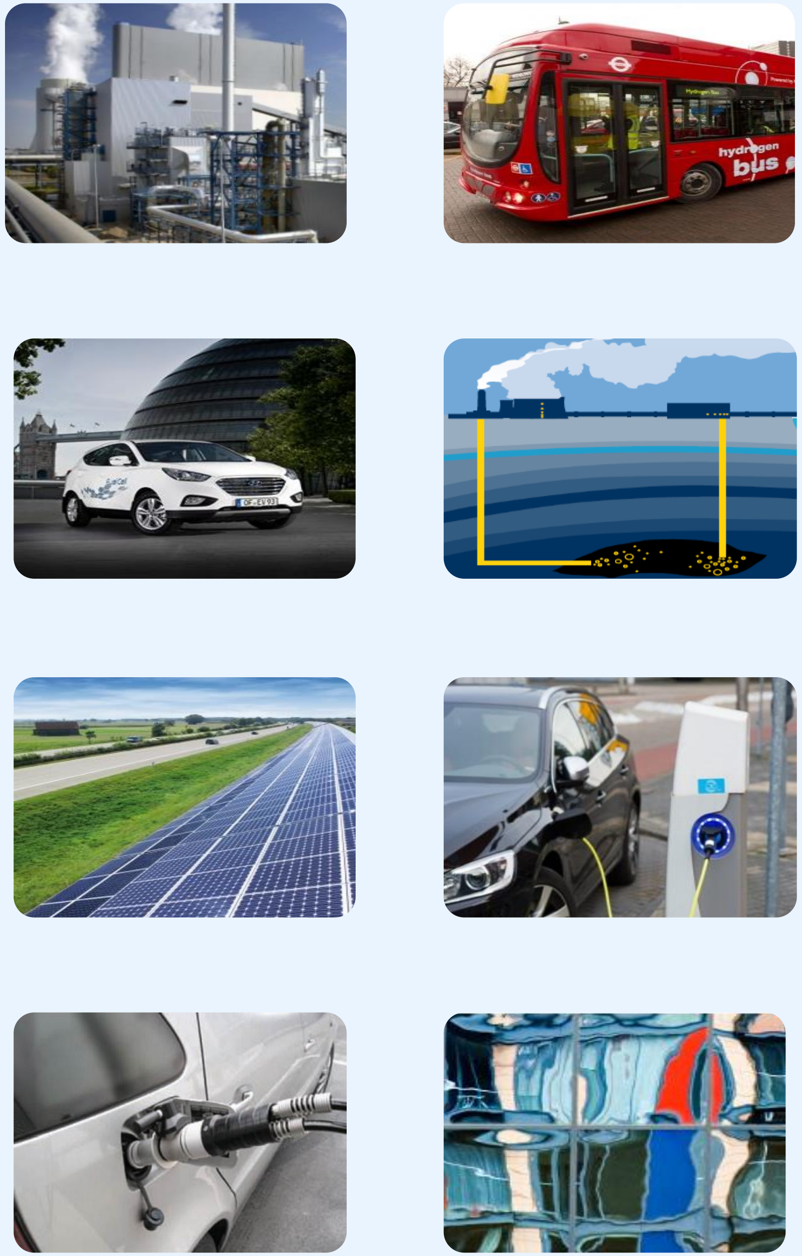


North & West Yorkshire Emissions Reduction Pathways

York and North Yorkshire LEP

elementenergy

Supported by:

UK CEH

February 2021

Final report

Emrah Durusut
Celine Cluzel
Antonia Mattos
Katherine Orchard
Yorukcan Erbay

Contents

- This contents shows the structure of the report and provides links for easy navigation through the document[1].
- The key findings section acts as an executive summary, providing the key messages on emissions reductions and regional actions required.
- The sectoral emissions pathways section shares the results of the technical analysis. It summarises the technology and behavioural measures which drive emissions reductions in each sector in turn.
- The roadmap section provides a visual depiction of the timing of activities and milestones.
- The policy section provides specific policies and actions that should be implemented to achieve the measures required in each sector.
- The discussion section provides commentary on the opportunities, challenges and co-benefits associated with the scenarios
- The Technical Appendix provides the detailed assumptions underpinning the pathways.

---

[1] Each slide in the document also contains a link back to the contents in the footer.

Contents

Introduction, context and aims

Context and key objectives

In May 2019, the Climate Change Committee (CCC) published ‘Net Zero: The UK’s contribution to stopping global warming’. The report set out the Committee’s advice that the **UK should commit to achieving net zero greenhouse gas emissions by 2050**. The Government and Devolved Administrations subsequently legislated for net zero greenhouse gas targets.

Authorities and LEPs within North and West Yorkshire have strengthened their commitments to local emissions reductions through the declaration of a Climate Emergency and the setting of targets to reach net zero carbon emissions by 2038. The region is now in the process of identifying and detailing technology options, measures, policies and interventions required to deliver its targets. This work will contribute to the region’s climate strategy through the following objectives:

- **Develop technically robust emissions reductions pathways**, to enable North and West Yorkshire to meet their respective net-zero emission reduction targets.
- **Identify key milestones, decision points, policies and interventions** that can drive the transition toward these outcomes, including timeframes of actions and roles of stakeholders in delivering actions.

Structure of the tasks and report

1 Emissions pathways

1. Policy review and agree scenario narrative with local stakeholders
2. Model sectoral emissions pathways for 5 sectors to 2038
   Transport, buildings, power, industry, land use
3. Combine sectoral emissions to form an economy-wide set of pathways
4. Stakeholder engagement to validate scenarios

2 Implementation roadmap

Develop a roadmap of the timing of decarbonisation measures and the associated milestones and decision points. Highlight the required technologies and infrastructure for each sector.

3 Policies and action plan

Develop a series of actions and policy recommendations for the delivery of the interventions required to meet decarbonisation goals, included the expected timing and role of stakeholders

Scope of the study - the study aims to assess the interventions which could enable the region to address the climate emergency

This study aims to assess the technologies, interventions and policies needed to drive reduction in scope 1 and 2 emissions across the region. Due to the extremely broad, cross-sectoral nature of the study, it is necessarily high-level in some areas. Further evidence would be required to support large-scale policy implementation and investment decisions.

Whilst the study allows comparison of the scenarios in terms of emissions, energy consumption and risks, **this study is not intended to enable a decision to be made on which scenario to pursue**. Crucial evidence is still being gathered and important national decisions are being made in the next few years. This does not mean that the region should wait to act, but that it should **take low regrets actions which can support any pathway.**

The study aims to show potential futures for the energy system through the use of scenarios. These are needed to represent uncertainties in timing and costs of technologies and infrastructure, as well as uncertainties in consumer perception and behaviour change. The study does not attempt to 'optimise' the future energy system. The analysis is not spatial, so cannot directly guide location of infrastructure or projects and does not incorporate detailed infrastructure considerations or costs.

Emissions in scope[1]

- ✓ Scope 1 (direct) and scope 2 (electricity consumption) CO_2e emissions from transport, buildings, industry, LULUCF and agriculture.
- ✓ High-level inclusion of emissions from domestic and international aviation and waste (for completeness but not modelled in detail).
- ✓ Emissions associated with land use and agriculture in the region, including CO_2, N_2O, CH_4.
- ✓ Negative emissions from Drax Bioenergy + Carbon Capture and Storage and new forest planting inside region.

Emissions out of scope

- Scope 3 emissions, including embedded emissions in product/service imports
- Emissions from power *generation* in the region are calculated, but the pathways only include emissions from regional electricity *consumption* at national carbon content[1].
- Emissions from shipping.
- Emissions offsetting outside region
- Circular economy and radical system changes are out of scope

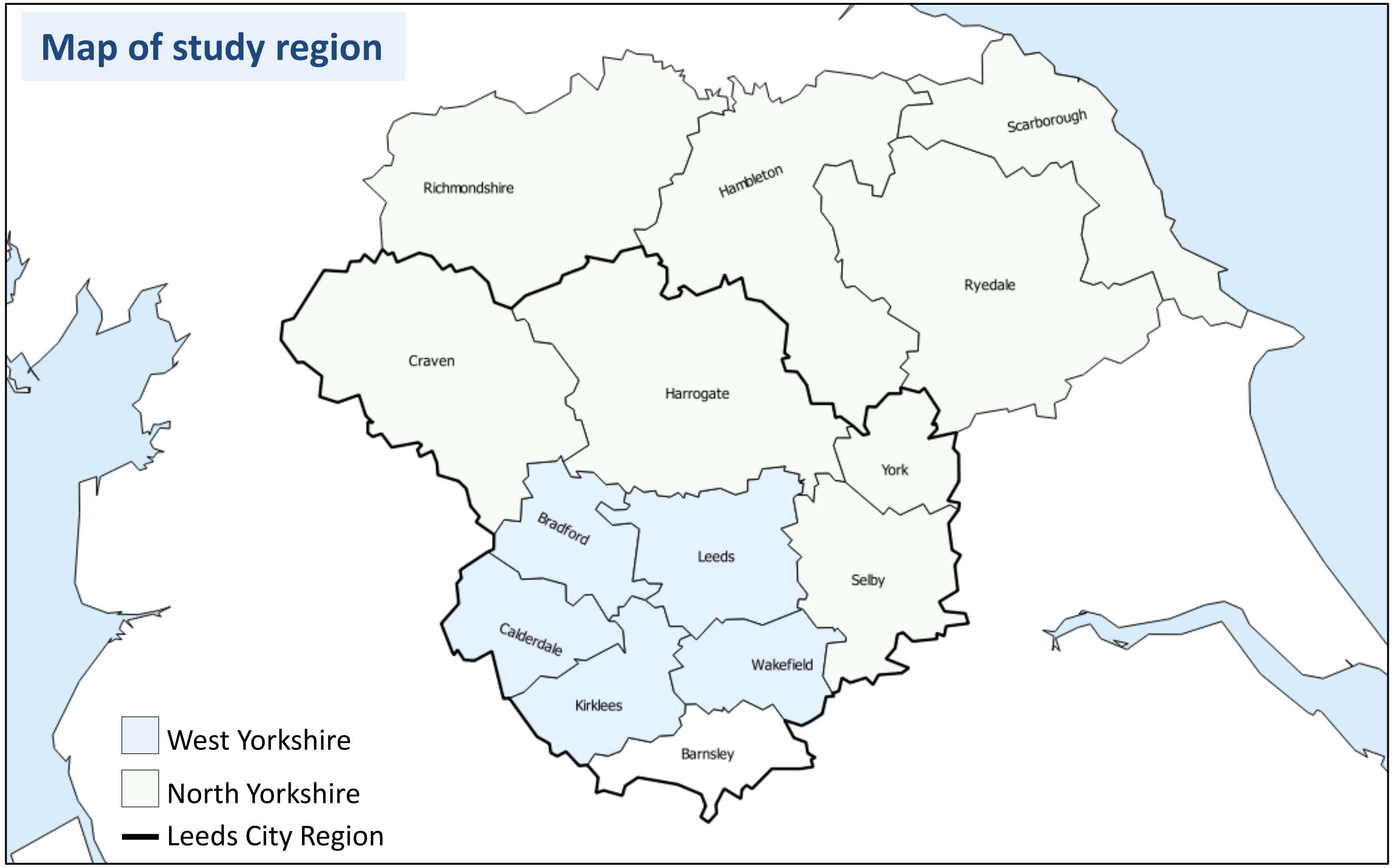
The modelling is based primarily on adjustments to the 'status quo' e.g. projected population growth, minimal change in industrial landscape, rather than radical changes in lifestyle or system function. There are some speculative/disruptive changes that may have implications further in the future.

---

[1] Scope suggested is similar to that of BEIS *'Emissions of CO_2 for LA areas dataset'*, however some additional emissions are included (aviation), the sectoral breakdown is different, LULUCF uses an updated methodology and agricultural non-CO2 emissions are included

Geography: The full study region includes 14 Local Authorities, with varying decarbonisation ambition

Study region
West Yorkshire
Y&NY



Map of study region

The emissions reduction pathways were modelled for the study region as a whole (green and blue area) and disaggregated into the subregions - West Yorkshire, York and North Yorkshire (Y&NY) and Leeds City Region. This pack will present the key quantitative results for West Yorkshire and Y&NY separately, using the coloured tags on the left of slides to signpost which subregion is being presented.

Scenario Characteristics: The emissions reduction pathways present a range of visions as to how the region can reach Net-Zero

1- Baseline

The baseline scenario represents the **likely outcome with current policies**.[1] There will be relatively low uptake of most technologies beyond 2025 in the absence of new policies, incentives and regulations.

2- Max Ambition

The Max Ambition scenario assesses how quickly the region could technically reduce emissions[2]. This will necessarily involve **significant electrification** of heat, transport and industry, supported by enabling technologies such as energy storage. Significant increases in low carbon power generation, with accelerated negative emissions technologies (e.g. BECCS) and ambitious forest planting rates.

3- High Hydrogen (H_2)

The high hydrogen scenario promotes **large-scale hydrogen and CCS roll-out.** The gas network is repurposed for H_2, enabling significant low carbon hydrogen use in buildings/heat, industry, power and transport. This is supported by land-use measures such as afforestation and bioenergy production; lower electricity system changes (production, distribution and storage) are required.

4- Balanced

The Balanced scenario encompasses a **balanced technology mix across sectors**, with contributions from hydrogen, electrification, bioenergy, CCS and decentralised energy production. This represents how technologies are deployed in parallel, with differing factors impacting their adoption, from location to price or consumer comfort.

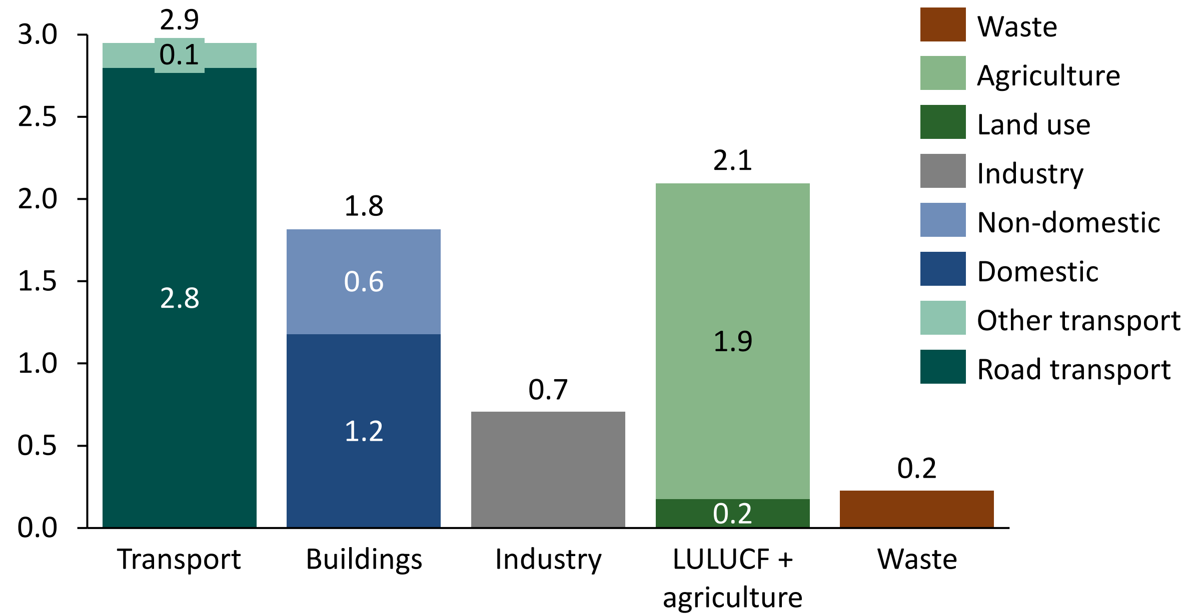
BECCS – Bioenergy Carbon Capture and Storage; CCS – Carbon Capture and Storage; H_2 – hydrogen. 1. Current as of January 2020; note that the Baseline does not include targets, such as the petrol & diesel car ban, that are currently not fully funded/defined policy; 2 pathway reflects what is perceived to be the fastest realistic decarbonisation

Link to contents

Contents

Current emissions by sector – the largest contributions are from road transport, building heat and agriculture

Current emissions $MtCO_2e/yr$*



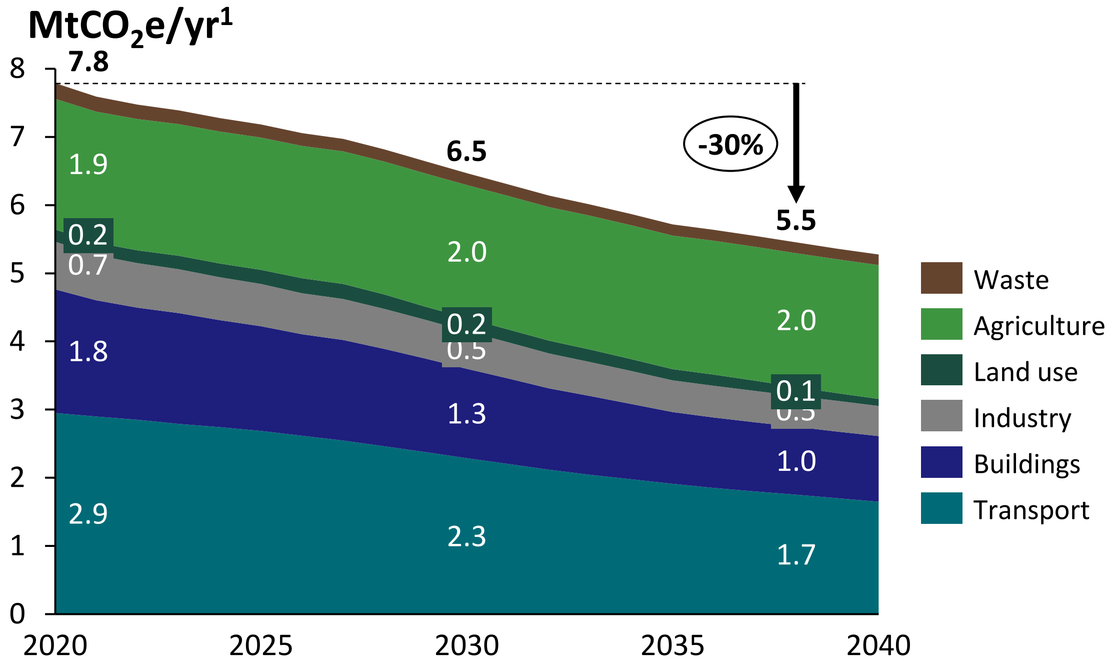
- This graph shows the region's current emissions (2020), broken down into sectors and key subsectors. More detail within this is shown in the main report sectoral results.
- The scope of emissions included is greater than that in the local authority emissions datasets (see scope slide).
- Due to the rural nature of much of Y&NY, there are large contributions from agriculture and transport, and limited emissions from heavy industry.

- Transport is the largest emitting sector, with emissions currently dominated by road transport, primarily private vehicle use.
- Much of the emissions from buildings and industry are due to heat generation, primarily using natural gas and some oil. Electricity related emissions will be addressed through decarbonisation of the power sector.
- There is limited heavy industry in the region, mostly in Selby; the largest heavy industry sectors are food and drink and minerals.
- Land use, land use change and forestry (LULUCF) + agriculture emissions are high in the region, dominated by agricultural non-CO_2 emissions
- Most of current waste emissions are from landfill, followed by wastewater treatment processes.

Note that the power sector is not explicitly shown in this graph or the following graphs, as this is included within the sectors consuming electricity. This aligns with the current UK government Local Authority accounting of emissions*.

*National electricity carbon content used. Electricity carbon intensity nationally has dropped significantly (43%) between 2017 (latest LA emissions dataset) and 2020, reducing the emissions contribution of electricity use, mostly in buildings and industry. Other transport includes rail, aviation (domestic and international) as well as aircraft support vehicles and emissions from lubricants. CO_2e is CO_2 equivalent, considering other GHG produced by combustion of fuels and in agriculture.

Baseline scenario – slow progress results in around 30% emissions reduction by 2038



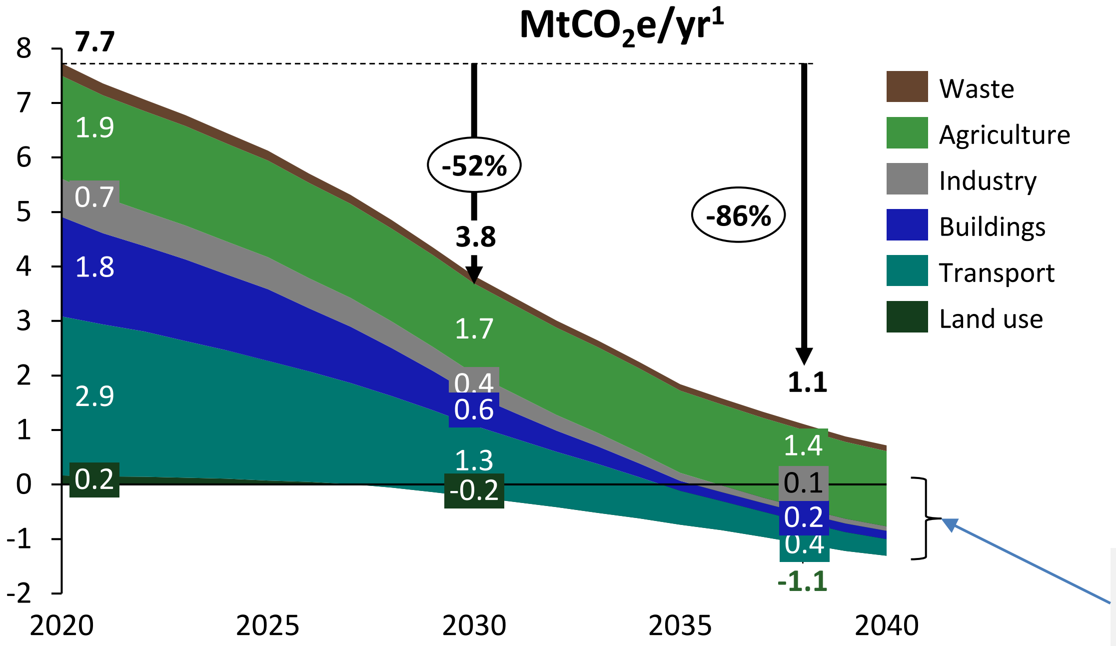
- This graph shows the region's emissions projection under the baseline scenario, divided into the contribution from each of the sectors. The numbers on the graph show the emissions in 2020, 2030 and 2038 for each sector and the total.
- **The baseline scenario sees a 30% reduction in emissions by 2038, with 5.5 MtCO$_2$e/yr remaining in 2038.**
- All sectors see slow change due to lack of strong incentives for consumers and businesses to switch to low carbon heat, transport and other practices.

- The transport sector sees the most progress due to the faster development of technically ready and cost-effective solutions, leading to uptake of electric vehicles.[1]
- The majority of the emissions reduction in the buildings and industry sectors is due to **national renewable electricity** and some energy efficiency implementation. **There is slow uptake of low carbon heat** due to high cost, low awareness and consumer behaviour challenges.
- **Agricultural emissions grow due to population growth** and, in the land use sector, new forest planting continues at the current rate and makes a small contribution to reducing emissions.
- **Power sector (not shown[2]) almost doubles its emissions** due to deployment of a new unabated large-scale gas power plant, which runs to balance the grid.
- The remaining emissions in 2038 are still primarily in the transport and agriculture sector due to the rural nature of much of the region.
- Note that the power sector is not explicitly shown in this graph or the following graphs, as this is included within the sectors consuming electricity. This aligns with the current UK government Local Authority accounting of emissions.

---

1. Note that the Baseline does not include targets, such as the petrol & diesel car ban, that are currently not fully funded/defined policy .2 National electricity carbon intensity; no BECCS negative emissions included in the charts for clarity. The final emissions with BECCS inclusion are low as demonstrated in the scenario comparison.

Max ambition scenario – highly ambitious roll out of electric vehicles, active travel, heat pumps and new forest planting makes rapid progress



- This graph shows the region's emissions projection under the Max ambition scenario, divided into the contribution from each of the sectors.
- The scenario sees an 86% reduction in emissions by 2038, with 1.1 $MtCO_2e/yr$ remaining in 2038. When BECCS negative emissions from Drax are included, the region reaches net zero in 2034 and by 2038 is considerably net negative (see later).
- All sectors see rapid change, requiring strong incentives for consumers and businesses to switch to low carbon heat, transport and other practices.

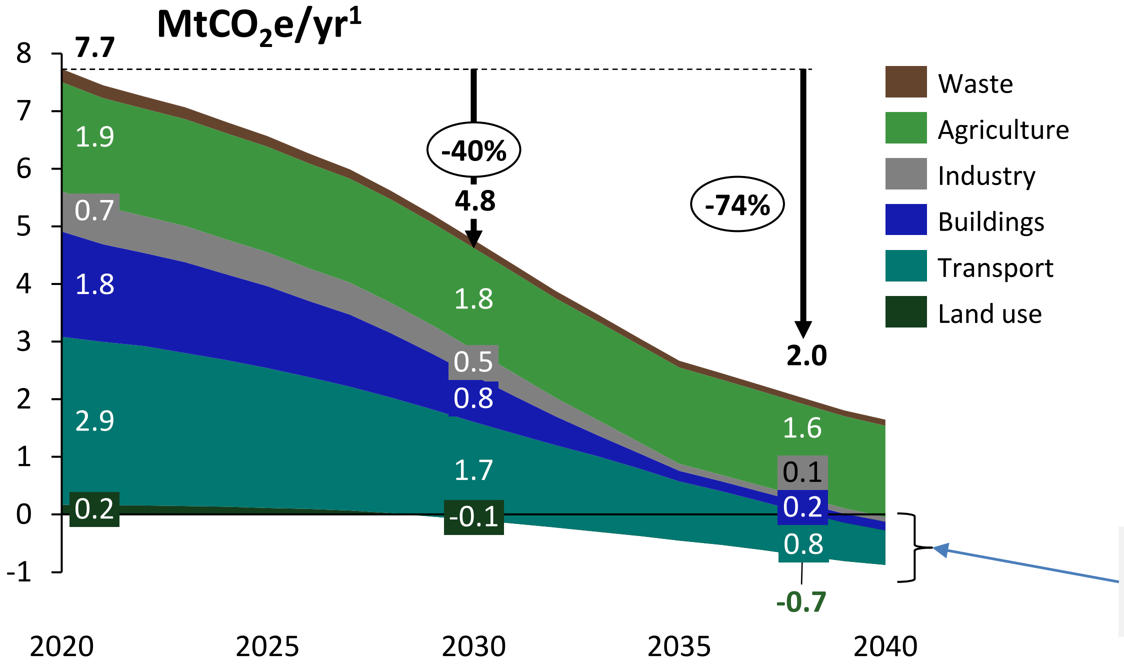
Land use emissions are negative, offsetting some residual emissions in other sectors

- The transport sector sees **rapid uptake of electric vehicles (EVs) alongside significant consumer and industry behaviour change** to reduce travel demand and to shift journeys from private cars to active and public transport.
- The buildings sector sees **highly ambitious roll out of heat pumps (270k domestic by 2038)** and heat networks, particularly between 2025-2035, and large-scale building efficiency retrofit in the 2020s.
- **Industry focusses on developing new technology** and switching to low carbon fuels (electricity, H_2, bioenergy)
- The power sector sees the **rapid roll-out of solar PV and onshore wind, as well as Carbon Capture and Storage (CCS)** on bioenergy and natural gas before 2030 to reach negative emissions (not shown[1]).
- Land use emissions rapidly drop to net-negative before 2030 due to **swift action in new forest planting** and peatland restoration. Agricultural emissions struggle to decarbonise in the timeframes, with significant emissions in 2038, however, the agriculture sector does play a crucial role in enabling land use emissions savings

---

1 National electricity carbon intensity; no BECCS negative emissions included in the charts for clarity. The final emissions with BECCS inclusion are lower.

High Hydrogen scenario – widespread availability of hydrogen by 2030 enables deployment of hydrogen boilers and fuel cell vehicles



- This graph shows the region's emissions projection under the High H_2 scenario, divided into the contribution from each of the sectors.
- The scenario sees a 74% reduction in emissions by 2038, with 2.0 $MtCO_2e/yr$ remaining in 2038.
- All sectors see rapid change, partially enabled by the **transition from natural gas to hydrogen**, used in hydrogen boilers, vehicles and power generation. Hydrogen conversion is a significant infrastructure challenge.

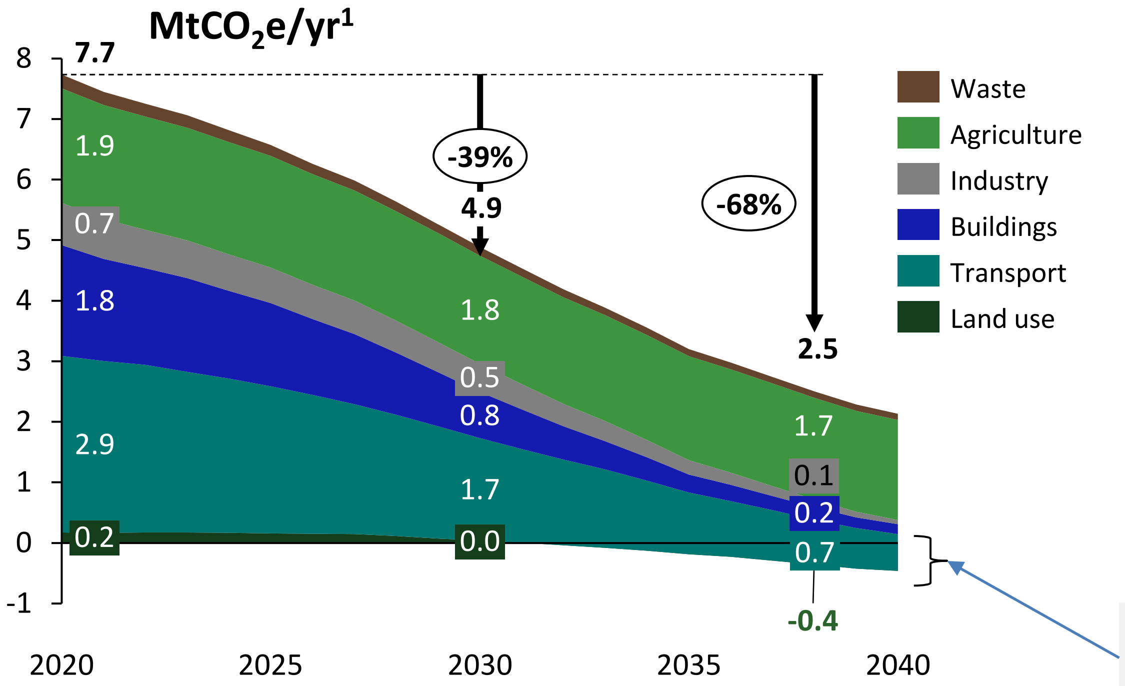
Land use emissions are negative, offsetting some residual emissions in other sectors

- The transport sector sees significant uptake of **hydrogen fuel cell vehicles**, particularly in the heavy goods vehicle and bus sectors during the 2030s, although battery electric vehicles still form a significant share of the vehicle fleet. Shift of journeys to active and public travel occurs more gradually between 2020-2038.
- The **buildings and industry sectors rely heavily on the conversion of the natural gas grid to hydrogen** from 2028 to supply low carbon heat. In the 2020s hybrid heat pumps and energy efficiency are implemented, and by 2038 there are over **180k homes heated by hydrogen**.
- The power sector sees **implementation of CCS** on bioenergy (BECCS is not shown[1]) and natural gas, as well as the **implementation of hydrogen fired gas turbines**.
- Land use emissions become net-negative around 2030 due to **swift action in new forest planting and peatland restoration**, but at a slower rate than the Max ambition scenario.
- The scenario relies on the deployment of CCUS and hydrogen at large scale, aligned with the government's 10 Point Plan, but there is still considerable uncertainty over the timeframes and the exact nature of their role in the energy system.

---

[1] National electricity carbon intensity; no BECCS negative emissions included in the charts for clarity. The final emissions with BECCS inclusion are lower.

Balanced scenario – the mix of technologies and fuels allows greater choice, with areas differing in their characteristics



- This graph shows the region’s emissions projection under the Balanced scenario, divided into the contribution from each of the sectors.
- The scenario sees a 68% reduction in emissions by 2038, with 2.5 $MtCO_2e/yr$ remaining in 2038.
- The pathway sees significant electrification of heat and transport, but also introduction of hydrogen in areas of the gas grid enabling hydrogen boilers.
- Progress is slower than the other scenarios, particularly in the land use sector, representing the uncertainty in feasible rates of deployment.

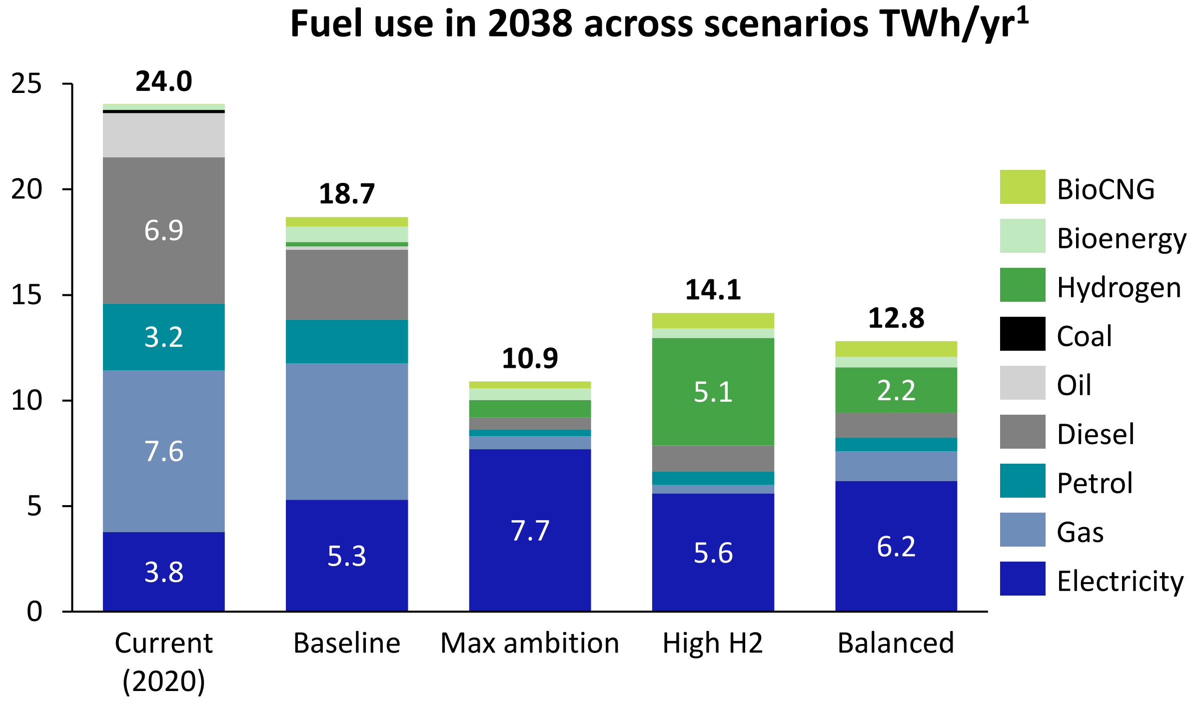
Land use emissions are negative, offsetting some residual emissions in other sectors

- The transport sector sees a mixed rollout of hydrogen and electric vehicles across vehicle types, alongside ambitious behaviour change.
- The **buildings and industry sectors rely on a mixture of hydrogen heating technologies and heat pumps**, due to the **partial nature of gas grid conversion to hydrogen**; the remaining areas of the gas grid remain a blend of natural gas and biomethane.
- The power sector sees implementation of **significant solar PV and onshore wind, as well as BECCS and CCS** on natural gas turbines.
- The **land use sector sees less progress due to slower rates of forest planting, peatland restoration and agroforestry** being achieved. This means the sector contributes less negative emissions and doesn’t come close to offsetting the remaining agricultural emissions.

---

[1] National electricity carbon intensity; no BECCS negative emissions included in the charts for clarity. The final emissions with BECCS inclusion are lower.

Scenario energy – the pathways rely on differing fuel mixes to reach their goals



- This graph compares the fuel demand across the scenarios by fuel type. This includes the fuel required for all sectors[1]. The numbers at the top represent the total fuel demand.
- In 2020, the fuel mix is primarily fossil fuel, with a small amount of electricity.
- All emissions reduction scenarios see significant reduction in the total amount of fuel required, due to increased technology efficiency as well as energy demand reduction measures.
- The transport and buildings sectors are the key components of the energy usage.

- By 2038, the scenarios rely on predominantly electricity or hydrogen, depending on the choices made.
- The Max ambition scenarios sees electrification of heat and transport, leading to a **102% increase in electricity demand between 2020 and 2038**. There is limited hydrogen and bioenergy use.
- In the High hydrogen scenario, with hydrogen widely available in the gas grid, 36% of fuel demand is hydrogen. The increase in electricity demand is only 46%.
- The balanced scenario sees a mix of fuels, with large amounts of electricity, but also hydrogen, bioenergy and some gas grid usage (including biomethane blending).

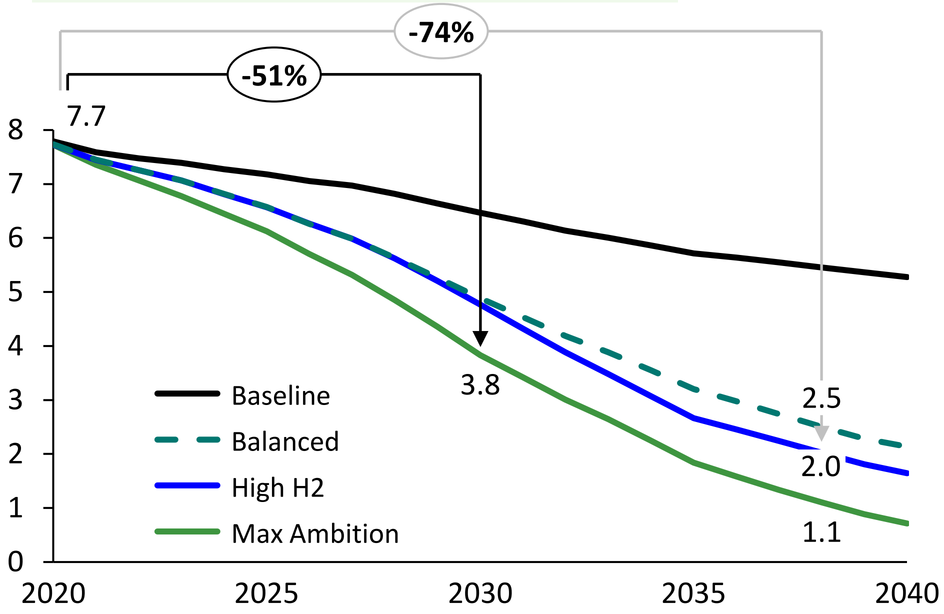
---

1 Aviation fuel is not included as this is not attributed to specific subregions; bioenergy is bio-LPG and biomass in buildings and industry, but excluding power as per other graphs; gas is from the gas grid, a blend of natural gas and biomethane

Scenario emissions trajectory – emissions reductions occur at different rates across the scenarios due to differing choices

Pathway emissions $MtCO_2e/yr$[1]

National electricity carbon intensity, no BECCS



- This graph compares the emissions trajectories across the scenarios[1]. All pathways make ambitious emissions reductions over the next 2 decades, using different technologies, measures and fuels.
- Without BECCS negative emissions (see next slide) no pathway reaches net-zero and the emissions remaining in 2038 are 1.1 – 2.5 $MtCO_2e/yr$ depending on the scenario.
- The key differences between the scenarios are the technology choice, level of electrification vs hydrogen in heat and transport and rate of technology deployment and behaviour change. More details can be found in the main report and Technical Appendix on the underlying assumptions.

- **The Max ambition scenario makes considerably more progress by 2030**, due to ambitious rates of electric vehicle roll-out and uptake of active travel,[2] unprecedented heat pump installation and faster rates of forest planting. Despite this, the emissions are still 49% of the current emissions by 2030, with challenges including misalignment with national policy timing, technology readiness, behaviour change and stock turnover rates.
- The High H_2 and Balanced scenarios make less progress in the next few years, but progress accelerates from the mid-2020s. **The High H_2 scenario sees rapid emissions reductions 2028-2035 as the gas grid is repurposed** for hydrogen, facilitating the switch of buildings, industry and some transport to hydrogen. The Balanced scenario sees steady progress through a mix of technologies deploying at different rates.

---

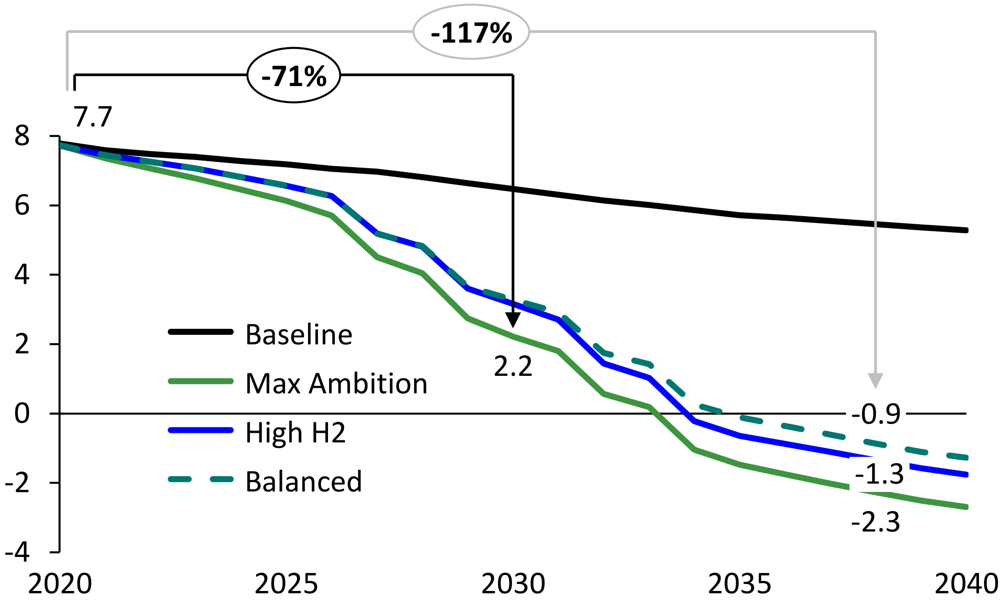
[1] excluding negative emissions from BECCS. National electricity carbon content is chosen for electricity consumed in the sectors to align with current GHG reporting, and regional power sector emissions are therefore not included. [2] See further discussion slide for impact of petrol and diesel ban date on the findings of this study.

Net-zero point – negative emissions is required to meet net-zero targets in the region by offsetting remaining emissions

- This graph compares the emissions trajectories across the scenarios, WITH the inclusion of 20% of the negative emissions from Drax BECCS plant[1,2].
- BECCS allows negative emissions as the CO_2 is removed from the atmosphere as the bioenergy grows, but on combustion of the bioenergy the CO_2 is then trapped and stored through CCS, leading to a net reduction in the CO_2 in the atmosphere.
- With BECCS accounted for, the Max ambition pathway reaches net-zero by 2034 and the other scenarios follow within the next few years.
- By 2038 the pathways have reached -0.9 to -2.3 $MtCO_2e/yr$ in negative emissions.

Pathway emissions $MtCO_2e/yr$

National electricity carbon intensity, with 20% Drax negative emissions



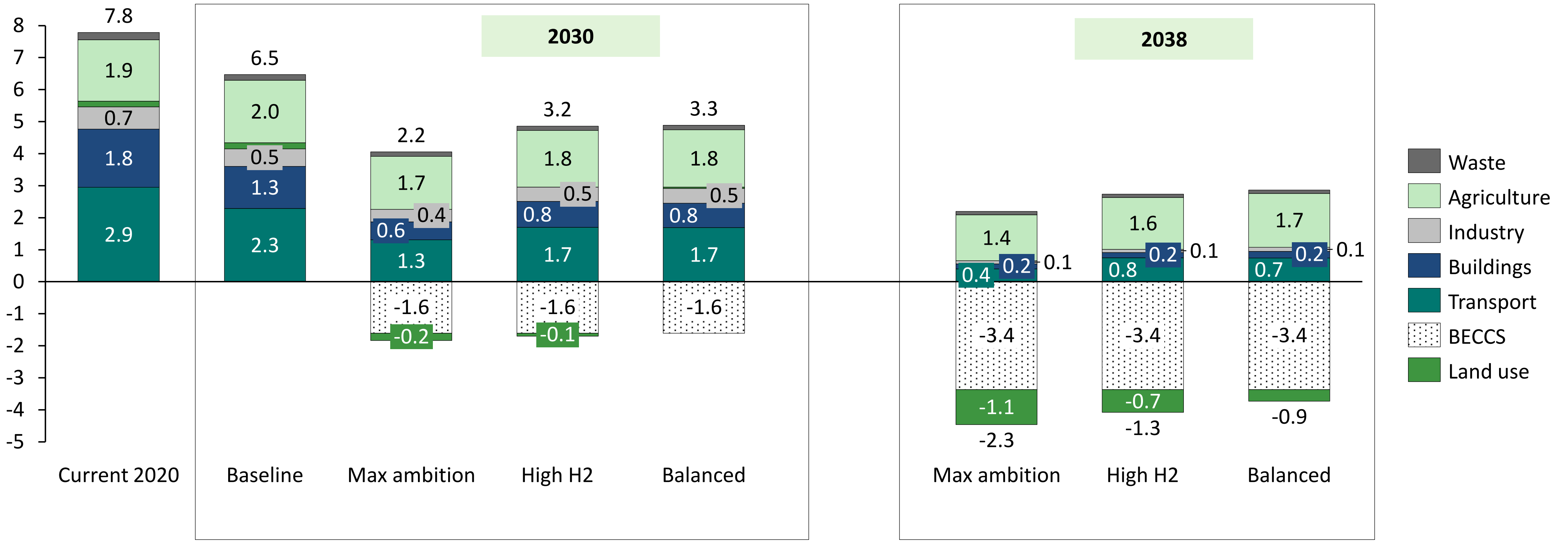
- Drax is currently planning to implement CCS before 2030, retrofitting two of its four bioenergy turbines by this point. However, there is significant uncertainty over the timeframes as there is currently no firm policy and funding support for the CCS infrastructure. Therefore, delays to these plans would jeopardize the region's net-zero plans and timeframes.
- The land-use sector also provides negative emissions through new forest planting activities, which remove CO_2 from the atmosphere to store it in the woodland. This is already accounted for in all graphs and new forest planting roughly offsets the remaining emissions from the agriculture sector at its most ambitious rates.

---

1 BECCS: Bioenergy Carbon Capture and Storage, NET Negative emissions technology 2 The net-zero date is highly sensitive to the % BECCS selected; 20% is used as it is the proportion of generated electricity in N Yorkshire that is consumed in NY in the Max ambition pathway by 2040

Remaining emissions are significant in 2030 across sectors, but by 2038 these have reduced and are offset by negative emissions

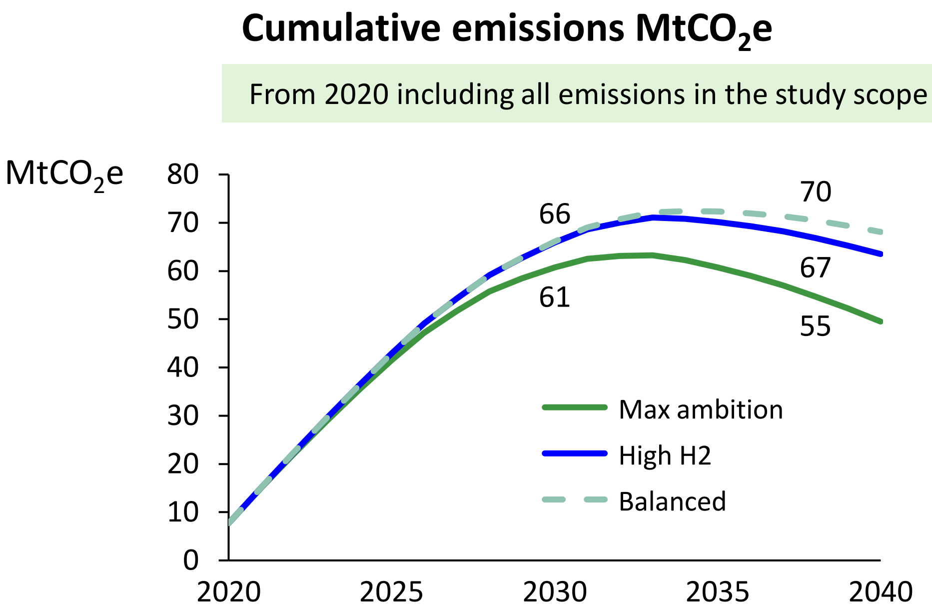
Emissions remaining compared with current $MtCO_2e/yr$

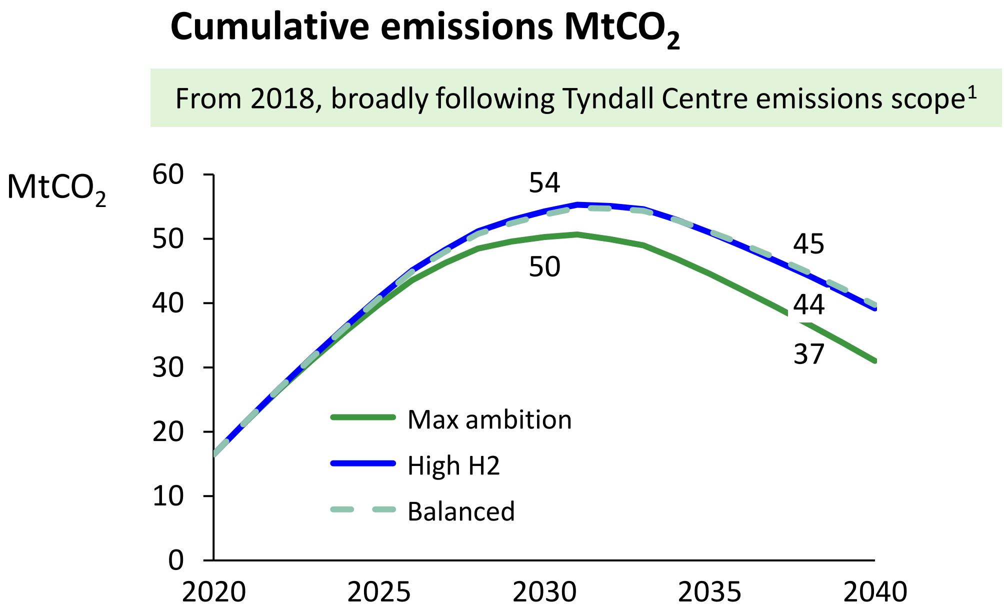


- In 2030 there are significant emissions remaining, particularly in agriculture, transport and buildings. A key challenge in buildings and transport is the stock turnover rate, and in agriculture is the time taken for both change (e.g. diet change) and for changes to take effect.
- In 2038, the majority of remaining emissions in Y&NY come from agriculture. Remaining emissions are more than offset by negative emissions to provide a net-negative region for all scenarios.
- More detail on the subsector contribution to remaining emissions can be found in the main report.

BECCS – bioenergy carbon capture and storage

Cumulative emissions reach a peak in the early 2030s before reducing due to rapid progress and BECCS implementation





- From a climate perspective, the net cumulative CO_2 emitted is the key factor, as this is the CO_2 contributing to global warming. The cumulative emissions of all scenarios rise rapidly during the 2020s, but then flatten around 2030 as interventions slow emissions and as BECCS is implemented.
- For all emissions (left), the **region reaches 55 – 70 $MtCO_2e$ cumulatively by 2038** depending on the scenario.
- The Tyndall Centre developed a science-based carbon budget for the region based on compliance with the Paris Agreement. The cumulative CO_2 budget is related to the energy system only and excludes land use, agriculture, aviation, waste and non-CO_2 emissions[1]. Under these conditions, the Y&NY net cumulative carbon emissions are 37 – 45 $MtCO_2e$ by 2038 depending on the scenario.
  - N+W Yorkshire's carbon budget is 134 $MtCO_2$ 2018-2100, and **the combined region breaches this in 2027, but cumulative net emissions fall in the 2030s** (due to negative emissions measures).

---

1 Cumulative carbon budget work is approximate, as Element modelling is not set up for the specific conditions of the Tyndall Centre carbon budgets.

Y&NY could be net negative by 2034, saving 7 $MtCO_2e/yr$ over baseline, if highly ambitious interventions are achieved

Y&NY is more rural than many areas of the UK, with lower emissions from buildings and industry, but larger % of emissions from agriculture and transport. The region faces specific challenges around private car use, off-gas homes and agricultural emissions. However, it has a key opportunity in negative emissions from forest planting and Bioenergy use with CCS (BECCS).

- **York and North Yorkshire could be a net negative region by 2034[1],** saving 6.9 $MtCO_2e/yr$ over baseline, if an ambitious strategy is deployed immediately, backed by strong policy.
- Cumulative emissions[2] reach 61 $MtCO_2e$ by 2034 in the Max ambition scenario then begin declining, enabling a **cumulative emissions saving of 71 $MtCO_2e$ by 2038 over the baseline scenario**.
- None of the scenarios reach net-zero in the 2030s without contributions from negative emissions and CCS. **Without CCS, the annual emissions in 2038 are 3.4 $MtCO_2e/yr$ higher** and the cost to heat buildings is over £0.5 billion higher cumulatively in the High hydrogen scenario.
- **The Max ambition scenario has the lowest cumulative and annual emissions, but requires highly ambitious leadership** and policy to drive extensive change across the economy. Support will be required from national government, both in terms of policy and funding, as well as upgrades to the regional electricity infrastructure.
- **The scenarios take different trajectories as the timing of actions differ**. For example, Max ambition begins electrification early, whereas the High H_2 accelerates progress in the late 2020s as hydrogen is deployed.
- **Key challenges include:** misalignment with national policy timing; rapid building of technology supply chains, skills and infrastructure; enabling consumer awareness, behaviour change and acceptance.
- Decision makers must consider a wide range of factors when comparing the pathways, such as climate, air quality, economic factors, employment, risks and deliverability, consumer impact and acceptance.
- **Key evidence must be gathered** in the next few years around remaining uncertainties. For example: viability, feasibility and consumer perception of hydrogen for heat; real world performance of new technologies; national policy changes; land availability for new infrastructure, land use measures and solar PV.

---

1 Assuming 20% Drax BECCS negative emissions; 2 emissions in study scope, from 2020.

The scale of the challenge – what must happen by 2038 to achieve the level of emissions reduction in the Max ambition scenario?

Transport

Sales of zero emissions cars reach ca. 20,000/yr by 2038

Walking increases by 50% and cycling increases 9x compared to today

Public transport capacity doubles compared to today

Buildings and industry

Retrofit of 250k homes to reach EPC C or better (reduced thermal energy demand)

270k heat pumps installed (62% homes), or 58/day from 2025-2035

Hydrogen equipment developed and deployed for industry

Land use and agriculture

100% peatland restored to minimise emissions

Forest area almost doubles, reaching 91 kha

Diet change to reduce meat and dairy consumption by 32%. 24% reduction in cattle and sheep numbers.

Power

Solar PV and onshore wind reach 2960 MW (175 MW/yr from 2020-2030)

CCS deployed at scale from 2027 enabling BECCS (-17 MtCO$_2$/yr, 2038)

Electricity infrastructure investment enabling 102% higher annual demand

Contents

The outcomes of the emissions pathways modelling have been used to define roadmaps for implementation and key policies and actions that the regions can take have been identified

The emissions pathway modelling defined the scale of action required to reduce emissions in each region across three possible scenarios. To empower the regions to take appropriate, targeted action to deliver their climate ambitions, these findings were used to develop the following tools:

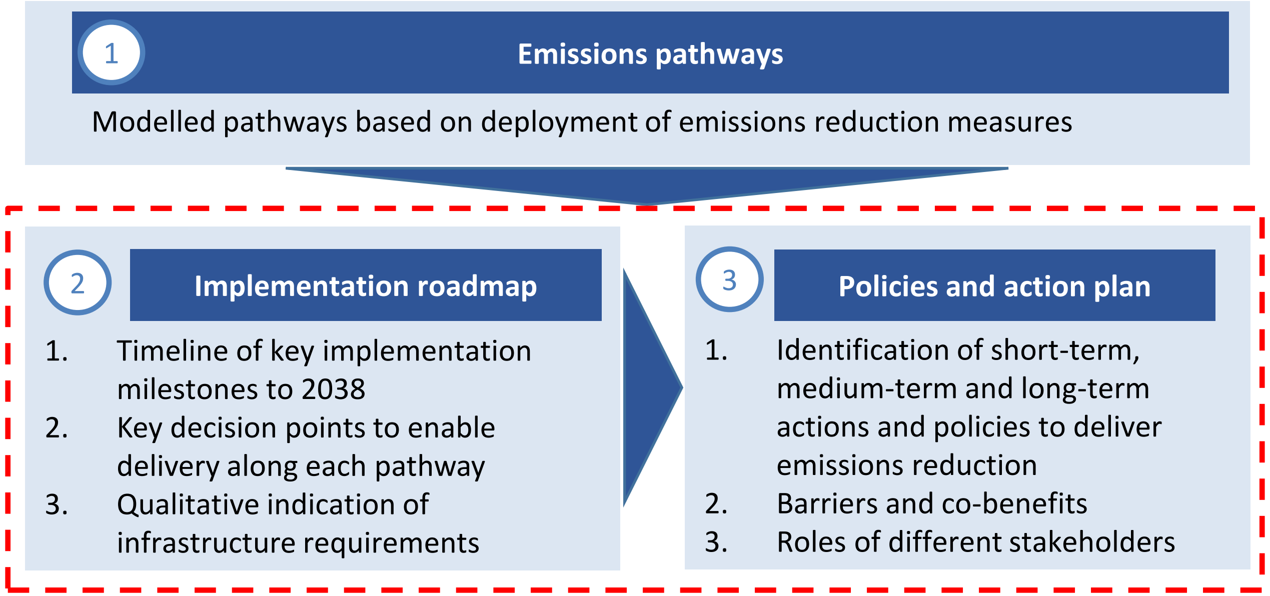
- **Implementation roadmaps** – outcomes from the emissions pathway modelling was used to identify key implementation timescales and activities to support delivery of the pathways, and milestones by which to monitor progress
- **Policies and action plans** – best practice examples and outcomes from wider consultation run by WYCA and YandNY LEP were used to identify policies for each sector that the regions can take towards delivering the modelled pathways and sectoral action plans for delivering these measures

Across each sector, key recommendations have been developed which identify:

- **Top priority** – outcomes that deliver benefits early and/or support all scenarios, that WYCA, YandNY LEP and the local authorities have highest influence to deliver
- **Short-term actions** – low regrets actions that support the top priority outcome and delivery of future actions, including strategy-setting and evidence gathering
- **Medium-term decisions** – decisions that will support the choice and rate of progress along the future emissions reduction pathways
- **Long-term options** – future actions that can be taken to refine the regions' approach in response to progress and future national developments

This report focusses on the role of West Yorkshire Combined Authority (CA), the Local Enterprise Partnership (LEP) and the North Yorkshire County Council in supporting the net-zero transition. This role ranges from strategic planning and coordination, to funding programmes and consumer campaigns. It is important to note that:

- The regions will still be **reliant on strong national policies** to achieve their goals and deploy many of the recommended policies
- The CA/LEP will **need additional resource (designated staff) and funding** to deploy these policies and take crucial actions



1 **Emissions pathways**

Modelled pathways based on deployment of emissions reduction measures

2 **Implementation roadmap**

1. Timeline of key implementation milestones to 2038
2. Key decision points to enable delivery along each pathway
3. Qualitative indication of infrastructure requirements

3 **Policies and action plan**

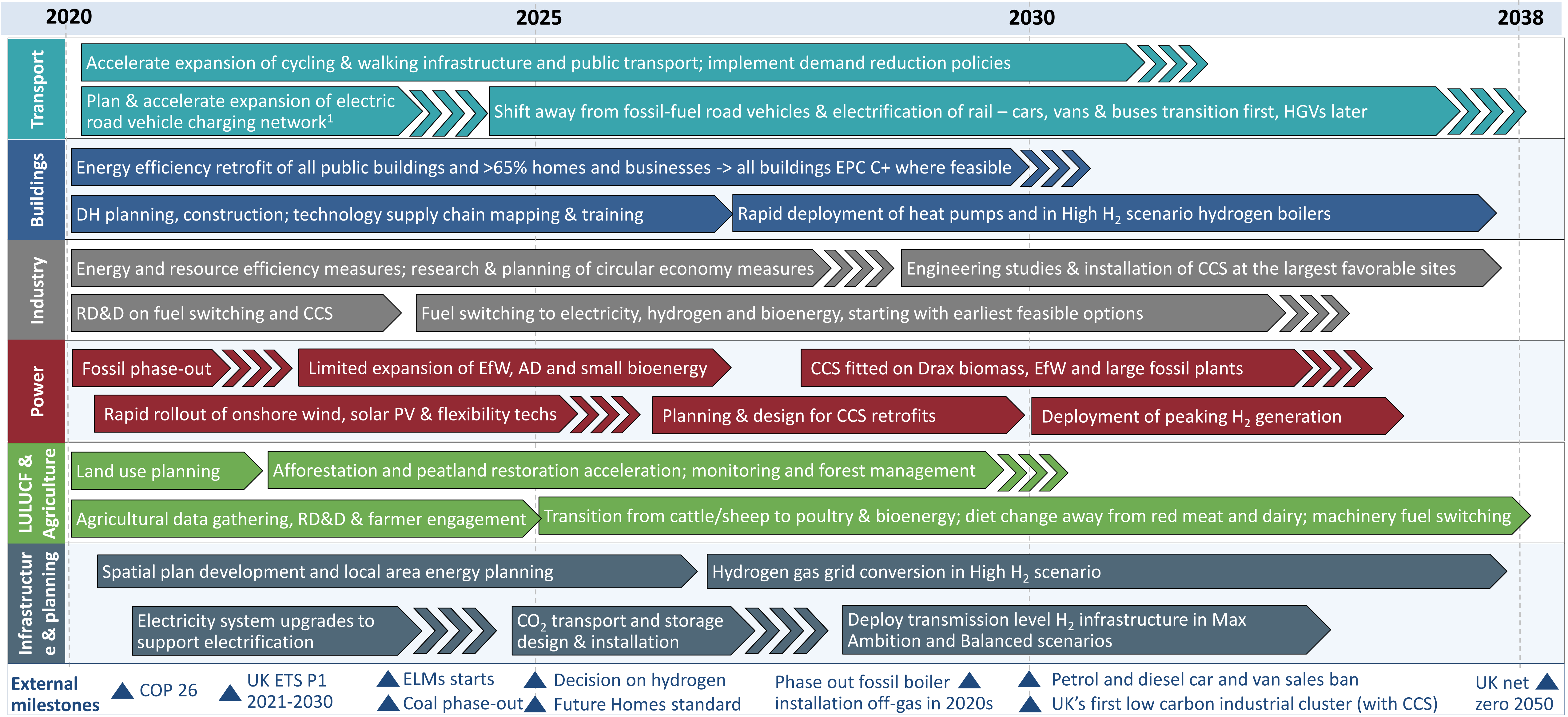
1. Identification of short-term, medium-term and long-term actions and policies to deliver emissions reduction
2. Barriers and co-benefits
3. Roles of different stakeholders

Cross-sectoral summary roadmap showing indicative timelines for implementation of the major measures

▲ Key decision points/ external milestones

Activity timings

»» Indicates continuous action until 2038



Transport

- Accelerate expansion of cycling & walking infrastructure and public transport; implement demand reduction policies
- Plan & accelerate expansion of electric road vehicle charging network[1]
- Shift away from fossil-fuel road vehicles & electrification of rail – cars, vans & buses transition first, HGVs later

Buildings

- Energy efficiency retrofit of all public buildings and >65% homes and businesses -> all buildings EPC C+ where feasible
- DH planning, construction; technology supply chain mapping & training
- Rapid deployment of heat pumps and in High H_2 scenario hydrogen boilers

Industry

- Energy and resource efficiency measures; research & planning of circular economy measures
- Engineering studies & installation of CCS at the largest favorable sites
- RD&D on fuel switching and CCS
- Fuel switching to electricity, hydrogen and bioenergy, starting with earliest feasible options

Power

- Fossil phase-out
- Limited expansion of EfW, AD and small bioenergy
- CCS fitted on Drax biomass, EfW and large fossil plants
- Rapid rollout of onshore wind, solar PV & flexibility techs
- Planning & design for CCS retrofits
- Deployment of peaking H_2 generation

LULUCF & Agriculture

- Land use planning
- Afforestation and peatland restoration acceleration; monitoring and forest management
- Agricultural data gathering, RD&D & farmer engagement
- Transition from cattle/sheep to poultry & bioenergy; diet change away from red meat and dairy; machinery fuel switching

Infrastructure & planning

- Spatial plan development and local area energy planning
- Hydrogen gas grid conversion in High H_2 scenario
- Electricity system upgrades to support electrification
- CO_2 transport and storage design & installation
- Deploy transmission level H_2 infrastructure in Max Ambition and Balanced scenarios

External milestones

- ▲ COP 26
- ▲ UK ETS P1 2021-2030
- ▲ ELMs starts
- ▲ Coal phase-out
- ▲ Decision on hydrogen
- ▲ Future Homes standard
- Phase out fossil boiler installation off-gas in 2020s ▲
- ▲ Petrol and diesel car and van sales ban
- ▲ UK's first low carbon industrial cluster (with CCS)
- UK net zero 2050 ▲

Acronyms: CCS: carbon capture and storage; H2: hydrogen; DH: district heating; EfW: energy from waste; AD: anaerobic digestion; ICE: internal combustion engine; HGV: heavy goods vehicle; EPC: energy performance certificate; RD&D: research development and demonstration; ETS: emissions trading system; ELMs: environmental land management scheme

Note: timings are indicative due to simplification – please see sectoral roadmaps for more detail; 1. Expansion of charging network will continue beyond 2025

Key recommendations – York and North Yorkshire

Note that while these are selected as key actions due to their importance in delivering key measures for emissions reductions, there are other essential actions outside these that must be taken to deliver the pathways

	Transport	**Buildings**	**Land use and agriculture**	**Power and industry**
Top priority ★	Reduce car use through modal shift and demand reduction	Reduce energy demand through energy efficiency	Ensure local land use priorities are met by setting the strategy	Support planning for CCUS & hydrogen technologies and infrastructure
Short term actions	• Improve cycling and walking infrastructure • Explore bus Partnership • Invest in digital infrastructure • Expand electric vehicle charging network • Work with partners to limit road building and decarbonise rail	• Set up a 'One-stop shop' to help consumers decarbonise • Retrofit existing LA buildings and put in place policy for wider building stock[1] • Implement heat networks • Influence Government to deliver planning policy and heat strategy	• Complete spatial land strategy • Gather data and evidence on optimal local LULUCF solutions • Develop food waste strategy • Influence Government to develop ELMs in a way that supports locally-relevant measures	• Complete regional energy planning, including solar PV • Setup green public procurement programme • Financial scheme for efficiency, renewables, RD&D. • Influence government to support CCUS/hydrogen infrastructure
Medium term decisions	• Level of financial support for vehicle uptake and modal shift • Role and level of support for shared mobility, including on-demand services	• Level and focus of financial support for energy efficiency and technology uptake • Heat zoning policy need • Role of H_2 for heat	• Level and focus of financial support • Strength of public messaging around diet change	• Role of CCS vs hydrogen vs electrification or renewables • Level and focus of financial support for fuel switching
Long term options	• Stronger regulatory and financial incentives • Support rollout of innovative technologies (inc. H_2 trains)	• Stronger regulatory and financial incentives • Public-led business models for communal and district heating	• Stronger regulatory and financial incentives • Support innovative technologies and techniques	• Stronger regulatory and financial incentives • Support novel technologies e.g. Direct Air Capture, DSR

Y&NY

CCUS: Carbon Capture Utilisation and Storage, DSR: demand side response, ELMs: Environmental Land Management Scheme, LULUCF: Land use, land use change and forestry.

[1] The County Council and the local authorities have greater influence and control over Retrofit of LA buildings and social housing, whereas facilitating private rented and owner-occupier homes will require a mix of regulation and incentives

Action to achieve decarbonisation must start now, but the choice of longer-term pathway relies on further local evidence and developments at national level

2020 | **Priority Actions & Evidence** | **2025 at latest** | **Max implementation of policy** | **2030** | **Adjustment and enhancement** | **2038**

① **Short-term action** should focus on driving ambitious change while keeping options open and gathering the evidence needed to support longer-term decisions.

