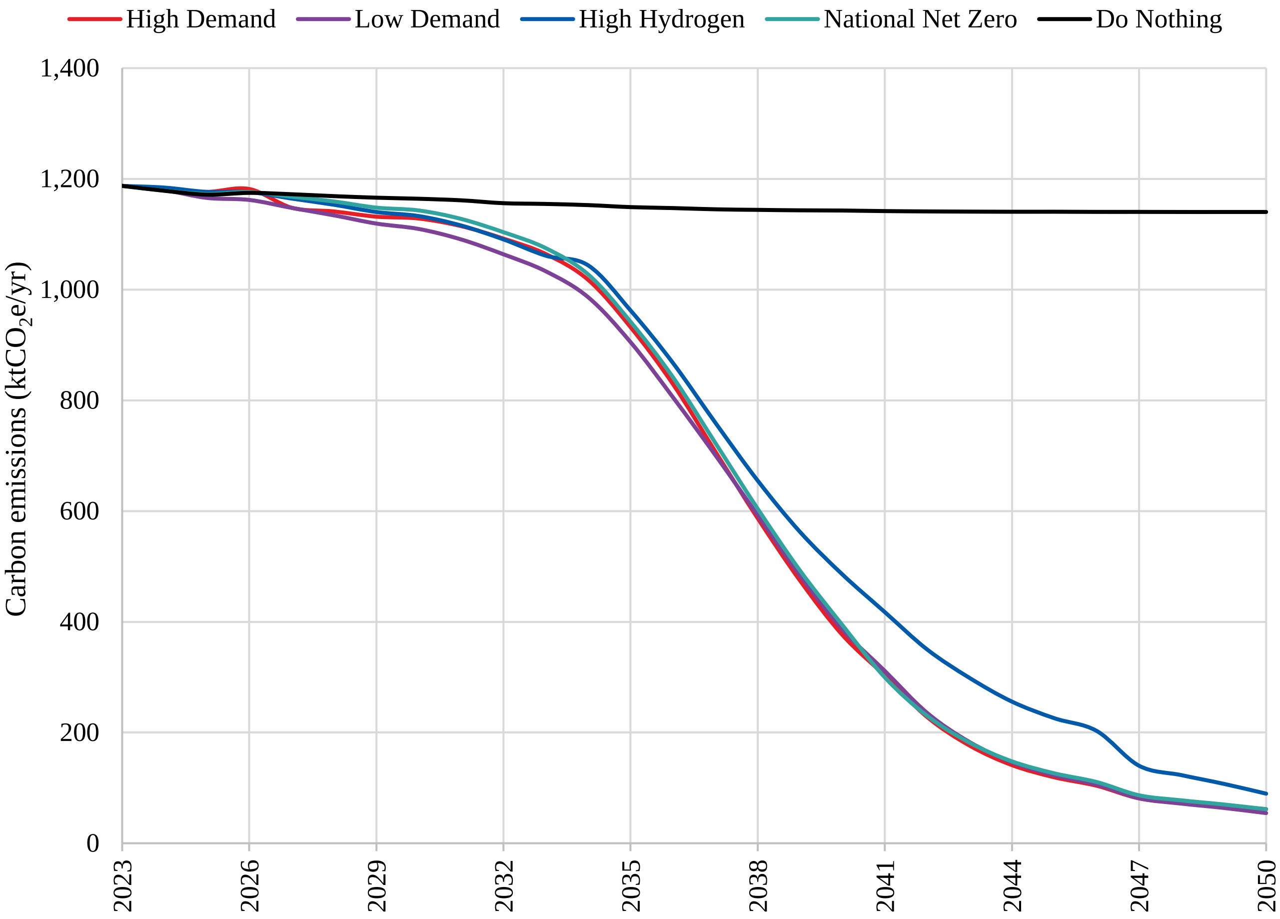


Figure 4.3.4: GHG emissions (ktCO2e) over time for each scenario compared to the Do Nothing scenario

Impact on employment

Reducing the amount of energy we use and using renewable energy can have wider benefits so it is important that they are understood to support decisions that impact the future of the energy system. The benefits realised can be economic, social and environmental. For example, for every £1 invested in energy efficiency measures, the NHS can save £0.42 (amounting to annual savings of £1.4 billion in England alone)[T35].

Employment impacts

Investments in local energy systems can be expected to have employment benefits by providing local, skilled jobs. These will include direct jobs from construction and operational phases of the development[T36].

Method

We conducted a literature review to extract relevant indicators to estimate the employment impacts derived from investment in different decarbonisation measures such as energy efficiency improvements, installing heat pumps and EV chargepoints or constructing a solar farm. We have selected indicators that reflect jobs created in the local area to assess the local benefits associated with each scenario, and, where possible, excluded impacts associated with employment that are likely to be felt beyond the local area. This means that "indirect" employment impacts, or jobs created within the supply chain to support a particular project (e.g. for a wind farm, this could be jobs supplying or manufacturing the blades for wind turbines) are not considered.

Our assessment considers jobs that might be displaced in other parts of the economy owing to an investment in energy efficiency or renewable energy. For example, investment in renewable energy might displace jobs in other parts of the power sector such as those associated with power generation from gas-fired plant. Where possible, indicators from surveys or studies completed for projects in Wales have been used so that the employment impacts reflect the economic conditions in Wales as closely as possible.

Results

Table 4.2.3 are presented in Full-Time Equivalent (FTE) so that employment impacts can be measured for the lifetime of the project or plant and duration. For example, a job that lasts 1 year for a project where plant lifetime is 10 years would count at 1*1*0.1 = 0.1FTEs over the duration of the project.

Both cumulative gross jobs added, and net additional jobs have been estimated. Net additional jobs are estimated by subtracting the gross jobs by the 'Do Nothing' scenario to net off jobs created if the money were invested in similar ways to what it is today.

Metric	Do Nothing	National Net Zero	High Demand	Low Demand	High Hydrogen
Energy change (GWh, relative to 2023)	0	-113 (-2%)	-94 (-2%)	-1,878 (-31%)	-206 (-3%)
Employment impacts between 2023-2050 relative to Do Nothing scenario (net FTE)	0	7,178	7,194	7,325	8,760

Table 4.3.4: Summary of economic impacts for each scenario: employment impacts and air quality activity costs. Figures shown relate to the period 2023 – 2050. Air quality activity costs are presented using 2022 prices and are not discounted

Impact on air quality

The energy system can also impact air quality, which in turn impacts human health, productivity, wellbeing and the environment. Accordingly, understanding the impacts to air quality is important when planning future policy or programmes of work.

Method

We used the Green Book supplementary guidance for air quality[T50] activity costs from primary fuel use and the transport sector to estimate the air quality cost for each year (2023 to 2050) for each scenario. Activity costs simplify evaluating the effects of air pollution by estimating the value of changes to air quality per unit of fuel consumed. Table 4.2.4 provides a summary of the activity costs used in 2023 for the fuel types included in this analysis. The activity cost for electricity was assumed to vary over time; the costs for all other fuels were assumed to remain constant. Appendix B8 provides additional details on the derivation and assumptions for each of these costs. Air quality activity costs are presented using 2022 prices and are not discounted.

The Green Book does not include air quality impacts of landfill gas, organic matter, sewage gas, or hydrogen. We assumed that these fuels have the same air quality impact as natural gas.

Fuel	Air quality cost (2022 p/kWh)
Electricity	0.15
Natural gas	0.16
Landfill gas	0.16
Organic matter	0.16
Sewage gas	0.16
Hydrogen	0.16
Biomass	4.70
Coal	3.74
Oil/LPG	1.25
Diesel	1.33
Petrol	0.17

Table 4.3.5: Air quality activity cost factors

Impact on air quality

Results

Activity costs presented in Table 4.3.6 show estimates for the impact of air pollution in each future energy scenario, compared to the Do Nothing scenario.

The costs associated with poorer air quality (for example, this could be health impacts such as mortality and morbidity effects, environmental impacts such as ecosystem damage, and economic effects such as productivity because of poor health) are less in all future energy scenarios that we modelled.

The greatest economic savings from improving air quality are produced in the National Net Zero scenario.

Metric	Do Nothing	National Net Zero	High Demand	Low Demand	High Hydrogen
Cumulative air quality activity costs between 2023-2050 (£'million) (2022 prices)	£0	£1,200m	£1,177m	£1,198m	£1,170m
Change in greenhouse gas (GHG) emissions (ktCO2e, relative to 2023)	-47	-1,126	-1,125	-1,133	-1,097

Table 4.3.6: Summary of economic impacts for each scenario: employment impacts and air quality activity costs. Figures shown relate to the period 2023 – 2050. Air quality activity costs are presented using 2022 prices and are not discounted

4. The future energy system
Deployment modelling

Investment requirements

High levels of investment will be required to achieve the scale of change required to achieve a net zero energy system. Table 4.2.6 overleaf shows the estimated capital investment (CAPEX) required to build out the critical system components for net zero, that were identified in our scenario analysis. These costs are presented as absolute figures and should be weighted against a suitable counterfactual to understand the additional investment required.

This table shows the parties responsible for these investments and key interdependencies.

The total capital investment requirements between now and 2030 are estimated to be from **£3 billion to £10 billion**, which is mostly invested in building retrofit and energy efficiency, heat decarbonisation and rooftop solar PV.

Some of these priority intervention areas will also have additional operational expenditure (OPEX) requirements. For example, heat electrification might result in higher operational costs for consumers. The final capital and operational costs of the energy system are also subject to potential changes in supply, policy, and consumer perception.

We haven’t estimated investment requirements where there is a high level of uncertainty in costs:

- Electricity network reinforcement costs will depend on the extent of network upgrades which will be needed across the LV, HV and EHV networks, requiring more detailed analysis.
- Costs for gas infrastructure have not been included due to the high uncertainty around the scale of the gas network in 2050

4. The future energy system
Deployment modelling

Investment requirements

	Indicative CAPEX (£m) to 2050	Basis for CAPEX estimate	Party responsible for CAPEX	Dependencies on other investments
1. Maximise energy efficiency of buildings	£320 – 4,540m	Cost of deep retrofit interventions	Local authority, housing associations, building developers, public	Supply chain
2. Ground-mounted solar PV	£240m	Equipment costs	Local authority, housing associations, building developers, public, renewable energy providers	Electricity network
3. Maximise rooftop PV	£430m	Build out of rooftop PV	Local authority (owned buildings), housing associations, building developers, public, renewable energy providers	Electricity network, potential structural costs
4. Decarbonise transport	£140 - 290m	Build out of EV chargers	Local authority, building developers, public	Electricity network
5. Decarbonise heat	£885 – 1,050m	Heat pump build out costs, heat network decarbonisation cost	Local authority, housing associations, building developers, public, heat network developers	Electricity network, energy efficiency
6. Electricity network reinforcement	£90m	Electricity network reinforcement costs will depend on the extent of network upgrades which will be needed across the LV, HV and EHV networks, requiring a more detailed analysis by the DNO.		
Project costs (incl contingency, prelims, professional and development costs etc) could be 50% of capital costs above				

Table 4.3.7: Indicative investment requirements

Sponsors:

Delivery partners:

Technical report

Chapter 5: Action planning (stages 6-7)

5. Action planning

Overview

Figure 5.0.0 shows the process followed to develop the complete LAEP and routemap to transition the local energy system in Flintshire.

Energy propositions

Identifying priority focus zones

We discussed what energy system components were common in all scenarios and asked stakeholders what they felt should be prioritised in the near-term. We considered this alongside other technical and social factors (e.g. generation and demand headroom) to prioritise focus zones where they might be deployed.

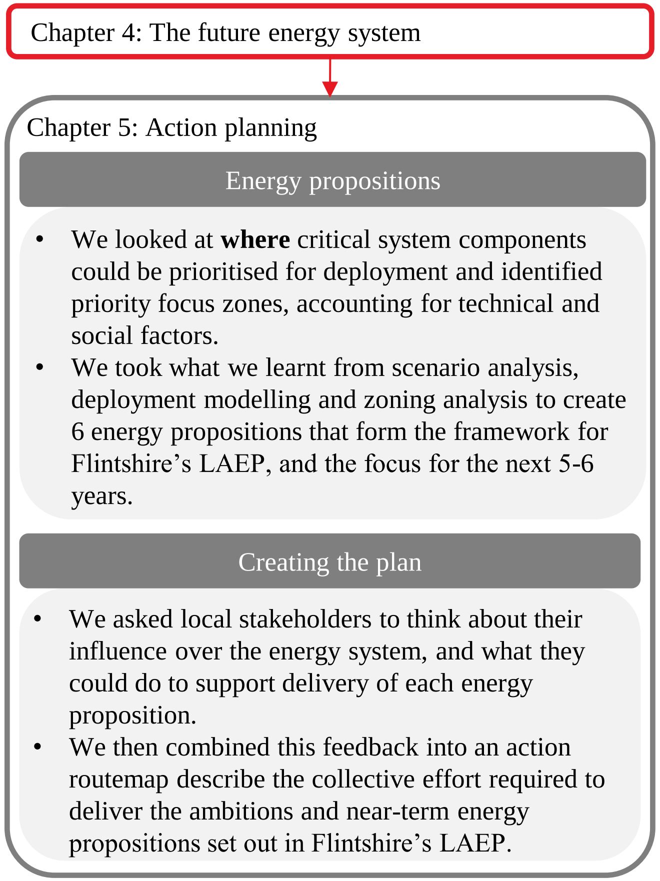
Creating energy propositions

After reviewing and discussing these results and revisiting what we learnt from scenario analysis and deployment modelling with stakeholders, **five energy propositions** were agreed. These form the strategic foundation for Flintshire’s LAEP and consolidate the evidence to describe what, how and where to prioritise the deployment of these energy system components.

Creating the plan

Enabling actions

Using input from stakeholders, highlighted overleaf, we created a routemap and action plan to drive the local energy system transition in Flintshire, which includes what needs to happen and what key stakeholders will do to contribute to delivery of the LAEP. This routemap and action plan can be found in the LAEP Main Report.



Chapter 4: The future energy system

Chapter 5: Action planning

Energy propositions

- We looked at **where** critical system components could be prioritised for deployment and identified priority focus zones, accounting for technical and social factors.
- We took what we learnt from scenario analysis, deployment modelling and zoning analysis to create 6 energy propositions that form the framework for Flintshire’s LAEP, and the focus for the next 5-6 years.

Creating the plan

- We asked local stakeholders to think about their influence over the energy system, and what they could do to support delivery of each energy proposition.
- We then combined this feedback into an action routemap describe the collective effort required to deliver the ambitions and near-term energy propositions set out in Flintshire’s LAEP.

Figure 5.1.1: Overview of the approach taken to develop the near-term recommendations for the LAEP

Identifying priority focus zones

Prioritising energy system components

Table 5.1.1 shows our approach to prioritise low-regrets energy system components in Flintshire to take forwards when identifying priority focus zones for their deployment. We consulted primary and secondary stakeholders across the county and asked:

- Is the energy system component deployed in all scenarios?
- Is this component a strategic priority identified by stakeholders during engagement?
- Does this energy system component align with the wider objectives that have been set for Flintshire's LAEP (described in Figure 5.0.1)?
- Is this energy system component identified as a priority area in North Wales's energy strategy?

We combined this feedback with insights from scenario modelling to develop Flintshire's energy propositions, which are the framework for Flintshire's LAEP. Flintshire's energy propositions focus on areas of the energy system that contribute significantly to the area-wide emissions and have been identified as a priority zone for change in the near term. Energy propositions are a combination of energy system components chosen as a priority to drive change in a particular part of the energy system, that have an indicative timeframe for deployment and magnitude. For example, an energy proposition that includes onshore wind as a critical energy system component will specify what capacity is needed and by when, as well as indicative investment requirements to achieve it.

	Outcome certain / clear	Outcome less certain / clear
Short term (0-5 years)	Onshore wind Rooftop PV EV chargers (public, private and commercial) Ground mounted PV Anaerobic digestion	EV chargers (domestic) Retrofit Biomass boilers Exporting to grid
Longer term	National grid supply Electrical network infrastructure Battery storage Heat pumps Blending hydrogen in to gas grid Small scale electrolysers	Heat networks Hydrogen infrastructure Electrolysers Hydrogen imports from abroad Tidal lagoons Active travel shift Energy from waste Hydrogen for heating

Table 5.1.1: Summary of feedback from workshop 5 (pathway prioritisation) – "prioritising energy system components"

5. Action planning

Energy propositions

Flintshire’s energy propositions in more detail

Scaling zero carbon buildings

Supporting and deploying energy efficiency measures across the county to reduce energy demand and costs.

Ensuring buildings are safe, healthy and low carbon in operation and design.

Decarbonising transport

Enabling the rollout of ultra low/zero carbon vehicles across the county and transitioning to a zero carbon council fleet.

Promoting active and sustainable travel within the region.

Increasing local renewable generation

Investigating opportunities for local and community ownership of renewables, providing low cost, clean energy to residents.

Supporting future green business

Encouraging and supporting businesses to adopt low carbon measures and reduce energy costs.

Create an attractive environment for sustainable businesses to make base in Flintshire.

Maturing hydrogen in industry

Exploring the potential for hydrogen within particular sectors and understand the infrastructure requirements for implementation.

Reinforce and transition energy networks

Grid reinforcement will be required to accommodate the shift towards electric vehicles and heating.

Even in a low hydrogen scenario the gas grid will require repurposing for hydrogen within some applications.

Figure 5.1.2: Summary of energy propositions

Identifying priority focus zones

Our “plan on a page” indicates the location and scale of recommended near-term changes required across Flintshire. The map highlights nine modelling zones identified as priority focus zones for the low-regret energy system components included in Flintshire’s energy propositions: heat pumps, EV chargers, rooftop PV, ground-mounted PV, onshore wind, and insulation retrofits. To prioritise where each low-regret energy system component should be deployed, each modelling zone was ranked using two or more of the considerations in Table 5.0.0, each weighted by the percentage indicated. A modelling zone was only considered for prioritisation if it was greater than 8% of its primary substation service area[x7].

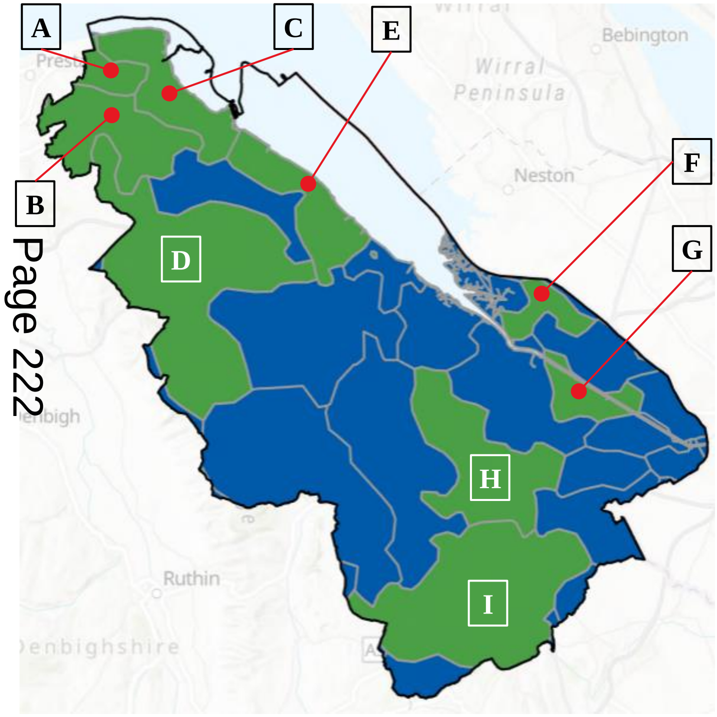
- **Off-gas homes** – prioritise zones with higher baseline proportion of off-gas housing. These homes will be the most challenging to transition to hydrogen and therefore are the most likely no-regrets targets for conversion to heat pumps.
- **Socioeconomics** - prioritise zones with higher baseline rates of deprivation (lower WIMD score).
- **Property ownership** - prioritise zones with the highest baseline percentage of social housing.
- **Substation generation headroom** – prioritise zones with the most baseline generation headroom available.
- **Listed buildings** – prioritise zones with the least number of currently listed buildings.
- **Domestic energy efficiency** – prioritise zones with the highest baseline percentage of homes with an EPC rating of D or below.
- **Built additional substation capacity** - prioritises zones where the least upgrades are required in the high demand scenario, since heat electrification is typically a major contributor to grid upgrade requirements (which may be back-logged by several years).
- **Built EV charging capacity** – prioritise zones with the most EV charging built in the high demand scenario.
- **Built additional capacity of each local generation technology** (rooftop PV, ground-mounted PV, or onshore wind) – prioritise zones where the most additional new capacity is built between the baseline and 2050 high demand scenario.

In the map (overleaf), green areas show zones identified as a priority focus zone for at least one energy system component. The callouts indicate the total scale of change required by 2030, according to the deployment model analysis, and indicate either the total capacity (MW) to be installed or the number of homes requiring retrofit and the associated investment figures.

Data	Heat pumps	EV chargers	Local generation	Insulation retrofits
Off-gas homes[T7]	25%	-	-	-
Socioeconomics[T28]	25%	30%	-	20%
Property ownership[T7]	25%	-	-	20%
Substation generation headroom[TN6]	-	-	50%	-
Listed buildings[T4]	-	-	-	5%
Domestic energy efficiency[T7]	-	-	-	35%
Built additional substation capacity	25%	40%	-	20%
Built EV charging capacity	-	30%	-	-
Built additional capacity of each local generation technology	-	-	50%	-

Table 5.1.2: Input data and relative weighting factors used in “plan on a page” calculations

5. Action planning



▨ Heat pumps
🚗 EV charger
☀ Rooftop PV
▦ Ground-mounted PV
🏠 Insulation measures

Figure 5.1.3: Flintshire's spatial representation of opportunities, including 2030 ambition and investment (million £) – in Low and High scenarios. Zone boundaries are the modelling zone boundaries.

To support the transformation of the energy system, pilot projects may be useful. The map (left) highlights areas that could provide a useful focus for these pilots. Figure 5.0.3 identifies zones with particularly favourable conditions for specific energy components, making them ideal locations for pilot studies. The summary tables detail key figures for each zone by 2030: **(i)** pilot ambition, **(ii)** required investment for each pilot and **(iii)** total investment for all deployment in the zone, including all energy components and electricity network infrastructure interventions. Ranges show the minimum and maximum results from each future energy scenario. Note: intervention should still be carried out in 'Progress' zones to transition the local area to Net Zero.

	(i)	(ii)	(iii)
A	**Church lane, Prestatyn**		
🏠	140-300 homes	£1.3-23.1m	£3-24m
B	**Graig Fawr**		
▨	280-480 kW	£210-360k	£3-28m
C	**Point of Ayr Colliery**		
▨	570-990 kW	£425-740k	£5-36m
☀	1 MW	£1.1m	
D	**Holywell**		
☀	1.1 MW	£1.3m	£9-69m

	(i)	(ii)	(iii)
E	**Greenfield**		
🏠	370-1,070 homes	£3.4-63.4m	£19-77m
F	**Shotwick**		
🚗	1 MW	£865k	£18m
G	**Queensferry**		
🚗	2 MW	£1.6m	£21-64m
H	**Buckley**		
▦	75 MW	£32.5m	£67-268m
I	**Caergwrle**		
▦	2.5 MW	£15.2m	£31-141m

5. Action planning

Plan on a page (as seen in main report)

Plan on a page

To support transformation of the energy system, pilot projects may be useful. The map below highlights areas that could provide a useful focus for these pilots.

Figure 0.4 identifies zones with particularly favourable conditions for specific energy components, making them ideal locations for pilot studies. The summary boxes detail the location, opportunity type, potential capacity, required investment for each component, and total investment necessary for both energy component installation and electricity network infrastructure in each zone by 2030. Ranges have been calculated by taking the minimum and maximum results from each future energy scenarios modelled.

Point of Ayr

Opportunities: Heat pumps	Rooftop PV
Potential: 95-165 units	1.0MW
Cost: £0.4m-0.7m	£1.1m

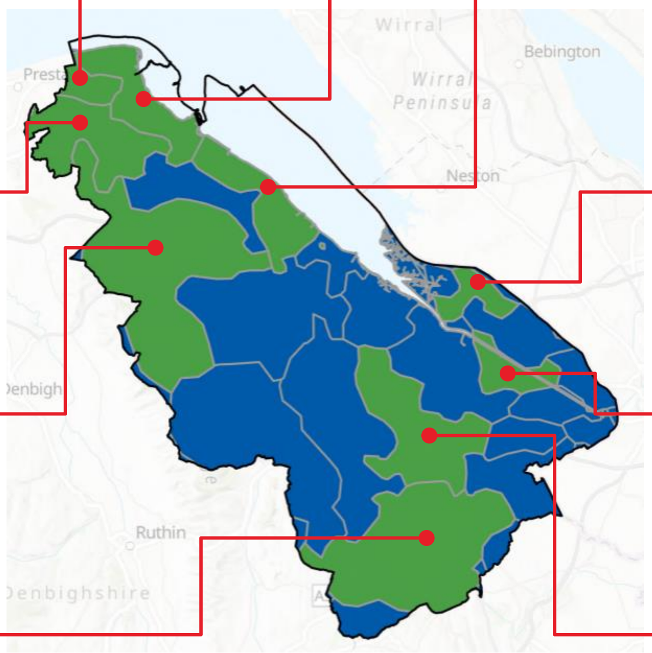
Total opportunities cost: £3m-24m

Gronant
Opportunity: Domestic retrofits
Potential: 138-298 homes
Cost: £1.3m-23.1m
Total opportunities cost: £3m-24m

Trelawnyd
Opportunity: Heat pumps
Potential: 47-80 units
Cost: £0.2m-0.4m
Total opportunities cost: £3m-28m

Caerwys
Opportunity: Rooftop PV
Potential: 1.1MW
Cost: £1.3m
Total opportunities cost: £9m-69m

Leeswood
Opportunity: Ground PV
Potential: 35.2MW
Cost: £15.1m
Total opportunities cost: £31m-141m



Greenfield
Opportunity: Domestic retrofits
Potential: 372-1,197 homes
Cost: £3.4m-63.4m
Total opportunities cost: £21m-79m

Shotwick
Opportunity: EV chargers
Potential: 261
Cost: £0.9m
Total opportunities cost: £18m-22m

Queensferry
Opportunity: EV chargers
Potential: 484
Cost: £1.6m
Total opportunities cost: £23m-66m

Buckley
Opportunity: Ground PV
Potential: 75.2MW
Cost: £32.5m
Total opportunities cost: £68m-269m

Figure 5.1.4: Flintshire's spatial representation of opportunities, including 2030 ambition and investment (million £) – in High and Low Demand scenarios. Zone boundaries are defined by primary substation service areas

5. Action planning
Scaling zero carbon buildings

Introduction

National policy indicates a “fabric, worst and low carbon first approach to improve the energy efficiency of the least thermally efficient low-income households in Wales”[T38]. In Flintshire, most homes will need insulation retrofit (discussed here) and heat pump installation (discussed overleaf).

Focus zones for insulation retrofit

We used several factors (Table 5.0.0) to compare each modelling zone’s favourability for near-term insulation retrofits. Figure 5.0.4 illustrates the results; the highest-scoring zones are included in Figure 5.0.3 as priority focus areas.

For reference, the zones which are focus zones for heat pump installation (discussed further overleaf) are also highlighted in Figure 5.0.5. In the “fabric first” approach, insulation retrofits would precede heat pump retrofits. Care should be taken in these areas to coordinate insulation and heat pump retrofits as needed.

Areas around Prestatyn and Greenfield have been identified as focus zones owing to their higher percentage of domestic properties that fall within areas with a higher index of multiple deprivation. There are approx. 4,900 homes in these substation zones.