- **Priority actions –** actions that are common to all pathways, are relatively low-cost, and deliver relatively large benefits. For example:
  - Accelerate **decarbonisation of public assets**
  - Deliver measures to drive **behaviour change**
  - Set **spatial strategies** to ensure common framework and alignment across the region and across all sectors
  - **Fund and support** rollout of mature technologies
- **Evidence gathering –** deliver trials and detailed studies, and engage with stakeholders to help the region to understand local feasibility of technologies and measures. For example:
  - **Deliver demonstrator projects** for high building energy efficiency and low carbon heating technology
  - **Determine local feasibility** for freight consolidation and traffic control measures
  - **Gather data on local land use** and farming practices so that appropriate local targets can be set

② **Decision on pathway** – use learnings from short-term actions and take account of national developments to decide level of ambition and focus of regional support

③ **Medium-term action** should implement regional policy in-line with agreed ambition and priorities

Max ambition – Deliver many or all highest ambition policies, with focus on rapid[1] progress (highest cost and risk)

- Maximum level and rate of behaviour change
- Maximum rate of technology change, primarily electrification
- Maximum deployment of land use and agriculture mitigation measures

High Hydrogen – Deliver many high ambition policies, with a focus on hydrogen (high cost and risk)

- High level and rate of behaviour change
- High level and rate of technology change, with maximum uptake of hydrogen
- High deployment of land use and agriculture measures

Balanced – Deliver many high ambition policies, with mix of targeted interventions (high cost and risk)

- High level and rate of behaviour change
- High level and rate of technology change, with selected support for hydrogen
- Medium deployment of land use and agriculture measures

④ **Long-term action** should monitor progress and adjust approach based on outcomes and national developments

Adjust approach and implement further measures where necessary, for example:

- Adjustment of strategies based on achieved level of deployment and changes in National Policy – e.g. balance between behaviour change and technology change, change focus of incentives
- Stronger regulatory measures to encourage uptake
- Stronger financial incentives for technology uptake
- Incorporating innovative technologies and techniques
- Adjustment of training programmes to meet skills shortages

---

1. The Max ambition pathway targets the fastest feasible rate of decarbonisation, with a focus on delivering as many emissions savings as possible by 2030 but necessarily relies on currently mature technologies

Action plan – Transport

Key[1]
Policy with higher significance for WY
Policy with higher significance for YNY

2020 | **Priority Actions and Evidence** | **2025 at latest** | **Max implementation of policy** | **2030** | **Adjustment and enhancement** | **2038**

Priority Actions (common across pathways)

- Develop an overarching strategy for road space reallocation
- Develop a region-wide parking strategy, including reducing on-street parking, banded parking charges and workplace parking levies
- Develop and implement a region-wide cycling and walking strategy and accelerate development and implementation of LWCIPs
- Develop a regional electric vehicle charging infrastructure strategy, including a procurement framework
- Expand reach and control over bus offering, e.g. through considering bus franchising or an Enterprise Partnership
- Implement flexible and integrated ticketing across transport services
- Invest in digital infrastructure
- Run a major publicity campaign to encourage behaviour change
- Invest in training to develop local skills in zero emission technology
- Influence Government to deliver policy that supports climate ambition
- Work with partners to limit road building and decarbonise rail

Evidence gathering (in parallel with priority actions)

- Assess local suitability of implementing traffic control measures such as zero emissions zones, traffic circulation plans and 20mph limits
- Assess local feasibility of freight consolidation and cycle freight in key delivery locations
- Assess feasibility and demand for passenger and freight rail services to determine capacity upgrade and develop strategy
- Support and deliver trials of innovative services and shared mobility
- Work with LAs to establish how best to use local planning policy to incentivise delivery of measures
- Engage with local fleets to understand their plans and raise awareness
- Engage with key stakeholders to understand plans for gas in transport
- Assess National Government support, priorities, and regulation

Decision on pathway by latest 2025

Max ambition

- Strong local and regional policy to support modal shift and technology change
- Maximum rate of expansion of active travel infrastructure, public transport services and chargepoint network
- Strong financial incentives offered to facilitate maximum rate of modal shift and zero emission vehicle uptake
- Rapid conversion of public fleets to zero emission vehicles
- Engagement with NPg to ensure electricity grid capacity upgrades are delivered to support transition

High Hydrogen

- Strong local and regional policy to support modal shift and technology change
- High rate of expansion of active travel infrastructure, public transport services and charging infrastructure
- Some financial incentives offered to facilitate high rate of modal shift and zero emission vehicle uptake
- Rapid conversion of public fleets to zero emission vehicles
- Engagement with NGN and fleet operators to ensure H_2 refuelling station rollout in region to meet demand

Balanced

- Strong local and regional policy to support modal shift and technology change
- High rate of expansion of active travel infrastructure, public transport services and charging infrastructure
- Some financial incentives offered to facilitate high rate of modal shift and zero emission vehicle uptake
- Rapid conversion of public fleets to zero emission vehicles
- Engagement with NGN to align targeted H_2 refuelling rollout, and NPg to ensure targeted electricity upgrades

Evaluate progress and implement further measures where necessary, for example:

- Adjustment of strategies based on achieved level of deployment and changes in National Policy
- Stronger regulatory measures to encourage uptake, such as through local planning requirements (if possible)
- Stronger financial incentives for technology uptake (e.g. scrappage schemes) , including support for HGV fleets
- CA/LEP-supported decarbonisation of rail, where feasible
- Support for rollout of innovative technologies and techniques, such as vehicle-to-grid, smart systems and H_2 fuel cell trains (as appropriate)
- Adjustment of training programmes to meet skills shortages

---

1. Policies with higher relevance for urban areas, such as traffic flow measures, parking restrictions, and freight consolidation, are considered more relevant for WY

Action plan – Buildings

2020 | **Priority Actions and Evidence** | **2025 at latest** | **Max implementation of policy** | **2030** | **Adjustment and enhancement** | **2038**

Priority Actions (common across pathways)

- Set up a ‘One-stop shop’ for energy efficiency and low carbon heating
- Develop a regional retrofit strategy for existing LA buildings and begin implementation
- Decide appropriate incentives and regulation to drive decarbonisation of private-rented and owner-occupied sectors
- Develop a regional district heat network strategy, including heat zoning policies
- Initiate new low carbon heat network schemes
- Develop a combined solar PV and battery storage offer
- Implement training programmes in energy efficiency retrofit and low carbon heating installation
- Influence Government to deliver policy and support that supports climate ambition

Evidence gathering (in parallel with priority actions)

- Identify skills shortages and gaps in the workforce
- Initiate exemplar and demonstrator projects for high energy efficiency buildings and low carbon heating technology to better understand viability in the local context
- Explore the most appropriate solutions for hard-to-decarbonise homes in the region
- Explore rooftop solar opportunity in the region
- Work with LAs to establish how best to use local planning policy to incentivise delivery of measures
- Engage with key stakeholders to stay informed of H_2 developments
- Assess National Government support, priorities, and regulation

Decision on pathway by latest 2025

Max ambition

- Strong local and regional policy support for energy efficiency, heat networks and electrification of heat
- Maximum retrofit of public sector buildings
- Strong financial incentives offered to facilitate maximum rate of energy efficiency retrofit and heat pump uptake in private sector[1]
- Rapid deployment of district heating networks, either CA/LEP led or in public-private partnership
- Engagement with NPg to ensure electricity grid capacity upgrades are delivered to support transition

High Hydrogen

- Strong local and regional policy support for hydrogen transition (H_2 boilers, hybrid heat pumps, heat pumps in off-gas properties)
- Maximum retrofit of public sector buildings
- Financial incentives in place to support early deployment of hy-ready boilers and hybrid heat pumps (on-gas), and heat pumps (off-gas) among homeowners, businesses and landlords
- Rapid deployment of district heat networks
- Lower and/or more targeted incentives for energy efficiency
- Engagement with NGN to ensure rapid H_2 rollout in region

Balanced

- Strong local and regional policy support for all appropriate measures
- Maximum retrofit of public sector buildings
- Financial incentives offered to support all types of heating as appropriate, and to drive high levels of energy efficiency retrofit by 2034
- Rapid deployment of district heat networks
- Engagement with NGN to align targeted H_2 rollout, and NPg to ensure targeted electricity upgrades

Evaluate progress and implement further measures where necessary, for example:

- Adjustment of strategies based on achieved level of deployment and changes in National Policy
- Stronger regulatory measures to encourage uptake, such as through local planning requirements (if possible)
- Stronger financial incentives for technology uptake (e.g. scrappage schemes) and energy efficiency
- Support for rollout of innovative technologies and techniques, such as battery-to-grid and smart systems
- Adjustment of training programmes to meet skills shortages
- Development of public-led business models for communal and district heating

---

1. Homeowners, private landlords and businesses

Action plan – Power

Key

Policy with higher significance for YNY

2020 | Priority Actions and Evidence | 2025 at latest | Max implementation of policy | 2030 | Adjustment and enhancement | 2038

Priority Actions (common across pathways)

- Complete regional spatial energy planning including determining favourable sites for generation (especially onshore wind), storage technologies and infrastructure development.
- Support infrastructure investments by efficiently granting planning permissions, aiding studies to identify regional requirements and gathering evidence for national funding applications.
- Develop and set up a finance scheme for supporting small to medium scale renewable generation and flexibility projects, encouraging joint installation of storage and generation.
- Setup a platform and grant scheme for community energy projects.
- Engage with EfW operators to develop decarbonisation strategies and ensure any new facilities will be CCUS ready.
- Run awareness campaigns to inform the public on potential benefits of CCUS, hydrogen, BECCS and onshore wind projects.
- Influence government for funding for infrastructure and CCUS projects, RD&D & facilitation of hydrogen generation, requiring CCUS readiness with EfW plants.

Evidence gathering (in parallel with priority actions)

- Identify current and future skills shortages and gaps in the workforce
- Support national RD&D funding applications, offer top-up financial support and coordinate national and regional stakeholders to provide evidence base for flexibility projects (storage/DSR), EfW CCS, hydrogen generation, CCS business models.
- Engage with LAs to establish how best to use local planning policy to incentivise delivery of measures
- Assess National Government changing support, priorities, and regulation

Decision on pathway by latest 2025

Max ambition

- Maximal level of support for community energy projects.
- Support RD&D for additional power flexibility evidence gathering and new technologies/schemes.
- Update local energy plans with additional areas and infrastructure dedicated for solar PV and onshore wind.
- Support local workforce training prioritizing solar and wind installers/maintainers and networks technicians.
- Support CCUS and CO$_2$ transport and storage planning as soon as possible and complete CCUS retrofits quickly.

High Hydrogen

- Medium level of support for community energy projects.
- Support RD&D for additional hydrogen power evidence gathering support feasibility studies in the region and Influence national government for investment in the region.
- Support local workforce training, focusing on H$_2$ related skills.
- Update local energy plans with additional areas and infrastructure dedicated for hydrogen power plants.
- Support CCUS and CO$_2$ transport and storage planning and achieve progress with CCUS retrofits.

Balanced

- High level of support for community energy projects.
- Support RD&D for additional flexibility evidence gathering.
- Update local energy plans with additional areas and infrastructure dedicated for solar PV and onshore wind.
- Support local workforce training with an emphasis on solar and wind installers/maintainers.
- Support CCUS and CO$_2$ transport and storage planning and implementation.

Evaluate progress and implement further measures where necessary, for example:

- Adjustment of strategies based on achieved level of deployment and changes in National Policy
- Stronger regulatory measures to encourage uptake, such as through local planning requirements (if possible)
- Stronger financial incentives for technology uptake (e.g. grants and direct investments).
- Support for rollout of innovative technologies and techniques, such as battery-to-grid and smart systems
- Adjustment of training programmes to meet skills shortages
- Acceleration of public-led business models for DSR, battery and renewables.

EfW: Energy from Waste; CCUS: Carbon Capture, Utilisation and Storage; BECCS: Bioenergy CCS; RD&D Research, development and demonstration; DSR: demand side response; CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership; WY: West Yorkshire; YNY York & North Yorkshire

Action plan – Industry

Key
Policy with higher significance for YNY

2020 | **Priority Actions & Evidence** | **2025 at latest** | **Max implementation of policy** | **2030** | **Adjustment and enhancement** | **2038**

Priority Actions (common across pathways)

- Support infrastructure investments through spatial planning, efficiently granting planning permissions, aiding studies to identify regional requirements and gathering evidence for national funding applications.
- Support/facilitate RD&D on industrial equipment & other measures (see below).
- Support decarbonisation feasibility studies of large industrial sites.
- Establish a financial support programme for deploying energy and resource efficiency measures (or extension of REF).
- Setup a green public procurement programme.
- Run awareness raising campaigns on circular economy and CCS/H_2.
- Influence government for funding for infrastructure and CCUS projects, RD&D & facilitation of hydrogen/electrification fuel switching, developing green procurement guides and stricter industrial emissions limits/trajectories

Evidence gathering (in parallel with priority actions)

- Identify skills shortages and gaps in the workforce by studying key low-carbon technology supply chains.
- Work with LAs to establish how best to use local planning policy to incentivize delivery of measures.
- Support national RD&D funding applications, offer top-up financial support and coordinate national and regional stakeholders to gain further evidence on: industrial fuel switching; resource efficiency and development of circular economy practices; HSE and regulatory practices around hydrogen; CO_2 utilization options.
- Fully map existing technologies, sites and processes in the region.
- Assess National Government support, priorities, and regulation

Decision on pathway by latest 2025

Max ambition

- Implement a small industry/SME financial support scheme focusing on early electrification.
- Support large industry fuel switching/CCS via applications for national funds and supplementary financial incentives.
- Support local workforce training, focusing on electrification related jobs such as heat pump installers.
- Update regional planning regarding CCS in accordance with new evidence and regional developments.

High Hydrogen

- Implement a small industry/SME financial support scheme focusing on hydrogen fuel switching.
- Swift completion of H_2 zoning and enforcement of H_2 readiness requirements of equipment.
- Support large industry fuel switching/CCS via applications for national funds and supplementary financial incentives.
- Support local workforce training, focusing on H_2 related jobs.
- Update regional planning regarding hydrogen infrastructure in accordance with new evidence and regional developments.

Balanced

- Implement a small industry/SME financial support scheme focusing on all technologies.
- Support large industry fuel switching/CCS via applications for national funds and supplementary financial incentives.
- Support local workforce training, focusing on electrification hydrogen and circular economy related jobs.
- Update regional planning regarding CCS and H_2 infrastructure in accordance with new evidence and regional developments.

Evaluate progress and implement further measures where necessary, for example:

- Adjustment of strategies based on achieved level of deployment and changes in National Policy
- Stronger regulatory measures to encourage uptake, such as through local planning requirements (if possible)
- Stronger financial incentives for technology uptake (e.g. scrappage schemes, direct investments, etc.) and energy efficiency
- Support for rollout of innovative technologies and techniques, such as demand side response, CO_2 utilisation, Direct Air Capture
- Adjustment of training programmes to meet skills shortages

REF: Resource Efficiency Fund; CCUS Carbon Capture Utilisation and Storage; RD&D Research, Development and Demonstration

Action plan – LULUCF and agriculture

Key
Policy with higher significance for YNY

2020 | **Priority Actions and Evidence** | **2024 at latest** | **Max implementation of policy** | **2030** | **Adjustment and enhancement** | **2038**

Priority Actions (common across pathways)

- Develop spatial land use strategy for the region that incorporates local expertise and evidence, and optimizes potential for both climate mitigation and Nature Recovery Network requirements
- Develop region-wide food waste strategy
- Implement public procurement policies to reduce food waste and to reduce red meat and dairy consumption
- Establish a package of support measures to help farmers and landowners choose appropriate interventions
- Run a major publicity campaign to encourage behaviour change
- Influence Government for funding to support climate mitigation measures, development of ELMs to ensure it supports locally-relevant measures, and efficient processes for accessing funding

Evidence gathering (in parallel with priority actions)

- Data collection on:
    - peatland restoration potential
    - carbon intensity of local farming
    - optimal livestock stocking densities
    - extent of food waste along local supply chains
    - carbon sequestration measurement and monitoring techniques
- Stakeholder feedback on proposed implementation measures, perceived barriers and required financial support
- Encourage local farmers to participate in Defra ELM Pilots
- Explore and trial private investment models
- Explore potential markets for end-products of land management practices
- Assess National Government support, priorities, regulation and details of ELMs

Decision on pathway by latest 2024[1]

Max ambition

- Strong local and regional policy support for all appropriate measures
- Strong financial incentives offered to facilitate maximum rate of change
- Strong markets for bioenergy and afforestation end-products in place
- Strong leadership and public messaging for diet change and food waste reduction

High Hydrogen

- Strong local and regional policy support for all appropriate measures
- Some financial incentives in place where appropriate to support afforestation, agroforestry, lowland and upland peat restoration, farming practice changes, and hedgerow planting
- Markets for bioenergy and afforestation end-products in place
- Strong leadership in diet change and food waste reduction
- Moderate public messaging for behaviour change

Balanced

- Strong local and regional policy support for all appropriate measures
- Low or no financial incentives above ELMs to support climate mitigation measures
- Strong leadership in diet change and food waste reduction
- Moderate public messaging for behaviour change

Evaluate progress and implement further measures where necessary, for example:

- Adjustment of spatial land strategy targets based on effectiveness of implemented measures, extent of behaviour change and developments in National policy
- Stronger regulatory measures, such as banning peatland burning or new/stronger local planning requirements for land use
- Stronger financial incentives for climate mitigation measures
- Support for rollout of innovative technologies and techniques
- Public incentives for behaviour change
- Adjustment of advice on machinery fuel switching based on markets and rollout of hydrogen vs electrification etc
- Shift away from short-rotation coppice and miscanthus towards longer-term forestry

ELMs = Environmental Land Management Scheme; 1. In-line with rollout of ELMs

The COVID-19 pandemic has implications for energy use and emissions going forward

- **The scenarios considered in this study were developed prior to the COVID-19 pandemic** and represent changes in energy demand relative to pre-pandemic behaviours and sector trends.
- Travel restrictions and social distancing measures put in place as a result of the pandemic have had a huge impact on the economy and on personal work and travel choices, with a number of associated implications for energy use and a net zero transition, including:

COVID-19 impact	Impact on energy/emissions	Implications for net zero transition
Economic recession – large sections of the economy slowed or ceased operations during lockdowns, with resulting increases in unemployment and delays to supply chains	• **Reduction and delayed growth in travel demand** as travel demand is linked to economic growth • **Reduced overall energy use** – both in domestic and commercial/industrial sectors	• **Reduced household spending power** limiting the competitiveness of new technologies with fossil-based incumbents • **Risk of delay to deployment of technologies** if public spending is cut back, particularly for technologies in demonstration or scale-up phase[1]
Increased working from home – a large proportion of the workforce have worked from home during lockdown and, surveys indicate that those who have worked from home intend to continue doing so more in future[2,3,4]	• **Reduced travel demand** due to commuting • **Change in distribution of energy demand –** Reduced non-domestic energy demand, for example where office space is no longer used, with increase in domestic energy use • **Changes in energy demand profiles**, with flattening of peak demand	• **Contributes to emissions reduction** where overall reduction in travel is maintained • **Complements renewables** where demand patterns match supply more closely
Changes in travel behaviour – increases in cycling and walking for leisure trips, but significant decreases in public transport patronage and capacity, and increases in personal car use as a result of social distancing	• **Reliance on high emissions modes** risks transport emissions surpassing pre-pandemic levels as restrictions ease • **Potential for more trips to be taken using active travel** through increased awareness/experience during lockdown	• **Risk that bus and rail services become unviable** limiting the potential for modal switch, with associated impacts on disadvantaged groups that rely on these services
Changes in purchasing behaviour – with increases in online shopping	• **Increased van and HGV demand**, particularly in retail and grocery sectors	• **Greater challenge in reducing van and HGV use** with greater need to manage growth alongside operational efficiency
Reduction in fossil fuel prices – due to reduced demand, with associated risk to the UK oil and gas sector[5]	• **Potential for higher emissions** where fossil fuel use is favoured over lower emissions alternatives	• Potential **reduced cost-competitiveness of low emissions technologies** however the long-term impacts are uncertain

1. *Energy Technology Perspectives Special Report on Clean Energy Innovation* (2020) IEA; 2. For example, 47% of respondents in Wave 1 of West Yorkshire COVID-19 Survey, June 2020; 3. Ipsos Mori online survey, May 2020; 4. SYSTRA survey, April 2020; 5. Just Transition Commission, Advice for a Green Recovery (2020)

The long-term impact of COVID-19 on the pathways is uncertain but the recovery can benefit both emissions and the economy

- The global response to the pandemic is still evolving, and both the longevity and overall positive or negative effect of its impacts are uncertain; however, many of these impacts are likely to be short-to-medium term.
- The emissions reduction pathways developed in this study all require ambitious action across three key areas with potential to be impacted by COVID-19:
  - **Energy demand reduction** through deployment of building energy efficiency measures, and reductions in travel through a combination of working from home, teleconferencing, co-location of homes and services, and reductions in waste
  - **Shift of travel away from private cars to lower emissions modes** such as shared, public and active travel
  - **Deployment of low carbon technology** including low carbon heating, zero emissions vehicles, industrial fuel-switching, and large-scale deployment of hydrogen and CCS
- The overarching actions that local authorities can take to deliver these pathways are likely to be the same as those available pre-COVID, but the primary impact of the pandemic is on the relative barriers to delivering these actions – either through providing opportunities that make action easier or, conversely, challenges that make action more difficult.

Opportunities: Some trends observed during the pandemic support emissions reduction measures, such as:

- **changes in working patterns** –businesses and employees have rapidly adapted to greater use of teleconferencing and more widespread home working, and a proportion of this is likely to be maintained going forward
- **increases in active travel** – increased interest in walking and cycling presents an opportunity to lock-in positive travel behaviours
- **changing perception of value of air quality** – more people report being willing to consider clean technology, such as an electric vehicle, to retain emissions and air quality benefits[1,2]
- **national funding streams for green recovery** – DfT has continued to develop its decarbonisation strategy,[3] and funding streams to support emergency active travel measures,[4] more efficient homes,[5] and a greener recovery have been announced during the pandemic;[6] although it is noted that this comes alongside conflicting funding announcements such as highways expansion
- **Alignment of funding priorities** – significant funding has been made available to support recovery from COVID-19. If this funding is spent wisely then it is possible that this money can achieve both goals of reducing emissions and supporting recovery

Challenges: The main emerging risks to delivery of the pathways are likely to be:

- **Long-term viability of shared and public transport** – reductions in patronage and restrictions on capacity mean that some services may be lost, particularly in low population density areas; ensuring that these services work for everyone in the future is one of the most important outcomes of a COVID-19 recovery, as it will support emissions reduction and will determine the impact of the transition on disadvantaged groups
- **Ensuring accelerated technology deployment** – delays to low emissions technology deployment due to reduced R&D support and/or supply chain risks have been suggested to result not only in a slower transition – with reduced potential for emissions savings – but also in slower rates of technology cost reduction.[7] The emissions reduction pathways already require strong policy both nationally and locally to deliver technology change at the required rate, and it is not yet clear whether COVID-19 will significantly change the level of support needed or increase the risk of it not being delivered
- **Diversion of local authority resources** away from climate action and towards COVID recovery

1. UK Motor article, April 2020; 2. Baringa, April 2020; 3. Decarbonising transport ; 4.Emergency active travel fund; 5. Green homes grant; 6. Green Recovery Challenge Fund 7. *Energy Technology Perspectives Special Report on Clean Energy Innovation* (2020) IEA

Summary table – Transport. This table shows how the modelled outcomes map to the measures and through to the required policies and actions

Sector	Modelled outcome	Measure	Roadmap theme	Policies and actions to deliver measure[1]
Transport	**Decreased private car use**	Decreased travel demand	Cars	**T1**, **T2**, T13, **T16**, **T19**
		Increased walking and cycling	Active travel	**T1**, T2, **T3**, T4, T6, T13
		Increased public transport use	Bus and rail	**T1**, T2, T6, **T7**, T8, T9, T11, T13, **T18**, T24
		Increased shared car use	Cars	**T1**, T2, T6, T13, **T15**, **T18**
	Decreased van and truck use	Consolidation and shift to cycle freight	Vans and HGVs	T10
		Shift from road to rail[2]	Vans and HGVs	T11
	Low emissions technology	Low emissions cars	Cars	**T5**, T6, T12, T16, **T18**, T19
		Low emissions vans and HGVs	Vans and HGVs	**T5**, T12, T17, **T18**, T19, T20, T21
		Low emission buses	Bus and Rail	**T7**, T22
		Electrification of trains and/or lines	Bus and Rail	T23, T24
	Decreased aviation emissions	Decreased flight demand	*Not included*	T24
		Aircraft support vehicle electrification	*Not included*	*Not included*

YNY transport results
Transport roadmap
Technical Appendix

1. Policies in bold represent direct delivery of funding or measures by the CA/LEP, other policies are considered supporting actions; 2. Note that modal shift to water transport (e.g. canals or rivers) was outside the scope of this study

Summary table – Buildings. This table shows how the modelled outcomes map to the measures and through to the required policies and actions

Sector	Modelled outcome	Measure	Roadmap theme	Policies and actions to deliver measure[1]
Buildings	**Improved energy efficiency**	Retrofit existing public buildings	Energy efficiency	**B2**, B5, B9, B10, **B11**
		Retrofit existing private buildings		B1, B5, B9, B10, **B11**, B13
		High standards for new buildings		B8, **B11**, B13
	Switch to district heating	Deploy district heating	District heating	B3, **B4**, B5, B13
	Switch to low carbon heating	Large-scale deployment of heat pumps	Heat pumps	B5, B10, **B11**, B13
		Deploy hybrid heat pumps		B5, B10, **B11**, B13
		Deploy H_2 boilers	H_2 boilers	B5, B10, B12, B13
	Rooftop solar PV	Deploy rooftop solar PV	Other	B6, **B7**, B8

YNY buildings results
Buildings roadmap
Technical Appendix

---

1. Policies in bold represent direct delivery of funding or measures by the CA/LEP, other policies are considered supporting actions

Summary table – Industry and Power. This table shows how the modelled outcomes map to the measures and through to the required policies and actions

Sector	Modelled outcome	Measure	Roadmap theme	Policies and actions to deliver measure[1]
Industry	**Increased efficiency**	Increased energy efficiency	Efficiency	I3, I4, I5, **I7**, **I10**, I11, I12, I14,
		Increased material efficiency/circularity	Efficiency	I3, I4, I5, **I7**, **I10**, I11, I12, I13, I15
	Decreased industrial carbon intensity	Increased electrification	Fuel Switching	I1, I2, I3, I4, I5, I6, **I8**, **I9**, **I10**, I11, I12, I14,
		Fuel switch to hydrogen	Fuel Switching	I1, I2, I3, I4, I5, I6, **I8**, **I9**, **I10**, I11, I12, I13, I14
		Fuel switch to bioenergy	Fuel Switching	I1, I3, I4, I5, **I8**, **I9**, **I10**, I11,
		Install CO$_2$ capture	CO$_2$ Capture	I1, I2, I3, I6, **I8**, **I10**, I11, I12, I13, I16
Power	**Larger-scale low carbon generation**	CCS retrofits to large biomass and fossil plants	Bioenergy and Large Fossil	P1, P4, P5, **P7**, P12
		Deployment of hydrogen generation	Other	P1, P4, P5, **P7**, P12, P13, P14
		Decarbonisation of EfW	Large EfW	P1, **P2**, P4, P5, **P7**, P9, P10, P11, P12
	Smaller scale low-carbon generation	Solar PV and onshore wind deployment	Solar and Wind	P1, **P2**, P5, **P6**, **P7**, **P8**, P12, P13, P14
		Limited expansion of AD & small bioenergy	Bioenergy	P1, **P2**, P11
	Infrastructure and flexibility[2]	Flexibility technologies (e.g. storage, DSR)	Other	P1, **P2**, P4, **P6**, **P7**, **P8**, P12, P15, P13, P14
		New infrastructure	*Not included*	P1, P3, P12, P15, P13, P14

YNY industry results
Industry roadmap

Industry Technical Appendix

YNY power results
Power roadmap

Power Technical Appendix

EfW: energy from waste; AD: anaerobic digestion; DSR: demand side response

1. Policies in bold represent direct delivery of funding or measures by the CA/LEP, other policies are considered supporting actions 2. not explicitly modelled

Summary table – LULUCF and agriculture. This table shows how the modelled outcomes map to the measures and through to the required policies and actions

Sector	Modelled outcome	Measure	Roadmap theme	Policies and actions to deliver measure[1]
LULUCF + agriculture	**Negative emissions through carbon sequestration**	New forest planting	Afforestation	L1, L2, L4, L5, L8, L10, **L11**, L12, L14, L15, L16
		Peatland restoration[1]	Peatland restor.	L1, L2, L4, L5, L8, **L9**, L10, **L11**, L12, L15, L16
		Agroforestry	*Not included*	L1, L2, L4, L5, L10, **L11**, L16
		Hedgerow increase	Agri measures and other	L1, L4, L5, L10, **L11**
		Increase in biomass crops		L1, L4, L5, L10, **L11**, L14
	Increased land availability and reduced agricultural emissions	Reduced red meat and dairy consumption	Diet and waste	L6
		Food waste reduction		L2, L3, L5, **L6**, **L7**, L8, **L11**, L15
		Increased stocking density	Agri measures and other	L1, L2, L4, L5
		Indoor horticulture		L4, L5, L13
		Improved crop yields	*Not included*	L4, L5, **L11**
		Other agricultural practices		L1, L4, L5, **L11**, L13
	Reduced emissions from agricultural machinery	Machinery fuel switching	Agri measures and other	L4, **L11**

YNY LULUCF results
LULUCF roadmap
Technical Appendix

LULUCF = Land use, land use change and forestry; 1. Policies in bold represent direct delivery of funding or measures by the CA/LEP, other policies are considered supporting actions; 2. Peatlands are currently an emissions source and do not become a sink within the timeframe of the emissions pathways

Link to contents

The main report includes some additional discussion sections to highlight particular features and co-benefits associated with the pathways, as well as external influences.

Discussion

The main report also includes wider discussion on the below topics:

1. **Scenario features** – overview of the key features of each scenario, including a summary of opportunities, risks and challenges, investment, infrastructure, skills and consumer considerations.
2. **Covid-19** – overview of the implications of Covid-19 for the energy transition, including the key opportunities and risks[1].
3. **Impact of National policy** and decisions on regional progress and targets. For example national regulations, research programmes, financial support and decisions (e.g. the future of heat decarbonisation)
4. **Co-benefits** – a summary of the co-benefits associated with climate action, for example health benefits, job creation, inclusive growth, circular economy measures, knowledge creation and skills development.
5. **Offshore wind** – outside the scope of the study, but discussed at high-level to ensure opportunity is considered in terms of the potential skills and investment in related manufacturing or infrastructure.

Technical Appendix

The Technical Appendix provides further detailed information to support the results. This includes:

- The assumptions underpinning the emissions scenarios for each sector.
- Information on the granularity of the subregion modelling, the emissions pathways for the Leeds City Region and the impact of not having CCS.
- Quantitative information on all the deployed measures to underpin the implementation roadmap.
- Information to support the policies and action plans, such as references of best practise and policy costing.
- Mention of additional factors outside the scope of this study, such as carbon offsetting, air quality, scope 3 emissions and SF6 emissions.

---

[1] also show in this executive summary

Glossary and Terminology

Term	Meaning
AD	Anaerobic digestion
BECCS	Bioenergy with carbon capture and storage
BEV	Battery electric vehicle
BioCNG	Compressed natural gas, 100% biomethane
CA	Combined Authority (WYCA)
Capex	Capital expenditure
CCGT	Combined cycle gas turbine (power plant)
CCS	Carbon capture and storage
CHP	Combined heat and power
$CO_{2(e)}$	Carbon dioxide (equivalent)
DSR	Demand side response
EfW	Energy from waste[1]
EV	Electric vehicle
FCEV/H2FC	(Hydrogen) Fuel Cell Electric vehicle
H_2	Hydrogen (as a fuel)
H2GT	Hydrogen gas turbine (power plant)
Ha (kha)	Hectares (land area)
HGV	Heavy good vehicle
HHP	Hybrid heat pump
kW (MW, GW)	Kilowatt – unit of power

Term	Meaning
kWh (MWh etc)	Kilowatt hour – unit of energy
LA	Local Authority
LEP	Local Enterprise Partnership
LPG	Liquefied petroleum gas
LULUCF	Land Use, Land Use Change and Forestry
MBT	Mechanical biological treatment (of waste)
$MtCO_2e/yr$	Mega tonnes of CO_2 equivalent per year
Opex	Operational expenditure
Passenger km	Passenger travel activity (number of passengers x average distance travelled)
PHEV	Plug in hybrid electric vehicle
(Solar) PV	Solar Photovoltaic (electricity generation)
R&D	Research and development
T&S	Transport and storage
Tonne km	Freight travel activity (tonnes lifted x average distance transported)
Vehicle km, vkm	Vehicle transport activity (number of vehicles x average distance travelled)
WYCA	West Yorkshire Combined Authority
Y&NY	York and North Yorkshire
£m	£ million

[1] Energy from waste (EfW) includes electricity only EfW, EfW CHP, waste based AD and power from cooking oil, sewage sludge digestion and landfill gas.

Contents

Introduction: Main report body and sectoral pathways give further details on the interventions in each sector

The emissions trajectory for each sector is broken down further

- The purpose of this section is to provide an overview of the pathway results for each of the sectors below in turn. Note that waste is included at a very high-level for completeness of emissions accounting.

Transport	Buildings	Power	Industry	Land Use

- It is more detailed than the key findings section, as it breaks each sector down into the subsectors and explains some of the key measures and drivers behind the scenarios.

- For each sector, the section covers:
  - Current emissions and state for the region
  - Baseline pathway and then the 3 emissions reduction pathways, including the emissions remaining in 2030 and 2038
  - Comparison of the pathways and key differences
  - Conclusions and key messages

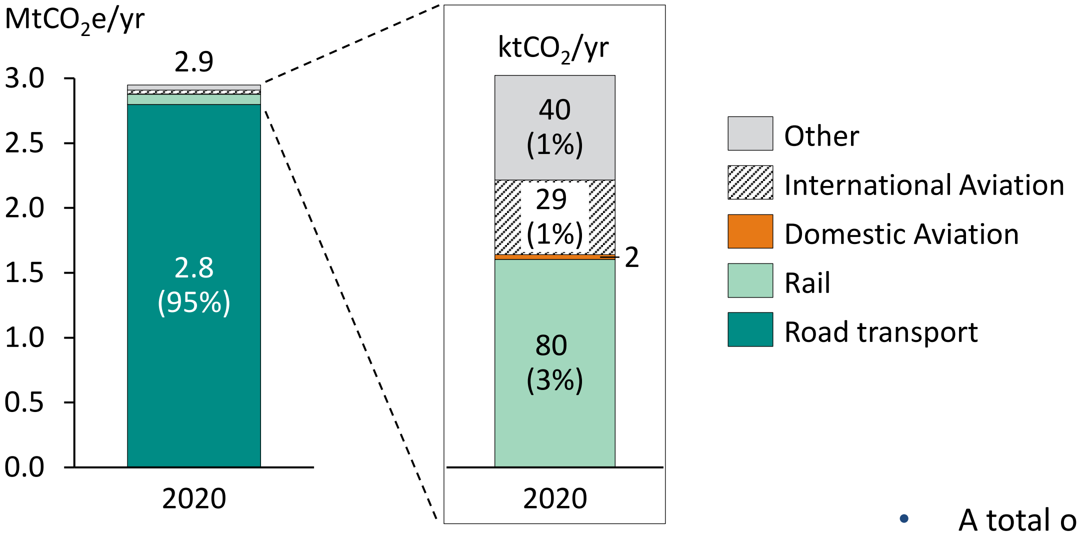
- The sections finishes with some key supporting information, such as the scope of emissions included, cross-sectoral hydrogen generation, and a summary of bioenergy end-uses.

- For those interested in the details and assumptions, a supporting Technical Appendix can be provided, including the key modelling assumptions

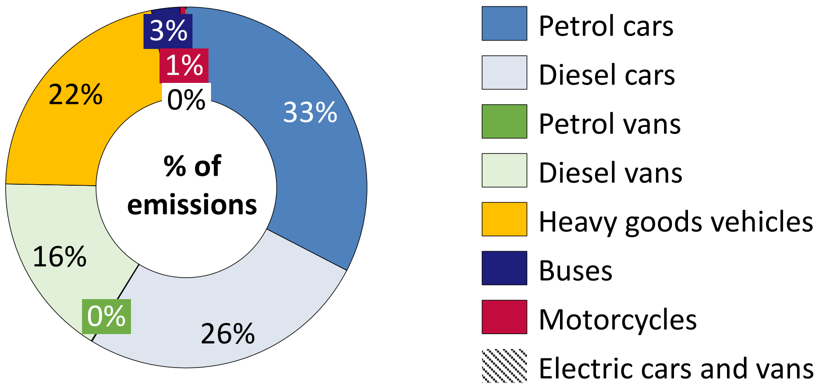
Contents

Current (modelled 2020) emissions situation in York & North Yorkshire - transport

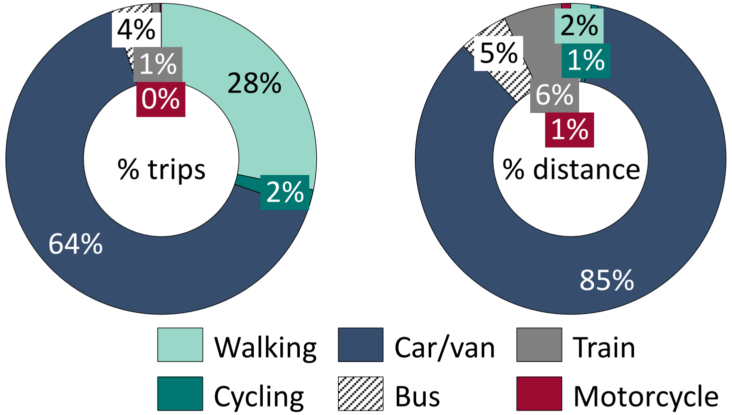
Current emissions in York & North Yorkshire[1]



Road transport emissions by vehicle and fuel type



Passenger travel by mode[3]

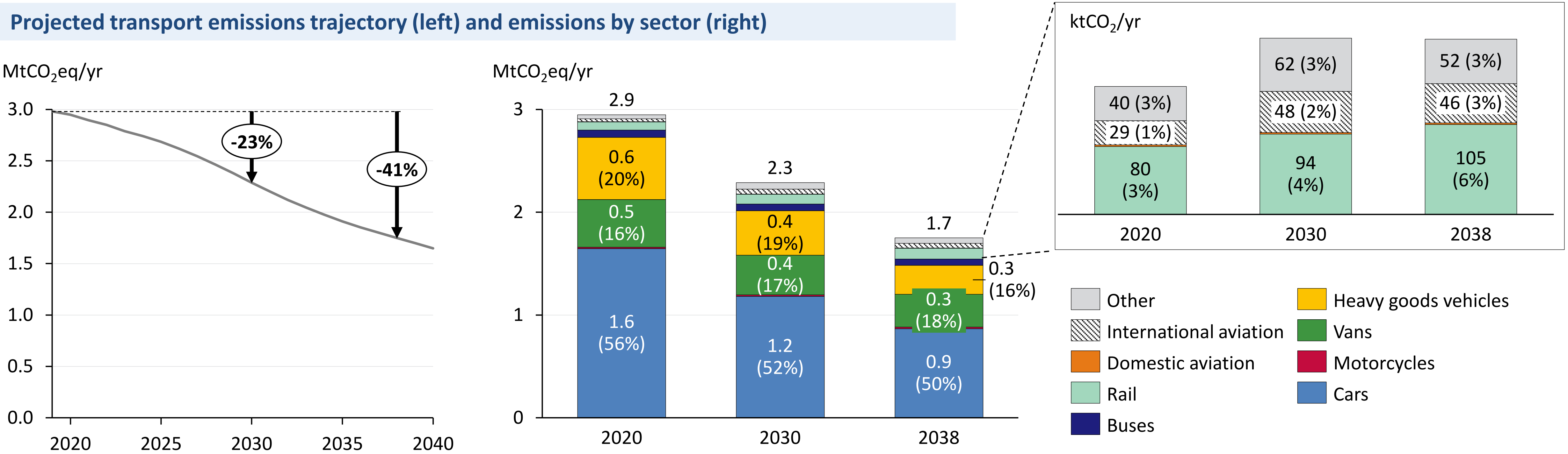


- A total of 2.9 MtCO$_2$e/yr are emitted across all forms of transport in the region
- **95% of transport emissions are due to road transport,** with more than three-quarters of road transport emissions due to cars and vans; more than 99% of vehicles have conventional fossil fuel engines (less than 0.5% of cars and vans are plug-in hybrids or battery electric)
- **More than half of non-road transport emissions are due to rail, while aviation contributes a relatively small proportion** of emissions (20% non-road transport emissions, 1% total emissions). It should be noted that the contribution of aviation was calculated at a **high-level**, scaled from national emissions in line with the proportion of passengers using Leeds Bradford Airport,[2] and therefore should be considered **indicative only**. (See Appendix for details)
- A higher share of passenger journeys are taken by car in York & North Yorkshire than the average for England (85% of distance travelled in Y&NY compared to 78% for England), whereas a below average number of journeys use rail (5% of distance travelled by rail in Y&NY compared to 10% for England)[3]

1: Aviation emissions are estimated by scaling from the UK National Inventory in-line with relative passenger numbers; Other transport emissions include coal railways, airport support vehicles and combustion of oils and lubricants; 2. 1.7% in 2017, representing 5% of passengers from Study Region LA's. Source: Civil Aviation Authority statistics; 3. Based on National Travel Survey data for 2016

The Baseline scenario represents the likely outcome with current policies alone, with limited emissions reduction

Projected transport emissions trajectory (left) and emissions by sector (right)



- The Baseline scenario represents the likely outcome if **no additional policies are put in place** to drive low emissions vehicle uptake beyond those in place today;[1] however, considering the UK's commitments to emissions reduction, it is unlikely that this will be the case and as such this scenario should be considered to represent **a realistic lower bound of possible future trajectories** that is **far from reaching national targets.**
- **Under this scenario, total transport emissions decrease by 23% by 2030 and 41% by 2038,** with remaining emissions of 2.3 $MtCO_2e$ in 2030 and 1.7 $MtCO_2e$ in 2038. Cumulative emissions from transport reach 29 $MtCO_2e$ between 2020 and 2030, and 45 $MtCO_2e$ by 2038.
- Road transport experiences the largest decrease in emissions due to uptake of low emissions technologies, whereas rail and aviation experience increased emissions due to increased passenger numbers and limited change in technology.

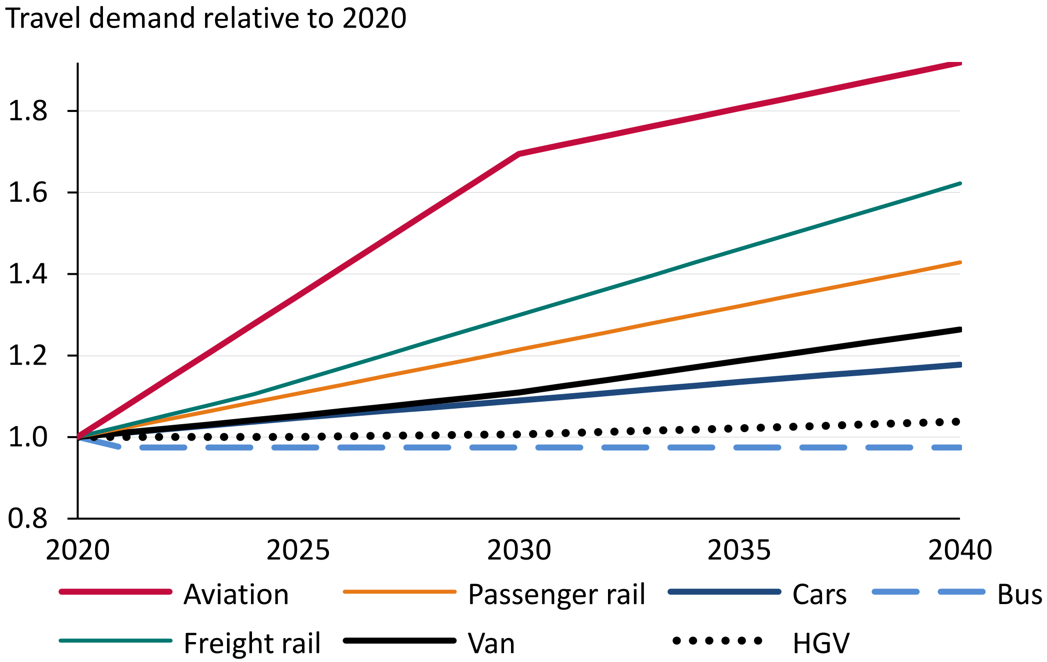
Y&NY

---

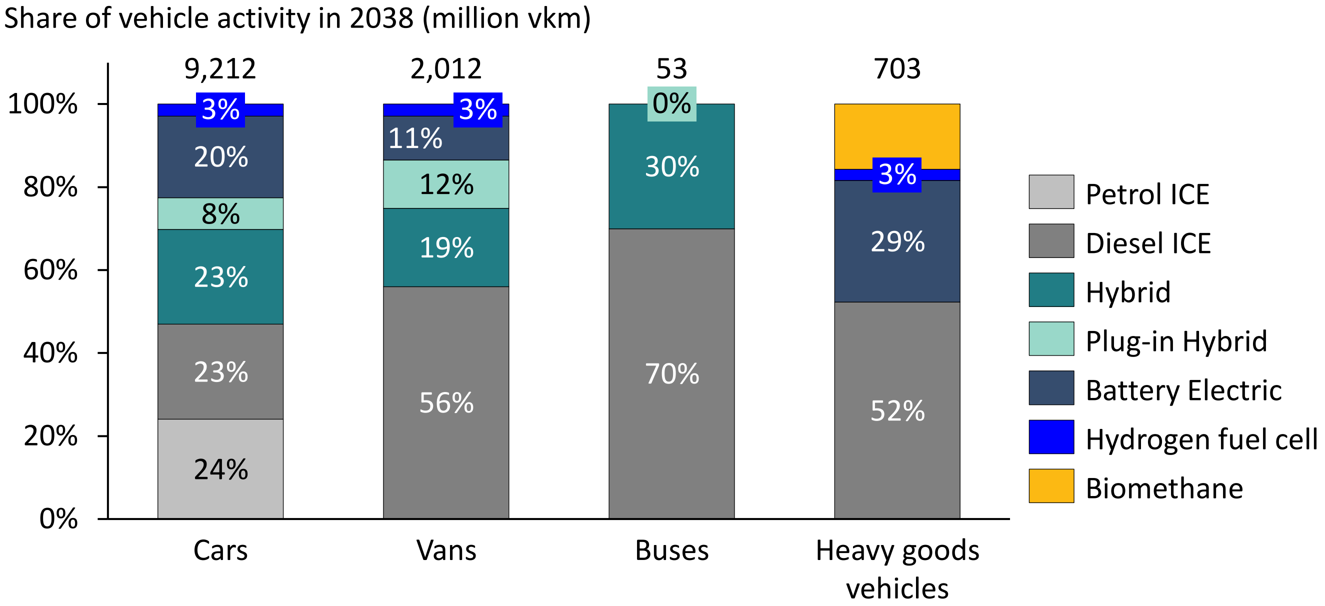
1. This includes existing and announced tax incentives and grants but does not reflect ambitions that do not currently have supporting policy defined, such as targets set out in the government's Road to Zero strategy; Note that these scenarios were developed before the release of the government's 10 Point Plan in November 2020.

Baseline emissions reductions are driven by improvements in conventional technology and limited low emissions vehicle deployment

Growth in travel demand across modes in the Baseline scenario



Road vehicle technology mix in 2038 in the Baseline scenario



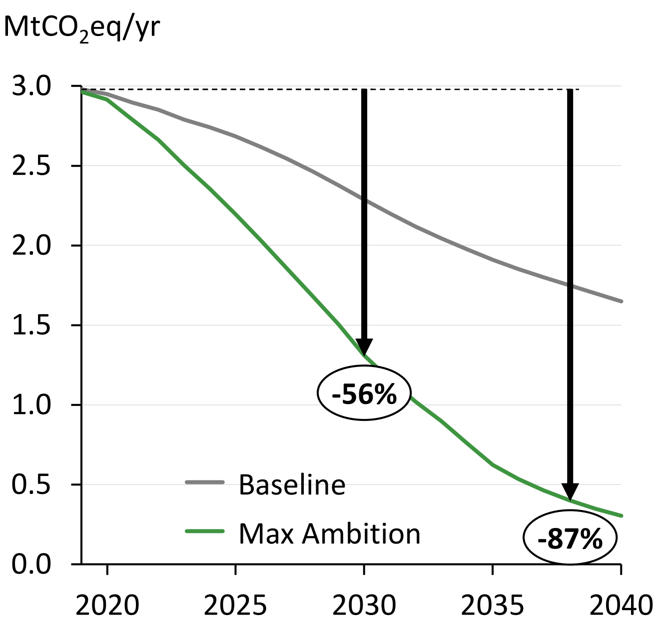
- **Travel demand and activity** – represented by vehicle kilometres (vkm), passenger kilometres or freight tonne kilometres[1] – **increases across all transport types**, with the exception of buses (see technical report for detailed assumptions), and private cars are expected to remain the dominant mode of travel
- Reductions in emissions are a result of improvements in internal combustion engine (ICE) vehicle fuel efficiencies[2] and a shift away from pure ICEs in road transport
- In the absence of strong national or local policy to drive uptake, the shift to low emissions vehicles is primarily driven by EU manufacturer emissions targets, reductions in battery costs and improvements in electric vehicle range[3]
- Fossil fuel vehicles (including petrol, diesel and hybrid) are still the dominant technology, making up more than half of each vehicle fleet

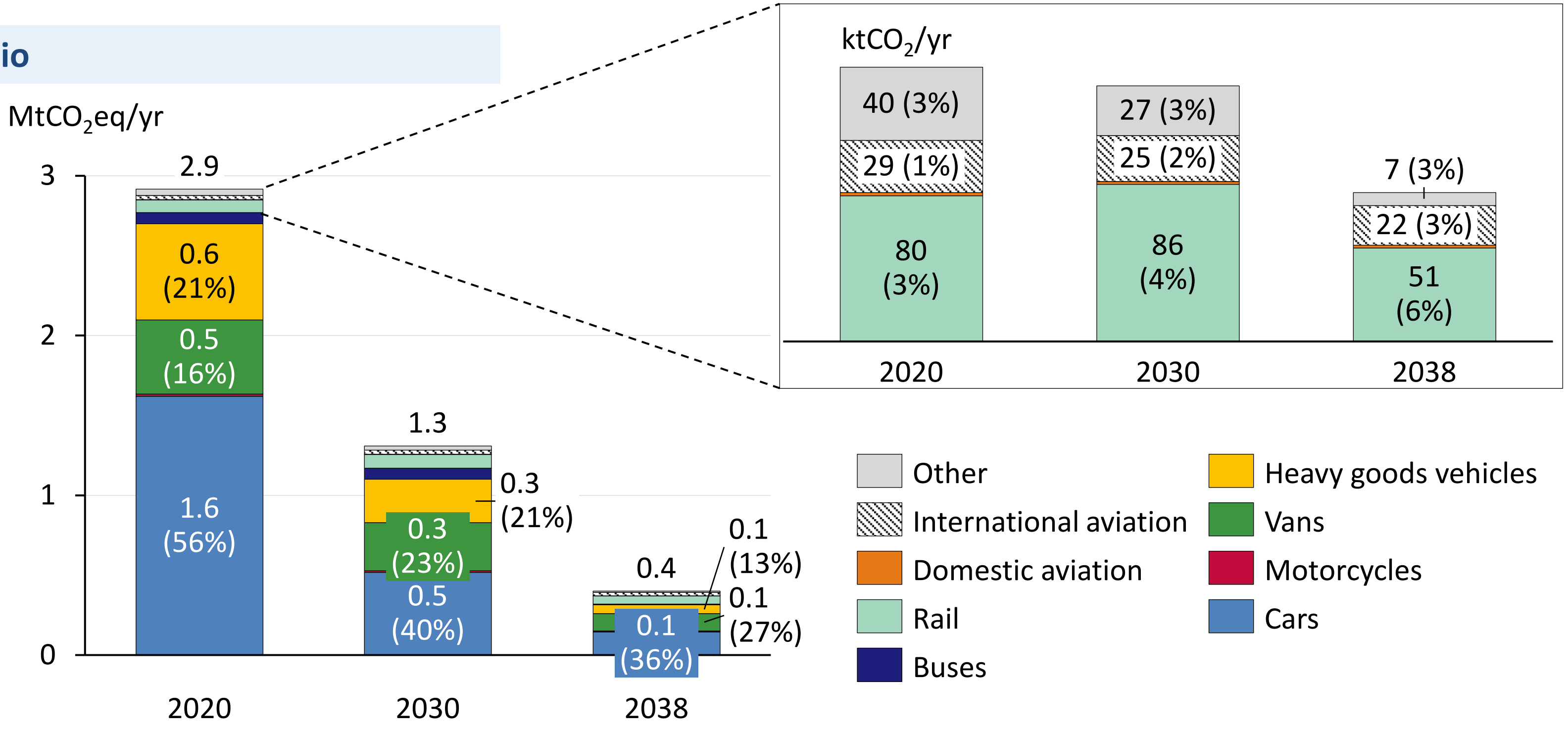
---

1. Vehicle km, passenger km and tonne km are measures of traffic, passenger and freight flow, determined by multiplying the number of vehicles, passengers or tonnes lifted by the average length of their trips; 2. For example, a diesel car improves by 15% by 2030 compared to 2020; 3. Assumptions in line with Element Energy modelling for DfT (ECCo)

The Max Ambition scenario assesses technology and policy requirements to decarbonise as quickly as possible

Transport emissions under the Max ambition scenario



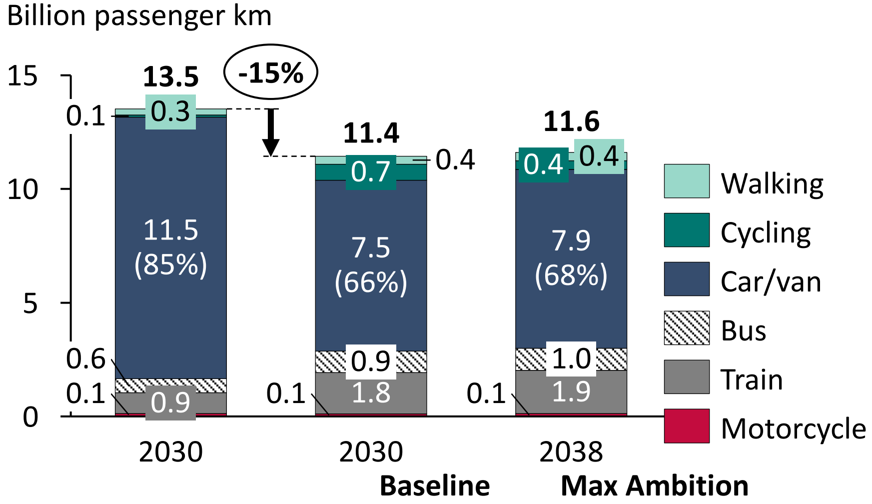


- The Max ambition scenario represents the **fastest feasible rate of emissions reduction**, achieved through a combination of rapid uptake of low emissions technology, reduction in overall travel demand and ambitious shift of both passengers and freight from high emissions modes (e.g. private cars, heavy goods vehicles) to low emissions modes (e.g. walking, cycling, rail)
- **Under this scenario, transport emissions decrease by 56% by 2030 and 87% by 2038,** with remaining emissions of 1.3 MtCO$_2$e in 2030 and 0.4 MtCO$_2$e/yr in 2038. Cumulative emissions from transport reach 22 MtCO$_2$e between 2020 and 2030, and 29 MtCO$_2$e by 2038 (46% decrease compared to the Baseline).
- All transport types experience decreased emissions; however, as road transport emissions decrease, the relative contribution of rail, aviation and other transport to the overall sector emissions increases (12% in 2038 compared to 7% in 2020)

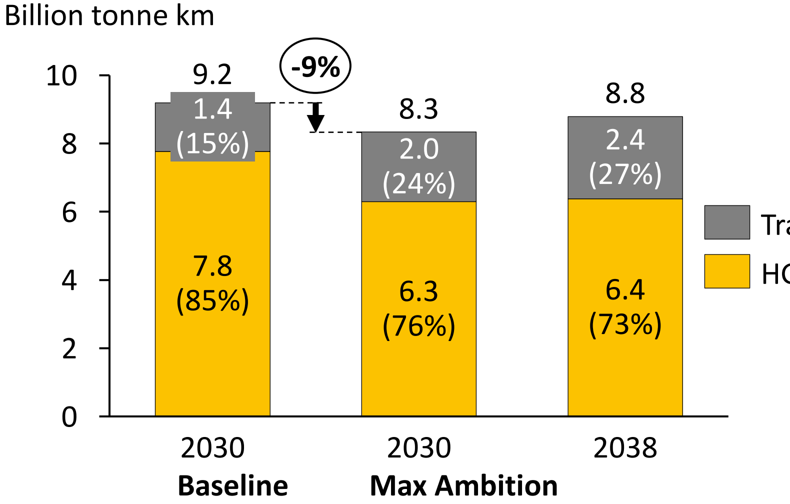
The Max ambition scenario requires ambitious changes in travel behaviour across all transport types over the next ten years

- Even with the maximum feasible rate of zero-emission vehicle roll-out, limited vehicle supply and stock turnover rates mean that rapid emissions reduction cannot be achieved through technology alone and must be supported by measures to reduce demand for travel and to shift journeys to more sustainable options
- **Compared to the Baseline**, in this scenario the maximum level of demand reduction and journey shift considered feasible is achieved by 2030, resulting in **private car use decreasing by 48%**, **van activity decreasing by 10%** and **heavy goods vehicle activity decreasing by 19%**[1]
- Significant reductions in passenger travel demand (15%) are assumed to be achieved through measures such as increased home working, teleconferencing, and closer proximity of housing to workplaces and amenities, while freight travel demand is reduced through measures such as consolidation, and reduction in food and consumer goods waste (10% for vans and 11% for heavy goods vehicles).
- **Close to half (45%) of remaining private car use (vkm) is shifted to public, shared and active travel**,[2] requiring (relative to Baseline):
  - **Car sharing to increase,** with 14% of car vehicle km shifting to shared cars (either car clubs or car sharing)
  - **Walking km to increase by over a third** (360m km in 2030) and **cycling km to increase by almost a factor of 9** (700m km in 2030)
  - **Public transport capacity to increase,** with passenger km increasing by two thirds for buses and doubling for trains by 2030
- **10% of freight is shifted from heavy goods vehicles to rail**, while **2% of van traffic is replaced by cycle freight**
- Domestic aviation demand is reduced by 20% relative to the Baseline[3] while international aviation is maintained at current levels[4]

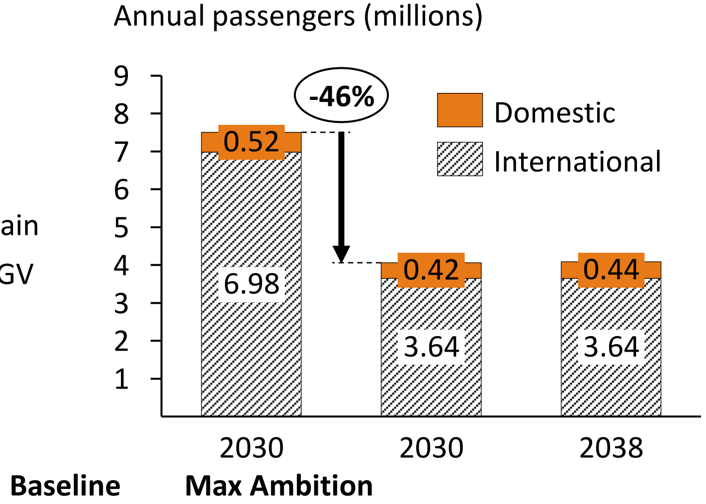
Passenger travel demand



Freight travel demand



Aviation demand (Study Region)[5]

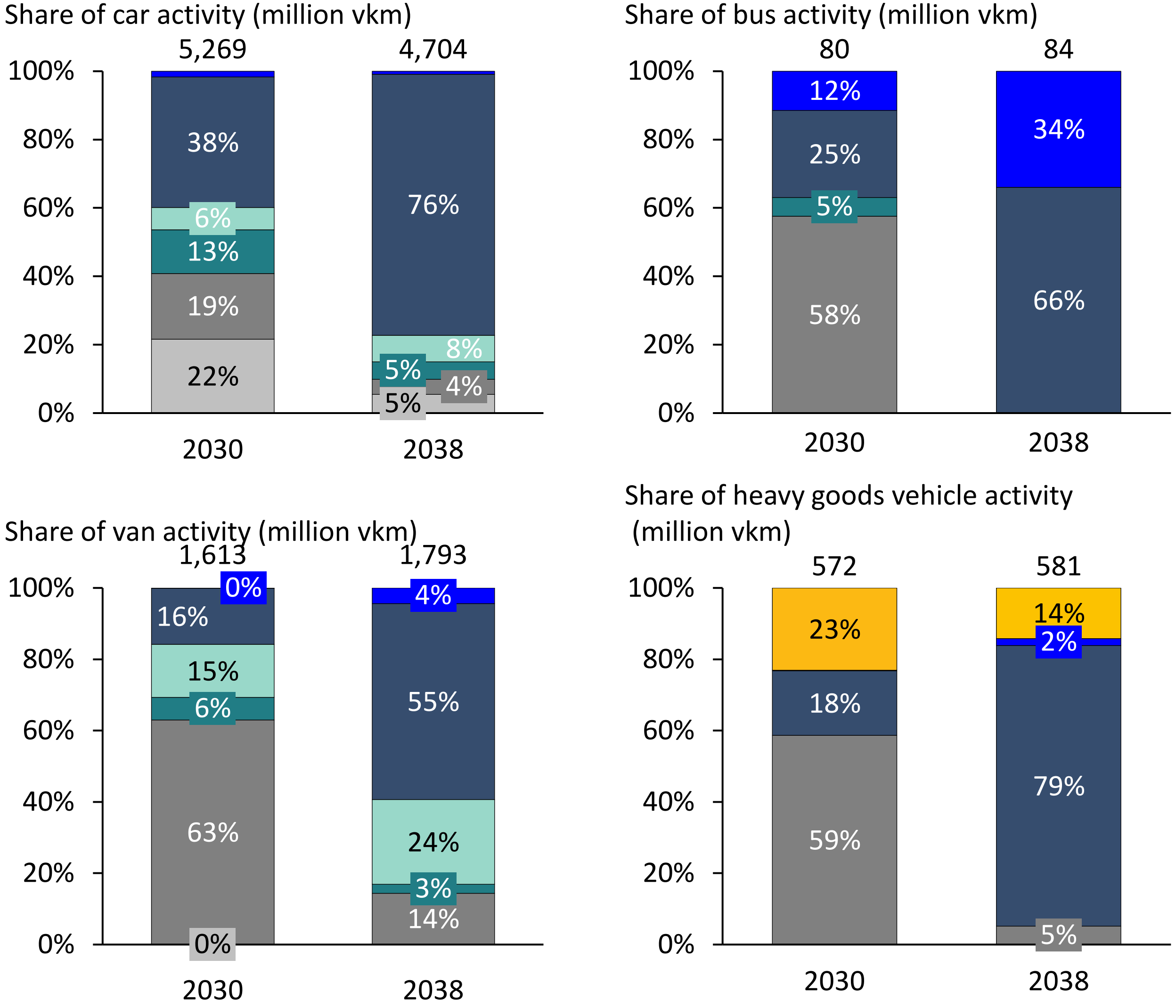


---

1. See Technical Report for detailed assumptions; 2. Based on analysis of 2016 National Travel Survey data; see Technical Report for details; 3. Representing a significant reduction primarily in business trips; 4. In line with the Committee on Climate Change's most ambitious scenario, intended to be illustrative of the potential for significant change; 5. Based on total passengers at Leeds Bradford airport, not disaggregated at subregion level

Max ambition: Rapid low emissions technology deployment is required, with significant electrification across all vehicle types

Share of vehicle travel demand by technology type


Share of car activity (million vkm)

Share of bus activity (million vkm)

Share of van activity (million vkm)

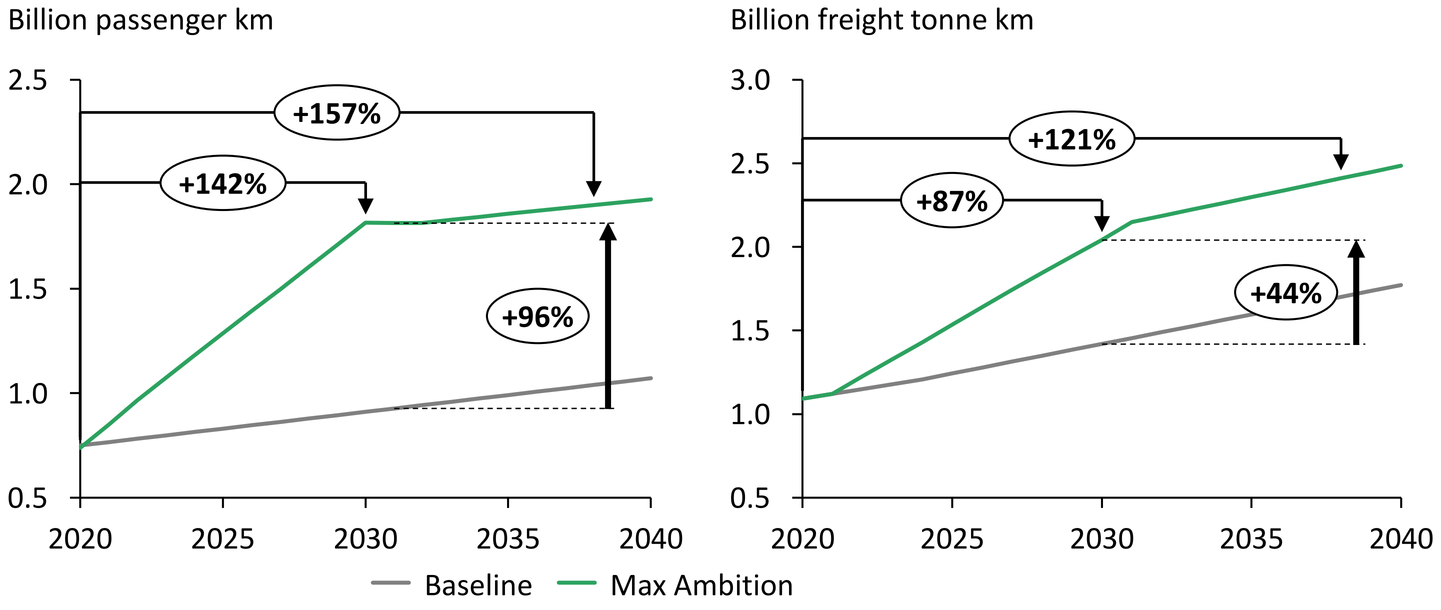
Share of heavy goods vehicle activity (million vkm)

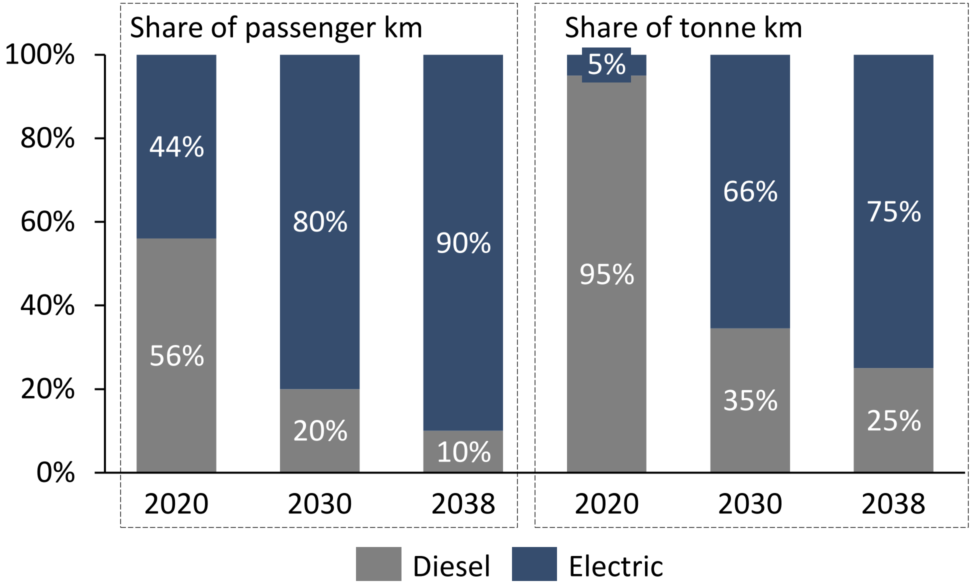
▢ Petrol ICE	▢ Plug-in Hybrid	🟨 Biomethane
▢ Diesel ICE	▢ Battery Electric	
▢ Hybrid	🟦 Hydrogen fuel cell	

- Low emissions technology rollout follows the fastest rate considered feasible, requiring an **end to conventional petrol and diesel vehicle sales by 2030 for cars and vans**, and 2031 for buses. Plug-in hybrids are removed from sale by 2035.
- For York and North Yorkshire, reaching this level of technology deployment requires **sales on the order of 10,000 zero emissions cars per year by 2025** in the region, going up to 20,000 per year by 2038 (compared to less than 1,000 in 2018)[1]
- Heavy goods vehicles are the hardest sector to decarbonise and sales of combustion engine vehicles continue until 2040; however, a switch to biomethane-fuelled vehicles (bio-compressed natural gas, BioCNG)[2] enables faster emissions reduction and can help to end the sales of diesel engines by the early 2030s.
- Reaching this technology mix requires sales on the order of 200 BioCNG vehicles per year between 2025 and 2030 (total of 1,000 – 1,500 total vehicles in the local stock), with **sales of zero emissions heavy goods vehicles** increasing from around 250 per year in 2030 to **close to 700 per year by 2038**
- For the whole transport sector in 2038, demand of 0.2 TWh of hydrogen and 1.6 TWh of electricity will need to be met through production and refuelling infrastructure

1. DfT vehicle registration statistics; 2. BioCNG vehicles use an internal combustion engine but use compressed natural gas as a fuel; if the gas is 100% sourced from biomass, well-to-wheel emissions can be 85% lower than diesel; deployed only for vehicles greater than 18 tones gross vehicle weight

Rail capacity increases to accommodate modal shift of passengers and freight; electrification eliminates most emissions



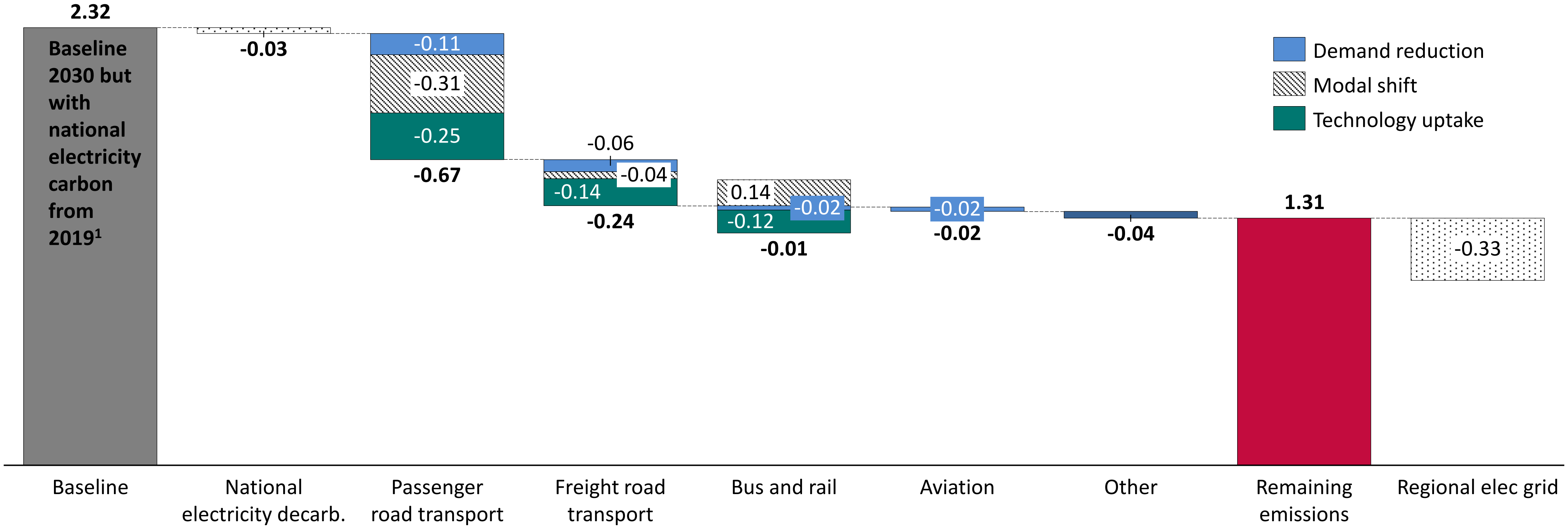


- Shift of passenger and freight transport from road to rail results **in rail passenger km increasing by 2.6 times** (reaching ca. 1.9 billion passenger km) **and rail tonne km doubling** (ca. 2.4 billion tonne km) between 2020 and 2038 (doubling of passenger km above the Baseline and 44% increase of freight tonne km above the Baseline).
- While some of the required capacity may be met using current infrastructure on some lines (e.g. by lengthening current trains)[1], increases in infrastructure will also be required, such as through Northern Powerhouse Rail.
- However, it should be noted that passenger km and tonne km are extrapolated based on road vehicle activity data (see Technical Appendix for details), and the analysis assumes that all shifted travel demand remains on rail routes within the region. As such, the analysis does not accurately represent real travel data and should be interpreted as **indicative of the scale of change only.**
- **Significant electrification of both passenger and freight activity is assumed to mitigate emissions.**[2] This degree of electrification refers to the share of activity and not the share of trains or track, and may be achieved through a combination of hybrid diesel trains, electrification of lines and battery electric trains (exact technology mix not modelled in detail here).

1. Based on Leeds City Region Capacity analysis draft report; 2. Current electrification level estimated based on Element Energy analysis of peak passenger loads across Leeds City Region.

Max ambition: In 2030, demand reduction and journey shift contribute nearly half of emissions reductions

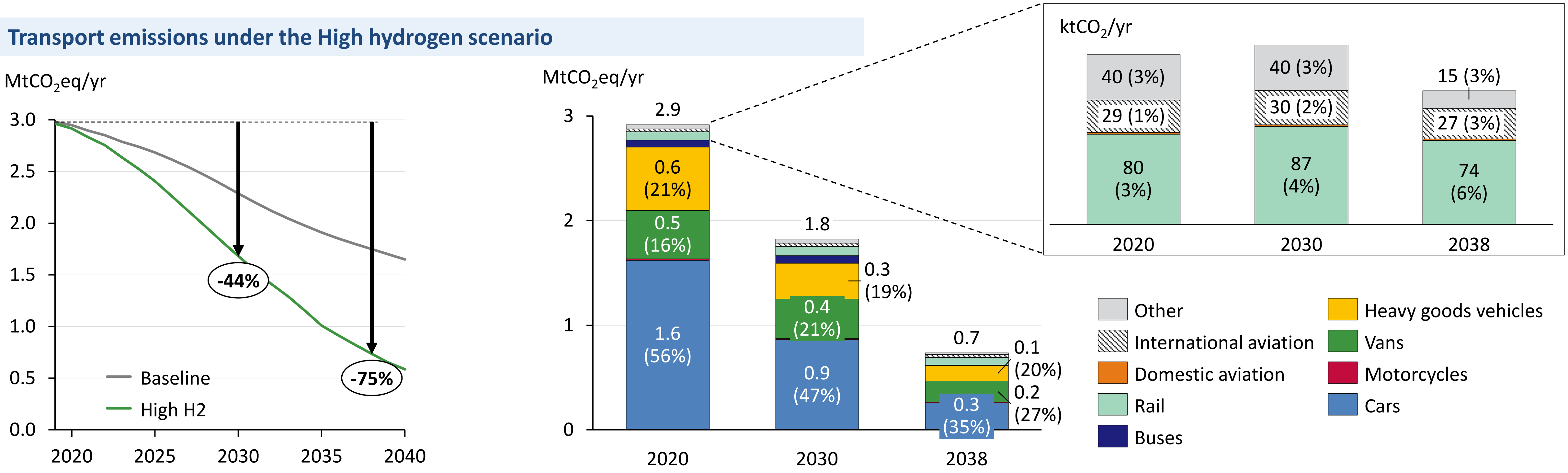
- The chart below demonstrates the relative impact of each of the measures modelled under the Max ambition scenario on emissions in 2030.
- In line with the relative contributions to total emissions, passenger transport measures contribute the majority of emissions reductions (67%).
- Due to the limited zero emissions vehicle uptake by 2030, behaviour change is particularly important – contributing net emissions savings of 0.44 $MtCO_2e$ (44% of emissions savings). However, behaviour change is also necessary to support technology roll-out – without behaviour change, up to 15,000 additional zero emissions cars would need to be sold per year to reach the same fleet share.
- Even with negative emissions from Drax (Regional elec grid in chart below), the transport sector does not reach net zero by 2030.



[1] Included to indicate the impact of decarbonisation of the national electricity grid; as electric vehicle deployment is low in the Baseline, the contribution of grid decarbonisation is relatively low

The High hydrogen scenario targets significant emissions reduction by 2038, with wider adoption of hydrogen fuel cell vehicles

Transport emissions under the High hydrogen scenario



- The High hydrogen scenario represents a trajectory in which hydrogen is widely available for use in transport. Levels of uptake of low emissions vehicles and behaviour change are highly ambitious but are allowed to progress more slowly than in the Max ambition scenario, to reflect a longer transition enabled by the 2038 target.
- **Under this scenario, transport emissions decrease by 44% by 2030 and 75% by 2038,** with remaining emissions of 1.8 $MtCO_2e$ in 2030 and 0.7 $MtCO_2e$/yr in 2038. Cumulative emissions from transport reach 25 $MtCO_2e$ between 2020 and 2030, and 36 $MtCO_2e$ by 2038 (20% decrease compared to the Baseline).
- As for the Max ambition scenario, as road transport emissions decrease, the relative contribution of rail, aviation and other transport to the overall sector emissions increases (12% in 2038 compared to 7% in 2020)

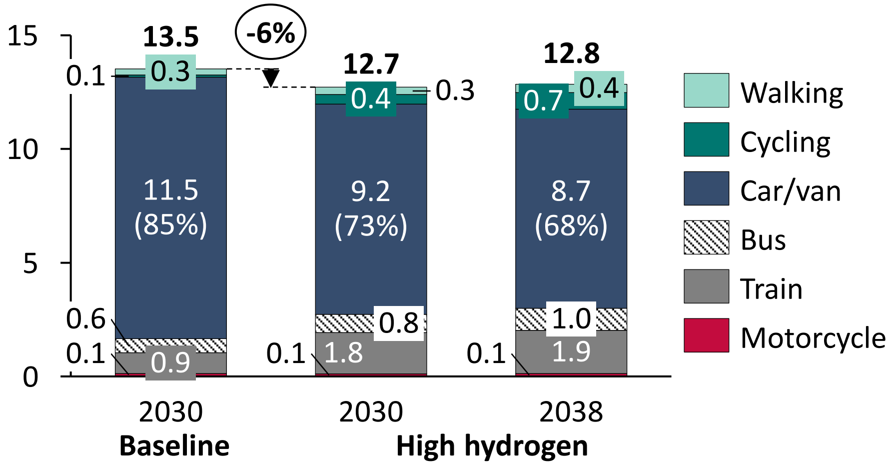
The High hydrogen scenario achieves ambitious changes in travel behaviour across all transport types by 2038

- Compared to the Max ambition scenario, lower but still ambitious levels of demand reduction are assumed for both the High hydrogen and Balanced scenarios: passenger km reduce by 6% compared to the Baseline in 2030 (10% in 2038) while freight travel demand decreases by 6% for heavy goods vehicles.
- For the remaining travel demand, the same level of journey shift to sustainable modes is assumed as in the Max ambition scenario, but the maximum level of passenger behaviour change is achieved by 2038 (8 years later than in the Max ambition)
- **20% of private car use (vkm) is shifted to public, shared and active travel by 2030,** reaching 36% by 2038:[2]
  - **Car sharing:** 8% of car vehicle km shift to shared cars by 2030 (either car clubs or car sharing; 14% by 2038)
  - **Walking:** increases by 17% in 2030 (314m km in 2030; 40% by 2038) and **cycling km to increase by a factor of 5** (425m km in 2030; factor of 8 by 2038)
  - **Public transport:** passenger km increase by 25% for buses and 50% for trains by 2030 (60% and 80% by 2038, respectively)
- Overall, compared to the Baseline, **private car use decreases by 30% by 2030 (44% by 2038)**, **van activity decreases by 2%** and **heavy goods vehicle activity decreases by 16%**[1]
- Ambition for domestic aviation demand reduction is assumed to be the same as for the Max ambition scenario (20% relative to the Baseline)[3] while international aviation growth is limited to 25% above current levels[4]

Y&NY

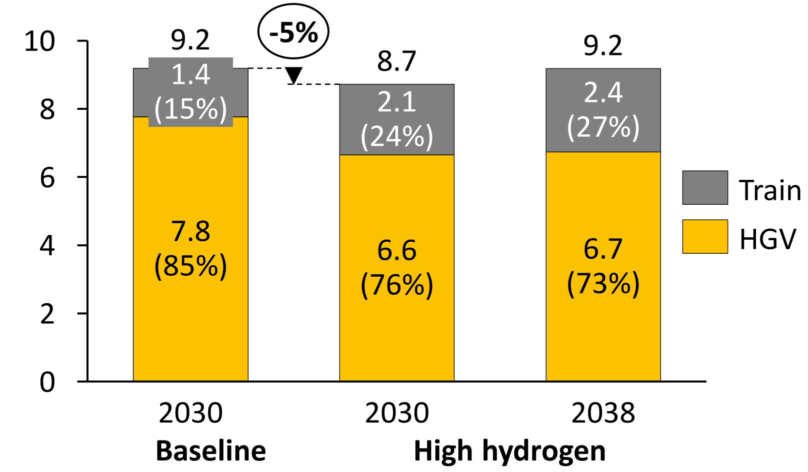
Passenger travel demand

Billion passenger km



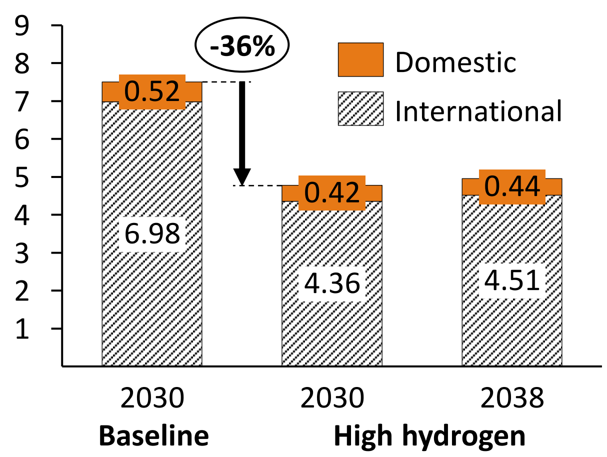
Freight travel demand

Billion tonne km



Aviation demand (Study Region)[5]

Annual passengers (millions)

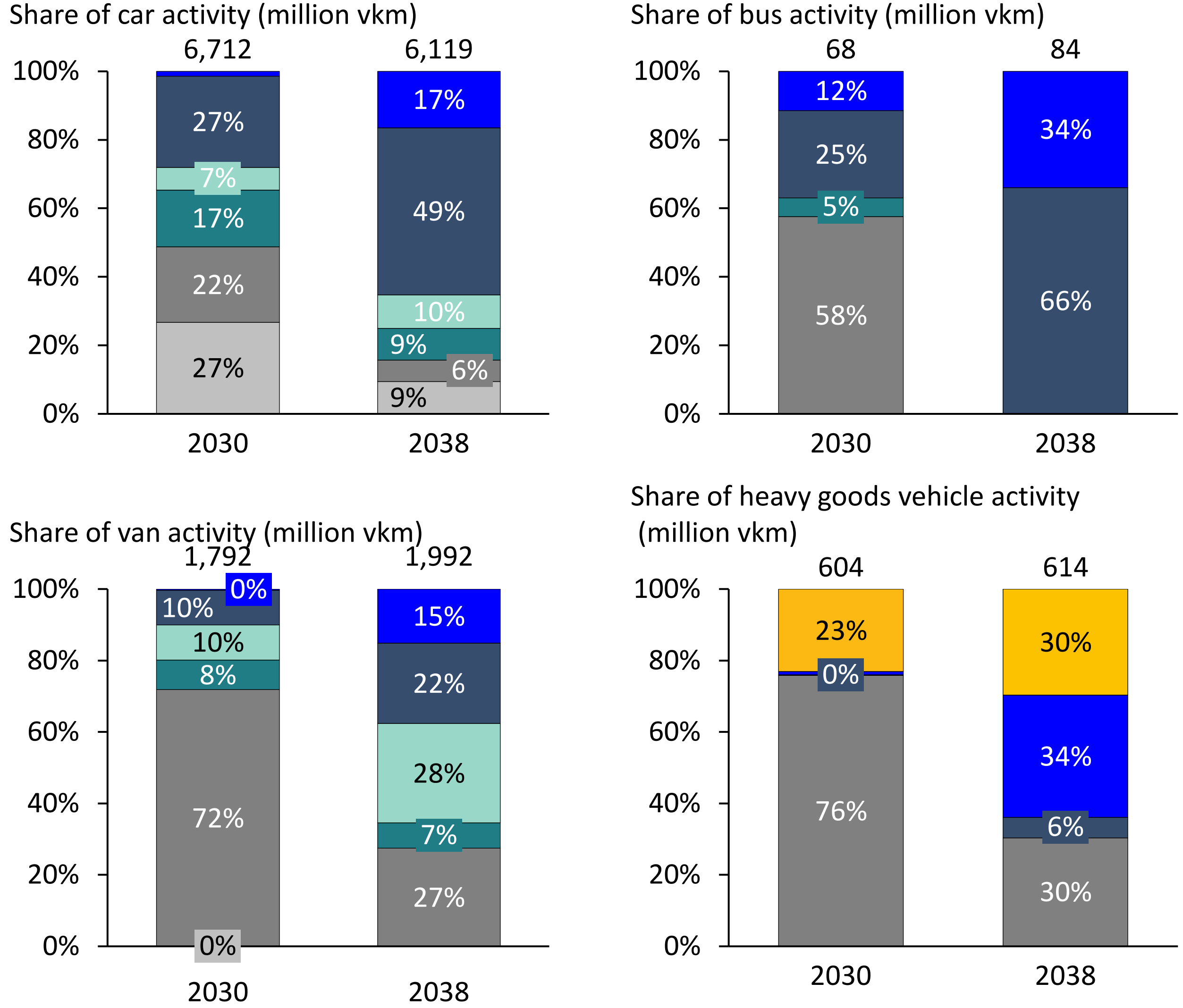


---

1. See Technical Report for detailed assumptions; 2. Based on analysis of 2016 National Travel Survey data; see Technical Report for details; 3. Representing a significant reduction primarily in business trips; 4. In line with the Committee on Climate Change's recommended growth limit; 5. Based on total passengers at Leeds Bradford Airport, not disaggregated at subregion level

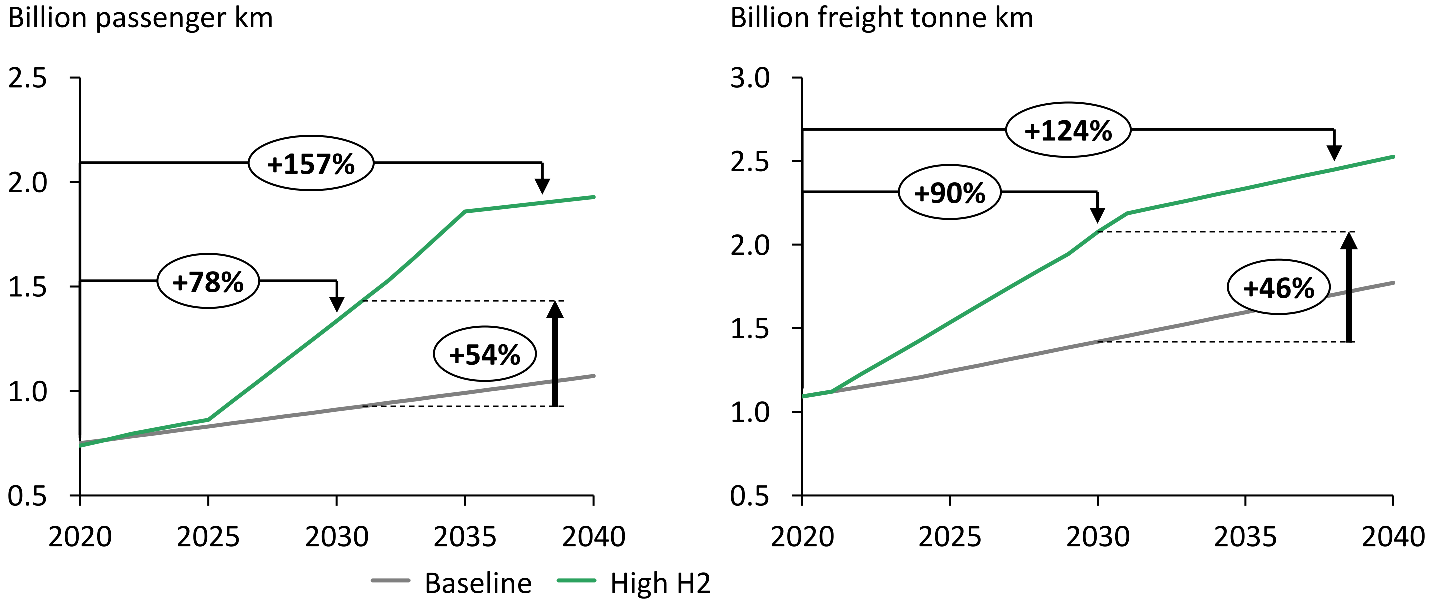
High hydrogen: Widespread low emissions technology deployment is required, with higher deployment of hydrogen across the fleet

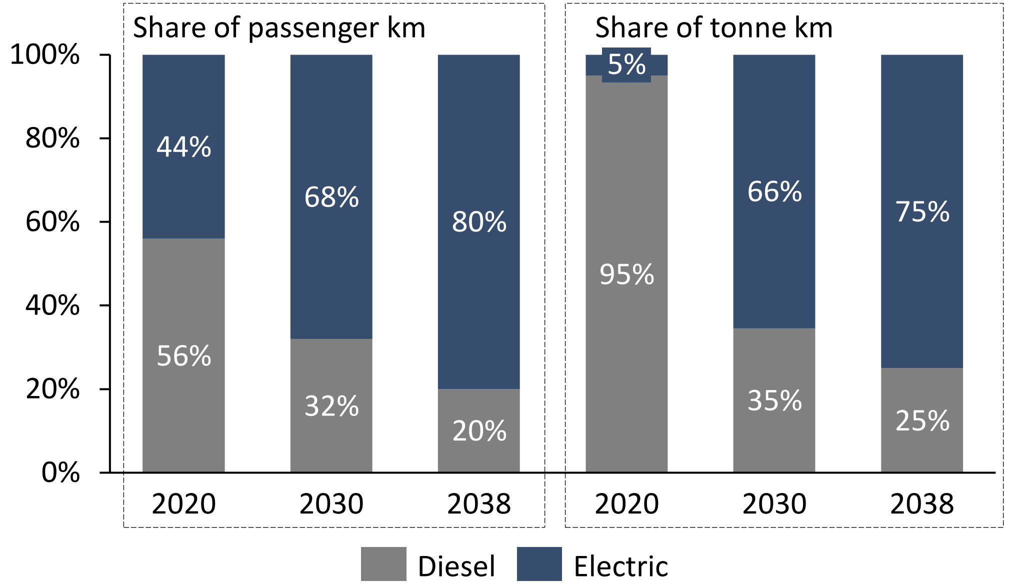
Share of vehicle travel demand by technology type



- In this scenario, **conventional petrol and diesel vehicle sales end by 2035 for cars and vans**, and 2031 for buses. Sales of plug-in hybrids continue beyond 2040.
- Sale of combustion engine vehicles continue beyond 2040 for heavy goods vehicles but biomethane-fuelled vehicles remain an important option to enable the end the sales of diesel engines in the late 2030s.
- Battery electric vehicles still make up a large share of the car and van fleets while hydrogen fuel cell vehicles achieve a significant market share of stock for buses and heavy goods vehicles.
- For York and North Yorkshire, reaching this level of technology deployment requires:
  - **Sales on the order of 8,000 zero emissions cars per year by 2025** in the region, going up to 15,000 per year by 2038, of which approximately half are hydrogen fuel cell vehicles
  - **Sales of zero emissions heavy goods vehicles** reaching around 400 per year in 2038, of which two thirds will be hydrogen fuel cell vehicles
- For the whole transport sector in 2038, demand of 0.8 TWh of hydrogen and 0.8 TWh of electricity will need to be met through production and refuelling infrastructure

Rail capacity increases to accommodate modal shift of passengers and freight; electrification eliminates most emissions





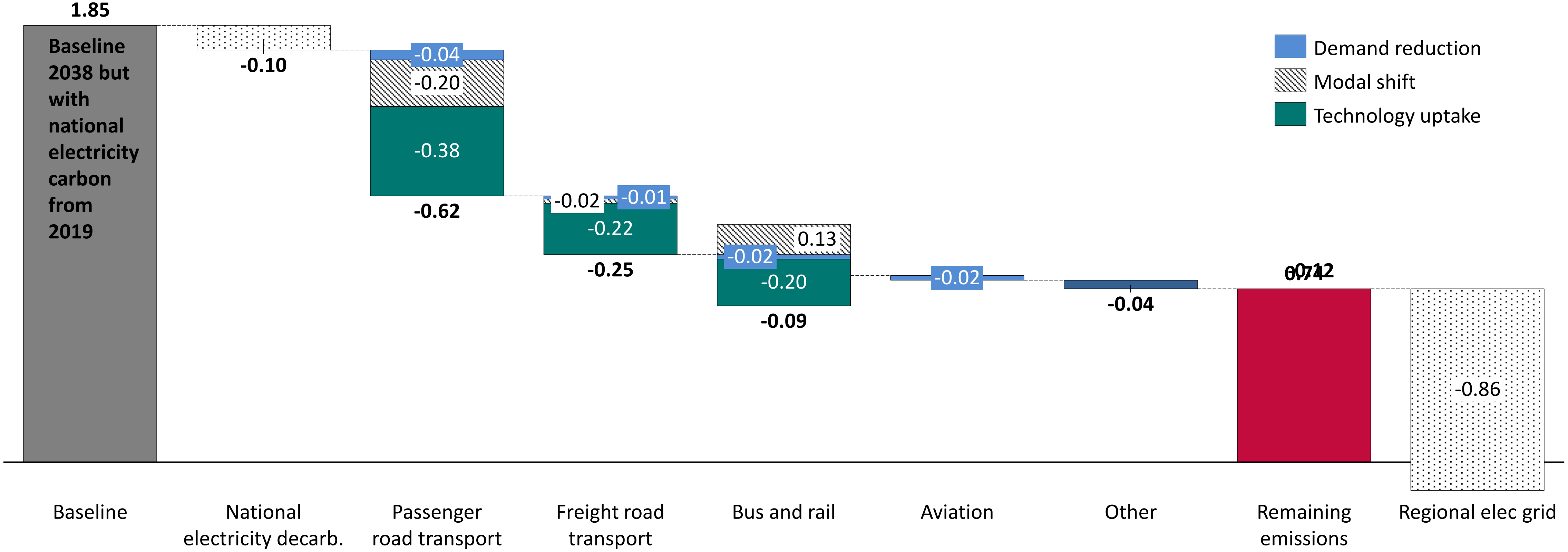
- Compared to the Max ambition scenario, modal shift to rail is slower but still results in **rail passenger km increasing by 2.6 times by 2038** (reaching ca. 1.9 billion passenger km) **and a doubling of rail tonne km** (ca. 2.4 billion tonne km) by 2038 (doubling of passenger km above the Baseline and 44% increase of freight tonne km above the Baseline).
- **Electrification of both passenger and freight activity is assumed to progress more slowly but is still significant**. As for the Max ambition, this may be achieved through a combination of hybrid diesel trains, electrification of lines and battery electric trains (exact technology mix not modelled in detail here).
- Hydrogen trains were not modelled as part of this work,[1] however may present an additional option for rural lines that are difficult to electrify. A detailed freight study to explore this option would be required

---

[1] As discussed with the steering committee.

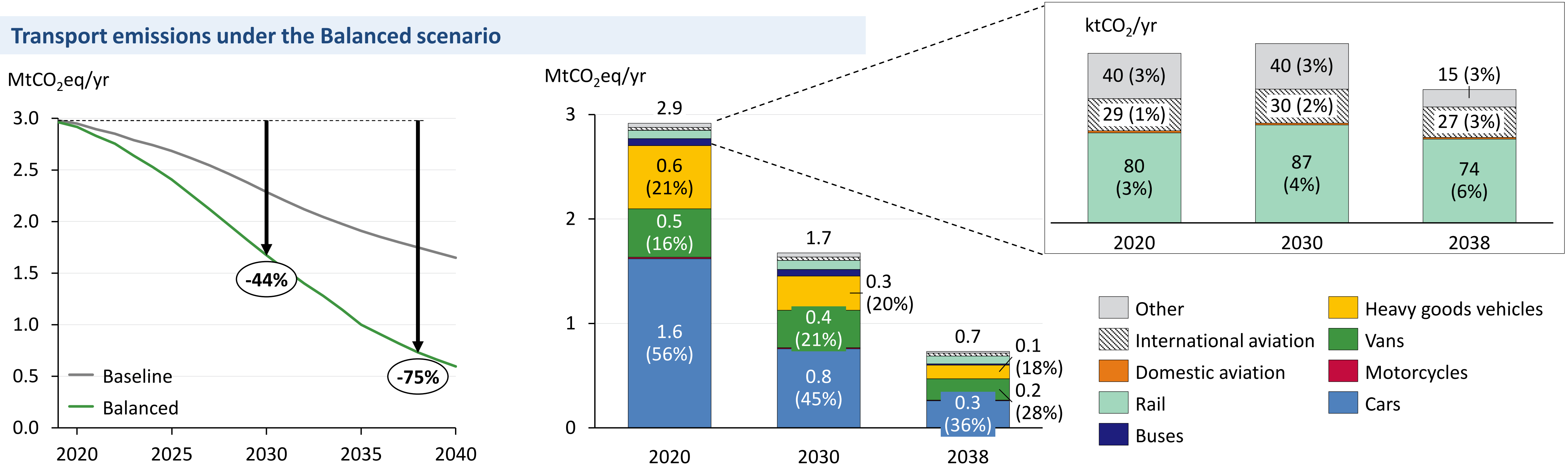
High Hydrogen: In 2038, behaviour change contributes just under a fifth of emissions savings

- The chart below demonstrates the relative impact of each of the measures modelled under the High hydrogen scenario on emissions in 2038.
- With more widespread zero emissions vehicle uptake by 2038, behaviour change contributes a lower proportion of the emissions savings (net savings of 0.18 $MtCO_2e$; 16% of emissions savings). However, behaviour change is still necessary to support technology roll-out – without behaviour change, up to 20,000 additional zero emissions cars would need to be sold per year to reach the same fleet share.
- With negative emissions from Drax (Regional elec grid in chart below), the transport sector becomes net negative by 2038.



The Balanced scenario targets significant emissions reduction by 2038, with a more balanced technology mix

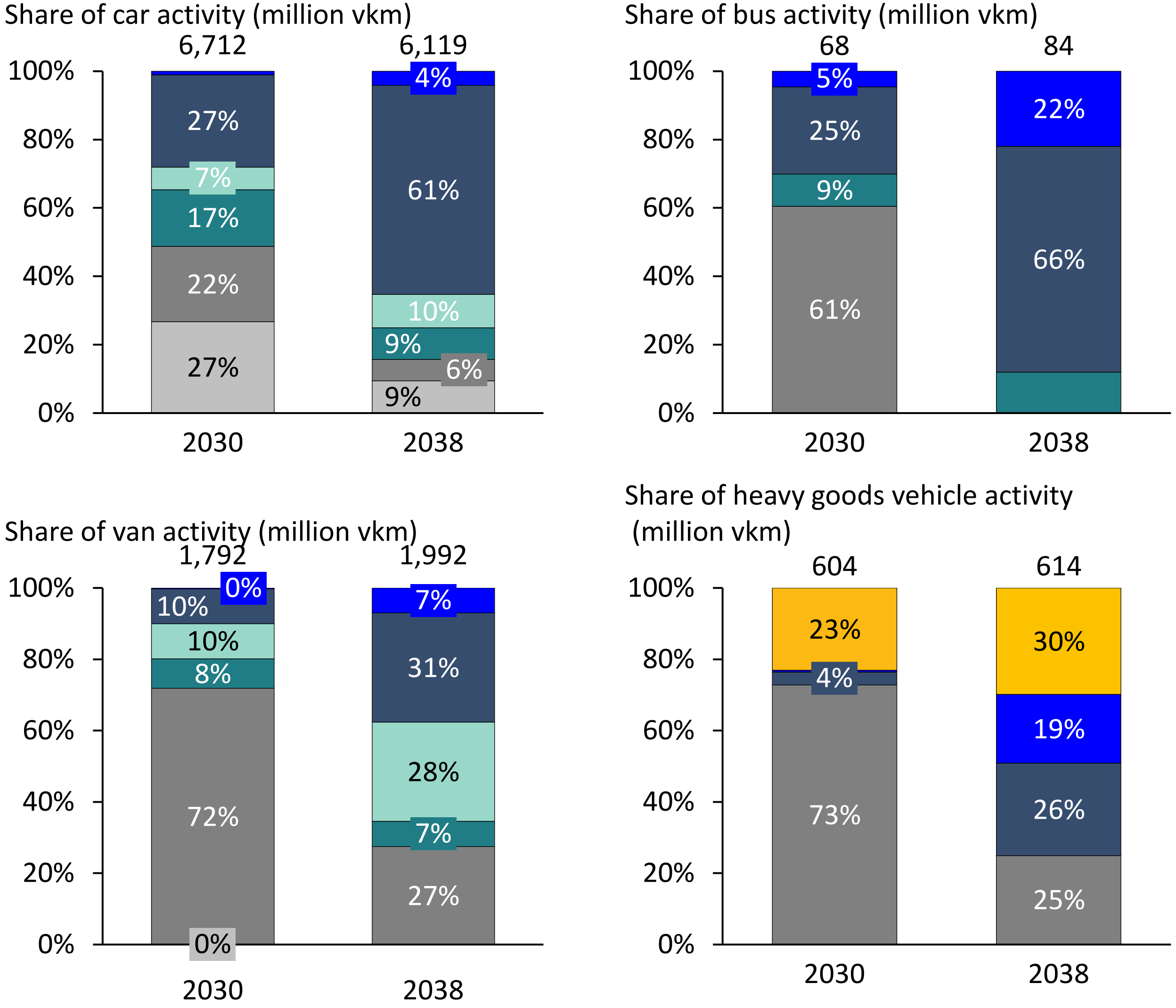
Transport emissions under the Balanced scenario



- The Balanced scenario represents a trajectory in which levels of uptake of low emissions vehicles and behaviour change follow the same path as for the High hydrogen scenario, but both hydrogen and battery electric technology are strong options across transport sectors.
- **Under this scenario, transport emissions decrease by 44% by 2030 and 75% by 2038,** with remaining emissions of 1.7 MtCO$_2$e in 2030 and 0.7 MtCO$_2$e/yr in 2038. Cumulative emissions from transport reach 25 MtCO$_2$e between 2020 and 2030, and 36 MtCO$_2$e by 2038 (20% decrease compared to the Baseline).
- As for the Max ambition scenario, as road transport emissions decrease, the relative contribution of rail, aviation and other transport to the overall sector emissions increases (12% in 2038 compared to 7% in 2020)

Balanced: Widespread low emissions technology deployment is required, with a mixture of hydrogen and electric vehicles

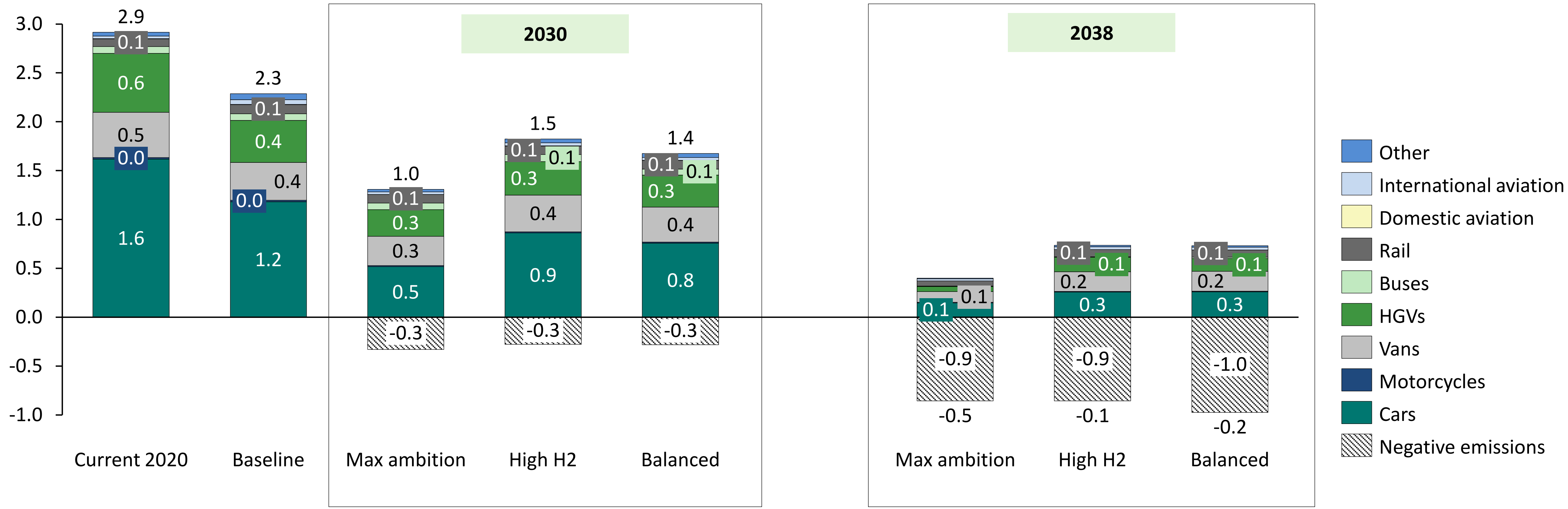
Share of vehicle travel demand by technology type



- In this scenario, **conventional petrol and diesel vehicle sales end by 2035 for cars and vans**, but sales of plug-in hybrids continue beyond 2040.
- Sales of diesel buses end in 2031, but sales of hybrid diesel buses are allowed to continue until 2040.
- Biomethane-fuelled vehicles remain an important option for heavy goods vehicles to enable the end of sales of diesel engines; the balance of hydrogen and battery technology leads to higher overall heavy goods vehicle fleet decarbonisation compared to the High hydrogen scenario.
- For York and North Yorkshire, reaching this level of technology deployment requires:
  - **Sales on the order of 8,000 zero emissions cars per year by 2025** in the region, going up to 15,000 per year by 2038, of which more than 90% are battery electric vehicles
  - **Sales of zero emissions heavy goods vehicles** reach around 450 per year in 2038, of which close to 80% will be battery electric vehicles
- For the whole transport sector in 2038, demand of 0.4 TWh of hydrogen and 1.0 TWh of electricity will need to be met through production and refuelling infrastructure

Pathway comparison: All pathways result in remaining emissions by 2038, but the sector can become net negative with negative emissions

Emissions remaining compared with current $MtCO_2e/yr$



- In 2030 there are significant emissions remaining across all transport sectors, primarily from remaining fossil fuel cars, vans and heavy goods vehicles. Electrification of road transport does not reach a sufficient level for negative emissions from regional electricity decarbonisation to reach net zero
- By 2038, widespread low emissions technology roll-out means that regional electricity decarbonisation is sufficient to offset all remaining emissions in all scenarios

The Max ambition scenario achieves the greatest decarbonisation but requires the most ambitious supporting policy to achieve

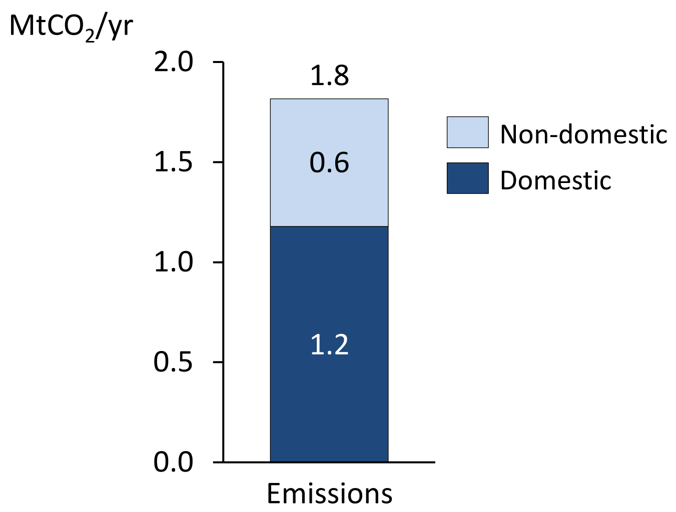
- All three emissions reduction scenarios require ambitious action from York & North Yorkshire to go beyond current national targets and policy commitments
- The Max ambition scenario delivers the highest emissions reduction (lowest gap to net zero and lowest cumulative emissions) in both 2030 and 2038, but also requires the highest level of behaviour change and greatest level of deployment of low emissions vehicles:
  - Sales of petrol and diesel cars in the region must end by 2030 in Max ambition, compared to 2035 in the High hydrogen and Balanced scenarios – both targets are ahead of current Government ambition (2040) but, if commitments are brought forward to 2035 (currently under consultation), the alignment with national targets would require less action at a local level
  - To reach the required technology deployment, the High hydrogen and Balanced scenarios require fewer zero emission vehicle sales – 15,000 cars per year in 2038 compared to 20,000 per year under Max ambition, and 400 zero emission heavy goods vehicles compared to close to 700 for the Max ambition scenario
  - Private car use must decrease by 48% by 2030 under Max ambition, compared to 30% under the High hydrogen and Balanced scenarios
  - Accordingly, journey shift to shared, active and public transport occurs faster in the Max ambition scenario, requiring 46 million more walking km, 275 million more cycling km and 12 million more bus km than in the High hydrogen and Balanced scenarios
  - All scenarios require significant, and similar, increases in rail passenger and freight capacity, which will need to be accommodated through expansions of infrastructure and/or service levels. Ambitious levels of electrification will be required to mitigate emissions from rail.
- Reflecting the different technology mixes, the High hydrogen scenario results in the highest demand for hydrogen (0.8 TWh/yr) while the Max ambition has the highest electricity demand (1.6 TWh/yr) by 2038; these energy demands must be met by deployment of appropriate refuelling infrastructure.
- Due to the higher zero emissions technology deployment, the Max ambition scenario has the lowest demand for biomethane for heavy goods vehicles, at 0.4 TWh/yr compared to 1.8 TWh/yr in the Balanced scenario; however, biomethane for transport does not need to be sourced locally under the Renewable Transport Fuel Obligation and therefore does not affect bioenergy considerations in the region.

Contents

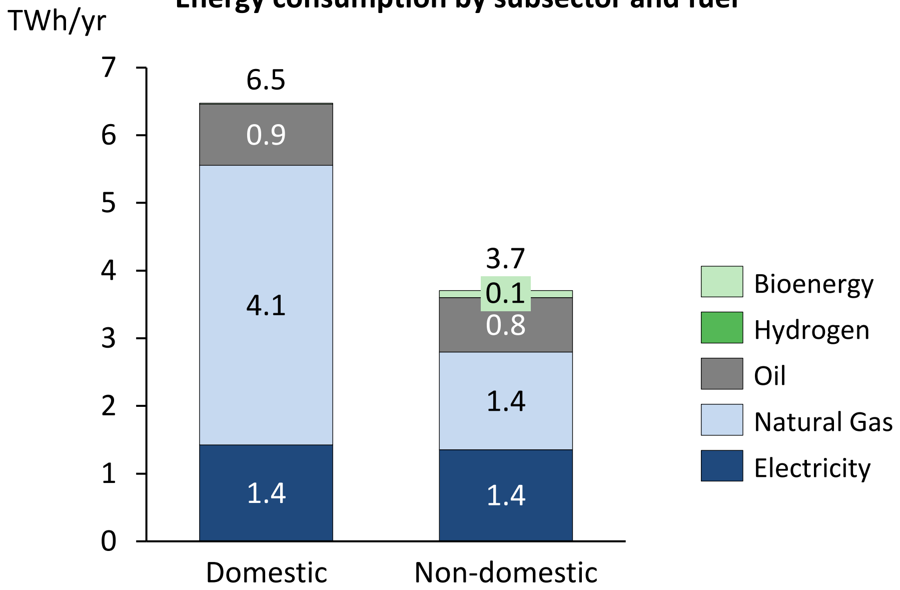
The current energy and emissions situation in the region - buildings

- Current emissions from the buildings sector are around 1.8 $MtCO_2e$/yr
- Approximately two thirds of the emissions are from domestic buildings
- Non-domestic buildings account for the remainder; this includes energy and emissions from buildings, but not industrial processes that may occur in some of the buildings.
- Natural gas is the most prevalent fuel for heating, with some oil and electricity present in off-gas homes. The number of other heating systems (heat pumps, district heating, bioenergy etc) is currently small
- The non-domestic sector uses a greater proportion electricity due to the higher demands from lighting, cooling and appliances

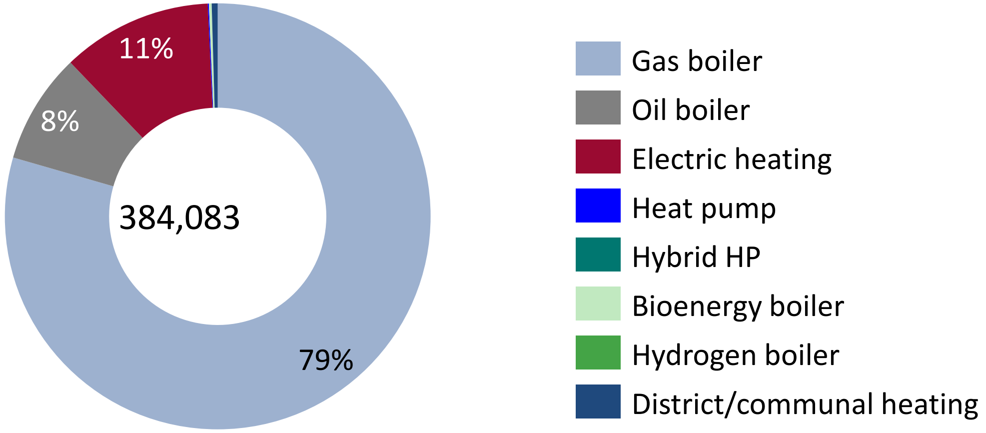
Buildings emissions by subsector



Energy consumption by subsector and fuel



Domestic heating systems



Source: BEIS subnational energy consumption and CO_2 emissions datasets; plumplot heating system breakdown & EE modelling
Note that all non-domestic results for the subregions are estimates, as the modelling was completed for the study region

Link to contents

Buildings – Y&NY has more off-gas buildings and requires unprecedented rates of efficiency and low carbon heat retrofit

Y&NY building stock characteristics:

- **High proportion of homes and businesses (~20%) not connected to the gas network[1]**, with higher resulting oil consumption and limited future heating system options (harder to deliver green gas such as hydrogen). These are likely to require heat pumps where suitable, or hybrid heat pumps fueled by electricity and bio-LPG.
- **Larger proportion of detached homes** (21%) & bungalows (16%) relative to the national average (16% & 10% respectively); this means a significant proportion of larger homes which are less space constrained and typically have high heat demand.[2]
- **Higher proportion of very old (pre-1919) homes** (24% relative to 19% nationally); typically these are less well insulated and often more difficult to retrofit.
- **Higher proportion of small businesses (72% units <5 employees) and business activities in agriculture** and forestry (18% relative to UK average of 5%).[3]
- **Higher proportion of poor thermal efficiency buildings** - currently 32% of homes are EPC A-C ratings (38% nationally) and 37% of non-domestic buildings (37% nationally)[4], requiring additional ambition around energy efficiency retrofit to maximise number which reach EPC C by 2030.

1 Off gas statistics LINK 2 Gov NEED LINK 3 ONS Uk business workbook LINK 4 Government statistics on energy performance of buildings – LINK

Buildings – emissions types and the key technologies and measures to address them

Buildings sector emissions can be categorized into:

1. **Electricity related emissions,** which will be addressed through decarbonisation in the power sector, supported by installation of efficient technologies to reduce demand. Electricity is used for lighting, appliances, cooling and some heating.
2. **Combustion emissions, from burning fossil fuels for heat.** These are the majority of emissions from buildings and must be addressed primarily by changes within the buildings. Thermal efficiency measures can reduce demand, but low carbon heat technologies must be installed to reach net-zero.

Key low carbon heating technologies are:

- Heat pumps, an efficient form of electric heating. These require reasonably high thermal efficiency standards.
- Hybrid heat pumps, combining a heat pump with a boiler (electric-hydrogen or electric-bioenergy). They reduce peak electricity demand and are feasible with lower thermal efficiency.
- Hydrogen boilers using low carbon hydrogen
- Bioenergy boilers using bioenergy (bio-LPG, biomethane or biomass)
- District/communal heating, with a large low carbon heat source providing heat for multiple buildings / units
- Air-to-air heat pumps, which are reasonably efficient electric and don't require a wet heating system
- Electric resistive/storage heating is a less efficient type of electric heating, but is an option in buildings which are space constrained

Key measures / assumptions:

- **Ambitious energy efficiency** improvements to raise all homes to EPC C or better where possible and cost-effective (Clean Growth Strategy), targeting 25%-35% heat demand reduction in existing buildings by the early 2030s.
- **New buildings** from early-mid 2020s to install low carbon system (heat pump or low carbon DH) and implement high efficiency **District heating in heat dense areas** (above ~30 kWh/m^2, national max potential 19% homes and 45% non-residential[1]), including many flats and commercial buildings (e.g. areas of Leeds, Bradford, York). 5-6 years from inception to operation.
- **Off-gas grid buildings** to be supplied by heat pumps, hybrid HP and/or bio-boilers[1A] (e.g. North Yorkshire)
- **Non-residential buildings** assumed suitable for energy efficiency + either heat pumps or heat networks[1]
- **Hydrogen:** in the High H_2 scenario, the gas grid is assumed to be converted to hydrogen from 2028. In the Balanced scenario, some areas are converted in the early 2030s. The Max ambition scenario has no hydrogen in the gas grid.

---

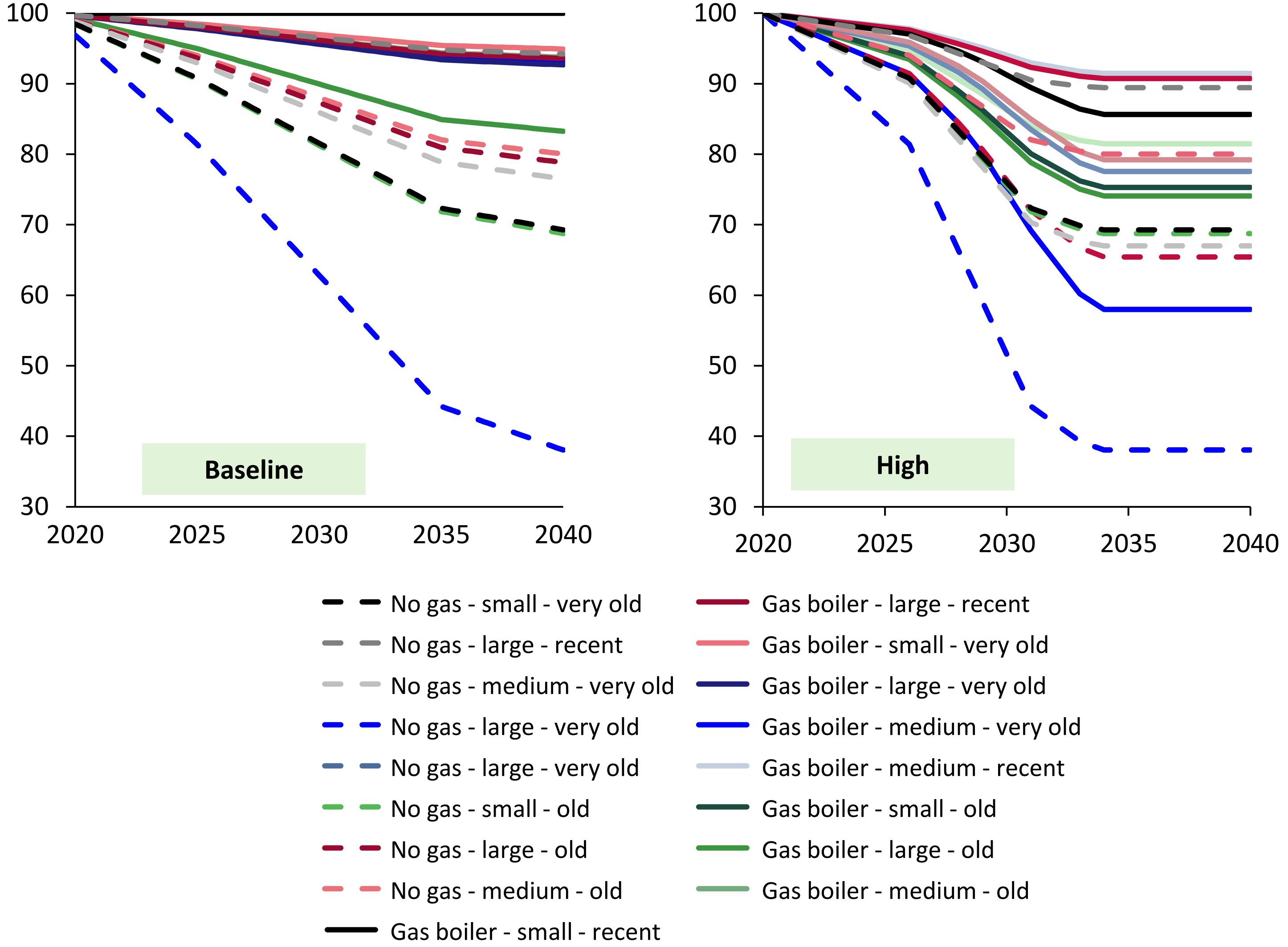
1 CCC Net-zero technical report

Underpinning measures: Domestic thermal efficiency level is applied according to home archetype

Study region

- Domestic energy efficiency measures, such as draft proofing, wall, loft and floor insulation and double/triple glazing, are crucial to reduce energy demand and enable low carbon technology installation.
- This study applies different energy efficiency trajectories to different parts of the domestic stock[1], as home archetype has a large impact on the cost-effective potential of measures. Trajectories are the same for these archetypes in each subregion (but stock differs).
- It should be noted that the work around energy efficiency is necessarily high level due to the extremely broad nature of this study; we have not looked at the individual measures with respect to their deployment levels. For the baseline (low), low cost measures are applied, which are cost effective in their own right (<0£/tCO$_2$). We adapted our recent work for the CCC and National Infrastructure[2] Commission to develop energy efficiency rollout scenarios.
- The medium efficiency scenario applies measures up to £150/tCO$_2$ applied (High H$_2$ scenario)
- For the Max ambition and Balanced scenarios, high efficiency is applied, all measures <£400/tCO$_2$ – see Appendix for more detail.

Thermal demand reduction in domestic buildings by archetype (%)



---

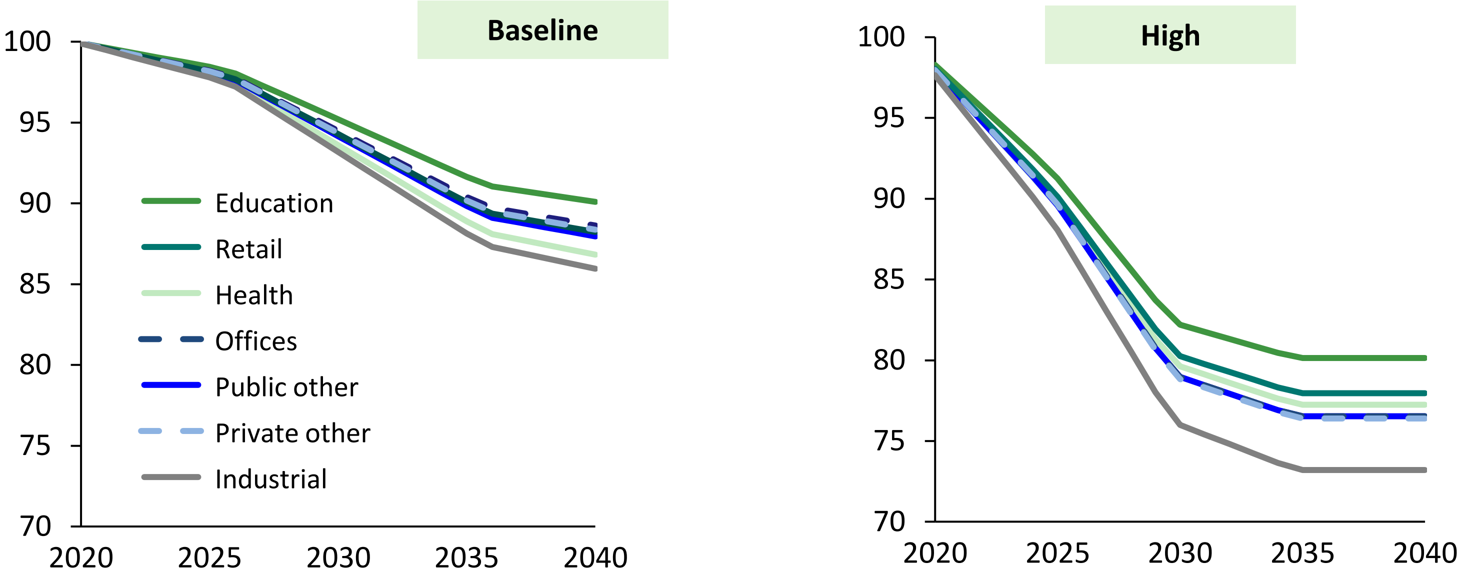
1 Very old pre-1919; Old 1919-1982; recent since 1982

https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf ; https://www.theccc.org.uk/publication/analysis-on-abating-direct-emissions-from-hard-to-decarbonise-homes-element-energy-ucl

Underpinning measures: Non-domestic thermal efficiency implementation reduces heat demand considerably

- For non-domestic energy efficiency measures, we consider 'Building fabric' measures (similar to domestic) and 'Building instrumentation and control'[1].
- This study applies different energy efficiency trajectories to different subsectors of the non-domestic stock, as subsector has an impact on the cost-effective potential of measures. Trajectories are the same for these subsectors in each subregion (but stock differs).
- It should be noted that the work around energy efficiency is necessarily high level due to the extremely broad nature of this study; we have not looked at the individual measures with respect to their deployment levels.

Thermal demand reduction in non-domestic buildings by sector (%)



- The underlying data for thermal energy efficiency in the non-domestic (I&C industrial and commercial buildings) stock is based on data from BEIS's Building Energy Efficiency Survey (2015 BEES). From this data, we have been able to estimate the savings potential and cost-effectiveness of the measures, as with the domestic stock (in £/tCO_2 abated). The cost bands are the same as in the domestic scenarios.
- In the I&C sector, all thermal efficiency measures fall in the 'low' and 'medium' cost bands i.e. less than £150/tCO_2 abated. The high scenario differentiates itself from the medium scenario by achieving the same abatement potential in a shorter amount of time.
  - For the baseline (low), low cost measures are applied, which are cost effective in their own right.
  - The medium efficiency scenario applies measures up to £150/tCO_2 applied (High H_2 scenario)
  - For the Max ambition and Balanced scenarios, high efficiency is applied, all measures <£400/tCO_2

---

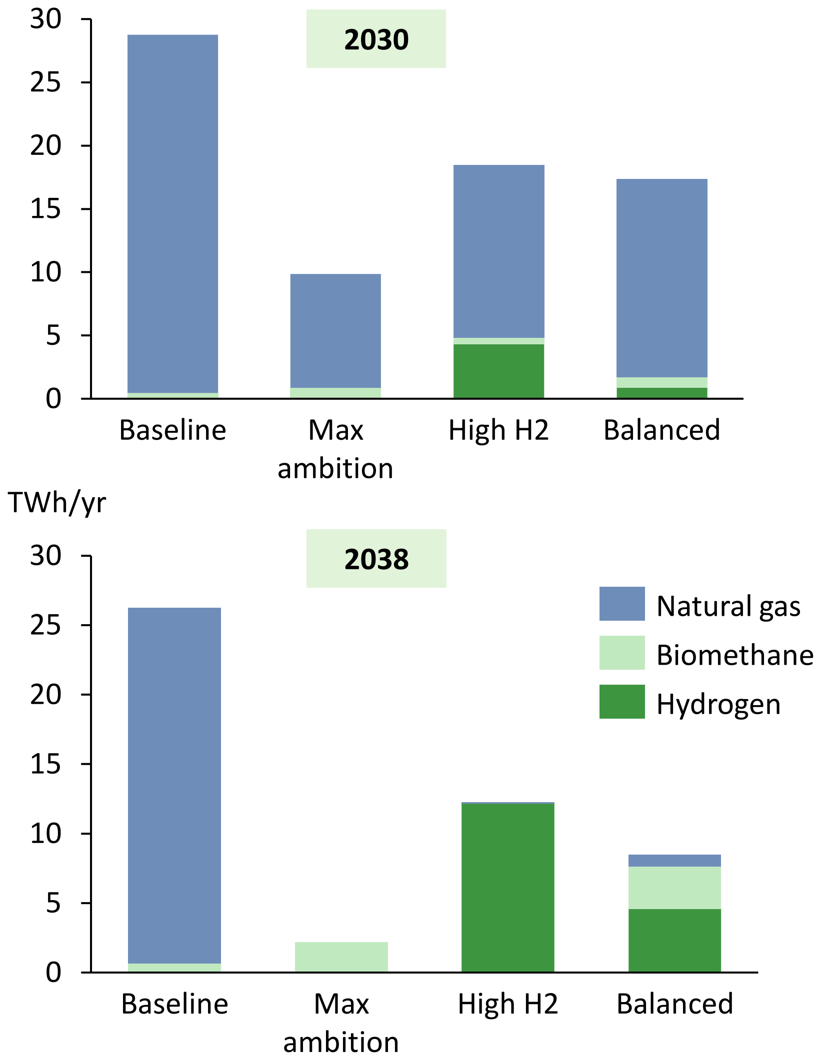
1 More information can be found in BEES data https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees
https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf ;
Details for non-heat efficiency (significantly lower impact), can be found in the Appendix.

Underpinning measures – the gas grid sees rapid changes in the 2030s, with demand decreasing and greening

Note that this slide refers to the study region, as the gas grid modelling was non-spatial. The same gas grid composition (natural gas, biomethane, hydrogen) was assumed for all subregions.

- The current natural gas grid will see dramatic changes if net-zero targets are to be met.
- In the Max ambition scenario, most heat and transport are electrified, leaving minimal gas demand by 2038.
- In the High hydrogen scenario, the gas grid is fully converted to hydrogen in 2028-2035, supplying buildings and industry with low carbon hydrogen.
- The Balanced scenario sees some areas of the gas grid converted to hydrogen, some remain a natural gas/biomethane blend and gas demand reduction through electrification.
- The maximum biomethane availability is taken from the NGN pathways work[1], reaching 8.6 TWh/yr in the full NGN network in 2040, scaled to the study region giving 3.6 TWh/yr. This biomethane is used for grid blending.
- Hydrogen is used for blending to a maximum of 20% by volume[2] (~6% by energy), which is thought to be the maximum limit for existing equipment without modification.
- Bioenergy is also used as BioCNG in transport and bio-LPG in off gas grid Hybrid heat pumps, both in relatively small quantities (see technical Appendix for full breakdown).

Gas grid composition TWh/yr



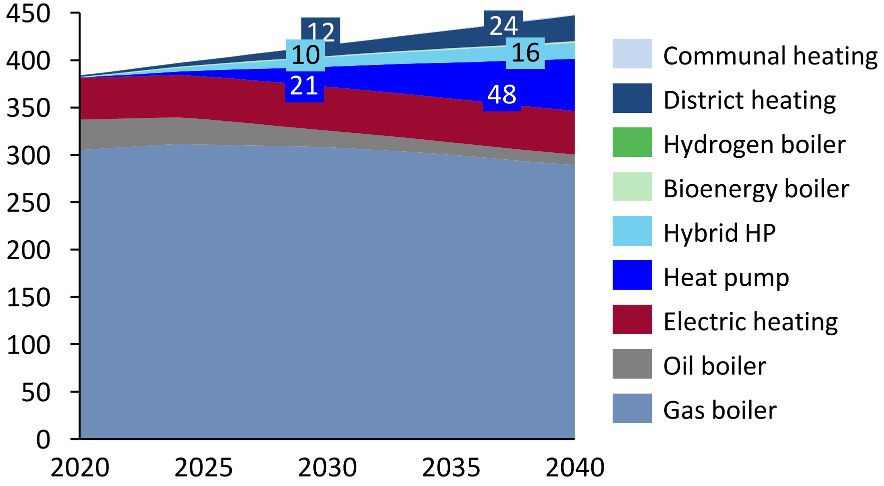
---

[1] Information provided by NGN, based on the ENA Navigant pathways LINK

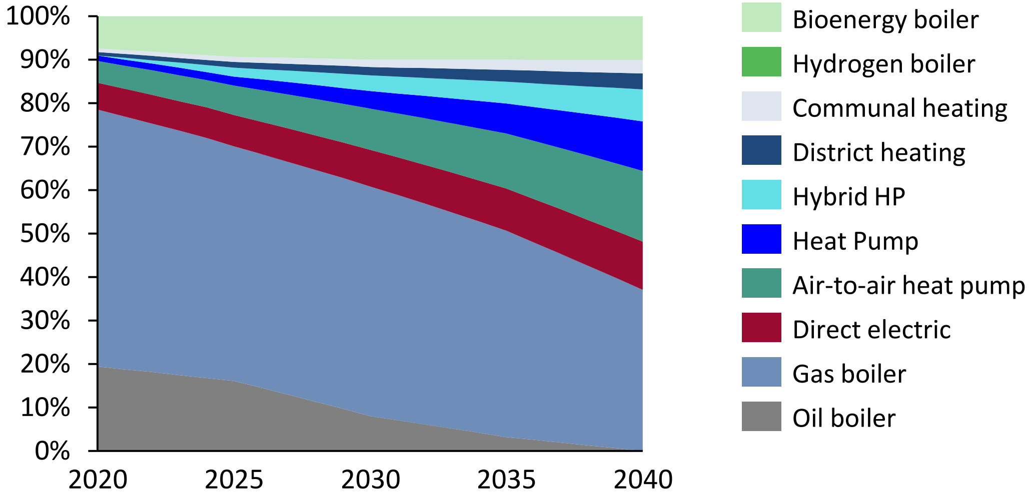
[2] The earliest H2 is blended is 2026 in the High H2 scenario. In the Balances scenario it reaches 6% vol by 2032

Buildings – baseline – installation of low carbon heating systems focusses primarily on the replacement of oil boilers

Number of heating systems in homes ('000)[1]



Heat supply to non-domestic buildings (% heat)[2]



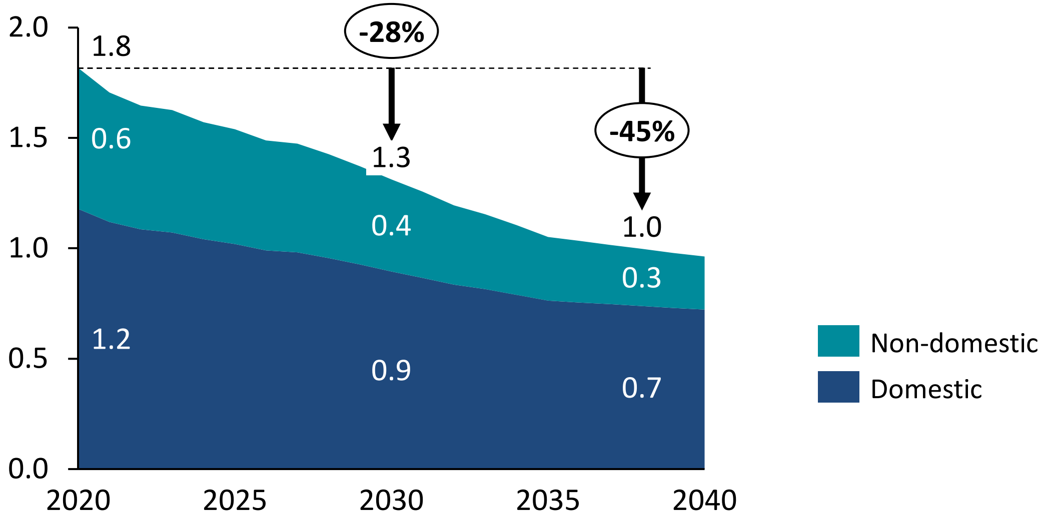
- **Growth:** It is assumed the number of existing homes remains constant, and the new build rate is determined by the Local Plans for each local authority; 380k existing homes and 63k new homes by 2038 (14% new). In the non-domestic sector, greater demolition and growth rates see 31% new build by 2038. All scenarios follow this growth rate.
- Heat pumps installations continue at a slow rate, increasing only a little from current rates under the RHI (varying from the same rate to 4x the current rate depending on building archetype).
- The fastest change is in buildings currently with oil heating, which have high emissions and costs. Around 60% of homes with oil heating switch to heat pumps or hybrid heat pumps by 2030. Non-domestic use of oil for heat drops to zero.
- District & communal heating increases to 6% buildings by 2038 under current government support schemes
- The non-domestic sector exhibits a more diverse heating mix, with greater use of oil and a greater proportion of warm air heating systems. The non-domestic sector sees more progress due to the higher frequency of retrofit and new build.
- New buildings have considerably lower emissions due to high energy efficiency standards and from 2025 installation of only low carbon heating technologies (electric heating, heat pumps and district heating).