Areas, such as Flint, with a higher proportion of properties with EPC A-C ratings are less favourable for insulation retrofits. There are approx. 6,700 homes in this substation zone.

Industrial and commercial zones with few domestic properties are considered less favourable for insulation measures. There are approx. zero homes in this substation zone.

The relative uniformity of focus zone rankings across the county indicates that insulation retrofits need to be considered in most properties.

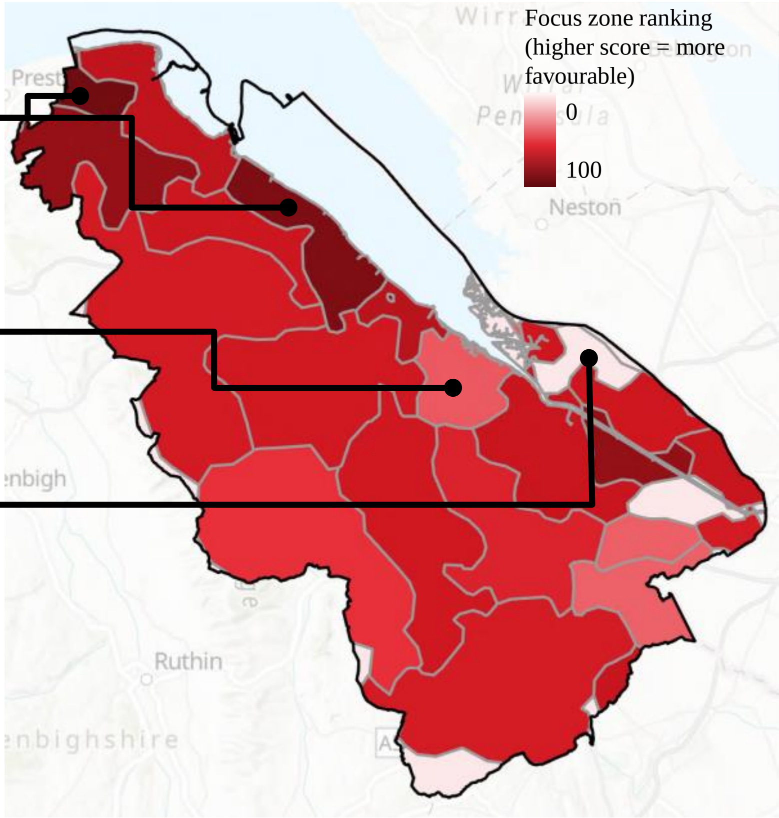


Figure 5.1.5: Focus zone rankings for domestic insulation retrofits by modelling zone

Now: **31,200 homes** rated EPC D or below

By 2030: **Up to 25,000 homes** retrofitted

By 2050: **Up to 61,100 homes** retrofitted

5. Action planning
Scaling zero carbon buildings

Introduction

Focus zones for heat pump retrofit

Electrifying building heat (e.g. via heat pumps) could play a dominant role in decarbonising the buildings sector. We used several factors (Table 5.0.0) to compare each modelling zone’s favourability for near-term heat pump retrofits. Figure 5.0.5 illustrates the results; the highest-scoring zones are included in Figure 5.0.3 as priority focus areas.

For comparison, Figure 5.0.6 shows the fraction of homes in Flintshire currently not served by the gas network. These homes could be low-regrets options for retrofits since they will be the most challenging to serve via a future hydrogen network. The most favourable zones for heat pump installations are therefore areas around Caerwys, Nannerch and Trelawnyd in the West and North West. There are approximately 5,700 homes in these substation areas.

For reference, the zones which are focus zones for insulation retrofits, discussed previously, are also highlighted in Figure 5.0.4.

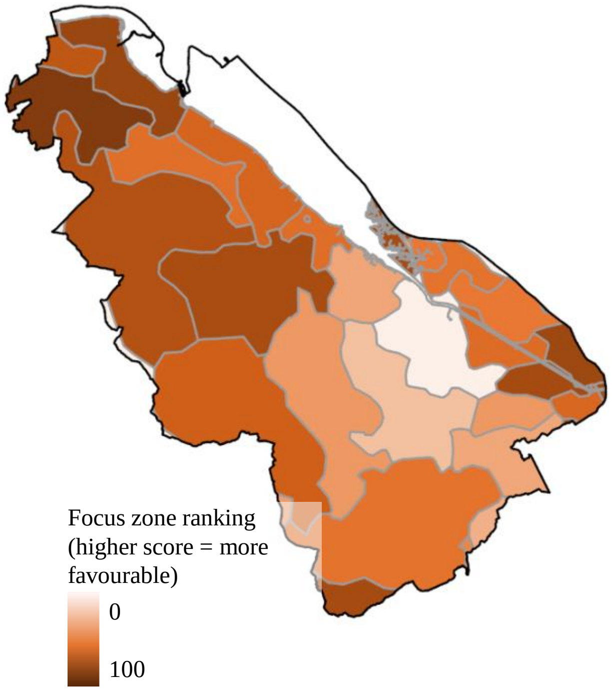


Figure 5.1.6: Focus zone rankings for heat pump installations across Flintshire by modelling zone

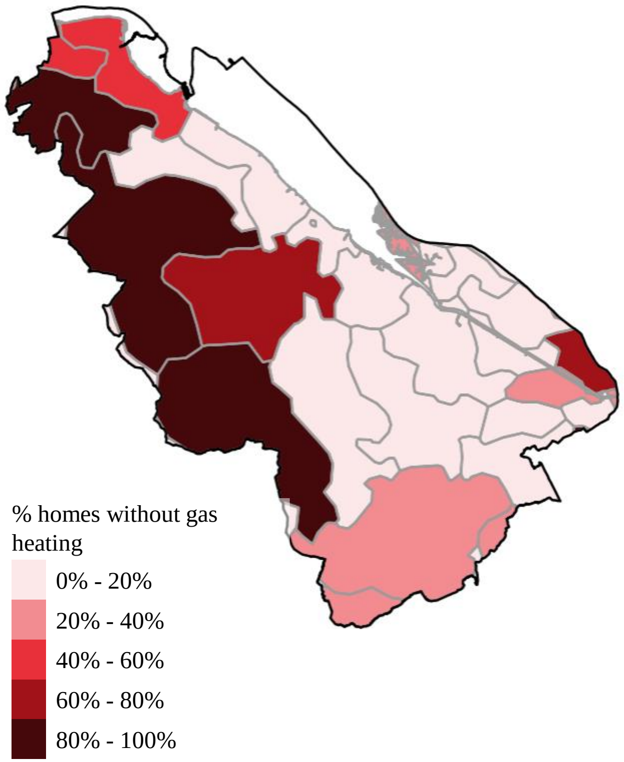


Figure 5.1.7: Baseline fraction of homes without gas heating in Flintshire

Now:

700 buildings with heat pumps

By 2030:

Up to 14,600 buildings with heat pumps

By 2050:

Up to 95,300 buildings with heat pumps

5. Action planning
Scaling zero carbon buildings

Investment requirements

The deployment model estimates the capital investment required for insulation retrofits and heat pumps. These are discussed separately below, along with potential funding opportunities.

Investment requirements for insulation retrofit

The upfront investment for insulation retrofit varies depending on the package of insulation measures appropriate for each archetype and the desired level of energy efficiency. In the High Demand scenario, the cost of retrofit can vary between £7,200 - £22,200 per household and £49,000 – £147,700 per commercial property. In the Low Demand scenario, the cost of retrofit between £47,250 - £101,500 per property and £89,250 - £381,800 per commercial property.

Investment requirements for heat pumps

On average, the upfront cost for a heat pump is estimated at £4,500[T42]. For most homeowners, the cost of equipment is a significant barrier to installation, which has contributed to a slow uptake across the UK[T43]

Investment requirements for heat pumps

On average, the upfront cost for one rooftop solar PV panel (4kW) is £4,400[T52].

Funding opportunities

Consider who is going to pay here, for instance, the LA might consider tackling social housing first because of grants, private rented is forced to get a particular EPC, how can we support them. How is the owner occupier supported – UK gov grants for specific income groups/EPCs for retrofit measures and heat pumps.

There are different funding sources that could be explored to support delivery of these interventions:

- Social housing grants
- Private rented properties can be eligible for the GBIS (Great British Insulation Scheme) and landlords are also required to get their properties to EPC C by 2030
- For owner-occupied housing – GBIS is limited, and uptake is low (throughout Great Britain there were only 1,000 installations in November 2023)
- The boiler upgrade scheme (BUS) is also available for eligible properties for up to 45kWth air and ground source heat pumps providing £7.5k of funding per property.
- Bulk purchasing schemes through the council can be attractive to increase uptake of solar PV, insulation and batteries. Many councils have trialled these programmes, so lessons learnt should be available
- Alternative funding such as Retrofit credits via the HACT scheme are available for social housing organisations, these are carbon credits related to the reductions and social value from the retrofit scheme which are sold to provide the investment funding.

Energy system component(s)	Investment (£m) in retrofit and heat electrification between 2023 and 2050
Retrofit (domestic)	£200 – 4,090m
Retrofit (non-domestic)	£125 – 450m
Heat pump	£885 – 1,050m
Heat networks	£370m

Table 5.1.3: Investment costs for the Scaling zero carbon buildings proposition for 2050

5. Action planning
Decarbonising transport

Introduction

The transport proposition for Flintshire covers active travel, public transport, feeds off the transport strategy for Flintshire, EV infrastructure on publicly-owned land. These are the things in the direct control of the Local Authority.

The transport proposition for Flintshire prioritises a reduction in car use as much as is possible through improved provision of active travel routes and public transport. Flintshire is a mix of large towns and some more sparsely populated areas, which means that private car usage is likely to play a role in the future of the local transport system, as is shown in our modelling. Therefore, the priority will also be to support the transition to electric vehicles through the provision of convenient, accessible chargepoint infrastructure, starting with opportunities on publicly-owned land.

Active travel and public transport

We used the transport hierarchy in our modelling which follows Welsh policy of 13% conversion to active travel. Most bus services are commercially operated in the County leaving limited influence for the Council to shape the service, such as setting fares and choosing vehicles. However, the Active Travel (Wales) Act 2013[TL05] places a duty on the Council to promote the use of active travel through means such as maintaining and expanding the active travel network and actively communicating information about the network.

5. Action planning
Decarbonising transport

Focus zones for EV chargers

EV chargers will be required across the local authority, with a fairly constant level of favourability across the county.

Areas with higher demand headroom, such as Deeside industrial estate and Shotwick, have been highlighted as more favourable.

Deeside has been flagged as a less favourable zone due to low levels of demand headroom and lower grading against the Welsh Index of Multiple Deprivation

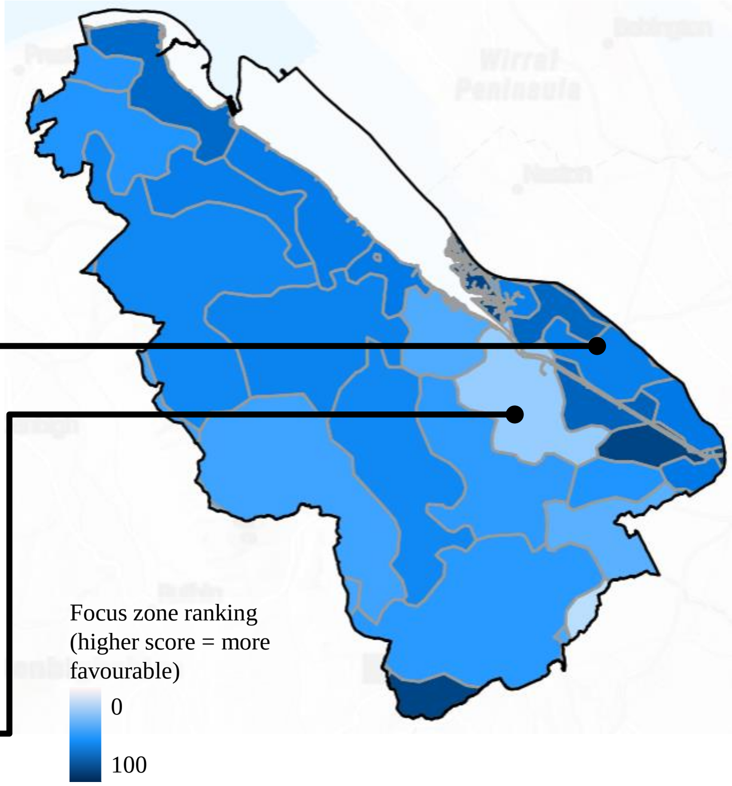


Figure 5.1.8: Focus zone rankings for EV chargers by modelling zone

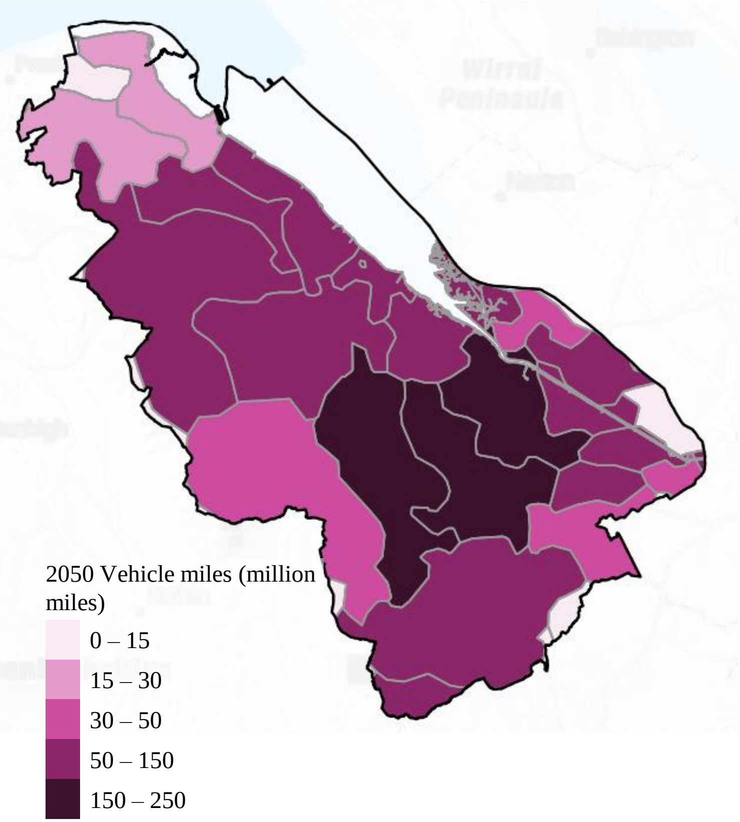


Figure 5.1.9: Future car mileage in 2050 by substation zone

5. Action planning
Decarbonising transport

EV charging infrastructure

Predicted EV charge point deployment from Wales' EV Charging Strategy[T44] is that by 2030, there are over 50,000 EV chargers in Flintshire, of which:

- 0.5% are rapid (43kW)
- 7.1% are fast (14.5kW)
- 92.4% are slow chargers (3kW)

Note that these numbers from Wales's EV Charging Strategy are likely to be amended imminently, reflecting a slower initial rate of deployment.

Our modelling indicates that by 2030, up to 8,400 chargers will need to be deployed to meet future transport demand (shown in Figure 5.0.7).

Now:
220
EV charge points

By 2030:
Up to 8,400
EV charge points

By 2050:
Up to 63,840
EV charge points

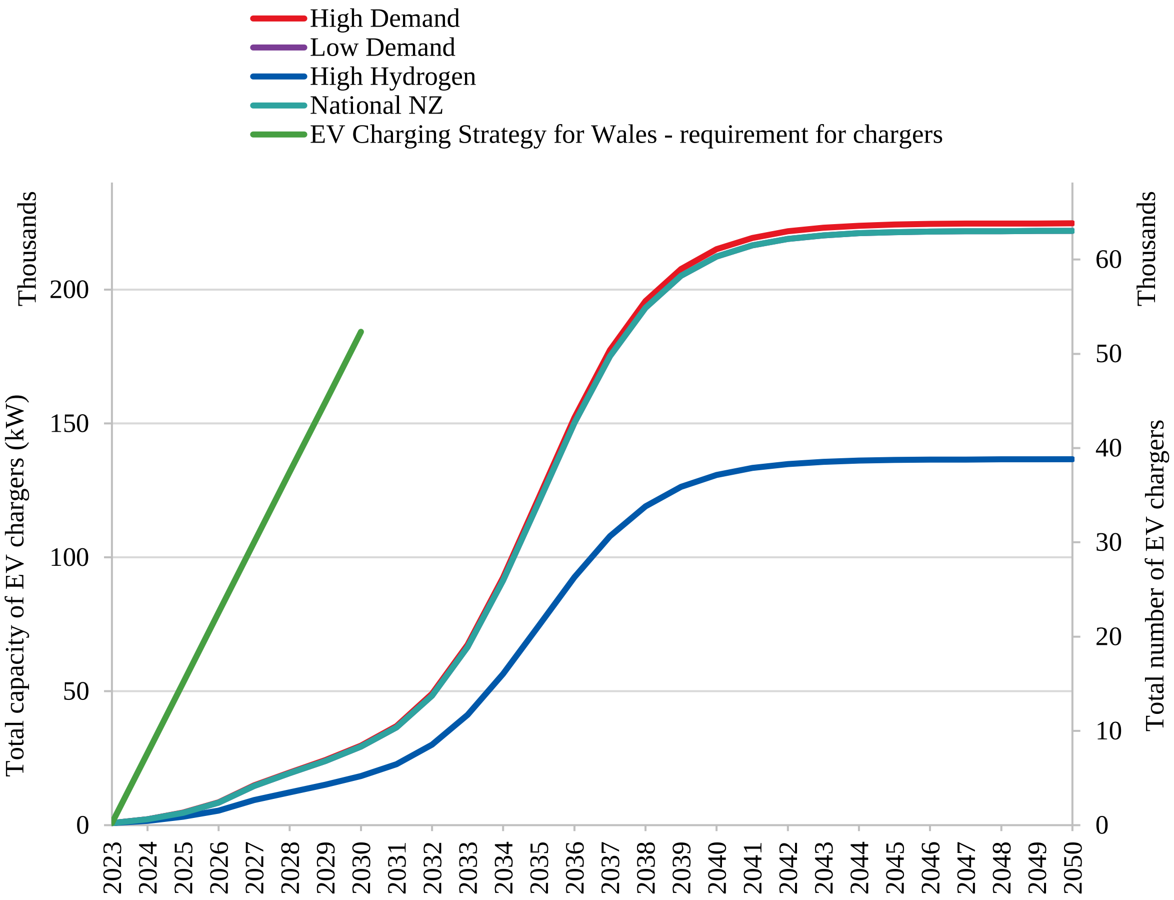


Figure 5.1.10: Capacity and EV chargepoint deployment over time

Focus zones for public transport and EV chargepoints

Electric vehicle ownership is expected to increase based on national policy and legislation that requires a phase-out of new combustion engine vehicle sales by 2035 under the zero emissions vehicles mandate[T48].

We used several factors (Table 5.0.0) to compare each modelling zone’s favourability for near-term installation of EV chargers. Figure 5.0.8 illustrates the results; the highest-scoring zones are included in Figure 5.0.3 as priority focus areas.

To support the development of an efficient, cost-effective EV charging network, further analysis of off-street parking availability, transport patterns and locations of ‘destinations’ for destination public charging will be required to refine the strategic placement of EV chargers. For example, considering charging hubs in areas with limited off-street parking, or at locations regularly visited by residents such as supermarket car parks.

The maps shown in Figure 5.0.8 and 5.0.9 (overleaf) show focus zones and projected vehicle mileage to prioritise for public EV charging infrastructure.

Priority focus zones are identified by assessing electricity demand headroom (40% weighting), Welsh Index of Multiple Deprivation (30% weighting) and the deployment of EV charging capacity (30% weighting) from scenario analysis.

This shows strategic areas for the development of EV charging infrastructure.

Investment requirements

The investment required for EV chargers could be about £290m by 2050. There are various UK government grants for renters, flat owners, houses with on-street parking, as well as workplace charging schemes.

Energy system comp onent(s)	Investment (£m) in retrofit and heat electrification between 2023 and 2050
EV chargers	£140 - 290m

Table 5.1.4: Investment costs for the Decarbonising transport proposition for 2050

5. Action planning

Increasing local renewable generation

Focus zones for local electricity generation

To support Flintshire in getting to net zero, renewables are shown in the scenario analysis to reach the maximum in every model run for this Local Authority.

In the future, the maximum theoretical amount of wind energy isn’t expected to be any different to the baseline due to constraints from land use, protected areas and flight paths. We have overlaid this map with the generation headroom, renewables should be prioritised where there is generation headroom in the short-term. Where there is no capacity in the grid for renewables, see the energy networks proposition.

Whilst we recognise this scale of build out to be ambitious, we suggest that the shaded orange areas on the map would be priority locations for the development of solar PV infrastructure.

We suggest that the shaded blue areas on the map would be the possible areas for the development of solar and wind infrastructure. However, in our modelling we have favoured solar PV in these locations due to the lower capital costs.

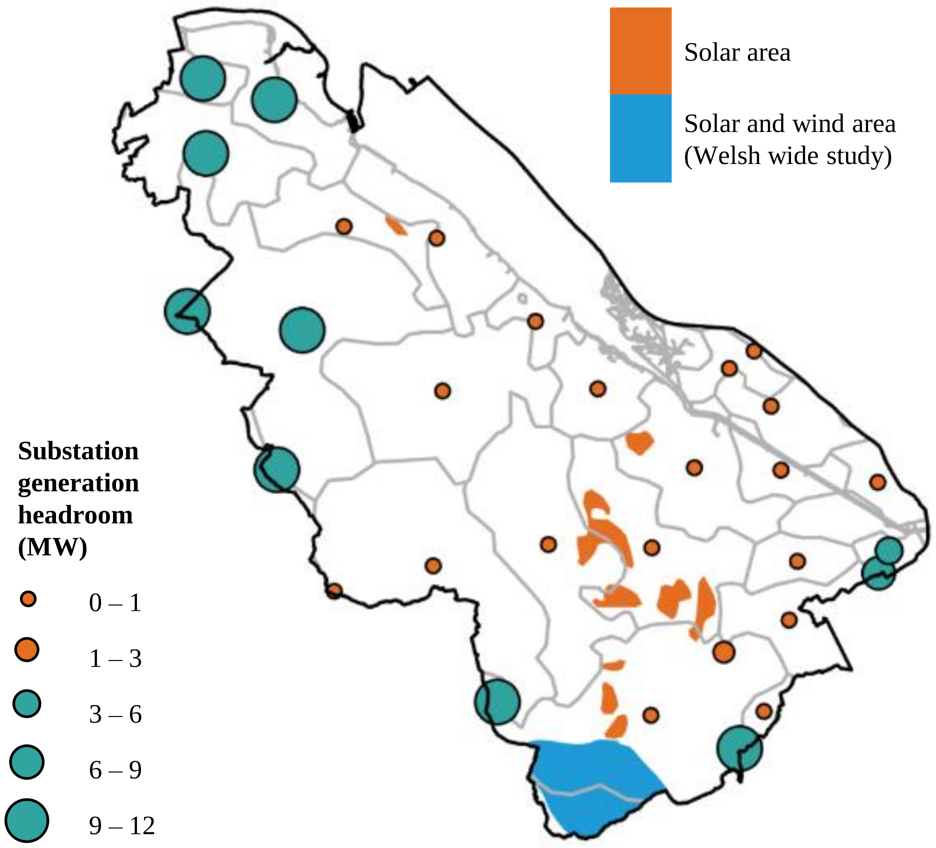


Figure 5.1.11: Areas suitable for wind and ground-mounted solar PV development in Flintshire and substation generation headroom (MW)

5. Action planning

Increasing local renewable generation

Focus zones for local electricity generation

Areas in the Northwest of Flintshire have been highlighted as more favourable locations for rooftop solar panel installations due to the higher generation headroom available.

Buckley has been highlighted as a more favourable location for ground-mounted solar PV based on results from renewable energy assessments, substation upgrades will be required, however.

No additional onshore wind generation is suggested for Flintshire.

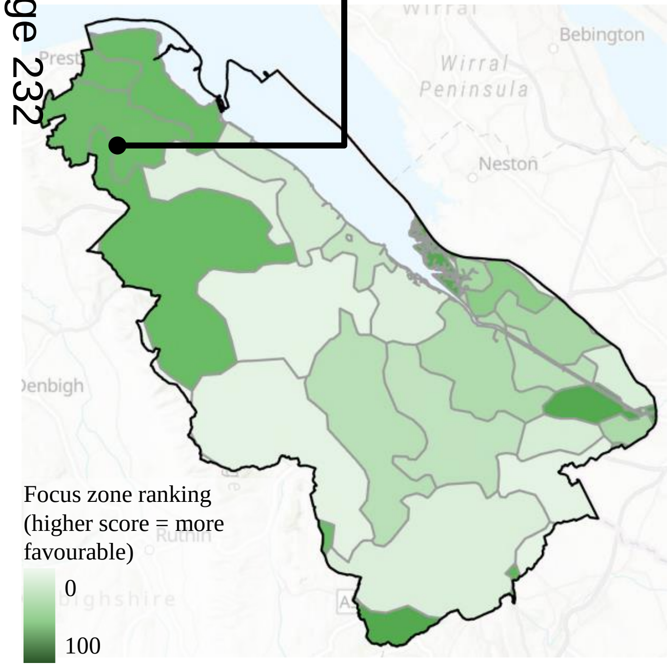


Figure 5.1.12: Focus zone rankings for rooftop solar PV by modelling zone

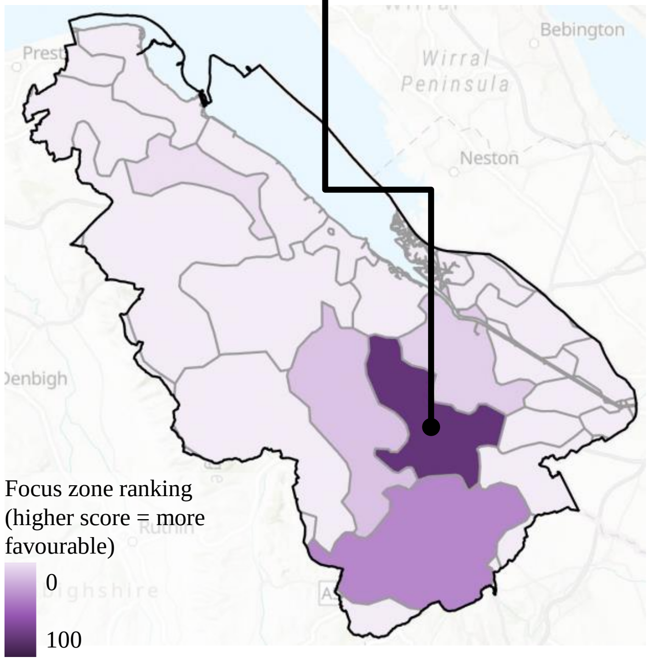


Figure 5.1.13: Focus zone rankings for ground-mounted solar PV by modelling zone

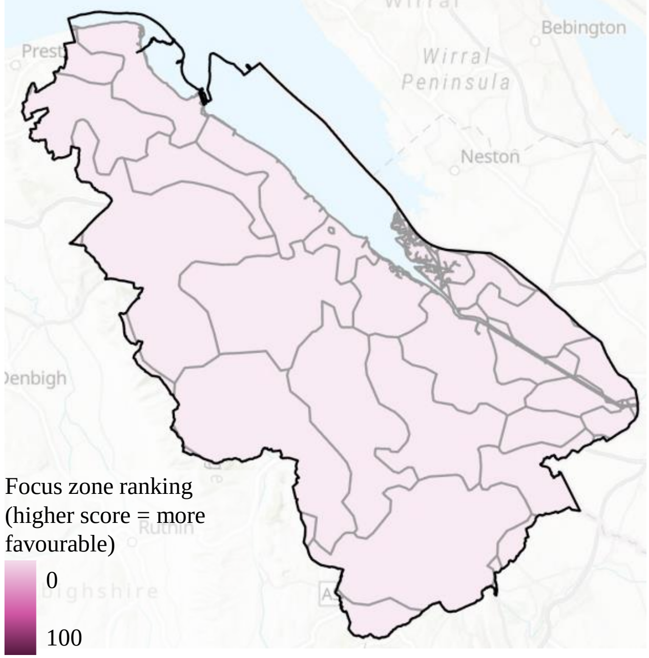


Figure 5.1.14: Focus zone rankings for onshore wind by modelling zone

5. Action planning
Increasing local renewable generation

Focus zones for local electricity generation

Figure 5.1.15 shows all electricity generation projects in the pipeline. There are plans to develop large scale solar PV and battery projects in the Queensferry area, with a smaller such project also in the pipeline for the Saltney area. The 2050 results suggest that all these projects could be built in any scenario, since the projected capacities in each scenario exceed the combined theoretical capacity of projects in the pipeline.