---

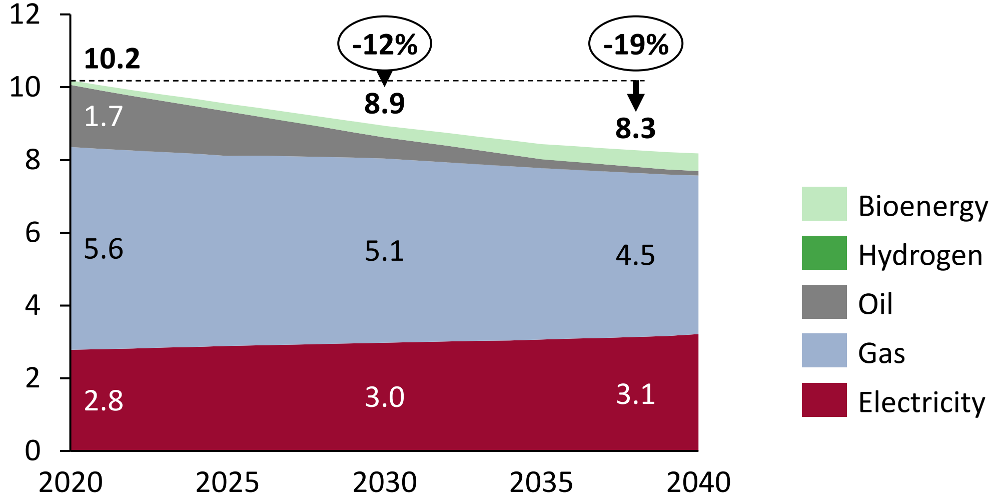
1 Numbers on the chart represent the number of select technologies in 2030 and 2038; 2 The non-domestic building modelling was completed at study region level in GWh, as the source data is in GWh, not number of buildings. The subregion breakdown is an estimate only.
3: Domestic - Element Energy study for Bristol heat LINK non-domestic growth rates following regional subsector growth provided by LCR

Buildings – baseline scenario – energy consumption and emissions both see a steady decrease, but limited progress in heat supply

Emissions from buildings MtCO$_2$e/yr[1]



Fuel demand in buildings TWh/yr

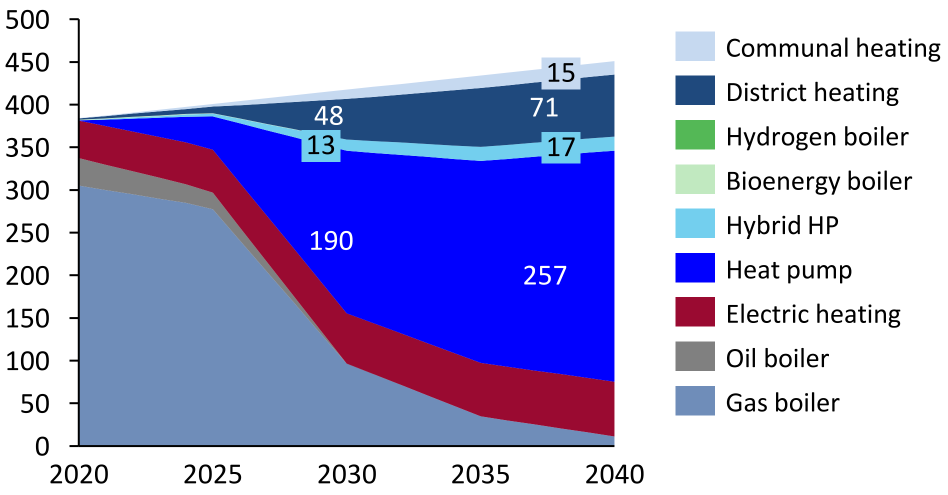


- **Total buildings emissions decrease by around 45% in the baseline scenario, reaching 1 MtCO$_2$e/yr by 2038.** The main contribution is decarbonisation of the national electricity grid. Other supporting measures are energy efficiency measures, some non-domestic demolition and a steady switch away from oil use[2] due to its cost and emissions.
- **Fuel consumption reduces by 19% by 2038** due to efficiency measures. It remains predominantly natural gas and electricity, with only slow uptake of further electric heating forms and phase out of oil.
- **Solar PV** (building scale): Domestic solar PV installations increase from 17k to 27k by 2038, following NPg 'Steady Progression". Non-domestic solar PV increases at half the rate it did under the Feed In Tarif subsidy (FiT) over the passed 9 years, reaching 32 GWh/yr by 2038. Installations make a small contribution to offsetting electricity emissions in buildings (~4% electricity consumed).
- **Non-heat energy:** The majority is supplied through electricity (~77% non-domestic and almost 100% domestic), for example cooling, ventilation, computing, lighting, appliances and some catering. All applications which currently use electricity remain on electricity (as this will decarbonise). It is assumed that there is an increase of 20% in non-domestic cooling demand[4].
- **The contribution of new buildings to emissions is small** (~4% by 2038), due to higher building standards (inc. potential Future Homes Standard[3]) and greater uptake of low carbon heating (>80% of new build by 2038).

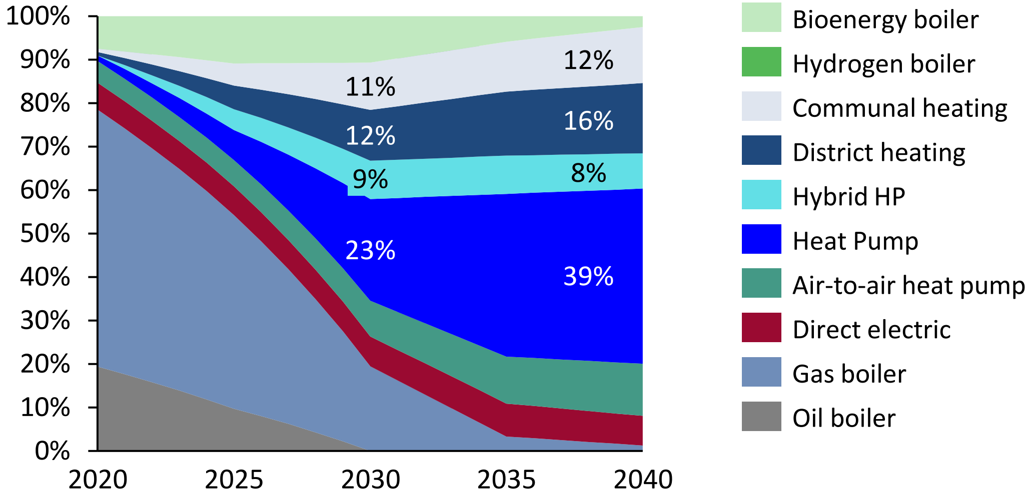
1 - National electricity carbon intensity used 2 - Clean Growth Strategy LINK; 3 - Future Homes Standard LINK 4 – London's Climate action Plan; non-heat energy demand does not fluctuate much

Buildings – Max ambition - to make significant progress in the 2020s, heat pumps are deployed at an unprecedented scale

Number of heating systems in homes ('000)[1]



Heat supply to non-domestic buildings (% heat)[2]

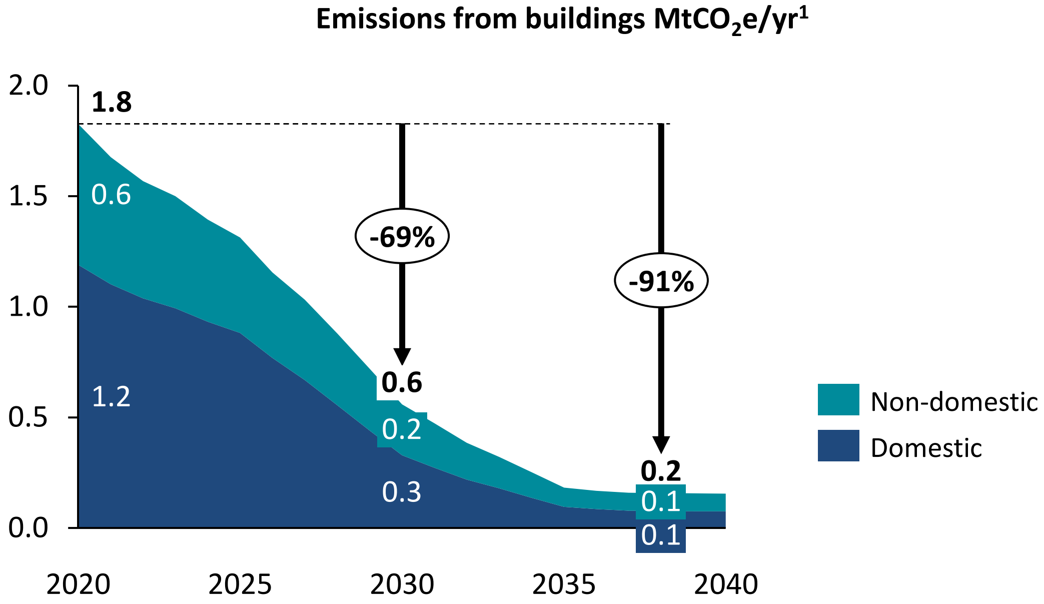


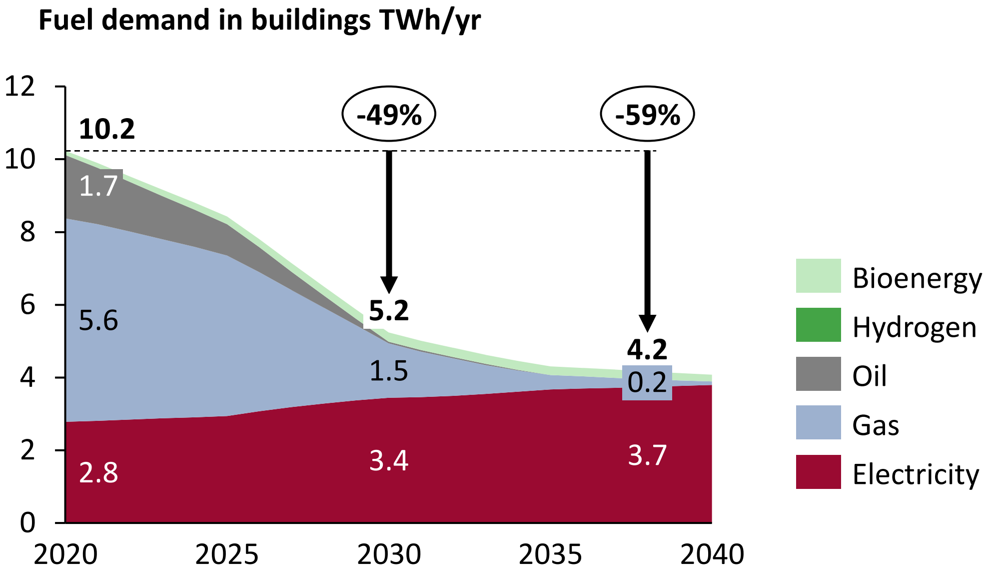
- **The Max ambition scenario focusses on highly ambitious heat pump installation, reaching 203k domestic heat pumps by 2030 and 274k by 2038**. By 2038 heat pumps[3] also serve 47% of non-domestic heat.
- **Hydrogen conversion of the gas grid is not assumed** in this scenario due to the uncertainty and timeframes, so no hydrogen is used for heat in buildings (only large industrial sites). This also limits the roll-out of hybrid heat pumps to a reasonably small proportion, as the supplementary boiler is hydrogen (not readily available) or bioenergy.
- **Oil heating is rapidly phased out** in off-gas buildings (primarily replaced by heat pumps & hybrids) in all scenarios.
- **District & communal heating increases to 86k homes and 28% non-domestic buildings** by 2038. These heat systems are primarily in heat dense / urban areas or multi-building complexes.
- The significant amount of bioenergy used currently is reduced during the 2030s to improve air quality and conserve supply. It may still be used in hybrid heat pumps off the gas grid (e.g. hybrid electricity-bioLPG)
- **Direct electric heating is deployed in buildings which are not suitable for heat pumps**, for example those with space or efficiency constraints. Air-to-air heat pumps are deployed in the non-domestic sector where dry heating systems are required.

---

1 Numbers on the chart represent the number of select technologies in 2030 and 2038; 2 The non-domestic building modelling was completed at study region level in GWh, as the source data is in GWh, not number of buildings. The subregion breakdown is an estimate only.
3 heat pumps referring to air-to-water and hybrid air-to-water (not air-to-air)

Buildings – the Max ambition scenario sees rapid emissions reductions due to almost complete electrification





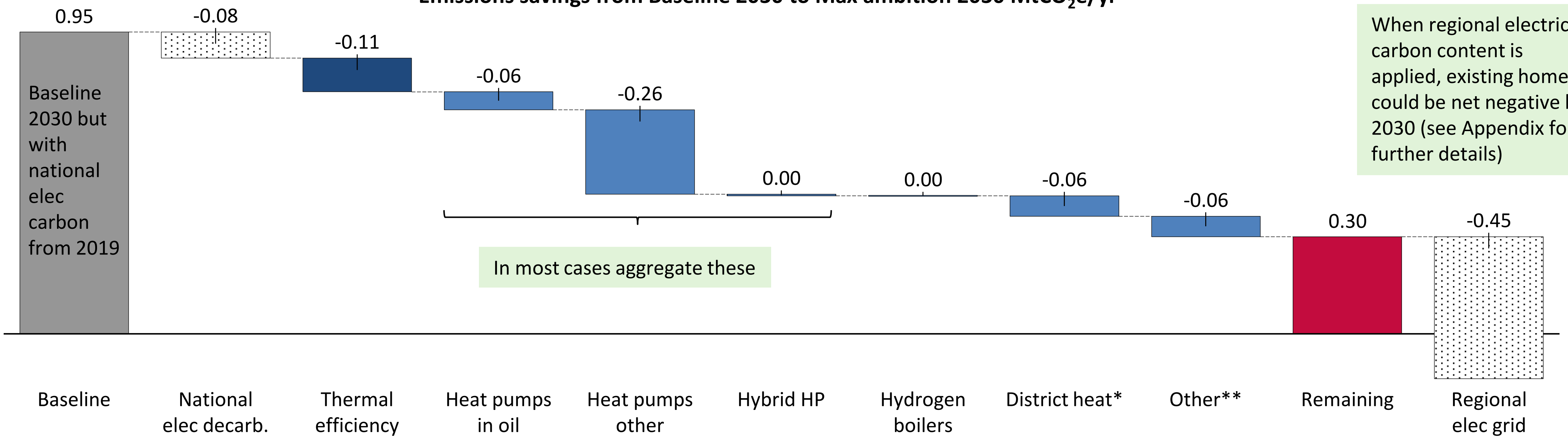
- **Total buildings emissions decrease by 69% by 2030 and 91% 2038, reaching 0.2 $MtCO_2e/yr$.** The main contribution is ambitious deployment of heat pumps, supported by high efficiency measures (required for heat pump installation) and decarbonisation of the national electricity grid.
- **Fuel consumption reduces by 59% by 2038** due to energy efficiency measures and the increased efficiency of heat pumps relative to counterfactual fossil boilers (a gas boiler is ~90% efficient, whereas a heat pump can be over 300% efficient). Oil is phased out by 2030 in all scenarios[2]. By 2038, fuel consumption is almost entirely electricity, and the annual electricity demand has increased by 34%, with implications for electricity generation and distribution infrastructure.
- **Solar PV** (building scale): Domestic solar PV installations increase to 101k by 2038, following NPg 'Community renewables" for all 3 scenarios. Non-domestic solar PV increases at the rate it did under the Feed In Tarif subsidy (FiT) over the passed 9 years, reaching 48 GWh/yr by 2038. Installations make a contribution to offsetting electricity emissions in buildings (~6-9% electricity consumed[4]).
- **Non-heat energy** (appliances, catering etc) switches almost exclusively to electricity, with a small amount of bioenergy.

Y&NY

1 - National electricity carbon intensity used 2 - Clean Growth Strategy LINK; 3 - Future Homes Standard LINK 4 Solar PV installation is the same across the 3 emissions reduction scenarios, but the electricity consumption varies

Contribution of different measures: the largest contribution to the Max ambition scenario by 2030 is heat pump deployment

Emissions savings from Baseline 2030 to Max ambition 2030 $MtCO_2e/yr$



When regional electricity carbon content is applied, existing homes could be net negative by 2030 (see Appendix for further details)

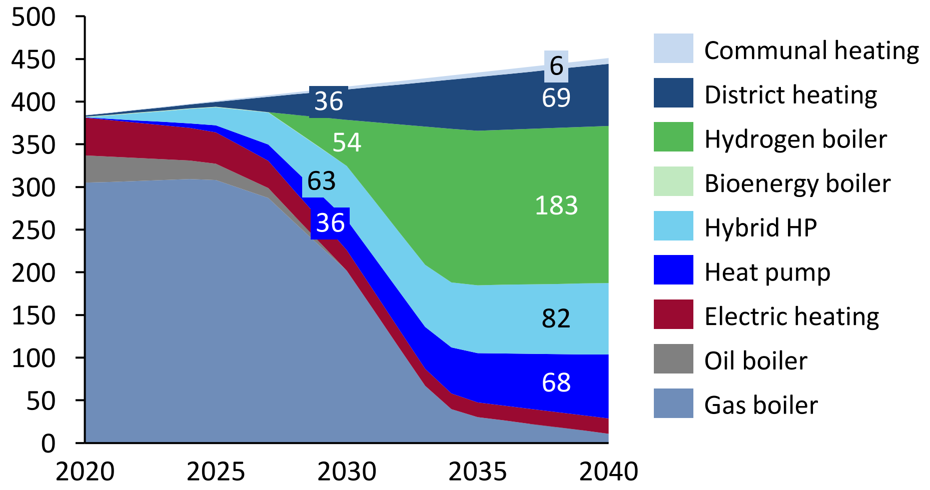
- Waterfall charts are used to give 2 illustrations of the contribution of different measures to emissions reductions in domestic buildings. We examine the Max ambition scenario in 2030 (shown here) and the High H_2 scenario in 2038.
- This graph compares the Baseline and Max ambition, **both in 2030**, to show the additional contribution of measures over the baseline [The grey baseline bar includes electricity at the 2019 carbon intensity, and the next bar then reduces this to the 2030 carbon intensity]
- **The greatest emissions saving is from heat pumps, which combined save 0.34 $MtCO_2e/yr$**. These savings will increase as heat pumps continue to be installed after 2030 and as the electricity grid decarbonises further.
- **Thermal efficiency also has large savings over baseline**, especially considering the baseline pathway already includes significant savings from efficiency measures (at a lower level).

These are estimates only, due to the overlap of many measures in contributing to the reductions in each building. It is important when using these figures to be clear on what comparison you are making (e.g. is this the absolute savings, or relative to Baseline etc).

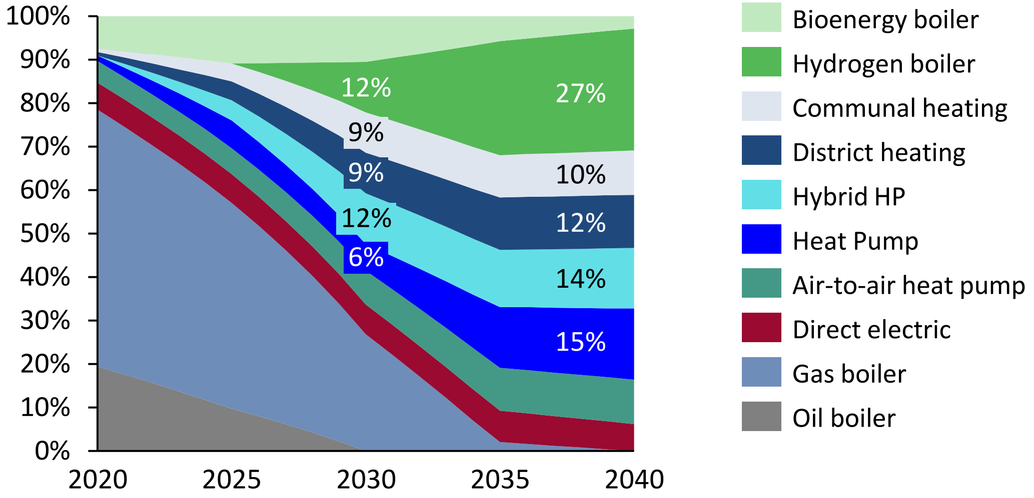
*District heating includes communal heating, which may be a single building (e.g. flats) or site ** Other includes Solar PV, lighting and appliance efficiency, biomethane grid belnding biomass boilers and electric heating. The division between heat pumps in oil and heat pumps “other” is simplified by assuming all oil homes that install a heat pump (approx. 85%) install a full heat pump rather than hybrid

Buildings – the High H_2 scenario sees switchover from natural gas to hydrogen boilers, as well as heat pump installation

Number of heating systems in homes (‘000)[1]



Heat supply to non-domestic buildings (% heat)[2]



- **The High H_2 scenario is driven by the use of hydrogen for heat, including 183k hydrogen boilers in homes and 27% non-domestic heat** supplied by hydrogen boilers by 2038. It relies on conversion of the natural gas grid to hydrogen from 2028. The early 2020s require completion of all safety testing, equipment development, planning and engineering design.
- Hydrogen also enables significant use of hybrid heat pumps (electric-hydrogen) in domestic and non-domestic sectors. Hybrid heat pumps can be rolled out during the 2020s, as they don’t require high efficiency standards and can be later converted to hydrogen.
- **Oil heating is rapidly phased out** in off-gas buildings (primarily replaced by heat pumps & hybrids) in all scenarios.
- **District & communal heating increases to 75k homes and 22% non-domestic buildings** by 2038 in heat dense areas. The energy supply utilizes hydrogen fuel as well as electricity.
- The significant amount of bioenergy used currently is reduced during the 2030s to improve air quality and conserve supply. It may still be used in hybrid heat pumps off the gas grid (e.g. hybrid electricity-bioLPG)
- **Direct electric heating is deployed in buildings which are not suitable for heat pumps**, however the quantity required is lower due to the availability of hydrogen in homes on the gas grid.

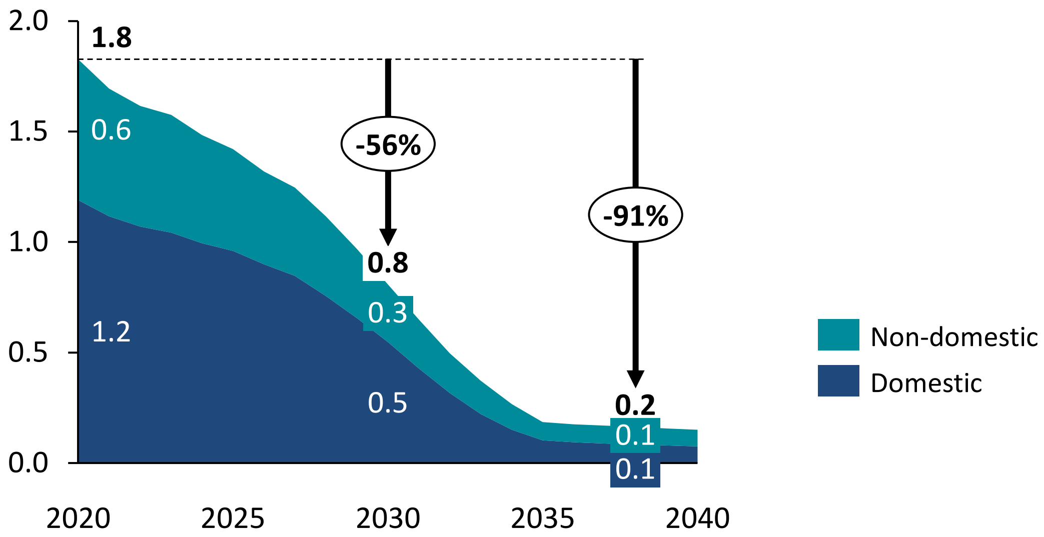
Y&NY

---

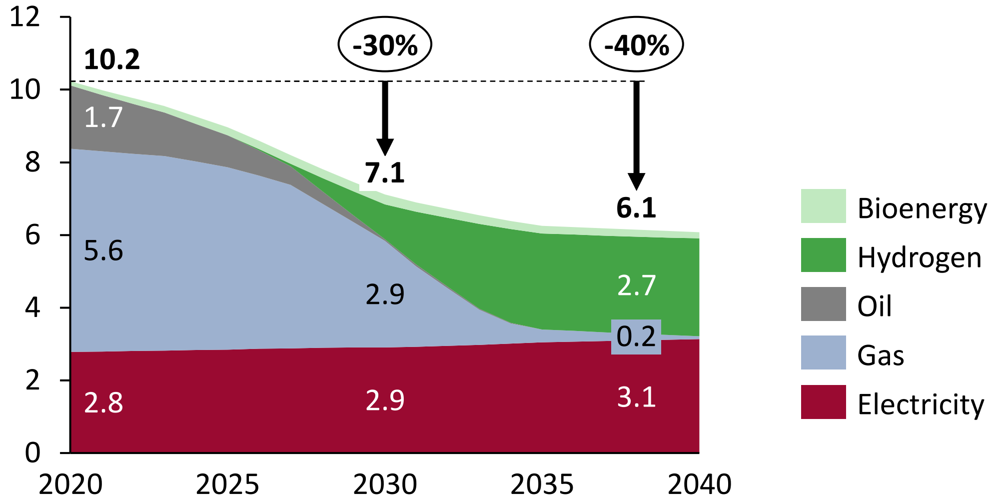
1 Numbers on the chart represent the number of select technologies in 2030 and 2038; 2 The non-domestic building modelling was completed at study region level in GWh, as the source data is in GWh, not number of buildings. The subregion breakdown is an estimate only.

Buildings – the High H_2 scenario utilises hydrogen and electricity to reach 91% emissions reduction

Emissions from buildings $MtCO_2e/yr$[1]



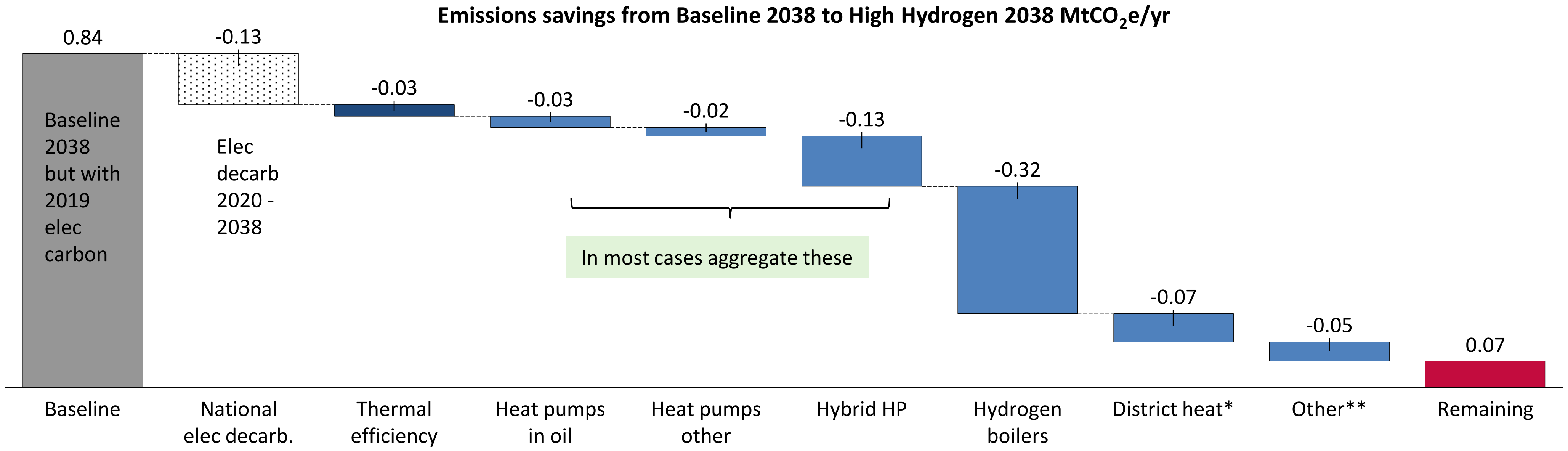
Fuel demand in buildings TWh/yr



- **Total buildings emissions decrease by 56% by 2030 and 91% 2038, reaching 0.2 $MtCO_2e/yr$.** The main contribution is conversion of the natural gas grid to hydrogen, enabling hydrogen boilers and hybrid heat pumps. The emissions decrease is steady before 2028, then rapidly drops 2028-2035; hydrogen is predominantly supplied through gas reforming with CCS, which has a very low carbon intensity[2], lower than that of national electricity in the 2030s.
- **Fuel consumption reduces by 40% by 2038**; the 2038 fuel demand is higher than the Max ambition scenario as hydrogen boilers are less efficient than heat pumps and lower energy efficiency is required in buildings with gas boilers. By 2038, fuel consumption is roughly 50% electricity and the remainder is mostly hydrogen. Annual electricity demand has increased by only 11%, reducing the impact on electricity infrastructure over the Max ambition scenario.
- **Non-heat energy** (appliances, catering etc) is currently mostly electricity. Other fuels switch to electricity or hydrogen depending on the application; hydrogen has already been proven in some catering applications.
- Buildings scale solar PV, as in other scenarios, reaches 101k domestic installations and 48 GWh/yr non-domestic generation by 2038.

1 - National electricity carbon intensity used 2 See technical Appendix for H2 production assumptions 2 - Clean Growth Strategy LINK; 3 - Future Homes Standard LINK

Contribution of different measures: the largest contribution to the High H_2 scenario by 2038 is hydrogen boilers



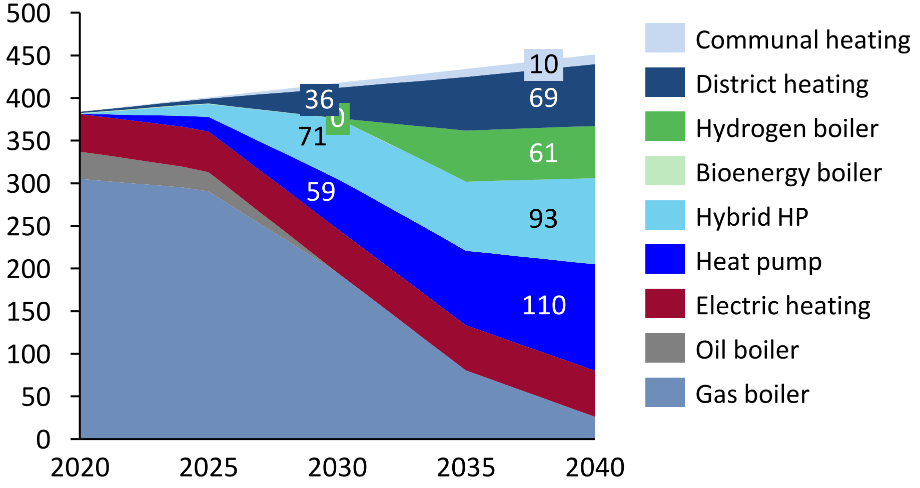
- This chart compares the domestic emissions in the Baseline and High Hydrogen scenarios, both in 2038, to show the additional contribution of measures over the baseline [The grey baseline bar includes electricity at the 2019 carbon intensity]
- **The greatest emissions saving is from hydrogen boilers, which save 0.32 $MtCO_2e/yr$**. The contribution of hydrogen boilers is significantly greater than that of heat pumps for 3 reasons: there are more hydrogen boilers; the hydrogen has lower carbon intensity than electricity; and there are no hydrogen boilers in the baseline scenario (whereas there are some heat pumps).
- **Thermal efficiency has a smaller emissions saving** than in Max ambition for 2 reasons: the High H_2 scenario has thermal efficiency applied to a lesser extent; by 2038 the baseline scenario has slightly 'caught up' in energy efficiency.
- National electricity decarbonisation has made greater emissions savings by 2038 than by 2030.

These are estimates only, due to the overlap of many measures in contributing to the reductions in each building. It is important when using these figures to be clear on what comparison you are making (e.g. is this the absolute savings, or relative to Baseline etc).

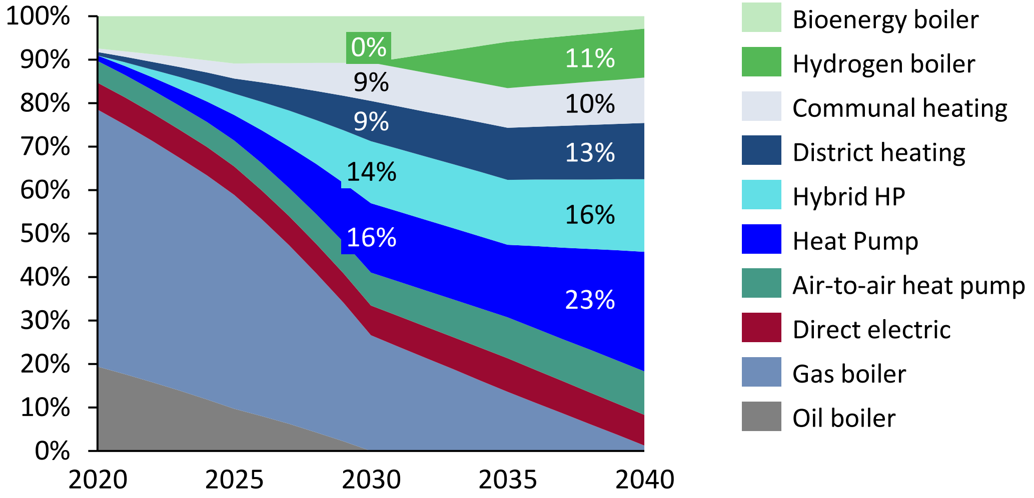
*District heating includes communal heating, which may be a single building (e.g. flats) or site
** Other includes Solar PV, lighting and appliance efficiency, biomethane grid blending biomass boilers and electric heating

Buildings – the Balanced scenarios sees a wide range of heat technologies deployed

Number of heating systems in homes ('000)[1]



Heat supply to non-domestic buildings (% heat)[2]

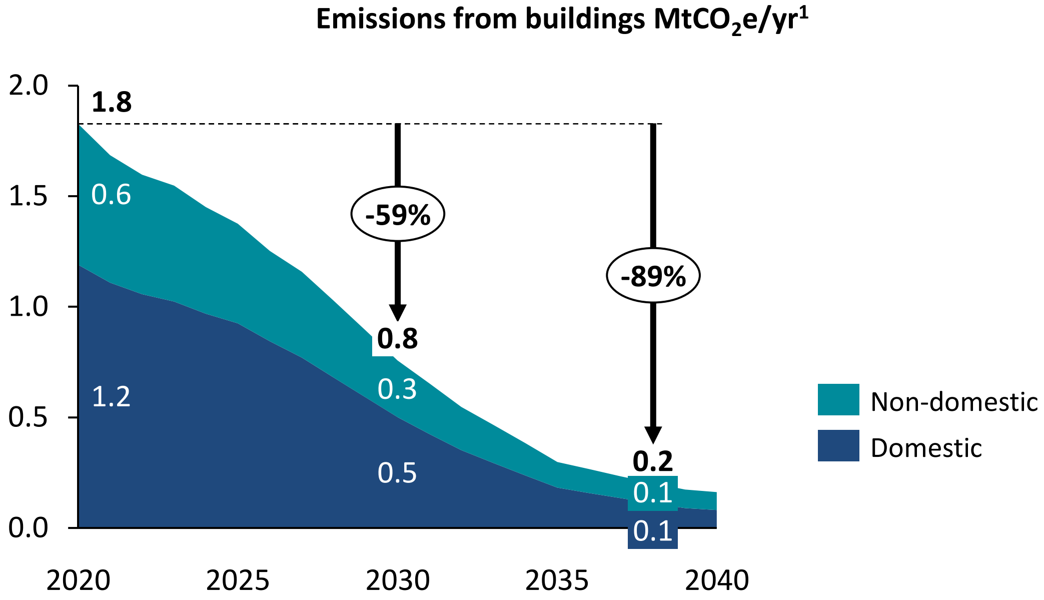


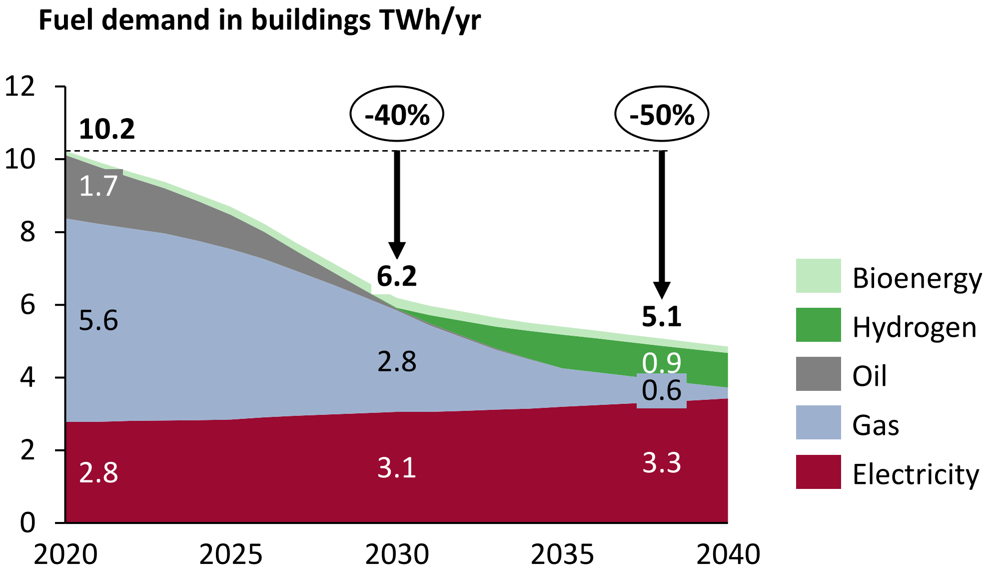
- **The Balanced scenario sees installation of multiple different heating systems, using both electricity and hydrogen.** Hydrogen becomes available from 2030, as areas of the gas grid are converted.
- **By 2038, there are around 200k heat pumps and 61k hydrogen boilers in domestic homes.** Many of the hybrid heat pumps will use hydrogen as their supplementary fuel, although those off-gas will use bioenergy.
- The non-domestic sector sees 11% heat supplied by hydrogen, 16% by hybrid heat pumps (using hydrogen) and 23% through full heat pumps by 2038.
- **The Balanced scenario offers a greater range of technology options** for some buildings and is likely to result in a more resilient energy system. However, effort is split across many areas and more infrastructure investment may be needed.
- **Oil heating is rapidly phased out** in off-gas buildings (primarily replaced by heat pumps & hybrids) in all scenarios.
- **District & communal heating increases to 78k homes and 23% non-domestic buildings** by 2038 in heat dense areas. The energy supply utilizes primarily heat pumps, but some hydrogen boilers for peaking (times of high demand).
- Direct electric heating is deployed in buildings which are not suitable for heat pumps; the number of buildings assumed is between that of the Max ambition and High H_2 scenarios

---

1 Numbers on the chart represent the number of select technologies in 2030 and 2038; 2 The non-domestic building modelling was completed at study region level in GWh, as the source data is in GWh, not number of buildings. The subregion breakdown is an estimate only.

Buildings – the Balanced scenario sees significant electrification and reduces emissions by 89% by 2038

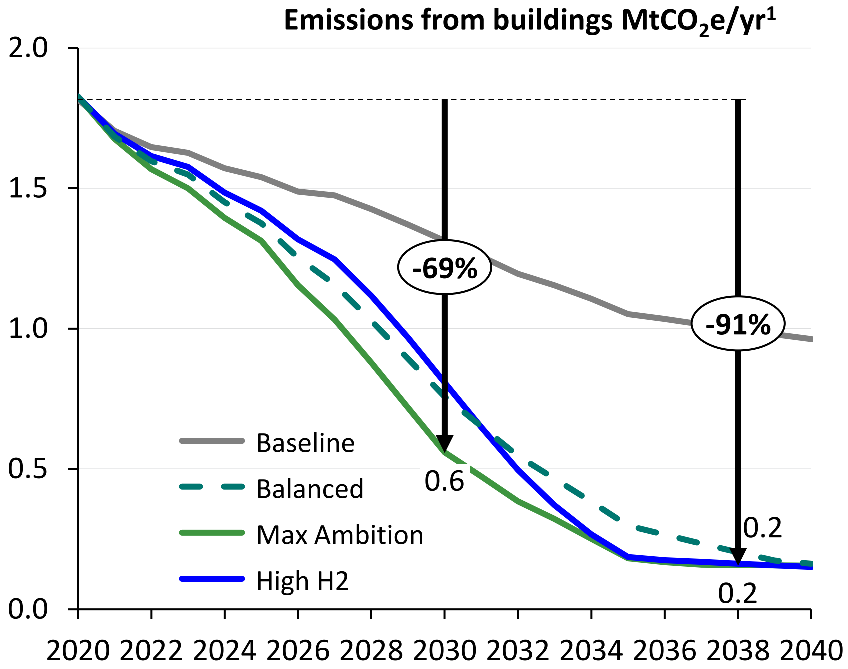


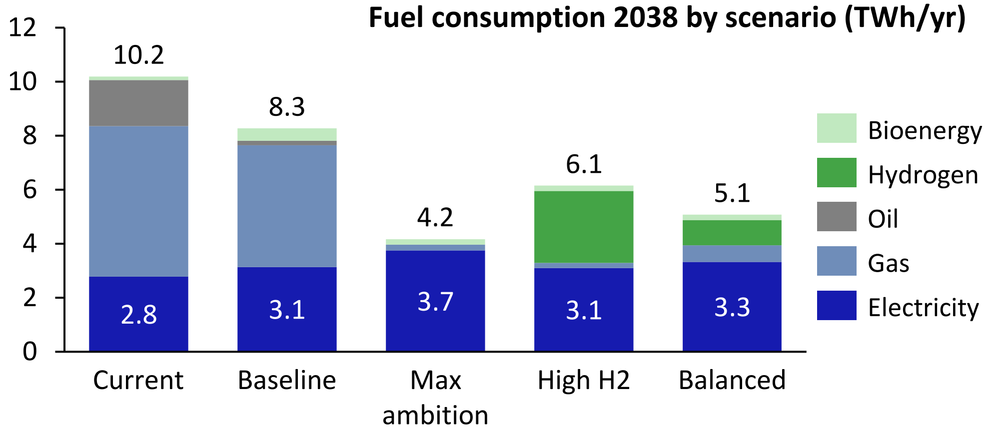


- **Total buildings emissions decrease by 59% by 2030 and 89% 2038, reaching 0.2 MtCO$_2$e/yr.** There are contributions from both conversion of areas of the gas grid to hydrogen and high installation rates of heat pumps from 2025. Supporting measures are high levels of energy efficiency (Both thermal and electrical) and decarbonisation of the national electricity grid.
- **Fuel consumption reduces by 50% by 2038, which is intermediate between the reductions seen in the other scenarios. Again, the reductions are due to both building level efficiency measures and improve heating system efficiency.** By 2038, fuel consumption is mostly electricity, which some hydrogen and remaining use of the gas grid; the gas grid carbon intensity has reduced significantly due to biomethane blending. Annual electricity demand has increased by 20% by 2038.
- **Non-heat energy** (appliances, catering etc) not already electricity switch fuel, primarily to electricity, but a small amount of hydrogen and bioenergy is used depending on the application.
- Buildings scale solar PV 101k domestic installations and 48 GWh/yr non-domestic generation by 2038.
- The Balanced scenario has slightly higher 2038 emission due to some remaining natural gas use.

1 - National electricity carbon intensity used 2 See technical Appendix for H2 production assumptions 2 - Clean Growth Strategy LINK; 3 - Future Homes Standard LINK

Buildings scenario comparison – the extent of electrification vs hydrogen conversion is the main difference



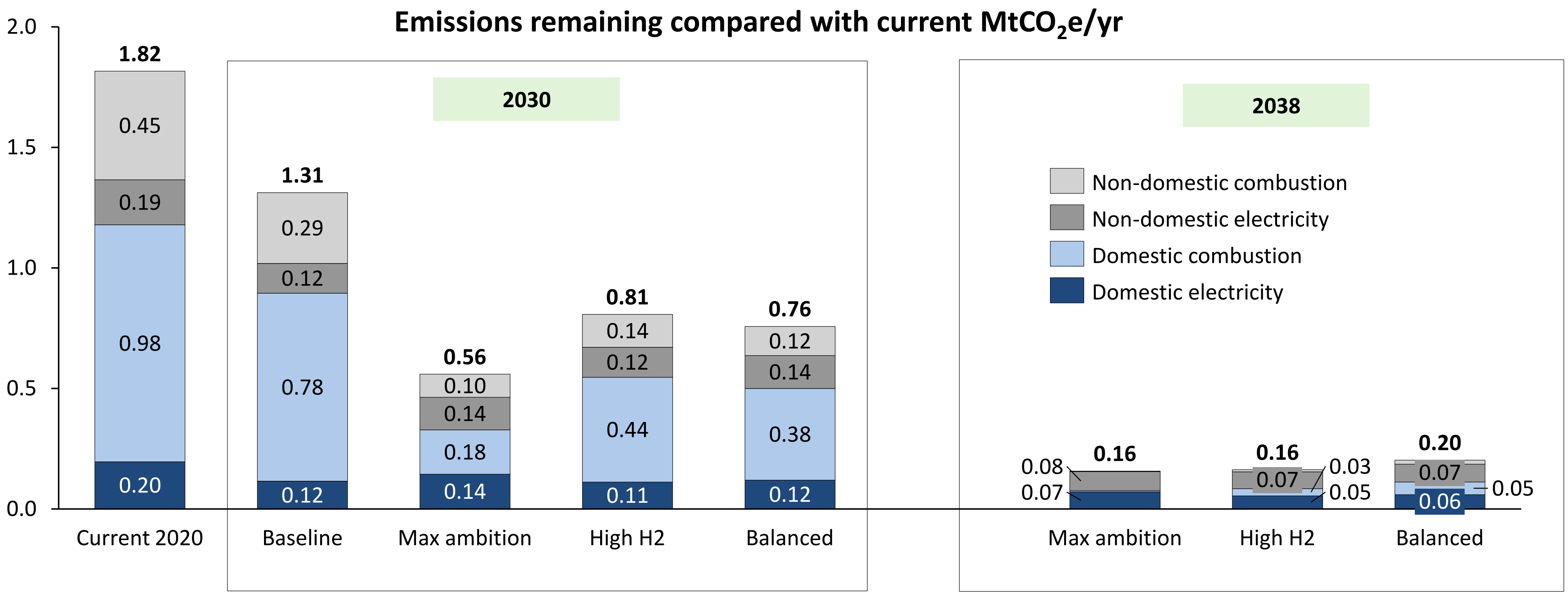


Y&NY

- **The Max ambition scenario is focused on rapid and extensive deployment of heat pumps,** supported by ambitious energy efficiency improvements. It reaches 69% emissions reduction by 2030 and 91% by 2038. There is no hydrogen for heat, so homes which are not in heat network areas and are not suitable for heat pumps use electric storage heating. Fuel consumption is almost entirely electricity by 2038.
  - Key infrastructure requirements sit in the electricity grid and generation assets, and this is the key risk to the rate of change
- **The High hydrogen scenario relies on conversion of the natural gas grid to hydrogen** to enable hydrogen boilers and hybrid heat pumps. Emissions reductions are slow before hydrogen becomes available from 2028 but accelerate to reach 90% emissions reduction by 2038. A greater amount of fuel is required to heat homes than in other scenarios, but lower electricity consumption means lower electricity infrastructure upgrades.
  - Gas grid conversion to hydrogen, and the retrofit / replacement of gas boilers is a large infrastructure and coordination challenge in a relatively short period; electricity demand is low.
- **The Balanced scenario represents a technology mix**, with hydrogen boilers in areas of gas grid conversion, significant heat pumps and hybrids and some remaining gas boilers using a blend of natural gas and biomethane. Direct electric storage heating plays a role, primarily in space constrained homes. Emissions reach $0.2MtCO_2e/yr$ by 2038 and fuel consumption is primarily electricity, supplemented by other fuels.
  - The mix of infrastructure required, from electricity and hydrogen to district heating, creates a challenge but also likely a more resilient energy system.

1 National electricity carbon intensity (HMT Green Book) is used in all scenarios

Remaining emissions in 2038 are primarily electricity-related



- **In 2030, all scenarios see significant emissions remaining,** although the Max ambition scenario has made the most progress on combustion emissions through heat pumps and thermal efficiency.
- **In 2038, the majority of remaining emissions are from electricity use** at non-zero carbon intensity (for both heat and non-heat applications), but some combustion emissions remain:
  - Electricity-related emissions are highest in the Max ambition scenario, with barely any other fuels used
  - the High H_2 scenario also sees a small amount of combustion emissions from hydrogen
  - the Balanced scenario has the highest 2038 emissions, from both electricity and residual natural gas usage

Y&NY

Buildings – key messages

- **Buildings sector emissions reduce by 69% by 2030 & 91% by 2038 in the Max ambition scenario, leaving 0.2 $MtCO_2e$/yr.**
- **The majority of emissions from buildings arise from heat generation**. Low carbon heating options include heat pumps, hybrid heat pumps, district/communal heating, hydrogen boilers or bioenergy.
- **Y&NY contains a large proportion of off-gas grid homes** (~20%), often relatively large and using oil boilers, many of which require heat pumps or hybrid HP (electricity-bioLPG). Oil is phased out by 2030 in all three emissions reduction scenarios.
- **Ambitious energy efficiency improvements** are needed in the 2020s, retrofitting over 250k homes, to reduce energy demand and support the technical feasibility of low carbon heating systems such as heat pumps.
- **The Max ambition scenario focusses on highly ambitious heat pump[1] installation, reaching 203k domestic heat pumps by 2030** and 274k by 2038. By 2038 heat pumps also serve 47% of non-domestic heat. This is supported by deployment of district heating in urban areas and electric storage heating in space constrained homes. By 2038, fuel consumption is almost entirely electricity, and the **annual electricity demand has increased by 34%,** with implications for electricity generation and distribution infrastructure.
- **The High H_2 scenario is driven by the use of hydrogen for heat, including 183k hydrogen boilers in homes and 27% non-domestic heat** supplied by hydrogen boilers by 2038. Emissions reductions are slow during the 2020s, but rapid from 2028 as hydrogen deploys; hybrid heat pumps should be deployed during the 2020s to then utilise the H_2 after conversion. There are considerable uncertainties around the cost, infrastructure and consumer perception of hydrogen, but it has the advantage of reducing the additional strain on the electricity grid and minimizing consumer behaviour change required.
- **The balanced scenario sees a mix of technologies**, with heat pumps and hybrids installed rapidly from the mid-2020s, and hydrogen boilers in the early 2030s. District heating is used mainly for heat dense urban areas. Annual electricity demand increases by 20% by 2038. This scenario sees opportunities in greater consumer choice and a likely more resilient system.
- **Emissions remaining in 2038 in the buildings sector are largely electricity related**, so will reduce as the national electricity grid decarbonises. The High H_2 has some emissions from hydrogen (production emissions) and the Balanced scenarios sees some emissions remaining from residual natural gas usage and hydrogen.
- **Key challenges remain** around infrastructure (electricity system, H_2 & district heating), quality and consumer acceptance of heat pumps and achieving high thermal efficiency.

[1] heat pumps referring to air-to-water and hybrid air-to-water (not air-to-air)

Buildings – there are significant challenges remaining

The challenge to be addressed is huge, both in terms of capacity and cost

Key challenges remain in all scenarios around:

- Infrastructure (electricity system, hydrogen & district heating)
- Quality and consumer acceptance of heat pumps, as well as consumer acceptance of hydrogen
- Achieving the high thermal efficiency standards required to underpin heat pump deployment
- Investment and high cost to consumers

The Max ambition scenario stretches what could be deemed feasible. This case assumes no hydrogen in the gas grid, so it relies on electrification of most heat, primarily through installation of heat pumps & hybrid heat pumps by 2030. The challenges with the rapid timing are:

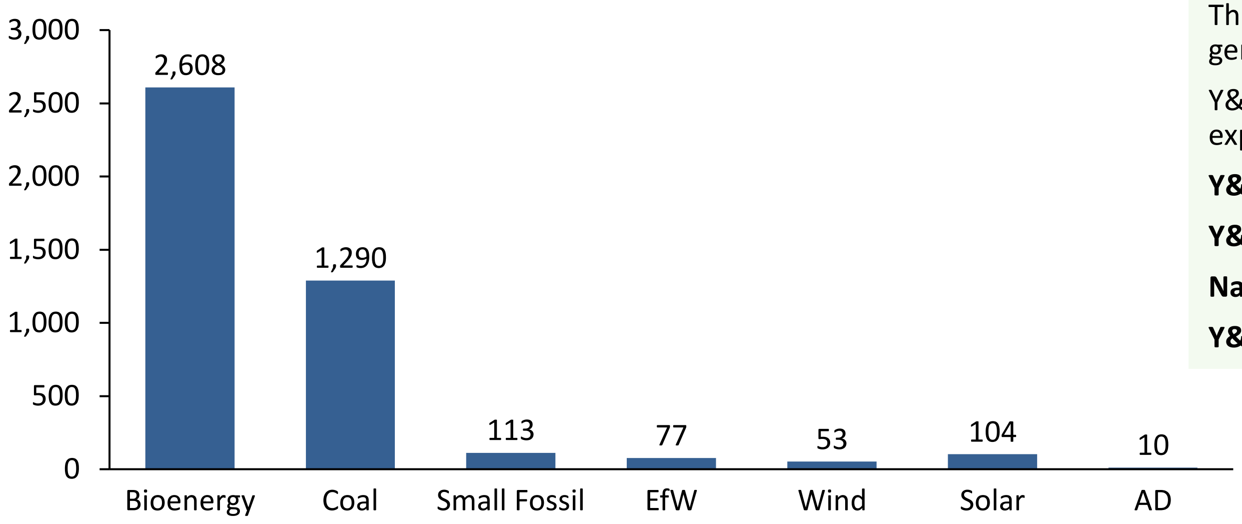
- **The natural turnover rate of heating systems is typically around 15 years**, so many must be replaced early, adding additional cost of technology scrappage
- **Misalignment with current national policy and the national 2050 target.** For example the RHI is delivering only ‘000s heat pumps (<0.5% stock) per year across the country, so significant additional incentives would be needed locally. The 2050 target implies national policy will aim for transition over that timeframe, rather than pushing in the 2020s for early heating system replacement.
- **Limited existing heating system regulation** currently and many existing buildings won’t pass through the planning system e.g. owner occupier homes. This gives limited control over consumers choices.
- **The supply chain for new heating system technologies is not currently fully developed**, so requires support for regional training programs and developing heat pump manufacture relationships

The policy tasks will look in further detail at the level of incentives and support needed regionally and nationally to realise these changes.

Contents

Power sector- current (2020 as modelled) capacity, generation and emissions of York and North Yorkshire

Installed Capacity- MWe



The power sector comprises of both centralised and decentralised electricity generation except for rooftop solar PV.

Y&NY has lower regional grid carbon intensity than the national average and exports most of its power to outside the region.

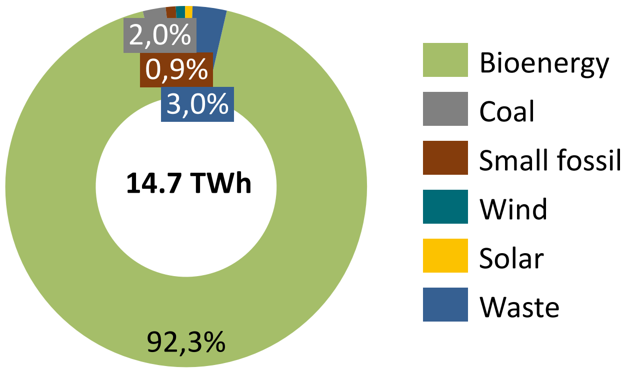
Y&NY Grid Intensity: ~62 gCO$_2$/kWh

Y&NY + WY + Barnsley Grid Intensity: ~82 gCO$_2$/kWh

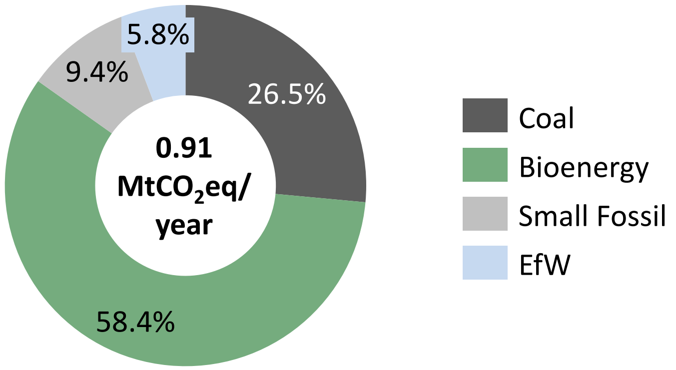
National Grid Intensity: ~128 gCO$_2$/kWh

Y&NY Power Internal Use: 26%.

Power Generation: Bioenergy dominates power generation due to Drax, which accounts for 93% of all generation.



Emissions: Drax is responsible for 84% of power sector emissions; most other generators are small renewables, small fossil, and EfW.



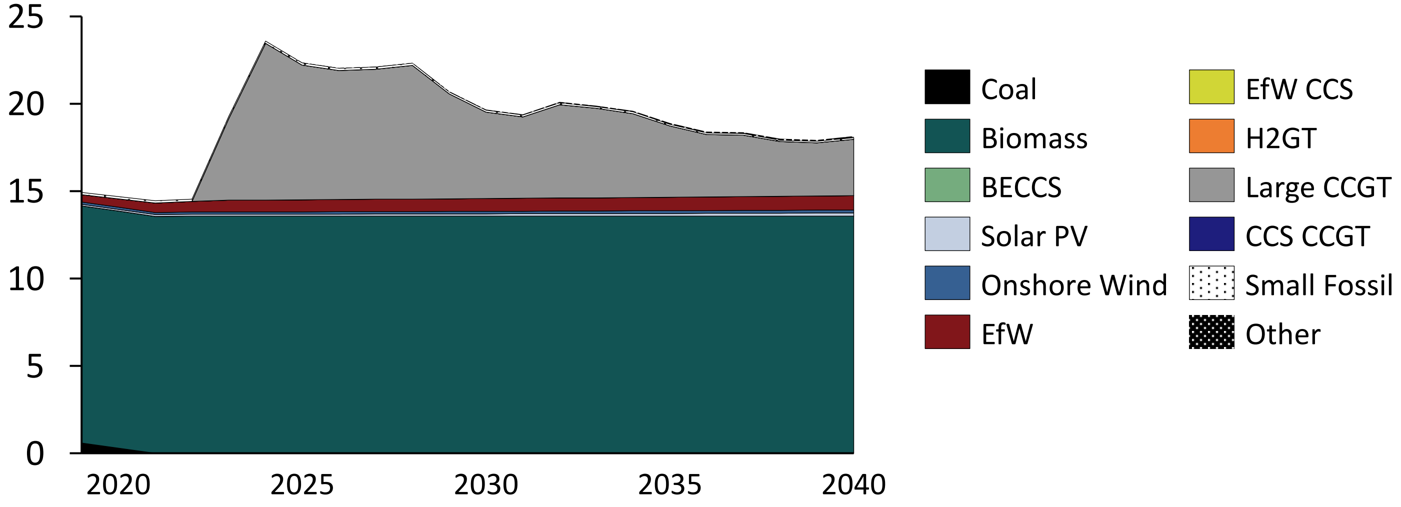
Y&NY

Energy from waste (EfW) includes waste incineration for electricity production or combined heat and power generation, power production through waste based anaerobic digestion and power from cooking oil, sewage sludge digestion and landfill gas.

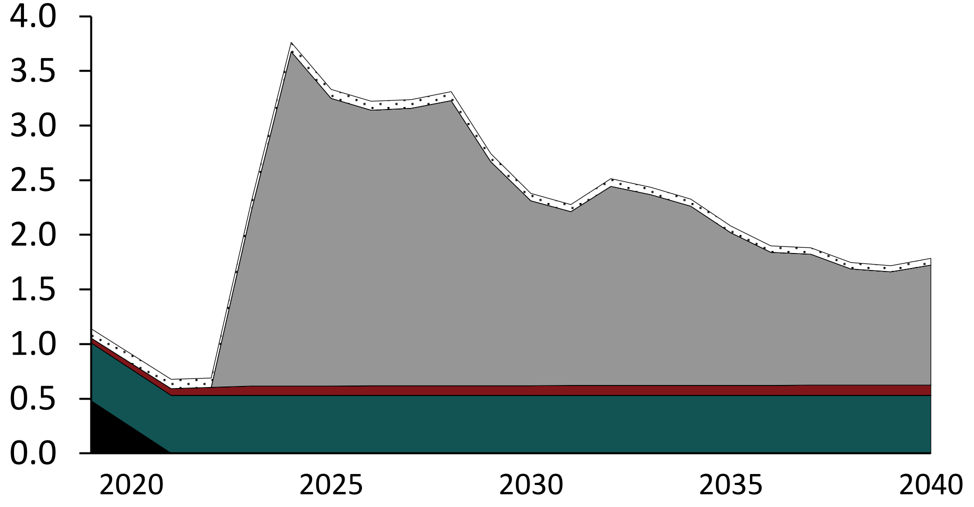
Baseline pathway – power generation significantly increases due to replacement of peaking coal with gas turbines which run more frequently

Y&NY

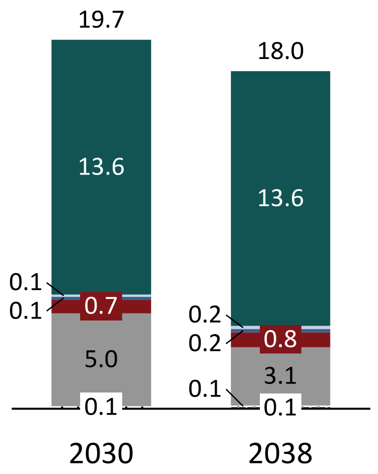
Generation- TWh/year



Emissions*- MtCO$_2$eq/year



Generation (TWh/year)



Emissions (MtCO$_2$eq/year)**

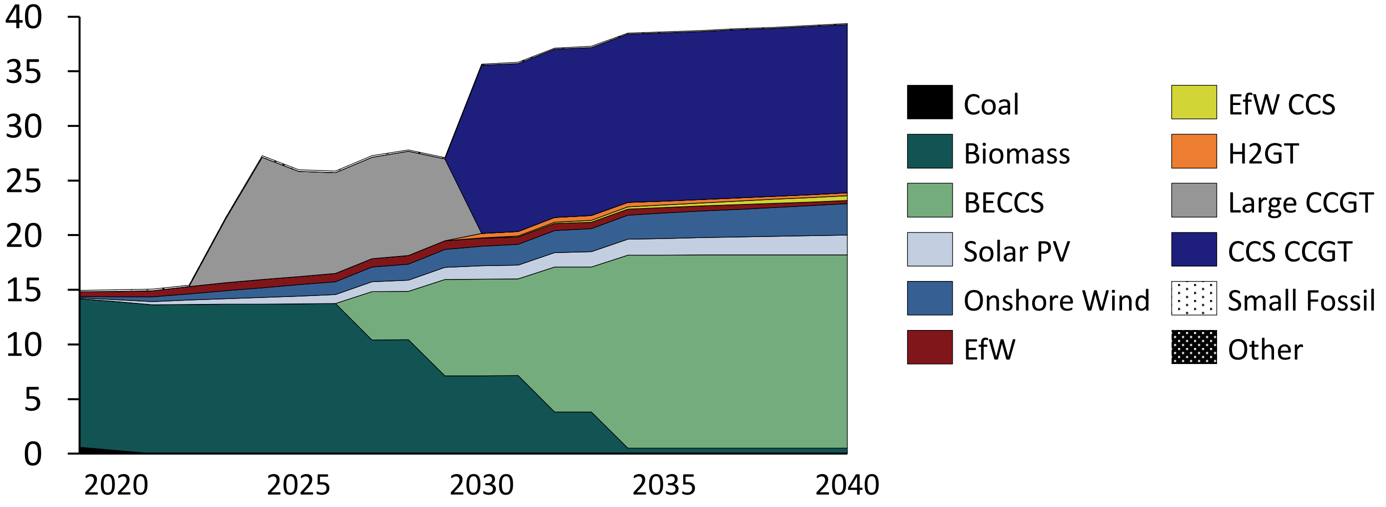
- In the baseline scenario CCS and related technologies (BECCS, Hydrogen) are not deployed due to lack of policy support.
- Coal is phased out in 2021 in accordance with Drax capacity contracts running out.
- In the mid-2020s new unabated CCGTs are added to the system which significantly increase emissions and total power generation in the region.
- Wind, solar, small fossil, small biomass and energy from waste- currently small in the region and continue to grow slowly.
- Region's power export decreases from 74% in 2020 to 71% in 2038 and emissions increase by 92% over the same period.

* Only positive emissions displayed. BECCS and EfW CCS is omitted from the graph.

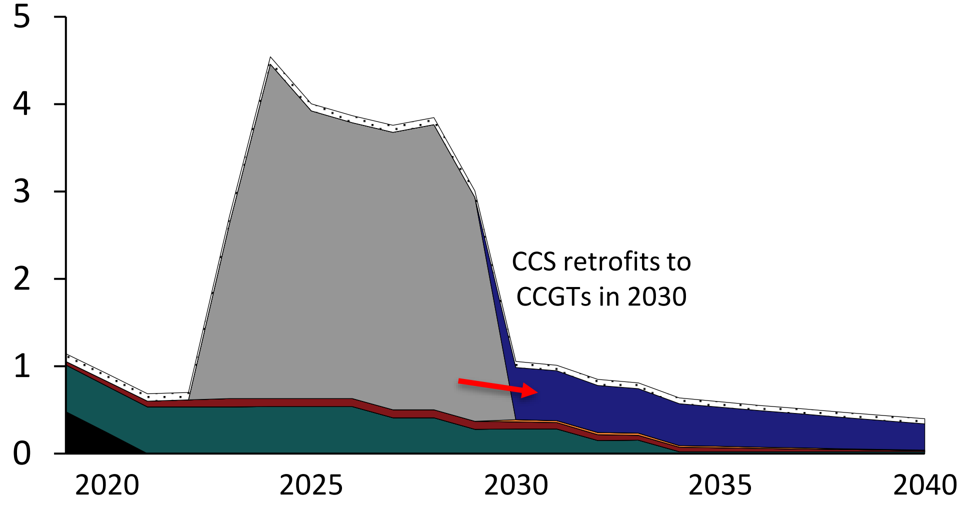
** BECCS negative emissions are not shown.

Max Ambition- power decarbonisation may be sped up by 2030, but nearing zero positive emissions is limited by regional CCS timetables

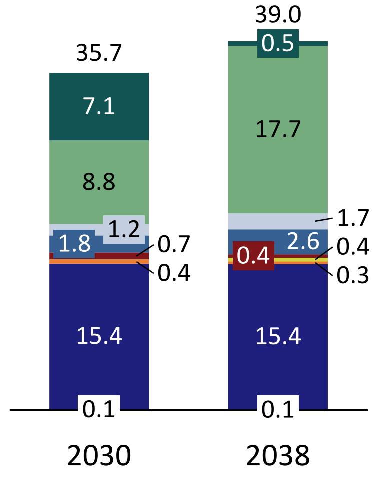
Generation- TWh/year



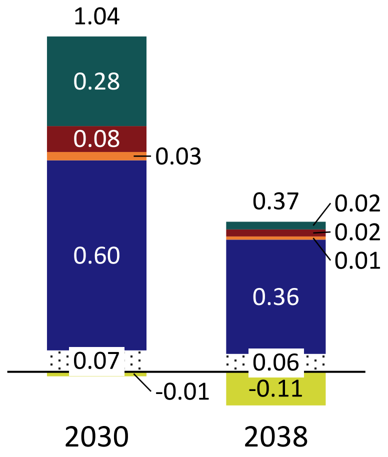
Emissions*- MtCO$_2$eq/year



Generation (TWh/year)



Emissions (MtCO$_2$eq/year)**



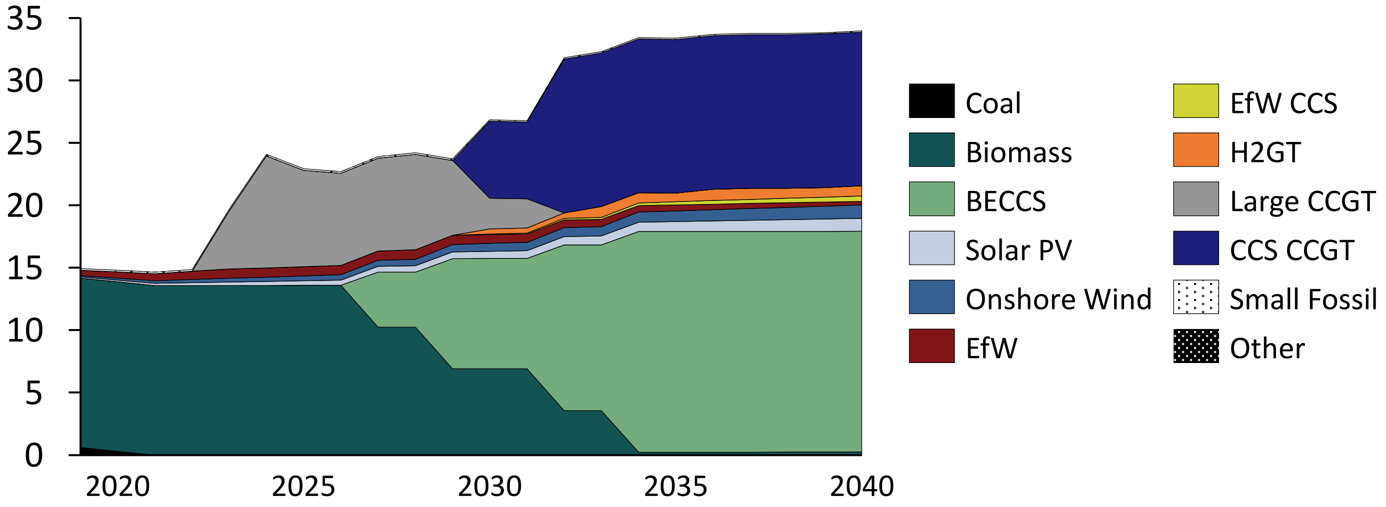
- The Max Ambition Scenario accelerates deployment of low carbon technologies to achieve rapid decarbonisation in 2020s.
- Region's power export increases from 74% in 2020 to 81% in 2038.
- Considering negative EfW CCS emissions (excluding BECCS), generation based grid intensity of the region is reduced by 52% and 85% (compared to 2020) by 2030 and 2038, respectively.
- CCS technologies (both BECCS and CCGT CCS) are the main drivers behind emissions reduction. Decarbonization in 2030 is limited by the adoption rate of CCS in the region, in particular Drax.
- Please see the power sector appendix for no CCS and no CCGT sensitivities.

* Only positive emissions displayed. BECCS and EfW CCS is omitted from the graph.