Investment requirements

The deployment model estimates the capital investment required for rooftop solar, ground-mounted solar and onshore wind. These are shown in Figure 5.1.4.

Energy system component(s)	Investment (£m) in renewables between 2023 and 2050
Rooftop solar PV	£425m
Ground-mounted solar PV	£240m
Onshore wind	£0m

Table 5.1.5: Investment costs for the Decarbonising transport proposition for 2050

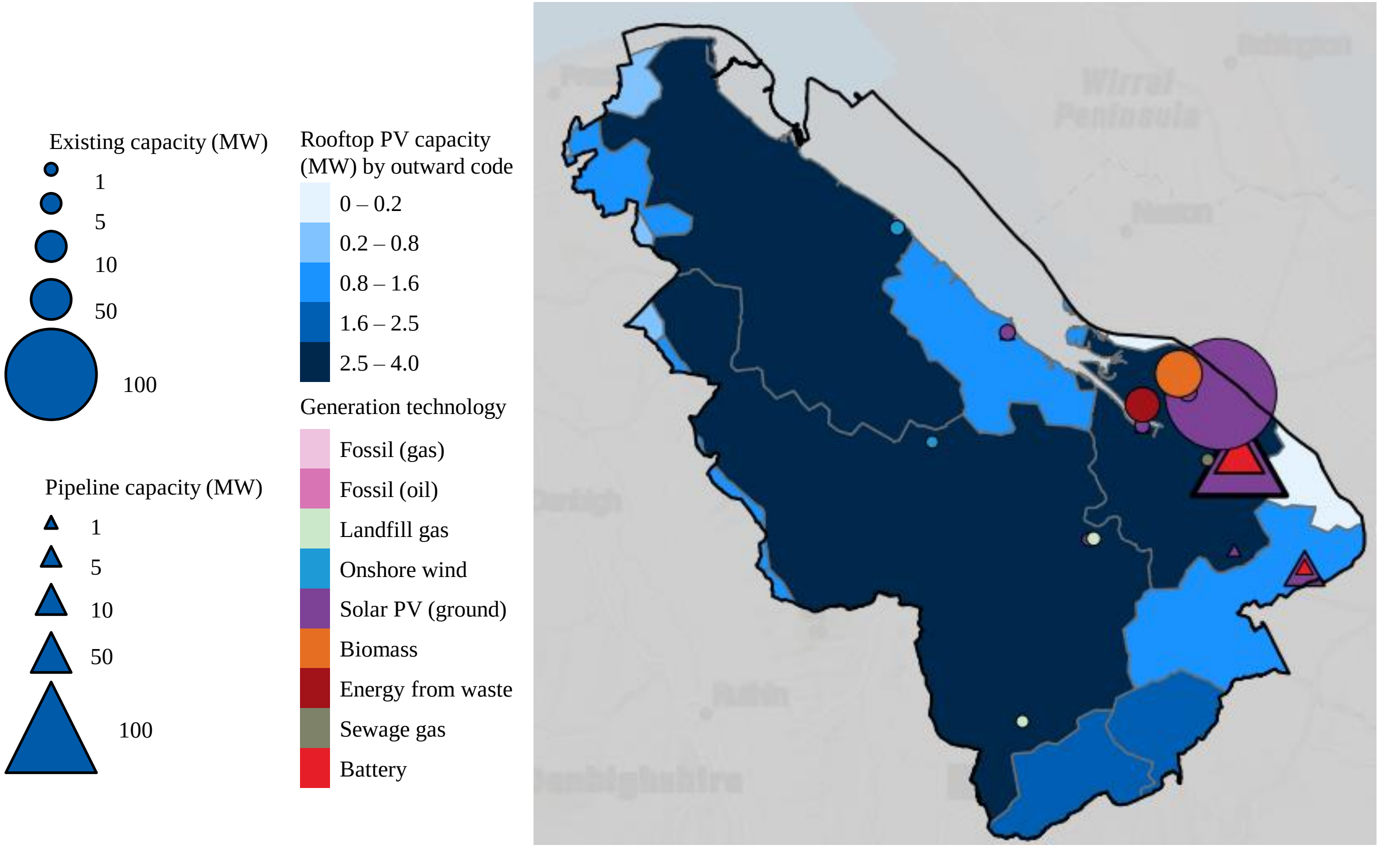


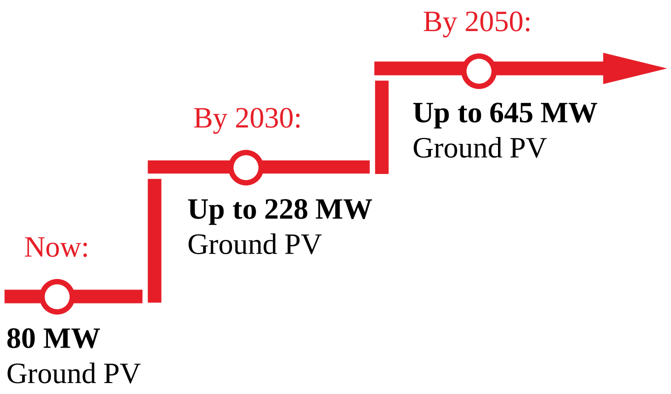
Figure 5.1.15: Electricity generation projects in the pipeline and baseline rooftop solar PV by outward code, investment requirements for priority focus zones for onshore wind and ground-mounted solar PV

5. Action planning
Increasing local renewable generation

Introduction

All scenarios show a shift to electrified heating and transport, which could increase the need to harness renewable electricity sources to meet increasing electricity demand. Figure 5.1.10 shows the range of possible deployment of ground-mounted solar and onshore wind across the scenarios in Flintshire.

Flintshire’s Renewable Energy Assessment (2019)[x] was used to understand the amount of land suitable for ground-mounted solar PV and onshore wind. All scenarios indicated an additional 538 MW of ground-mounted solar PV would be needed to meet future energy demand. This maximises the theoretical potential for ground-mounted solar PV in Flintshire.



Now:

80 MW
Ground PV

By 2030:

Up to 228 MW
Ground PV

By 2050:

Up to 645 MW
Ground PV

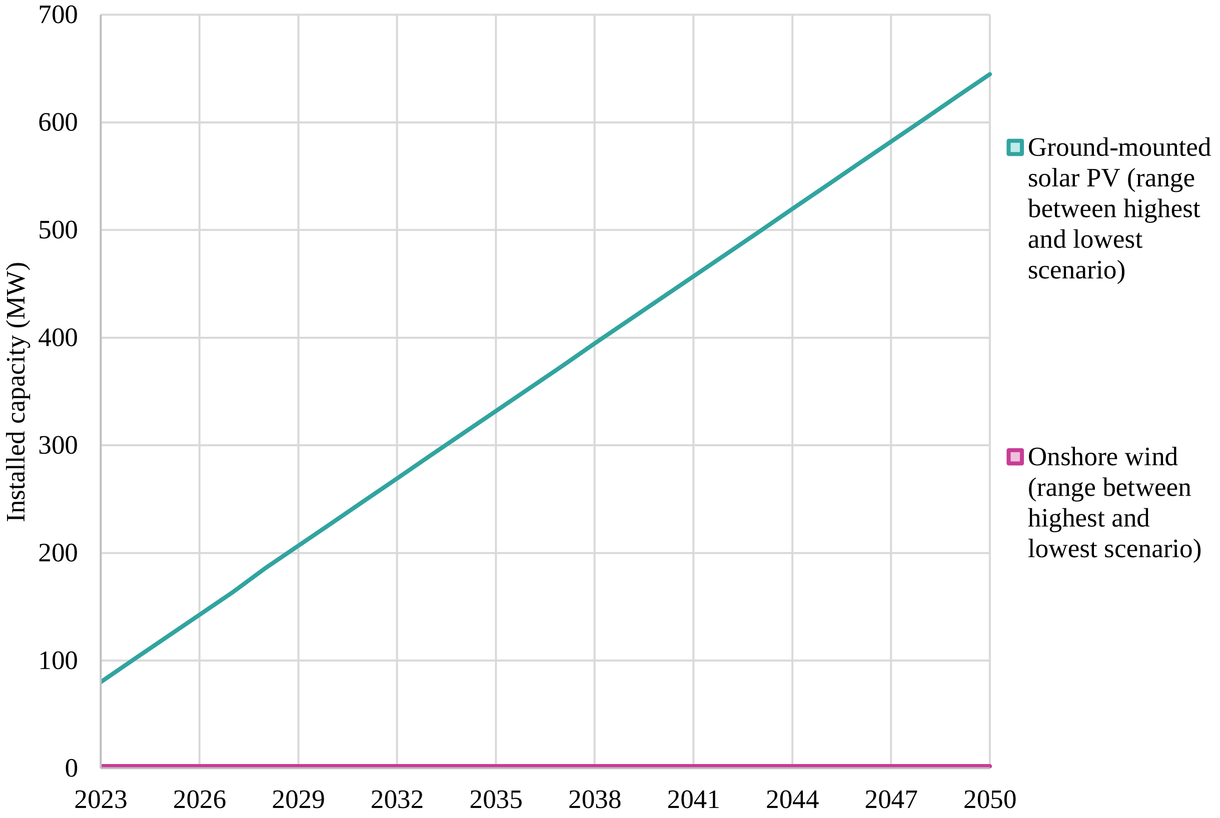


Figure 5.1.16: Summary of scale of renewables deployment across scenarios

Network transition planning

To achieve a net zero energy system, there are major changes needed to both the electricity and gas networks. SPEN (electricity distribution network operator in North Wales) and WWU (gas distribution network operator in Wales) are regulated utilities, and their operation is controlled by business planning cycles. They submit business plans in cycles:

- For electricity networks: RIIO-ED2 runs from 2023-2028, and ED3 will commence in 2028; the exact time period hasn't been announced yet.
- For gas networks: GD2 runs from 2021 to 2026. It was considered whether to extend GD2 to align the two networks. However, it's been announced that GD3 will start in 2026 for a "medium term ex-ante" period. Consideration is being given to the length of GD3.
- Outside of these cycles, a strategic reopener can be submitted to Ofgem to determine if there is sufficient evidence to make a case for additional investments beyond the business plans.

SPEN undertakes an annual modelling, planning and reporting process called Distribution Future Energy Scenarios (DFES) to support business planning, shown in Figure 5.1.15. WWU similarly uses historical data and modelling tools such as Pathfinder to forecast expected demands, resilience and storage needs, and general system operation. While these forecasting tools each incorporate some amount of input from the other network type (for example, DFES considers different options for heat pumps vs hydrogen for heating), they don't typically actively interlink and cross-communicate throughout the analysis processes. Therefore, the whole systems modelling undertaken within the LAEP process can be used as evidence to make strategic changes to the networks.

It is clear from the stakeholder engagement undertaken throughout the project, that one of the barriers currently is that the costs and timeframes of getting grid connections for renewable schemes and new development can make projects unviable.

The gas network provides natural gas to 82% of homes in Flintshire. Policy context for hydrogen shifted on 14th December 2023 with a decision to allow blending of 20% hydrogen into the network which will reduce the carbon emissions from the gas network by 7%, however this isn't a zero-carbon solution.

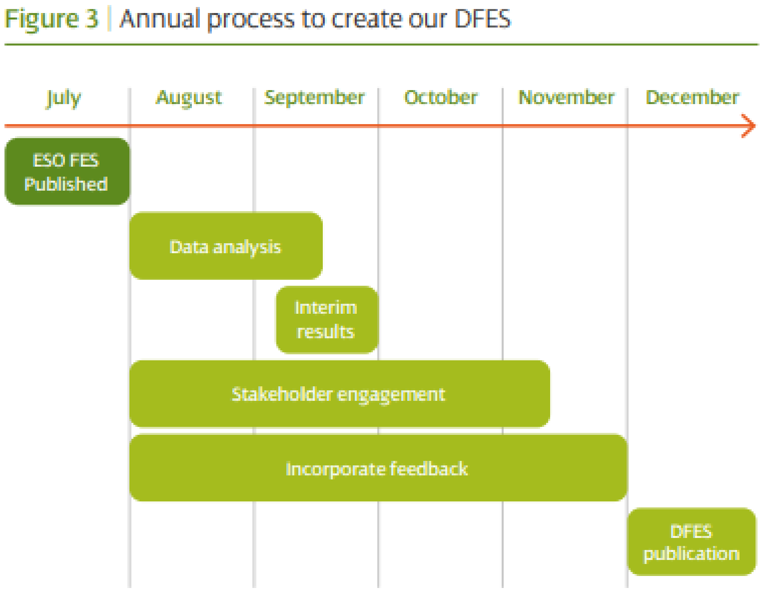


Figure 5.1.17: SPEN's annual DFES process (credit: SPEN)

5. Action planning

Reinforce and transition energy networks

Network transition planning

Gas distribution network

The gas network provided natural gas to 75% of homes in 2023.

£1.4million is invested in the iron mains replacement programme every week, which will make the current gas network hydrogen-ready. Policy context for hydrogen shifted on 14th December 2023 with a decision to allow blending of 20% hydrogen into the network which will reduce the carbon emissions from the gas network by 7%, however this isn't a zero-carbon solution.

Investment

The price control periods set out the allowances needed to complete the required mains replacement for that period, for RIIO-GD2 due to end in 2026 this was already awarded. WWU is currently preparing our RIIO-GD3 business plan which will set out the requirements needed to deliver the programme for the next price control period.

Most funding provided is through innovation funding. Ofgem provide WWU with Network Innovation Allowance funding (NIA) for innovative projects on our whole network. WWU looks for opportunities to deliver innovation that benefit the entire network and all local authorities within it, but also welcome any opportunities to collaborate with a specific local authority if there are relevant projects in their area.

There is additional funding available from Ofgem via re-openers (described earlier) which allow access to funding based on specific criteria.

WWU are actively involved in a range of innovation projects. Some examples specific to WWU's network in Wales:

Regional decarbonisation pathways – Completed in 2022, these pathways provide a strategic plan to decarbonise Wales (and Southwest England), outlining future gas network requirements to achieve the optimal energy system for the WWU network. Most of the projects described below have been designed to progress these findings and the resulting roadmap.

North Wales Conceptual Plan – Assess capability of existing infrastructure in North Wales for transporting hydrogen from Hynet Phase 3.

Hyline Cymru – plans for a new dedicated hydrogen pipeline across south Wales, linking hydrogen production with industrial demand.

Industrial Fuel Switching – Feasibility of fuel switching two sites in North Wales.

For more information on WWU's active projects, visit Network Innovation Allowance - Annual Report 22-23

5. Action planning
Reinforce and transition energy networks

Network transition planning

The future position

Our modelling shows that the electricity network needs upgrades and reinforcement to get ahead of the pace of change in renewables, heat pumps, EV charging and electrolysis. The map in Figure 5.1.16 shows areas where substation upgrades are needed if the rest of LAEP is carried out.

The substation upgrade areas, are those that should be prioritised for investment from the electricity network, considered for hydrogen or consider as part of a smart local energy system (SLES).

Electricity networks

To undertake the level of change shown in the map above which will be required if the uptake in EVs, renewables, heat pumps and electrolysis meets the modelled amounts, the number of substations that will need upgrading is 28. This equates to a total of 545MW additional capacity.

Additional upgrades to the network may be required following comprehensive contingency analysis

The cost of this is over £3m per year between the baseline and 2050. In total, this amounts to approximately £1,250 per home (in the high demand scenario).

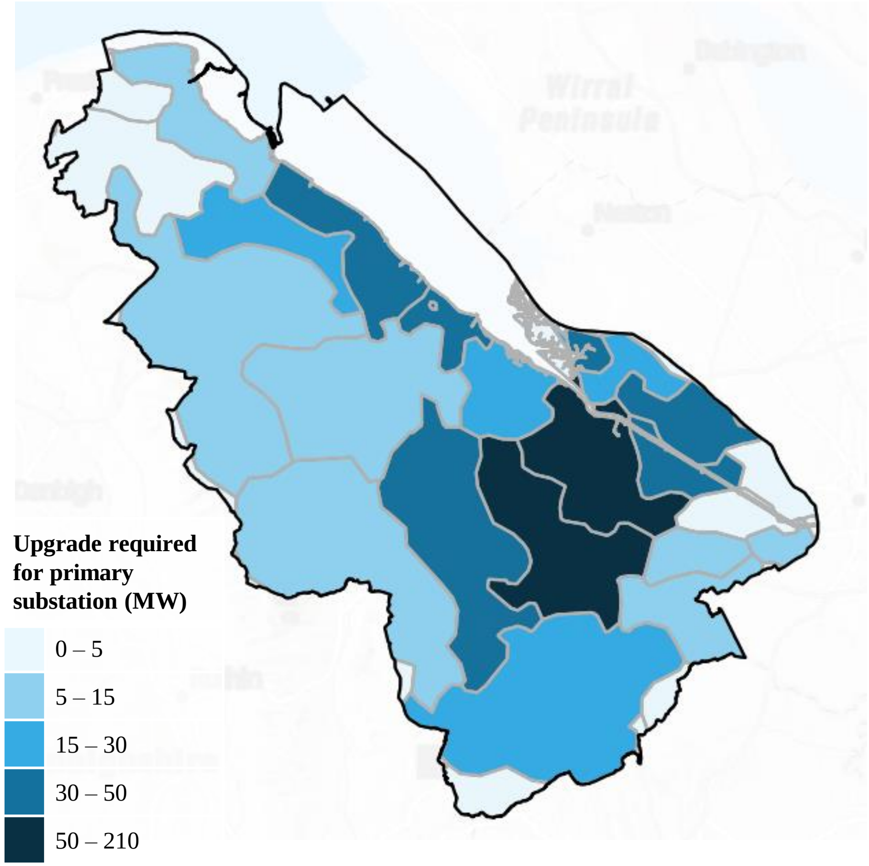


Figure 5.1.18: Map showing where substation interventions will be required by 2050 if the rest of the plan is followed

5. Action planning
Reinforce and transition energy networks

Network transition planning

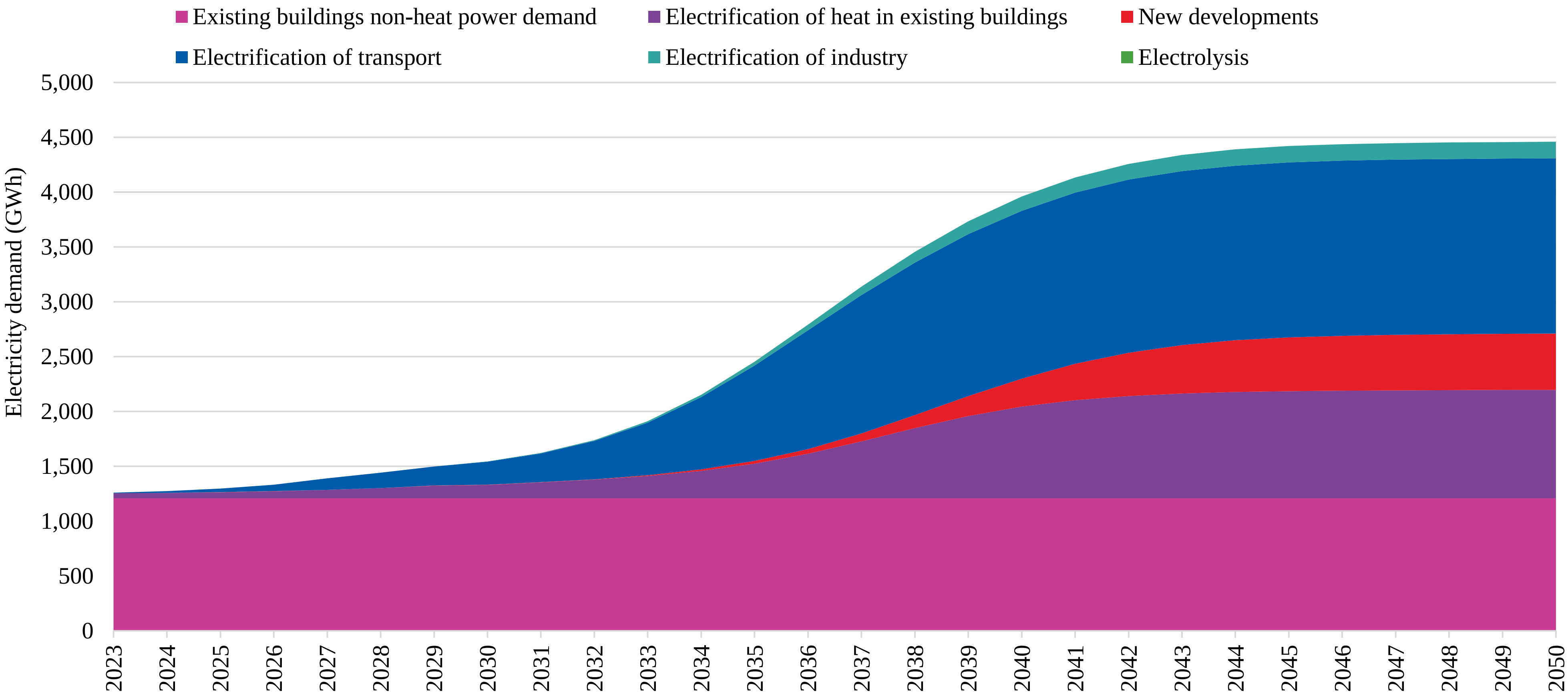


Figure 5.1.19: Projected change in electricity demand by end use between 2023 and 2050 in the High Demand scenario

Network transition planning

Hydrogen networks

There is more uncertainty around the changes needed to the gas network to enable the transition to net zero. There is a need to understand the role of the gas network in 2050, by continuing to explore the transition to 100% hydrogen and alternatives such as biomethane for specific locations. It's important to continue to explore this, and to make sure that changes made in the energy system do not negatively impact the gas network transition. We know that the deployment levels required for heat pumps will be difficult to achieve and therefore need to keep alternative options open. Our modelling excludes the cost of decommissioning the gas network, which is expected to be significant.

The gas network is undergoing a significant REPEX programme to make the gas networks more suitable for hydrogen by replacing iron mains within 30 meters of a property. The programme is mandated by UK Health and Safety Executive and funded by OfGem. Across Wales, WWU is currently 22 years into the 30-year programme, with a projected end date in 2032. In Flintshire this is 66.57% complete.

Our modelling has shown a demand of up to 220GWh/year for hydrogen in the future from industry and up to 710GWh/year for transportation. These numbers need additional verification with the industry within Flintshire

The optimisation model chooses hydrogen boilers for peak capacity only, which is a very unlikely domestic set up since it would be expensive per household. Therefore, we believe the future of hydrogen for home heating is still uncertain and have excluded this from the short-term road map and propositions, unless the LA is already underway with pilot projects.

The model shows the hydrogen required for industry and transportation is produced via electrolysis could be 0.04MW, supporting far less than 1% if the UK ambition of 10GW[T51] of low carbon hydrogen production by 2030. Hydrogen is currently localised in the model, which means it is used at the point of production, or imported into the system from a national asset.

The investment needed for hydrogen in Flintshire is £107m between now and 2050, mainly for hydrogen refuellers.

5. Action planning
Reinforce and transition energy networks

Network transition planning

Storage

Short term and seasonal storage also needs consideration. While our modelling does not show a lot of electrical storage, the majority of scenarios use the electricity grid as storage, choosing to export when there is excess renewable energy in the system and to import when there is a deficit of renewable energy in the system. Especially since neighbouring local authorities which opt for weather-dependent renewables (e.g. PV and wind) are likely to be generating (and thus exporting) renewable energy at similar times, there is a need for national asset level storage to provide flexibility and resilience in the energy system. This could come in many forms, including batteries, hydrogen storage with CCGT and CCUS, or more innovative alternatives. Especially where these storage solutions incorporate multiple energy vectors (for example, hydrogen storage) the relevant network operators will require close collaboration to ensure the storage solution effectively meets the needs of the regional or national energy system.

An approximate cost that would be available for national asset level production of electricity and storage would need to be commensurate to the OPEX costs for electricity imports in the model. Our model uses wholesale electricity costs; based on a cost of 6.3p/kWh for 3,130GWh/year of electricity imported in the high demand scenario, this equates to £188million/year.

Reinforce and transition energy networks

Network transition planning

Smart Local Energy Systems (SLES): SLES use different energy assets and infrastructure (known as Distributed Energy Resources (DERs)) to enable an area-level optimised demand and supply balance. SLES minimises unnecessary transition between vectors and can lead to benefits in terms of costs and carbon emissions. They are particularly beneficial where there is strong interplay between demand energy vectors (heating, cooling, electricity, and hydrogen).

SLES technologies can provide flexibility services to the national or local power networks, by shifting electricity demand in response to pricing or carbon signals. Technologies can interact directly with the DNO, or they may be aggregated by a central SLES market / control platform which enables the different technologies to interact with one another, and even enable peer to peer trading of energy generation, demand and storage.

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Smart local energy systems

We have undertaken model runs at hourly, 3 hour and 24 hour intervals. These show that as the interval shortens, the annual electricity use (i.e. the GWh shown in the Sankey diagram) increases which is due to the peaks in the demand. When the demand is smoothed out over 24 hours, the annual electricity use smaller. If there were mechanisms to manage local supply vs demand, the annual electricity use could be decreased.

Areas to focus on would be those which need substation interventions (see Figure 5.0.16), liaising with the networks on the order of planned upgrade to the network will enable the Local Authority to prioritise where pilot programmes and roll-out of SLES would be most appropriate.

Investment in SLES can reduce the cost of upgrades needed in the electricity network. We haven’t included specific costs for SLES because they should be undertaken in circumstances where it will reduce the cost to the electricity network and expediate the time that it takes to get a grid connection. Applying SLES as a means to avoid reinforcing the electricity network (thus reducing the cost of network upgrades) has nuanced impacts on the reliability and safety of the network which should be carefully considered by each community before implementing this approach.

Regulations need to make it easier for local communities to benefit from renewables installed behind the substation (as opposed to behind the meter). Local communities should be able to respond to signals about their demand to use their localised electricity. Electricity suppliers are rolling this out on a national basis (for instance Octopus saver sessions), and localised trials have been happening, however this is not easy to put in place currently.

Cyngor Sir y Fflint
Flintshire County Council

Sponsors:

Llywodraeth Cymru
Welsh Government

Uchelgais Gogledd Cymru
Ambition North Wales

Delivery partners:

ARUP

CARBON TRUST

Technical report

Appendices

Appendices

Section A

Appendix A1
Actions and recommendations

Scaling zero carbon buildings

	1.1	1.2
Description	Develop and implement programme of support for off-gas grid homes	Develop programme for retrofit of Council owned buildings
Lead	FCC	FCC
Timescale	2024-2030	2024-2026
Benefits	Reduced emissions from domestic sector, less reliance on fuels with fluctuating prices	Safe, healthy, low carbon homes for those who most need them. Clear plan for needs, investment, and capital across the local authority.
Investment	Staff resources required from planning team	Staff resources required from planning team
Contributing stakeholders	Flintshire County Council	Flintshire County Council

Appendix A1
Actions and recommendations

Scaling zero carbon buildings

	1.3	1.4
Description	Promote rollout of EPCs to all Flintshire residents	Complete existing ECO4 and ORP 2 and 3 funding programmes
Lead	FCC	FCC
Timescale	2024-2026	2024-2025
Benefits	Greater awareness of energy performance of Flintshire’s domestic stock, and potential for carbon reduction measures	
Investment	Unknown	
Contributing stakeholders	Local EPC contractors, the public, property owners	

Appendix A1
Actions and recommendations

Scaling zero carbon buildings

	1.5	1.6
Description	Upskill Council planning and regeneration team staff on retrofit of ‘heritage’ buildings, and novel technologies (e.g. heat pumps and charging hubs)	Develop emissions standards for operation and construction of Council new builds and retrofits
Lead	FCC	FCC
Timescale	2024-2025	2024-2025
Benefits	Greater in-house knowledge for hard to decarbonise areas of the domestic stock	Low energy, low carbon, safe and warm homes for residents, and council staff
Investment	Cost of training	
Contributing stakeholders	Training providers	External advisors

Appendix A1
Actions and recommendations

Scaling zero carbon buildings

	1.7	1.8 (linked to regional action B.1.8)
Description	Explore opportunities to engage with the supply chain to ensure they are adequately aware of the scale of change required for domestic retrofit	Apply lessons learnt from Optimised Retrofit Programme to retrofitting the privately rented and owner-occupied sectors through Welsh Zero Carbon Hwb.
Lead	FCC	Welsh Government
Timescale	2024-2026	2024 - 2030
Benefits	Lower cost and faster build out of decarbonisation and retrofit measures	
Investment		
Contributing stakeholders	Supply chain: producers, sellers, installers of decarbonisation retrofit measures	Welsh Zero Carbon Hwb

Appendix A1
Actions and recommendations

Scaling zero carbon buildings

	1.9 (linked to regional action B.2.1)	1.10 (linked to regional action R.1.4)
Description	Using the learning from other information hubs to develop an information service that provides a trusted source of retrofit and energy efficiency information for consumers. Explore the potential of establishing an advice hub to support regional decarbonisation / low carbon energy initiatives.	Work with Community Interest Companies (CIC) to provide a regional service of wrap around support for residents covering education, behaviour change, energy advice and support.
Lead	Welsh Government	Warm Wales
Timescale	2024-2026	2024-2028
Benefits		
Investment		
Contributing stakeholders		Community Interest Companies (CIC)

Appendix A1
Actions and recommendations

Scaling zero carbon buildings

	1.11 (linked to regional action 3A)	1.12 (linked to regional action 3C)
Description	Provide support and incentives for households to install energy efficiency measures and low-carbon heating systems, ensuring such support is targeted at those in fuel poverty and/or in most need.	Ensure PAS 2035 surveys and a clear plan for retrofit measures are prepared for individual social homes, in accordance with the Welsh Housing Quality Standard (WHQS)[M20].
Lead	RSLs	FCC and RSLs
Timescale	2024-2030	2024-2030
Benefits		
Investment		
Contributing stakeholders		

Appendix A1
Actions and recommendations

Scaling zero carbon buildings

	1.13 (linked to regional action 3D)	1.14 (linked to regional action 3C)
Description	Review current support provision to tenants and landlords in the private-rented sector to ensure minimum energy efficiency standards are met. Review enforcement provisions to ensure minimum statutory standards within the sector are achieved.	Explore development of support mechanisms for small to medium-sized enterprises (SMEs) to encourage uptake of energy efficiency improvements to commercial buildings.
Lead	Welsh Government	Business Wales / M-Sparc; North Wales Mersey Dee Business Council
Timescale	2024-2026	2024-2030
Benefits		
Investment		
Contributing stakeholders	Local Authorities	

Appendix A1
Actions and recommendations

Scaling zero carbon buildings

	1.15 (linked to regional action B.1.7)	1.16 (linked to regional action B.5.1 and 3E)
Description	Work with local authorities and regional bodies to determine an approach to coordinated, street-by-street approach to retrofit and the mechanisms for delivery (e.g. governance, resource, finance, policy). Co-ordinate a retrofit plan for all housing tenures which expands on the Optimised Retrofit Programme.	Identify specific local planning constraints (e.g. permitted developments i.e. 3 metre rule for heat pumps, permissive planning for listed buildings, new build regulations) limiting progress to net zero and delivering the LAEPs and work with Welsh Government to resolve these.
Lead	Welsh Government	Welsh Government and Local Authorities
Timescale	2024-2030	2024-2030
Benefits		
Investment		
Contributing stakeholders	Local Authorities, regional bodies	

Appendix A1
Actions and recommendations

Scaling zero carbon buildings

	1.17 (linked to regional action B.5.2)	1.18 (linked to regional action B.1.2 and 3B)
Description	Consider tighter building regulations to support delivery of net zero ready buildings including a consultation on Part L regulations in 2024	Develop and agree an approach and delivery plan for tackling owner-occupied retrofit. Review existing and explore new potential financial mechanisms to support owner-occupiers and building owners seeking to undertake energy efficiency retrofit works.
Lead	Welsh Government	Welsh Government
Timescale	2024-2026	2024-2026
Benefits		
Investment		
Contributing stakeholders	Local Authorities, regional bodies	

Appendix A1
Actions and recommendations

Scaling zero carbon buildings

1.19 (linked to regional action E.4.1)

Description	Identify procurement frameworks for renewable technologies which consider local and ethical sourcing of goods and services. Develop national procurement framework, learning from previous ECO 4 roll out and the Optimised Retrofit Programme, to deliver street-by-street retrofit.
Lead	Welsh Government
Timescale	2024-2026
Benefits	
Investment	
Contributing stakeholders	

Appendix A1
Actions and recommendations

Decarbonising transport

	2.1	2.2
Description	Apply pressure to Welsh Government for greater direction for on street EV charging	Explore EV charging technologies for kerbline properties where no off-street options are available FCC
Lead	FCC	2024-2026
Timescale	2024-2025	
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Decarbonising transport

	2.3	2.4
Description	Understand charging facilities potential within town centre regeneration and place making plans, explore SPF and ORCS funding	Ensure commitment to high speed broadband connections for everyone in Flintshire
Lead	FCC	FCC
Timescale	2024-2026	2024-2025
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Decarbonising transport

	2.5	2.6
Description	Lobby for investment in the rail infrastructure to improve service frequency and reduce travel time	Further develop active travel networks and principles, keeping in mind impacts of equalities act FCC
Lead	FCC	2024-2025
Timescale	2024-2026	
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Decarbonising transport

	2.7	2.8
Description	Develop plans for last mile sustainable mobility requirements within the scope of new and improved stations in the North Wales metro programme	Provide public finance options and national standards for EV charging infrastructure.
Lead	FCC	FCC
Timescale	2024-2026	2024-2026
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Decarbonising transport

	2.9	2.10 (linked to regional action 4C)
Description	Release pilot EV charge point locator and costing tool for EV charge points.	Collaborate on opportunities to decarbonise the public sector fleet, public service vehicles, and commercial and industrial fleets and the co-ordination of associated infrastructure design and development across local authority boundaries.
Lead	FCC	ANW and WGES
Timescale	2024-2026	2024-2030
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Decarbonising transport

	2.11 (linked to regional action 4D)	2.12 (linked to regional action 4F)
Description	Work together to deliver the most appropriate electric vehicle public charging infrastructure across the region, aligning with national work being undertaken through Transport for Wales.	Support greater awareness raising of UK Government funding for development of electric vehicle charging infrastructure such as the on-street residential charging scheme.
Lead	ANW; North Wales Corporate Joint Committee; TfW; SPEN	ANW
Timescale	2024-2026	2024-2028
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Decarbonising transport

	2.13 (linked to regional action 4G)	2.14 (linked to regional action R4.1)
Description	Continue to support organisations such as local community car clubs to deliver community-oriented, low-carbon transport infrastructure and services.	Establish a Regional Transport Officer's Group that provides a forum for collaboration and alignment between local and national government in addition to Transport for Wales.
Lead	ANW; WGES	North Wales Corporate Joint Committee
Timescale	2024-2030	2024-2026
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Decarbonising transport

	2.15 (linked to regional action R4.2)	2.16 (linked to regional action R4.3)
Description	Explore opportunities around bus franchising across the region.	Produce the first Regional Transport Plan (RTP) in line with that Welsh Government statutory guidance.
Lead	ANW	ANW
Timescale	2024-2026	2024-2025
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Decarbonising transport

2.17 (linked to regional action T.2.4)

Description	Develop a national procurement framework for EV infrastructure
Lead	Welsh Government
Timescale	2024
Benefits	
Investment	
Contributing Stakeholders	

Appendix A1
Actions and recommendations

Increasing local renewable generation

	3.1	3.2
Description	Promote community energy schemes	Continue to rollout renewables in line with REAs, land assessments and constraints mapping
Lead	FCC	FCC
Timescale	2024-2025	2024-2030
Benefits		
Investment		
Contributing stakeholders		

Appendix A1
Actions and recommendations

Increasing local renewable generation

	3.3	3.4
Description	Facilitate rooftop solar PV uptake in owner-occupied dwellings through knowledge sharing and signposting	Understand local potential for solar carports
Lead	FCC	FCC
Timescale	2024-2027	2024-2026
Benefits		
Investment		
Contributing stakeholders		

Appendix A1
Actions and recommendations

Increasing local renewable generation

	3.5	3.6
Description	Support SMEs with rooftop solar installation for reducing energy costs	Further explore possibilities for geothermal energy generation within old coal fields, this can build on the work that has been undertaken by the Coal Authority.
Lead	FCC	FCC
Timescale	2024-2027	2024-2027
Benefits		
Investment		
Contributing stakeholders		The Coal Authority

Appendix A1
Actions and recommendations

Increasing local renewable generation

	3.7 (linked to regional action G)	3.8 (linked to regional action 2A)
Description	Explore the development of an investment prospectus for renewable developments currently in the pipeline.	Engage with Welsh Government to identify and build on opportunities that Ynni Cymru could provide to North Wales.
Lead	ANW	Ynni Cymru and ANW
Timescale	2024-2025	2024-2030
Benefits		
Investment		
Contributing stakeholders		

Appendix A1
Actions and recommendations

Increasing local renewable generation

	3.9 (linked to regional action 2B)	3.10 (linked to regional action 2D)
Description	Explore how to improve communication of available funding sources for the development and delivery of a range of low-carbon power generation projects (e.g. onshore and offshore wind, solar PV, nuclear, and tidal and marine energy).	Support workstreams in increasing local ownership of energy projects to be delivered in line with proposed guidance on local and shared ownership in Wales.
Lead	ANW	Ynni Cyrmu and ANW
Timescale	2024-2025	2024-2030
Benefits		
Investment		
Contributing stakeholders		

Appendix A1
Actions and recommendations

Increasing local renewable generation

	3.11 (linked to regional action 2E)	3.12 (linked to regional action 2F)
Description	Explore the potential of establishing an advice hub to support regional decarbonisation / low carbon energy initiatives.	Maximise opportunities for public procurement to support the acceleration of renewable energy generation and secure local economic and social value. Ensure that public procurement strengthens local supply chains / local jobs (social value). Ask the supply chain to deliver against public sector carbon ambitions through procurement frameworks.
Lead	ANW	ANW
Timescale	2024-2026	2024-2030
Benefits		
Investment		
Contributing stakeholders		

Appendix A1
Actions and recommendations

Increasing local renewable generation

	3.13 (linked to regional action 2G)	3.14 (linked to regional action R2.1)
Description	Maximise opportunities for community benefits funds from energy infrastructure projects (on the distribution network) to support local and regional decarbonisation initiatives, recognising the need to target those communities and areas most impacted by such developments.	Explore the opportunities that Power Purchasing Agreements could provide to energy generation across the region.
Lead	ANW	ANW
Timescale	2024-2030	2024-2026
Benefits		
Investment		
Contributing stakeholders		

Appendix A1
Actions and recommendations

Increasing local renewable generation

	3.15 (linked to regional action R2.2)	3.16 (linked to regional action RN.4.1)
Description	Continue to explore the opportunities presented by solar canopies in car parking spaces and the enablers to scale the technology across the region.	Identify and explore opportunities for the development of renewables on public sector owned land.
Lead	ANW and WGES	Welsh Government and Trydan Gwyrdd Cymru
Timescale	2024-2027	2024-2030
Benefits		
Investment		
Contributing stakeholders		

Appendix A1
Actions and recommendations

Supporting green business

	4.1	4.2
Description	Promote work undertaken by AMRC where appropriate	Continue to support Deeside Decarbonisation Forum and signpost funding opportunities
Lead	FCC	FCC
Timescale	2024-2026	2024-2030
Benefits		
Investment		
Contributing stakeholders		

Appendix A1

Actions and recommendations

Supporting green business

	4.3	4.4
Description	Understand potential for redevelopment plan of Mostyn dock, undertake opportunities mapping	Understand how sustainability can be worked in to Flintshire's digital strategy and potential for data supported decarbonisation
Lead	FCC	FCC
Timescale	2024-2026	2024-2025
Benefits		
Investment		
Contributing stakeholders		

Appendix A1
Actions and recommendations

Supporting green business

	4.5	4.6
Description	Look to undertake heat mapping exercise and understand heat network potential	Support SMEs to develop plans to decarbonise and signpost to funding opportunities
Lead	FCC	FCC
Timescale	2024-2026	2024-2030
Benefits		
Investment		
Contributing stakeholders		

Appendix A1
Actions and recommendations

Supporting green business

	4.7
Description	Continue to support town centre place making investment and signpost funding opportunities available to businesses and social enterprises
Lead	FCC
Timescale	2024-2030
Benefits	
Investment	
Contributing stakeholders	

Appendix A1
Actions and recommendations

Maturing hydrogen in industry

	5.1	5.2
Description	Plan for and be aware of upcoming hydrogen project funding opportunities	Develop local strategy to understand local need, requirements, challenges, and opportunities for hydrogen
Lead	FCC	FCC
Timescale	2024-2026	2024-2026
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Maturing hydrogen in industry

	5.3	5.4 (linked to regional action E)
Description	Look to support research into hydrogen co-challenges for local businesses	Support the emerging hydrogen economy, taking account of proposed hydrogen projects across the region.
Lead	FCC	ANW
Timescale	2024-2027	2024-2030
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Maturing hydrogen in industry

	5.5 (linked to regional action N.4.4)	5.6
Description	Publish a Welsh Government carbon intensity standard for hydrogen production based on that of UK Government. This standard can be used as a basis for future permitting by Natural Resources Wales.	Publish findings from North Wales Conceptual Plan for hydrogen infrastructure.
Lead	Welsh Government and NRW	WWU
Timescale	2024-2025	2024-2025
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Maturing hydrogen in industry

	5.7 (linked to regional action N.3.5)	5.8 (linked to regional action N.4.4)
Description	Make the network hydrogen ready. Deliver programme to convert remainder of gas network not covered by the REPEX programme to enable a 100% hydrogen conversion, WWUs sustainability strategy from 2023 identifies a desire to complete this between 2035-2040.	Develop hydrogen and bio-methane projects.
Lead	WWU	WWU
Timescale	2024-2040	2024-2050
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Maturing hydrogen in industry

5.9 (linked to regional action N.4.5)

Description	Develop a more detailed understanding of potential hydrogen transport demand and incorporate this demand within existing network demands. This action will be supported by WWU's innovation project HyDrive.
Lead	WWU
Timescale	2024-2025
Benefits	
Investment	
Contributing Stakeholders	

Appendix A1
Actions and recommendations

Reinforce and transition energy networks

	6.1 (linked to regional action N.1.2)	6.2 (linked to regional action N.2.2 and N.3.3)
Description	Hold regular engagement meetings between Flintshire County Council, SPEN and WWU	FCC and SPEN to work collaboratively to understand future demands (electricity) and use this to influence ED3 Planning and investment from OFGEM.
Lead	SPEN, WWU	FCC, SPEN
Timescale	2024-2030 (on an ongoing basis)	2024-2026
Benefits		
Investment		
Contributing Stakeholders	Flintshire County Council	

Appendix A1
Actions and recommendations

Reinforce and transition energy networks

	6.3 (linked to regional action N.2.1)	6.4 (linked to regional action N.2.3)
Description	Inform local authorities about available data resources by providing access to the DFES report and the resulting NDP (Network Development Plan) via SPEN's Open Data Portal as well as other datasets such as heat maps, network infrastructure & usage. Requests for additional, bespoke reports can also be made via the portal.	Use all relevant outputs from the LAEPs to inform SPEN's DFES (Distribution Future Energy Scenario) Report, in turn SPEN will share the trends and highlights from the DFES with individual LAs.
Lead	SPEN	SPEN
Timescale	2024-2030	2024-2025
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Reinforce and transition energy networks

	6.5 (linked to regional action N.2.4)	6.6 (linked to regional action N.2.5)
Description	Provide low carbon technology (LCT) optioneering services to Local Authorities to support them with site optioneering (cost and timescale) for EV charging, heat pump rollout and renewable generation infrastructure planning.	Co-ordinate Net Zero clinics for Local Authorities to discuss decarbonisation of heat, transport and renewables strategies, and willingly contribute to workshops organised by the Local Authorities for local small-medium enterprises (SMEs).
Lead	SPEN	SPEN and WWU
Timescale	2027-2029	2024-2030 (on an ongoing basis)
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Reinforce and transition energy networks

	6.7 (linked to regional action N.2.6)	6.8 (linked to regional action N.1.3)
Description	Discuss and agree any strategic optimisation opportunities with each Local Authority to continue progressing decarbonisation and economic growth plans.	Plan a method to consolidate the pipelines for all energy-related projects across the electricity and gas/hydrogen networks. This will consolidate all actions planned by electricity and gas/hydrogen networks within an area into one common database. As a starting point, set up ongoing engagement meetings with DataMapWales, NGED SPEN, and WWU to coordinate if and how DataMap Wales may be an appropriate platform to consolidate this information.
Lead	SPEN and WWU	SPEN and WWU
Timescale	2024-2030 (on an ongoing basis)	2024-2030 (on an ongoing basis)
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Reinforce and transition energy networks

	6.9 (linked to regional action N.3.1)	6.10 (linked to regional action N.3.2)
Description	Highlight gas infrastructure opportunities. Support Local Authorities in exploring new opportunities to develop the existing gas networks in advance of 100% transition to existing hydrogen network.	Include new projects from the LAEP in strategic planning process.
Lead	WWU	WWU
Timescale	2024-2030 (on an ongoing basis)	2024-2027
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Reinforce and transition energy networks

	6.11 (linked to regional action N.3.4)	6.12
Description	Share LAEP outputs on DataMapWales, plan how to keep this data up to date and relevant	Raise awareness of SPEN's Flexibility Service procurement to support a smarter system.
Lead	Welsh Government	SPEN
Timescale	2024-2025	2024-2025
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Reinforce and transition energy networks

	6.13 (linked to regional action N.2.7)	6.14
Description	SPEN is already looking at industrial decarbonisation through their partnership in the NEW-ID (North East Wales Industrial Decarbonisation) Project. Any opportunities/benefits identified as part of work on this project will be shared with the affected Local Authorities, including Flintshire.	Explore opportunities for partnership delivery of district heating and cooling networks, using waste heat sources such as mine water.
Lead	SPEN	WG; Coal Authority; WWU
Timescale	2024-2030	2024-2027
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Reinforce and transition energy networks

	6.15 (linked to regional action 5B)	6.16 (linked to regional action R5.1)
Description	Understand the role that micro-grids and other innovative solutions can play in existing industrial clusters such as those in Deeside and Flintshire.	Explore and recognise opportunities that will be made available from the Flintshire/Wrexham investment zone.
Lead	ANW; DDF	North Wales Corporate Joint Committee; DDF
Timescale	2024-2028	2024-2028
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Enabling actions

	7.1(linked to regional action A)	7.2 (linked to regional action D)
Description	Ensure effective alignment between local, regional and national energy strategies, plans and initiatives.	Provide regional support in the delivery of commitments made in the Climate Action Wales public engagement strategy (July 2023) to help citizens take action to reduce demand, improve energy efficiency and use energy in a way which supports our vision.
Lead	ANW	ANW
Timescale	2024-2030	2024-2030
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Enabling actions

	7.3 (linked to regional action I.1.3 and F)	7.2 (linked to regional action R1.2)
Description	Continue to explore and support opportunities for smart local energy systems in the region. Using outputs from the LAEP, map smart local energy system opportunities and identify feasibility/demonstrator projects through engagement with key stakeholders including community energy groups and general public.	Ensure alignment between the scope and function of the new Regional Energy Strategic Planners (RESPs) with Ofgem's policy design. Consultation of the policy design will be published in the summer of 2024 with the RESPs in operation by late 2025/early 2026
Lead	ANW; Ynni Cymru; WG	WG; Ofgem; National Grid ESO
Timescale	2024-2030	2024-2026
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Enabling actions

	7.5 (linked to regional action R1.2)	7.6 (linked to regional action E3.1 and C)
Description	North Wales Corporate Joint Committee to support the Race to Zero campaign and provide oversight on carbon emissions across the region	Lead on developing the skills requirements identified in the Regional Skills Partnership's (RSP's) Green Skills Report and Welsh Government's Net Zero Skills Action Plan. Map and identify skills and labour needs and gaps up to 2050 for retrofit and low carbon new builds; renewable deployment; decarbonised transport and business / industry decarbonisation.
Lead	North Wales Corporate Joint Committee	RSP; WG
Timescale	2024-2030	2024-2030
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Enabling actions

	7.7 (linked to regional action E3.2)	7.8 (linked to regional action E3.3)
Description	Review and develop educational programmes to meet skills needed	Develop a communication strategy to educate, promote skills, training and the need for a supply chain
Lead	Welsh Government	Welsh Government
Timescale	2024-2030	2024-2030
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Enabling actions

	7.9 (linked to regional action R1.5)	7.10 (linked to regional action E2.2)
Description	Work with Welsh Government to create a governance structure and performance management framework for the LAEPs to facilitate monitoring of progress and performance of the LAEPs across the Region.	Using the outputs from the LAEPs and REPs, create a national plan which covers the gaps such as national and regional assets.
Lead	ANW; WGES	Welsh Government
Timescale	2024-2025	2024
Benefits		
Investment		
Contributing Stakeholders		

Appendix A1
Actions and recommendations

Enabling actions

	7.11 (linked to regional action R1.3)	7.12 (linked to regional action H)
Description	Develop the first regional Strategic Development Plan (SDP). Include policies in the plan that support low carbon building practices and low carbon new builds.	Strengthen the link between research, development and innovation with regards to current and emerging technology and the Energy Strategy priorities.
Lead	North Wales Corporate Joint Committee	Bangor University / M-Sparc; Wrexham University; ANW
Timescale	2024-2028	2024-2030
Benefits		
Investment		
Contributing Stakeholders		

Appendix A2

Deployment modelling – National, regional and local policies applied

National (UK or Wales) proposed and committed policies	Source
No more fossil vehicles from 2035	UK Government – Decarbonising Transport – A Better, Greener Britain. Available at: https://www.gov.uk/government/publications/transport-decarbonisation-plan
No new gas boilers from 2035	UK Government – Net Zero Strategy: Build Back Greener. Available at: https://www.gov.uk/government/publications/net-zero-strategy
Phase out unabated coal by 2024	
UK Government committed to deploying CCUS at scale in 2030s	
UK Government committed to 10GW H_2 production by 2030	
New homes low carbon heating ready by 2025	Rigorous new targets for green building revolution. Available at: https://www.gov.uk/government/news/rigorous-new-targets-for-green-building-revolution
UK Government projects 600,000 heat pumps a year by 2028 (UK), up from 35,000 in 2021	Energy Security Bill factsheet: Low-carbon heat scheme. Available at: https://www.gov.uk/government/publications/energy-security-bill-factsheets/energy-security-bill-factsheet-low-carbon-heat-scheme
700,000 building retrofits by 2025, and all buildings by 2050 (UK)	UK Government – Energy efficiency: what you need to know. Available at: https://www.gov.uk/government/news/energy-efficiency-what-you-need-to-know

Appendix A2

Deployment modelling – National, regional and local policies applied

National (UK or Wales) proposed and committed policies	Source
Private rented homes EPC C by 2030, and EPC B for commercial units	UK Government – Heat and Buildings Strategy (2021). Available at: https://www.gov.uk/government/publications/heat-and-buildings-strategy/heat-and-building-strategy-accessible-webpage
Only 4 low carbon industrial clusters by 2030, and one net zero cluster by 2050 (UK)	UK Government – Industrial Decarbonisation Strategy. Available at: https://www.gov.uk/government/publications/industrial-decarbonisation-strategy
Quicker and more proportionate consenting regime for energy storage - all planning applications have been delegated to Welsh Local Planning Authorities	Welsh Government Developments of national significance (DNS). Available at: https://www.gov.wales/developments-national-significance-dns-guidance
Welsh Government requirement to explore heat networks within Future Wales	Heat strategy for Wales. Available at: https://www.gov.wales/heat-strategy-wales

Appendix A2

Deployment modelling – National, regional and local policies applied

Local proposed and committed policies	**Source**
New jobs over the plan period (2015-2030)	Flintshire LDP 2015-2030
Hectares of employment land	Flintshire LDP 2015-2030
New homes over plan period (2015-2030)	Flintshire LDP 2015-2030
New homes in Tier 1 locations (Main Service Centres listed on page 47 of LDP)	Flintshire LDP 2015-2030
New homes in Tier 2 locations (Local Service Centres listed on page 47 of LDP)	Flintshire LDP 2015-2030
New homes in Tier 3 locations (Sustainable Settlements listed on page 47 of LDP)	Flintshire LDP 2015-2030
New homes in Tier 4 locations (Defined Villages listed on page 47 of LDP)	Flintshire LDP 2015-2030
New homes in Tier 5 locations (Undefined Villages listed on page 47 of LDP)	Flintshire LDP 2015-2030
New homes on Northern Gateway Mixed Use Development Site	Flintshire LDP 2015-2030
New hectares of B2/B8 employment land at Warren Hall Development Site	Flintshire LDP 2015-2030
New hectares of B1 and B2 employment land at Warren Hall Development Site	Flintshire LDP 2015-2030
New commercial hub at Warren Hall Development Site	Flintshire LDP 2015-2030
New employment land allocation at Chester Aerospace Park, Broughton	Flintshire LDP 2015-2030

Appendix A3

Glossary of terms

Term	Definition or meaning
Action	The process of doing something – a specific action assigned to a responsible person preferably with a date to be completed.
Anaerobic Digestion	Processes biomass (plant material) into biogas (methane) that can be used for heating and generating electricity.
Baseline	The baseline is the data showing the current energy system, containing the 2019 data sets provided by the LA and publicly available data.
Batteries	Devices that store electrical energy to be used at a later time.
Biomass boiler	A boiler which burns wood-based fuel (e.g. logs, pellets, chippings) to generate heat and electricity.
Carbon Capture and Storage (CCS)	The process of capturing and then storing carbon emissions before they enter the atmosphere.
Certainties	A fact that is definitely true or an event that is definitely going to take place. In terms of a local energy system, certainties include funded projects, etc.
Demand	Local energy demand that the local energy system needs to meet.
Demand headroom	The difference between the electrical capacity of a substation, and the electricity demand at the substation at the time of peak demand.