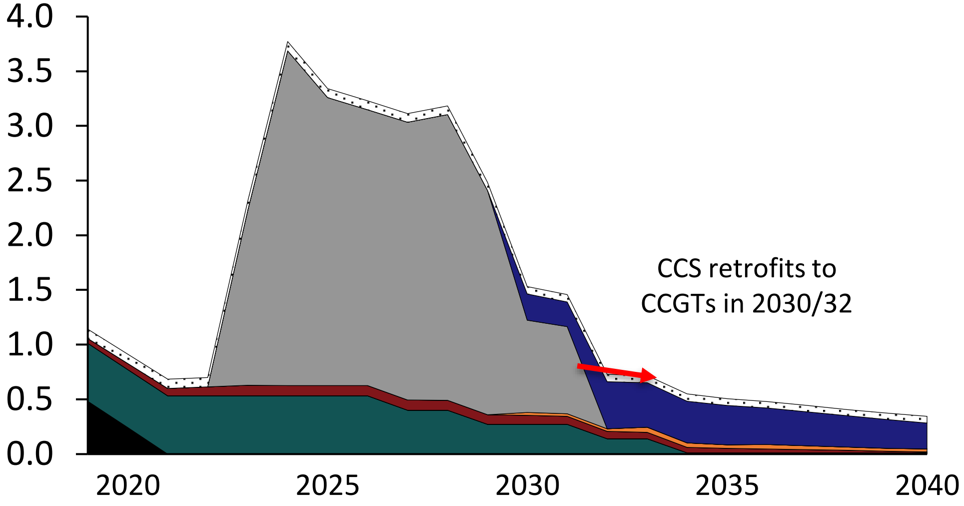
** BECCS negative emissions are not shown.

High H_2 Scenario- hydrogen reduces the required uptake of other low carbon power technologies to achieve similar levels of decarbonisation

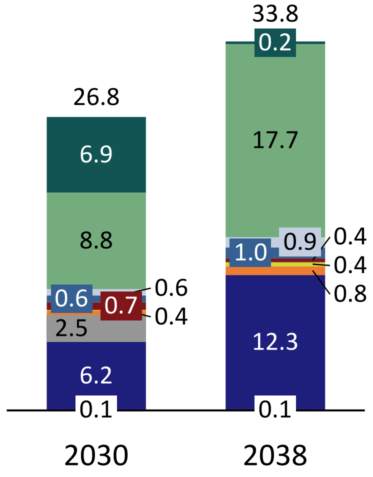
Generation- TWh/year



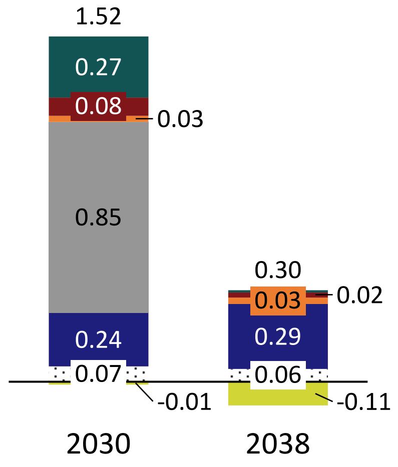
Emissions*- $MtCO_2eq$/year



Generation (TWh/year)



Emissions ($MtCO_2eq$/year)**



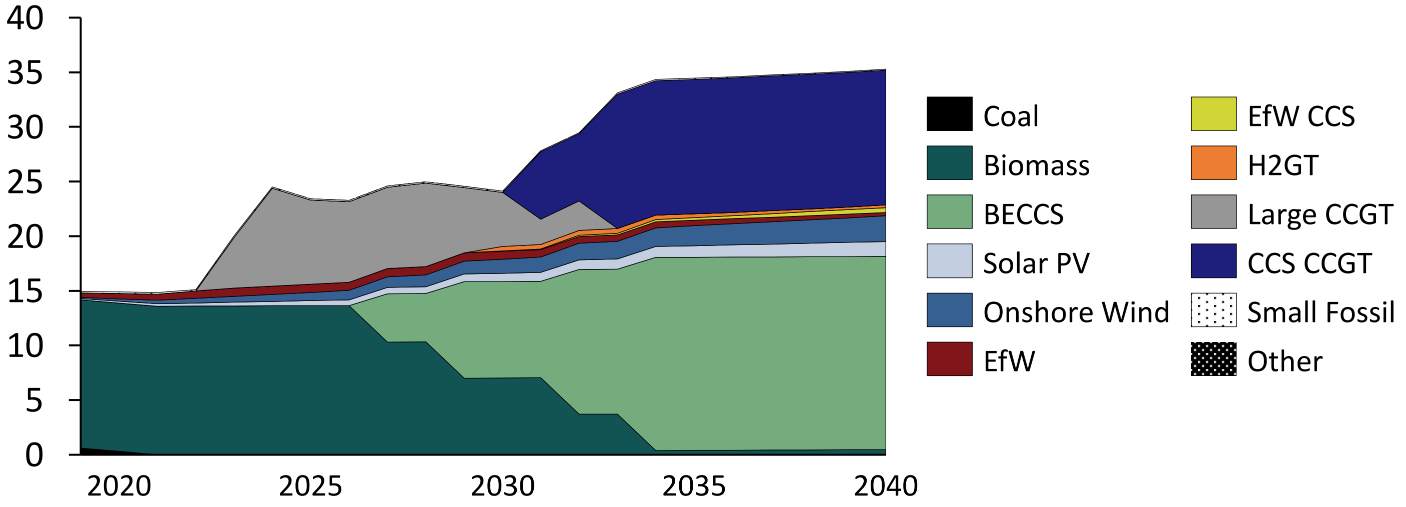
- High H_2 Scenario deploys 3 times the hydrogen power of other scenarios. Power demand from other sectors are lower due to hydrogen usage.
- Region's power export increases from 74% in 2020 to 85% in 2038.
- Considering negative EfW CCS emissions (excluding BECCS), generation based grid intensity of the region is reduced by 8% and 85% by 2030 and 2038 (compared to 2020), respectively.
- CCS technologies (both BECCS and CCGT CCS) are the main drivers behind emissions reduction. Decarbonization in 2030 is limited by the adoption rate of CCS in the region, in particular Drax.
- Please see the power sector appendix for no CCS and no CCGT sensitivities.

* Only positive emissions displayed. BECCS and EfW CCS is omitted from the graph.

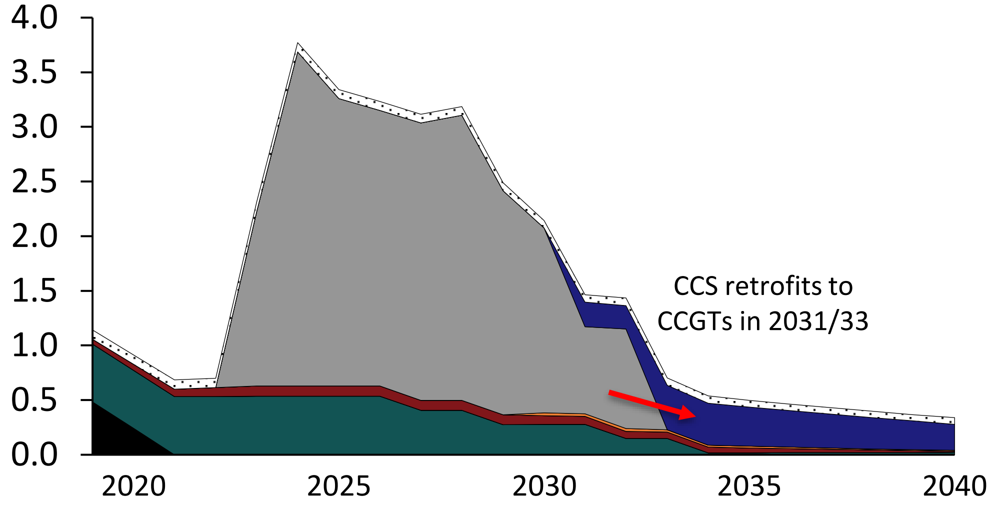
** BECCS negative emissions are not shown.

Balanced Scenario- power generation is amplified through renewables, which are deployed evenly across the model timeframe

Generation- TWh/year

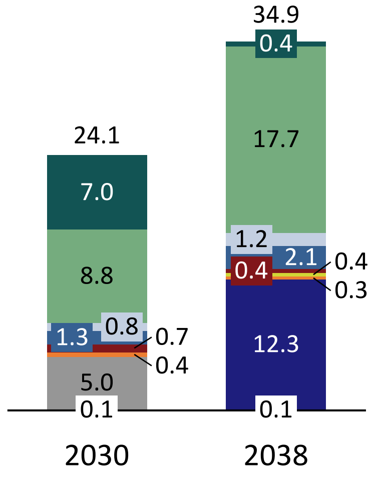


Emissions*- MtCO$_2$eq/year

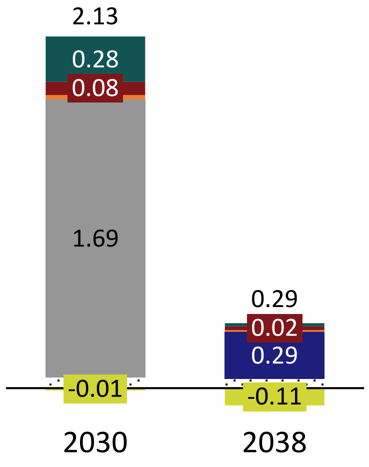


Y&NY

Generation (TWh/year)



Emissions (MtCO$_2$eq/year)**



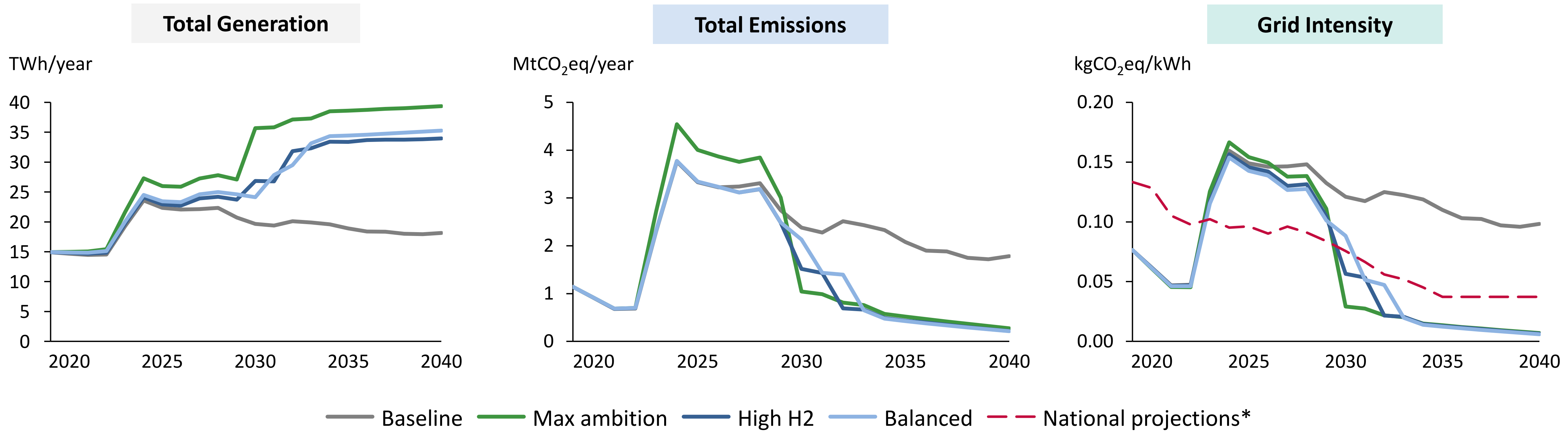
- Balanced Scenario deploys high levels of decentralised technologies, mostly renewables, split more evenly over time.
- Region's power export increases from 74% in 2020 to 83% in 2038.
- Considering negative EfW CCS emissions (excluding BECCS), generation based grid intensity of the region is increased by 44% by 2030 and reduced by 87% by 2038 compared to 2020.
- CCS technologies (both BECCS and CCGT CCS) are the main drivers behind emissions reduction. Decarbonization in 2030 is limited by the adoption rate of CCS in the region, in particular Drax.
- Please see the power sector appendix for no CCS and no CCGT sensitivities.

---

* Only positive emissions displayed. BECCS and EfW CCS is omitted from the graph.

** BECCS negative emissions are not shown.

All three decarbonisation scenarios reach similar emission reduction levels where Max Ambition opts in for higher generation levels



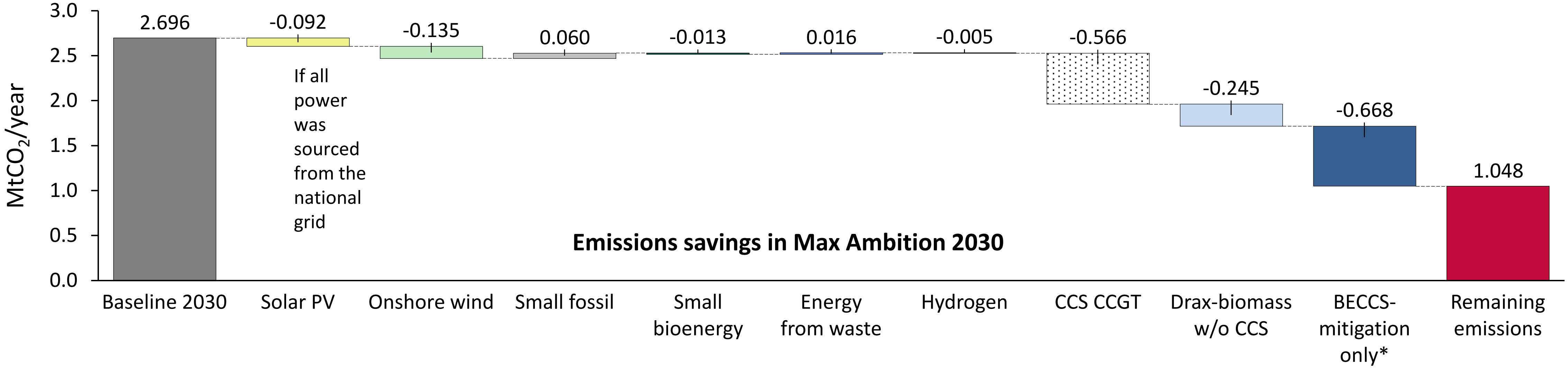
- **These graphs exclude negative emissions from BECCS** (BECCS is taken as zero emissions).
- All 3 scenarios achieve similar levels of emissions reduction in 2038 (79-83%) compared to the baseline, however Max Ambition achieves faster decarbonisation in 2030 by accelerating deployment of all technologies, especially CCS retrofits on CCGTs.
- General decarbonisation patterns of the 3 scenarios are also similar because major changes in the power sector relate to the fate of large-scale generation such as coal phase-out, CCGT deployment and CCS retrofits. Since these have mostly similar timescales across scenarios, the differences across scenarios are smaller compared to other sectors.
- The other modelled sectors require more power in the Max Ambition Scenario, therefore this scenario maximizes generation by ramping up renewables, bioenergy and deploying 2.5 GW of CCS CCGTs, as opposed to 2 GW in other scenarios.
- Perhaps counter intuitively, Max Ambition ends up with slightly higher emissions by 2038 as ramping up electricity generation requires more CCS CCGT capacity, which has residual emissions associated with it.
- Even without accounting for the negative emissions of BECCS, regional grid carbon intensity is lower than the projected national grid intensity in all scenarios once new CCGTs are fitted with CCS in early 2030s.

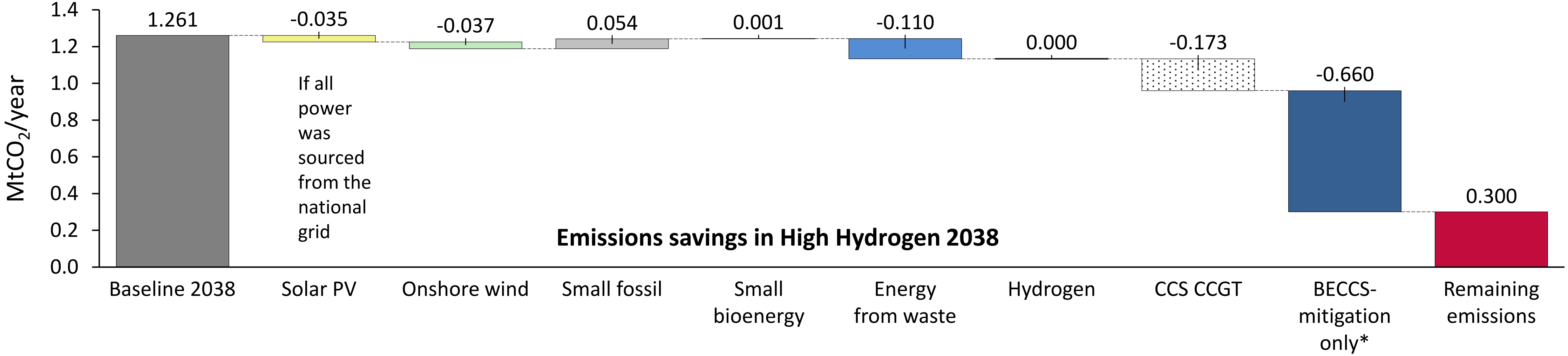
Y&NY

*Based on Treasury's Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas emissions.

Link to contents

Waterfall charts showing emission reductions in the power sector for Max Ambition 2030 and High Hydrogen 2038





Please see next slide for explanation and notes. Note that these are estimates only.

Positive values indicate increase in emissions compared to national grid.
*"BECCS- mitigation only" refers to reducing biomass emissions at Drax to zero; no BECCS negative emissions are shown here.

Notes for power sector waterfall charts

- The charts show the emissions reduction in Y&NY for one year: 2030 for Max Ambition and 2038 for High H_2.
- The baseline figure shows how much CO_2 would be emitted if all the power **generated** in the region in that particular year was sourced from the national grid, at the grid intensity for that given year according to the Treasury Green Book's Supplementary Guidance. Since the grid is expected to decarbonise over time, the 2038 baseline emissions are lower than 2030.
- Each bar represents how much CO_2 each technology saves compared to importing from the grid. Positive values represent technologies that emit more than the grid average at that time. These technologies are still needed to achieve the power production levels required in the scenarios.
- Small fossil incudes small CCGTs, small oil and small gas plants. Small biomass includes dedicated biomass, except Drax, and biomass AD plants. Energy from waste (EfW) includes electricity only EfW, EfW CHP, EfW CCS, waste based AD and power from cooking oil, sewage sludge digestion and landfill gas.
- Drax negative emissions are not included. “BECCS- mitigation only” represents the effect of reducing biomass emissions at Drax to net zero compared to current emissions. “Drax biomass w/o CCS” in year 2030 refers to the savings achieved by the unabated biomass turbines at Drax. These are converted to BECCS by 2038.
- Note that waterfall graphs are estimates and represent one particular way of illustrating the scenarios. Savings for some technologies appear to be very small or non-existent. This means that the technology emits the same amount of CO_2 as the grid, which is already decarbonised to a great extent in 2030s.

Power – Key Messages for York & North Yorkshire

- **Most of the current emissions arise from coal and biomass generation at Drax.** Large-scale generation is likely to dominate emissions, especially when new CCGTs are built in the region.
- **New large-scale generation is expected to restore the older power export levels of the region.** New CCGT capacity and transitioning to CCS (which operate at higher load factors) would increase the power export capability of York & North Yorkshire to pre-coal phase-out era. Power exports may rise from 74% in 2020 to 81%-85% in 2038.
- In 2038 decarbonisation scenarios **remaining emissions are mostly from CCS CCGTs and small-scale generation,** such as Energy from Waste (EfW), biomass and small fossil plants. Around 22% of these emissions may be removed by **installing CCS on all the electricity only EfW plants (47 MW)** to generate negative emissions.
- **The modest renewable capacity in the region must expand very rapidly to reduce grid intensity.** Despite representing 3.4% of UK's land, solar (~0.8% of UK) and onshore wind (~0.4%) capacity in the region is very limited. Significant support is required to add up to 130% and 107% of the current wind and solar capacity, respectively, every year until 2030 in the Max Ambition Scenario.
- **Drax negative emissions are likely to help offset remaining emissions in other sectors.** Power sector is projected to have residual emissions of 0.29-0.37 Mt/year in 2038, which would easily be compensated by the 17 Mt/year negative emissions of Drax, even when only a small portion is attributed to the region.
- **Y&NY is expected to host large-scale, centralized power plants and export most of its power.** Early CCS and hydrogen infrastructure is likely to be located around Drax in Selby[2], therefore York & North Yorkshire is positioned to be a net power exporter compared to some of its neighboring regions, such as West Yorkshire, which has limited distributed generation and is likely to rely on electricity imports.
- **Disabling CCS significantly increases emissions and curbs electricity generation** across scenarios, especially if unabated CCGTs are added. On the other hand, removing new build CCGT, thus CCS CCGTs, from the models result in a tradeoff between lower power generation and elimination of residual power emissions.

CCGT: combined cycle gas turbine

[2] Zero Carbon Humber initiative LINK

Power – Y&NY is positioned to host future large-scale CCS plants and deploy very high capacities of renewables

York & North Yorkshire characteristics of power generation assets:

- **Remaining peaking coal capacity** of Drax is 1.3 GW, compared to the 5.8 GW UK total. On the other hand, York & North Yorkshire has **no large-scale gas generation** despite the 33 GW UK fleet of CCGTs and OCGTs.
- **High renewable energy generation through Drax biomass** units accounts for 11% of all UK renewable electricity and ~55% of all UK biomass capacity in 2019.
- **Disproportionately low solar and onshore wind assets** represent the lack of distributed generation in Y & NY. Despite having 3.4% of UK land and 1.24% of UK population, solar and onshore wind capacities are only ~0.8% and ~0.4% of the UK total, respectively.
- **Only a single Energy from Waste plant (27 MW) serves the region** even though North Yorkshire has ~67% more waste sent to landfills per capita than West Yorkshire which has 159 MW EfW facilities, including a new 11.6 MW EfW CHP plant.
- **Small-scale fossil generation is relatively limited in North Yorkshire**, which only has 26% of oil generators, 42% of small gas generators and none of the 2 small CCGTs of the total study region consisting of North and West Yorkshire + Barnsley.

The scale and rate of change for power generation in York & North Yorkshire:

- **Very swift action is needed to deploy CO_2 transport infrastructure** as BECCS (17 $MtCO_2$/yr), CCS CCGT (4.5-5.5 $MtCO_2$/yr) and EfW CCS (0.2 $MtCO_2$/yr) represent a CO_2 storage requirement of 22-23 $MtCO_2$/yr by 2038. This compares to the total annual injection capacity of 30 $MtCO_2$/yr of all the 4 offshore CO_2 storage sites off the East England coast which underwent detailed appraisal studies.
- In the Max Ambition Scenario **solar PV and onshore wind capacities in the region must increase by 108 MW and 66 MW every year until 2030**, which corresponds to 107% and 130% of currently installed capacity, respectively. In 2038, total land area required for solar PV and onshore wind correspond to 0.4% and 3.5% of total Y&NY land area, respectively*.
- In all decarbonisation scenarios, **electricity only EfW capacity doubles by 2023 to 57 MW and is all converted to CCS** from 2030 onward, while new 11.5 MW EfW CHP capacity is added.
- Most manufacturers target 2030 for development of a modern low-carbon large-scale hydrogen gas turbine for power generation. However, **a full scale (300 MW) first-of-a-kind hydrogen turbine already comes online by 2030**, along with its related infrastructure, in Y&NY, with potential 300 MW additions every 3 years in the High H_2 Scenario.

---

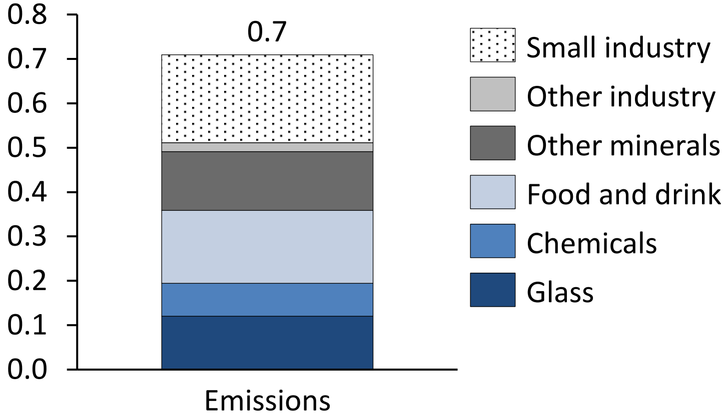
* For wind, this covers all the area between turbines. For both technologies the covered land area can also be used for other purposes such as agriculture, forestry, etc. Further studies are needed to assess the full impact on land availability.

Contents

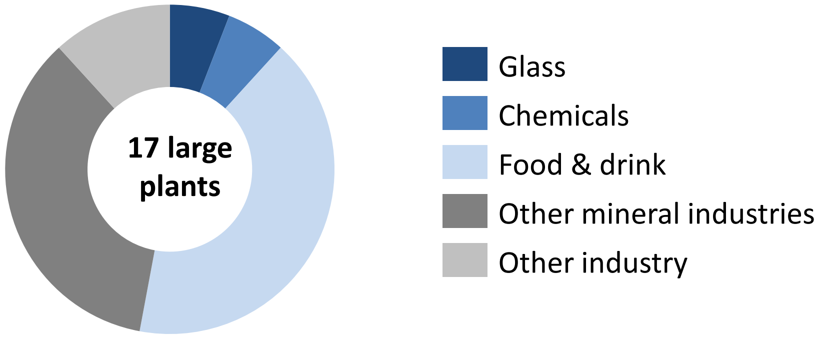
Current energy and emissions situation in the region - industry

- “Heavy Industry” in the context of this study relates to large, energy and emissions intensive sites (approximately the 17 largest in York and North Yorkshire).
- Other energy and emissions from industrial processes are included in the “Small industry” category.
- The commercial sites and building related emissions from small industry sites are included in the non-domestic buildings sector.
- Industrial emissions in the region are small, at 0.7 $MtCO_2e$/yr, due to the limited heavy industry.
- Much of the heavy industry is located in a cluster around Selby, with 9 sites in the LA, covering glass, chemicals, minerals and food sectors.

Industrial emissions by sector $MtCO_2$/yr

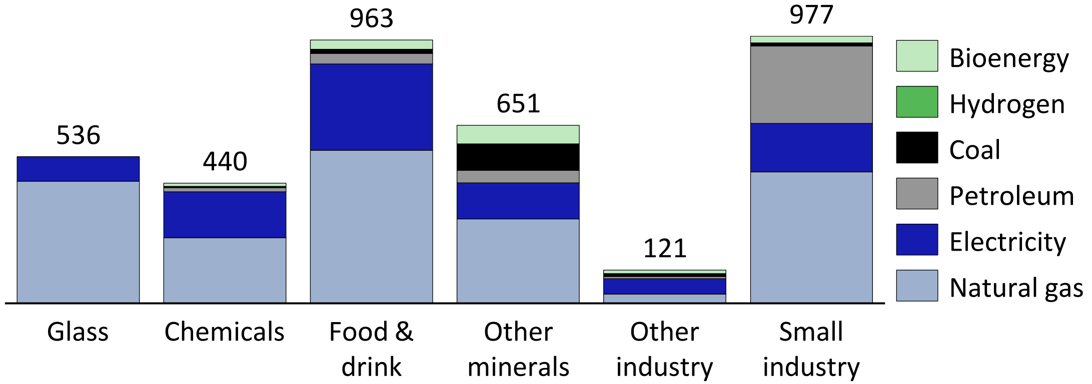


Energy intensive Industry: The primary heavy industry sectors in the region are food and drink and other minerals[1]



Much of the heavy industry is located in a cluster around Selby

Industrial energy by sector & fuel (estimate only) GWh/yr

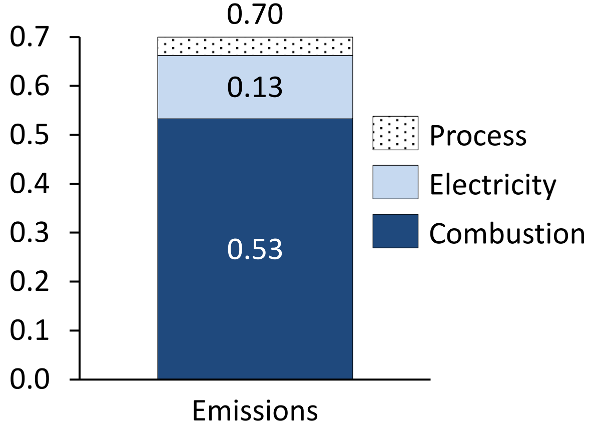


Source: NAEI point source emissions, ECUK fuel breakdown, discussion with British Glass
Note that combustion emissions are CO_2eq as other GHG are included in fuel emissions factors and process emissions are just CO_2 as agreed
[1] The “other minerals” sector is minerals excluding glass and covers sectors such as ceramics, building products, lime and asphalt

Industry – the majority of emissions are from fuel combustion and can be addressed through using low carbon fuels

The largest and most challenging portion of emissions is combustion emissions

Industry emissions MtCO$_2$e/yr



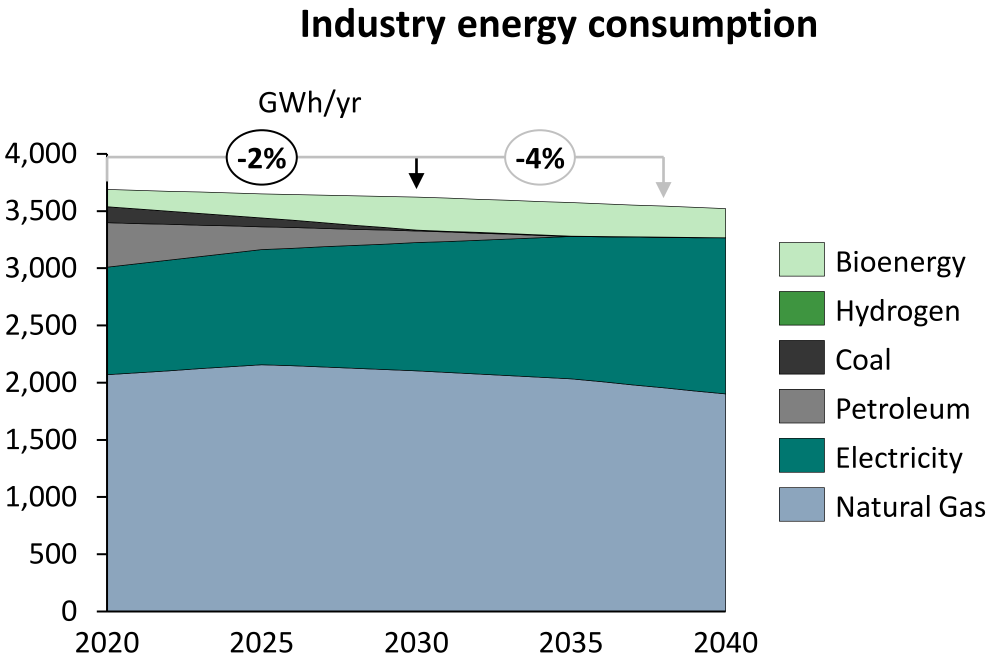
- **Process emissions are directly from the raw materials** or process, so can only be addressed by CCS or through changing the production process, both challenging solutions. The majority of process emissions in the region are from the glass sector.
- **Electricity related emissions will be addressed through decarbonisation in the power sector**, supported by installation of efficient technologies to reduce demand.
- **Combustion emissions are from burning fossil fuels**; they are the majority of industry emissions and are usually associated with heat generation. They can be reduced through energy efficiency and through fuel switching to low carbon fuels (electricity, hydrogen or bioenergy). However, currently many industrial applications don't have new equipment developed to run on low carbon fuels, so RD&D is required to address the technical barriers. It may be costly due to the need to retrofit equipment and the likely higher fuel cost of low carbon fuels.

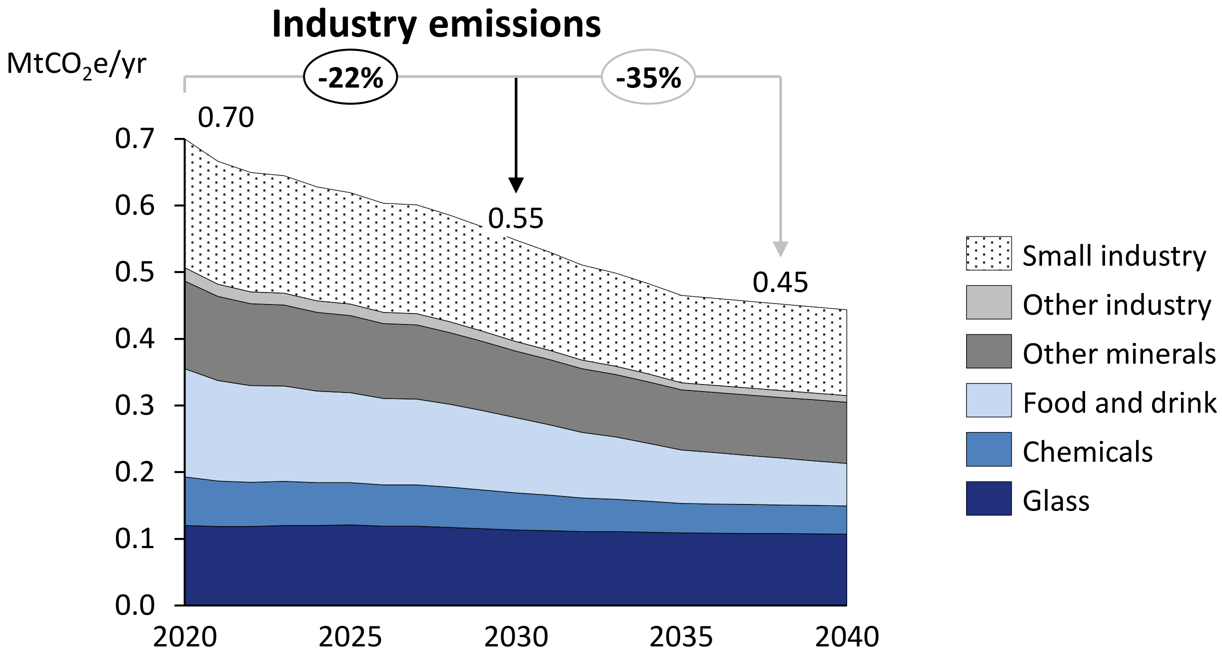
Key Features and assumptions for industry (see technical Appendix for more detail):

- **Energy and resource efficiency:** range of improvements (based on Max Tech[1], CCC & UKERC, and regional work) to reduce the energy consumption of industrial sites e.g. through waste heat recovery, increased recycling rates etc.
- **Hydrogen fuel switching is possible** for many applications currently using natural gas e.g. food and drink, glass, chemicals. Hydrogen production begins at scale in the late 2020s (near Humber) and can either be distributed through new pipelines, or through conversion of the current natural gas grid.
- **Electrification** of low temperature heat and heat on smaller sites; in the Max Ambition Pathway rapid deployment of further electrification options will be required (technology development accelerated)
- **CCS on large sites** in sectors with process emissions, such as glass and chemicals. CCS is anticipated to first be available near the Humber e.g. at Drax (or Teesside), just before 2030, with infrastructure expanding during the 2030s.
- **Bioenergy and waste** for some applications, particularly those with limited alternatives. Bioenergy is particularly effective in sectors where it can be combined with CCS to provide negative emissions through BECCS.

[1] Industrial decarbonisation and energy efficiency roadmaps to 2050
Note that combustion emissions are CO$_2$eq as other GHG are included in fuel emissions factors and process emissions are just CO$_2$ as agreed

Industry – The Baseline scenario sees limited change, with emissions reductions mostly from electricity decarbonisation





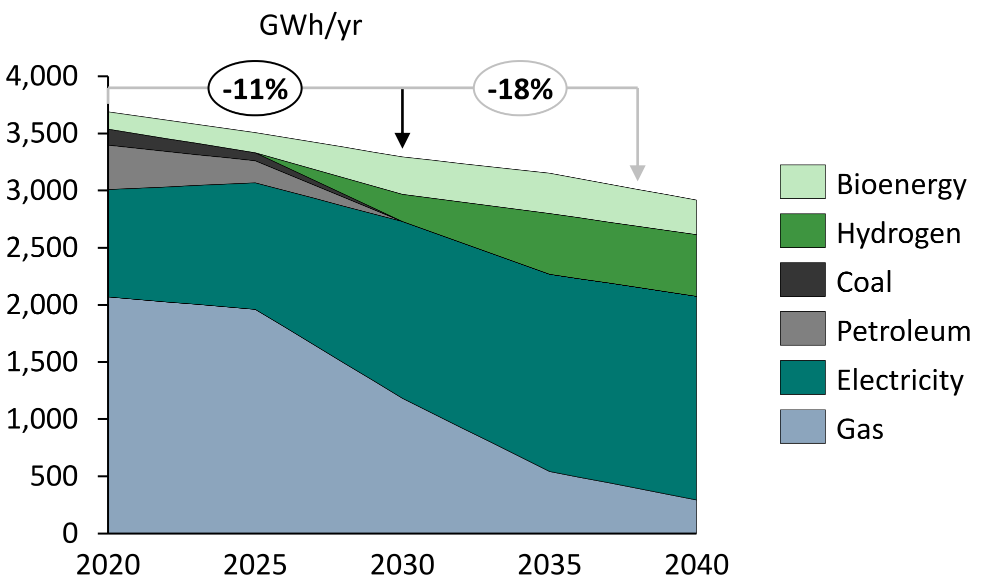
- Industry growth follows regional growth forecasts by subsector (from 0-30% across heavy industry)
- Energy efficiency and resource efficiency reach <15% reduction in energy consumption each, which roughly offsets the growth leading to a stable energy demand
- **Fuel switching to low carbon fuels is limited** and focused primarily on phasing out coal/oil and a small amount of electrification of heat. Energy consumption remains primarily natural gas and electricity.
- CCS – there is not currently sufficient policy to develop any CCS projects so we assume **no CCS in the baseline scenario**
- Process emissions remain a challenge in glass, with small reductions from increased recycling rates
- **Industry emissions reduce by 35% by 2038 (to 0.45 $MtCO_2e/yr$).** The emissions reduction is primarily due to decarbonisation of the electricity consumed, following the national electricity carbon intensity projections.

Y&NY

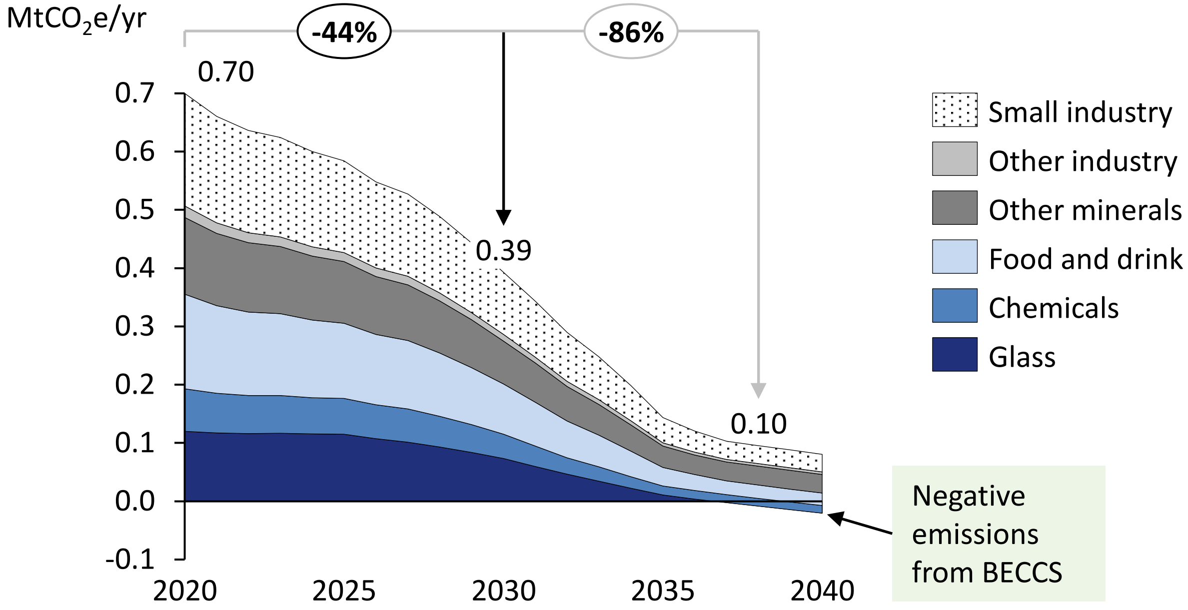
Please note that assumptions and modelling were done for the study region, so subregion level results are indicative

Industry – The Max ambition see progress accelerate from the mid-2020s, to reach 86% emissions reduction by 2038

Industry energy consumption



Industry emissions



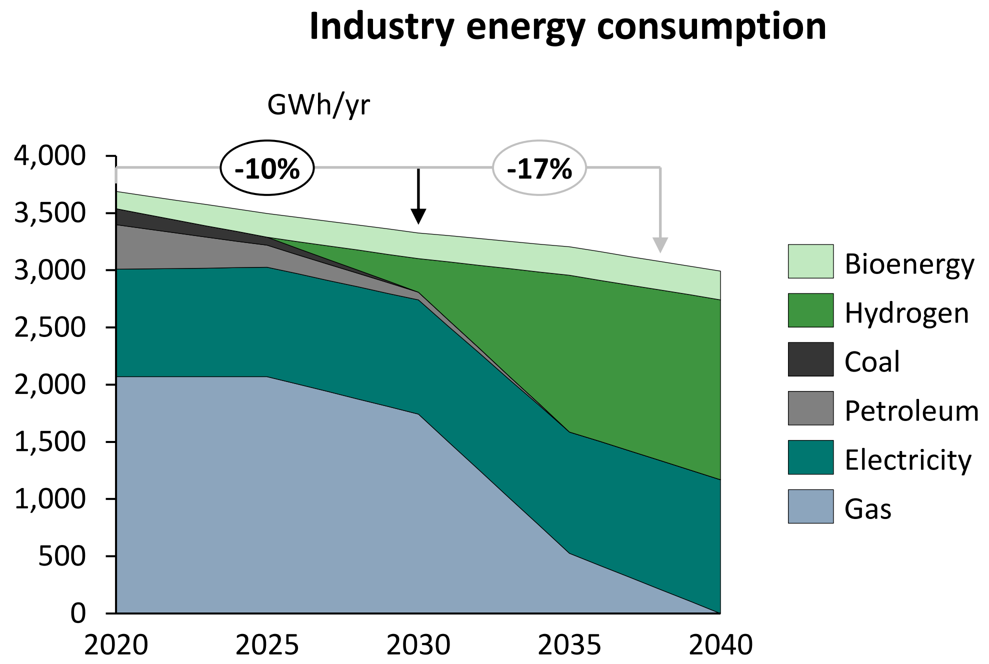
Negative emissions from BECCS

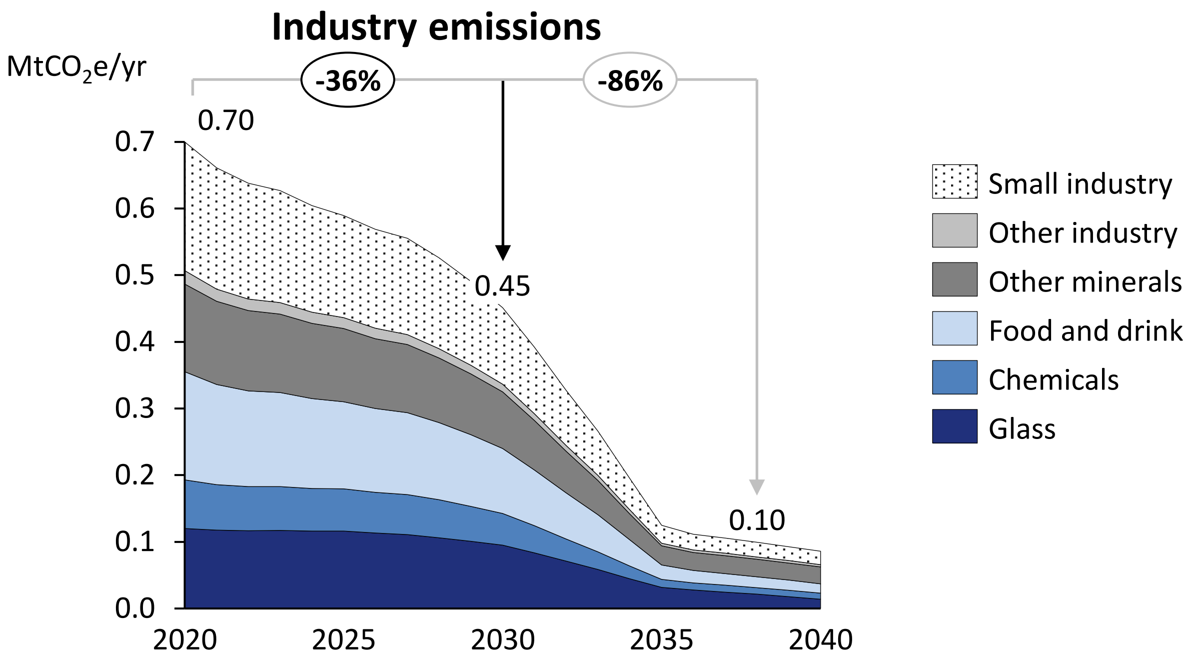
- The Max ambition scenario sees **rapid emissions reduction from 2025, reaching 86% reduction by 2038 to 0.10 MtCO$_2$e/yr**
- Energy efficiency and resource efficiency reach 15%-40% reduction in energy consumption each[1], which more than offsets the growth, leading to reduction in energy demand. The same efficiency is applied across the 3 emissions reduction scenarios.
- In all scenarios, **oil and coal are phased out in the 2020s**, replaced with electricity, bioenergy, waste (or gas in medium-term)
- **Natural gas is replaced from the mid-2020s onwards** with electricity, hydrogen or bioenergy. Some 'gas' use remains in 2038, which will have low carbon intensity due to significant biomethane blending.
- **CCS is implemented during the 2030s** to large plants in the glass and chemicals sectors (likely only one plant in each[2]); other sectors do not have large enough plants to make CCS cost-effective in this region.
- CCS enables **negative emissions in glass plants burning bioenergy (BECCS)** by 2038, highest in the Max ambition scenario.

---

1 See technical Appendix or model for details
2 Please note that assumptions and modelling were done for the study region, so subregion level results are indicative. They do not account for the small number of plants in the subregions and therefore the discrete nature of solutions.

Industry – The High H_2 scenario sees slower emissions reductions in the 2020s, but rapid hydrogen conversion 2028-2035

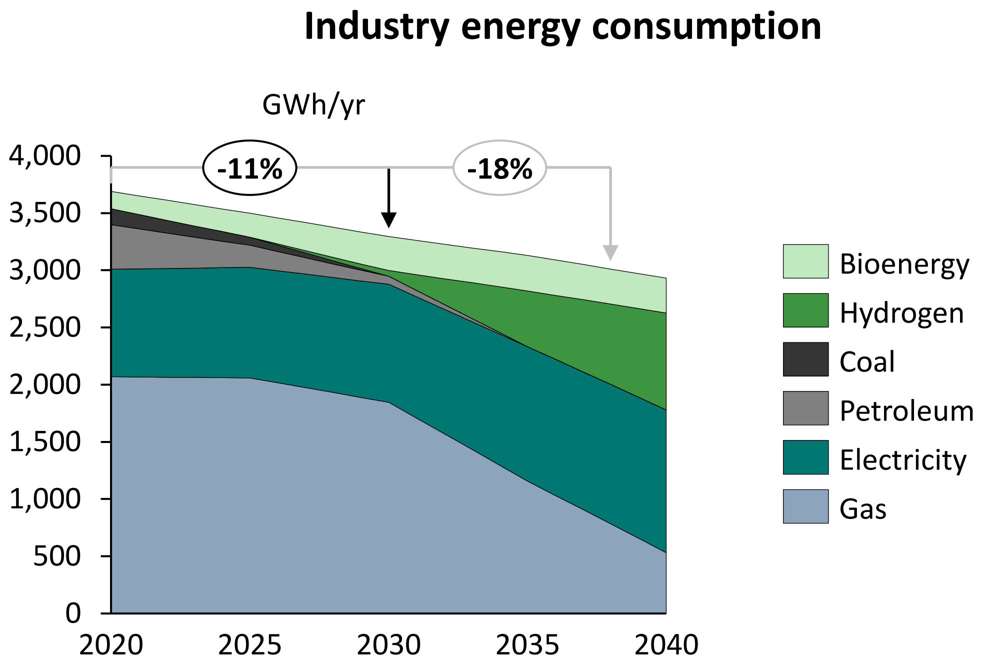


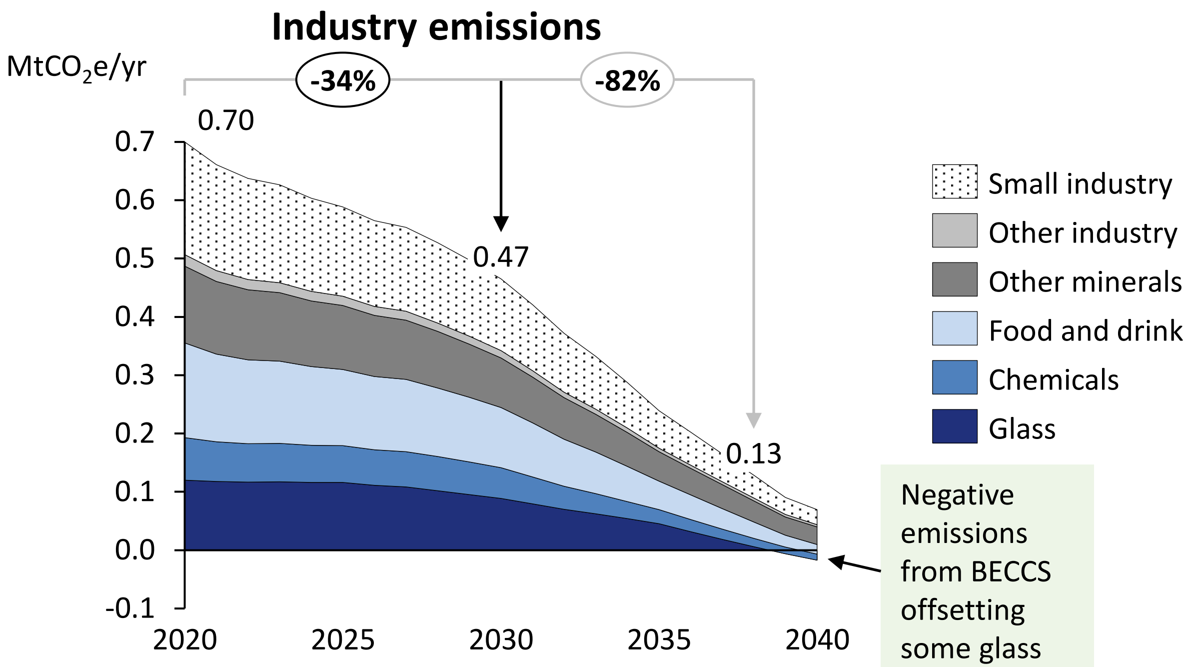


- The High H_2 scenario sees **emissions reduce to 86% by 2038 to 0.10 $MtCO_2e$/yr**
- However, the **decarbonisation occurs later than the Max ambition scenario, starting in the late 2020s when hydrogen becomes available at scale.** This causes rapid decarbonisation 2028-2035, with near zero carbon H_2 (lower carbon intensity than electricity). There is less electrification of heat in the 2020s than the Max ambition scenario.
- Similar energy efficiency and resource efficiency are applied, and oil and coal are mostly phased out in the 2020s.
- **Fuel use is almost entirely electricity and hydrogen; no natural gas use remains** by 2040, as the gas grid has been converted to H_2, so all applications use H_2 or alternative fuels.
- **CCS is implemented during the 2030s, but only on glass plants switching to bioenergy,** as all fossil fuel use in phased out in this scenario due to hydrogen conversion. This means there are remaining process emissions in the glass sector, but these are offset by the negative emissions from BECCS.

1 See technical Appendix or model for details
2 Please note that assumptions and modelling were done for the study region, so subregion level results are indicative. They do not account for the small number of plants in the subregions and therefore the discrete nature of solutions.

Industry – The Balanced scenario makes slow progress in the 2020s, but makes use of a range of fuels in the 2030s



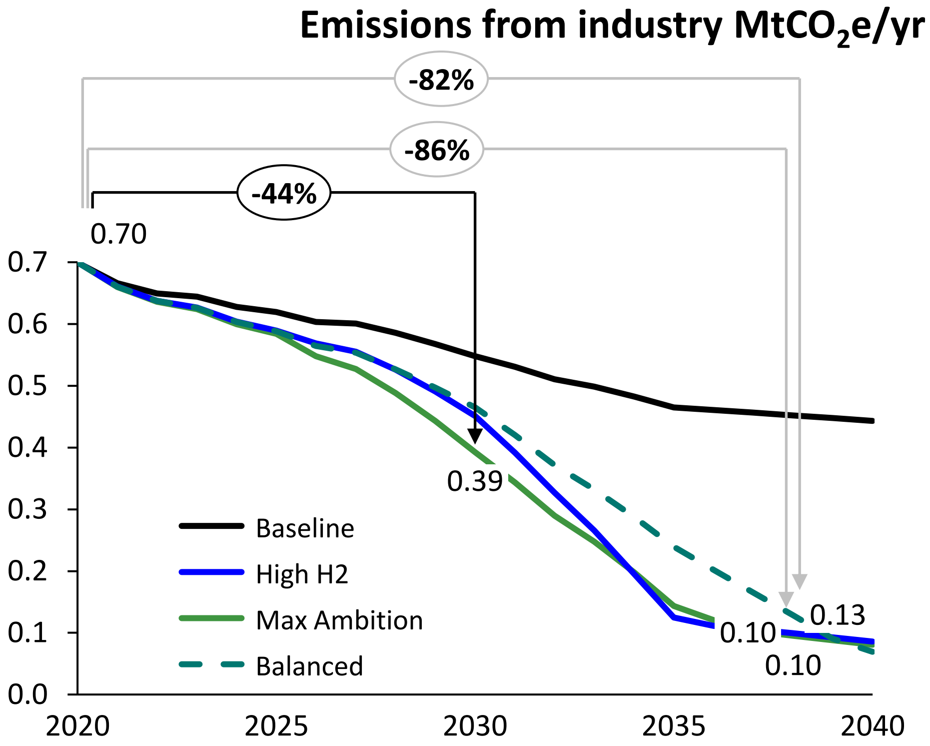


- The Balanced scenario sees **emissions reduce to 82% by 2038 to 0.13 $MtCO_2e$/yr**
- There is slow progress in the 2020s, with the majority of emissions reductions coming from energy & resource efficiency and decarbonisation of the electricity grid. Only one plant (glass) is using hydrogen by 2030 through dedicated pipelines.
- During the 2030s, the decarbonisation rate increases as equipment RD&D means more applications are commercially available for low carbon fuels, and hydrogen becomes more widely available.
- By 2038, industry is using a **mix of hydrogen, bioenergy, hydrogen and significant gas**; the gas from the gas grid has low carbon intensity due to **biomethane blending**. This uses valuable biomethane resources.
- **CCS is implemented** again at one chemicals plant and at the glass plants which are using bioenergy or natural gas.
- Emissions remaining in 2038 are largely electricity-related emissions in all scenarios due to electricity consumption at non-zero carbon intensity; this will be addressed by further power sector progress (nationally).

Y&NY

1 See technical Appendix or model for details
2 Please note that assumptions and modelling were done for the study region, so subregion level results are indicative. They do not account for the small number of plants in the subregions and therefore the discrete nature of solutions.

Industry – fuel switching and CCS mostly deploy in the 2030s due to technology availability timescales



- The chart shows the emissions projections for the industry sector across the scenarios.
- The numbers represent the total annual net emissions in 2020, 2030 (Max ambition) and 2038; the arrows show the % change from 2020.
- All emissions reduction scenarios see implementation of energy and resource efficiency at a similar level.
- The total emissions in the industry sector decrease by up to 44% by 2030 and reach only **0.1 MtCO2e/yr by 2038 in the Max ambition scenario.**

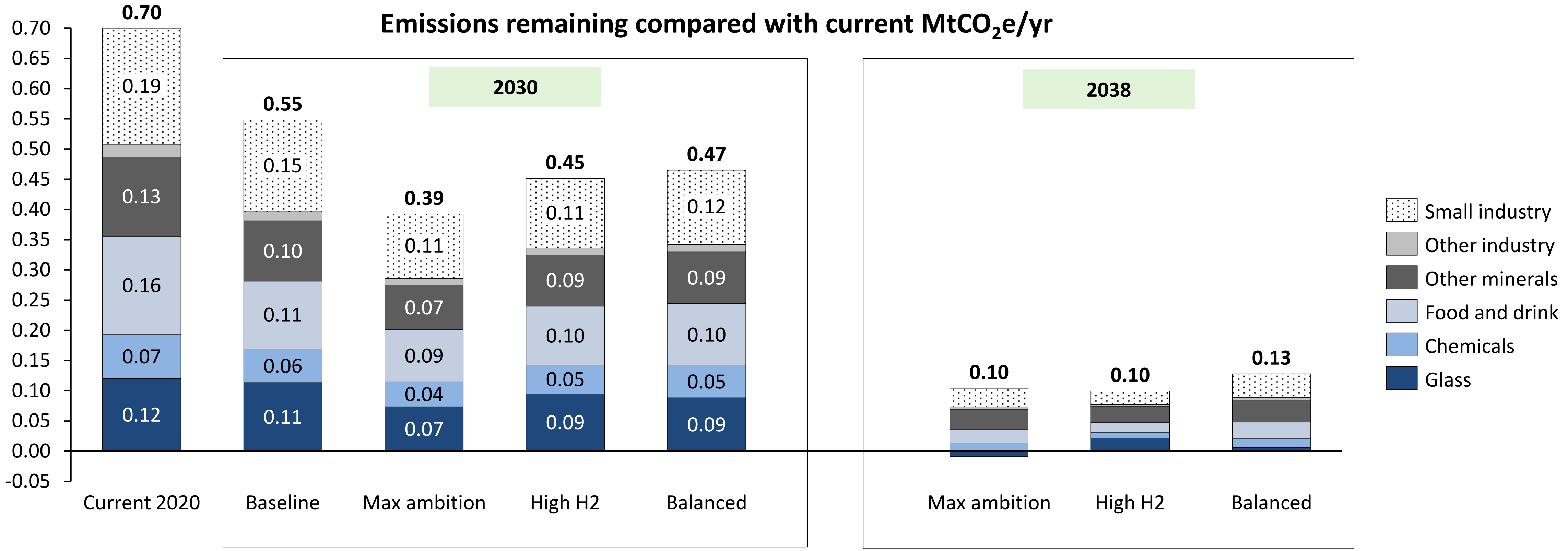
- The Max ambition scenario makes quickest progress, with **early measures including further efficiency, electrification** of some heat and oil replacement with either natural gas, electricity or bioenergy. Significant BECCS in the glass sector offsets some electricity-related emissions, mostly in the Max ambition and Balanced scenarios.
- **The High H_2 scenario undergoes rapid change from 2028 to 2035** as many sites undergo the switch from natural gas to hydrogen, which is now widely available. Hydrogen has a lower fuel carbon intensity than electricity in the 2030s[1]. This allows the High H_2 scenario to reduce emissions to below the Max ambition.
- The Balanced scenario sees limited progress in the 2020s, but catches up with the other scenarios in the 2030s as hydrogen and CCS become available and **gas grid decarbonisation (biomethane blending) support sites which haven't switched fuel**.

---

[1] due to high CCS capture rates and biogas blending into the feedstock, see technical Appendix.

Please note that assumptions and modelling were done for the study region, so subregion level results are indicative

Remaining emissions are significant in 2030 across scenarios, but by 2038 equipment and solutions become available



- **Due to technology readiness, industry decarbonises slowly in the 2020s**, with only limited equipment available to reach maximum 44% reduction by 2030, through efficiency and some electrification of heat. During the 2030s, emerging technologies become commercially ready and hydrogen and CCS become available at certain sites.
- **In 2038, the majority of remaining emissions are from electricity use at non-zero carbon intensity**.
    - Electricity-related emissions are highest in the Max ambition scenario, but are offset by some BECCS;
    - the High H_2 scenario sees process emissions remaining from the glass sector;
    - the Balanced scenario has the highest residual gas usage

Y&NY

Industry – Y&NY heavy industry, focused in Selby, is an opportunity for early hydrogen conversion

Y&NY industry characteristics

- **Y&NY has limited heavy industry**. **Geographically, industry is clustered in Selby,** with 9 medium-large plants and only a handful of others with significant point source emissions[1]
- **The largest heavy industry sectors are food & drink and minerals,** with 7 and 6 medium-large plants respectively. There is a high proportion of business activities around agriculture, forestry and fishing (18% compared with a UK average of 5% units), although this is not generally emissions intensive.
- Only two industrial sites in Y&NY have emissions of 50 ktCO$_2$/yr or over (one glass one chemicals), so **CCS has limited potential in Y&NY industry,** but may be possible on some smaller sites.
- Some areas contain very little industry, such as Craven, Ryedale and Harrogate. **Isolated plants will struggle to connect to H$_2$/CCS infrastructure**, so should consider electrification or options such as biomass/bio-LPG.

The scale of change for industry in York and North Yorkshire:

- **Y&NY (Selby) may become the home to one of the UK's first large-scale hydrogen generation and CCS** projects[2], facilitating decarbonisation of heat and industry, as well as power sector BECCS. Ambitious plans are aiming at constructing this H$_2$ production and CCS network in the mid-2020s, which requires urgent action and funding to begin the engineering design and planning work.
- Early potential for hydrogen use could be Saint-Gobain Glass in Eggborough or Sedalcol UK chemicals in Selby due to their proximity to planned hydrogen production and sectoral H$_2$ potential / research[3].
- The Max ambition scenario sees **coal phased out by 2030 and oil shortly afterwards,** being primarily switched to electricity or bioenergy and waste. There is an 87% increase in electricity use, despite efficiency measures, and the first plant starts using hydrogen through dedicated new pipelines in 2026.
- In the High hydrogen scenario, **hydrogen supplies over 50% of industrial energy by 2038 (1.6 TWh/yr)**, requiring large scale generation and distribution infrastructure to be developed swiftly.
- Due to the lower technology readiness levels (TRL), **industrial RD&D projects must be supported immediately** to ensure solutions are available by 2030 for a wide range of industrial applications.

---

1 NAEI point source emissions 2017 LINK

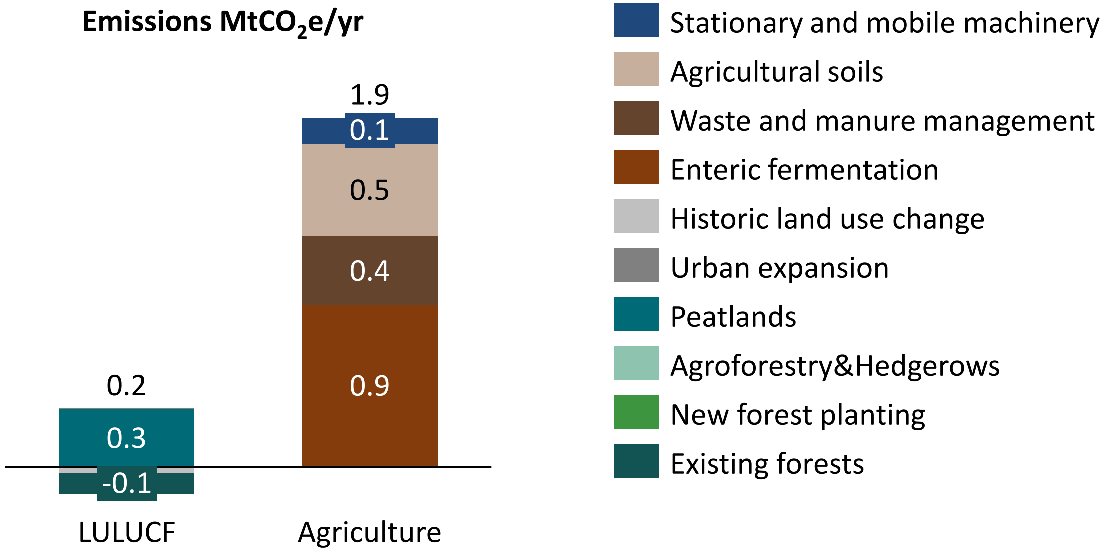
2 Zero Carbon Humber initiative LINK LINK 3 Dependent on fast progress in RD&D of equipment

Industry – key messages

- **There is limited heavy industry in the region**; the sectors most represented are minerals and food & drink and there is a cluster of industry in Selby.
- **The industry sector sees slow progress in the 2020s** due to significant RD&D being required to develop commercially ready solutions; the progress is primarily phase out of coal and oil, efficiency improvements and some electrification of heat.
- **By 2038 the emissions have reduced by 86% to 0.1 $MtCO_2e$/yr** due primarily to fuel switching to low carbon fuel (electricity, hydrogen or bioenergy) in the 2030s. Electricity is considered low carbon as the national power sector is decarbonising.
- **In 2038, the majority of remaining emissions are from electricity use at non-zero carbon intensity,** but there are contributions from residual natural gas usage and process emissions.
- The scenarios use similar technologies and measures, but at differing levels and timeframes:
  - **The Max ambition scenario focusses on early electrification of heat,** followed by some later hydrogen, bioenergy and CCS application.
  - **The High H_2 scenario undergoes rapid change from 2028 to 2035** as many sites undergo the switch from natural gas to hydrogen.
  - The Balanced scenario sees the slowest progress in the 2020s, but accelerates in the 2030s as hydrogen and CCS become available and **gas grid decarbonisation (biomethane blending) support sites which haven't switched fuel**.
- **Solutions are very sector and application specific, with RD&D needed and considerable uncertainty on feasible pathways**
  - The food and drink sector sees heavy electrification in the Max ambition scenario, particularly of low temperature heat, but 50% hydrogen use in the High H_2 scenarios where it is available in the grid.
  - The minerals sector, with applications such as raw material grinding, drying and kiln firing, switches away from coal and oil (to bioenergy, waste and electricity) in the 2020s and uses hydrogen to replace natural gas where this is available.
- Depending on the scenario the electricity demand increase could be as much as 87%, or hydrogen could supply >50% energy.
- **Hydrogen and CCS infrastructure will be geographically specific**, with it likely nucleating near the Humber in Selby. Hydrogen and/or CO_2 pipelines may extending from there to nearby industrial plants in the late 2020s or early 2030s. Teesside is an alternative industrial cluster which may see infrastructure development in the 2020s.