Appendix A3
Glossary of terms

Term	Definition or meaning
Deployment modelling	A model investigating rates by which to deploy specific technologies between the baseline year and 2050 to achieve the end state developed by the optimisation model for each scenario. The model considers broader plan objectives and local, regional, and national strategic priorities, policies, and targets to help us to define a suitable level of ambition and inform an action plan.
Dispatchable energy generation	Energy generation that can turn on and off (i.e. isn't controlled by the weather) – this is likely to be gas turbines of some sort.
Distribution network	Takes energy from transmission network and delivers it to users via pipes or wires at low pressure / voltages.
Electricity network	Interconnected infrastructure which consists of power stations, electrical substations, distribution lines and transmission lines. The network delivers electricity from the producers to consumers.
Electrolyser	A piece of equipment that uses electricity to split water into hydrogen and oxygen.
Energy Proposition	A proposition is an energy component with a scale and a timescale. For instance, X MW of wind turbine to be built in 5 years, 10,000 buildings to retrofit with XX by 2030, or a pilot project such as hydrogen storage innovation. These are typically near term, low regrets energy components that are needed in future energy systems (it is likely that these appear in all scenarios).
Energy System Component	A term used to describe anything that can have a direct impact on energy demand and/or the way energy is supplied. E.g. installing retrofit measures can reduce overall heating demand, increasing solar PV capacity can change the supply mix and the way that the energy system operates.
Focus zone	A modelling zone which has been identified as an area in which to target near-term installation, upgrade, retrofit, or other activities related to a specific energy system component.
Generation	Local generation – size below 100MW.
Generation headroom	Generation headroom in a local authority's electricity distribution network refers to the remaining primary substation capacity at the time of peak generation, crucial for maintaining a stable and reliable power supply to meet the community's needs
Grid electricity	Electricity that is supplied by the electricity network.

Appendix A3
Glossary of terms

Term	**Definition or meaning**
Grid substation	The physical equipment comprising a substation with a 132kV-33kV transformer(s) connecting the grid-level, extra high voltage electricity lines to the primary-level, high voltage electricity lines. The grid substation facilitates connection with the national grid.
Heat network	A distribution system of insulated pipes that takes heat from a central source and delivers it to a number of domestic or non-domestic buildings.
Heat pump	A piece of equipment that uses a heat exchange system to take heat from air, ground or water and increases the temperature to heat buildings.
Hydrogen	A flammable gas that can be burned, like natural gas, to generate heat or power vehicles. The by-product is water only, no carbon.
Infrastructure	Local energy distribution infrastructure, includes storage assets if these are at grid level.
Landfill gas	Gases such as methane that are produced by micro-organisms in a landfill site that can be used as a source of energy.
Lever	We use the term policy levers to refer to the ‘governing instruments’ (Kooiman, 2003) which the state has at its disposal to direct, manage and shape change in public services.
Local energy system	The distribution level energy system, excludes the transmission and national assets.
Longer-term options	The likely outcome of these is less certain and dependent upon actions and decisions being made that are not under our control, e.g. a national policy or the capability / availability of a technology.

Appendix A3
Glossary of terms

Term	Definition or meaning
Major industrial load	The power demand of industrial sites in the 2019 NAEI Point Sources data are large enough to be classified as major industrial loads. Sites that aren't included in this database are likely too small to have a significant impact on the energy system singlehandedly.
Methane reformation	Process of producing hydrogen by heating methane from natural gas and steam, usually with a catalyst. Produces carbon dioxide as a by product.
Microgeneration	Small-scale generation of heat and electricity by individuals, households, communities or small businesses for their own use.
Modelling zone	A specified area in our modelling which is the smallest level of granularity for analysis. The zones are used through energy modelling, deployment modelling, and mapping. Zones were created by intersecting the Local Authority boundary with the primary substation service area boundary, as described in the "Methodology - electricity and gas network infrastructure" section of the Technical Report. *May also be called "zone" or "substation zone" in the reports.*
National Asset	National infrastructure (can be supply or demand and the accompanying transmission / distribution infrastructure) – defined as over 100MW, unless it produces heat which can only be used locally this is generally excluded from LAEP particularly the modelling.
National grid	A generic term used in the reports referring to the electricity network serving Wales, including both the transmission and distribution networks and facilitating the flow of electricity between neighbouring areas or regions. *May also be called generically "grid" in the reports.*
National Net Zero	The National Net Zero modelled in the LAEP. Details of assumptions are in the methodology section.
Natural Heritage	This includes features which are of ecological, geological, geomorphological, hydrological or visual amenity importance within the landscape, and which form an essential part of the functioning of the natural environment and natural assets of RCT.

Appendix A3
Glossary of terms

Term	Definition or meaning
Net Zero	Net zero when used in this LAEP is the energy net zero as it does not include all emissions, only energy emissions.
No regrets/ low regrets	Options which are common to all scenarios, cost-effective, provide relatively large benefits, and are very likely to be important parts of the future energy system, regardless of future uncertainty.
Optimisation modelling	Modelling to create the most cost and carbon optimal system.
Option	A term used to describe ways that a particular objective can be achieved. In the context of this LAEP, an option could be deploying a particular energy system component
Outward code	The first part of a postcode i.e. BS1.
Pathway	A pathway is how we get from the current energy system, to the most likely net zero end point. The pathway will consider what is needed from across the scenarios, the supply chain, number of installers etc. The propositions will make up the more certain part of the pathway, whereas the longer-term energy components will need further definition in the future.
Power purchase agreement (PPA)	A contract between two parties where one produces and sells electricity and the other purchases electricity.
Primary substation	The physical equipment comprising a substation with a 33kV-11kV transformer(s) connecting the primary-level, high voltage electricity lines to the consumer-level, low voltage electricity lines.
Primary substation service area	The area bounding the buildings or other electricity demands which are served by a primary substation (or, in ANW, a group of primary substations acting together to serve one area).

Appendix A3

Glossary of terms

Term	Definition or meaning
Programme	A series of projects, usually with a theme, that is run collectively.
Project	Strategic scale projects being implemented or planned for implementation in the local energy system that will significantly affect local demand or local supply.
Quick win projects	Very short-term actions, certain as no major blockers.
Renewable Energy Guarantees of Origin (REGO) Agreement	A scheme that tells consumers what proportion of their electricity comes from renewable sources.
Resistance heating/ heater	Generate heat by passing electrical currents through wires.
Scenario	A scenario is a set of assumptions for a particular end point (usually 2050) which are modelled in our optimisation model. We modelled 5 different scenarios to see what was common across the scenarios and therefore is a “no regrets” measure, and what changed between the modelled scenarios.
Sensitivities	Sensitivities of a specific scenario can be tested – for instance to test the impact of increasing electricity/hydrogen prices on the scenario. Testing a sensitivity is when you change one thing multiple times to assess the impact on the cost/carbon.
Sewage gas	A mixture of gases generated in sewer systems, used in a reciprocating gas engine to produce heat and electricity.
Solar PV	Convert solar radiation into electricity using photovoltaic (PV) cells.
Strategic objective	Strategic objectives are purpose statements that help create an overall vision and set goals and measurable steps to achieve the desired outcome. A strategic objective is most effective when it is quantifiable either by statistical results or observable data. Strategic objectives further the vision, align goals and drive decisions that impact change.

Appendix A3
Glossary of terms

Term	Definition or meaning
Strategic options	Strategic options are longer-term changes to demand, generation and infrastructure that will lead onto decarbonisation of the local energy system - and the key variables that determine scenarios.
Substation upgrades	Interventions at an existing primary substation designed to increase the capacity of the substation, such as upgrading an existing primary substation or installing a new primary substation. *May also be called 'substation interventions' in the reports.*
Supply	Energy supply options – this is how energy is delivered from the point of source – so a supply option would be solar PV.
Supply/generation headroom	The difference between the electrical capacity of a substation, and the power being supplied to the substation at a given time.
TfW zone	An area used by the Transport for Wales (TfW) as a point of origin or departure for vehicle trips. M*ay also be called "transport zone" within the reports.*
Transmission network	Move energy via pipes or wires for long distances around the country at high pressure/ voltages.
Uncertainties	Uncertainty results from lack of information or from disagreement about what is known or even knowable.
We	In this report, the term "we" has been used throughout to refer to the consultants that have been commissioned by Welsh Government to support the development of this LAEP.
Wind power	Harnessing the kinetic energy of wind to turn a turbine to generate electricity.

Appendix A4

Units of measure

Unit	Definition or meaning
°C	Degree(s) Celsius – a unit of temperature on the Celsius scale.
GWh	Gigawatt hour(s) – a unit of energy representing 1 billion watt-hours.
$kgCO_2e$	Kilogram(s) of carbon dioxide equivalents – a unit of measurement for greenhouse gas warming potential, expressing the equivalent weight of carbon dioxide with the same global warming potential.
$ktCO_2e$	Kilotonne(s) of carbon dioxide equivalents - a unit of measurement for greenhouse gas warming potential, expressing the equivalent weight of carbon dioxide with the same global warming potential. Represents 1 million kgCO2e.
kV	Kilovolt(s) – a unit of potential energy of a unit charge in a point of a circuit relative to a reference (ground) representing 1000 volts.
kW	Kilowatt(s) – a metric unit of power measuring rate of energy consumption or production representing 1000 watts.
kWh	Kilowatt hour(s) - a unit of energy representing 1000 watt-hours.
kWp	Peak kilowatt(s) – the maximum power rating possible produced by an energy generation source (i.e., amount of power produced in ideal generation conditions).
MW	Megawatt(s) – a metric unit of power measuring rate of energy consumption or production representing 1 million watts.
MWe	Megawatt(s) electric – a unit of electric power output from a generation source representing 1 million watts electric.

Appendix A4

Units of measure

Unit	Definition or meaning
MWth	Megawatt(s) thermal – a unit of thermal power output from a generation source representing 1 million watts thermal.
MWh	Megawatt hour(s) - a unit of energy representing 1 million watt-hours.
tCO_2 per capita	Tonne(s) of carbon dioxide per capita – a unit of mass of carbon dioxide emitted per member of a population per year. Represents 1000 $kgCO_2$ per capita.

Sponsors:

Delivery partners:

Appendix A5
Bibliography

Appendices
Section B

Appendix B1

Emissions sources in scope

LAEP emissions source	Inclusion	Comment
Domestic		
Electricity	✓	
Gas		
‘Other fuels’	✓	Oil, biomass, coal, LPG
Road transport		
‘A’ roads	✓	
Minor roads	✓	
Other (off-road, machinery)	✓	
Commercial and public sector		
Electricity	✓	
Gas		
‘Other fuels’	✓	
Industry	✓	
Electricity	✓	
Gas	✓	
‘Other fuels’	✓	
Large installations		Partial inclusion
Agriculture	✓	Emissions from agricultural processes not included but emissions from energy use is included.
Other fuels demand		
Domestic	✓	
Commercial	✓	
Industrial	✓	
Transport		

Appendix B1
Emissions sources in scope

LAEP emissions source	Inclusion	Comment
Gas network infrastructure		
Network coverage	✓	
Transport infrastructure		
EV charging infrastructure	✓	
Supply		
Non-renewable energy	✓	Includes: fossil (gas) and fossil (oil, LPG)
Renewable energy	✓	Includes: Ground- and roof-mounted solar PV, onshore wind, anaerobic digestion, biomass, energy from waste
Heat networks	✓	Undertaken for all LAs, only presented where appropriate
Generation		
Traditional electricity	✓	
Electricity demand		
Domestic	✓	
Commercial	✓	
Industrial	✓	
Transport	✓	

Appendix B1

Emissions sources in scope

LAEP emissions source		Comment
Gas demand		
Domestic	✓	
Commercial	✓	
Industrial	✓	
Electricity network infrastructure		
Primary substation headroom	✓	
Other		
Domestic and international shipping	X	Reserved as national priority
Domestic and international aviation	X	Reserved as national priority
Military transport	X	Reserved as national priority
Exports	X	Reserved as national priority
Waste	X	Emissions from waste treatment without energy recovery not included.
Storage		
Electrical	X	
Thermal	X	
Other	X	
Land use, land use change and forestry	X	LAEP focused on energy system and associated emissions, rather than all sources of territorial emissions.

Appendix B2
Emission factors

Technology	Value	Units	Notes
Biomass	0.0119	kgCO2e/kWh	DESNZ, 2023 (Average of 4 biomass fuels: wood logs, wood chips, wood pellets, grass/straw)
Sewage gas	0.0002	kgCO2e/kWh	DESNZ, 2023 (Biogas - Biogas)
Organic matter	0.0002	kgCO2e/kWh	DESNZ, 2023 (Biogas - Biogas)
Natural gas	0.1843	kgCO2e/kWh	DESNZ, 2023 (Gaseous fuels - natural gas, Gross CV)
Oil/LPG	0.2413	kgCO2e/kWh	DESNZ, 2023 (Average of LPG and Fuel Oil, Gross CV)
Diesel	0.2391	kgCO2e/kWh	DESNZ, 2023 (Liquid fuels - Diesel (average biofuel blend), Gross CV)
Petrol	0.2217	kgCO2e/kWh	DESNZ, 2023 (Liquid fuels - Petrol (average biofuel blend), Gross CV)
Landfill gas	0.0002	kgCO2e/kWh	DESNZ, 2023 (Biogas - Landfill gas)
Waste incineration	0.0380	kgCO2e/kWh	Tolvik, 2021 (https://www.tolvik.com/published-reports/view/uk-energy-from-waste-statistics-2021/)
Coal	0.3226	kgCO2e/kWh	DESNZ, 2023 (Coal - Industrial, Gross CV)

Grid electricity carbon factor source	FES 23 (average scenario)

Appendix B3
Buildings - assumptions

No.	Assumption Description
1	[BASELINE] EPC and AddressBase records are up to date from April 2023
2	[BASELINE] Properties without an EPC record were assigned most likely property attributes based on neighbouring buildings of the same age and archetype with EPC records. For example, a 1900s Victorian property (AddressBase) without an EPC will be assigned the most common house type and mean insulation levels for similarly aged properties in the same LSOA area. For flats in the same block (i.e. same building number/name), the same extrapolation method was used using flats in the same block in the first instance, instead of LSOA. Where there was insufficient data within an LSOA, the local authority average was used instead.
3	[BASELINE] Each non-domestic archetype is assigned a single energy benchmark value per unit floor area
4	[FUTURE ENERGY SYSTEM] The energy efficiency cost data is Carbon Trust proprietary data, incorporating a combination of inputs including Spon’s Architects’ and builders’ price book 2021, in-house market research and published construction market data. The Spon’s Architects’ and builders’ price book data was converted into a usable format using EPC building dimensions for the cost optimisation
5	[FUTURE ENERGY SYSTEM] The following assumptions were made to inform the application of the cost data to specific property types: • Pitched loft insulation happens at the joists (270mm) • Insulation on suspended floors is assumed to be “easy access” • Filled cavities are assumed to be fully insulated • Unfilled or partially filled cavities receive cavity wall insulation • Pre-1930s solid walls receive 100mm internal wall insulation • Post-1930s solid walls receive 200mm external wall insulation, with a higher rate for flats.
6	[FUTURE ENERGY SYSTEM] Pitched roofs include properties with roof rooms which account for a small percentage (<10%) of pitched roofs. Roof rooms are more challenging to insulate as it is more disruptive for the occupant – additional costs have not been considered in this analysis
7	[FUTURE ENERGY SYSTEM] The heat demand profile used in the analysis is based on 2018 weather conditions. Three individual profiles representing an intermediate day, a winter day, and an extreme winter day (Beast from the East) were applied across the whole year to generate annual energy consumption profiles.
8	[FUTURE ENERGY SYSTEM] The average lifetime of the packages of energy efficiency measures being installed is assumed to be 30 years.
9	[FUTURE ENERGY SYSTEM] Dwellings classed as EPC A will not make any additional fabric improvements

Appendix B3
Buildings – domestic archetypes

- For each domestic and non-domestic archetype, a property with median thermal attributes is selected to perform the energy efficiency analysis

Archetype	Description	Av. floor area (sqm)	Wall	Roof	Floor	Window	HTC* (W/K)
1	Detached - after 1930 - medium/high efficiency	121.9	Insulated cavity wall	Insulated pitched roof	Uninsulated solid floor	Double glazing	379.8
2	Detached - low efficiency	170.9	Uninsulated solid wall	Insulated pitched roof	Uninsulated solid floor	Double glazing	1192.1
3	Terrace - medium efficiency	77.1	Insulated cavity wall	Insulated pitched roof	Uninsulated solid floor	Double glazing	153.6
4	Terrace - before 1930 - low efficiency	89.5	Uninsulated solid wall	Uninsulated pitched roof	Uninsulated solid floor	Double glazing	422.5
5	Semi-detached - after 1930 - low efficiency	79.5	Uninsulated cavity wall	Partially insulated pitched roof	Uninsulated solid floor	Double glazing	288.6
6	Semi-detached - after 1930 - high efficiency	79.5	Insulated cavity wall	Insulated pitched roof	Uninsulated solid floor	Double glazing	231.7
7	Semi-detached - before 1930 - low efficiency	105.3	Uninsulated solid wall	Uninsulated pitched roof	Uninsulated solid floor	Double glazing	741.2
8	Semi-detached - before 1930 - high efficiency	102.4	Insulated cavity wall	Insulated pitched roof	Uninsulated solid floor	Double glazing	495.5
9	Flat - high efficiency	54.2	Insulated cavity wall	Insulated pitched roof	Other premises below	Double glazing	85.5
10	Top floor flat - low efficiency	64.6	Uninsulated solid wall	Uninsulated pitched roof	Other premises below	Double glazing	332.0
11	Bottom floor flat - low efficiency	61.7	Uninsulated solid wall	Other premises above	Uninsulated solid floor	Double glazing	231.8

** Heat Transfer Coefficient (HTC) is a measure of thermal efficiency and is proportional to heat demand.*
To calculate HTC, the heat flow rate is divided by the ideal indoor and lowest outdoor temperature difference

Appendix B3
Buildings – non-domestic archetypes

Archetype	Description	Age	Wall	Roof	Floor	Window	Heat demand (kWh/m²)	Electricity demand (kWh/m²)	Cooling demand (kWh/m²)
12	Office unit	Pre-1930	Uninsulated solid wall	Other premises above	Uninsulated solid floor	Double glazing	73.8	95.1	28.0
13	Retail	After 1930	Insulated cavity wall	Other premises above	Uninsulated suspended floor	Double glazing	95.1	117.0	28.0
14	Hotel / hostel	After 1930	Insulated cavity wall	Insulated flat roof	Uninsulated suspended floor	Double glazing	120.9	117.6	30.0
15	Leisure/sports facility	After 1930	Insulated cavity wall	Insulated flat roof	Uninsulated suspended floor	Double glazing	181.3	72.4	40.0
16	Schools, nurseries and seasonal public buildings	Pre-1930	Uninsulated solid wall	Uninsulated pitched roof	Uninsulated suspended floor	Double glazing	127.7	41.0	0.0
17	Museums / gallery / library / theatre	Pre-1930	Uninsulated solid wall	Part insulated pitched roof	Uninsulated suspended floor	Double glazing	107.3	59.7	0.0
18	Health centre/clinic	After 1930	Uninsulated cavity wall	Part insulated pitched roof	Uninsulated solid floor	Double glazing	141.0	55.7	0.0
19	Care home	Pre-1930	Uninsulated solid wall	Insulated pitched roof	Uninsulated suspended floor	Double glazing	113.3	64.6	30.0
20	Emergency services, local Gov services, law, military	After 1930	Insulated cavity wall	Insulated pitched roof	Uninsulated solid floor	Double glazing	177.8	94.5	0.0
21	Hospital	After 1930	Insulated cavity wall	Uninsulated flat roof	Uninsulated solid floor	Double glazing	162.6	86.4	45.0

Appendix B3
Buildings – non-domestic archetypes

Archetype	Description	Age	Wall	Roof	Floor	Window	Heat demand (kWh/m²)	Electricity demand (kWh/m²)	Cooling demand (kWh/m²)
22	Warehouse						24.8	24.2	0.0
23	Restaurant / bar / café						67.1	245.8	0.0
24	Religious building						33.0	12.8	0.0
25	Transport hub/station						71.3	32.5	0.0
26	University campus						105.8	35.3	0.0
27	Other non-domestic						61.0	56.8	0.0

- For non-domestic archetypes 22-27, no retrofit options were modelled due to the increased difficulty in improving the thermal efficiency of these property types

Appendix B3
High demand retrofit options – domestic

Archetype	Original HTC (W/K)	Cavity wall insulation	Internal wall insulation (complex interior)	External wall insulation	External wall insulation (complex façade)	Loft insulation (Joists) 100 - 270mm	Loft insulation (Joists) 0 - 150mm	Insulate solid floor	high performance triple glazing	New-build standard thermal bridging	Enerphit airtightness (1 n50)	AECB airtightness (1.5 n50)	New double panel double convector radiators	New distribution pipework and triple panel radiators	Hot water cylinder and associated pipework	MVHR (de-centralised)	MEV	New HTC (W/K)	Cost £
1	379.8									🟩			🟩		🟩			357.1	£2,755
2	1192.1							🟩						🟩	🟩			1059.5	£9,115
3	153.6											🟩			🟩			148.6	£1,250
4	422.5						🟩						🟩		🟩			367.1	£3,404
5	288.6	🟩					🟩								🟩			231.7	£4,562
6	231.7														🟩			229.5	£1,250
7	741.2						🟩			🟩			🟩		🟩			678.9	£4,242
8	495.5									🟩					🟩			487.5	£1,250
9	85.5														🟩			85.3	£1,250
10	332.0						🟩								🟩			246.8	£2,810
11	231.8							🟩					🟩		🟩			176.1	£10,071

Appendix B3

High demand retrofit options – non-domestic

Archetype	Original heat demand (kWh/m²)	Cavity wall insulation	Internal wall insulation (complex interior)	External wall insulation (complex façade)	Loft insulation (Joists) 0 - 270mm	New roof with insulation (complex)	Insulate flat roof	Insulate solid floor	Insulate suspended floor (difficult access)	high performance triple glazing	New-build standard thermal bridging	Building regs airtightness (5 n50)	AECB airtightness (1.5 n50)	New double panel double convector radiators	New triple panel triple convector radiators	Hot water cylinder and associated pipework	New distribution pipework to radiators	Communal thermal store	MEV	New heat demand (kWh/m²)	Cost £
12	73.8									🟩						🟩				66.5	£1,517 +£82/m²
13	95.8										🟩	🟩				🟩				94.8	£1,250 +£0/m²
14	120.9										🟩							🟩		118.5	£11,250 +£0/m²
15	72.4										🟩							🟩		70.9	£26,000 +£0/m²
16	127.7				🟩							🟩			🟩					110.0	£27,295 +£32/m²
17	107.3					🟩									🟩		🟩			88.5	£49,620 +£45/m²
18	141.0	🟩												🟩		🟩				132.7	£5,120 +£10/m²
19	113.3								🟩									🟩		108.4	£11,250 +£22/m²
20	177.8											🟩		🟩		🟩				173.7	£5,120 +£0/m²
21	162.6						🟩								🟩			🟩		157.8	£83,076 +£69/m²

22-27 not modelled, Industry modelled separately

Sponsors:

Delivery partners:

Appendix B3

Low demand retrofit options – domestic

Archetype	Original HTC (W/K)	Cavity wall insulation	Internal wall insulation (complex interior)	External wall insulation	External wall insulation (complex façade)	Loft insulation (Joists) 100 - 270mm	Loft insulation (Joists) 0 - 150mm	Insulate solid floor	high performance triple glazing	New-build standard thermal bridging	Enerphit airtightness (1 n50)	AECB airtightness (1.5 n50)	New double panel double convector radiators	New distribution pipework and triple panel radiators	Hot water cylinder and associated pipework	MVHR (de-centralised)	MEV	New HTC (W/K)	Cost £
1	379.8					🟩		🟩	🟩	🟩	🟩					🟩		302.4	£90,680
2	1192.1		🟩					🟩	🟩	🟩		🟩			🟩	🟩		710.5	£130,151
3	153.6							🟩	🟩	🟩		🟩			🟩			122.4	£18,186
4	422.5				🟩		🟩	🟩	🟩	🟩		🟩	🟩		🟩			226.5	£42,371
5	288.6	🟩					🟩	🟩	🟩	🟩		🟩				🟩		189.2	£30,945
6	231.7				🟩	🟩		🟩	🟩	🟩		🟩			🟩	🟩		189.2	£29,826
7	741.2			🟩			🟩	🟩	🟩	🟩		🟩				🟩		409.8	£76,134
8	495.5				🟩			🟩	🟩	🟩		🟩				🟩		393.2	£39,410
9	85.5								🟩		🟩				🟩		🟩	76.3	£10,255
10	332.0		🟩				🟩		🟩	🟩		🟩			🟩	🟩		166.6	£28,362
11	231.8																	111.6	£29,406

Appendix B3
Low demand retrofit options – non-domestic

Archetype	Original heat demand (kWh/m²)	Cavity wall insulation	Internal wall insulation (complex interior)	External wall insulation (complex façade)	Loft insulation (Joists) 0 - 270mm	New roof with insulation (complex)	Insulate flat roof	Insulate solid floor	Insulate suspended floor (difficult access)	high performance triple glazing	New-build standard thermal bridging	Building regs airtightness (5 n50)	AECB airtightness (1.5 n50)	New double panel double convector radiators	New triple panel triple convector radiators	Hot water cylinder and associated pipework	New distribution pipework to radiators	Communal thermal store	MEV	New heat demand (kWh/m²)	Cost £
12	73.8		🟩							🟩	🟩					🟩			🟩	52.6	£1,517 +£150/m²
13	95.8								🟩	🟩	🟩		🟩			🟩			🟩	56.6	£1,250 +£172/m²
14	120.9								🟩	🟩	🟩							🟩		112.8	£11,250 +£116/m²
15	72.4									🟩	🟩	🟩						🟩		69.2	£26,000 +£73/m²
16	127.7			🟩	🟩				🟩	🟩	🟩	🟩			🟩					44.9	£9,805 +£393/m²
17	107.3			🟩	🟩				🟩	🟩	🟩	🟩			🟩		🟩			43.2	£36,105 +£340/m²
18	141.0	🟩			🟩			🟩		🟩	🟩	🟩		🟩		🟩				86.3	£5,120 +£198/m²
19	113.3			🟩					🟩	🟩	🟩	🟩						🟩		72.9	£11,250 +£271/m²
20	177.8				🟩			🟩		🟩	🟩		🟩			🟩				127.9	£1,250 +£185/m²
21	162.6			🟩			🟩			🟩	🟩	🟩			🟩			🟩		133.2	£83,076 +£115/m²

Appendix B4
Transport - assumptions

No.	Assumption Description
1	[BASELINE] Typical 24-hour period for demand tables represented average day in a year.
2	[BASELINE] Rail supplied by transmission network so excluded.
3	[BASELINE] Trip distances = distance between zone centroids multiplied by route indirectness factor
4	[BASELINE] Total mileage of trips taken from zone A to zone B: Mileage$_{AB}$= distance$_{AB}$ * number of trips$_{AB}$
5	[BASELINE] Mileage summed and assigned to outbound zone (zone A)
6	[BASELINE] Multiply mileage by vehicle fuel consumption factors to estimate annual kWh.
7	[BASELINE] Fuel consumption factors for combustion vehicles: Car: 0.94 kWh/mile Van: 0.89 kWh/mile HGV: 6.21 kWh/mile Bus: 8.43 kWh/mile
8	[FUTURE] Car dependency factors (1: national average, <1: less car dependent, >1: more car dependent) based on average number of cars per household Flintshire: 1.09 Isle of Anglesey: 1.08 Gwynedd: 1.02 Wrexham: 1.01 Denbighshire: 1.00

Appendix B5
Renewable generation - assumptions

No.	Assumption Description
1	[BASELINE] For renewable generators identified in the REPD database, only those marked as “Operational” were captured, using 2019 as a baseline year.
2	[BASELINE] For renewable generators identified in NGED and SPEN registers (ECR), only those marked as “Connected” were captured, using 2019 as a baseline year.
3	[BASELINE] Generation (MWh) was calculated using LA-specific, hourly time-step profiles for wind and solar from PVGIS and Renewables.ninja. For other technologies, standard capacity factors from BEIS/DESNZ were used.
4	[PIPELINE] For REPD entries, only those marked as “Planning Application Granted – Awaiting Construction” and “Under Construction” were captured.
5	[PIPELINE] For ECR entries, only those marked as “Accepted to connect” were captured.
6	[FUTURE ENERGY SYSTEM] The solar and wind capacity factors (MW/km^2) used to calculate maximum available capacity (MW) at substation granularity were calculated using an average of the 4 factors from the renewable energy assessment (REA) undertaken by the Carbon Trust between 2020-2021. The REA factors used were for Blaenau Gwent, Caerphilly, Monmouthshire and Torfaen, all of which had values in the range of 50-60 MW/km^2 for solar PV, which agrees with literature. The final values used to estimate solar and wind resource were 53.4 MW/km^2 and 8.1 MW/km^2, respectively.
7	[FUTURE ENERGY SYSTEM] Overlap between areas suitable for both wind and solar were calculated to ensure that capacity was not double-counted.
8	[FUTURE ENERGY SYSTEM] Maximum roof-mounted PV capacity was estimated using roof-area coverage at the LA- and substation-level. It was assumed that 50% of roofs would be north-facing and therefore unsuitable and assumed a further 50% would be unsuitable due to further technical or planning constraints (e.g.: unsuitable roof type, extensive shading, listed buildings…). As both residential and commercial roofs were considered, a factor of 7.2 m^2/kW was used to estimate maximum available capacity.
9	[FUTURE ENERGY SYSTEM] Areas suitable for wind and solar developments were mapped using a variety of sources provided by the individual LAs. In instances where no shapefiles were provided, areas were traced manually using publicly-available information (REA, LDP or similar). The additional areas identified in the Welsh-wide study (Arup, 2019) were included for LAs where data was either outdated or missing detail, see adjacent table.
10	[FUTURE ENERGY SYSTEM] It was assumed that of the areas identified in the Welsh-wide study (which primarily considered planning constraints and not technical constraints), 10% of the land could be developed on for solar and/or wind.