Contents

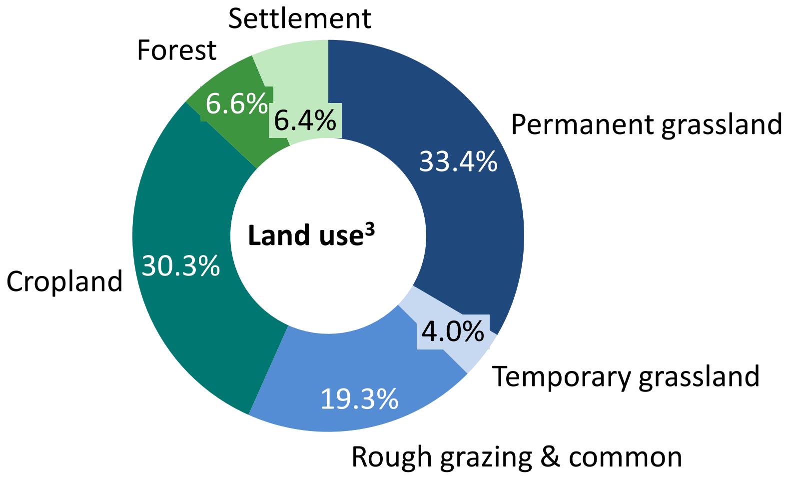
Current emissions situation in the region – LULUCF and Agriculture



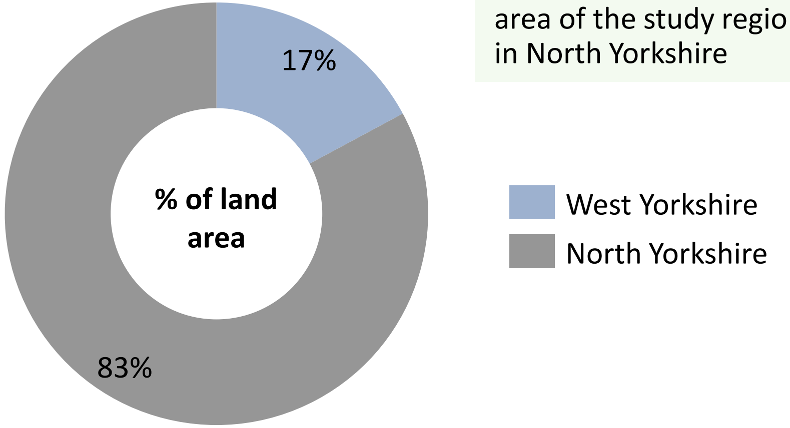
Land Use, Land Use Change and Forestry (LULUCF)
Covers carbon stock changes in soil, vegetation and timber and GHG emissions from non-agri land management

Agriculture
Covers emissions associated with livestock, manure, fertilizer, agricultural land management

- source of CH_4 and N_2O, the primary greenhouse gases (And included in this
- Limited CO_2 emissions and energy consumption, primarily from agricultural machinery



The majority of the land area of the study region is in North Yorkshire

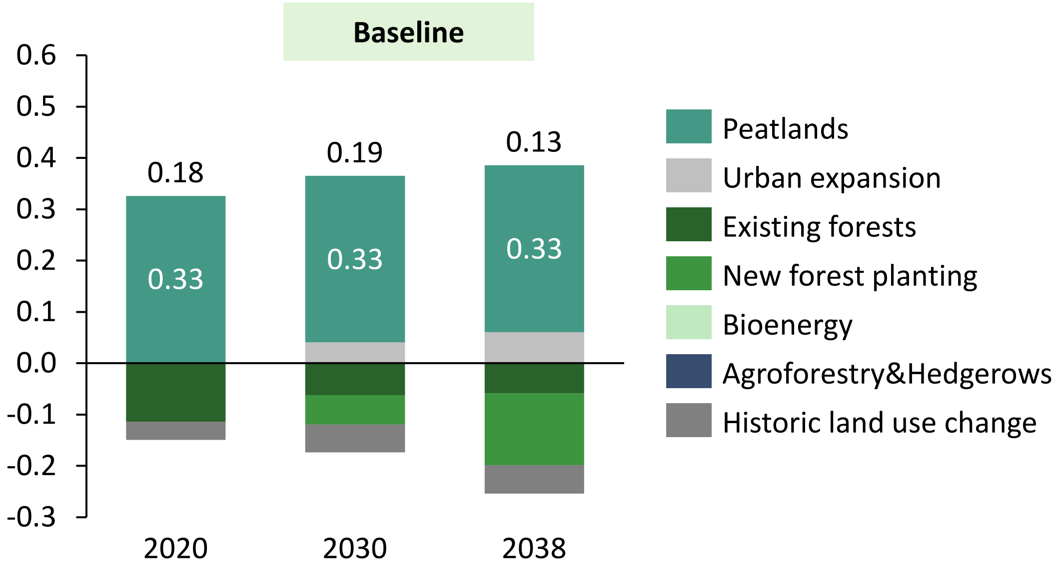


---

1 Source: BEIS GHG emissions inventory and subnational energy consumption and CO_2 emissions datasets 2017, combined with new methodology. 2 Agriculture area/number data is for 2016 (most recently published regionally disaggregated data).
3 Note that peat soils can sit within any of the categories

LULUCF Baseline: LULUCF makes slow progress, primarily due to new forest planting

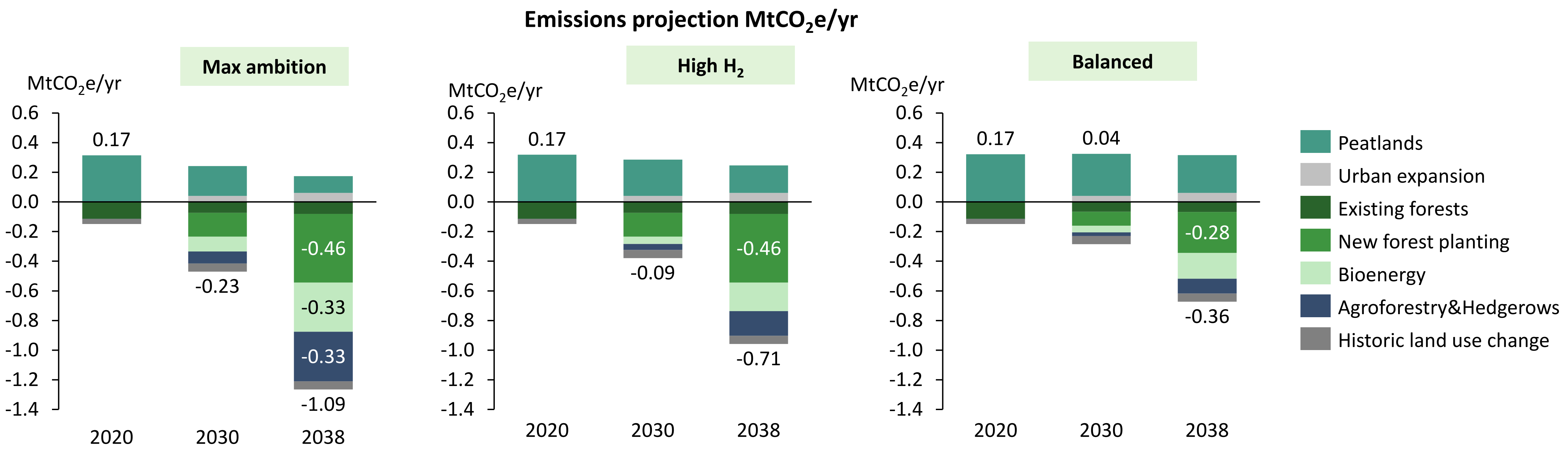
Emissions projection $MtCO_2e/yr$



- The chart shows the emissions change from the land use sector in the baseline scenario. The bars are split into contributions from the 7 main subsectors.
- The numbers on each bar show the total net emissions, once the positive and negative contributions have been summed.
- Current land use emissions are dominated by peatlands as the main positive source. Peatlands in Yorkshire have a lower carbon intensity than the national average due to their location/type, but there is a high proportion of peatland.
- The total **emissions in the land use sector reduce by 0.05 $MtCO_2e/yr$ by 2038 in the baseline scenario**, primarily due to some new forest planting.

- **Y&NY has a large potential for mitigation** because of its predominantly rural character, low projected population growth and high potential for peatland emission reductions through restoration.
- The baseline scenario assumes no increase in bioenergy or implementation agroforestry.
- For all scenarios, it is assumed that the area of **urban development** increases in line with the projected human population for the region (ONS statistics). The area required for urban development is upscaled from that required for housing. The same projections are used across all scenarios.
- Forest planting rates have been adjusted to take account of the aspirational targets for afforestation in the region for the White Rose Forest initiative.
- Whilst there are some peatland restoration activities ongoing, which are likely to be improving the emissions associated with peatlands, there is limited evidence as to the quantitative magnitude, so the baseline scenario assumes no change in the associated emissions. However, the emissions reduction scenarios do include this impact.

LULUCF makes significant progress to negative emissions through ambitious forest planting and peatland restoration



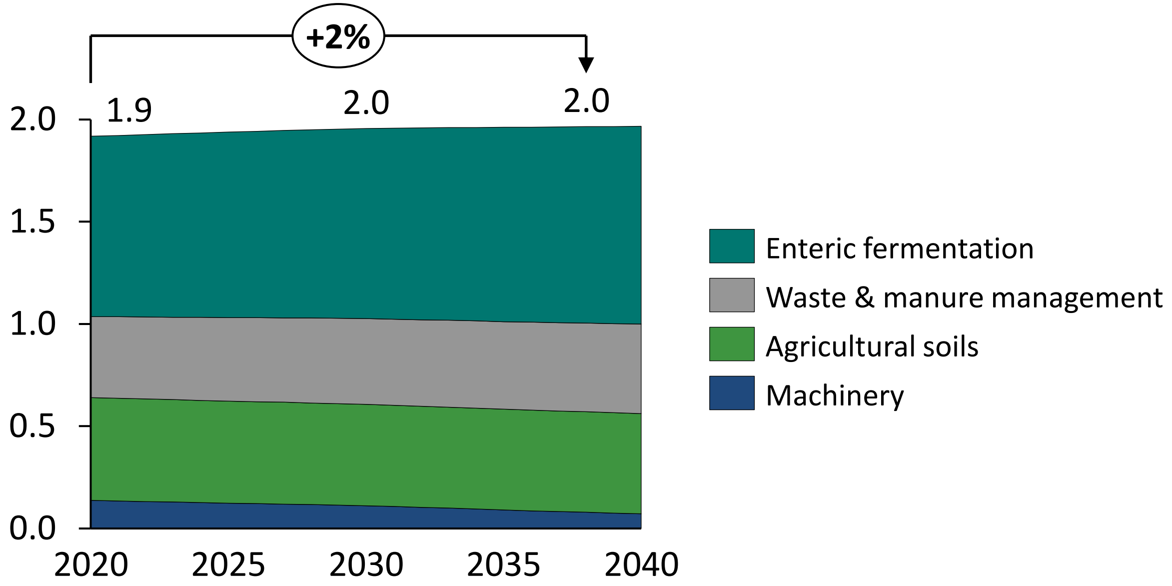
- The scenarios see LULUCF go net negative around 2030, or earlier in Max ambition, with the main emissions reduction being from **new forest planting, peatland restoration, bioenergy crops and agroforestry & hedgerows**.
- **Y&NY land use sector reaches -1.1 MtCO$_2$e/yr by 2038 in the Max ambition pathway**, with the High H$_2$ and Balanced pathways reaching -0.71 and -0.36 MtCO$_2$e/yr respectively.
- In the Max ambition scenario, forest area increases by 37 kha, from 54 to 91 kha by 2038. This rate is replicated in the high H$_2$ scenario, but a less ambitious target is achieved in the Balanced scenario (23 kha by 2038)
- Peatland restoration aims to achieve 100% of all peatland restored by 2038 in the Max ambition scenario, with slower rates applied to the other scenarios, to represent the challenges in achieving this rate.
- Hedgerows increase[1] by 8-20% by 2038 and agroforestry measures include up to 9% of cropland converted to alley cropping, 11% of permanent and rough grazing converted to woodland grazing by 2038
- Bioenergy crops reach ~50kha by 2038 in the Max ambition scenario, but 21 and 18 kha in the others respectively.

---

[1] This refers to new hedgerows which will be taking up carbon (existing hedgerows are assumed to be in steady state and carbon neutral)

Agricultural emissions increase in the baseline scenario due to population growth requiring greater production

Agriculture emissions $MtCO_2e/yr$

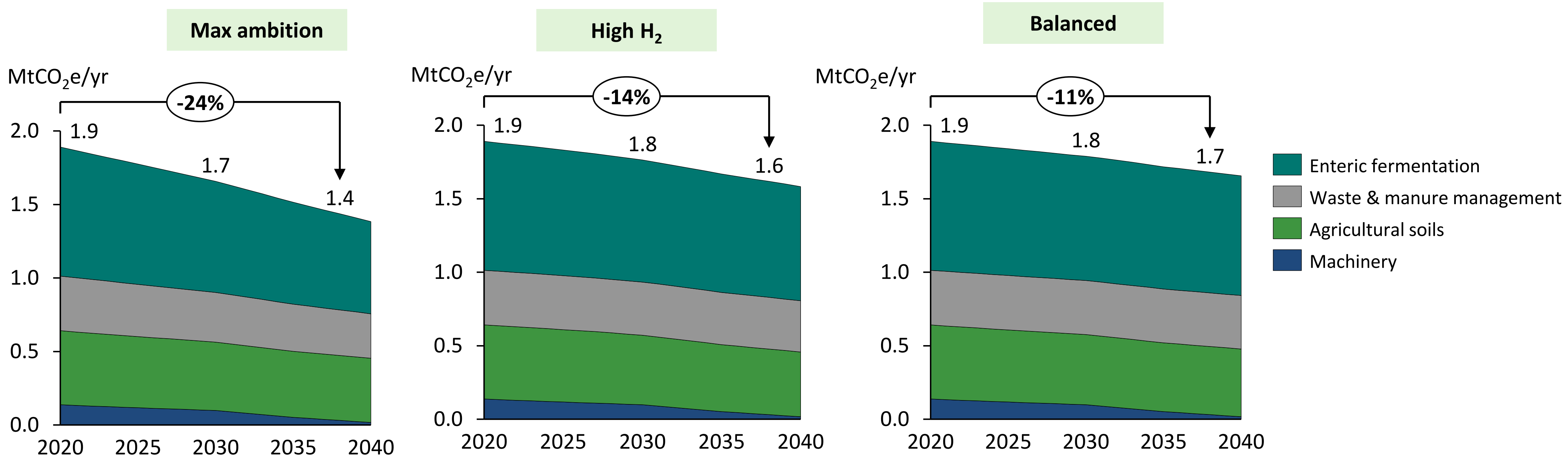


- The chart shows the emissions change from the agriculture sector in the baseline scenario. The graph is split into contributions from the 4 main subsectors.
- The numbers represent the total annual emissions form the agriculture sector in 2020, 2030 and 2038.
- Current agricultural emissions are dominated by enteric fermentation and agricultural soils.
- The majority of the emissions from the sector are CH4 and N20, rather than CO_2 (CO_2 is predominantly from machinery)
- The total **emissions in the agriculture sector increase by 2% by 2038 in the baseline scenario.**

- Some agricultural emissions struggle to decarbonise, partially due to the timescales of many mitigation measures. It is assumed that the region maintains per capita agricultural production in study region, therefore agricultural output must increase to feed a growing population.
- Agricultural yield increases slowly, following the current trend, in the baseline scenario.
- The baseline scenario does not assume significant agricultural innovation in terms of either farming practices or technology development.
- Agricultural machinery makes some progress through fuel switching, but some machinery is still petrol/diesel by 2038.
- The slow progress is insufficient to offset the increase in production required, leading to an increase in emissions overall.

Thomson, Misslebrook et al (2018).

Agriculture sees some emissions reduction through increased agricultural efficiency, diet change and food waste reduction



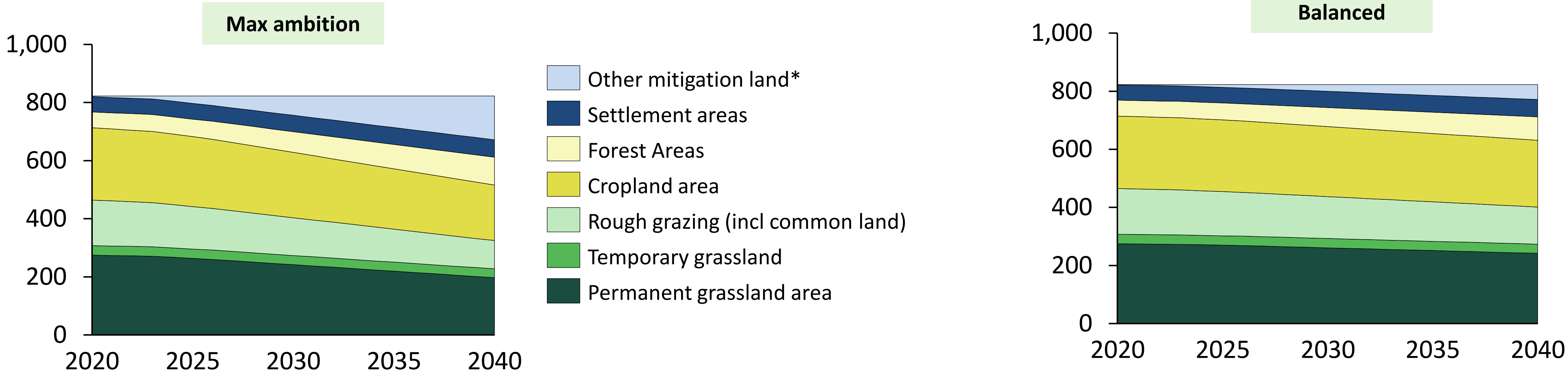
Agriculture emissions

- Some agricultural emissions struggle to decarbonise, partially due to the timescales of many mitigation measures. Livestock directly produces emissions from the animal, so there are limited options to mitigate these beyond diet change. However, agricultural land management practices play a crucial role in supporting emissions reductions in the land use sector (through freeing up land) and the energy system (through bioenergy crops), so the contribution should not be dismissed.
- **Even under the highest ambition, only a 24% reduction in emissions is seen by 2038.**
- Measures include increased stocking density, improved crop yields, Nitrogen use efficiency, food waste reduction, human diet change and manure management.
- The Max ambition scenario has greatest emission reductions because it has higher ambition for diet change and food waste reduction (32% reduction in red meat and dairy and 35% reduction in food waste by 2038). This not only reduces emissions from livestock, but also spares more land for land-based mitigation activities.
- The High H_2 and Balanced scenarios assumed only 13% reduction in meat and dairy consumption and the Balanced scenario sees lower ambition in food waste reduction (20%), stocking density and indoor horticulture.

Y&NY

Thomson, Misslebrook et al (2018).

Land use and agriculture Land area is dominated by cropland and grassland, with increasing forest and woodland



Land Area (thousand hectares)

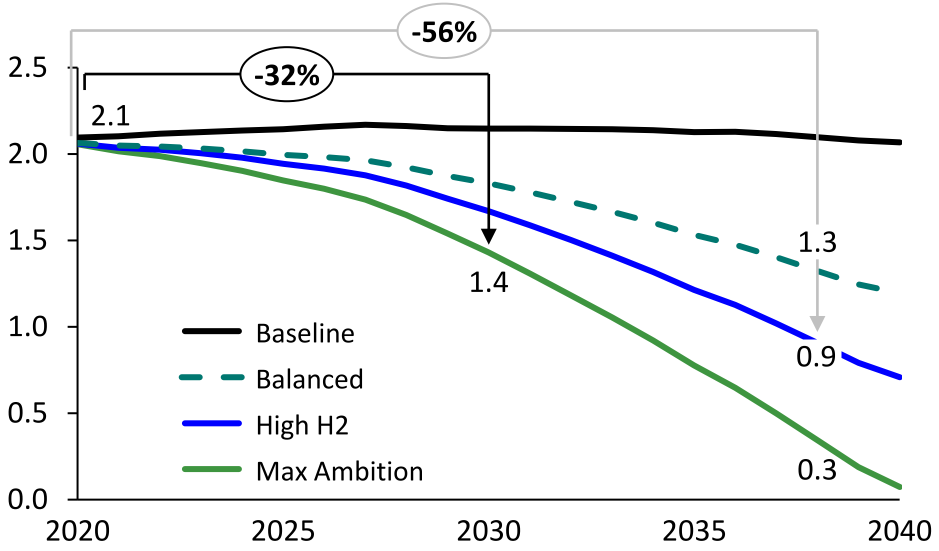
- In the Max ambition scenario, forest area increases by 37 kha, from 54 to 91 kha by 2038.
- Y&NY has a low proportion of settlement areas so a high potential for applying land-based mitigation activities.
- There is a reduction in grassland, grazing land and cropland areas (for example through increased agricultural efficiency and diet change) to make space for forest area and other mitigation land. These measures are applied at the highest level in the Max ambition scenario, allowing for the most land-based mitigation. Permanent grassland is in highest demand for conversion to urban and forested land.
- *Not all land spared by agricultural mitigation has been used for land-based mitigation, leaving a ‘buffer’ for:
  - possible future land losses, e.g. due to flooding, loss of forest due to natural disturbances and pests;
  - or for additional mitigation, solar PV or wind power, “re-wilding” or increased agricultural production.

  In YNY this amount of surplus land is around 180 kha in the Max ambition scenario in 2038. with the High H_2 and Balanced scenarios at about 48 and 68 kha respectively
- Note that peatland can sit within any of the land area categories. Mitigation from peat restoration comes from restoration of cropland and intensive grassland on peat soils and restoration of degraded upland peat soils

Settlement areas: Density of housing development is based on study region average densities from the Ministry of Housing, Communities and Local Government (MHCLG) (21.85 dwellings/hectare, range 17.17-31.91)

LULUCF and Agriculture – the land use sector becomes net-negative, offsetting the majority of agricultural emissions

Emissions projection LULUCF + agriculture $MtCO_2e/yr$



- The chart shows the emissions change from the land use and agriculture sectors combined across the scenarios.
- The numbers represent the total annual net emissions form the combined sector in 2020, 2030 (Max ambition) and 2038.
- Current emissions are dominated by enteric fermentation and agricultural soils
- Conversely, emissions reductions are dominated by new forest planting, peatland restoration, bioenergy crops and agroferestry.
- The total **emissions in the combined LULUCF and agriculture sector decrease by up to 32% by 2030 and reach only 0.3 $MtCO_2e/yr$ by 2038.**

- **The Max ambition scenario sees the combined land use and agriculture sectors reduce emissions from 2.1 to 0.3 $MtCO_2e/yr$ by 2038 (83% reduction),** although only 34% reduction is achieved by 2030 due to the timeframe for measures to take effect.
- Land use emissions drop below zero ~2030 as the impact of afforestation and peatland restoration is realised.
- **Some agricultural emissions (mainly non-CO_2) struggle to decarbonise**, partially as the timescales of many mitigation measures may be decades and partly as some emissions are directly from livestock, so particularly challenging to mitigate. However, agricultural changes are crucial in freeing up land for land based mitigation activities, such as new forest planting.
- The main differences in the LULUCF scenarios are around the rate of forest planting, bioenergy crop plating and peatland restoration.
- The main differences in the agricultural scenarios are the extent of diet change, food waste reduction and agricultural innovation.
- More details on the underpinning assumptions can be found in the Appendix.

Agriculture and land use – North Yorkshire should leverage it's rural character to maximise land-based emissions mitigation

North Yorkshire land and agricultural characteristics:

- **Y&NY has strong potential for land-based emissions mitigation,** because of its predominantly rural character, low projected population growth and high potential for forest planting and peatland emission reductions through restoration.
- **Y&NY is rural in character compared with the UK average.** The population density is ~1 person/ha in Y&NY compared with 2.7 in the UK and 4.3 in England. The land area of Y&NY is ~823 kha, which is 3.4% of the UK.
- **High agricultural emissions** in the area provide a challenge to mitigate whilst still maintaining agricultural output. This will require both incentives and agricultural innovation.
- There is a **high proportion of peatland** in North Yorkshire, although peatlands in Yorkshire have a lower carbon intensity than the national average due to their location/type.
- Y&NY may choose to use some of its **land area to support mitigation in other sectors** (& regions), such as solar PV or wind electricity generation, hydrogen and CCS infrastructure and bioenergy production.

The scale of change for agriculture and land use in North Yorkshire:

The highest levels of ambition include:

- **Over 2000 hectares of new forest planting a year** between now and 2038 and over 2000 ha of bioenergy crops.
- **100% of peatland restored by 2038**, both lowland and upland
- **32% reduction in red meat and dairy consumption** and 35% reduction in food waste by 2038
- By 2038, 9% of cropland converted to alley cropping[1] and 11% of permanent and rough grazing converted to woodland grazing.
- **7% increase in animal stocking density** by 2038.

[1] more trees on cropland, for example field boundaries or alley cropping

Land use and agriculture – key messages

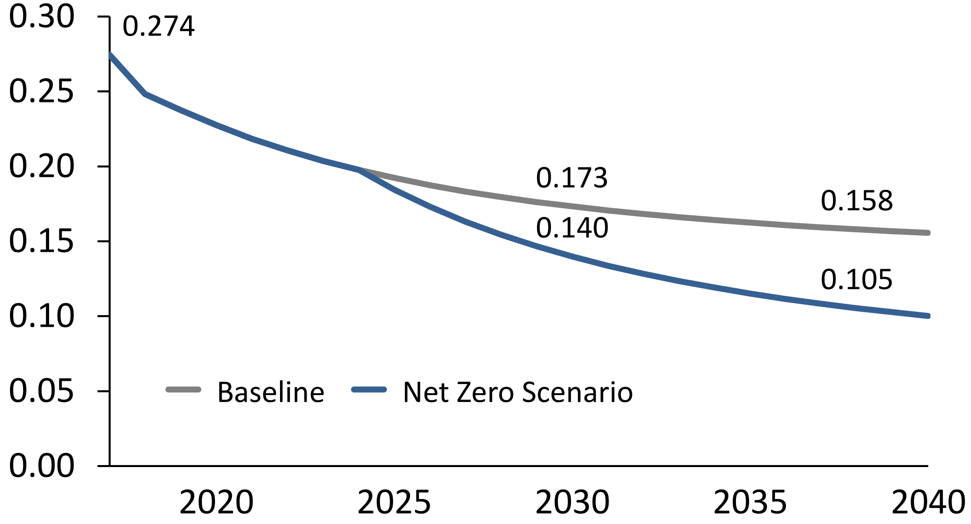
- **The emissions in the land use and agriculture sector reduce by 83% by 2038, from 2.1 to 0.3 MtCO$_2$e/yr,** so do not reach net-zero by the target 2038.
- **The scenarios see LULUCF go net negative in 2028** in the Max ambition scenario and by 2032 in the other scenarios:
  - The main emissions reduction being from new forest planting, peatland restoration, bioenergy crops and agroforestry & hedgerows.
  - Y&NY land use sector reaches -1.1 MtCO$_2$e/yr by 2038 in the Max ambition pathway.
- **Even under the highest ambition, only a 24% reduction in agricultural emissions is seen by 2038, with 1.4 MtCO$_2$e/yr remaining.**
  - Emissions Agricultural emissions struggle to decarbonise, partially due to the timescales of many mitigation measures.
  - The main contribution is diet change, which not only reduces the emissions from meat and dairy production, but also frees up land for other mitigation activities.
- **The Max ambition scenario has greater emission reductions than the High hydrogen and Balanced scenarios because it has higher ambition for diet change and food waste reduction, sparing more land for land-based mitigation activities.**
- Y&NY has high potential for mitigation, because of its predominantly rural character, low projected population growth and high potential for peatland emission reductions through restoration.
- Bioenergy production through bioenergy crops is important not just for its potential to reduce emissions in the land use sector, but also to support decarbonisation of other sectors such as heat, power and industry.
- There must be trade-offs in the choice of land use between uses that provide employment (e.g. agriculture), uses that reduce emissions in the sector (e.g. forests), other mitigation uses (e.g. solar PV) and land for urban development or infrastructure.

Note that modelling is based on changes in the current 'status quo', rather than more speculative / radical system changes. More novel concepts, such as lab grown food, should be explored in the coming years.

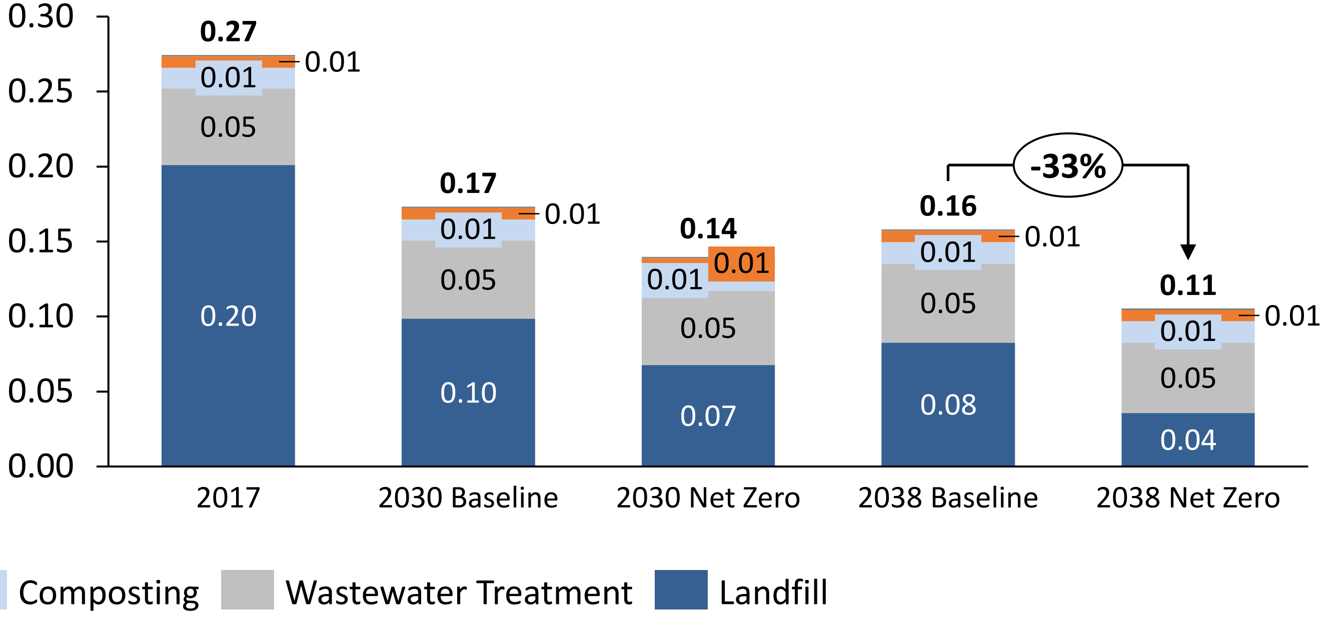
Contents

Waste: following CCC's net zero modelling, emissions reduce by 62% by 2038 compared to 2017 and by 33% compared to the baseline in 2038

Total Emissions- $MtCO_2eq$/year



Breakdown- $MtCO_2eq$/year



- Current waste sector emissions and decarbonisation pathways are based on CCC's Net Zero Report (2019) and the Further Ambition Scenario within it. Only one Net Zero waste scenario is created for this study for simplification purposes.
- The distribution of waste emissions at regional level is obtained by proportioning England-level emissions according to the tonnes of waste disposed in the region through each technology*. Wastewater treatment emissions are distributed according to population.
- Composting, MBT (mechanical biological treatment) and waste incineration emissions stay almost constant over the period.
- Compared to baseline, wastewater treatment emissions reduce by 11% by 2038 due to efficiency and process improvements. These actions may result in cost savings or may be achieved at zero net cost.
- Landfill emissions constitute the largest reductions (31% by 2030 and 57% by 2038 over the baseline) due to the England-level targets set by CCC's Further Ambition Scenarios: 20% reduction in avoidable food waste, eliminating 5 key biodegradable waste streams sent to landfill and increasing recycling of municipal waste to 70% by 2025.

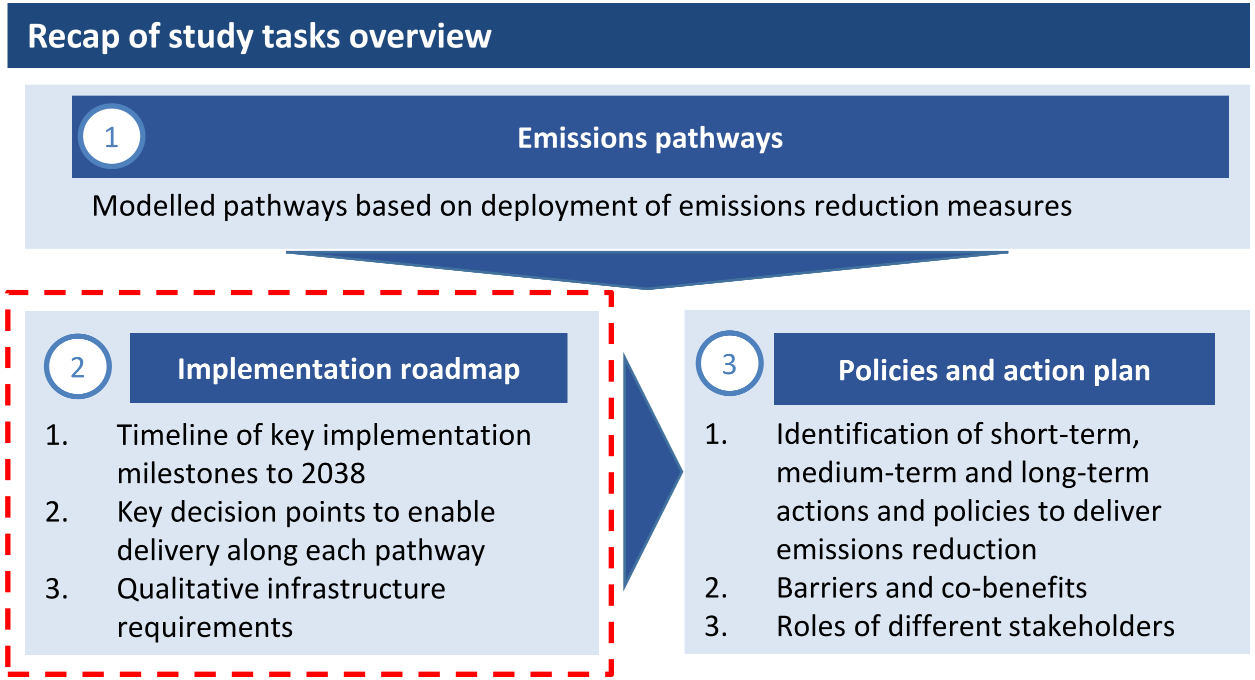
MBT: Mechanical biological treatment

* Defra- Local Authority Collected Waste Statistics, 2019.

Contents

Outcomes of the emissions pathways modelling have been used to develop sectoral roadmaps

- The modelled emission reduction pathways require large-scale ambitious action to deliver a wide range of decarbonisation measures across buildings, transport, power, industry, and LULUCF and agriculture
- The sectoral roadmaps presented here aim to highlight how the modelled outcomes are expected to be achieved and provide a framework by which the regions can plan and monitor their actions by outlining:
  - The timeline of key activities and technology rollout
  - Key decision points along the pathways
  - Key implementation milestones to monitor progress by



Recap of study tasks overview

1 **Emissions pathways**

Modelled pathways based on deployment of emissions reduction measures

2 **Implementation roadmap**

1. Timeline of key implementation milestones to 2038
2. Key decision points to enable delivery along each pathway
3. Qualitative infrastructure requirements

3 **Policies and action plan**

1. Identification of short-term, medium-term and long-term actions and policies to deliver emissions reduction
2. Barriers and co-benefits
3. Roles of different stakeholders

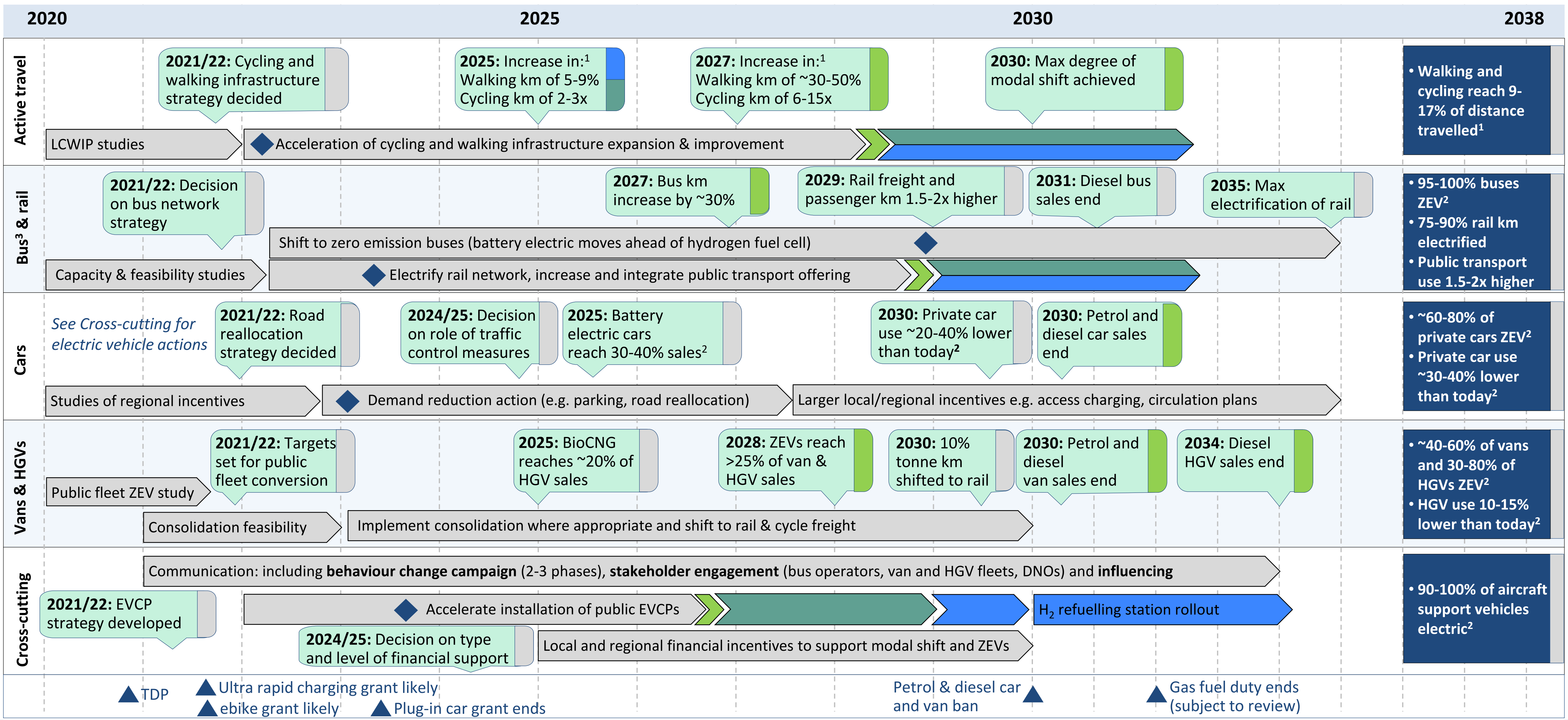
- There is inherent uncertainty around the timing of action and national policy backdrop, represented by the different scenarios. The roadmap diagrams aim to show the range of uncertainty but also provide a clear picture of the required progress, particularly that which is common across scenarios.
- Key information is represented on the roadmaps using the following indicators:
  - Key milestones are represented by bubbles assigned to a fixed date — Milestones
  - Start dates for deployment at scale are marked — ◆ Deployment at scale begins
  - The duration and expected end date of large-scale action is indicated by arrows — Activity & scenario timings
  - Final 2038 milestones (maximum achievement in the modelled scenarios) are highlighted in blue — **2038 milestones**
  - The scenario that milestones and arrows refer to is indicated by colour

⬜ All scenarios
🟩 Max ambition
🟦 High H2
▨ Balanced

Roadmap - Transport

Back to Transport summary table

- Milestones
- Activity & scenario timings
- **2038 milestones**
- ◆ Deployment at scale begins
- ▲ External policy milestones
- ☐ All scenarios
- 🟩 Max ambition
- 🟦 High H_2
- ▨ Balanced



2020	2025	2030	2038

Active travel

- **2021/22:** Cycling and walking infrastructure strategy decided
- **2025:** Increase in:[1] Walking km of 5-9% Cycling km of 2-3x
- **2027:** Increase in:[1] Walking km of ~30-50% Cycling km of 6-15x
- **2030:** Max degree of modal shift achieved
- LCWIP studies
- ◆ Acceleration of cycling and walking infrastructure expansion & improvement

2038 milestones:
- **Walking and cycling reach 9-17% of distance travelled[1]**

Bus[3] & rail

- **2021/22:** Decision on bus network strategy
- **2027:** Bus km increase by ~30%
- **2029:** Rail freight and passenger km 1.5-2x higher
- **2031:** Diesel bus sales end
- **2035:** Max electrification of rail
- Shift to zero emission buses (battery electric moves ahead of hydrogen fuel cell) ◆
- Capacity & feasibility studies
- ◆ Electrify rail network, increase and integrate public transport offering

2038 milestones:
- **95-100% buses ZEV[2]**
- **75-90% rail km electrified**
- **Public transport use 1.5-2x higher**

Cars

See Cross-cutting for electric vehicle actions

- **2021/22:** Road reallocation strategy decided
- **2024/25:** Decision on role of traffic control measures
- **2025:** Battery electric cars reach 30-40% sales[2]
- **2030:** Private car use ~20-40% lower than today[2]
- **2030:** Petrol and diesel car sales end
- Studies of regional incentives
- ◆ Demand reduction action (e.g. parking, road reallocation)
- Larger local/regional incentives e.g. access charging, circulation plans

2038 milestones:
- **~60-80% of private cars ZEV[2]**
- **Private car use ~30-40% lower than today[2]**

Vans & HGVs

- **2021/22:** Targets set for public fleet conversion
- **2025:** BioCNG reaches ~20% of HGV sales
- **2028:** ZEVs reach >25% of van & HGV sales
- **2030:** 10% tonne km shifted to rail
- **2030:** Petrol and diesel van sales end
- **2034:** Diesel HGV sales end
- Public fleet ZEV study
- Consolidation feasibility
- Implement consolidation where appropriate and shift to rail & cycle freight

2038 milestones:
- **~40-60% of vans and 30-80% of HGVs ZEV[2]**
- **HGV use 10-15% lower than today[2]**

Cross-cutting

- Communication: including **behaviour change campaign** (2-3 phases), **stakeholder engagement** (bus operators, van and HGV fleets, DNOs) and **influencing**
- **2021/22:** EVCP strategy developed
- ◆ Accelerate installation of public EVCPs
- H_2 refuelling station rollout
- **2024/25:** Decision on type and level of financial support
- Local and regional financial incentives to support modal shift and ZEVs

2038 milestones:
- **90-100% of aircraft support vehicles electric[2]**

External policy milestones

- ▲ TDP
- ▲ Ultra rapid charging grant likely
- ▲ ebike grant likely
- ▲ Plug-in car grant ends
- Petrol & diesel car and van ban ▲
- ▲ Gas fuel duty ends (subject to review)

TDP = Transport Decarbonisation Plan; EVCP = Electric vehicle chargepoint; ZEV = zero emissions vehicle; CWIP = Cycling and Walking infrastructure Plan; 1. Higher value refers to WY, lower value YNY; 2. Higher value Max ambition, lower value High H_2 and Balanced; increases relative to modelled 2020 values; 3. See WYCA Zero Emission Bus Roadmap (2019) for more detailed actions and milestones for bus decarbonisation

Roadmap - Buildings

Back to Buildings summary table

Milestones

Activity & scenario timings

2038 milestones

◆ Deployment at scale begins

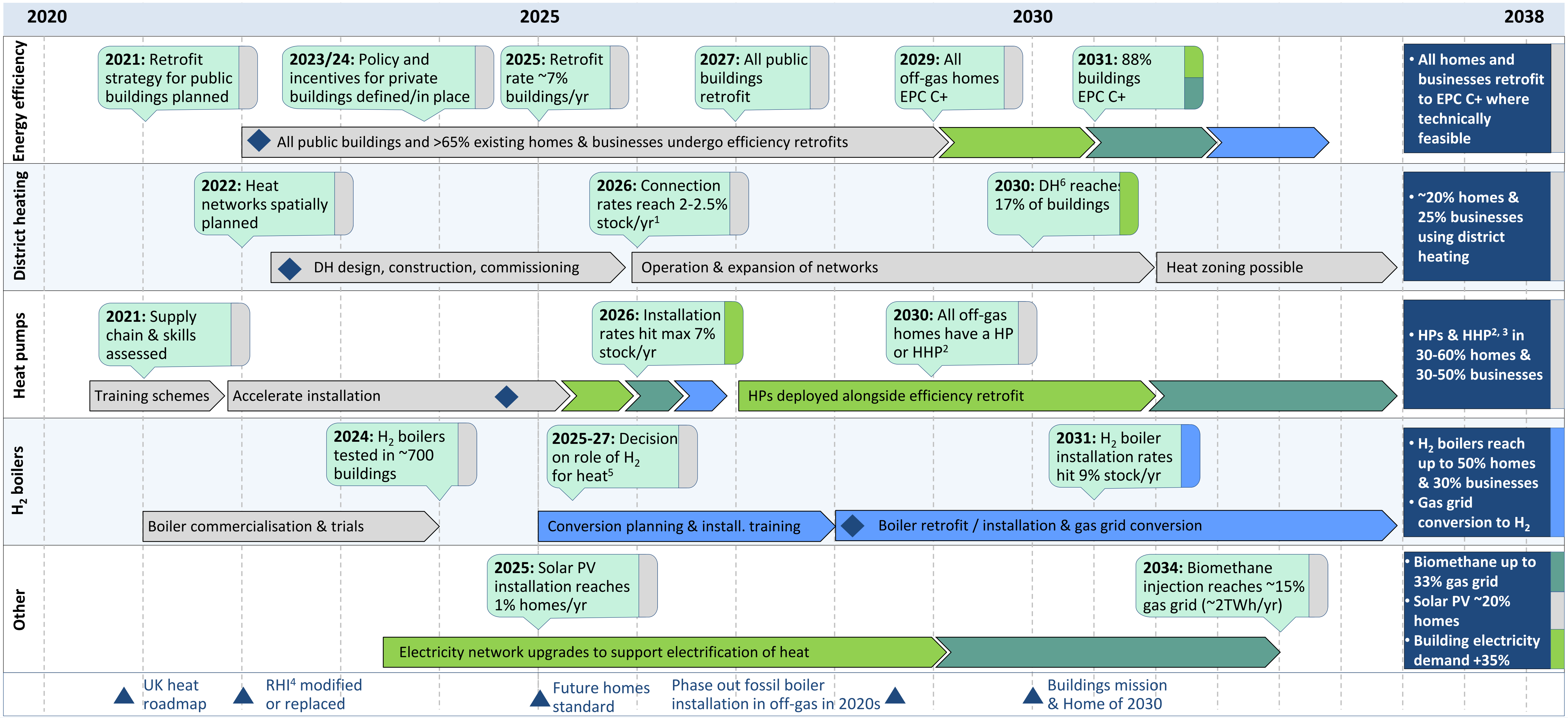
▲ External policy milestones

⬜ All scenarios

🟩 Max ambition

🟦 High H_2

🟩 Balanced



2020 | 2025 | 2030 | 2038

Energy efficiency

2021: Retrofit strategy for public buildings planned

2023/24: Policy and incentives for private buildings defined/in place

2025: Retrofit rate ~7% buildings/yr

2027: All public buildings retrofit

2029: All off-gas homes EPC C+

2031: 88% buildings EPC C+

◆ All public buildings and >65% existing homes & businesses undergo efficiency retrofits

- **All homes and businesses retrofit to EPC C+ where technically feasible**

District heating

2022: Heat networks spatially planned

2026: Connection rates reach 2-2.5% stock/yr[1]

2030: DH[6] reaches 17% of buildings

◆ DH design, construction, commissioning

Operation & expansion of networks

Heat zoning possible

- **~20% homes & 25% businesses using district heating**

Heat pumps

2021: Supply chain & skills assessed

2026: Installation rates hit max 7% stock/yr

2030: All off-gas homes have a HP or HHP[2]

Training schemes

Accelerate installation ◆

HPs deployed alongside efficiency retrofit

- **HPs & HHP[2, 3] in 30-60% homes & 30-50% businesses**

H_2 boilers

2024: H_2 boilers tested in ~700 buildings

2025-27: Decision on role of H_2 for heat[5]

2031: H_2 boiler installation rates hit 9% stock/yr

Boiler commercialisation & trials

Conversion planning & install. training

◆ Boiler retrofit / installation & gas grid conversion

- **H_2 boilers reach up to 50% homes & 30% businesses**
- **Gas grid conversion to H_2**

Other

2025: Solar PV installation reaches 1% homes/yr

2034: Biomethane injection reaches ~15% gas grid (~2TWh/yr)

Electricity network upgrades to support electrification of heat

- **Biomethane up to 33% gas grid**
- **Solar PV ~20% homes**
- **Building electricity demand +35%**

▲ UK heat roadmap

▲ RHI[4] modified or replaced

▲ Future homes standard

Phase out fossil boiler installation in off-gas in 2020s ▲

▲ Buildings mission & Home of 2030

1. Higher value Max ambition, lower value High H_2 and Balanced; 2. HP = heat pump, HHP = hybrid heat pump (heat pump plus boiler); 3. Higher value Max ambition, lower value High H_2; 4. RHI = Renewable Heat Incentive; 5. Largely dependent on national decisions 6. District Heating

Roadmap – Industry

[Back to Industry summary table]

Milestones

Activity & scenario timings

2038 milestones

◆ Deployment at scale begins

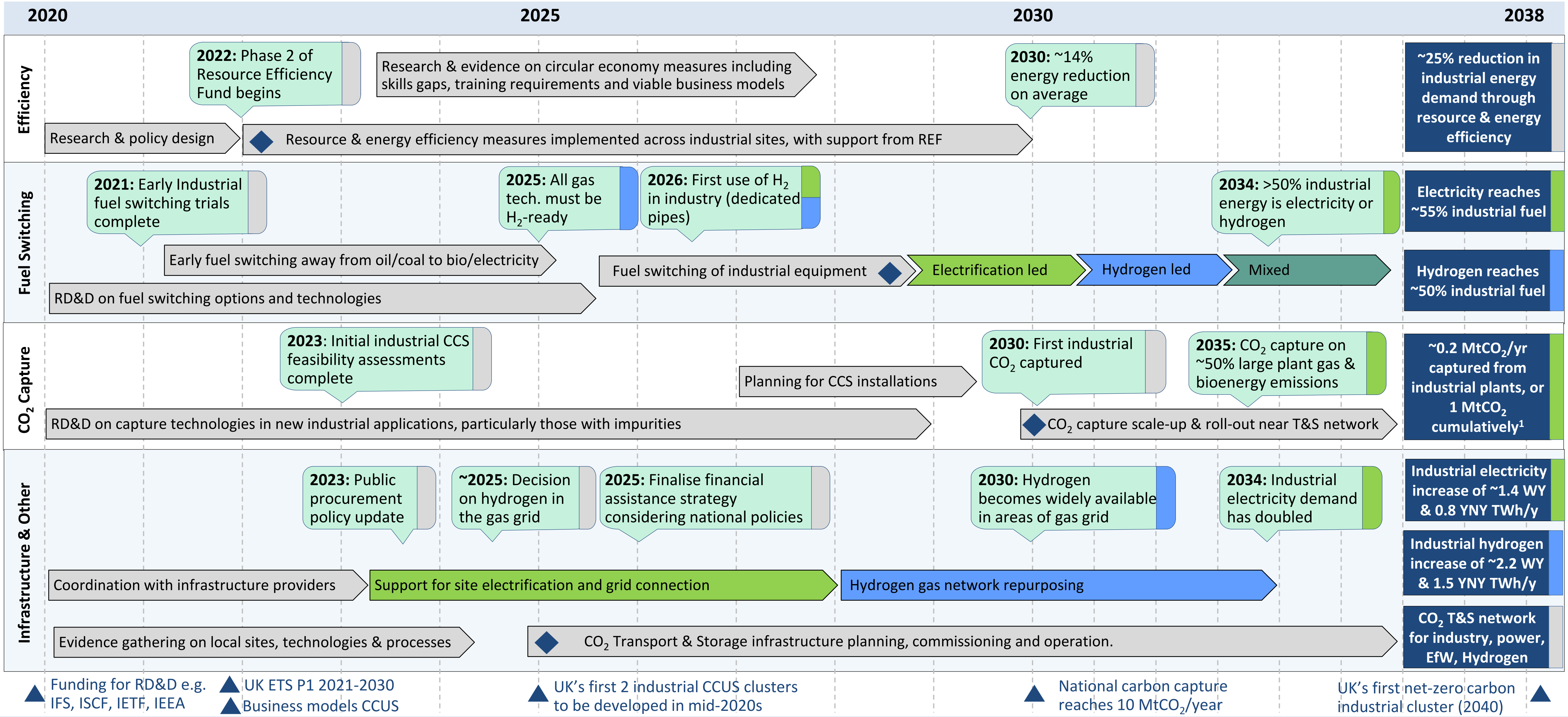
▲ External policy milestones

⬜ All scenarios

🟩 Max ambition

🟦 High H_2

▨ Balanced



2020 | 2025 | 2030 | 2038

Efficiency

2022: Phase 2 of Resource Efficiency Fund begins

Research & evidence on circular economy measures including skills gaps, training requirements and viable business models

2030: ~14% energy reduction on average

Research & policy design

◆ Resource & energy efficiency measures implemented across industrial sites, with support from REF

~25% reduction in industrial energy demand through resource & energy efficiency

Fuel Switching

2021: Early Industrial fuel switching trials complete

2025: All gas tech. must be H_2-ready

2026: First use of H_2 in industry (dedicated pipes)

2034: >50% industrial energy is electricity or hydrogen

Early fuel switching away from oil/coal to bio/electricity

Fuel switching of industrial equipment ◆

Electrification led

Hydrogen led

Mixed

RD&D on fuel switching options and technologies

Electricity reaches ~55% industrial fuel

Hydrogen reaches ~50% industrial fuel

CO_2 Capture

2023: Initial industrial CCS feasibility assessments complete

Planning for CCS installations

2030: First industrial CO_2 captured

2035: CO_2 capture on ~50% large plant gas & bioenergy emissions

RD&D on capture technologies in new industrial applications, particularly those with impurities

◆ CO_2 capture scale-up & roll-out near T&S network

~0.2 $MtCO_2$/yr captured from industrial plants, or 1 $MtCO_2$ cumulatively[1]

Infrastructure & Other

2023: Public procurement policy update

~2025: Decision on hydrogen in the gas grid

2025: Finalise financial assistance strategy considering national policies

2030: Hydrogen becomes widely available in areas of gas grid

2034: Industrial electricity demand has doubled

Coordination with infrastructure providers

Support for site electrification and grid connection

Hydrogen gas network repurposing

Evidence gathering on local sites, technologies & processes

◆ CO_2 Transport & Storage infrastructure planning, commissioning and operation.

Industrial electricity increase of ~1.4 WY & 0.8 YNY TWh/y

Industrial hydrogen increase of ~2.2 WY & 1.5 YNY TWh/y

CO_2 T&S network for industry, power, EfW, Hydrogen

▲ Funding for RD&D e.g. IFS, ISCF, IETF, IEEA

▲ UK ETS P1 2021-2030

▲ Business models CCUS

▲ UK's first 2 industrial CCUS clusters to be developed in mid-2020s

▲ National carbon capture reaches 10 $MtCO_2$/year

UK's first net-zero carbon industrial cluster (2040) ▲

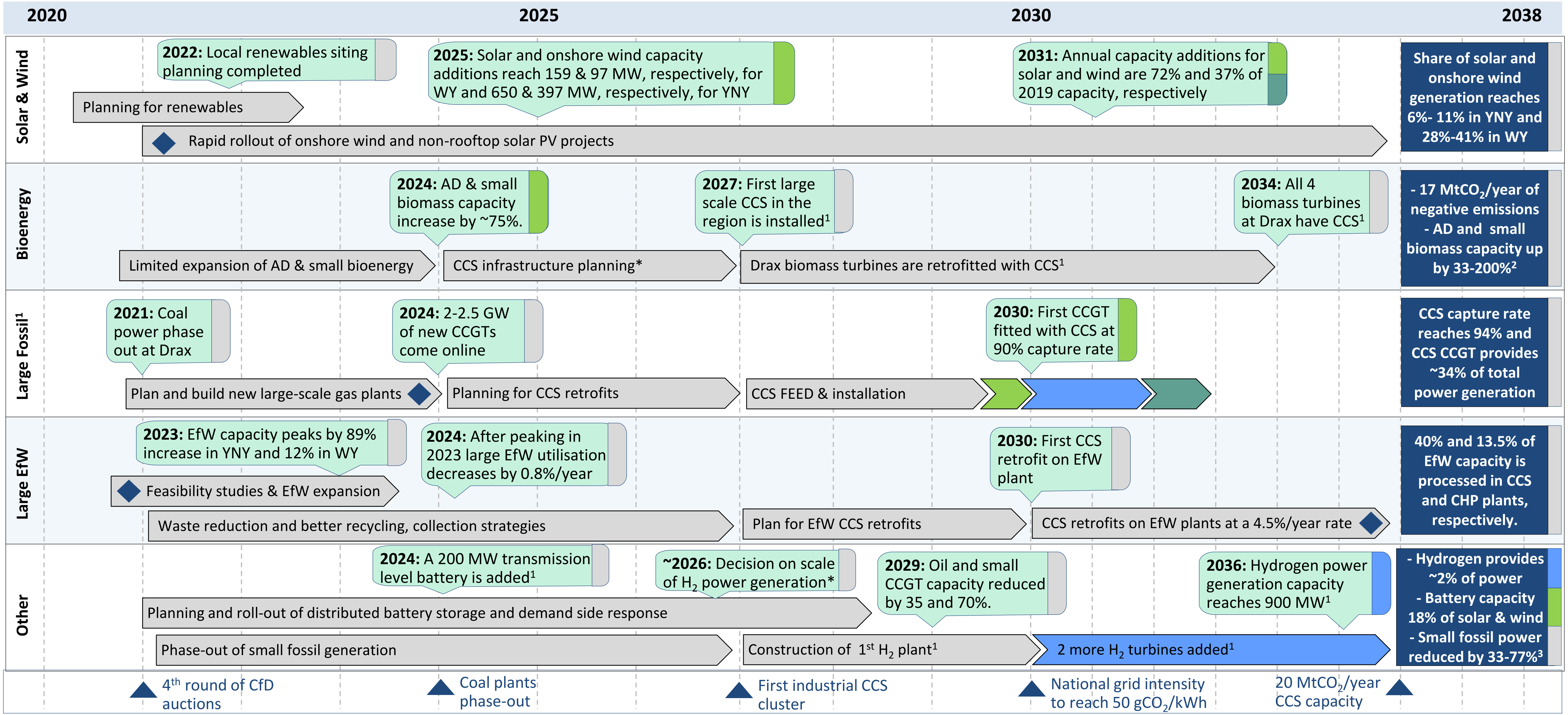
---

1 For the whole study region Acronyms: T&S: transport and storage; IFS: industrial fuel switching ISCF: Industrial Strategy Challenge Fund; The Industrial Energy Transformation Fund; IEEA: industrial energy efficiency accelerator; ETS Emissions trading system; CCS Carbon capture and Storage

Roadmap - Power

Back to Power summary table

- Milestones
- Activity & scenario timings
- 2038 milestones
- ◆ Deployment at scale begins
- ▲ External policy milestones
- ⬜ All scenarios
- 🟩 Max ambition
- 🟦 High H_2
- 🟩 Balanced



2020 | 2025 | 2030 | 2038

Solar & Wind

2022: Local renewables siting planning completed

2025: Solar and onshore wind capacity additions reach 159 & 97 MW, respectively, for WY and 650 & 397 MW, respectively, for YNY

2031: Annual capacity additions for solar and wind are 72% and 37% of 2019 capacity, respectively

Planning for renewables

◆ Rapid rollout of onshore wind and non-rooftop solar PV projects

Share of solar and onshore wind generation reaches 6%- 11% in YNY and 28%-41% in WY

Bioenergy

2024: AD & small biomass capacity increase by ~75%.

2027: First large scale CCS in the region is installed[1]

2034: All 4 biomass turbines at Drax have CCS[1]

Limited expansion of AD & small bioenergy

CCS infrastructure planning*

Drax biomass turbines are retrofitted with CCS[1]

- 17 $MtCO_2$/year of negative emissions
- AD and small biomass capacity up by 33-200%[2]

Large Fossil[1]

2021: Coal power phase out at Drax

2024: 2-2.5 GW of new CCGTs come online

2030: First CCGT fitted with CCS at 90% capture rate

Plan and build new large-scale gas plants ◆

Planning for CCS retrofits

CCS FEED & installation

CCS capture rate reaches 94% and CCS CCGT provides ~34% of total power generation

Large EfW

2023: EfW capacity peaks by 89% increase in YNY and 12% in WY

2024: After peaking in 2023 large EfW utilisation decreases by 0.8%/year

2030: First CCS retrofit on EfW plant

◆ Feasibility studies & EfW expansion

Waste reduction and better recycling, collection strategies

Plan for EfW CCS retrofits

CCS retrofits on EfW plants at a 4.5%/year rate ◆

40% and 13.5% of EfW capacity is processed in CCS and CHP plants, respectively.

Other

2024: A 200 MW transmission level battery is added[1]

~2026: Decision on scale of H_2 power generation*

2029: Oil and small CCGT capacity reduced by 35 and 70%.

2036: Hydrogen power generation capacity reaches 900 MW[1]

Planning and roll-out of distributed battery storage and demand side response

Phase-out of small fossil generation

Construction of 1st H_2 plant[1]

2 more H_2 turbines added[1]

- Hydrogen provides ~2% of power
- Battery capacity 18% of solar & wind
- Small fossil power reduced by 33-77%[3]

▲ 4th round of CfD auctions

▲ Coal plants phase-out

▲ First industrial CCS cluster

▲ National grid intensity to reach 50 gCO_2/kWh

20 $MtCO_2$/year CCS capacity ▲

1- BECCS, CCS CCGT, Hydrogen turbines and one 200 MW transmission level battery are only installed in the York & North Yorkshire region.

2- Variation due to scenarios and technologies over the whole study region. 3- Savings are constant across scenarios with higher values representing WY and lower values YNY.

CCS: carbon capture and storage, BECCS: bioenergy with CCS, CCGT: combined cycle gas turbine, EfW: energy from waste, AD: anaerobic digestion, H2: hydrogen, CHP: combined heat and power

Link to contents

Roadmap – LULUCF and agriculture

Back to LULUCF summary table

Milestones

Activity & scenario timings

2038 milestones

◆ Deployment at scale begins

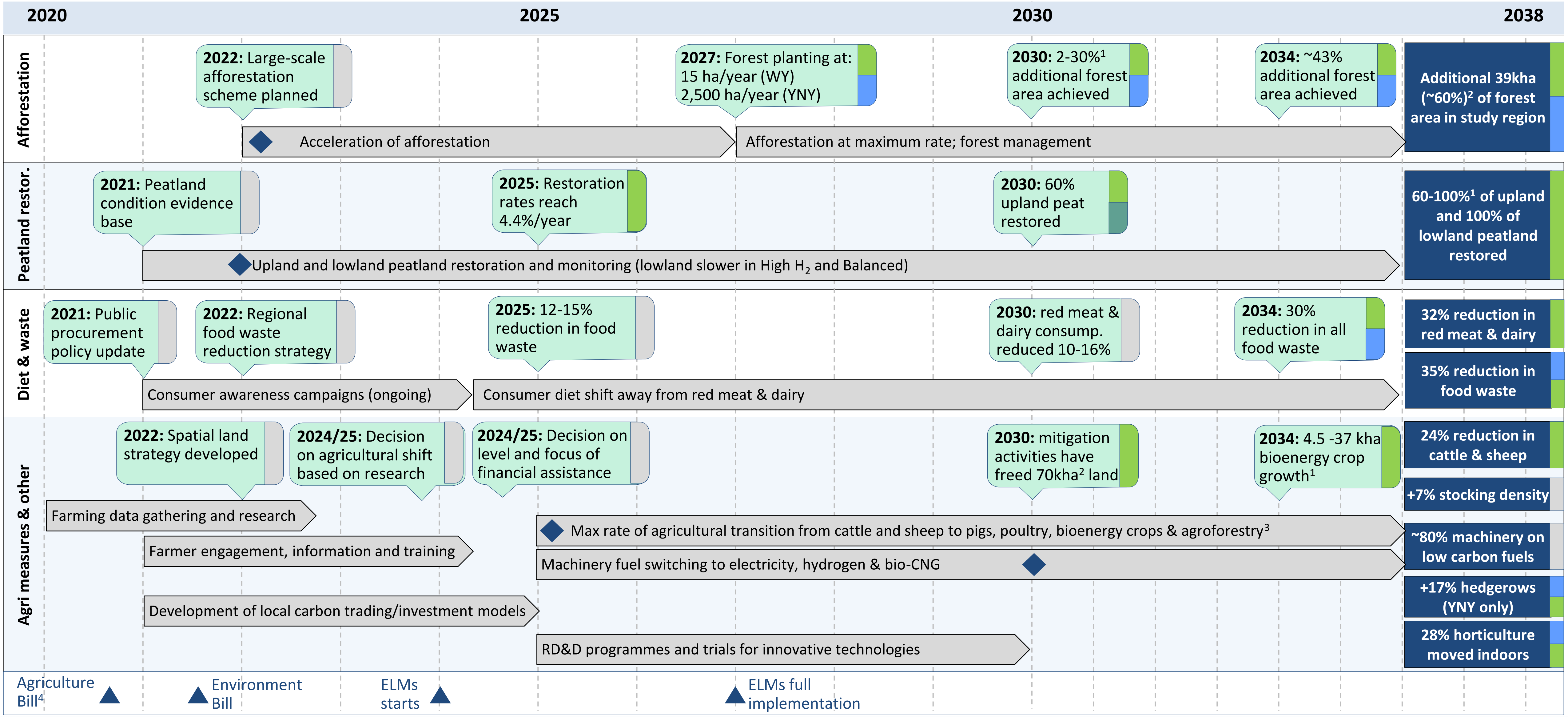
▲ External policy milestones

⬜ All scenarios

🟩 Max ambition

🟦 High H_2

▨ Balanced



2020 | 2025 | 2030 | 2038

Afforestation

2022: Large-scale afforestation scheme planned

2027: Forest planting at: 15 ha/year (WY) 2,500 ha/year (YNY)

2030: 2-30%[1] additional forest area achieved

2034: ~43% additional forest area achieved

◆ Acceleration of afforestation

Afforestation at maximum rate; forest management

Additional 39kha (~60%)[2] of forest area in study region

Peatland restor.

2021: Peatland condition evidence base

2025: Restoration rates reach 4.4%/year

2030: 60% upland peat restored

◆ Upland and lowland peatland restoration and monitoring (lowland slower in High H_2 and Balanced)

60-100%[1] of upland and 100% of lowland peatland restored

Diet & waste

2021: Public procurement policy update

2022: Regional food waste reduction strategy

2025: 12-15% reduction in food waste

2030: red meat & dairy consump. reduced 10-16%

2034: 30% reduction in all food waste

Consumer awareness campaigns (ongoing)

Consumer diet shift away from red meat & dairy

32% reduction in red meat & dairy

35% reduction in food waste

Agri measures & other

2022: Spatial land strategy developed

2024/25: Decision on agricultural shift based on research

2024/25: Decision on level and focus of financial assistance

2030: mitigation activities have freed 70kha[2] land

2034: 4.5 -37 kha bioenergy crop growth[1]

Farming data gathering and research

Farmer engagement, information and training

Development of local carbon trading/investment models

◆ Max rate of agricultural transition from cattle and sheep to pigs, poultry, bioenergy crops & agroforestry[3]

Machinery fuel switching to electricity, hydrogen & bio-CNG ◆

RD&D programmes and trials for innovative technologies

24% reduction in cattle & sheep

+7% stocking density

~80% machinery on low carbon fuels

+17% hedgerows (YNY only)

28% horticulture moved indoors

Agriculture Bill[4] ▲

▲ Environment Bill

ELMs starts ▲

▲ ELMs full implementation

---

1 Lower value is for WY, higher value YNY; 2. For the whole study region; 3. Agroforestry only in YNY, reaching 17-68 kha by 2038 (lower value Balanced scenario, higher value Max ambition) 4. Agriculture Bill passed into law Nov 2020; 5. ELMs = Environmental Land Management Scheme

Contents

Policies and actions – overview

Overview

- **The target dates for decarbonisation of the WYCA and York & North Yorkshire LEP regions represent a substantially accelerated timeline** for emissions reduction relative to the UK Government's target of net zero by 2050. Meeting these targets will require a wide range of ambitious actions that go beyond current policy and likely entail higher risk and cost to the local authorities.
- **Delivering these actions relies on coordinated action** from regional authorities, businesses, communities, industry and other stakeholders, and national Government, and some aspects of the decarbonisation pathways are reliant on external decisions.
- **A long-list of policy actions that WYCA and Y&NY can take for each sector has been drawn up** based on best practice examples, established reports, and feedback received from consultation carried out by WYCA and YNY LEP. The scale and pace of change in many sectors is unprecedented, so not every policy has a prior example of successful implementation at this scale. **Note that the policies are written from the perspective of the local / regional authorities and the actions they can take**; many of these actions are supporting action by the private sector.

Action plans and policy tables

- The policies have been summarised into action plans, which highlight the priority actions to take in the short-term (next 4-5 years), medium term (5-10 years) and long term:
  - These priority actions have been broadly identified as those which are relatively low cost, provide relatively large benefits, and which are common to all pathways.
  - These actions aim to begin the process of ambitious change while keeping options open where possible so that each region's strategy can adapt in response to external changes, such as changes to the national policy environment and technology learning.
  - In addition, learnings through small-scale trials and studies will put the regions in a better position to make decisions which may involve more significant trade-offs (between carbon emissions savings, cost, consumer/citizen choice and so on).
- Further information is included in detailed policy tables for each sector, with a focus on the short-to-medium term actions. References for illustrative costs and selected best practice examples are provided in the Appendix.

Policies and actions – overview of information contained in the policy tables

Role of WYCA and Y&NY LEP

- WYCA and Y&NY LEP can take a leading role in delivering emissions reduction through providing strategic vision, coordinating and aligning action by local authorities, engaging with and influencing stakeholders, and influencing policy and funding (e.g. through devolution) from Government
- However, the **scale of action needed will require significant resources** – both financial and staffing – to deliver, which is not currently available; further funding will therefore need to be secured in order to achieve the climate ambition of each region
- While there is significant action that WYCA and Y&NY LEP can take to deliver the pathways, delivery of many key measures and supporting infrastructure is outside the remit and control of the CA and LEP, and will necessarily require direct action by other national and regional stakeholders as well as public-private partnerships and action by individuals

The regions will still be reliant on strong national policies to achieve their goals and deploy many of the recommended policies

Role of stakeholders

- The policy recommendations given here **focus specifically on the action that the CA/LEP can take** but, where applicable, the stakeholders that will lead delivery are highlighted in the policy tables (see next slide for layout of tables)
- For example, key delivery partners include:
  - **Hydrogen pipeline network** – will be coordinated and delivered by National Grid Gas and Northern Gas Network, with the primarily role of the CA/LEP to ensure that data and plans are shared with these partners
  - **Electricity infrastructure** – led by Northern PowerGrid (NPg) for example grid reinforcement, renewable generation connection, flexibility systems and electrification or industrial sties.
  - **Local planning** – Local Plans and their enforcement will be delivered by the Local Authorities, with the main role for the CA/LEP to deliver the wider strategy and direction
  - **Zero emission technology uptake** – outside of public sector buildings and fleets, uptake will require residents and businesses to switch technology, with the main role of the CA/LEP to help provide the conditions to support them (e.g. information, financial support, charging infrastructure etc)

Policies and actions – Overview of sectors and recommended actions

Policies and action plans are provided for the following sectors:

- **Cross-cutting policies** – policies that relate to wider, overarching actions that impact multiple sectors including through awareness-raising and spatial strategy development (*policy tables provided only*) - **strategy development should be conducted in an integrated manner to ensure alignment of goals across sectors**
- **Transport** – early actions primarily target behaviour change alongside strategy setting, wider evidence gathering, and working with partners to accelerate larger schemes (e.g. rail decarbonisation), with later action focused on driving low emission technology uptake
- **Buildings** – urgent, early action targets improvements to public sector buildings and social housing, with later action focused on driving/incentivising targeted change in owner-occupier and private rented buildings
- **Power** – early actions target planning, evidence gathering, public procurement of solar and flexibility services and awareness raising. Later actions focus on support for infrastructure development, incentives for low-carbon generation deployment and decarbonisation of energy from waste.
- **Industry** – early actions target planning, evidence gathering, supporting feasibility studies and efficiency improvements. Later actions focuses on financial incentives for fuel switching/CCS and support for infrastructure development.
- **LULUCF and agriculture** – early actions focus on strategy-setting, evidence gathering and awareness raising, alongside direct public sector action. Later action focuses on targeted incentives to drive deployment of land use solutions.