Local Authority	Welsh-wide Arup renewable study (2019)
Blaenau Gwent	No
[AREA]	No
Cardiff	Yes
Merthyr Tydfil	Yes
Monmouthshire	No
Torfaen	No
Rhondda Cynon Taf	No
Vale of Glamorgan	No
[AREA]	Yes
Flintshire	Yes
Isle of Anglesey	Yes
Gwynedd	Yes
Wrexham	Yes

Appendix B6
Heat networks – assumptions

- Counterfactual techno-economic assumptions - For developing a LCoH value for decentralised ASHPs

Assumptions log – 1/2

Item	Value	Units	Source/notes	Item	Value	Units	Source/notes
ASHP plant capex cost	700	£/kWth	Taken from calliope inputs – average of now and 2050 costs	Elec boiler plant capex cost	150	£/kWth	Taken from calliope inputs
ASHP lifetime	18	Years	Taken from calliope inputs	Elec boiler lifetime	20	Years	Typical technology assumption
ASHP O&M costs	0.01	£ p.a./kWhth	Used in the NCA study – calliope input looks like it has an error	Elec boiler O&M costs	0	£ p.a./kWhth	Taken from calliope inputs
ASHP peak capacity	50	% of peak building heat	Assumption based on typical load duration curves	Elec boiler peak capacity	50	% of peak building heat	Electric boilers are assumed to provide peaking role
ASHP annual supply	80	% of annual building heat	Assumed to be lower than the 90% heat network figure due to less thermal storage at building level	Elec boiler annual supply	20	% of annual building heat	Assumed to be higher than 10% heat network figure due to less thermal storage at building level
Ambient air temperature	5	°C	Typical ambient temperature during heating hours – inputs give equivalent COP to calliope	Elec boiler efficiency	100	%	Taken from calliope inputs
ASHP carnot cycle efficiency	50	%	Typical ambient temperature during heating hours – inputs give equivalent COP to calliope	Electricity unit cost	0.1304	£/kWhe	HMT Green Book central commercial/public sector price
ASHP source ΔT	10	°C	Typical ambient temperature during heating hours – inputs give equivalent COP to calliope	Electricity supply connection cost	200	£/kWe	Based on average of DNO connection offers in urban areas
ASHP supply ΔT	5	°C	Typical ambient temperature during heating hours – inputs give equivalent COP to calliope	Building supply temperature	65	°C	Typical building supply temperature – inputs give equivalent COP to calliope

Appendix B6

Heat networks – assumptions

- Counterfactual techno-economic assumptions - For developing a LCoH value for decentralised ASHPs

Assumptions log – 2/2

Item	Value	Units	Source/notes
Discount rate	3.5	%	HMT Green Book for public sector projects
Project lifetime	60	Years	DESNZ assumption
Testing & commissioning costs	2	% of Capex	High level assumption used in Arup HNDU feasibility studies
Builders work costs	3	% of Capex	High level assumption used in Arup HNDU feasibility studies
Preliminaries costs	10	% of Capex	High level assumption used in Arup HNDU feasibility studies
Overheads & profits costs	5	% of Capex	High level assumption used in Arup HNDU feasibility studies
Design & professional fees	12	% of Capex	High level assumption used in Arup HNDU feasibility studies
Optimism bias	15	% of Capex	High level assumption used in Arup HNDU feasibility studies

Appendix B6

Heat networks – assumptions

- For using in HeatNet's TEM to estimate the LCoH of networks

Assumptions log – 1/3

Item	Value	Units	Source/notes	Item	Value	Units	Source/notes
ASHP plant capex cost	420	£/kWth	Assumes large plant is 60% price of decentralised plant based on work on other Arup projects	Elec boiler plant capex cost	90	£/kWth	Assumes large plant is 60% price of decentralised plant based on work on other Arup projects
ASHP lifetime	18	Years	Taken from calliope inputs	Elec boiler lifetime	20	Years	Typical technology assumption
ASHP O&M costs	0.01	£ p.a./kWhth	Used in the NCA study – error in calliope input	Elec boiler O&M costs	0.0075	£ p.a./kWhth	Used in Arup HNDU feasibility studies; based on DECC report
ASHP peak capacity	50	% of EC peak heat	Assumption based on typical load duration curves	Elec boiler peak capacity	50	% of EC peak heat	Electric boilers are assumed to provide peaking role
ASHP annual supply	90	% of EC annual heat	Assumption based on typical load duration curves	Elec boiler annual supply	10	% of EC annual heat	Assumption based on typical load duration curves
Ambient air temperature	5	°C	Typical ambient temperature during heating hours – same as counterfactual	Elec boiler efficiency	100	%	Taken from calliope inputs
ASHP carnot cycle efficiency	60	%	Applied to ideal carnot cycle COP; typical technology assumption; higher than for smaller equipment	Electricity unit cost	0.1304	£/kWhe	HMT Green Book central commercial/public sector price
ASHP source ΔT	10	°C	Typical technology assumption – same as counterfactual	Electricity supply connection cost	200	£/kWe	Based on average of DNO connection offers in urban areas
ASHP supply ΔT	5	°C	Typical technology assumption– same as counterfactual	Heat network supply temperature	65	°C	Consistency in supply temperature

Appendix B6

Heat networks – assumptions

- For using in HeatNet’s TEM to estimate the LCoH of networks

Assumptions log – 2/3

Item	Value	Units	Source/notes	Item	Value	Units	Source/notes
Waste-heat heat pump plant capex cost	420	£/kWth	Assumes large plant is 60% price of decentralised plant based on work on other Arup projects	Waste heat capture plant capex cost	*See note*	£/kWth	See waste heat assumptions; depends on source
Waste-heat heat pump lifetime	20	Years	Typical technology assumption	Waste-heat capture plant O&M costs	*See note*	£/kWhth	See waste heat assumptions; depends on source
Waste-heat heat pump O&M costs	0.01	£ p.a./kWhth	Used in the NCA study	Thermal storage capex cost	24	£/kWhth	Supplier quotes; used in Arup HNDU feasibility studies
Waste-heat heat pump peak capacity	50	% of EC peak heat	Assumption based on typical load duration curves	Thermal storage sizing	4	Hours of EC peak	High-level assumption
Waste-heat heat pump annual supply	90	% of EC annual heat	Assumption based on typical load duration curves	Network pipework cost	2000	£/m	DESNZ assumption
Waste-heat source temperature	*See note*	ºC	See waste heat assumptions; depends on source	Network losses	20	%	DESNZ assumption and limit of acceptable losses in CIBSE CP1
Waste-heat heat pump carnot cycle efficiency	60	%	Typical technology assumption; higher than for smaller equipment	Network O&M costs	0.5	£/m pipework	Based on data from Arup projects
Waste-heat heat pump source ΔT	5	ºC	Typical technology assumption; lower ΔT than for air	Energy centre ancillaries costs	20	£/kWth	Based on supplier quotes; used in Arup EfW heat network opportunities study
Waste-heat heat pump supply ΔT	5	ºC	Typical technology assumption	Ancillary electricity usage (e.g., for pumps)	3	% of EC annual heat	Used in Arup HNDU feasibility studies

Appendix B6

Heat networks – assumptions

- For using in HeatNet's TEM to estimate the LCoH of networks

Assumptions log – 3/3

Item	Value	Units	Source/notes	Item	Value	Units	Source/notes
Energy centre building cost	100	£/kWth	Used in the NCA study	Discount rate	3.5	%	HMT Green Book for public sector projects
Hydrogen boiler capex cost	90	£/kW	Takes calliope input and assumes large plant is 60% price of decentralised plant based on work on other Arup projects	Testing & Commissioning costs	2	% of Capex	High level assumption used in Arup HNDU feasibility studies
Hydrogen boiler lifetime	15	Years	Calliope inputs	Builders work costs	3	% of Capex	High level assumption used in Arup HNDU feasibility studies
Hydrogen boiler efficiency	84	%	Calliope inputs	Preliminaries costs	10	% of Capex	High level assumption used in Arup HNDU feasibility studies
Hydrogen boiler O&M	0.005	£ p.a./kWhth	O&M costs half that of heat pumps – based on calliope inputs	Overheads & profits costs	5	% of Capex	High level assumption used in Arup HNDU feasibility studies
Hydrogen fuel cost	0.07	£/kWh	Calliope inputs	Design & professional fees	12	% of Capex	High level assumption used in Arup HNDU feasibility studies
Hydrogen boiler backup capacity	100	% of EC peak heat	Assumed that backup boilers able to meet full peak will be available	Optimism bias	15	% of Capex	High level assumption used in Arup HNDU feasibility studies
Project lifetime	60	Years	DESNZ assumption				

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Heat networks – assumptions

- Waste heat capture techno-economic assumptions - For using in HeatNet's TEM to estimate the LCoH of networks

Assumptions log: Substations

Item	Value	Units	Source/notes
Substation capturable heat (kW)	1.82	kWth/MVA	LSBU waste heat research
Substation capturable heat (kWh)	15,910	kWhth/MVA	LSBU waste heat research
Source temperature	45	°C	LSBU waste heat research
Heat capture ΔT	5	°C	Typical industry assumption
Capture plant capex rate	850	GBP/kWth	Estimate based on data from other Arup projects
Capture plant Opex rate	0.005	GBP/kWhth	Estimate based on data from other Arup projects

Appendix B6

Heat networks – assumptions

- Waste heat capture techno-economic assumptions - For using in HeatNet’s TEM to estimate the LCoH of networks

Assumptions log: WWTW

Item	Value	Units	Source/notes
Waste production rate	32.5	Kg dried solids p.a./person	Sludge Treatment - Huber Technology UK - Rotamat Ltd.
WWTW capturable heat (kW)	0.035	kWth/PE	LSBU waste heat research
WWTW capturable heat (kWh)	302	kWhth/PE	LSBU waste heat research
Source temperature	17.5	°C	LSBU waste heat research
Heat capture ΔT	5	°C	Typical industry assumption
Capture plant capex rate	180	GBP/kWth	Estimate based on data from other Arup projects
Capture plant Opex rate	0.005	GBP/kWhth	Estimate based on data from other Arup projects

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Heat networks – assumptions

- Waste heat capture techno-economic assumptions - For using in HeatNet’s TEM to estimate the LCoH of networks

Assumptions log: Minewater treatment plants

Item	Value	Units	Source/notes
Capturable heat per plant	2000	kW/plant	LSBU waste heat research
Operational hours	7884	hours	Assumes constant operation with 90% availability
Source temperature	20	°C	LSBU waste heat research
Heat capture ΔT	5	°C	Typical industry assumption
Capture plant capex rate	180	GBP/kWth	Estimate based on data from other Arup projects
Capture plant Opex rate	0.005	GBP/kWhth	Estimate based on data from other Arup projects

Appendix B6

Heat networks – assumptions

- Waste heat capture techno-economic assumptions - For using in HeatNet’s TEM to estimate the LCoH of networks

Assumptions log: Data centres

Item	Value	Units	Source/notes
DC power density	1	kW IT/m^2	Estimate based on data from other Arup projects
Utilisation factor	80%	% of IT capacity utilised	Estimate based on data from other Arup projects
Capturable heat rate	35%	% of DC heat produced	Estimate based on data from other Arup projects
Source temperature	32.5	ºC	LSBU waste heat research
Heat capture ΔT	5	ºC	Typical industry assumption
Capture plant capex rate	180	GBP/kWth	Estimate based on data from other Arup projects
Capture plant Opex rate	0.005	GBP/kWhth	Estimate based on data from other Arup projects

Appendix B6

Heat networks – assumptions

- Waste heat capture techno-economic assumptions - For using in HeatNet’s TEM to estimate the LCoH of networks

Assumptions log: EfW plants

Item	Value	Units	Source/notes
EfW capturable heat rate	33%	% of MWe capacity	Based on 10 MWth heat available from 30 MWe Cardiff facility
Plant operational hours	7884	hours	Assumes constant operation with 90% availability
Source temperature	>65	°C	Assumes high grade heat; no heat pump boosting required
Capture plant capex rate	350	GBP/kWth	Estimate based on data from other Arup projects
Wholesale electricity cost	0.06	GBP/kWhe	Taken from calliope inputs
Z factor	10		https://assets.publishing.service.gov.uk/media/605b862ed3bf7f2f0b5830ec/draft-sap-10-2-appendix-c.pdf
Capture plant Opex rate	0.010	GBP/kWhth	Estimate based on data from other Arup projects plus lost electricity production costs

Appendix B6
Heat networks – assumptions

- Waste heat capture techno-economic assumptions - For using in HeatNet’s TEM to estimate the LCoH of networks

Assumptions log: Cold stores

Item	Value	Units	Source/notes
EfW capturable heat rate	33%	% of MWe capacity	Based on 10 MWth heat available from 30 MWe Cardiff facility
Plant operational hours	7884	hours	Assumes constant operation with 90% availability
Source temperature	>65	^oC	Assumes high grade heat; no heat pump boosting required
Capture plant capex rate	350	GBP/kWth	Estimate based on data from other Arup projects
Wholesale electricity cost	0.06	GBP/kWhe	Taken from calliope inputs
Z factor	10		https://assets.publishing.service.gov.uk/media/605b862ed3bf7f2f0b5830ec/draft-sap-10-2-appendix-c.pdf
Capture plant Opex rate	0.010	GBP/kWhth	Estimate based on data from other Arup projects plus lost electricity production costs

Appendix B6

Heat networks – assumptions

- Waste heat capture techno-economic assumptions - For using in HeatNet’s TEM to estimate the LCoH of networks

Assumptions log: Industry – water-based capture

Item	Value	Units	Source/notes
EfW capturable heat rate	33%	% of MWe capacity	Based on 10 MWth heat available from 30 MWe Cardiff facility
Plant operational hours	7884	hours	Assumes constant operation with 90% availability
Source temperature	>65	ºC	Assumes high grade heat; no heat pump boosting required
Capture plant capex rate	350	GBP/kWth	Estimate based on data from other Arup projects
Wholesale electricity cost	0.06	GBP/kWhe	Taken from calliope inputs
Z factor	10		https://assets.publishing.service.gov.uk/media/605b862ed3bf7f2f0b5830ec/draft-sap-10-2-appendix-c.pdf
Capture plant Opex rate	0.010	GBP/kWhth	Estimate based on data from other Arup projects plus lost electricity production costs

Appendix B6

Heat networks – assumptions

- Waste heat capture techno-economic assumptions - For using in HeatNet’s TEM to estimate the LCoH of networks

Assumptions log: Industry – flue gas-based heat capture

Item	Value	Units	Source/notes
Heat capture rate	20%	% of kWh fuel use	Estimate based on data from other Arup projects
Plant operational hours	7884	Hours	Assumes constant operation with 90% availability
Source temperature	>65	ºC	Assumes high grade heat; no heat pump boosting required
Capture plant capex rate – large sites	650	GBP/kWth	Estimate based on data from other Arup projects – for sites >3 MWth
Capture plant capex rate – small sites	350	GBP/kWth	Estimate based on data from other Arup projects - for sites <3 MWth
Wholesale electricity cost	0.06	GBP/kWhe	Taken from calliope inputs
Z factor for power producers	10		Assumes same Z factor as EfW plants
Capture plant Opex rate – non-power producers	0.004	GBP/kWhth	Estimate based on data from other Arup projects
Capture plant Opex rate – power producers	0.010	GBP/kWhth	Uplifts rate to account for lost electricity sale revenue

Appendix B7

Technology parameters for future energy system scenario modelling

Technology	Setting	Value	Units	Reference	Notes
Anaerobic digestion	Energy CAPEX	4,760.00	£ / kW	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	CAPEX includes Pre-development cost (medium scenario) in £/kW, Construction cost (medium scenario) in £/kW and Infrastructure cost. Infrastructure cost (£'000) is converted to £/kW by dividing by reference plant size (MW*1000). Assumed price in 2020 is equivalent to projected 2025 price. No change across years
Anaerobic digestion	Energy efficiency	0.32	fraction	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	From the BEIS electricity generation costs 2020. This is the load factor multiplied by the plant efficiency to account for the fact that the plant cannot operate at full load throughout the year.
Anaerobic digestion	Lifetime	20.00	years	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Anaerobic digestion	Operational cost of production	0.07	£ / kWh generated	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	OPEX includes Fixed O&M, Variable O&M, Fuel Costs, Decommissioning and waste, Steam Revenue, Additional Costs (all provided in £/MWh). No change across years
Anaerobic digestion	Operational fuel consumption cost	0.00	$kgCO_2e$ / kWh fuel in	BEIS (2020). Greenhouse gas reporting: conversion factors 2020. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020	Biogas scope 1 emissions factor used

Appendix B7
Technology parameters for future energy system scenario modelling

Technology	**Setting**	**Value**	**Units**	**Reference**	**Notes**
Hydrogen import	Lifetime	1	years	n/a	Selected to have no effect
Hydrogen import	Operational fuel consumption cost	0.0203	kgCO2e / kWh	BEIS Hydrogen Production Costs 2021 report and annex. Availabe at: https://www.gov.uk/government/publications/hydrogen-production-costs-2021 (Accessed 2023).	Carbon capture rate for SMR + CCUS of 93% (BEIS hydrogen production costs) multiplied by the carbon emissions per kWh of hydrogen produced.
Hydrogen import	Operational cost of production	0.051	£ / kWh	BEIS Hydrogen Production Costs 2021 Annex, average of all the methane reformation technologies for the wholesale price (central) in 2050. Availabe at: https://www.gov.uk/government/publications/hydrogen-production-costs-2021 (Accessed 2023).	Average of all the methane reformation technologies for the wholesale price (central) in 2050.
Biomass import	Energy efficiency	1	fraction	n/a	Default
Biomass import	Lifetime	1	years	n/a	Default
Biomass import	Operational cost of production	0.04	£ / kWh generated	Heat roadmap EU (2017) EU28 fuel prices for 2015, 2030 and 2050. Available at: https://heatroadmap.eu/wp-content/uploads/2020/01/HRE4_D6.1-Future-fuel-price-review.pdf (Accessed 2023).	Price for wood pellet - medium labour share + fuel handling charges medium scenario. Converted from Euros using 0.91 exchange rate.
Biomass import	Operational fuel consumption cost	0.01053	kgCO2e / kWh	BEIS (2022). Greenhouse gas reporting: conversion factors 2022. https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-20202	
Electrolyser	Annual investment fraction	0.02	(fraction) of capex	BEIS (2021) Hydrogen Production Costs 2021. Available at: https://www.gov.uk/government/publications/hydrogen-production-costs-2021 (Accessed 2023).	50:50 SEM and Alkaline electrolyser from 2050.

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Technology	Setting	Value	Units	Reference	Notes
Electrolyser	Energy CAPEX	750	£ / kW	BEIS (2021) Hydrogen Production Costs 2021. Available at: https://www.gov.uk/government/publications/hydrogen-production-costs-2021 (Accessed 2023).	50:50 SEM and Alkaline electrolyser from 2050.
Electrolyser	Energy CAPEX	535.5	£ / kW	BEIS (2021) Hydrogen Production Costs 2021. Available at: https://www.gov.uk/government/publications/hydrogen-production-costs-2021 (Accessed 2023).	50:50 SEM and Alkaline electrolyser from 2050.
Electrolyser	Energy efficiency	0.65	fraction	BEIS (2021) Hydrogen Production Costs 2021. Available at: https://www.gov.uk/government/publications/hydrogen-production-costs-2021 (Accessed 2023).	50:50 SEM and Alkaline electrolyser from 2050.
Electrolyser	Energy efficiency	0.82	fraction	BEIS (2021) Hydrogen Production Costs 2021. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011506/Hydrogen_Production_Costs_2021.pdf (Accessed 2023).	Medium scenario for both Alkaline and PEM electrolysers.

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Technology	Setting	Value	Units	Reference	Notes
Electrolyser	Lifetime	30	years	BEIS (2021) Hydrogen Production Costs 2021. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011506/Hydrogen_Production_Costs_2021.pdf (Accessed 2023).	Medium scenario for both Alkaline and PEM electrolysers.
Ground PV	Energy CAPEX	431.25	£ / kW	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	Large-scale Solar. CAPEX includes Pre-development cost (medium scenario) in £/kW, Construction cost (medium scenario) in £/kW and Infrastructure cost. Infrastructure cost (£'000) is converted to £/kW by dividing by reference plant size (MW*1000).
Ground PV	Energy CAPEX	531.25	£ / kW	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Ground PV	Lifetime	35	years	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	

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Technology	Setting	Value	Units	Reference	Notes
Ground PV	Operational cost of production	7.3	£ / kW /year	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	OPEX includes Fixed O&M, Variable O&M, Fuel Costs, Decommissioning and waste, Steam Revenue, Additional Costs (all provided in £/MWh)
Hydrogen CCGT	Energy CAPEX	623.42	£ / kW	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	CCGT H Class. CAPEX includes Pre-development cost (medium scenario) in £/kW, Construction cost (medium scenario) in £/kW and Infrastructure cost. Infrastructure cost (£'000) is converted to £/kW by dividing by reference plant size (MW*1000).
Hydrogen CCGT	Energy efficiency	0.53	fraction	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	From the BEIS electricity generation costs 2020. This is the average fuel efficiency.
Hydrogen CCGT	Lifetime	25	years	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Hydrogen CCGT	Operational cost of production	0.004	£ / kWh generated	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	OPEX includes Fixed O&M, Variable O&M, Fuel Costs, Decommissioning and waste, Steam Revenue, Additional Costs (all provided in £/MWh).

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Technology	Setting	Value	Units	Reference	Notes
Hydrogen CCGT	Opex	18.8	£/kW/year	BEIS (2020) Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	Includes fixed O&M, insurance, connection and use of system charges for CCGT H Class.
Hydrogen CHP	Annual operational cost	14.2	£/kW/year	Battelle Memorial Institute (2016) Manufacturing Cost Analysis of 100 and 250 kW Fuel Cell Systems for Primary Power and Combined Heat and Power Applications. Available at: https://www.energy.gov/eere/fuelcells/articles/manufacturing-cost-analysis-100-and-250-kw-fuel-cell-systems-primary-power (Accessed 2023).	Converted using 0.71 USD to GBP.
Hydrogen CHP	Energy CAPEX	2094	£ / kW	Battelle Memorial Institute (2016) Manufacturing Cost Analysis of 100 and 250 kW Fuel Cell Systems for Primary Power and Combined Heat and Power Applications. Available at: https://www.energy.gov/eere/fuelcells/articles/manufacturing-cost-analysis-100-and-250-kw-fuel-cell-systems-primary-power (Accessed 2023).	
Hydrogen CHP	Energy efficiency	0.42	fraction	2G Energy Ltd (2024) Leading Combined Heat and Power Technology. Available at: https://www.2-g.com/en/hydrogen-chp/ (Accessed 2023).	Heating efficiency

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Technology	Setting	Value	Units	Reference	Notes
Hydrogen CHP	Lifetime	15	Years	Alan Beech, Clarke Energy (2024) CHP - here to stay. Available at: https://www.energymanagermagazine.co.uk/chp-here-to-stay/#:~:text=INNIO%20Jenbacher%20gas%20engines%20can,into%20the%20net%20zero%20world. (Accessed 2023).	
Hydrogen refueller	Energy CAPEX	1076	£ / kW	Mariya Koleva and Marc Melaina (2020)Hydrogen Fuelling Stations Cost. Available at: https://www.hydrogen.energy.gov/pdfs/21002-hydrogen-fueling-station-cost.pdf (Accessed 2023).	Assuming a 24hr flat usage profile and an exchange rate of 0.74£/$.
Hydrogen refueller	Energy efficiency	0.65	fraction	G. Sdanghi, G. Maranzana, A. Celzard, and V. Fierro (2019), Review of the current technologies and performances of hydrogen compression for stationary and automotive applications. Available at: https://www.sciencedirect.com/science/article/abs/pii/S1364032118307822 (Accessed 2023).	Efficiency accounting for compression losses.

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Technology	Setting	Value	Units	Reference	Notes
Hydrogen refueller	Lifetime	18	years	NREL (2014) Hydrogen Station Compression, Storage, and Dispensing Technical Status and Costs. Available at: https://www.nrel.gov/docs/fy14osti/58564.pdf (Accessed 2023).	
Hydrogen storage tank	Lifetime	30	years	NREL (2014) Hydrogen Station Compression, Storage, and Dispensing Technical Status and Costs. Available at: https://www.nrel.gov/docs/fy14osti/58564.pdf (Accessed 2023).	
Hydrogen storage tank	Energy efficiency	0.94	fraction	Department of Mechanical Engineering, The University of Hong Kong (2006) An Overview of Hydrogen Storage Technologies. Available at: https://journals.sagepub.com/doi/pdf/10.1260/014459806779367455 (Accessed 2023).	
Hydrogen storage tank	Operational cost of production	0.34	£ / kWh	HM Government (2021) Defining and organising functional documentation to meet functional standards. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760479/H2_supply_chain_evidence_-_publication_version.pdf (Accessed 2023).	Medium pressure tank - Unlikely to decrease over time.

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Technology	Setting	Value	Units	Reference	Notes
Hydrogen storage tank	Storage CAPEX	11.45	£ / kWh	HM Government (2021) Defining and organising functional documentation to meet functional standards. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760479/H2_supply_chain_evidence_-_publication_version.pdf (Accessed 2023).	Medium pressure tank - Unlikely to decrease over time.
Onshore wind	Energy CAPEX	1088.63	£ / kW	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	CAPEX includes Pre-development cost (medium scenario) in £/kW, Construction cost (medium scenario) in £/kW and Infrastructure cost. Infrastructure cost (£'000) is converted to £/kW by dividing by reference plant size (MW*1000). Assumed price in 2020 is equivalent to projected 2025 price.
Onshore wind	Lifetime	25	years	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Onshore wind	Opex	30	£/kW/year	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Onshore wind	Operational cost of production	0.006	£ / kWh generated	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	OPEX includes fixed O+M, Variable O+M, fuel costs, decommissioning & waste, Steam revenue, and additional costs. Costs are assumed constant between 2040 and 2050. No change across years.

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Technology	Setting	Value	Units	Reference	Notes
Onshore wind	Operational cost of production	0	kgCO2e / kWh fuel in	Default value	Renewable energy, assume operational emissions are zero.
Hydrogen distribution	Energy CAPEX per energy capacity per distance	1.2	£/kW/km	Arup (2023) Future of Great Britain's Gas Networks. Available at: Future of UK Gas Networks, https://nic.org.uk/app/uploads/Arup-Future-of-UK-Gas-Networks-18-October-2023.pdf (Accessed 2023).	This is equivalent to the value for the LTS backbone as stated in the source document. Transformed from a capex and distance, to a capex/distance.This is then divided by 1m kW which is a typical capacity in the system to give 1.2 £/kW/km If the additional services were also transitioned the total cost per m would be 4.8£/kW/km.
Hydrogen distribution	Energy efficiency	1	fraction	To account for in demands	
Hydrogen distribution	Lifetime	40	years	NG2050 - from WWU	
Hydrogen export	Lifetime	1	years	n/a	Selected to have no effect.
Hydrogen export	Operational cost of production	-0.051	£ / kWh	BEIS Hydrogen Production Costs 2021 Annex, average of all the steam reformation technologies	
Hydrogen export	Operational fuel consumption cost	0	kgCO2e / kWh	n/a	Hydrogen for export only produced via electrolysis so assumed zero emissions.

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Technology	Setting	Value	Units	Reference	Notes
Rooftop PV	Energy CAPEX	1100	£ / kW	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	Solar PV 4-10 kW, assume 10 kW. CAPEX includes Pre-development cost (medium scenario) in £/kW, Construction cost (medium scenario) in £/kW and Infrastructure cost. Infrastructure cost (£'000) is converted to £/kW by dividing by reference plant size (MW*1000). Rooftop PV costs do not change.
Rooftop PV	Lifetime	30	years	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Rooftop PV	Annual operational cost	7	£/kW/year	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Rooftop PV	Operational cost of production	0	kgCO2e / kWh	Default value	Renewable energy, assume operational emissions are zero.
Hydroelectricity	Energy CAPEX	3000	£ / kW	BEIS (2020) Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	No new ones being built.
Hydroelectricity	Energy efficiency	1	fraction	DESNZ, Environmental Agency and BEIS (2013) Harnessing hydroelectric power. Available at: https://www.gov.uk/guidance/harnessing-hydroelectric-power#:~:text=Hydroelectric%20energy%20uses%20proven%20and, factor%20of%2035%20to%2040%25. (Accessed 2023).	Assumed to be equal to 1, with the capacity factor dictating the amount of electricity produced.

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Technology	Setting	Value	Units	Reference	Notes
Hydroelectricity	Capacity factor	0.3605	fraction	DUKES (2023) Load factors for renewable electricity generation (6.3). Available at: https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes. Accessed 2023.	Hydro load factor for 2019.
Hydroelectricity	Lifetime	41	years	BEIS (2020) Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	
Hydroelectricity	Operational cost of production	0	kgCO2e / kWh fuel in	Default value	Renewable energy, assume operational emissions are zero.
Hydroelectricity	Operational cost of production	0.006	£ / kWh generated	BEIS (2020) Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	OPEX only variable O+M
Hydroelectricity	Opex	48.1	£/kW/year	BEIS (2020)Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	Fixed O&M
Tidal	Energy efficiency	1	fraction	n/a	Default
Tidal	Capacity factor	0.2	fraction	North Wales Tidal Energy (2024) Electricity consumption keeps rising. Available at: https://www.northwalestidalenergy.com/energy-generation (Accessed 2023).	Assumption that 4TWh per year of electricity could be generated from 2-2.5GW. This translates to a capacity factor of 0.182 - 0.228.

Technology	Setting	Value	Units	Reference	Notes
Tidal	Lifetime	120	years	Tidal Lagoon Swansea Bay plc (2014) Environmental Statement Volume 3 Appendix 5.1 Sustainability: Carbon Balance. Available at: http://www.tidallagoonpower.com/wp-content/uploads/2018/02/App-5.1-Sustainability-%E2%80%93-Carbon-Balance.pdf (Accessed 2023).	
Tidal	Energy CAPEX	3331	£ / kW	Arup experience. Available at: http://www.poyry.co.uk/sites/www.poyry.co.uk/files/tidallagoonpower_levelisedcoststudy_v7_0.pdf (Accessed 2023).	
Tidal	Opex	0.02	£ / kW	n/a	Arup experience
Anaerobic digestion	Energy CAPEX	4760	£ / kW	BEIS (2020)Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	CAPEX includes Pre-development cost (medium scenario) in £/kW, Construction cost (medium scenario) in £/kW and Infrastructure cost. Infrastructure cost (£'000) is converted to £/kW by dividing by reference plant size (MW*1000). Assumed price in 2020 is equivalent to projected 2025 price. No change across years.
Anaerobic digestion	Energy efficiency	0.4	fraction	BEIS (2020)Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	From the BEIS electricity generation costs 2020. This is the load factor multiplied by the plant efficiency to account for the fact that the plant cannot operate at full load throughout the year.

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Technology	Setting	Value	Units	Reference	Notes
Anaerobic digestion	Lifetime	20	years	BEIS (2020)Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	
Anaerobic digestion	Operational cost of production	0.07	£ / kWh generated	BEIS (2020)Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	OPEX includes Fixed O&M, Variable O&M, Fuel Costs, Decommissioning and waste, Steam Revenue, Additional Costs (all provided in £/MWh). No change across years.
Anaerobic digestion	Operational fuel consumption cost	0.00022	kgCO2e / kWh fuel in	BEIS (2022). Greenhouse gas reporting: conversion factors. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022 (Accessed 2023).	Biogas scope 1 emissions factor used.
Sewage gas	Energy CAPEX	5906.67	£ / kW	BEIS (2020)Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	CAPEX includes Pre-development cost (medium scenario) in £/kW, Construction cost (medium scenario) in £/kW and Infrastructure cost. Infrastructure cost (£'000) is converted to £/kW by dividing by reference plant size (MW*1000). Assumed price in 2020 is equivalent to projected 2025 price. No change across years.
Sewage gas	Energy efficiency	0.46	fraction	BEIS (2020)Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	From the BEIS electricity generation costs 2020. This is the load factor, which can be used as an efficiency to ensure the plant does not operate at full capacity all year.

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Technology	Setting	Value	Units	Reference	Notes
Sewage gas	Lifetime	20	years	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Sewage gas	Operational cost of production	0.014	£ / kWh generated	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Sewage gas	Opex	105	£/kW/year	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Sewage gas	Operational cost of production	0.00022	kgCO2e / kWh fuel in	BEIS (2022). Greenhouse gas reporting: conversion factors 2022. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022 (Accessed 18/03/2024).	Biogas scope 1 emissions factor used.
Biogas import	Operational cost of production	0.017	£ / kWh	IEA (2020) Outlook for biogas and biomethane: prospects for organic growth. Available at: https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth/sustainable-supply-potential-and-costs (Accessed 2023).	

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Technology	Setting	Value	Units	Reference	Notes
Biogas boiler	Annual operational cost	6	£/kW/year	Climate Change Committee (2018) Analysis of alternative UK heat decarbonisation pathways (Imperial). Available at: https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways/ (Accessed 2023).	Assumed same maintenance cost as hydrogen boiler.
Biogas boiler	Energy CAPEX	150	£ / kW	Imperial College London for CCC (2018) Analysis of alternative UK heat decarbonisation pathways. Available at: https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways. (Accessed 2023).	Assumed same cost as hydrogen boiler.
Biogas boiler	Energy efficiency	0.84	fraction	HM Government (2013) Part L Domestic Building Services Compliance Guide. Available at: https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l. (Accessed 2024).	Assuming same efficiency as a gas boiler.
Biogas boiler	Lifetime	15	years	Currie & Brown and AECOM for CCC (2019) The costs and benefits of tighter standards for new buildings. Available at: https://www.theccc.org.uk/publication/the-costs-and-benefits-of-tighter-standards-for-new-buildings-currie-brown-and-aecom/. (Accessed 2024).	Assuming same lifetime as a gas boiler.

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Technology	Setting	Value	Units	Reference	Notes
Biogas CHP	Energy efficiency	0.42	fraction	2G Energy Ltd (2024) Leading Combined Heat and Power Technology. Available at: https://www.2-g.com/en/hydrogen-chp/ (Accessed 2023).	Assume same as hydrogen CHP. Heating efficiency.
Biogas CHP	Lifetime	15	years	2G Energy Ltd (2024) Leading Combined Heat and Power Technology. Available at: https://www.2-g.com/en/hydrogen-chp/ (Accessed 2023).	Assume same as hydrogen CHP.
Biomass boiler to heat	Energy CAPEX	750	£ / kW	Biomass boilers: SPONS mechanical and electrical services	
Biomass boiler to heat	Energy efficiency	0.7	fraction	BEIS (2019) Measurement of the in-situ performance of solid biomass boilers. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/831083/Full_technical_report.pdf (Accessed 2023).	Mean gross %
Biomass boiler to heat	Lifetime	20	years	BEIS (2019) Measurement of the in-situ performance of solid biomass boilers. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/831083/Full_technical_report.pdf	
Biomass boiler to heat	Operational cost of production	0.004	£ / kWh generated	IRENA (2012) Biomass for Power Generation. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2012/RE_Technologies_Cost_Analysis-BIOMASS.pdf (Accessed 2023).	Variable OPEX from the report is stated as 0.005 USD/kWh. Adjusted for 2012 exchange rate (0.7271 GBP) and inflation from 2012 to 2022 (33%), shown to one significant figure.

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Technology	Setting	Value	Units	Reference	Notes
Biomass boiler to electricity	Energy CAPEX	3141.74	£ / kW	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	CAPEX includes Pre-development cost (medium scenario) in £/kW, Construction cost (medium scenario) in £/kW and Infrastructure cost. Infrastructure cost (£'000) is converted to £/kW by dividing by reference plant size (MW*1000).
Biomass boiler to electricity	Energy efficiency	0.29	fraction	BEIS (2020) Electricity Generation Costs.	
Biomass boiler to electricity	Lifetime	25	years	BEIS (2020) Electricity Generation Costs.	
Biomass boiler to electricity	Operational cost of production	0.009	£ / kWh generated	BEIS (2020) Electricity Generation Costs.	OPEX includes Fixed O&M, Variable O&M, Fuel Costs, Decommissioning and waste, Steam Revenue, Additional Costs (all provided in £/MWh).
Biomass boiler to electricity	Opex	96	£ / kW / year	BEIS (2020) Electricity Generation Costs.	
Biomass CHP	Operational cost of production	0.013	£ / kWh	BEIS (2020) Electricity Generation Costs.	
Biomass CHP	Energy CAPEX	5551.4	£ / kW	BEIS (2020) Electricity Generation Costs.	
Biomass CHP	Lifetime	24	years	BEIS (2020) Electricity Generation Costs.	
Biomass CHP	Annual operational cost	307	£ / kW / year	BEIS (2020) Electricity Generation Costs.	
Biomass CHP to heat	Energy efficiency	0.43	fraction	Digest of UK Energy Statistics (DUKES) (2023) combined heat and power. Available at: https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2023 (Accessed 2023).	Heat efficiency calculated using heat output and total CHP fuel use in 2022.

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Technology	Setting	Value	Units	Reference	Notes
Biomass CHP to electricity	Carrier output ratio	0.57	fraction	Digest of UK Energy Statistics (DUKES) (2023) combined heat and power. Available at: https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2023 (Accessed 2023).	The carrier output ratio indicates that 0.57 units of electricity are produced for every unit of heat produced. Calculated using the ratio of electricity generation efficiency to heat generation efficiency.
Ground PV	Operational cost of production	0	kgCO2e / kWh fuel in	Default value	Renewable energy, assume operational emissions are zero.
Heat pump	Energy CAPEX	750	£ / kW	Imperial College London for CCC (2018) Analysis of alternative UK heat decarbonisation pathways. Available at: https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways. (Accessed 2023).	Average of ASHP and GSHP. For ASHP: Annual maintenance costs for medium business +industry ASHP £2966.04 Divided by the reference size (150kW) does not change between years. For GSHP - https://core.ac.uk/download/pdf/141667173.pdf
Heat pump	Energy CAPEX	650	£ / kW	Imperial College London for CCC (2018) Analysis of alternative UK heat decarbonisation pathways. Available at: https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways. (Accessed 2023).	Average of ASHP and GSHP. For ASHP: Annual maintenance costs for medium business +industry ASHP £2966.04 Divided by the reference size (150kW) does not change between years. For GSHP - https://core.ac.uk/download/pdf/141667173.pdf
Heat pump	Energy efficiency	2.5	fraction	HM Government (2021) Defining and organising functional documentation to meet functional standards. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/606818/DECC_RHPP_161214_Final_Report_v1-13.pdf (Accessed 2023).	

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Technology	Setting	Value	Units	Reference	Notes
Heat pump	Lifetime	18	years	Currie & Brown and AECOM for CCC (2019) The costs and benefits of tighter standards for new buildings. Available at: https://www.theccc.org.uk/publication/the-costs-and-benefits-of-tighter-standards-for-new-buildings-currie-brown-and-aecom/	
Heat pump	Annual operational cost	11.18	£ / kW / year	Imperial College London for CCC (2018) Analysis of alternative UK heat decarbonisation pathways. Available at: https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways. (Accessed 2023).	Average of ASHP and GSHP. For ASHP: Annual maintenance costs for medium business +industry ASHP £2966.04 Divided by the reference size (150kW) does not change between years. For GSHP - https://core.ac.uk/download/pdf/141667173.pdf
Hydrogen boiler to heat	Annual operational cost	6	£/kW/year	Imperial College London for CCC (2018) Analysis of alternative UK heat decarbonisation pathways. Available at: https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways. (Accessed 2023).	Annual maintenance costs for residential hydrogen boiler 120. Divided by the reference size (20kw) does not change between years.
Hydrogen boiler to heat	Energy CAPEX	150	£ / kW	Imperial College London for CCC (2018) Analysis of alternative UK heat decarbonisation pathways. Available at: https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways. (Accessed 2023).	CAPEX includes unit and installation costs. Values used for residential. Does not change through the years.

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Technology parameters for future energy system scenario modelling

Technology	Setting	Value	Units	Reference	Notes
Hydrogen boiler to heat	Energy efficiency	0.84	fraction	HM Government (2013) Part L Domestic Building Services Compliance Guide. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/697525/DBSCG_secure.pdf	
Hydrogen boiler to heat	Lifetime	15	years	Currie & Brown and AECOM for CCC (2019) The costs and benefits of tighter standards for new buildings. Available at: https://www.theccc.org.uk/publication/the-costs-and-benefits-of-tighter-standards-for-new-buildings-currie-brown-and-aecom/	
Hydrogen OCGT	Energy CAPEX	345.65	£ / kW	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	OCGT 600MW 500hr. CAPEX includes Pre-development cost (medium scenario) in £/kW, Construction cost (medium scenario) in £/kW and Infrastructure cost. Infrastructure cost (£'000) is converted to £/kW by dividing by reference plant size (MW*1000).
Hydrogen OCGT	Energy efficiency	0.34	fraction	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Hydrogen OCGT	Lifetime	25	years	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Hydrogen OCGT	Operational cost of production	0.004	£ / kWh generated	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	Assuming 300MW OCGT. Variable O&M.

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Technology parameters for future energy system scenario modelling

Technology	Setting	Value	Units	Reference	Notes
Hydrogen OCGT	Opex	11	£/kW/year	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	Assuming 300MW OCGT. OPEX includes fixed O&M, insurance, connection and use of system charges.
Methane reformation	Variable opex, annual operational cost of production	0.041	£ / kWh generated	BEIS (2021) Hydrogen Production Costs 2021. Available at: https://www.gov.uk/government/publications/hydrogen-production-costs-2021 (Accessed 2023).	Levelised Cost Estimates (£/MWh H2 (HHV)) for Projects Commissioning in 2050; Wholesale Price (Central); average of total cost (not including capex and fixed opex)for all SMR and ATR technologies.
Methane reformation	Fixed opex, annual operational cost of production	0.003	£ / kWh generated	BEIS (2021) Hydrogen Production Costs 2021. Available at: https://www.gov.uk/government/publications/hydrogen-production-costs-2021 (Accessed 2023).	Levelised Cost Estimates (£/MWh H2 (HHV)) for Projects Commissioning in 2050; Wholesale Price (Central); average of the fixed opex of all SMR and ATR technologies.
Methane reformation	Energy CAPEX	500	£ / kW	BEIS (2021) Hydrogen Production Costs 2021. Available at: https://www.gov.uk/government/publications/hydrogen-production-costs-2021 (Accessed 2023).	From the "technical and cost assumptions" data, average capex (medium scenario) for all SMR and ATR technologies, £/kW H2 HHV.
Methane reformation	Lifetime	40	years	BEIS (2021) Hydrogen Production Costs 2021. Available at: https://www.gov.uk/government/publications/hydrogen-production-costs-2021 (Accessed 2023).	Operating lifetime of SMR and ATR technologies.
Methane reformation	Operational cost of production	0.0203	kgCO2e / kWh	Available at: https://www.sciencedirect.com/topics/engineering/methane-steam-reforming	We assume in 2020 no CCS.

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Technology	Setting	Value	Units	Reference	Notes
Methane reformation	Operational cost of production	0.01	kgCO2e / kWh	Timmerberg, Kaltschmitt, and Finkbeiner (2020)Hydrogen and hydrogen-derived fuels through methane decomposition of natural gas – GHG emissions and costs. Available at: https://doi.org/10.1016/j.ecmx.2020.100043 (Accessed 2023).	Assuming that our methane reformation technology is SMR with CCS. After converting units, the value to 3 significant figures is 0.013kgCO2e/kWh.
Resistance heating	Annual operational cost	0	£/kW/year	Imperial College London for CCC (2018) Analysis of alternative UK heat decarbonisation pathways. Available at: https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways. (Accessed 2023).	Annual maintenance costs for resistance heaters zero. Does not change between years.
Resistance heating	Energy CAPEX	150	£ / kW	Imperial College London for CCC (2018) Analysis of alternative UK heat decarbonisation pathways. Available at: https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways. (Accessed 2023).	CAPEX includes unit and installation costs. Values used for Residential. Does not change through the years.
Resistance heating	Energy efficiency	1	fraction	National Renewable Energy Laboratory (1997) Saving Energy with Electric Resistance Heating. Available at: https://www.nrel.gov/docs/legosti/fy97/6987.pdf	All incoming electricicty is converted to heat by resistance heaters.
Resistance heating	Lifetime	20	years	Indeeco (2017) Heater life expectancy. Available at: https://indeeco.com/news/2017/06/20/heater-life-expectancy/. (Accessed 2024)	Assuming that the life expectancy of a resistance heater is dictated by the lifetime of the heating element.

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Technology parameters for future energy system scenario modelling

Technology	Setting	Value	Units	Reference	Notes
National grid import	Lifetime	1	years	n/a	Set to have no impact.
National grid import	Operational cost of production	0.063	£ / kWh	BEIS (2020) Updated energy and emissions projections 2019, Annex M. Available at: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2019 (Accessed 2023).	Annex M
National grid import	Operational fuel consumption cost	0	kgCO2e / kWh	Assume 0 emissions in 2050 as Welsh government has committed to net zero by 2050.	
National grid export	Lifetime	1	years	n/a	Selected to have no effect
National grid export	Operational cost of production	-0.063	£ / kWh	BEIS (2020) Updated energy and emissions projections 2019, Annex M. Available at: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2019 (Accessed 2023).	Annex M
National grid export	Operational fuel consumption cost	0	kgCO2e / kWh	n/a	Export set to zero carbon because export is when there are excess renewables
Electricity distribution lines (grid level)	Energy CAPEX	625.54	£/kW	NGED charging statements - CDCM model for South Wales (2021)	Assuming grid level electricity distribution lines correspond to 132kW network level assets, which have a cost of 13.9 £/kW/year. Multiplying by the asset lifetime of 45 years gives an energy CAPEX of 625.54.

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Technology parameters for future energy system scenario modelling

Technology	Setting	Value	Units	Reference	Notes
Electricity distribution lines (primary substation level)	Energy CAPEX	0	£/kW	n/a	Assuming that the cost of the distribution lines are free, as they have already been built. The costs of new lines to be built in the future will be associated with substation upgrades.
Primary substation upgrades	Energy CAPEX	165.15	£ / kW	NGED charging statements - CDCM model for South Wales (2022) Available at: https://www.nationalgrid.co.uk/our-network/use-of-system-charges/charging-statements-and-methodology (Accessed 2023).	The cost of 132kV/HV network level assets in 2022 was 3.68 £/kW/year. Multiplying by the asset lifetime of 45 years gives an energy CAPEX for primary substation upgrades of 165.15 £/kW.
Battery	Annual operational cost	3	£ / kW/ year	Mott MacDonald for BEIS (2018) Storage cost and technical assumptions for BEIS. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/910261/storage-costs-technical-assumptions-2018.pdf 50MW Frequency Management battery	
Battery	Storage CAPEX	186.42	£ / kWh	Cole, Wesley and Akash Karmakar.(2023) Cost Projections for Utility-Scale Battery Storage: 2023 Update. Golden, CO: National Renewable Energy Laboratory. Available at: NREL/TP-6A40-85332 https://www.nrel.gov/docs/fy23osti/85332.pdf (Accessed 2023).	Converted from USD to GBP 01.03.22

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Technology parameters for future energy system scenario modelling

Technology	**Setting**	**Value**	**Units**	**Reference**	**Notes**
Battery	Energy efficiency	0.92	fraction	Cole, Wesley and Akash Karmakar.(2023) Cost Projections for Utility-Scale Battery Storage: 2023 Update. Golden, CO: National Renewable Energy Laboratory. Available at: NREL/TP-6A40-85332 https://www.nrel.gov/docs/fy23osti/85332.pdf (Accessed 2023).	Changed energy efficiency to 0.92 this means a round trip efficiency of 0.85
Battery	Lifetime	15	years	Cole, Wesley and Akash Karmakar. 2023. Cost Projections for Utility-Scale Battery Storage: 2023 Update. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-85332. Available at: https://www.nrel.gov/docs/fy23osti/85332.pdf	
EV chargers	Energy CAPEX	817	£ / kW	Michael Nicholas (2019) Estimating electric vehicle charging infrastructure costs across major U.S.metropolitan areas. Available at: https://theicct.org/sites/default/files/publications/ICCT_EV_Charging_Cost_20190813.pdf (Accessed 2023). Calculations: https://arup.sharepoint.com/:x:/t/prj-28041700/EZof4JF_CH5HngEuZKZWJ5gBSDd8irdD4zCUWBIbznK54A?e=vjQttT	Networked 50 kW Rapid DC charger - Capex includes hardware, labour and materials (3-5 chargers per location)
EV chargers	Energy efficiency	1	fraction	n/a	Selected to have no effect

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Technology parameters for future energy system scenario modelling

Technology	Setting	Value	Units	Reference	Notes
EV chargers	Lifetime	12	years	Deloitte (2019) UK EV charging infrastructure update (part 2): Show me the money. Available at: https://www2.deloitte.com/uk/en/pages/energy-and-resources/articles/uk-ev-charging-infrastructure-update-show-me-the-money.html (Accessed 2023).	
Landfill gas	Energy CAPEX	2740	£ / kW	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Landfill gas	Variable OPEX	0.01	£/kWh	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Landfill gas	Fixed OPEX	95	£/kW/year	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Landfill gas	Carbon OPEX	0.18387	kgCO2e/kWh	BEIS (2020). Greenhouse gas reporting: conversion factors 2020. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022 (Accessed 2024).	Assumed same as natural gas
Landfill gas	Energy efficiency	0.58	fraction	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	
Landfill gas	Lifetime	28	years	BEIS (2020) BEIS Electricity Generation Costs (2020). Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020	

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Technology parameters for future energy system scenario modelling

Technology	Setting	Value	Units	Reference	Notes
Energy from Waste	Energy efficiency	0.28	fraction	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (accessed 2023).	
Energy from Waste	Lifetime	35	years	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (accessed 2023).	
Energy from Waste	Energy CAPEX	8806.666667	£ / kW	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (accessed 2023).`	CAPEX includes pre-development cost (medium scenario) in Â£/kW, construction cost (medium scenario) in Â£/kW and infrastructure cost. Infrastructure cost (Â£'000) is converted to Â£/kW by dividing by reference plant size (MW*1000).
Energy from Waste	Carbon OPEX	0.038	kgCO2e / kWh	DESNZ (2023) Greenhouse gas reporting: conversion factors 2023, and Tolvik (2021) UK Energy from Waste Statistics. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023 and https://www.tolvik.com/published-reports/view/uk-energy-from-waste-statistics-2021/ (accessed 2024).	The DESNZ data provides a refuse combustion conversion factor of 21.280kgCO2e/tonne. Average energy from waste export electricity per tonne fuel input averaged over 2017-2021 is found at 558.4kWh/tonne (Tolvik, Figure 10). This results in a carbon OPEX of 21.280/558.4 = 0.0381kgCO2e/kWh.

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Technology parameters for future energy system scenario modelling

Technology	Setting	Value	Units	Reference	Notes
Heat storage	Energy efficiency	0.95	fraction	Arup expertise	
Heat storage	Storage loss	0.018164	fraction	Arup expertise	
Heat storage	Storage CAPEX	29	£ / kW	Arup expertise	
Heat storage	Lifetime	30	years	Arup expertise	
Canopy PV	Energy CAPEX	1100	£ / kW	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	Solar PV 4-10 kW, assume 10 kW. CAPEX includes Pre-development cost (medium scenario) in £/kW, Construction cost (medium scenario) in £/kW and Infrastructure cost. Infrastructure cost (£'000) is converted to £/kW by dividing by reference plant size (MW*1000). Rooftop PV costs do not change.
Canopy PV	Annual operational cost	7	£/kW/year	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	
Canopy PV	Lifetime	30	years	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	

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Technology parameters for future energy system scenario modelling

Technology	Setting	Value	Units	Reference	Notes
Pumped storage	Lifetime	41	years	BEIS (2020) BEIS Electricity Generation Costs. Available at: https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020 (Accessed 2023).	Assumed Lifetime of pumped storage the same as hydropower.
Pumped storage	Energy efficiency	0.75	fraction	Mott MacDonald for BEIS (2018) Storage cost and technical assumptions for BEIS. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/910261/storage-costs-technical-assumptions-2018.pdf 50MW Frequency Management battery (Accessed 2023).	Round Trip Efficiency value used.
Pumped storage	Energy CAPEX	1362.9	£ / kW	Mott MacDonald for BEIS (2018) Storage cost and technical assumptions for BEIS. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/910261/storage-costs-technical-assumptions-2018.pdf Connected peak lopping, 200MW (Accessed 2023).	CAPEX includes infrastructure costs, design costs, capital costs and installation costs. Medium value.
Pumped storage	Annual operational cost	17.8	£/kW/year	Mott MacDonald for BEIS (2018) Storage cost and technical assumptions for BEIS. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/910261/storage-costs-technical-assumptions-2018.pdf Connected peak lopping, 200MW (Accessed 2023).	OPEX includes Operation, Inspection, Maintenance, Replenishment / refurbishment of consumables, Insurance, Security. Medium Value.

Appendix B8
Air quality – method, assumptions, and data sources

Calculation Method (all fuels other than electricity)

We used the Green Book supplementary guidance for air quality (AQ) activity costs from primary fuel use and the transport sector [1] to estimate the air quality cost for each year (2030 to 2050) for each scenario per the following calculation method.