Layout of policy tables:

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
0	*Describes the policy, including the type of incentive / support and the mechanism to deliver it* ***Policy categories** are given in bold before the policy description* ***Recommended timeframe for delivery** is given below each policy*	*High-level estimate of the number of full-time equivalents (FTEs) needed to run the program and, where appropriate, the cost (e.g. of direct financial support)*	*Key risks and expected barriers to delivery of the project or achieving the project aims e.g. around engagement and uptake, national policy support, overspend etc*	*Summary of the different roles at each level of governance (i.e. WYCA/YNY LEP, local authorities). Other key stakeholders to interact with or that are crucial to delivery.*	*Significant co-benefits*	- *Details of the primary aim of the action and key interventions that the policy targets* - *Links with other policies*

Contents

Cross-cutting policy table (1/3)

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
C1	**Coordination, Information, Facilitation:** Run a **major publicity and engagement campaign** that targets all key stakeholders, which: • Outlines the ambition and delivery strategy to raise awareness of targets • Provides information on low carbon technology and behaviour change options available across sectors • Advertises local and national schemes, incentives, and initiatives available to help different groups • Provides resources to enable behaviour change • Aims to encourage acceptance of large-scale technology solutions, such as on-shore wind and BECCS Key sectors supported by this campaign are expected to be buildings, transport, LULUCF and Agriculture *See Appendix for sector details* **Setup by 2021, with ongoing activities and review**	Costs dependent on format and scale of scheme, but could be in the region of:[1] **Initial setup**: ~£300-400k for brand design, website design, content preparation and engagement planning **2020-2025**: £150-300k per year for period of main marketing, social media presence and engagement activities **2025 onwards**: £50-100k per year for reviewing content and approach, and monitoring progress 1-2 FTE per campaign (i.e. 1-2 FTS for WYCA and 1-2 for Y&NY LEP) to manage campaign, with additional resource and coordination with other engagement activities	• Risk of not reaching sufficient proportion of target audience; in particular risk that vulnerable residents may be missed (e.g. fuel poor and elderly) • Risk of becoming outdated rapidly due to evolving national RD&D and policy landscape – can be mitigated by frequent reviews and updates • Risk of low behaviour change despite targeted information – needs to be accompanied by 'hard' measures as well as information to maximise impact	• **Led and delivered by CA/LEP**, with support from/engagement with Local Authorities and existing local programmes/schemes • Key stakeholders for engagement include residents, local businesses, local fleets • Key industry stakeholders to engage with in the process of delivery include technology and service providers, DNOs, LEPs	Co-benefits are assigned to the measures facilitated by the campaign	• Key enabling measure to facilitate delivery of community actions and effectiveness of local initiatives, e.g.: − Widening reach of financial support (e.g. **B10**, **T17**) − Supporting transport modal shift (**T2, T3, T6, T7**) − Supporting waste reduction (**L3, L7, I13, P11**) − Encouraging uptake of community land use and food projects in **L16** • Raises awareness and empowers residents and local businesses to take ownership of ambition

---

[1] Costs based on Element Energy experience for a Local Authority campaign

Cross-cutting policy table (2/3)

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
C2	**Regulatory & planning:** Develop a **spatial development strategy for the region**[1] which considers and incorporates competing land use needs for the region, including: • LULUCF potential and nature recovery network future needs • Potential and required capacity for renewables • Housing growth, with a focus on densification (*WY-specific*) and co-location of homes, workplaces and services (e.g. '15 minute neighbourhood' concept) • Transport infrastructure, including road reallocation to cycle infrastructure • Public transport integration • Infrastructure needs for future transitions to H_2 and CCS, as well as increased electrification **By 2022/23, with ongoing review**	Up to £50-100k depending on whether supporting studies beyond those in each sector are required 1-2 FTE to oversee delivery	• Some infrastructure needs are difficult to predict, requiring regular periodic review • Need to be dynamic to avoid risk of misalignment with current or future National priorities • Likely misalignment of current local plans with spatial requirements to meet climate ambition	• **Led and delivered by CA/LEP** with significant engagement with key stakeholders including: − All local authorities − Transport for the North − National Park Authorities − NGN and NPg − Industry − Drax − Housing, renewables & infrastructure developers − Land use projects (e.g. Northern Forest and White Rose Forest)	−	Enables a holistic approach to achieving the climate ambition across sectors, with the aim of ensuring competing needs across sectors are resolved. Gives policy certainty to key industry stakeholders. Will draw on and feed into sector-specific strategies, e.g.: • Land-use strategy, **L1** • Heat network strategy, **B3** • Power strategy, **P1** • Local planning needs, **B8, T5** and **L15**
C3	**Coordination, information and facilitation:** Create a **working group** to ensure that regional priorities are aligned between WY, YNY, neighbouring LAs (e.g. inc. those in the Humber region which will strongly contribute to H_2 future of the region), DNOs and LEPs. **By 2021**	<1 FTE to chair working group	• Coordination of priorities across regions complex to achieve, especially where net zero targets differ (or aren't established in some areas)	• Led by CA/LEP	−	Aims to ensure alignment with wider regional objectives.

1. "Region" refers to either West Yorkshire or York & North Yorkshire

Cross-cutting policy table (3/3)

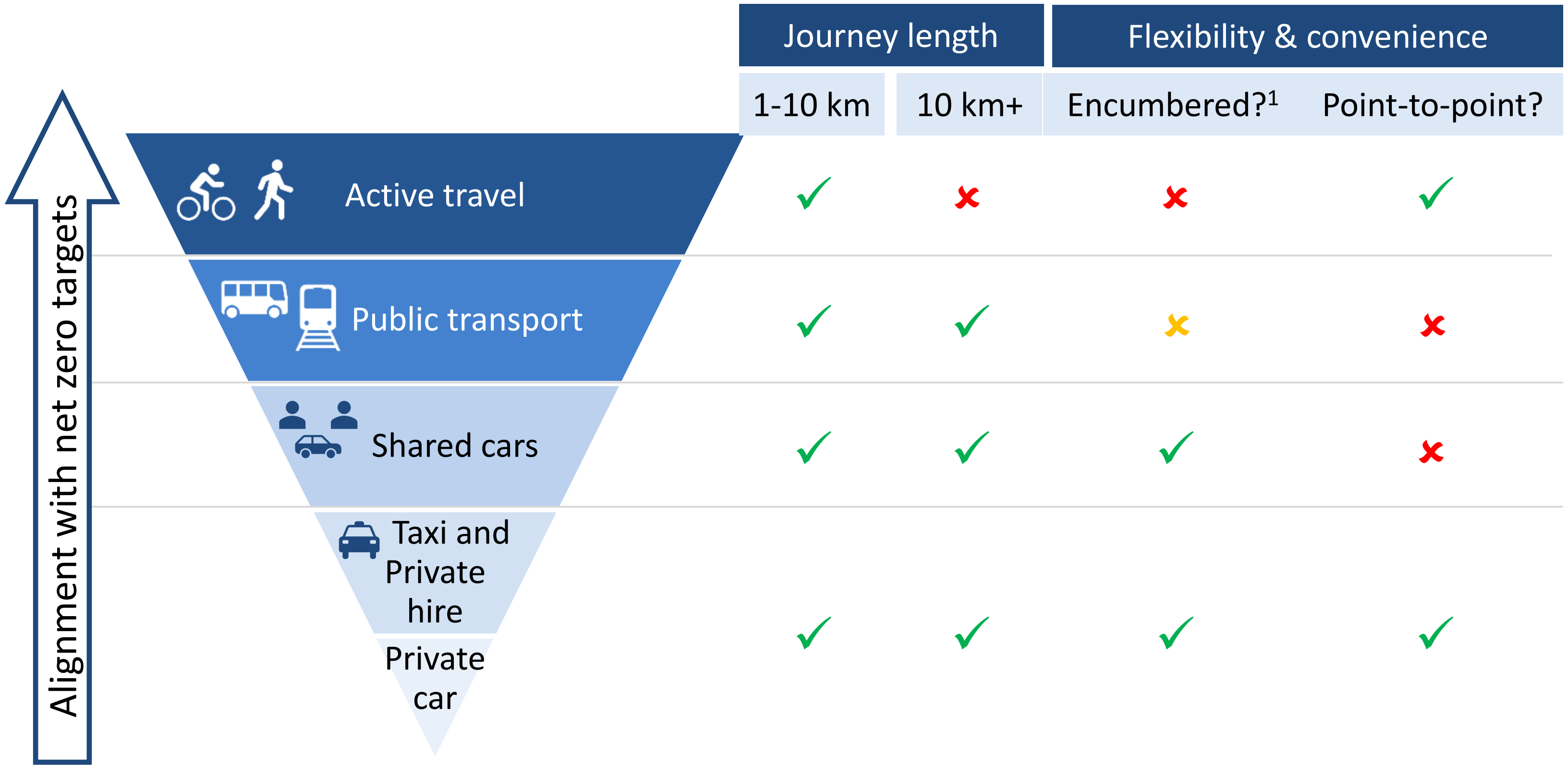
No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
C4	**Infrastructure: Support development of CCS, hydrogen and electricity infrastructure**, through coordinating necessary parties, ensuring planning permission and land are granted/available, supporting funding applications of DNOs to national government, etc. Completing this action successfully will depend on updating local energy plans to better reflect novel low carbon technologies. **2024 onward**	1 FTE to coordinate all relevant offices and parties. Majority of the work to be delivered through existing capacity.	• Infrastructure investment can be very costly and involve cross-party risk if assets are not guaranteed to be utilised. • Chicken and egg problem with downstream processes.	CA/LEP to lead coordination. **Direct delivery of infrastructure by support Northern Powergrid, Northern Gas Networks and other developers**. Also ensure communication with the industry + other stakeholders.	–	- Enabling policy for power capacity expansion and decarbonisation, and transition to H_2. - Coordination needed with planning policy and must be supported by influencing central bodies.
C5	**Planning & regulatory:** consider implementing a **hydrogen zoning plan** by pre-determining areas of the gas network which will be converted to hydrogen in the future. Follow up by requiring and regulating that gas boilers and industrial gas equipment installed in these regions are hydrogen ready. If this policy is nationally led, complement by communicating, enforcing and supporting implementation of H_2-ready equipment. ***Applicable to High H_2 scenario only*** **2025 - early 2030s**	1 FTE for communication and general oversight of the scheme. Initial zoning, if developed regionally, requires consultation fees.	• Requires national support or risks high regional costs. • Enforcement of regulation may face backlash. • Risks changes in future plans and hydrogen not being used in regions.	CA/LEP to lead the programme with significant planning related help from LA/CC. **Delivery of heat zoning likely through LAs/CC.** Strong communication with local industry and coordination with NGN, NPg and regional projects such as H21.	• Reduce costs by anticipating future needs • Increased transparency	• Enabling policy. • Relates to hydrogen fuel switching measures. • Should be linked to planning and infrastructure. Should prioritise national H_2 strategy.
C6	**RD&D: Explore speculative options to reach net zero** including development of an **offsetting strategy**, **supporting local trials** of innovative technologies such as BECCS in industry and direct air capture, the potential for greater land use solutions (inside and outside the region; link with land use data and evidence gathering, **L2**), and options for achieving fully renewable electricity supply. ***Primarily applicable to WYCA*** **2025 - early 2030s**	Cost and resource dependent on the trial.	• Risk that options are unsuitable for the region • Constantly evolving science base may quickly make results outdated	CA/LEP to lead the programme, but strong engagement and collaboration will be required with industry and private partners in the case of trials. Where measures are employed outside the region, collaboration with other regions will be needed.	–	• Enabling policy for closing the gap to net zero in the region

Contents

Reducing car travel is an important measure underpinning all decarbonisation pathways which will require an integrated, sustainable transport system to achieve

- Reducing car ownership requires consumers to be confident that they can meet all their travel needs by other, sustainable means
- While walking, cycling and public transport should take a leading role in future transport choices, not all journeys are suited to these modes (see Figure below)
- Therefore, to deliver the most benefits, an integrated transport system is needed that comprises a range of mobility options that, together, meet the full range of personal travel needs
- Additionally, measures that focus solely on discouraging car use (e.g. access charging, road pricing, parking charges and levies etc) risk disproportionately impacting low-income residents and future transport must be designed to mitigate this risk
- To enable consumers to reduce reliance on private cars, future sustainable journeys must be competitive on cost and convenience – requiring both affordable pricing and alignment between the mobility modes in terms of timetabling (for public transport) and ticketing
- As such, local and regional authorities must use a combination of measures to discourage car use supported by improvements to shared, active and public transport – and the interchanges between them – to deliver their climate ambitions
- Both types of measures are considered in the recommendations on the following slides

Hierarchy of travel modes and comparison of suitability for travel needs



	Journey length		Flexibility & convenience	
	1-10 km	10 km+	Encumbered?[1]	Point-to-point?
Active travel	✓	✗	✗	✓
Public transport	✓	✓	✗	✗
Shared cars	✓	✓	✓	✗
Taxi and Private hire Private car	✓	✓	✓	✓

---

1. e.g. carrying large luggage or escorting passengers

Action plan – Transport

Key[1]
Policy with higher significance for WY
Policy with higher significance for YNY

2020 | **Priority Actions and Evidence** | **2025 at latest** | **Max implementation of policy** | **2030** | **Adjustment and enhancement** | **2038**

Priority Actions (common across pathways)

- Develop an overarching strategy for road space reallocation
- Develop a region-wide parking strategy, including reducing on-street parking, banded parking charges and workplace parking levies
- Develop and implement a region-wide cycling and walking strategy and accelerate development and implementation of LWCIPs
- Develop a regional electric vehicle charging infrastructure strategy, including a procurement framework
- Expand reach and control over bus offering, e.g. through considering bus franchising or an Enterprise Partnership
- Implement flexible and integrated ticketing across transport services
- Invest in digital infrastructure
- Run a major publicity campaign to encourage behaviour change
- Invest in training to develop local skills in zero emission technology
- Influence Government to deliver policy that supports climate ambition
- Work with partners to limit road building and decarbonise rail

Evidence gathering (in parallel with priority actions)

- Assess local suitability of implementing traffic control measures such as zero emissions zones, traffic circulation plans and 20mph limits
- Assess local feasibility of freight consolidation and cycle freight in key delivery locations
- Assess feasibility and demand for passenger and freight rail services to determine capacity upgrade and develop strategy
- Support and deliver trials of innovative services and shared mobility
- Work with LAs to establish how best to use local planning policy to incentivise delivery of measures, including "15 min city" principles
- Engage with local fleets to understand their plans and raise awareness
- Engage with key stakeholders to understand plans for gas in transport
- Assess National Government support, priorities, and regulation

Decision on pathway by latest 2025

Max ambition

- Strong local and regional policy to support modal shift and technology change
- Maximum rate of expansion of active travel infrastructure, public transport services and chargepoint network
- Strong financial incentives offered to facilitate maximum rate of modal shift and zero emission vehicle uptake
- Rapid conversion of public fleets to zero emission vehicles
- Engagement with NPg to ensure electricity grid capacity upgrades are delivered to support transition

High Hydrogen

- Strong local and regional policy to support modal shift and technology change
- High rate of expansion of active travel infrastructure, public transport services and charging infrastructure
- Some financial incentives offered to facilitate high rate of modal shift and zero emission vehicle uptake
- Rapid conversion of public fleets to zero emission vehicles
- Engagement with NGN and fleet operators to ensure H_2 refuelling station rollout in region to meet demand

Balanced

- Strong local and regional policy to support modal shift and technology change
- High rate of expansion of active travel infrastructure, public transport services and charging infrastructure
- Some financial incentives offered to facilitate high rate of modal shift and zero emission vehicle uptake
- Rapid conversion of public fleets to zero emission vehicles
- Engagement with NGN to align targeted H_2 refuelling rollout, and NPg to ensure targeted electricity upgrades

Evaluate progress and implement further measures where necessary, for example:

- Adjustment of strategies based on achieved level of deployment and changes in National Policy
- Stronger regulatory measures to encourage uptake, such as through local planning requirements (if possible)
- Stronger financial incentives for technology uptake (e.g. scrappage schemes) , including support for HGV fleets
- CA/LEP-supported decarbonisation of rail, where feasible
- Support for rollout of innovative technologies and techniques, such as vehicle-to-grid, smart systems and H_2 fuel cell trains (as appropriate)
- Adjustment of training programmes to meet skills shortages

---

1. Policies with higher relevance for urban areas, such as traffic flow measures, parking restrictions, and freight consolidation, are considered more relevant for WY

Transport policies (1/8)

Back to Transport summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
T1	**Regulatory & Planning:** Develop **overarching strategy for road space reallocation** on key corridors to cycling, walking and public transport to ensure that individual transport mode strategies are aligned and complementary. Limit new road building on CA/CC-owned roads. **By 2023 (in parallel with other strategies)**	Negligible – under the remit of strategic and planning policy teams <1 FTE to coordinate LAs	• Resistance from road users • Risk of increased congestion, which may impact goods movement	• County Council/CA to lead development of the plan in collaboration/consultation with Local Authorities • Freight organisations to be consulted to bring on-board	• Safer streets for cycling & walking • Better infrastructure for active and public transport	• Decreased car use • Modal shift • Needs to link with working with other regional and national partners (**T23**)
T2	**Regulatory & Planning:** Develop a region-wide[1] **parking strategy** that discourages private car use and encourages low emissions technology uptake. This should include: • **reducing on-street parking** and reallocating to other uses such as: car clubs, cycle parking, parklets, microconsolidation etc. Likely steps include: an audit of available parking across all local authorities, consultation with residents and businesses to determine priorities, development of an implementation strategy. • Implementing **banded parking charges** that vary with vehicle emissions, including residents permits and both on-street and off-street public parking. It is recommended that charges for ICE vehicles are raised above current levels, particularly for on-street parking. • Introducing **workplace parking levies** where appropriate, and to assess implementing a cap on business parking permits. **2020-2022**	~£50-100k for initial parking audit commission and any further feasibility studies ~1 FTE to coordinate strategy development Upfront costs of ~£50k per Council may be incurred for implementing banded parking charges, although efficiencies may be gained through a central approach (i.e. if led by WYCA/Y&NY to create region-wide regulation). Revenues from parking charges and levies likely to cover ongoing costs.	• Resistance from residents and local businesses • Need for buy-in from all LAs • Reduction in revenue from parking, although this can be mitigated by increasing charges for remaining spaces • Limited access for those reliant on cars • High upfront costs for low emissions vehicles • Low income households could be disproportionately affected by increased charges • Loss of revenue from residents permits in future years if charges aren't adjusted • Risk of workplace levy cost being passed on to employees, disproportionately affecting low income workers • Increased parking pressure in non-controlled parking zones	• Strategy led at County Council (CC) and CA level. • **Direct delivery of measures by LAs and CC** • Residents and local businesses will be key to consultation to ensure their priorities are taken into account • Car club providers should be engaged to assess potential to move into the area	• Improved local air quality • Reduced local traffic where cars are removed • Improved local air quality where ICE cars are removed • Reduced congestion where commuting journeys are replaced by public transport	• Enabling policy to support delivery of: – Decreased private car use – Increased low emission vehicle uptake – Modal shift • Needs to link to LA planning policy around parking and meeting transport ambitions, see **T6**

[1] Region-wide refers to policy on West Yorkshire or York & North Yorkshire level (i.e. WY-wide and YNY-wide remit); CC = County Council

Transport policies (2/8)

Back to Transport summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
T3	**Regulation & Planning/Financial:** Develop and implement **region-wide cycling & walking strategy** that significantly expands active travel infrastructure provision. Accelerate/ encourage development and implementation of **LWCIPs,** including expanding reach beyond town and city centres **Plan development by 2022/23** **Full implementation 2024-2030**	~£50-100k to develop strategy, including commissioned study 1-2 FTEs to oversee delivery	• Resistance from road users • Risk that cycle route accessibility is not sufficient to encourage levels of uptake required and/or not matched by relevant neighbouring areas	• Led by CA/Council • **Direct delivery of infrastructure by LAs/CC** • Residents, commuters and local businesses should be consulted	• Safer routes for cycling & walking • Health benefits of increased active travel	• Enabling policy to support modal shift • Needs to link with other strategies (**C2** and **T6**) • Needs to be in place before incentives (**T18**)
T4	**Financial:** Expand **cycle parking** provision across the region, including hubs at major rail and bus stations and secure storage in residential areas, and catering for a range of bike types (including cargo bikes) **By 2025**	Costs in the region of £7-10m (WY) or £3-5m (YNY) for cycle hubs at key locations. Costs up to £10's millions for residential parking.	• Lack of space or loss of space providing other source of revenue (e.g. parking spaces) • Insufficient modal shift despite provision	• **Delivered by CA/County Council** working in partnership with LAs and transport providers	• Health benefits of more active travel	• Supports modal shift • Rollout needs to begin to maximise effectiveness of incentives (**T18**)
T5	**Regulation & planning:** Develop a regional **electric vehicle charging strategy** to increase the availability of public chargepoints throughout the region (for road vehicles),[2] and encourage local authorities to develop their own strategies to support this. This can include or be supported by **establishing an EV chargepoint procurement framework** to facilitate the procurement process for LAs. The strategy should consider and support the needs all key user groups (e.g. taxis, shared cars, van fleets, residents and visitors). This should also be supported by **funding to support EV chargepoint rollout** for LAs and community schemes, and to trial both innovative on-street solutions and demonstrator rapid charging hubs **By 2022/23**	~£50-100k for study <1 FTE to oversee commission and strategy development Funding level at the discretion of CA/LEP but could be in the region of £10s of millions	• Risk that power demand exceeds grid capacity in certain areas, needing costly upgrades • Barriers include finding space and conflicts over pavement space for on-street provision • Risk of locking in car use if supported ahead of behaviour change and/or not complemented by modal shift measures • Risk that investment does not deliver the required uptake of zero emission technology	• Strategy and framework led by CA/LEP in partnership with LAs. • **Delivery by LAs/private providers** • Will need to link with existing LA strategies/ambitions where relevant (e.g. Harrogate) • Residents, local businesses, charge point providers, and UKPN will be key for engagement	–	• Enabling policy for increasing zero emission vehicle uptake

1: Region-wide refers to policy on West Yorkshire or York & North Yorkshire level (i.e. WY-wide and YNY-wide remit); CC = County Council; 2. Already commissioned in West Yorkshire by Kirklees Council

Transport policies (3/8)

[Back to Transport summary table]

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
T6	**Regulation and planning:** Convene LAs to establish how to **use local planning policy** to incentivise delivery of measures. Likely levers include: • Requiring **minimum standards for new developments** on number of EV chargepoints and secure cycle parking • targeting **mixed use developments**, which enable sustainable travel through: high accessibility to services by public and active travel (e.g. **'15 minute neighbourhoods**'), incentives for residents to use public and shared transport, low access to private car parking • **Establishing a framework** that ensures that all strategic decisions, plans and policies consider transport emissions reduction ambitions **2020-2025**	Negligible – under the remit of strategic and planning policy teams <1 FTE to coordinate LAs	• Requires sustainable transport options to be in place • Relocating services away from existing city or town centres reduces potential benefits to those centres • Risks conflict with existing local plans	• Coordinated by CA/County Council, **delivered by Local Authorities** • Delivery will require engagement with developers	• Reduced congestion from new developments • Anchor demand for public services	• Enabling policy for delivering: – Decreased private car use – Modal shift – Demand reduction – Uptake of zero emission vehicles • Can empower LA planning officers to take decisions that support climate ambition, e.g. in road reallocation • Linked to wider strategy **C2**
T7	**Regulation & Planning:** Explore options to deliver expanded and improved bus services across the region, including **bus franchising** or **Enterprise Partnership**. Steps will include full design of optimum network and either tendering (franchising) or close working with bus operators to deliver the full network. The network must meet the needs of all user groups and be fully integrated into the future transport network to ensure optimum connectivity. Where mass transit and/or trams have been identified to have a significant role in delivering public transport, the optimum bus network must be complementary to this. **By 2025**	£10s-100s of millions depending on scale of bus depot purchase	• Long process to establish • Risk of financial loss due to revenue gap if patronage drops	• **Led and delivered by CA/CC,** with engagement with LAs to determine routes • Bus operators and any non-CA/Council-depot owners must be engaged	• Equity – reducing the cost of modal shift where ticket prices can be centrally decided; providing services to otherwise unprofitable areas	• Key supporting action for delivering modal shift • Can give greater powers over bus decarbonisation through tendering requirements

1: Region-wide refers to policy on West Yorkshire or York & North Yorkshire level (i.e. WY-wide and YNY-wide remit);

Transport policies (4/8)

[Back to Transport summary table]

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
T8	**Regulatory & Planning:** Implement **flexible and integrated ticketing** across services (e.g. standard ticketing across bus services, multi-modal platforms, rail services etc). Ensure alignment of timetables (where relevant) to increase efficiency of sustainable transport and work with providers to reduce fares to make the service competitive with private cars. **By 2023**	~£0.5-2m	• Risk of alienating users less comfortable with technology if smart ticketing is used • Risk around data protection if smart ticketing is used	• **Led by CA/County Council**, with buy-in from city councils • Will need to work with mobility and public transport providers	–	• Key supporting action for delivering modal shift – enables end-to-end public, active and shared transport journeys
T9	**RD&D:** Continue to support **trials of innovative services**, such as on-demand shared transport to support public transport provision, to integrate into wider strategy (*already being explored in both YNY and WY*) **By 2022/23**	Dependent on scheme, grants of up to £1.5m offered through rural mobility fund	• Risk of services being unviable in target areas	• **Led by CA/County Council** in partnership with LAs but with the aim of becoming commercial	• Equity – enabling access to public transport for all	• Supports modal shift, particularly in areas otherwise unviable • Supports **T7**
T10	**RD&D:** Assess feasibility and implement trials of **freight modal shift, consolidation and sustainable last mile delivery** (including cycle freight and electric road vehicles). Consolidation most applicable in existing areas of high delivery activity and within new developments. **Feasibility and trials by 2025** **Full implementation in feasible areas by 2030**	~£50-100k for feasibility study Costs dependent on form of trial but can range from cost of providing land, to £20-500k for funded support, or several £m if solely publicly run	• Loss of space that could generate alternative revenue • Insufficient uptake from businesses to sustain commercial operation • Insufficient scope for emissions impact through consolidation	• **Council/CA to lead delivery** through partnership/tender • Logistics companies and local businesses will need to be engaged – can be via Business Improvement Districts and/or LEPs	• Improved air quality in city centres • Reduced congestion	• Key supporting policy for decreased van and truck use
T11	**RD&D:** Update studies of **feasibility and demand for passenger and freight rail services** to determine scale of capacity upgrade needed and develop strategy, including reopening of lines, protecting sidings and investment in interchanges.[1] Needs to link with decarbonisation plans to incorporate benefits of electrification to capacity **By 2022/23**	~£50-100k if commissioning independent study FTE commitment dependent on the scale of strategy design and in-house development	• Risk that capacity cannot be met to align with climate ambitions	• **Led by CA/County Council** with engagement with rail operators, National Rail and TfN	–	• Enabling policy for setting targets for feasible levels of local modal shift and decreased HGV use through better data

---

[1] Already underway in WY through the Connectivity Plan and Rail Strategy

Transport policy (5/8)

Back to Transport summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
T12	**Influence and support:** Work with LAs to lead by example by developing and implementing roadmaps to **convert their own fleets to zero emission vehicles** and to address emissions from 'grey fleets' (e.g. travel policies to discourage car use, partnership with car clubs, purchasing low emission pool vehicles etc) **Plans by 2021/22**	<1 FTE to manage engagement	• Potential need to collect data to inform LA targets for grey fleets • Risk of inaction by LAs • High upfront costs of vehicles • Transition limited by suitability of current zero emission vehicles for some vehicle types	• CA/LEP main role in influencing**, delivery led by LAs** (North Yorkshire County Council to deliver plan for own fleet)	• Reduced cost – where total cost of ownership is lower for zero emissions options	• Direct delivery of zero emission vehicle uptake and modal shift (where shifting grey fleet)
T13	**Influence & support: Work with LAs and local employers** to assess staff travel needs and to implement sustainable policies including: flexible working, discouraging flying, offering cycle-to-work schemes etc **By 2022**	<1 FTE to manage engagement	• Resistance or lack of buy-in from local businesses with low modal shift as a result	• **Engagement led by CA/LEP** • Travel surveys and policy review could be led by businesses or outsourced to 3rd party	• Health benefits of more active travel • Equity where cost of shift is facilitated by incentive scheme	• Enabling policy to encourage modal shift and demand reduction
T14	**Financial:** Provide **telematics services** for local fleets and small businesses to help them identify suitable zero emission options **From 2022/23**	£2-30 per vehicle – upper limit of £200k-£3m (WY) or £100k-£1.6m (YNY) if all local vehicles used the service	• Limited funding • Risk of insufficient uptake despite offering service	• **Led by CA/LEP** in partnership with telematics providers (under tender)	• Improved air quality where fleets shift vehicles	• Enables zero emission vehicle uptake by addressing key data barrier for fleets
T15	**Financial/RD&D:** Explore opportunities for **Council/CA-supported shared mobility**, such as bike sharing and increasing the car club offering **By 2022/23**	~£50-100k for commissioned study	• Risk that mobility services are commercially unviable in target areas	• **Led by CA/County Council** in partnership with mobility providers (under tender or through joint funding)	• Improved air quality	• Direct delivery of services to enable modal shift
T16	**Financial:** Invest in **digital infrastructure** to enable working from home and transport technology rollout, and training to improve local digital skills **By 2022**	£10s of millions depending on scale of rollout – for example, Greater Manchester broadband programme £24m for 2,700km	• Risk that rural communities are left out unless deliberately targeted • Risk that provision is insufficient to meet needs	• **CA/LEP led,** through funding raised from Government (application or devolution) • Tender for delivery	• Equity and skills – improving access to online opportunities	• Direct delivery of demand reduction • Enabler of smart services such as EV charging payments
T17	**Skills & training:** Invest in **training to develop local skills** in zero emission road vehicle technology (installation, maintenance) and rail electrification **From 2022/23**	1 FTE to coordinate with local education and training providers	• Insufficient uptake of training to meet market need	• Led by CA/LEP and **delivered through training organisations and higher education providers**	• Local skills • Resilience of local workforce to net zero transition	• Enabler of zero emission vehicle uptake - develops supply chain

Transport policies (6/8)

Back to Transport summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
T18	**Financial:** Provide **financial incentives** for low emission technologies and to encourage behaviour change. This can take the form of: • **Purchase grants** for ebikes, cars and vans • **Low or no interest loans** for ebikes, cars and vans • **Mobility credit** for low income residents to use for public transport and shared transport options (such as car clubs, bike share and cargo bike hire schemes); can be linked to scrappage scheme • **Scrappage scheme** to incentivise modal shift or ULEV uptake **Decision on support level by 2025**[1]	Costs up to £1bn (WY) or £400mn (YNY) to match fund current National Government offer out to 2030 Costs up to £600mn (WY) or £200m (YNY) to provide a full no interest loan (cars only) Upper limit for mobility credit costs of up to £100m (WY) or £50m (YNY) depending on eligibility and if offered out to 2030 <1 FTE	• Limited funding to support scheme • Future public transport price rises either increase costs or limit benefit of scheme • Insufficient switch to active, public and shared transport or low emissions vehicles despite grants • Switch to low emissions vehicles may still be inaccessible to low income households despite grants	• **Delivered by CA/County Council** • Local bike shops and mobility providers will be key partners, depending on the chosen scheme(s) • Finance providers may be required to support/administer loans	• Equity – enables wider uptake of cycling (e.g. among older age groups) and mitigates income inequality of modal shift and technology change • Health benefits of increased active travel	• Supports delivery of: – Modal shift – Decreased car use – Zero emission vehicle uptake
T19	**Regulatory & Planning:** Implement traffic control measures such as: • **zero emissions zones (ZEZs)** in key city and town centres. • **traffic circulation plans** for key city centres to reduce through-traffic and confine traffic to defined routes e.g. through strategic road closures and/or limiting travel to within defined zones • **20mph limits** on all residential roads and appropriate major roads • Access charging (linked to ZEZs, circulation plans etc) and road user charging where appropriate **Feasibility by 2023** **Implementation 2025-2030**	**ZEZ:** £10s to-100s of millions per ZEZ, depending on size of zone and supporting measures for vehicles **Circulation plan:** Up to £5m per plan, expected to cover infrastructure, communication about the scheme and supporting services (e.g. new bus routes) 2-3 FTE per scheme	• Resistance from freight organisations, road users and local businesses • Disproportionate impact on vulnerable residents and SMEs • Risk of redirecting traffic to other roads • Risk of cutting off essential routes for residents unless sufficient alternatives are provided (e.g. regular bus services) • Risk of redirection of traffic to other routes	• **Delivered by LAs/County Council** with the CA and LEPs supporting funding applications and delivery where appropriate • Residents and local businesses will need to be consulted	• Safer streets for cycling & walking if traffic is reduced • Reduced traffic and congestion in town centres	• Uptake of zero emission vehicles (for ZEZs) • Decreased car use • Modal shift

---

1. Decision on level of support will be influenced by a number of factors including level of on-going national support, cost reductions in zero emission technology and target group for support (e.g. focus on low-income households etc)

Transport policy (7/8)

Back to Transport summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
T20	**Coordination, information, facilitation: Engage with local van and HGV fleets** to understand their plans and to ensure that refuelling infrastructure is in place to support them. Opportunities to support joint procurement to address vehicle supply chain can be explored. **Ongoing from 2020**	<1 FTE to manage engagement	• Vehicle and infrastructure supply and certainty currently limit uptake • Higher upfront vehicle costs for operators	• Engagement delivered by CA/LEP • **Switch to low emission vehicles delivered by local fleets**	–	• Enabling policy for encouraging zero emission vehicle uptake • Linked to LA heavy fleet decarbonisation where joint procurement is possible
T21	**RD&D:** Engage with Northern Gas Networks, HGV fleets, bioCNG refuelling station providers and AD plant developers **to understand their plans for gas in transport** in the region, and the potential role of the Council/CA in facilitating rollout (e.g. funding, providing land, partnership etc) and future-proofing for a potential transition from bioCNG to H_2 **2020-2022**	~£50k if commissioning a study <1 FTE to coordinate engagement	• Risk that pace of wider stakeholder plans does not meet local ambition	• Engagement led by CA/LEP • **Refuelling infrastructure delivered by gas networks and refuelling station developers**	–	• Interdependence with hydrogen generation (nationally and locally)
T22	**Regulatory & planning:** Work with bus operators to **decarbonise the bus fleet**, including engagement to raise awareness of zero emission options *(already complete for West Yorkshire)*[1] and strategic introduction of zero emission requirements in tendered services. Where mass transit is expected to play a role in delivering public transport, plans to decarbonise must be in place. **Engagement from 2020** **Tender requirements from 2025**	<1 FTE to coordinate engagement	• Risk of low uptake despite engagement • Higher upfront costs for operators	• Engagement led by CA/LEP • **Low emission vehicle switch delivered by bus operators**	• Improved air quality where zero emission buses are deployed	• Enabling policy for encouraging zero emission vehicle uptake • Focus of engagement/strategy dependent on choice of action in **T7**

AD = anaerobic digestion; bioCNG = compressed natural gas, derived from biomass sources (biomethane). 1: See WYCA Zero Emission Bus Roadmap for further details of actions to decarbonise buses

Transport policy (8/8)

Back to Transport summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
T23	**Influence and support:** Work with key stakeholders to **accelerate decarbonisation of transport** including: • **Halt or limit increases in highway capacity** primarily aimed at enhancing capacity for private cars, and redistribute funds to active and public transport (*with TfN and Highways England*) • **Accelerate decarbonisation of rail** in the region, including funding and implementing a rolling programme of electrification where feasible, exploring and/or trialling hydrogen trains, and opportunities for additional measures such as reopening lines, improving signalling, junction improvements etc (*with TfN, Network Rail and rail operators*) • Consider the future of aviation growth in the region **Ongoing from 2021/22**	<1 FTE to manage and coordinate all engagement Additional resources will be required where greater in-house control over highway and rail planning	• Risk that engagement does not deliver outcome desired or sufficient support to assist delivery • Risk that national and wider regional priorities differ from those at local level	• Engagement led by the CA/LEP, in partnership with other local and regional authorities • **Delivery will require responsible authorities (e.g. Network Rail, Highways England etc)**	–	• Enabling measure to ensure local priorities are shared and compatible within the local and national context • Outcomes will determine the level of supporting measures required in the long-term
T24	**Influence & support: Influence Government and relevant key stakeholders** to deliver policy and support that supports climate ambition, including: • **increased devolution powers** to give greater control over rail to the region • produce a **national decarbonisation strategy** for aviation • introduce a **frequent flyer levy** • Consider **expanding rail services** from the North to mainland Europe (e.g. sleeper services) to offer replacement to air travel **Ongoing from 2021/22**	Negligible 1 FTE to manage and coordinate all influencing asks	• Risk that influencing does not deliver outcome desired or sufficient support to assist delivery • Risk that national priorities differ from those at local level	• Led by the CA/LEP, in partnership with other local and regional authorities, LEPs and industry stakeholders where it strengthens the ask • **Delivery of key asks by Government and national bodies**	–	• Enabling measure to ensure policy certainty and to determine the level of support and investment that can be delivered through **T18**

Contents

Action plan – Buildings

2020 | **Priority Actions and Evidence** | **2025 at latest** | **Max implementation of policy** | **2030** | **Adjustment and enhancement** | **2038**

Priority Actions (common across pathways)

- Set up a 'One-stop shop' for energy efficiency and low carbon heating
- Develop a regional retrofit strategy for existing LA buildings and begin implementation
- Decide appropriate incentives and regulation to drive decarbonisation of private-rented and owner-occupied sectors
- Develop a regional district heat network strategy, including heat zoning policies
- Initiate new low carbon heat network schemes
- Develop a combined solar PV and battery storage offer
- Implement training programmes in energy efficiency retrofit and low carbon heating installation
- Influence Government to deliver policy and support that supports climate ambition

Evidence gathering (in parallel with priority actions)

- Identify skills shortages and gaps in the workforce
- Initiate exemplar and demonstrator projects for high energy efficiency buildings and low carbon heating technology to better understand viability in the local context
- Explore the most appropriate solutions for hard-to-decarbonise homes in the region
- Explore rooftop solar opportunity in the region
- Work with LAs to establish how best to use local planning policy to incentivise delivery of measures
- Engage with key stakeholders to stay informed of H_2 developments
- Assess National Government support, priorities, and regulation

Decision on pathway by latest 2025

Max ambition

- Strong local and regional policy support for energy efficiency, heat networks and electrification of heat
- Maximum retrofit of public sector buildings
- Strong financial incentives offered to facilitate maximum rate of energy efficiency retrofit and heat pump uptake in private sector[1]
- Rapid deployment of district heating networks, either CA/LEP led or in public-private partnership
- Engagement with NPg to ensure electricity grid capacity upgrades are delivered to support transition

High Hydrogen

- Strong local and regional policy support for hydrogen transition (H_2 boilers, hybrid heat pumps, heat pumps in off-gas properties)
- Maximum retrofit of public sector buildings
- Financial incentives in place to support early deployment of hy-ready boilers and hybrid heat pumps (on-gas), and heat pumps (off-gas) among homeowners, businesses and landlords
- Rapid deployment of district heat networks
- Lower and/or more targeted incentives for energy efficiency
- Engagement with NGN to ensure rapid H_2 rollout in region

Balanced

- Strong local and regional policy support for all appropriate measures
- Maximum retrofit of public sector buildings
- Financial incentives offered to support all types of heating as appropriate, and to drive high levels of energy efficiency retrofit by 2034
- Rapid deployment of district heat networks
- Engagement with NGN to align targeted H_2 rollout, and NPg to ensure targeted electricity upgrades

Evaluate progress and implement further measures where necessary, for example:

- Adjustment of strategies based on achieved level of deployment and changes in National Policy
- Stronger regulatory measures to encourage uptake, such as through local planning requirements (if possible)
- Stronger financial incentives for technology uptake (e.g. scrappage schemes) and energy efficiency
- Support for rollout of innovative technologies and techniques, such as battery-to-grid and smart systems
- Adjustment of training programmes to meet skills shortages
- Development of public-led business models for communal and district heating

---

1. Homeowners, private landlords and businesses

Buildings policy table (1/5)

Back to Buildings summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
B1	**Coordination, information, facilitation:** Set up a **'One-stop shop'** for energy efficiency and low carbon heating.[1] The service should act as a single point of contact for residents, private landlords and businesses and greatly simplify the process of installing these measure by offering: • tailored information and advice on appropriate measures, which could include funded on-site assessment • information on the available funding and support in the application process • a preferred list of trusted local suppliers to build consumer confidence, and help to ensure high quality installation **By 2021/22**	Estimated costs over 2020-2034:[2] West Yorkshire: £10-15m York & North Yorks = £4-6m The majority of the budget is likely to be staff costs (other costs are mainly information resources e.g. website, leaflets). Estimated staff requirements of 6-10 FTE (WY) or 3-8 FTE (YNY) over the course of the programme.	• Risk that engagement fails to meet high levels required. • Risk that an incomplete service rolled out as a 'one-stop shop' might alienate the most interested residents/businesses.	• **Delivered by the CA/LEP,** collaboration with neighbouring regions possible • Active collaboration with other providers of similar services will be necessary to prevent doubling up of effort and confusing customers	• Health – warmer homes, reduced mould and damp, and improved indoor air quality • Local jobs - possible benefits to local suppliers and installers • Reduced fuel bills	• Enabling policy for energy efficiency retrofit and low carbon technology rollout – raises awareness, empowers residents and businesses, and helps to build supply chain
B2	**RD&D:** Develop a **regional retrofit strategy for existing public sector buildings and social housing** and determine appropriate routes to drive change in private-rented and owner-occupied sectors. For public buildings, this should include assessment of: • Current energy efficiency of all buildings • What is needed to improve energy efficiency to EPC bands C, B and A and cost implications • Appropriate low carbon heating technology solutions and cost implications • Areas to target for early action e.g. fuel poor households, easy wins, phasing out of oil boilers This assessment should be used to set appropriate targets and inform delivery. **Strategy by 2021; Begin implementation latest 2023**	~50-100k for initial study, with up to 1 FTE overseeing strategy development Implementation cost will depend on targeted level of improvement; see **B11** for costs of demonstrator projects	• Risk of limited buy-in from LAs • Risk of supply chain limiting delivery – can be mitigated through local skills initiatives (see **B9**)	• Strategy led/overseen by the CA/LEP in partnership with LAs and housing associations • **Delivered by LAs and housing associations** • Social rented sector tenants will need to be consulted	• Local jobs – potential to build local skills and supply chain where local contractors are used	• Enabling policy for energy efficiency retrofit • Having a regional strategy allows for aggregated demand and better value for money • Links to **B11** where demonstrator projects are part of delivery • Strategy will need to feed into skills assessment in **B9**

1. Aligned to Scaling Up Better Homes Yorkshire recommendation of a Retrofit Hub; 2. All energy efficiency retrofit measures are assumed to be installed by 2034 and is therefore the latest date to require support;

Buildings policy table (2/5)

Back to Buildings summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
B3	**Regulatory & planning:** Develop a **district heat network strategy** for the region. This should build on/update existing studies where appropriate and include: • Mapping of heat demand to identify suitable areas to establish new networks and expand existing networks (e.g. Leeds PIPES, Northallerton) • Identification of public sector buildings that can act as anchor load • Assessment of opportunities to use heat at industrial sites, sewage works, canals, rivers etc • Identification of appropriate business models and ways to de-risk and commercialise schemes • Assessment of policy interventions to increase HNDU support and drive LA DH projects **By 2021/22**	~£50-100k for commissioned study Up to 1 FTE to oversee delivery of strategy	• Risk of natural monopolies forming in areas where heat networks are mandated	• Strategy led by CA/LEP, with partnership with Las • **LAs deliver by incorporating into local plans.** • Engagement with developers and existing networks will be required	–	• Enabler of **B4** • Needs to feed into **B2** where district heating is a cost-effective solution for public sector buildings and social housing • Will also feed into wider strategies **C2** and **C3**
B4	**Financial: Initiate new low carbon heat network schemes** in cost-effective and heat density-appropriate areas, either directly, through joint venture or through granting concessions to private sector schemes. **Project completion by mid-2020s**	Cost to CA/LEP of £5-40m per scheme, depending on scale of network and level of private investment.[1] Potential total costs of up to £1-4bn (WY) or £300mn-1bn (YNY)[2] 1-3 FTE per project to procure and manage contractors	• Long construction and payback timeframes • Heat networks powered by waste heat are relatively novel with limited UK precedent • Capital risk if scheme fails • Demand forecasting uncertain	• **Delivery and initial investment may be by CA/LEP or through public-private partnership.** Potential national support; contractors to run scheme and residents to be engage to build buy-in	• Reduced fuel costs, especially in off-gas properties • Improved air quality in homes (no CO risk)	• Direct delivery of heat networks • Policy (planning or otherwise) to encourage/mandate connection likely to be required – see **B8**
B5	**RD&D:** Explore the **most appropriate solutions for hard-to-decarbonise homes** in the region, including: • Back-to-back terraced homes • Very old (pre-1919) properties **By 2021/22**	~£50-100k for commissioned study Up to 1 FTE to oversee delivery of strategy	• Homogeneity in building stock may prevent generalised or clear strategy • Optimal solutions may be prohibitively high cost	• **Study led by CA/LEP** with input from LAs, and academic and industry experts	–	• Enabler of reaching full potential in the reaching – overcomes barrier of housing unique to the region

1. Based on ranges of costs of existing schemes, lower end represents schemes primarily covering expansion of networks with upper end indicative of large, new schemes (without external investment); 2. Assumes delivery of all district heating schemes under Max ambition scenario without private investment

Buildings policy table (3/5)

Back to Buildings summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
B6	**RD&D:** Explore **rooftop solar opportunity** in the region. This should quantify and map where greatest opportunity is to enable support and advice to be targeted. It could include development of an online resource (e.g. GLA's Solar Opportunity map). **By 2022/23**	~£50-100k for commissioned study and development of resource	• Risk of low uptake of solar in high opportunity areas	• **Study led by CA/LEP** in partnership with LAs • Engagement with building owners may be required to collect data	–	• Enables targeted delivery of incentives in **B10** if appropriate • Enables informed strategy development, e.g. **C3**
B7	**Financial:** Develop a **combined solar PV and battery storage offer** for residents and businesses, for example through aggregated demand services such as Solar Together[1] **By 2021/22**	Negligible/low cost to LAs or CA <1 FTE to oversee setting up scheme	• Risk of low uptake • Price reduction likely to be insufficient to enable uptake in low income households without additional grants	• Procurement/programme setup led by CA/LEP • **Delivery by third-party provider**	• Reduced upfront and fuel costs for participating households	• Enables delivery of rooftop solar rollout
B8	**Regulatory & planning:** Convene LAs to establish how to **use local planning policy** to incentivise delivery of measures. Likely levers include: • Adopting region-wide high energy efficiency standards and low carbon technology[2] requirements for new builds ahead of the Future Homes Standard • Allowing low carbon alternatives to be permitted development • Exploring relaxation of conservation area planning restrictions to enable older house retrofit • Working towards a region-wide heat network connection policy through 'heat zoning' • Transitioning from CHP to low carbon sources in heat networks **From 2021**	Negligible	• Increased obligations on developers might reduce the number of new build projects and raise prices • The scope of possible changes may be limited • Planning officers need support and resource to enforce their full powers • Risk that consensus not reached across region	• Coordination by CA/LEP with **direct delivery by LAs**	–	• Provides local regulatory support to deliver measures • Where measures make the transition easier for residents or businesses (e.g. relaxation of planning laws), this should be communicated through the publicity campaign (**C1**)

1. Aligned with recommendations of Scaling Up Better Homes Yorkshire; 2. Could consider requiring a share of new build public buildings and homes to be Passivhaus standard to build local evidence and skills

Buildings policy table (4/5)

Back to Buildings summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
B9	**Skills & training:** Identify skills shortages and gaps in the workforce (current and future), and **implement training programmes** to address these gaps and build the local skills base. Participation in training programmes can be linked to certification and requirement for being included in list of preferred suppliers (policy B1), to build quality assurance. **Study by 2021/22** **Implementation from 2023,** with ongoing review	~£50k for initial skills assessment 1 FTE to coordinate with local education and training providers	• Risk of insufficient uptake of programmes and/or programmes not resulting in increase in career choice in the sector	• Led by CA/LEP and **delivered through training organisations and higher education providers** • Engagement with industry and experts will inform skills assessment and ongoing review of targets	• Development of local skills chain • Potential resilience of local workforce to future decline in high carbon sectors by transition to low carbon sectors	• Builds local skills supply to support delivery of all measures • Supports delivery of local strategies **B2** and **B3**
B10	**Financial:** Provide **financial incentives** to support uptake of low carbon measures. These can include: • **Purchase grants or low interest loans** for technology or energy efficiency above those currently offered locally and nationally • **Scrappage schemes**, e.g. early focus on oil and biomass boilers, with later focus on gas boilers • **Top-up funding** to the Renewable Heat Incentive and any national successor scheme **Energy efficiency from 2021/22** **Technology grants from 2025-28**	Cumulative costs for supporting technology rolloout to 2030 in the region of:[1] WY: £400mn - £2bn YNY: £150-800mn Similar costs expected for energy efficiency 1-3 FTE to administer scheme(s)	• High administrative burden • Setting the price point of the subsidy too high risks unnecessary expenditure. • Setting the price point too low risks lack of uptake at the required scale. • Risk of insufficient uptake despite support	• **Delivered and run by regional authorities** with support from experts where needed • Collaboration and engagement with local businesses and residents	• Lowered upfront costs reduces financial barrier; targeting support at lower income households can improve equity of net zero transition	• Supports delivery of all measures
B11	**Financial:** Initiate **exemplar and demonstrator projects** of new build high energy efficiency standards, and whole house retrofits (energy efficiency and low carbon technology) in social housing, with the aim of assessing effectiveness and consumer acceptance of different measures in the local context.[2,3] **By 2025**	~£500,000-1 million investment for retrofits, with opportunity to recoup costs through energy service plans ~£15-50 million investment for new builds, depending on scale. 1-3 FTE depending on project	• Appropriate sites for new development must be found • Capital risk must be taken on, and cost may be higher without part financing by housing providers or grants • Risk of no further uptake beyond these projects	• **Funded/led by CA/LEP** in partnership with LAs, housing associations, developers etc	• Health benefits of improved energy efficiency for tenants • Allows for targeting towards fuel poor residents	• Direct delivery of energy efficiency and low carbon technology • Needs to link/follow from **B2** and **B3** as well as wider strategies

---

1. Lower value represents either a low interest loan or 10% grant, and the upper value represents match funding for the proposed Clean Heat Grant.2. Aligns with recommendations of Scaling Up Better Homes Yorkshire; 3. Could consider demonstrators of Passivhaus standard to build local evidence and skills (see also **B8**)

Buildings policy table (5/5)

Back to Buildings summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
B12	**Coordination, information, facilitation: Engage with key stakeholders** including NGN, H21 project and local industrial partners to stay informed of H_2 developments and plans. As plans progress, there will be a need to work in partnership to develop rollout strategy to homes where appropriate. *For York & North Yorks, this could include influencing for accelerated delivery to the region as the H_2 supply scales up beyond initial pilots/clusters*	Negligible <1 FTE to coordinate plans	• Risk that H_2 supply does not develop fast enough to enable choice of H_2 future to remain open for the region – may also result in mismatch between WY and YNY strategies • Final strategy dependent on national decisions and those of the key stakeholders	• Engagement led by the CA/LEP with cross-communication between the two regions recommended • **Delivery of network conversion by NGN, National Grid Gas and other industrial partners**	–	• Enabling policy for strategy decision-making
B13	**Influence & support: Influence Government** to deliver policy and support that supports climate ambition: • Clear policy direction on future of heat • Design a more ambitious successor to the RHI from 2022 (*note initial consultation ran in 2020)* • Revise Minimum Energy Efficiency Standards for private rented sector, **with immediate action** to respond to open consultation • Implement regulation of the district heat network industry (*note initial consultation ran in 2020*) • Either retain local control or set high national standards in National Planning Policy Framework Part L revision • Enable greater local influencing over the targeting of ECO funding • Provide long-term devolved funding for achieving net zero **From 2020**	Negligible 1 FTE to manage and coordinate all influencing asks	• Risk that influencing does not deliver outcome desired or sufficient support to assist delivery • Risk that national priorities differ from those at local level	• Led by the CA/LEP, in partnership with other local and regional authorities, LEPs and industry stakeholders where it strengthens the ask • **Delivery of key asks by Government and national bodies**	–	• Enabling measure to ensure policy certainty and to determine the level of support and investment that might be required in **B10** and **B11**

Contents

Action plan – Power

Key
Policy with higher significance for YNY

2020 | **Priority Actions and Evidence** | **2025 at latest** | **Max implementation of policy** | **2030** | **Adjustment and enhancement** | **2038**

Priority Actions (common across pathways)

- Complete regional spatial energy planning including determining favourable sites for generation (especially onshore wind), storage technologies and infrastructure development.
- Support infrastructure investments by efficiently granting planning permissions, aiding studies to identify regional requirements and gathering evidence for national funding applications.
- Develop and set up a finance scheme for supporting small to medium scale renewable generation and flexibility projects, encouraging joint installation of storage and generation.
- Setup a platform and grant scheme for community energy projects.
- Engage with EfW operators to develop decarbonisation strategies and ensure any new facilities will be CCUS ready.
- Run awareness campaigns to inform the public on potential benefits of CCUS, hydrogen, BECCS and onshore wind projects.
- Influence government for funding for infrastructure and CCUS projects, RD&D & facilitation of hydrogen generation, requiring CCUS readiness with EfW plants.

Evidence gathering (in parallel with priority actions)

- Identify current and future skills shortages and gaps in the workforce
- Support national RD&D funding applications, offer top-up financial support and coordinate national and regional stakeholders to provide evidence base for flexibility projects (storage/DSR), EfW CCS, hydrogen generation, CCS business models.
- Engage with LAs to establish how best to use local planning policy to incentivise delivery of measures
- Assess National Government changing support, priorities, and regulation

Decision on pathway by latest 2025

Max ambition

- Maximal level of support for community energy projects.
- Support RD&D for additional power flexibility evidence gathering and new technologies/schemes.
- Update local energy plans with additional areas and infrastructure dedicated for solar PV and onshore wind.
- Support local workforce training prioritizing solar and wind installers/maintainers and networks technicians.
- Support CCUS and CO_2 transport and storage planning as soon as possible and complete CCUS retrofits quickly.

High Hydrogen

- Medium level of support for community energy projects.
- Support RD&D for additional hydrogen power evidence gathering support feasibility studies in the region and Influence national government for investment in the region.
- Support local workforce training, focusing on H_2 related skills.
- Update local energy plans with additional areas and infrastructure dedicated for hydrogen power plants.
- Support CCUS and CO_2 transport and storage planning and achieve progress with CCUS retrofits.

Balanced

- High level of support for community energy projects.
- Support RD&D for additional flexibility evidence gathering.
- Update local energy plans with additional areas and infrastructure dedicated for solar PV and onshore wind.
- Support local workforce training with an emphasis on solar and wind installers/maintainers.
- Support CCUS and CO_2 transport and storage planning and implementation.

Evaluate progress and implement further measures where necessary, for example:

- Adjustment of strategies based on achieved level of deployment and changes in National Policy
- Stronger regulatory measures to encourage uptake, such as through local planning requirements (if possible)
- Stronger financial incentives for technology uptake (e.g. grants and direct investments).
- Support for rollout of innovative technologies and techniques, such as battery-to-grid and smart systems
- Adjustment of training programmes to meet skills shortages
- Acceleration of public-led business models for DSR, battery and renewables.

EfW: Energy from Waste; CCUS: Carbon Capture, Utilisation and Storage; BECCS: Bioenergy CCS; RD&D Research, development and demonstration; DSR: demand side response; CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership; WY: West Yorkshire; YNY York & North Yorkshire

Policy table – power (1/6)

Back to Power summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Key Impact & interdependence
P1	**Planning (strategic):** Building on existing local evidence base, complete a comprehensive **regional strategic spatial plan** which designates best areas to develop future power projects. Provide special emphasis on onshore wind by providing pre-designated areas ideal for project development both from a land availability and infrastructure/grid connection point of view. Initial work should focus on renewables and EfW with additional planning for infrastructure and flexibility technologies as more evidence is gathered. **2021-2027**	~1 FTE as part of the general planning team + outside consultancy support (~£50-100k) providing expertise. Planning for the power sector should be aligned with other sectors.	• Reaching consensus among multiple local authorities may be difficult. • Evidence gaps still exist and the exact decarbonisation routes unknown. • Planning covers many interrelated sectors. • Land in West Yorkshire is constrained.	**Planning is delivered by LA/CC** with strategic oversight from CA/LEP which provide coordination between different stakeholders. Collaborate with regional generators, project developers and NPg, as well as public.		• Delivery policy • Relates to many measures especially solar PV, wind, EfW and flexibility. • Has to link to other delivery/coordination policies, as well as cross-sectoral spatial planning.
P2	**Financial:** Launch a programme providing **low-interest loans** for small and medium scale low carbon power technologies including solar, wind, AD, energy from waste (landfill gas, cooking oil, sewage sludge digestion, etc.), leveraging combination with heat networks to improve efficiency. Include support for flexibility technologies (demand side response, storage) and encourage joint installation of generation and storage. **From 2023**	Consultancy and legal support to develop the scheme (~£50-100k), 2-3 FTE to run the scheme administratively and provide advice. Indicative cost: ~15% of total loans. [~£40-160 million by 2038 for the study region in max ambition scenario for covering 10%-40% of renewables deployed.]	• High administrative burden. • Loans may not be suitable for all technologies.	Programme run by CA/LEPs in collaboration with the LA/CC. **Physical delivery through technology suppliers.** Effective communication with project developers, DNOs, the public and other related organisations. Scheme may be complemented by national funding.	• Job creation • Increased competitiveness of local industry • Support for SME • Reduced fuel poverty • Increased access to new markets	• Delivery policy. • Relates to many generation and flexibility technologies. • Should be supported by information or coordination policies.
P3	**Infrastructure:** Support **development of new electricity infrastructure**, through coordinating necessary parties, ensuring planning permissions and land are granted/available, supporting funding applications to national government, etc. Support NPg to make a case to Ofgem for strategic infrastructure investments. **2022 onward**	1 FTE to coordinate all relevant offices and parties. Majority of the work to be delivered through existing capacity.	• Potential for infrastructure investment to be expensive • Cross-party risk if assets are not guaranteed to be utilised	Overseen by CA/LEPs with direct support from LA/CC. Communicate with NPg to optimise approach and planning. **Infrastructure will be delivered by NPg.**	• Job creation • Support for the local economy	• Delivery policy. • Enables power capacity expansion. • Linked to spatial planning (inc. of H_2 & CCS) and supported through influencing. Carry out in conjunction to broader C4 policy.

CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership

Policy table – power (2/6)

Back to Power summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Key Impact & interdependence
P4	**RD&D:** Facilitate urgently needed RD&D by forming partnerships and providing coordination between academics, higher education, private industry and other national RD&D programmes. Share results of regional RD&D activities with national stakeholders and vice versa. Feed results back into regional planning and action plan. Also supplement national funding by providing additional financial support in the form of **loans, grants or OPEX support for initial demonstration projects** in the region to prove innovative technologies, business models and gather evidence. Areas include: storage technologies (hydrogen, ammonia, compression, chemical flow), demand side response, hydrogen electricity generation, CO_2 capture, CO_2 utilization. **2021- early 2030s**	2-3 FTE for information sharing, stakeholder engagement, evaluation of projects and running the financial schemes. Costs highly dependant on project type and number. Project costs may be £100k to millions.	• Risks of duplication of other RD&D programmes in other areas of UK/abroad • Results may not be applicable to all sites • Potential cost overruns and possibility of failed demos • Lack of national funding may render demos financially unfeasible	**Projects delivered by academics, researchers or private companies.** CA/LEPs to provide funding and coordination between stakeholders, including LA/CC, national government, other RD&D programmes.	• Innovation and knowledge creation • Increased private RD&D spending • Knowledge transfer partnerships • Enable future jobs and skills export	• Enabling policy • Most relevant to storage, demand side response, BECCS, CCS and hydrogen techs. • RD&D is required to provide evidence to underpin most policies such as finalizing planning, proceeding with other financial schemes, influencing appropriate parties.
P5	**Information:** Awareness raising campaigns to increase public knowledge and acceptance around local power projects and strategy. Particular value can be added for onshore wind, CCUS, hydrogen and BECCS. Allow communities to input into large regional plans and facilitate communication between project developers and the public, which can reduce project costs by alleviating some of the burden on developers and accelerate deployment rates. **2021- 2030**	1-2 FTE for managing engagement activities and associated costs of information campaigns which may be contracted out to experts.	• Must have unbiased approach • Challenges around public interest, understanding and acceptance	**Delivered by CA/LEPs** with support/engagement from LAs/CC. Key partners include the public or community groups as well as project developers, DNOs, technical bodies.	• Inclusive growth • Further co-benefits from specific projects supported	• Enabling policy. • Most helpful for emerging technologies in RD&D stage. • Complements policies about attracting private investors and community outreach.
P6	**Procurement:** Installation of solar PV, battery storage, demand side response or other related small scale generation and flexibility technologies on council owned land & buildings, including affordable housing, offices and commercial space. Generation and flexibility should be considered together. Size and technology choice will depend on individual circumstances of each building/asset and engagement with local residents or stakeholders. This policy can be linked to other activities of the council such as pairing some new transport infrastructure with renewables + storage. **2021 onward**	2-3 FTE to manage and run the scheme. Indicative cost: ~£1.5 million per MW for rooftop solar and £500k-1 million per MWh for battery storage in 2020	• The scheme may introduce administrative and financial burden considering the number of stakeholders • Unique solution needed for each asset	Scheme to be delivered by all entities owning public buildings/assets. LA/CC to be the main drivers with CA/LEPs providing overview and coordination. **Physical delivery via technology suppliers.** Engagement with NPg, the public, suppliers and other public offices.	• Job creation • Cost reduction • Increased efficiency • Reduction of fuel poverty • Inclusive growth	• Delivery policy. • Mostly relates to rooftop solar PV and flexibility • Supported by planning and infrastructure. This policy may demonstrate novel community energy project models and provide opportunity for skills training

CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership

Policy table – power (3/6)

Back to Power summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Key Impact & interdependence
P7	**Finance, facilitation, attraction:** Combine and advertise **a package of policies/actions to attract larger-scale private investment** in low-carbon energy and flexibility technologies. Actions include supportive local planning policy, pre-designated areas for project development, support with grid connection and infrastructure through coordination with DNOs, enhanced public acceptance, providing land/estate owned by the local government or co-investment. Pension funds may also be used in directly investing to the region or by having bilateral investment agreements with partner councils. **2023 onward**	1 FTE to coordinate various support delivered under different policies by existing teams. Additional cost depends on land/estate available for support and choice of co-investment.	• Engagement with investors must be unbiased. • Using pension funds to invest in the region increases civil servants' exposure to risks involving the regional economy • Local resources (such as land) may be locked away in energy projects creating an opportunity cost.	The efforts are best led by the CA/LEPs with support from the LA/CC. Multiple teams and departments have to be engaged with including external stakeholders such as NPg as well as the public and private investors themselves. **Physical delivery will be led by technology developers and private investors.**	• Job creation • Investment in local businesses • Private investment in region over other competing regions • Enable other co-benefits to be delivered by the projects	• Delivery policy. • Most effective with renewables, also applies to larger CCS/hydrogen projects. • Combines policies such as planning, information campaigns and infrastructure with financial/land support.
P8	**Coordination, facilitation, finance:** Provide **guidance and support to community renewable projects**. Building on NPg's work on community energy projects, develop a common platform to provide guidance and share knowledge on resources and tools available for community project developers. Support applications for national and regional funds and maintain effective communication between communities and other stakeholders, such as DNOs and relevant public offices. Provide free expert consultation to developers directly or through partnerships. Set up a grant and loan scheme to finance feasibility studies and capital investments into community energy projects. Ensure projects are accessible and beneficial to combat fuel poverty. Operational financial incentives may be considered if uptake stays limited. **2021 onward**	1 FTE to maintain the platform and partnerships + 1-2 FTE directly or contracted for providing expertise + 1-2 FTE to run the financial support programme. Grants of up to £40,000 per project.	• The small scale of the projects may introduce inefficiencies in terms of people who need to be engaged and higher administrative burden • Setting the level of financial support and the grant/loan distribution may be difficult to ensure it is attractive but does not overcompensate – needs re-evaluation and adjustment	The coordination role is led by CA/LEPs in partnership with NPg, which already has tools and good understanding of local community projects. LAs/CA provide support. **Physical delivery of the technologies through specific communities and suppliers.**	• Job creation • Inclusive growth • Sustainability awareness • Fuel cost and fuel poverty reduction • Better access to low-carbon technologies	• Delivery policy. • Mostly accelerates roll-out of rooftop solar PV, battery storage and aggregated demand side response. • Execution of this policy should be coordinated with planning teams and infrastructure policies.

CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership

Policy table – power (4/6)

Back to Power summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Key Impact & interdependence
P9	**Planning & Regulatory:** Require all large new EfW facilities to be ready for future CCUS retrofits or alternative deep decarbonisation plans. Future contract renewals should also require development of decarbonisation strategies, including robust business plans relating to future reduced availability of waste, and actively working with the LAs to achieve such goals. Start communications quickly as facilities tend to be bound by long term contracts. **Start immediately**	< 1 FTE as this engagement and contracting can happen mostly within existing teams.	• EfW facilities have long contracts so may be difficult to require them to change operations • CCUS integration may be too costly for some facilities • If national regulations or financial support is not available, facilities would be at a significant competitive disadvantage with CCUS	**Delivered by LA/CC** as they are directly in charge of waste disposal. CA/LEPs to provide guidance and coordination. Strong communication with EfW contractors and CCUS developers in the region as well as the national government.	• Future proofing local businesses • Increased jobs • Potential to save more CO_2 by attracting additional waste from other regions • Contributing to local CCUS cluster	• Enabling policy • Impacts large EfW facilities • Depend on CCUS availability in the region and wider national support programmes. Influencing is likely to be needed
P10	**Feasibility:** Work with existing EfW facilities in developing decarbonisation strategies and future CCUS retrofit plans. This may include grants for having feasibility assessments of decarbonisation strategies. Facilitate communication between the facilities and future CO_2 infrastructure developers or other large customers in the region. **2023-2030**	Can be delivered by existing capabilities since the number of facilities are low. Grants can be determined case-by-case, if needed at all. Indicative cost: ~£50-£100k per facility.	• Risk of being a high financial burden • Studies are not guaranteed to be successful • Should be handled on a case-by-case basis and requires cooperation from the other side • Requires additional evidence gathering	Lead by LA/CC as they are directly in charge of waste disposal. CA/LEPs to provide guidance and coordination. Close collaboration with EfW companies. **Studies are delivered by EfW companies & consultancies.**	• Future proofing local businesses • Increased jobs • Potential to save more CO_2 by attracting additional waste from other regions • Contributing to local CCUS cluster	• Delivering policy. • Impacts large EfW facilities. • Success requires additional evidence gathering and depends on regional CCUS availability.
P11	**Information:** Awareness raising around waste reduction, recycling and increased waste separation, including separate food waste collection. Communication around local waste strategies and current/future waste disposal plans. These actions would ensure that EfW and AD EfW operate as the last option. Complement this policy by waste audits the determine the likely changes in waste steam availabilities. **From 2021**	1 FTE for coordination and running engagement campaigns together with existing capacity. Additional marketing costs may be incurred.	• Perceived dilemma between waste reduction and EfW facilities must be addressed • Multiple different targets and procedures in each LA may introduce challenges	**Lead by CA/LEPs as a wider regional strategy** with significant help from LAs/CC and EfW companies. Effective engagement with the community and various public groups.	• Increased inclusiveness and transparency • Reduced costs • Increased resource efficiency • Reduced landfill use • Enhanced circular economy and reduced use of resources	• Enabling policy. • Maintains social licence of EfW • This policy must be linked to the wider waste, recycling and circular economy strategies of the region

CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership

Link to contents

Policy table – power (5/6)

Back to Power summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Key Impact & interdependence
P12	**Influencing:** Engage with the central government to inform and direct national policies on certain issues: • Decouple generation and storage components when dealing with Nationally Significant Infrastructure Projects[1] so local planning has larger influence over medium size projects. • Support early deployment of CCUS infrastructure in Yorkshire & Humber as attractive location and critical for UK decarbonisation • Develop business models for supporting CCUS and hydrogen power generation. • Large-scale research on hydrogen for power and storage. • Receive additional investment from Ofgem for infrastructure upgrades in the region. • Push for future EfW facilities to be required to be CCS ready or have tangible plans to fully decarbonise. **Start immediately**	~1 FTE + associated expenses is likely required for power sector influencing which may be provided by a larger influencing team in charge of all climate and sustainability related issues.	• Dependence on a third party • Potential concessions to secure future support	Best if managed centrally by CA/LEPs in collaboration with the LAs/CC and regional or national energy companies, unions, bodies. Support NPg and NGN in making the case for additional infrastructure investments to Ofgem. **Policies delivered by the national government.**	• Actions of the central government would have additional impact across the UK.	• Enabling policy • Related to most measures, especially hydrogen, CCS CCGTs, BECCS, EfW CCS, storage technologies • Enables other policies such as infrastructure support, planning and RD&D. Must be carried in coordination with other influencing efforts
P13	**Skills & Training:** Research to understand the future skills and capacity needs for emerging industries and identify pathways to develop this skills base locally. Develop a strategy to build local skills for power infrastructure (including plan for legacy skills). Examples: solar installers, wind turbine repairers, DSR or battery installers, community energy project developers. **2021 and updated regularly (5 years)**	<1 FTE to manage engagement. Periodic updates likely to be provided by studies performed by outside contractors (each £50k-£100k)	• Required skills may change as national policy is implemented and decisions are taken (pre-empting national decisions risks stranded skill capacity).	**Delivered by CA/LEPs with studies carried out by contractors.** Engage with local schools and training organisations.	• New jobs in priority areas • Increased workforce resilience • Improving equity	• Enabling policy • Enables fast and cost effective delivery of many technologies and policies • This will inform direct skills & training support
P14	**Skills & Training:** Collaborate with local training organisations, colleges, companies, etc. to improve and expand their programmes. Disseminate evidence gathered on future skills requirements and influence design of new courses/trainings. Provide financial support for increasing capacity. Establish an internship programme – connecting skilled interns/students with organisations developing low-carbon technologies. Supplement the programme via grants or compensating part of the interns costs, which will be in addition to any national incentives. **2021 onwards**	Up to 1 FTE to coordinate and facilitate programme development. Financial support in addition to national incentives.	• Timing and types of training should be determined carefully • Uncertainty around the choice of future technologies • Requires public's active participation and interest	CA/LEPs to coordinate the strategy. **Local schools and training organisations deliver.** LAs/CC engage the public and provide financial support.	• New jobs in priority areas • Increased workforce resilience • Improving equity	• Enabling policy • Enables fast and cost effective delivery of many technologies and policies • This policy should be informed by skills gap analysis

CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership

[1] Currently projects >50 MW must get planning approval from a national body, even if composed of separate generation and storage components <50 MW totalling to >50 MW.