For each scenario and fuel (other than electricity), and in each year 2030 – 2050:

$$AQ\ activity\ cost\ (£) = fuel\ (kWh)\ *\ fuel\ AQ\ activity\ cost\ \left(\frac{p}{kWh}\right)\ *\ \frac{1\ £}{100\ p}$$

For electricity only, for each scenario and in each year 2030 – 2050:

$$AQ\ activity\ cost\ (£) = \ \ annual\ electricity\ (kWh)\ *\ electricity\ AQ\ activity\ cost\ \left(\frac{p}{kWh}\right)\ *\ \frac{1\ £}{100\ p}$$

where

- Fuel (kWh) and annual electricity (kWh) were calculated in the deployment model.
- Fuel AQ activity costs (p/kWh) were from the Green Book guidance [1]. Refer to the remainder of this appendix for further assumptions. Electricity was the only "fuel" where the activity cost was allowed to vary each year between 2023 and 2050, reflecting the changing nature of the electricity grid.

For each scenario and year, the air quality impacts from each fuel then were summed to derive a total impact per year.

Appendix B8
Air quality – method, assumptions, and data sources

Primary Fuel Use

Electricity was the only “fuel” which was allowed to vary each year between 2023 and 2050, reflecting the changing nature of the electricity grid. We used the air quality values from the National Average scenario in Table 15 of the Green Book supplementary guidance [1]. These are documented in Table B9.1 below for reference.

All other primary fuels used the same activity cost for each year in 2023-2050, again reflecting the pattern shown in Table 15 of the Green Book supplementary guidance [1]. We used the activity costs shown in Table B9.2 below, each documented along with any relevant assumptions.

Table B9.1. Air quality activity costs from primary fuel use, 2022 p/kWh – Electricity [1]

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Electricity	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00

Table B9.2. Air quality activity costs from primary fuel use, 2022 p/kWh – Non-electric primary fuels

Fuel	Air quality cost (2022 p/kWh)	Data source(s) and assumptions
Natural gas	0.16	[1] Data Table 15 *Air quality activity costs from primary fuel use*, National Average (p/kWh) for gas.
Landfill gas	0.16	Assume the air quality impacts are similar to natural gas.
Organic matter	0.16	
Sewage gas	0.16	
Hydrogen	0.16	
Biomass	4.70	[1] Data Table 15 *Air quality activity costs from primary fuel use*, National Average (p/kWh) for biomass
Coal	3.74	[1] Data Table 15 *Air quality activity costs from primary fuel use*, National Average (p/kWh) for coal
Oil/LPG	1.25	[1] Data Table 15 *Air quality activity costs from primary fuel use*, average of the National Average (p/kWh) for burning oil (2.28 p/kWh) and LPG (0.22 p/kWh)

Appendix B8

Air quality – method, assumptions, and data sources

Transport Sector

We calculated activity costs from the transport sector (diesel and petrol) per the following procedure:

1. Estimating the proportion of diesel vs petrol vehicle using licensing data. The figures in Tables B9.3 and B9.4 below reflect 2019 Q4 data in the UK [2].
2. Taking the air quality activity cost (p/litre) for each vehicle type from the Green Book supplementary guidance, Table 14, Transport Average. The values for rigid HGV diesel (6.35 p/litre) and articulated HGV diesel (2.22 p/litre) were averaged to derive the value for HGV diesel in Table B9.3 below.
3. Calculating a weighted average air quality factor (p/litre) for each fuel type, weighted by the proportion of vehicles.
4. Converting this to air quality factors in p/kWh using:
    - The GHG intensity of each fuel by volume [3]
        - Diesel, average biofuel blend: 2.48 kgCO_2e / litre
        - Petrol, average biofuel blend: 2.08 kgCO_2e / litre
    - The GHG emission factor for each fuel (kgCO2e/kWh), documented in the deployment model Appendix B2

Table B9.3. Air quality activity costs transport (diesel)

Vehicle type	Quantity [2]	Air quality activity cost (p/litre) [1]
Car diesel	687,916	13.02
HGV diesel	22,360	4.29
LGV diesel	214,969	17.15
Air quality factor, weighted average by fuel (p/litre)		13.77
Air quality factor, converted to p/kWh		1.33

Table B9.4. Air quality activity costs transport (petrol)

Vehicle type	Quantity [2]	Air quality activity cost (p/litre) [1]
Car petrol	876,250	1.58
LGV petrol	6,167	1.28
Air quality factor, weight average by fuel (p/litre)		1.57
Air quality factor, converted to p/kWh		0.17

Appendix B8
Air quality – method, assumptions, and data sources

References

[1] Department for Energy Security and Net Zero (2023) Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal. Available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

[2] Department for Transport and Driver and Vehicle Licensing Agency (2023) vehicle licensing statistics data tables. Available at: https://www.gov.uk/government/statistical-data-sets/vehicle-licensing-statistics-data-tables

[3] Department for Energy Security and Net Zero (2023) Greenhouse gas reporting: conversion factors 2023. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023.

The committee has chosen to focus in this report on surface water flooding. Flintshire also faces issues with fluvial and coastal flooding, and these areas deserve full exploration in future work by the committee and council. The issue of surface water flooding impacts every part of the county, and as such is of broad interest. In order to give a focus to its work, the committee has chosen to use the Sandycroft, Pentre and Mancot area as a case study, as this area's issues are broadly applicable to other areas. It has almost every type of problem that the committee has received reports of from elsewhere.

The committee's starting point is the strong evidence that climate change means extreme weather will happen more frequently in Flintshire, and that when it does occur, it will be increasingly severe. Approaching this through the narrow perspective of surface water flooding, the consequence of this will be that the limits of drainage systems will be exceeded more often, and more severely, in the future. There is evidence that this effect is already being felt, with flooding of homes in parts of the county now a regular occurrence where previously this was not the case.

If drainage systems are already failing catastrophically, by which we mean homes are being flooded, then there is a clear need to improve those systems. The committee has received evidence as to the cause of those failures in cases across Flintshire.

It is important to be clear at the outset what the consequences of the current situation are. There are few events more traumatic than the flooding of a home. What we are talking about is sewer water entering every part of homes, destroying treasured possessions, and seeping into the very fabric of the building. There is the horror of seeing faeces in the kitchen. There are huge costs associated with remedial work, as all furniture is removed, often replastering and rewiring is required, and during this time, being forced into living in a hotel at further expense and without basic conveniences like the ability to cook. Entire lives are turned upside down for months, and at the end of it, every time there's heavy rain outside the fear of going through it again rises and the stress comes back.

This situation cannot be allowed to continue. One consistent message the committee has heard throughout this inquiry is that the levels of funding devoted to tackling this problem is not adequate, and that this is in no small part a result of sizable cuts to this work as a result of austerity. The committee wishes to put on record its firm view that this is simply not acceptable. The horrors of flooding mean that this must be considered a priority - and the architects of the austerity and cuts which have got us to this position must reckon with the fact that they have caused this.

Poor / Reduced Maintenance

One cause highlighted to the committee is a lack of maintenance on systems. This heading covers a broad range of problems. No witnesses have disagreed that maintenance is, to a greater or lesser extent, lacking.

In some parts of the county, drainage systems have become blocked or partially blocked, reducing their capacity. The committee has heard evidence that the Pentre Drain, in Sandycroft, suffered a significant build-up of silt which has been partially cleared by Flintshire County Council. This culvert is under the regulatory control of Natural Resources

Wales, who have scheduled more work to clear the build-up along the length of the Pentre Drain.

On a smaller scale, clearance of highway drainage was raised at the oral evidence session. It has been suggested that the council should invest in clearing highway drainage more frequently. All members of the committee are familiar with examples of blocked drains in the county which have not received attention for long periods after they have been reported. Concerns have been raised that drain clearance capacity has been scaled back as a result of austerity measures, and that this has had a detrimental impact.

Besides buildup of silt and debris, a related issue is root ingress, culvert collapses, and more serious damage which can be considered under the broad umbrella of maintenance. The committee has again received evidence that a culvert running into the Pentre Drain has been damaged by severe root ingress, which is blocking the flow of water through the system. In an ideal world, this would be observed and monitored, particularly in high risk areas known to suffer surface water flooding, at a much earlier stage. The committee understands that this was detected after severe flooding from Storm Christoph, and that Natural Resources Wales has sought to repair the damage, however we are concerned at the length of time this has taken.

There are other examples of potential culvert collapses as a result of ancient pipework that have been brought to the committee's attention. In some areas, such as Dobshill, there has already been flooding. In any event, detecting these is difficult as there are no maps of buried drains for the vast majority of systems in the county, leaving camera surveys as the only viable means of identifying problems in most cases. These are expensive and time consuming.

It is clear to the committee that routine maintenance has not been as frequent or comprehensive as would have ideally been the case over the last ten to fifteen years. This is in large part due to the significant budget pressure that the relevant public sector bodies have been under as a result of austerity measures. Necessarily, limited resources have been dedicated to dealing with the most urgent, obvious and catastrophic cases, however this has allowed the build-up of issues and an increase in the number of such cases.

There is also a serious lack of maintenance by landowners of ditches on their land. This has in particular affected low-lying areas of the county around Broughton and Bretton. Responsibility for this rests with landowners, however where landowners have not cleared ditches adequately, there has been limited enforcement from statutory bodies, owing to a combination of limited enforcement powers, and limited resources to carry out inspections.

Added Pressure From Development

The committee has heard evidence that new developments have placed additional pressure on existing drainage systems. This has been the cause of a degree of disagreement between witnesses and the committee.

Least controversially, in the historical context there is evidence that this has been the case. The tightening of regulations relating to sewerage and drainage in recent years has not come about without good reason. Developments have been given permission to connect to combined sewers in the not too distant past where the same development, in the same location, would not be given that permission under today's rules. While permissible at the time, this has caused problems for residents by increasing the baseline level of sewage and surface water runoff in old systems, and therefore limiting excess capacity to deal with stormwater. The effect of this is most intensely felt downhill from the developments themselves, with the problem exported to lower-lying areas. In the case-study area, development up the hill in Mancot and Hawarden over the last 50 years has significantly increased pressure on the Pentre drain, causing problems in Sandycroft.

In the present context, the evidence and views the committee has received are more mixed. The sustainable drainage solutions (SuDS) requirements are generally accepted as an improvement on what came before. Whether they are adequate is more controversial.

The committee feels that it helps to consider SuDS from two related perspectives. Firstly, whether the rules themselves are adequate, and secondly, the extent to which the requirements are implemented in practice.

One witness, Cllr Sam Swash, was clear in his belief that SuDS is not adequate to the task of preventing increased run-off from new developments. He expressed particular concern that a proposed site in the LDP in his ward, known as the Ash Lane site, would add to the issues faced by residents at the bottom of the hill in Mancot, Pentre and Sandycroft.

Officers from Flintshire County Council did not agree with this assessment. Their perspective was that it is possible to design schemes which reduce flow, especially peak flow, into drainage systems and that SuDS compliant schemes genuinely achieve this, notwithstanding the viability of implementing SuDS schemes in clay-based catchments. This view was most strongly advanced by Mr Andy Roberts.

The committee agrees with Mr Roberts that it is possible in theory to design schemes which represent at least no detriment, and possible improvement, compared with the status quo. We do not doubt that Cllr Swash also would agree on this point. The question is whether SuDS, which aims to represent that standard, does so in practice or not. On this point, the committee does not have adequate technical expertise to form a view. However, we do feel that this is a vital issue which is deeply consequential to resolving the problem of surface water flooding. We would point out that hindsight has shown us that what we once considered adequate in planning applications was, in fact, not. Equally, we are loath to criticise SuDS when we have no firm evidence that it is not that adequate standard.

The committee notes that the Welsh Government commissioned a report from Arup on the implementation of the SuDS rules, which was published in 2023. In particular, section 8.2 of this report touches on this question. The committee is interested that the sole statutory, and almost a third (6 out of 19 responding) of SuDS approval bodies felt that the rules do not do enough to protect downstream networks in terms of surface water runoff[1], with one

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[1] p57-58, Ove Arup & Partners Limited (2023) *Sustainable Drainage Systems (SuDS) Schedule 3 Post Implementation Review*. 287773-ARP-00-00-RP-ZX-0001. Welsh Government. https://www.gov.wales/sites/default/files/publications/2023-07/sustainable-drainage-systems-suds-schedule-3-post-implementation-review.pdf (Accessed: October 10, 2024).

recommendation from a dissenting respondent being to add a requirement to demonstrate that the receiving system can accommodate proposed flows. This report, while relevant, is primarily focussed on the SuDS procedure rather than an analysis of comparative outcomes for flooding and drainage had SuDS not been implemented, and we recommend that the Welsh Government commissions such a comparative analysis to better understand the impact SuDS has on downstream systems. Such a report would address the disagreement in views this committee heard.

On the issue of compliance with submitted schemes, the committee can understand the position expressed by Cllr Swash and to a lesser extent the other elected representatives who attended the oral evidence session on this point. Their argument is that, regardless of the merits of SuDS schemes, if they are not constructed to plan then they do not work. The committee is readily prepared to believe that this has been the case on some developments. This raises the question of resourcing for inspections of SuDS schemes upon completion. Given the potential long term damage a scheme which has not been completed to plans can do, the committee recommends that thorough inspections are vital and should be a funding priority for the council.

Run-off from land to adjoining properties

Large parts of Flintshire have clay rich soil, and there are significant parts of the county which are susceptible to significant amounts of run-off during wet periods, according to data from the UK Soil Observatory[2]. Traditionally, this has been carried away by drainage ditches at the side of fields. The committee has heard reports that a number of these have been poorly maintained over a number of years, becoming blocked and levelled out, reducing their capacity to withhold run-off from adjoining property. This is an issue across the county, but has been a particular problem in Broughton and Bretton.

In addition to this, historic drainage ditches are often inadequate to cope with the levels of rainfall in short periods of time that we have seen more frequently in recent years. This is especially the case when storms have occurred after the ground is already saturated by long periods of rain. Where drainage ditches are operating well, there is the further question of where they drain to. In some cases, they convey run-off into combined sewers or streams which are later culverted, adding to flood risk in populated areas.

Besides run-off from agricultural land, surface water from residential properties in a number of older developments enters combined sewers. This can be via run-off to the highway, and entering into highway drainage channels, and ultimately causing flooding downstream, or cna be through direct connections from within the property to combined sewers. Replacing these connections with soakaways could, in some parts of the county, make a significant positive difference to flood levels if done at scale.

Infrastructure Capacity

It is a simple fact that large parts of the drainage networks in the county are both old and ramshackle - by which we mean they have been added to, partially replaced, culverted and so on without any coherent plan. In some areas, this means that culverts laid a long time ago are unable to take the volume of water now put into them. In some cases, it means that

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[2] https://mapapps2.bgs.ac.uk/ukso/home.html

where two pipes meet, the combined bore of the joining pipes is narrower than the one they merge into. In some areas, sections of culvert have been replaced with a narrower bore pipe than those on either side. The committee has heard how surface water which drains into the Dee at some locations cannot do so at high tide, causing backing up of the system.

This is the norm across the UK, and there is no easy means to address it. The problem is systemic, and so changes made to one part can serve only to transfer, rather than fix, the problem. This is complicated further by the lack of any comprehensive map of the networks, giving indications as to the type and size of channels carrying drainage and sewage.

Chief amongst the infrastructure problems is that sewage and storm water combine in the same channel throughout most of the county, meaning flood water contains excrement.

Carrying out significant works is also costly and disruptive. Where replacement work is carried out, in the best case scenario this involves digging up roads or open space, however many of the lines in question pass under people’s homes or gardens. The capital costs of making improvements across the county are orders of magnitude bigger than the capital budgets of any of the agencies involved.

Within the area of the case study, the committee has sought assurance that the Pentre Drain, if running at full capacity, is adequate to handle one in fifty year storms. Witnesses have been unable to provide any such assurance.

Who is Responsible?

There are three main agencies involved: Natural Resources Wales, Welsh Water, and Flintshire County Council.

The committee wishes to put on record that the staff of all three of these agencies have behaved in an exemplary fashion in addressing these issues. Their assistance with this inquiry has been invaluable, and they continue to work to solve the problems that cause flooding as best they can. However, it is clear that they face considerable constraints in doing so - principally financial, but also in terms of recruitment and retention of staff.

While Welsh Water is funded by customers, its ability to determine its level of investment is constrained by the regulatory environment in which it operates. The committee firmly believes that the company’s not for profit model, without shareholders, is of huge benefit compared with the rest of the water industry. However, as Ofwat benchmarks against the market as a whole, the failure of other providers to adequately invest in their systems indirectly impacts Welsh Water as well, and limits the ability to undertake the kind of capital works the committee might wish to see.

Natural Resources Wales is wholly dependent on the Welsh Government for investment. It is in constant competition with other services, including the health service, for funding. With the services it provides not being seen as politically advantageous to promote investment into (while individual schemes may be politically advantageous, providing general Wales-wide capital budgets to NRW is not seen as a vote-winner), the only way further investment is likely is if the public sector as a whole is better funded, or if the political cost of not doing so increases.

Flintshire County Council is in a different position. While the vast majority of its budget comes from the Welsh Government, it does have tax-raising powers through council tax and does have borrowing powers. The council could make a political decision to increase investment in drainage in the county. However, this would be costly and may be subject to local resistance.

Beyond these three organisations that are directly responsible for most drains, there are wider opportunities and responsibilities which could make a significant difference to the problems. Riparian owners of watercourses can take responsibility for sections of drains within the curtilage of their property. Even basic steps such as being aware of where culverts lie and preventing root ingress by removing plants which threaten them can make a positive difference. Diverting water from drains, at scale across communities, offers the highest degree of effectiveness relative to cost. Digging soakaways instead of sewer connections, or adding water butts on downspouts to hold stormwater back until after the immediate risk of flooding has passed offer significant reductions in the amount of floodwater at impacted sites downstream. The committee feels that there is a role for community councils in promoting uptake of these schemes, and, where appropriate, offering grant funding to implement them.

There is a wider role for community councils in response to flooding as well. The committee heard of good practice from Sandycroft, where the community council is co-ordinating volunteer flood wardens, as well as maintaining a stock of sand to make up sandbags -

something which the committee heard Hawarden Community Council also does. Flintshire's strategy for flood response is at best confused. The council outwardly says it will not provide sandbags to protect individual dwellings from flooding, as it cannot prioritise delivery of these during severe weather, but the committee is aware of examples where sandbags have been provided for this purpose by the council. This inconsistent approach is unacceptable - it results in sandbags being given out on a postcode lottery basis, with properties at greatest risk left unprotected while others are given sandbags and yet prove not to be affected, and there have been allegations made of favouritism playing a part in these decisions. The committee believes that the council should agree a policy and stick to it in respect of sandbags.

There are also issues regarding Flintshire County Council's response in respect of road closures where flooding has occurred. When vehicles continue to drive along flooded roads, they create bow waves which can overtop defences and push flood water into homes that would otherwise be unaffected.

Within the Sandycroft area, there is now a much greater degree of partnership working between agencies than was previously the case. This has sadly not extended more broadly, and the committee is concerned by cases where residents have been passed from pillar to post, with the council, Natural Resources Wales, Welsh Water or landowners each saying that problems are the fault of one of the others. This merry-go-round of responsibility is deeply unhelpful at the best of times, and especially when flood waters are rising and action is required. The committee recognises that the complexity of systems means it can be difficult at times to demarcate between who is responsible for what, and that there can be legitimate confusion. However, this is an issue that needs to be addressed. In Sandycroft, this has happened, not least thanks to the involvement of the local member of parliament, Mark Tami, and the close working relationships that have been formed should be extended more broadly to cover the whole county.

The committee has been struck throughout its inquiry that the barrier to more serious action is the funding available to implement it. There is no shortage of solutions, and officers at Flintshire County Council and Natural Resources Wales both had clear visions for how flooding at key points can be seriously reduced, and ideally, eliminated entirely. The problem is that there is no funding to make this a reality.

Throughout the last fifteen years, the blockage in the funding pipeline has been at Westminster. The UK Government has introduced a programme of austerity which has impacted the whole public sector, but has had a disproportionate impact on those parts of the state which are generally hidden from public view. The same has applied in Wales, where the lack of ability to meaningfully differ from Westminster's spending levels has seen the axe wielded at both Natural Resources Wales and at local government. For as long as UK Governments fail to invest in our crumbling infrastructure, there will be no meaningful improvement, and the committee believes the situation will get considerably worse.

The committee has solicited views on whether council tax, the only real alternative lever to UK Government funding, could be used to tackle this issue. This would be a controversial step with some residents - those who are not affected by flooding are likely to oppose rises on the scale needed to deal comprehensively with the issues, a very small percentage of properties within Flintshire are subject to flooding in any given year, and taking local initiative to fix the problems will prevent the council accessing funding that may become available in future. Nonetheless, the level of devastation that being flooded out can bring, and the increasing number of people liable to be impacted by this, mean this option deserves serious exploration.

The committee would expect resistance to this suggestion from some quarters. However, we were struck by the opposition from those affected to this idea. The view from Cllr Dee Milner, who represents flooded residents in Sandycroft and has been flooded herself, was unequivocal that council tax is not a fair way to meet the cost of the required work. This was echoed by other witnesses from affected communities. The strong feeling was that those with the broadest shoulders should bear this burden, and that it should be met by less regressive forms of taxation at a UK-wide level. On the basis of the views received, the committee does not advocate that hypothecated increases in council tax should be used to meet the costs of drainage improvements.

The committee does not, however, believe that this opposition to council tax rises precludes any use of local government resources to tackle the issue. There are particular areas of expenditure which the committee feels have not been accorded appropriate priority within the council, relative to other expenditure, and we call for a reallocation of resources to some services.

Recommendations
Having considered the matter carefully, the committee wishes to make a number of recommendations. We have divided these into two classes: those which we believe should be implemented immediately, and those which we recognise will require more funding than is presently available, but which we believe should be considered when greater resources become available.

Immediate Recommendations:

1. The Welsh Government should commission a comparative analysis of the effect of SuDS on downstream drainage systems, looking at the extent to which SuDS has or hasn't reduced the impact of new development on drainage systems compared with the previous system, and compared with not developing sites.

2. Flintshire County Council should prioritise inspections of new developments for which a drainage scheme has been submitted to the SAB for compliance with the submitted scheme. This should include inspections while development is underway to ensure that buried channels are built in the approved locations and to the approved standard.

3. Flintshire County Council should consider maintenance of gullies to be a higher priority in budget setting. A programme of more intensive maintenance in known flood risk areas should be commenced prior to Winter 2025.

4. The Welsh Government should acknowledge that cuts to Natural Resources Wales' budget have been a false economy, and the maintenance backlog is having a severe impact. The Welsh Government should appropriately resource Natural Resources Wales to eliminate this backlog.

5. Community councils across Flintshire should produce local flood plans. These should be in two sections, and consider flood prevention measures the community council can take, or encourage residents to take, and flood response actions, which should include preparation for flooding, such as circulating flood alerts, and whether the community council will provide emergency responses such as sandbags.

6. Flintshire County Council should continue efforts to develop a comprehensive map of drainage systems in the county. The council should make clear that any unmapped services encountered during street works by any agency should be reported, and the council should ensure that these are passed through to the flooding and drainage team.

7. Flintshire County Council, Natural Resources Wales, and Welsh Water should take steps to work more closely together and avoid situations where residents are passed from one to the other. The Welsh Government should give consideration to whether budgets for flooding and drainage works should be pooled between agencies to help prevent such situations.

8. Flintshire County Council, Natural Resources Wales, and Welsh Water should be much clearer about known issues within their systems - for example, where combined sewers merge into a pipe of smaller bore than the combined bore of the merging sewers, or where root ingress has blocked or collapsed drains. This would allow funding of improvements to be more easily discussed.

9. Flintshire County Council should better use sources of local intelligence, especially elected members and community councils, to identify what problems may exist across the county. Local members are likely to receive information from other agencies on the ground, which may not reach council officers through more formal channels.

10. Flintshire County Council's planning department should be bolder in including drainage improvements in the council's internal capital bidding process. Elected members should take a more active role in prioritising and refining capital bids than is presently the case. Scrutiny committees should be asked to order capital bids from their subject areas by priority each year to assist the finance department in paring down the list to the level of funding available.

11. Flintshire County Council should more actively promote clearance and maintenance of ditches than at present. Inspection of drainage ditches should be a regularly scheduled task of Streetscene area coordinators as is already the case with inspection of street lighting columns. The council and Natural Resources Wales should work more energetically to require that work is undertaken by private landowners where necessary.

12. The UK Government should make funding available for larger scale flooding and drainage improvements, resulting in Barnett consequentials for Wales, which should be fully passported to Welsh flooding and drainage improvements.

13. Ofwat should give careful consideration to resourcing in water companies' plans for work to improve, rather than merely maintain, sewerage, and in particular to separate out drainage from sewage.

Long term recommendations:

14. Flintshire County Council, Natural Resources Wales, and Welsh Water should agree a joint plan for upgrading outflows into the Dee, providing pumping stations where appropriate and making such other improvements as may be necessary. This plan should include a ranked list of priorities for upgrades, and funding should be pooled by the agencies to deliver the most vital schemes first.

15. Where main drains are struggling to cope with levels of water in them, these should be upgraded. In particular, the committee recommends that the Pentre Drain should be assessed for residual capacity and considered for a significant upgrade.

16. Work should be undertaken in high risk areas to separate sewers and drainage, as already has happened through some SuDS schemes, in addition to and outside future SuDS development applications.

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Climate Change Committee Forward Work Programme 2024/25

Date of Meeting	Subject	Purpose of Report/Presentation	Responsible/Contact Officer	Submission Deadline
6th Sept 2024	Climate Change Programme Progress Report	To receive an update on progress within the climate change programme, and identified areas of focus for the coming year.	Programme Manager Climate Change	
	Climate Risk – extreme heat	To receive a report on the impacts of extreme heat and recommend that further work be carried out to ensure the risks to Council services and communities are considered and where possible mitigated.	Cabinet Member Climate Change / Programme Manager Climate Change	
26th Nov 2024	Decarbonisation of supply chain	An update on the work of the Procurement Business Partner - Decarbonisation	Programme Manager Climate Change	
	Local Area Energy Plan Flintshire	To recommend endorsement of the final Local Area Energy Plan for Flintshire	Programme Manager Climate Change	
8th Jan 2025	Financing the Climate Change Programme	How have projects been funded to date, and how can future projects be funded?	Programme Manager Climate Change	
	Council's Carbon Footprint 2023-24	Report on the Council's Carbon Footprint for 2023-24, areas of success and areas for focus.	Programme Manager Climate Change	
	Strategy Review progress	An update on the strategy review process, messaging and trends from internal and external engagement, and direction of travel.	Programme Manager Climate Change	
	Feasibility of leasing car park spaces to third party companies for vehicle charging	Feasibility of leasing car park spaces to third party companies so that they may install electric car charging points at strategic places within the County (CCM3)	Chief Officer – Streetscene & Transportation	
	Use of Bio-diesel for fleet	Feasibility of the use of biodiesel for fleet. How	Chief Officer –	

		is FCC currently supplied with diesel for its fleet and whether either bio-diesel or HVO biodiesel could be supplied and used instead, and the potential provision of fuel to employees/members (CCM2, CCM5, CCM6).	Streetscene & Transportation	
26th March 25	Feasibility of utilisation of Mine Water Heat Embedding carbon within decision making	A report in response to the Coal Authority report, identifying areas within Flintshire with potential for harnessing heat from mine water. Update report on climate change training attendance and Carbon Literacy pledges, scoping of Council strategies and policies, and other works to key planning documents including Integrated Impact Assessments and Capital Business Case template.	Programme Manager Climate Change Programme Manager Climate Change	
24th June 25				