Policy table – power (6/6)

Back to Power summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Key Impact & interdependence
P15	**RD&D**: Carry out a study to gather more evidence on how much flexibility (demand side response and various storage technologies) is needed in different regions. Engage with NPg to help signpost which parts of the system would benefit from more flexibility, and help publicise/raise awareness of this. Expand the study to understand who can provide flexibility through which means (local businesses or residents through DSR or dedicated storage). Link results with local energy planning. Integrate results with NPg's online mapping tools, or develop such tools through CA/LEP, to extend reach to potential providers. **2021-2023, may be updated around 2030**	<1 FTE to manage engagement with NPg and local stakeholders + contracting fees for the study.	• The study must be technology neutral, especially NPg can't be prescriptive • Further evidence may be needed to finalise the study • Results may be outdated depending on more evidence or final decarbonisation pathway chosen	**CA/LEP to lead the study with significant input from NPg.** Need to engage with the communities and local businesses to understand opportunities. Outcomes communicated to different teams running related policies.	• Co-benefits through projects supported by this evidence.	• Enabling policy • Relates directly to storage and DSR • Feeds into energy planning, additional finance and community energy project support policies. Facilitates deployment of EV's, heat pumps etc

Contents

Action plan – Industry

Key
Policy with higher significance for YNY

2020 | Priority Actions & Evidence | 2025 at latest | Max implementation of policy | 2030 | Adjustment and enhancement | 2038

Priority Actions (common across pathways)

- Support infrastructure investments through spatial planning, efficiently granting planning permissions, aiding studies to identify regional requirements and gathering evidence for national funding applications.
- Support/facilitate RD&D on industrial equipment & other measures (see below).
- Support decarbonisation feasibility studies of large industrial sites.
- Establish a financial support programme for deploying energy and resource efficiency measures (or extension of REF).
- Setup a green public procurement programme.
- Run awareness raising campaigns on circular economy and CCS/H_2.
- Influence government for funding for infrastructure and CCUS projects, RD&D & facilitation of hydrogen/electrification fuel switching, developing green procurement guides and stricter industrial emissions limits/trajectories

Evidence gathering (in parallel with priority actions)

- Identify skills shortages and gaps in the workforce by studying key low-carbon technology supply chains.
- Work with LAs to establish how best to use local planning policy to incentivize delivery of measures.
- Support national RD&D funding applications, offer top-up financial support and coordinate national and regional stakeholders to gain further evidence on: industrial fuel switching; resource efficiency and development of circular economy practices; HSE and regulatory practices around hydrogen; CO_2 utilization options.
- Fully map existing technologies, sites and processes in the region.
- Assess National Government support, priorities, and regulation

Decision on pathway by latest 2025

Max ambition

- Implement a small industry/SME financial support scheme focusing on early electrification.
- Support large industry fuel switching/CCS via applications for national funds and supplementary financial incentives.
- Support local workforce training, focusing on electrification related jobs such as heat pump installers.
- Update regional planning regarding CCS in accordance with new evidence and regional developments.

High Hydrogen

- Implement a small industry/SME financial support scheme focusing on hydrogen fuel switching.
- Swift completion of H_2 zoning and enforcement of H_2 readiness requirements of equipment.
- Support large industry fuel switching/CCS via applications for national funds and supplementary financial incentives.
- Support local workforce training, focusing on H_2 related jobs.
- Update regional planning regarding hydrogen infrastructure in accordance with new evidence and regional developments.

Balanced

- Implement a small industry/SME financial support scheme focusing on all technologies.
- Support large industry fuel switching/CCS via applications for national funds and supplementary financial incentives.
- Support local workforce training, focusing on electrification hydrogen and circular economy related jobs.
- Update regional planning regarding CCS and H_2 infrastructure in accordance with new evidence and regional developments.

Evaluate progress and implement further measures where necessary, for example:

- Adjustment of strategies based on achieved level of deployment and changes in National Policy
- Stronger regulatory measures to encourage uptake, such as through local planning requirements (if possible)
- Stronger financial incentives for technology uptake (e.g. scrappage schemes, direct investments, etc.) and energy efficiency
- Support for rollout of innovative technologies and techniques, such as demand side response, CO_2 utilisation, Direct Air Capture
- Adjustment of training programmes to meet skills shortages

REF: Resource Efficiency Fund; CCUS Carbon Capture Utilisation and Storage; RD&D Research, Development and Demonstration

Policy table – industry (1/5)

Back to Industry summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Key Impact & interdependence
I1	**Planning: Strategic spatial planning** establishing best locations for future industrial sites and infrastructure development considering clustering. New permits should be contingent upon facilities to have a decarbonisation plan and the space & technology to implement this e.g. CCS ready sites and Hydrogen-ready equipment. **2021-2027**	~1 FTE as part of the general planning team. Planning for the industry sector should be done in sync with other sectors.	• Reaching consensus among multiple local authorities across multiple sectors priorities may be difficult. • Evidence gaps still exist and the exact decarbonisation routes unknown.	**Planning is delivered by LA/CC** with overview from CA/LEP which provide coordination between different stakeholders. Collaborate with regional industries, NPg and NGN. Effective communication with the public and tech developers.		• Delivery policy • Relates to most measures, especially fuel switching and infrastructure • Planning should be updated with future evidence base and inform infrastructure policies
I2	**RD&D:** Facilitate urgently needed RD&D by forming partnerships and providing coordination between academics, higher education, private industry and other national RD&D programmes. Share results of regional RD&D activities with national stakeholders and vice versa. Feed results back into regional planning and action plan. Supplement national funding where needed by providing additional financial support in the form of **loans, grants or OPEX support for initial demonstration projects.** Priority should be given to technologies with potential for large emissions reductions in the region (e.g. alternatively fuelled glass furnaces, food and drink heating equipment, hydrogen appliances including hydrogen safety). **2021- early 2030s**	2-3 FTE for information sharing, stakeholder engagement, evaluation of projects and running the financial schemes. £0.2-2 million per project in conjunction with national support.	• Risks of duplication of other RD&D programmes in other areas of UK/abroad. • Results may not be applicable to all sites. • Potential cost overruns. • Possibility of failed demos and equipment may not be available in time. • Lack of national funding may render demos financially unfeasible.	**Projects delivered by academics, researchers or private companies.** CA/LEPs to provide funding and coordination between stakeholders, including LA/CC, national government, other RD&D programmes.	• Innovation and knowledge creation & sharing • Increased private RD&D spending • Enable future jobs and skills export	• Enabling policy • Most relevant to CCUS, hydrogen and electrification measures • RD&D is required to provide evidence to underpin most policies such as finalizing planning, proceeding with other financial schemes, influencing appropriate parties
I3	**Feasibility (large sites):** Support (including financial) for large industrial sites to carry **audits and feasibility studies** for developing complete decarbonisation roadmaps depending on their specific circumstances. Exact strategy may be finalised after more evidence is gathered. Feeds back into regional strategies. Consider clustering opportunities, such as around Humber, Drax or sub-regional industrial clusters. **2021-2027**	1 FTE to run the programme and manage collaboration. Grants in the range of 20%-50% cost (~£10k-50k per site).	• Uncertainty in early studies around future infrastructure and technology availability. • Each site has unique circumstances and the actions of one site may inform the actions of others, so plans must be co-developed.	**Feasibility studies to be delivered by consultants hired by industry.** CA/LEP provide grants, support and coordination.	• Inclusive growth • Unlock further private RD&D • Assistance for local industry competitiveness	• Delivery policy • Related to all measures. • Ensures progress in each site and enables the other financial policies directly supporting deployment

CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership

Policy table – industry (2/5)

Back to Industry summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Key Impact & interdependence
I4	**RD&D, strategy:** Survey the small industry sites to understand the current technologies on all sites and applicability of low carbon options. Feed these results into future planning and infrastructure policies, especially for hydrogen network development in late 2020s. **2021-2025**	1 FTE to manage the project and cost of consultancy work to complete data gathering and analysis: ~£100-£400k, depending on level of detail.	• Difficulty of reaching out to individual industrial sites • Confidentiality of data • Uncertainty on technologies which will be available in the future and their cost/performance	**Delivered by CA/LEP** with support from LA/CC for engaging with local businesses. Collaboration with national studies.	• Inclusive growth • Providing data for wider national studies	• Enabling policy • Relates to all measures • Informs small industry financial support, planning and infrastructure. Links to national strategies.
I5	**Feasibility (small sites):** Further evidence gathering and develop archetypal decarbonisation routes for small industries (including on-site green power or fuel production) using the survey results and national evidence. Provide practical advice services for SMEs, linked to the Resource Efficiency Fund & I7. Provide partial grants where audits/feasibility studies are needed. Ensure that these services are consistent with the actions of the heavy industry and regional strategies. **2023-2027**	~2-3 FTE to run the programme, manage collaborations and provide advice. Consultancy work for developing archetypal actions. Grants in the range of 20%-50% costing (~£5-25k / site).	• Uncertainty in early studies around future infrastructure and technology availability. • Best decarbonisation actions may depend on strategies of larger nearby facilities. • Grant level balance between minimising cost and sufficient incentive.	Led by CA/LEP in partnership with auditing, consulting or engineering firms. LAs help with local engagement. **Feasibility studies delivered by contractors/auditors.**	• Inclusive growth • Increased competitiveness of local small industry and SMEs	• Enabling policy • Related to measures applicable for small industry: electrification, hydrogen, energy and material efficiency • Needs to be informed by larger regional plans
I6	**Infrastructure:** Support development of CCS, hydrogen and electricity infrastructure, through coordinating necessary parties, ensuring planning permission and land are granted/available, supporting funding applications to national government, etc. Support NPg and NGN make a case to Ofgem for strategic infrastructure investments. **2023 onward**	1 FTE to coordinate all relevant offices and parties. Majority of the work to be delivered through existing capacity.	• Potential for infrastructure investment cost or time overruns • Cross-party risk if assets are not guaranteed to be utilised (stranded assets) • Relies on national suport	Overseen by CA/LEPs with direct support from LA/CC. Communicate with NPg and NGN to optimise approach and planning. **Physical delivery by NPg, NGN.**	• Job creation (e.g. engineering / construction) • Support for the local economy.	• Delivery policy • Enables CCS, hydrogen and electricity fuel switching. • Policy works closely with strategic planning. Should be supported with planning • Link to the broader C4 policy
I7	**Financial:** Provide **funding and access to finance for energy and material efficiency improvement projects** in all industry. For the SMEs this can build on the existing Resource Efficiency Fund and focus on circular economy models. For larger industry it may be in the form of zero interest loans for projects which pay back through reduced energy costs or are also nationally supported (e.g. IETF). **From 2021**	Consultancy to develop the scheme, 2-4 FTE to run the scheme administratively and in advice. SME grants of up to £10k per site. Additional loans for small and large industry.	• High administrative burden • Risk of setting the support levels too high or low • A level of dependence on continued national support	CA/LEPs to provide funding and run the scheme. LA/CC help with outreach and communications. Engagement with local businesses and industrial organisations. **Physical delivery via suppliers.**	• Increased circular economy • Increased business competitiveness • Lower costs • New jobs • SME support	• Delivery policy • Relates to energy and material efficiency measures.

CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership; REF Resource Efficiency Fund; IETF: Industrial Energy Transformation Fund

Policy table – industry (3/5)

Back to Industry summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Impact & interdependence
I8	**Financial, collaboration:** Support large-scale fuel switching and CCS projects by aiding their application for national funds, speeding up permitting applications and providing support for infrastructure upgrades. Funding likely to be industry/nationally led but financing support (e.g. loan guarantees) may be used to partially support projects on a case by case basis. **From 2025**	1-2 FTE to coordinate different parties and maintain engagement.	• Strong dependence on national support • Needs a case-by-case approach rather than a one size fits all approach.	Overall nationally led. CA/LEP led for site / regionally coordination and link to National Government. **Physical delivery of projects through the technology developers.**	• Increased competitiveness of local industry • Maintaining industrial jobs	• Delivery policy • Relates to fuel switching and CCS measures. • Should be supported by influencing for national funding. Further evidence gathering needed before launching the programme
I9	**Financial:** Establish a **small industry and SME decarbonisation support programme** providing top-up grants and favourable loans (could be extension of REF, see I7). Mainly covers fuel switching to electricity, hydrogen and bioenergy. Introduce a scrappage scheme from 2030 giving grants for early equipment switching, initially focusing on oil boilers to industrial heat pumps. **From 2023 onward**	Consultancy to develop the scheme, 2-3 FTE to run the scheme administratively and in advice. Grant 20-50%. Scrappage scheme ~50% remaining value.	• High administrative burden • Risk around setting support levels too high or low • A level of dependence on continued national support.	CA/LEPs to provide funding and run the scheme. LA/CC help with outreach and communications. Engagement with local businesses and industrial organisations. **Physical delivery through suppliers.**	• Job creation • Increased competitiveness of local industry • Support for SMEs	• Delivery policy. • Relates to all measures appropriate for small industries. • Requires further evidence gathering
I10	**Procurement:** Adopt a green public procurement scheme relating to industrial products such as glass, chemicals, food and drinks, cement, asphalt, ceramics, lime, etc. Construction materials for council owned buildings can also be added. Ideally benchmark carbon intensities and framework nationally led and regionally implemented, but regional leadership may accelerate if needed. **From 2023 onward**	1-2 FTE to run the programme and train staff on new processes. Consultancy work to develop the scheme from scratch; adopt an existing scheme if nationally developed.	• Likely to introduce significant administrative burden requiring regularly updating practices • High costs if no national scheme is developed • Risk of setting benchmarks too high or low.	Scheme to be developed by CA/LEP potentially in collaboration with national authorities. New procedures would be run by all public organisations with purchasing power. **Products or services physically delivered by suppliers.**	• Leveraging local procurement • Additional criteria such as minimum recycled content may be included • Influence other regions	• Enabling policy. • Relates to all measures for a given industry. • Likely to be part of a greater green procurement scheme covering all sectors.
I11	**Information:** Building on the Clean Growth Audit, collect environmental data through audits and working with sites and industry associations (e.g. Food and Drink Federation) to create a comprehensive view of regional energy use, emissions, technologies/ processes and applicability of future low carbon options. **From 2022**	<= 1 FTE to collate data and present in a comparable format. Teams/contractors delivering policy I4 may help with initial information gathering for this action.	• Lack of measured data by small industry • Some businesses may hesitate to get compared to others • Data may not be available in an easily comparable format	**CA/LEP to deliver** and reach out to large industrial sites. SMEs may be involved voluntarily and LA/CC may help reaching out to SMEs.	• Increased transparency • Better community involvement • Additional ESG related data may be published alongside	• Enabling policy. • Related to all measures. • Can be integrated with green procurement database and compliment behaviour change campaigns.

CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership

Policy table – industry (4/5)

Back to Industry summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Key Impact & interdependence
I12	**Influencing:** Engage with the central government to inform and direct national policies on certain issues: • Support early deployment of CCUS infrastructure in Yorkshire & Humber as attractive location and critical for UK decarbonisation • Develop business models and financial incentives for industrial fuel switching • Research/evidence gathering on H_2 and electrification technologies for industry. • Receive additional investment from Ofgem for infrastructure upgrades in the region. • Development of national green procurement guidelines • Stricter industrial emissions regulations and carbon intensity targets/trajectories **Start immediately**	~1 FTE + associated expenses is likely required for industry sector influencing which may be provided by a larger influencing team in charge of all climate and sustainability related issues.	• Dependence on a third party • Potential concessions to secure future support	Best if managed centrally by CA/LEPs in collaboration with the LAs/CC and regional or national energy companies, unions, bodies. Support NPg and NGN in making the case for additional infrastructure investments to Ofgem. **Policies delivered by the national government.**	• Actions of the central government would have additional impact across the UK.	• Enabling policy. • Related to all measures. • Interdependence to most policies, especially: CCS & H_2 infrastructure, grid decarbonisation. Enables many other policies
I13	**Behaviour change, awareness:** Information and social campaigns to reduce waste, increase recycling rates and incentivise circular industrial products including food and drinks. Promote SMEs using circular economy principles. Adapt the programme as new circular products become available or new labelling schemes emerge. Also raise awareness about less known technologies such as CCS, BECCS and hydrogen. Try to increase public acceptance of such technologies and help project developers with their public outreach and consultation programmes. This will ultimately be part of C1 programme. **2020-2030**	2 FTEs to oversee the programmes or more if combined with campaigns for different sectors. Marketing and engagement costs	• Require unbiased approach • Challenges around public interest, understanding and acceptance • Difficult to directly measure policy success	**Delivered by CA/LEP** with support from LA/CC to reach more communities. Direct collaboration with project developers and waste related stakeholders.	• Promotion of circularity, waste reduction • Reduced costs • Likely to help reduce non regional emissions as well	• Enabling policy • Directly support energy and material efficiency • Demand creation for green products and enable proceeding with new technologies
I14	**Skills & training:** Collaborate with local training organisations, colleges, companies, etc. to improve and expand their programmes. Disseminate evidence gathered on future skills requirements and influence design of new courses/trainings. Provide financial support for increasing capacity. Establish an internship programme – connecting skilled interns/students with organisations developing low-carbon technologies. Supplement the programme via grants or compensating part of the interns costs, which will be in addition to any national incentives. Example skills: industrial equipment installers, retrofit experts, new operation and health and safety training for hydrogen technologies, etc. **From 2021, accelerating in 2025-30**	Up to 1 FTE to coordinate and facilitate programme development. Financial support per worker may be provided in addition to national incentives.	• Timing and types of training should be determined carefully • Uncertainty around future technologies -> stranded skills • Requires public's active participation and interest	CA/LEPs to coordinate the strategy. **Local schools and training organisations deliver.** LAs/CC engage the public and provide financial support.	• Skilled workforce & new jobs in priority areas • Increased workforce resilience • Improving equity	• Enabling policy. • Policy especially relates to reducing small industry emissions and roll-out of high efficiency and fuel switching equipment

CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership

Policy table – industry (5/5)

Back to Industry summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits	Key Impact & interdependence
I15	**RD&D/strategy:** Research and coordinate schemes to increase circular economy through industrial recycling, especially close loop recycling for glass, plastics, aggregates, etc. Develop additional capacity in waste services and work in partnership with businesses to link those who have the waste with those who can use them. Investigate integration of circular economy models that provide business opportunities for small independent businesses and entrepreneurs. **From 2022**	<=1 FTE as the scheme can be run with existing personnel + cost of new recycling, collection capacity	• Needs a degree of behaviour change of both the public and other businesses	**Delivered by LA/CC waste collection services** with coordination of the CA/LEP. Engagement with waste disposal services, and businesses	• Increased circularity • Competitiveness of local businesses • Cost reduction	• Delivery policy • Relates to material efficiency measures. • Should be paired with financial incentives, planning and procurement
I16	**RD&D:** Procure a study investigating current CO_2 sources and sinks in the region. Facilitate their early coordination and investigate the potential of the region to expand its CCU opportunities (e.g. synthetic fuels, aggregates, etc.). Support early RD&D for new CCU routes in the region and learn from national RD&D programmes. **2021-2027 with specific support afterwards**	<1 FTE to oversee studies which are contracted to consultants. ~2 studies needed costing ~£30-80k each.	• CCU may not end up being favourable in the region • Sites may be locked in long-term for CO_2 storage • Constantly evolving science base may quickly make results outdated	CA/LEP to fund and manage the projects. Engagement with local businesses using or producing CO_2. **Studies delivered by consultancies.**	• Knowledge creation • Incentivise private sector RD&D • Help reduce CO_2 exports • Improve circularity	• Supportive policy • Relates to CCS, BECCS • Can inform planning and infrastructure policies.

CC: County Council; CA: Combined Authority; LA: Local Authority; LEP: Local Enterprise Partnership

Contents

Action plan – LULUCF and agriculture

Key

Policy with higher significance for YNY

2020 | Priority Actions and Evidence | 2024 at latest | Max implementation of policy | 2030 | Adjustment and enhancement | 2038

Priority Actions (common across pathways)

- Develop spatial land use strategy for the region that incorporates local expertise and evidence, and optimizes potential for both climate mitigation and Nature Recovery Network requirements
- Develop region-wide food waste strategy
- Implement public procurement policies to reduce food waste and to reduce red meat and dairy in public sector catering
- Establish a package of support measures to help farmers and landowners choose appropriate interventions
- Run a major publicity campaign to encourage behaviour change
- Influence Government for funding to support climate mitigation measures, development of ELMs to ensure it supports locally-relevant measures, and efficient processes for accessing funding

Evidence gathering (in parallel with priority actions)

- Data collection on:
    - peatland restoration potential
    - carbon intensity of local farming
    - optimal livestock stocking densities
    - extent of food waste along local supply chains
    - carbon sequestration measurement and monitoring techniques
- Stakeholder feedback on proposed implementation measures, perceived barriers and required financial support
- Encourage local farmers to participate in Defra ELM Pilots
- Explore and trial private investment models
- Explore potential markets for end-products of land management practices
- Assess National Government support, priorities, regulation and details of ELMs

Decision on pathway by latest 2024[1]

Max ambition

- Strong local and regional policy support for all appropriate measures
- Strong financial incentives offered to facilitate maximum rate of change
- Strong markets for bioenergy and afforestation end-products in place
- Strong leadership and public messaging for diet change and food waste reduction

High Hydrogen

- Strong local and regional policy support for all appropriate measures
- Some financial incentives in place where appropriate to support afforestation, agroforestry, lowland and upland peat restoration, farming practice changes, and hedgerow planting
- Markets for bioenergy and afforestation end-products in place
- Strong leadership in diet change and food waste reduction
- Moderate public messaging for behaviour change

Balanced

- Strong local and regional policy support for all appropriate measures
- Low or no financial incentives above ELMs to support climate mitigation measures
- Strong leadership in diet change and food waste reduction
- Moderate public messaging for behaviour change

Evaluate progress and implement further measures where necessary, for example:

- Adjustment of spatial land strategy targets based on effectiveness of implemented measures, extent of behaviour change and developments in National policy
- Stronger regulatory measures, such as banning peatland burning or new/stronger local planning requirements for land use
- Stronger financial incentives for climate mitigation measures
- Support for rollout of innovative technologies and techniques
- Public incentives for behaviour change
- Adjustment of advice on machinery fuel switching based on markets and rollout of hydrogen vs electrification etc
- Shift away from short-rotation coppice and miscanthus towards longer-term forestry

ELMs = Environmental Land Management Scheme; 1. In-line with rollout of ELMs

LULUCF and agriculture policies (1/6)

Back to LULUCF summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
L1	**Regulatory & planning:** Develop a **spatial land use strategy for the region**[1], covering public and private land, which plans ahead for/accelerates Local Nature Recovery Strategy design, and ensures a coordinated approach to delivering net gain in local development.[2] The strategy should identify local suitability and optimum feasible deployment for: • Tree planting, including through existing programmes (e.g. Northern Forest, White Rose Forest) as well as new areas of afforestation, including in urban areas and rural ago-forestry • Hedgerow restoration and planting, including potential for expansion of existing schemes (e.g. North York Moors traditional boundary scheme) • Peatland restoration • Bioenergy crop production • Other changes in land use and/or land use management techniques **By 2022**	Up to ~£200-250k, based on funding awarded to Local Nature Recovery Network Strategy pilots 1-2 FTEs to oversee delivery	• Risk of poor buy-in from stakeholders • Competing land use requirements must be managed (e.g. housing development targets, local renewables development, conflicts with existing Local Plans etc) • Risk of optimal local suitability for measures not delivering carbon ambition	• **Strategy design should be led by the CA/LEP,** with significant coordination with LAs. • Support for plan design can come from national bodies, primarily Natural England • Engagement and co-design with farmers, landowners and key regional stakeholders, including Yorkshire Water, Yorkshire Dales and North York Moors National Parks, Moors for the Future, Yorkshire Peat Partnership, and other local partners and schemes[2] will be essential to ensure a joint vision that incorporates local knowledge and expertise • Need for coordination across teams to align strategies[3]	• Biodiversity gain • Ecosystem services such as water management and climate resilience (e.g. nature based solutions for flood management) • Health and well-being through access to green space for residents	• Key enabling policy that will ensure support in policy **L12** is targeted, that appropriate packages are developed in **L4**, and that local plans are used effectively in **L11** • Needs to feed in to and develop alongside wider spatial plan, **C2**
L2	**RD&D:** Improve **local data and evidence and carry out detailed local modelling.** Data to include: • Current peatland condition and potential for restoration • Carbon intensity of local farming techniques • Optimal livestock stocking densities • Carbon sequestration measurement and monitoring techniques • Extent of food waste along supply chain **By 2021/22**, in parallel with and informing **L1**	£50-100k per study	• Risk of data being unavailable, incomplete or unreliable	• **Studies led/commissioned by the CA/LEP** • Key partners will be landowners, farmers, National Parks, Peatland projects (e.g. Moors for the Future) and academic experts • Carbon measurement must be verified by accredited bodies[4]	–	Enabling measure for **L1**

1: "Region" refers to policy on West Yorkshire or York & North Yorkshire level (i.e. WY-wide and YNY-wide remit). 2. For example, Yorkshire Wildlife Trust, Rewilding Britain, West Yorkshire Ecology Service, the Canals & River Trust, National Trust, Woodland Trust, and local forest schemes (list is non-exhaustive); 3. Including transport, heat and energy strategies; 4. Peatland Carbon Code, Woodland Carbon Code

LULUCF and agriculture policies (2/6)

Back to LULUCF summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
L3	**Regulatory & planning:** Develop a **region-wide food waste reduction strategy**, which sets informed targets and explores locally-relevant measures to deliver them **By 2022**	~£50-100k if commissioning a study	• Risk of strategy and identified measures not delivering the level of change required – e.g. poor uptake among residents and rural businesses	• **Strategy led by/commissioned by the CA/LEP**	Equity – reduction in household spend on food; increased profitability for farmers	• Ensures that efforts are locally relevant and implemented in a coordinated manner
L4	**Coordination, information, facilitation:** Establish a **package of measures** to equip farmers and landowners with the information and support they need to make decisions that are good for their business and the environment. This can include: • Centralised resources with information about: – Options and interventions available – Best practice examples – Sources of funding and support • Access to trusted local advisors • Establishing knowledge-sharing networks to ensure best practice and latest evidence is shared, and to embed a shift in culture among local stakeholders towards sustainable, climate-friendly practices • Access to training programmes in relevant land use and land management options/techniques **By 2022/23** with on-going updates	Primary costs will be development and on-going maintenance of a website as well as access to local advisors, especially if provided in-house. Indicative costs for website development are ~£150,000 - £300,000 depending on level of social media presence, with ongoing costs of ~£50-100,000 per year. At least 1 FTE to oversee delivery	• Risk of not reaching sufficient proportion of target audience; • Risk of becoming outdated rapidly due to evolving national policy landscape – can be mitigated by frequent reviews and updates • Risk that insufficient measures are taken up despite providing the resource	• **Delivered by the CA/LEP** • Key partners will be existing restoration and afforestation programmes, authorities (e.g. National Parks), sector experts and existing networks (e.g. York Land Anchor Network) and Defra • Landowners and farmers are the target audience as well as key partners in forming and participating in knowledge-sharing networks	–	• Key enabling measure that supports the effectiveness of all delivery measures, such as **L12**
L5	**Skills & training:** Develop **educational programmes** (qualifications, apprenticeships etc) to ensure that young people can access a career in land management, forestry, agro-forestry etc **By 2023/24**	Up to 1 FTE to coordinate and facilitate programme development	• Risk of insufficient uptake of programmes and/or programmes not resulting in increase in career choice in the sector	• Led by CA/LEP, courses **delivered by higher education institutions and land-based colleges**	–	• Key enabling measure to ensure local supply chain

1: “Region” refers to policy on West Yorkshire or York & North Yorkshire level (i.e. WY-wide and YNY-wide remit)

LULUCF and agriculture policies – (3/6)

Back to LULUCF summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
L6	**Regulatory & planning:** Implement **food purchasing policies for the public sector** that reduce red meat and dairy, and reduce waste. This can include: • Purchasing locally where possible and using 'imperfect' produce where offered • Requiring fully plant-based options to be available for all public-sector catering menus, including schools, with the share increasing over time • Offering different portion sizes in public canteens **By 2021**	<1 FTE to oversee delivery	• Risk of resistance from employees, parents, and meat and dairy industry • Risk that low behaviour change outside of public sector settings (e.g. school meals do not translate to a shift to more plant-based diets in later life)	• **Led by CA/LEP** in partnership with LAs (joint delivery)	Health – through diet change Cost – plant-based menus may result in operational savings	• Directly delivers diet change in proportion of local meals consumed • Supporting measure for wider behaviour change through exposing consumers to novel foods and leading by example
L7	**Regulatory & planning:** Work with Local Authorities to implement **region-wide separate food waste collection** **By 2021/22**	Unknown	• Potential additional cost to LAs • Risk of low participation, especially by residents in shared properties such as flats • Risk of conflict with AD plant objectives	• Led by CA/LEP in partnership with LAs • **direct delivery by LAs** • Needs coordination with food waste processing facilities	–	• Reduced landfill emissions • Provides supply to enable growth of local AD facilities[1]
L8	**Coordination, information & facilitation:** Establish new **partnerships** and utilise existing links to deliver climate ambitions. These can include: • Building partnerships between LAs and the Forestry Commission to use LA land for tree-planting • Build on existing networks (e.g. Yorkshire Land Anchors Network) to coordinate efforts and to raise further funding to restore peatlands and deliver tree planting • Establish development partnerships to help development of appropriate brownfield sites • Building partnerships with food banks to reduce food waste **By 2022**	<1 FTE to oversee coordination activities	• Risk of partnerships not delivering required ambitions	• **Led/overseen by CA/LEP in partnership with LAs** • Key partners will include: Forestry Commission, Yorkshire Water, SSI landowners, Moors for the Future, Yorkshire Peat Partnership, land developers, food banks and other community groups	–	• Enabling measure in helping to ensure delivery and local buy-in from key stakeholders

---

[1] AD = Anaerobic Digestion

LULUCF and agriculture policies – (4/6)

Back to LULUCF summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
L9	**Regulatory & planning:** Consider **banning damaging practices** such as rotational burning and peat extraction **2025-2030** dependent on evidence of impact and stakeholder feedback	Dependent on enforcement requirements	• Risk of non-compliance and/or expensive enforcement • Risk of conflict with grouse moors (particularly YNY)	• **Led by the CA/LEP** in partnership with National Park Authorities and Peatland Restoration Programmes • Need for consultation with landowners	• Biodiversity gain • Pleasant landscapes for tourists and residents	• Direct emissions savings from peat degradation
L10	**Regulatory & planning:** Work with LAs **to use local plans to deliver climate ambitions**. This can include: • Ensuring local plans are aligned with the wider regional strategy • Using net gain requirements to support and deliver natural solutions • Reviewing local regulations as appropriate, for example to enhance protection for hedgerows **By 2024**	<1 FTE to coordinate with LAs	• Risk of differing policy across the region if not fully coordinated/suitable for each local context	• Led by the CA/LEP to facilitate **delivery by LAs**	• Biodiversity gain • Increased connectivity and quality of green spaces and green corridors	• Enabling policy by creating mechanisms to generate private funding for natural solutions (e.g. through mechanisms to deliver net gain) and by designing protective policy
L11	**Financial:** Develop a programme of **grants and financial incentives** for farmers and landowners to deliver measures. These can be complementary to ELMs and should aim to fairly reward rural businesses for actions that positively contribute to the net zero target. This can include support for: • Establishing and maintaining woodland • Peatland restoration and management • Positive soil management • Hedgerow restoration • Waste reduction • Bioenergy crop production and distribution • Best available techniques in cattle farming **By 2024 at latest**, to coincide with start of ELMS	Dependent on the level of support and number of funding programmes but could be on the scale of £10s of millions (WY) or £100s of millions (YNY)	• Risk that funding enables initial uptake but does not maintain land use for the period required to enable change	• **Delivery by CA/LEP** • The level of support will be determined by the funding provided through ELMs and by Government, as well as other local grants (e.g. Beyond Nature and Traditional Boundaries) – it will be important to work with local partners and monitor changes in local landscape	• Equity – Reduces cost to farmers and landowners of implementing schemes	• Enabling policy to ensure delivery of measures and interventions

---

1: "Region" refers to policy on West Yorkshire or York & North Yorkshire level (i.e. WY-wide and YNY-wide remit); ELMs = Environmental Land Management Scheme

LULUCF and agriculture policies – (5/6)

Back to LULUCF summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
L12	**Financial:** Develop and trial **private investment models** to attract funding for land use solutions, such as a carbon trading scheme. **Study options by 2023** **Rollout by 2025**	~£50-100k for commissioned study to explore options	• Risk of off-setting being used by organisations to avoid direct action to reduce their own emissions • Risk of insufficient investment to make scheme viable	• Led by CA/LEP, in partnership with landowners and existing schemes • **Likely delivered by 3rd party** • Need to avoid double-counting e.g. through the Peatland Code, Woodland Carbon Code, Woodland Carbon Guarantee	• Co-benefits assigned to measures enabled by the scheme	• Can reduce the level of support
L13	**RD&D:** Establish **R&D programmes and** support **demonstrator trials** to support innovation and gather evidence on new solutions for the region. This can include for example: • Alternative proteins[2] • Vertical farming • Methane reduction techniques • Advanced technology (e.g. robotic harvesting, machine learning) **Ongoing from 2023/24**	Potential for low cost to CA/LEP if externally funded	• Risk that trials are unsuccessful or technologies unviable	• Led by CA/LEP with direct **delivery of trials by farmers and landowners** • LAs, landowners, farmers and local organisations will be key partners • Collaboration with Defra and/or agricultural research institutions could be pursued to locate trials in the region	• Developing local skills and expertise	• Enables innovative options and gathers evidence for developing local strategy as the emissions reduction pathways progress
L14	**Regulatory & planning:** Establish **markets for end-products** of agriculture and land management practices, including: • Bioenergy crops – for example, by requiring biomass combustion facilities to source a set share of feedstock from the region[3] • Harvested material from new woodland – such as in construction Established markets must align with local biodiversity and land use goals (i.e. ensuring that end products are crops and materials suitable for the region) **By 2025**	£50-100k for studies Up to 1 FTE for fixed term to liaise with key stakeholders and to oversee development	• Risk of market not being commercially viable, particularly in early stages as supply scales-up	• Led by CA/LEP, **delivery likely by 3rd party** • Key partners will be buildings developers, biomass combustion facilities (small-scale and large-scale, including Drax)	• Developing local supply chains and circular economy	Develops the **business case** for adoption by landowners and farmers. Reduces the potential level of support required in **L11**; developments should be shared through the resource package in **L4**

1: "Region" refers to policy on West Yorkshire or York & North Yorkshire level (i.e. WY-wide and YNY-wide remit). 2. Including cultured meat;
3. Increasing in-line with realistic scale-up of sustainable supply

LULUCF and agriculture policies – (6/6)

Back to LULUCF summary table

No	Policy Description	Cost & resources	Risk and barriers	Role of stakeholders	(Co) benefits?	Key Impact & interdependence
L15	**Financial: Promote and support community schemes** that contribute to net zero aims, such as: • Community food growth in urban areas • Community tree and hedgerow planting • Outlets for produce that does not meet supermarket standards **From 2023**	Cost depends on level of support. For example, small-scale individual grants of ~£2,000 per project could be awarded with up to 10 projects per year	• Risk of low impact on behaviour or in delivering overall strategy • Risk of poor quality planting if not coordinated appropriately	• Led by CA/LEP in partnership with LAs • **Schemes delivered by Community groups** • Existing larger programmes could be key partners to ensure local action aligns with wider regional action		Contributes to delivery of interventions and supports diet/behaviour change through local initiatives
L16	**Influence & support: Influence Government** to deliver policy and support that supports climate ambition: • Funding for tree planting, hedgerow planting, agro-forestry and peatland restoration – nationally and/or as part of devolution deal • Ensure that ELMS adequately supports measures targeted for delivering net zero • Streamlining application process for afforestation **Ongoing from 2021**	<1 FTE to coordinate and deliver influencing	• Risk of influencing not achieving intended aim	• Influencing led by CA/LEP with input from LAs and local partners • **Delivery of key asks by Government and national bodies**		Enabling measure to ensure policy certainty and to determine the level of support that might be required in **L11** and **L15**.

1: "Region" refers to policy on West Yorkshire or York & North Yorkshire level (i.e. WY-wide and YNY-wide remit); ELMs = Environmental Land Management Scheme

Contents

Scenario features (1/2) – the Max ambition scenario enables regional leadership but faces challenges in cost and rapid behaviour change

The table below (over 2 slides) compares key features of the scenarios in terms of benefits, challenges, investment, infrastructure and consumer considerations. It is not intended to show a "winner" or to provide an exhaustive list of features on which to evaluate a pathway.

	Baseline	Max ambition	High H_2	Balanced	All scenarios
Key benefits & opportunities	• Little need for consumer behaviour change or investment in innovation • Lower need for investment in infrastructure, supply chains and other technologies	• Fastest emissions reduction with associated climate and health benefits • Regional leadership in climate emergency enabling export of skills and services, as well as job creation	• Regional leadership in hydrogen and CCS technology and skills • Potential for regional export of low carbon hydrogen and electricity	• Flexible, resilient energy system relying on multiple fuels / technologies • More consumer choice	• Health benefits of active travel and reduced air pollution • New forest planting improves landscape and supports environment
Key risks & challenges	• Failure to hit climate targets and carbon budget exceeded in less than 10 years • Continued emissions lead to high cost of carbon, particularly damaging for industrial sites where job losses may occur • Air quality health implications of continued fossil fuel use • Natural landscapes are not improved • Climate change causes further challenges[1] • Region falls behind UK in innovative technologies, with potential reduction in jobs and GVA and higher costs for consumers	• Required electricity system upgrades (generation, network, DSR, storage) delayed, restricting heat pump & EV deployment • Consumer acceptance of heat pumps (visual/noise concerns, behaviour change, level of service etc.). • Poor quality heat pump installation impacts comfort • High energy efficiency requirements not met • Consumer resistance to diet change • Potential to exacerbate social inequalities due to higher costs	• Large-scale H_2 production (or CCS) is not available / viable in time, causing delays in emissions reduction. • Reliance on natural gas import for blue H_2 production impacts energy security. • Many H_2 applications are at early stages and evidence is changing quickly • Consumers perceive hydrogen as unsafe or the switchover as inconvenient • Risk of stranded H_2/CCS assets if plans change • Reliance on national support for large infrastructure projects	• Many of the risks of the Max ambition & High H_2 scenarios, but generally at a reduced level due to the wider range of technologies deployed. • Risk of higher costs in some areas due to deployment of multiple types of infrastructure • Risk of delayed uptake from consumers, waiting for a clear strategic direction	• Misalignment with national targets and priorities • Regional authorities don't have the powers required • Coordination challenge across regions & stakeholders • Competing land uses may restrict measures e.g. forest planting • Low carbon industrial equipment not proven • Requirement for consumer behaviour change • Consumer acceptance of technologies (e.g. CCS, H_2, onshore wind) & regulation • Rapid building of supply chains and infrastructure • Challenge to distribute costs to protect the vulnerable

---

[1] e.g. flooding, heat waves etc

Scenario features (2/2) – scenarios differ in the profile and focus of investment, infrastructure and consumer change

	Baseline	Max ambition	High H_2	Balanced
Cost & investment	• Lower initial capital costs of technology and infrastructure, although incumbent technologies may become more expensive over time • Higher fuel costs of existing heating and transport technologies. • Low RD&D spending.	High capital cost due to: • Rapid deployment causing scrappage and an 'un-optimised' system • High capital cost of heat pumps Cost is focused largely in buildings, with smaller infrastructure changes.	• Uncertain cost, depending largely on hydrogen fuel cost. • High investment required in H_2 & CCS infrastructure, with significantly lower building level capital costs • H2 refuelling infrastructure investment alongside EV charging	Some applications will be lower cost due to the ability to choose most cost-effective technology/fuel/ intervention for the application
Infrastructure, skills & coordination	• Lower electricity network reinforcements and no hydrogen gas grid conversion • Limited skills transition required at slower pace	• Rapid electricity network reinforcements alongside battery storage, DSR & renewable generation • Early heat pump installer training and supply chain development • Rapid EV charge point deployment	• Hydrogen generation, distribution and end-use technology deployment • Lower electricity system impacts • Skills around installation and operation of hydrogen technologies • Rapid EV charge point deployment and electricity network reinforcements	• Some investment required in both electricity and hydrogen infrastructure • Rapid EV charge point deployment • Wider range of skills required
Consumer considerations	• Limited behaviour change • Fuel poverty still challenging, with increasing fuel costs • Poor health due to air quality and urbanisation	• Rapid behaviour change required e.g. mode shift to active travel, diet change, heat pumps • Limited consumer choice due to timeframes of transition ruling out some technologies	• Consumer acceptance of hydrogen and CCS uncertain • Lower behaviour change required in homes, businesses and industry (H_2 boilers)	• Potential for greater consumer choice due to availability of multiple fuels and technologies • Equality between consumers who have hydrogen and those who don't must be considered.

- The scenarios differ in the extent of change required, and whether the change is primarily for the consumers (buildings and transport) or in the infrastructure system.
- The investment profile also differs, with differing cost breakdown between technology capital cost, fuel cost, infrastructure and other resources.

This study allows high-level comparison of the pathways, but should not be used to 'choose a scenario/pathway'

Whilst in some places we compare the scenarios in terms of emissions, energy, technologies or cost, this study is not intended to enable a decision to be made on which scenario to pursue. A pathway should not be chosen immediately, for a number of reasons:

1. The study is not detailed enough to have considered all factors which have implications for which the 'optimal' scenario is. For example, a detailed spatial infrastructure assessment would be needed, including high resolution temporal modelling of the electricity network impacts and the associated infrastructure costs, to have full visibility of some important costs and constraints.
2. There is some crucial evidence not yet in place on certain technologies. For example, there are still research and demonstration steps required to prove the feasibility and viability of hydrogen for heat.
3. The pathway followed in Yorkshire will be impacted by some important national decisions during the 2020s. These will impact the national government incentives and the availability of infrastructure and fuels.

This does not mean the region should wait to act, but should **take low regrets actions which can support any pathway, and gather further evidence to support a decision.**

The scenarios are there to represent different potential pathways, depending on a number of uncertainties in technology development, cost, policy and consumer preference/behaviour.

There are options to further reduce emissions, but many of these are speculative and further evidence is needed

Whilst the emissions scenarios have modelled a wide range of measures to reduce emissions, there are some additional options which could be explored to further mitigate emissions. Some of these are changes to the scope and assumptions on the energy system, while others are speculative options from less mature technologies or concepts.

- **Even more ambitious renewable electricity generation** (e.g. solar PV and onshore wind) to offset remaining electricity related emissions from the national grid.
- **Offsetting emissions through negative emissions methods, which include**
  - Further BECCS in the industry sector to produce negative emissions – e.g. large glass plants (primarily West Yorkshire)
  - Further BECCS in hydrogen generation (biogas blending into ATR feedstock or biomass gasification with CCS)
  - **Direct air capture** with CCS – CO_2 is captured directly from the atmosphere and used or stored. This provides negative emissions to offset remaining emissions from the region. This will depend on the development of cost-effective capture technologies and significant CO_2 transport infrastructure.
  - **Increased forest planting:** West Yorkshire has space constraints looking forward as population grows which limits measures such as new forest planting. Increasing the density of urban development and outsourcing some agriculture to other areas of the UK could be used to free up space for new forest planting and peatland restoration, thus reducing emissions – for example, planting covering 75% of the area identified as “low-risk” for tree planting in WY could reduce emissions by ~0.3 $MtCO_2e$ per year in 2038.[1] These measures must be completed as soon as possible to realise the emissions reductions in time.
- **Innovative land management and further diet change**, including novel proteins
- **Transport:** quicker lifestyle change than modelled, e.g. following the COVID pandemic, the shift to remote working and decrease in business trips, including decreased aviation. Wider economy changes, such as avoiding just-in-time delivery and next-day delivery could also reduce emissions from freight.
- **Circular economy system changes,** for example to reduce material consumption, processing and disposal. This primarily impacts the industry and waste sectors, including further waste prevention and diversion, new product design and new processing methods.
- **Changes in construction materials to reduce emissions and store carbon in new buildings** – for example, increased use of wood-based materials or aggregates made from CO_2 (Carbon capture and utilisation - CCU)
- **Carbon offsetting** outside the region (e.g. through supporting emissions reduction schemes elsewhere) – this is a short-medium term solution only, as ultimately every region and country should reach net-zero, at which point offsetting can only be achieved through negative emissions beyond this.

All of these options require detailed assessment to fully understand the impact, scale and wider implications. Further research is recommended over the next few years to determine which of these options are feasible and preferrable.

---

[1] Area identified by White Rose Forest Carbon Study; emissions savings estimated based on mix of broad-leaf and conifer forest planting

Co-benefits - table below lists the most important measures relating to the co-benefits

Co-benefits*	Applicable measures
Job creation/retention	Almost all measures lead to some form of job creation, retention or upskilling; however, the most impactful measures are distributed and scalable technologies/actions, such as: infrastructure development, renewables, industrial electrification, efficiency improvements, energy storage, DSR, land management, forestry, low carbon buildings heating, ZEVs, hydrogen applications
Support for local economy/SMEs	The following measures are likely to improve local economy and support small businesses: renewables, Energy from Waste, energy storage, DSR, all types of infrastructure, SME fuel switching, industrial and domestic efficiency, buildings retrofits, agricultural measures
Cost reduction	The following would reduce costs for consumers, tax payers or corporations: all energy & material efficiency improvement measures, food waste prevention, energy storage, DSR, better public/shared/active transport, rail electrification
Health/air quality improvements	Road transport demand reduction and zero emissions vehicles, low carbon heat networks, increased building efficiency, industrial fuel switching, increased active travel, reduction of red meat/diary, ecosystem restoration, afforestation
Fuel poverty reduction	These measures reduce fuel costs for the most economically disadvantaged: buildings energy efficiency and retrofit schemes, community renewables, energy storage, DSR, food waste prevention
Inclusive growth/equity	These measures ensure better equity and inclusivity: all information/public engagement actions, community renewables, energy storage, DSR, house retrofits, better public transport, mobility schemes, innovative shared transport models, ecosystem preservation
Increased circular economy/waste reduction	Waste reduction strategies (including food), better recycling (including for industrial use), expanding Energy from Waste and EfW CHP plants, retrofitting CCS on EfW power plants, industrial circular economy uptake, CO_2 utilisation, wood in construction
Knowledge creation & increased private RD&D	Further research/evidence gathering on following technologies will lead to this co-benefit: all hydrogen applications, all CCUS applications, energy storage, DSR, industrial electrification, circular economy, heating for hard-to-decarbonise homes, alternative proteins, vertical farming, robotic harvesting, soil carbon MMV, current peatland conditions
Ecosystem services & biodiversity improvement	Afforestation, reforestation, peatland restoration, hedgerow restoration, expanding agroforestry practices, positive soil management, banning of rotational burning all contribute to biodiversity and ecosystem services such as flood management

*Almost all actions reduce climate change and dependence on scarce fossil fuels. These are not listed as separate co-benefits.

CCUS: carbon capture utilisation and storage, BECCS: bioenergy with CCS, EfW: energy from waste, DSR: demand side response, ZEV: zero emission vehicle, CHP: combined heat and power, MMV: measurement, monitoring and verification

Impact of national decisions and policy

The emission reduction targets set by West Yorkshire and York & North Yorkshire are significantly more ambitious than the UK national target of net zero by 2050. While there are a significant number of actions that the regions can take to deliver the pathways, as set out previously, the regions cannot fully deliver the pathways alone and the final pathway chosen will depend on decisions and policy set at national level. Key examples include:

- **Transport:**
  - **Petrol & diesel car and van bans:** The scenarios in this study were developed ahead of announcements in 2020 for accelerating the date of the petrol & diesel car and van ban – first moved back from 2040 to 2035, and now set at 2030 for internal combustion engines and 2035 for plug-in hybrids.[1] **The current national ambition for cars and vans is now more ambitious than the Balanced and High Hydrogen pathways**. Transport emissions in these pathways are reduced by 20-25% if this trajectory is followed. Although the exact form of policy and support to deliver this ambition has not been announced, the level of support that needs to be provided at regional level beyond that at national level may be lower than previously estimated. However, significant action such as expanding charging infrastructure to support this ambition still needs to be taken at regional level.
  - **Heavy duty vehicle strategies and fossil fuel bans:** The Government recently announced intentions to consult on ending the sale of diesel HGVs and to publish a national bus strategy.[1] These ambitions will provide greater certainty for key industry stakeholders and shape the engagement required with fleets at regional level.
  - **Grants and funding:** The degree to which existing funding schemes will be continued, such as the plug-in car grant[2] and electric vehicle charging infrastructure grants,[3] and new funding schemes introduced, such as for ebikes,[4] will strongly impact the level of additional support that needs to be provided at regional level.
- **Heat:**
  - **Decision on role of hydrogen vs electrification:** National strategies for heat and for hydrogen are expected in 2021,[1] although decisions on the role of hydrogen for homes are not expected until at least the mid-2020s once trials are complete. The extent to which a High Hydrogen future is possible in WY and Y&NY will depend on the pace of development nationally, and the role of regional hydrogen in the national context.
  - **Future Homes Standard:** The degree of local control and/or the level of national ambition set for new buildings in the upcoming Future Homes Standard will impact how far the regions can influence energy efficiency and low carbon technology uptake through local planning.[5]
  - **Grants and funding:** The form of the replacement (if any) for the Renewable Heat Incentive (RHI) and the degree of further funding provided, such as the Green Homes Grant, will strongly impact the level of additional support that needs to be provided at regional level.
- **Wider strategy and funding:**
  - **Environmental land management scheme (ELMs):** the nature and level of support will strongly impact the level of additional support at regional level
  - The Government has announced intentions to publish a number of strategies and provide sources of funding to support a green transition that will influence the actions that need to be taken at regional level as well as funding that the regions can draw on (or support stakeholders to use). Relevant target sectors for strategy and funding include:[1] Industrial decarbonisation, Transport decarbonisation, Heat & Buildings, Tree planting (England), Nature recovery, Energy, and Hydrogen.

1. Ten Point Plan, Nov 2020; 2. Plug in car grant; 3. OLEV grant schemes; 4. Set out in *Gear Change*, July 2020;
5. Future Homes Standard; 6. Green Homes Grant

The COVID-19 pandemic has implications for energy use and emissions going forward

- **The scenarios considered in this study were developed prior to the COVID-19 pandemic** and represent changes in energy demand relative to pre-pandemic behaviours and sector trends.
- Travel restrictions and social distancing measures put in place as a result of the pandemic have had a huge impact on the economy and on personal work and travel choices, with a number of associated implications for energy use and a net zero transition, including:

COVID-19 impact	Impact on energy/emissions	Implications for net zero transition
Economic recession – large sections of the economy slowed or ceased operations during lockdowns, with resulting increases in unemployment and delays to supply chains	• **Reduction and delayed growth in travel demand** as travel demand is linked to economic growth • **Reduced overall energy use** – both in domestic and commercial/industrial sectors	• **Reduced household spending power** limiting the competitiveness of new technologies with fossil-based incumbents • **Risk of delay to deployment of technologies** if public spending is cut back, particularly for technologies in demonstration or scale-up phase[1]
Increased working from home – a large proportion of the workforce have worked from home during lockdown and, surveys indicate that those who have worked from home intend to continue doing so more in future[2,3,4]	• **Reduced travel demand** due to commuting • **Change in distribution of energy demand –** Reduced non-domestic energy demand, for example where office space is no longer used, with increase in domestic energy use • **Changes in energy demand profiles**, with flattening of peak demand	• **Contributes to emissions reduction** where overall reduction in travel is maintained • **Complements renewables** where demand patterns match supply more closely
Changes in travel behaviour – increases in cycling and walking for leisure trips, but significant decreases in public transport patronage and capacity, and increases in personal car use as a result of social distancing	• **Reliance on high emissions modes** risks transport emissions surpassing pre-pandemic levels as restrictions ease • **Potential for more trips to be taken using active travel** through increased awareness/experience during lockdown	• **Risk that bus and rail services become unviable** limiting the potential for modal switch, with associated impacts on disadvantaged groups that rely on these services
Changes in purchasing behaviour – with increases in online shopping	• **Increased van and HGV demand**, particularly in retail and grocery sectors	• **Greater challenge in reducing van and HGV use** with greater need to manage growth alongside operational efficiency
Reduction in fossil fuel prices – due to reduced demand, with associated risk to the UK oil and gas sector[5]	• **Potential for higher emissions** where fossil fuel use is favoured over lower emissions alternatives	• Potential **reduced cost-competitiveness of low emissions technologies** however the long-term impacts are uncertain

1. *Energy Technology Perspectives Special Report on Clean Energy Innovation* (2020) IEA; 2. For example, 47% of respondents in Wave 1 of West Yorkshire COVID-19 Survey, June 2020; 3. Ipsos Mori online survey, May 2020; 4. SYSTRA survey, April 2020; 5. Just Transition Commission, Advice for a Green Recovery (2020)

The long-term impact of COVID-19 on the pathways is uncertain but the recovery can benefit both emissions and the economy

- The global response to the pandemic is still evolving, and both the longevity and overall positive or negative effect of its impacts are uncertain; however, many of these impacts are likely to be short-to-medium term.
- The emissions reduction pathways developed in this study all require ambitious action across three key areas with potential to be impacted by COVID-19:
  - **Energy demand reduction** through deployment of building energy efficiency measures, and reductions in travel through a combination of working from home, teleconferencing, co-location of homes and services, and reductions in waste
  - **Shift of travel away from private cars to lower emissions modes** such as shared, public and active travel
  - **Deployment of low carbon technology** including low carbon heating, zero emissions vehicles, industrial fuel-switching, and large-scale deployment of hydrogen and CCS
- The overarching actions that local authorities can take to deliver these pathways are likely to be the same as those available pre-COVID, but the primary impact of the pandemic is on the relative barriers to delivering these actions – either through providing opportunities that make action easier or, conversely, challenges that make action more difficult.

Opportunities: Some trends observed during the pandemic support emissions reduction measures, such as:

- **changes in working patterns** –businesses and employees have rapidly adapted to greater use of teleconferencing and more widespread home working, and a proportion of this is likely to be maintained going forward
- **increases in active travel** – increased interest in walking and cycling presents an opportunity to lock-in positive travel behaviours
- **changing perception of value of air quality** – more people report being willing to consider clean technology, such as an electric vehicle, to retain emissions and air quality benefits[1,2]
- **national funding streams for green recovery** – DfT has continued to develop its decarbonisation strategy,[3] and funding streams to support emergency active travel measures,[4] more efficient homes,[5] and a greener recovery have been announced during the pandemic;[6] although it is noted that this comes alongside conflicting funding announcements such as highways expansion
- **Alignment of funding priorities** – significant funding has been made available to support recovery from COVID-19. If this funding is spent wisely then it is possible that this money can achieve both goals of reducing emissions and supporting recovery

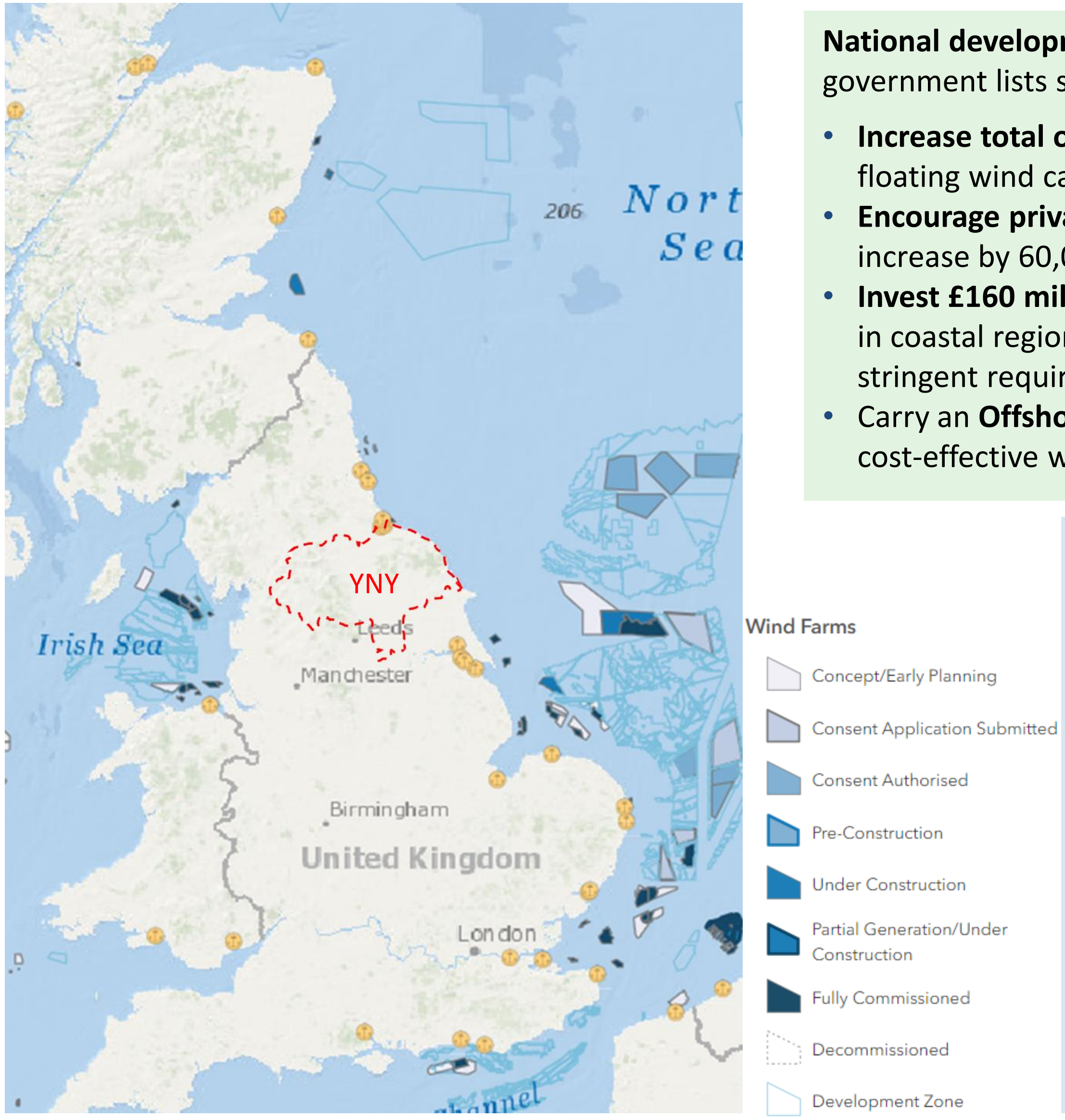
Challenges: The main emerging risks to delivery of the pathways are likely to be:

- **Long-term viability of shared and public transport** – reductions in patronage and restrictions on capacity mean that some services may be lost, particularly in low population density areas; ensuring that these services work for everyone in the future is one of the most important outcomes of a COVID-19 recovery, as it will support emissions reduction and will determine the impact of the transition on disadvantaged groups
- **Ensuring accelerated technology deployment** – delays to low emissions technology deployment due to reduced R&D support and/or supply chain risks have been suggested to result not only in a slower transition – with reduced potential for emissions savings – but also in slower rates of technology cost reduction.[7] The emissions reduction pathways already require strong policy both nationally and locally to deliver technology change at the required rate, and it is not yet clear whether COVID-19 will significantly change the level of support needed or increase the risk of it not being delivered
- **Diversion of local authority resources** away from climate action and towards COVID recovery

---

1. UK Motor article, April 2020; 2. Baringa, April 2020; 3. Decarbonising transport ; 4.Emergency active travel fund; 5. Green homes grant; 6. Green Recovery Challenge Fund 7. *Energy Technology Perspectives Special Report on Clean Energy Innovation* (2020) IEA

The offshore wind industry is not directly location in the region but recent national targets and support programmes present valuable opportunities to get involved



National development: In their recently published Ten Point Plan for a Green Industrial Revolution the government lists specific ambitious targets and support for expanding national offshore wind capacity:

- **Increase total offshore wind capacity** from ~10.5 GW in late 2020 to 40 GW by 2030 including a 1 GW floating wind capacity in the highest potential regions;
- **Encourage private investment** of up to £20 billion into the UK which could **double jobs in the sector** (an increase by 60,000) over the next decade.
- **Invest £160 million into modern ports and manufacturing infrastructure**, providing high quality employment in coastal regions. Also enable the delivery of **60% UK content** in offshore wind projects through more stringent requirements for supply chains in the Contract for Difference auctions.
- Carry an **Offshore Transmission Network Review** to set out a strategy to connect offshore wind in a clean and cost-effective way. Outline plans to deploy smart systems and introduce competition in onshore networks.

Regional opportunities:

- As can be seen in the UK offshore wind map on the left, the study region does not include any ports to support offshore wind and there are no operational farms close to or directly across the YNY coast. There are, on the other hand, large development zones further out and numerous ports/farms around and across the Humber.
- As offshore wind capacity scales in the future new infrastructure may be built in the study region, bringing direct investment and jobs. To facilitate this CA/LEPs may influence the government, actively engage with project developers, run public information campaigns and be willing to quickly issue necessary permits or make planning changes.
- The region (YNY and WY) may still benefit from other nearby projects through utilising its skilled workforce or attracting manufacturing industries to the region. Establishing a solid workforce through onshore wind projects would be beneficial, but this must be done swiftly considering the 2030 target. These external projects would amplify job creation co-benefits of other policies by increasing the workforce and ensuring job security.

Offshore wind is not included in the model for this study due to their geographic separation from the land and limited influence of local authorities over deployment. Map is from 4C Offshore- Global Offshore Map (accessed 22.11.2020)

Link to contents

Contents

Contents

Introduction: The technical Appendix provides the key assumptions

- The purpose of this section is to provide further details to support the results. These include a summary of the modelling methodology, key information sources and key assumptions.

- This section is intended for a technical audience, so uses more technical terminology and assumes a level of existing knowledge on the sector. It also assumes knowledge of the study, so the reader should read the main report prior to, or in conjunction with, this Technical Appendix.

- We begin with some general assumptions around fuels, such as hydrogen, bioenergy and emissions factors. Information on the granularity of the subregion modelling, the emissions pathways for the Leeds City Region and the impact of not having CCS.

- We then come to each sector in turn (Transport, Buildings, Power, Industry, Land use and agriculture) and provide more detail on the scenario modelling. For each sector, the section covers:
  - Summary of the modelling methodology and key information sources
  - Key assumptions in general and for each subsector or technology
  - Any additional details which are useful to a technical audience.

To support the roadmap and policy tables:

- Quantitative information on all the deployed measures to underpin the implementation roadmap.
- Information to support the policies and action plans, such as references of best practise and policy costing
- Mention of additional factors outside the scope of this study, such as carbon offsetting, air quality, scope 3 emissions and SF_6 emissions.

Scope of emissions in region included

In Scope

- ✓ Fuel combustion for heat in industry and buildings, including district heating
- ✓ Transport emissions from road kms travelled in the region on a well-to-wheel basis.
- ✓ Transport emissions from rail and aviation (considered at a high-level)
- ✓ Emissions from electricity consumed in the region at national electricity carbon content
- ✓ Emissions from producing hydrogen (for hydrogen consumed in the region)
- ✓ Industrial emissions captured through CCS will be removed from the inventory.
- ✓ Emissions associated with agriculture and land use in the region, including CO_2, N_2O, CH_4.
- ✓ Negative emissions from BECCS, new forest planting and bioenergy crops inside the region

Out of scope

- CO_2 emissions associated with electricity generation and export (surplus power).
- Emissions from shipping
- Scope 3 embedded emissions in product/service imports
- Non-CO_2 GHG emissions from buildings, transport, industry, power (except those from fuel combustion)
- Emissions offsetting outside region
- Only a % of the negative emissions of national projects e.g. Drax can be allocated to the region
- Fundamental economy changes and circular economy analysis

NET: Negative Emissions Technology

What areas of the modelling and results are at sub regional level (West Yorkshire and York & North Yorkshire separately)?

Sector	Notes on sub-regional level of information
Transport	• Travel activity (vehicle km and modal share) is derived and modelled at subregion level • Vehicle uptake and broad demand reduction assumptions are applied across the study region[1] • Rail emissions are modelled relative to historic emissions, based on modelled change in rail activity at subregion level; however, assumptions of proportion of freight activity and split of diesel/electricity are estimated and applied at the study region level • Aviation emissions are modelled at study region level and disaggregated to subregions afterwards
Buildings	• Domestic building stock and pathways are built up individually for the subregions • Non-domestic modelling is as the full study region, based on energy (not building number). This is disaggregated afterwards to estimate the energy and emissions for each subregion. • Assumptions are specific to the building type, not the region, but this translates through the domestic stock
Power	• Current power assets are fully mapped to subregions and modelling is mostly on a subregional basis • New assets are placed based on a combination of factors: land area, current power plant planning applications, current capacity of power technology in subregion • Spatial feasibility assessment of power assets is not completed (e.g. wind generation in National Parks)
Industry	• Industry emissions are separated by subregion, with better spatial resolution over the heavy industry (70% emissions) than small industry, which is estimated by business units. The subregion breakdown of fuel and emissions going forward is approximate as assumptions are based on the study region as a whole and the small number of plants in each subregion was not modelled individually.
LULUCF & agriculture	• LULUCF and agriculture pathways are based on local authority level land mapping • Assumptions are based on land type and agricultural activity (rather than region) but are adjusted to reflect space constraints by sub region.

---

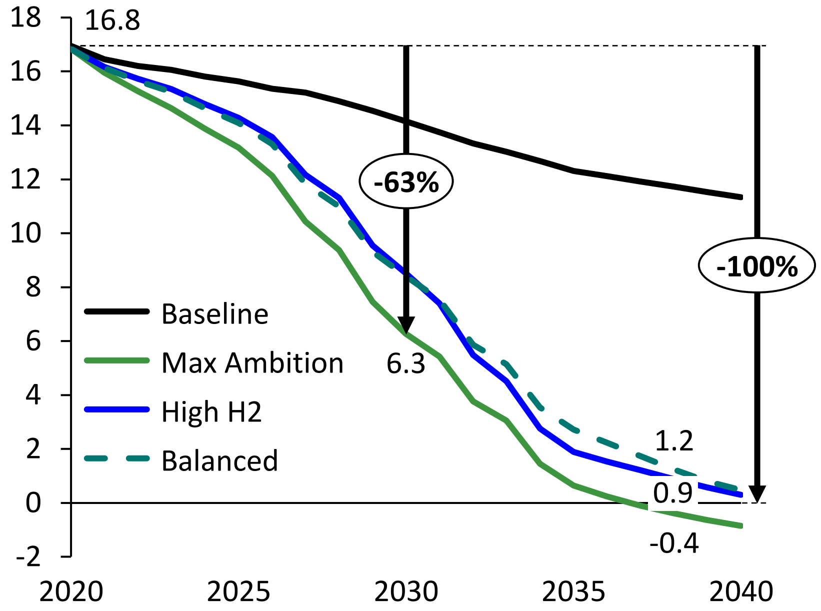
1. Some small variations for subregions are applied where possible and appropriate

Leeds City Region – scenario emissions (1/3)

- This graph compares the emissions trajectories across the scenarios. All pathways make ambitious emissions reductions over the next 2 decades, using different technologies, measures and fuels.
- The pathways include 20% of the negative emissions from Drax BECCS plant[1,2] as with Y&NY. This relies on retrofit of the bioenergy turbines with CCS. New forest planting activities also provide negative emissions.
- **The Max ambition pathway reduces emissions by 63% by 2030 and reaches net-zero by 2038**; the other scenarios don't reach net-zero until just after 2040, with 0.9 and 1.2 $MtCO_2e/yr$ remaining in 2038 in the High H_2 an Balanced scenarios respectively.
- The key differences between the scenarios are the technology choice, level of electrification vs hydrogen in heat and transport and rate of technology deployment and behaviour change.

Pathway emissions $MtCO_2e/yr$

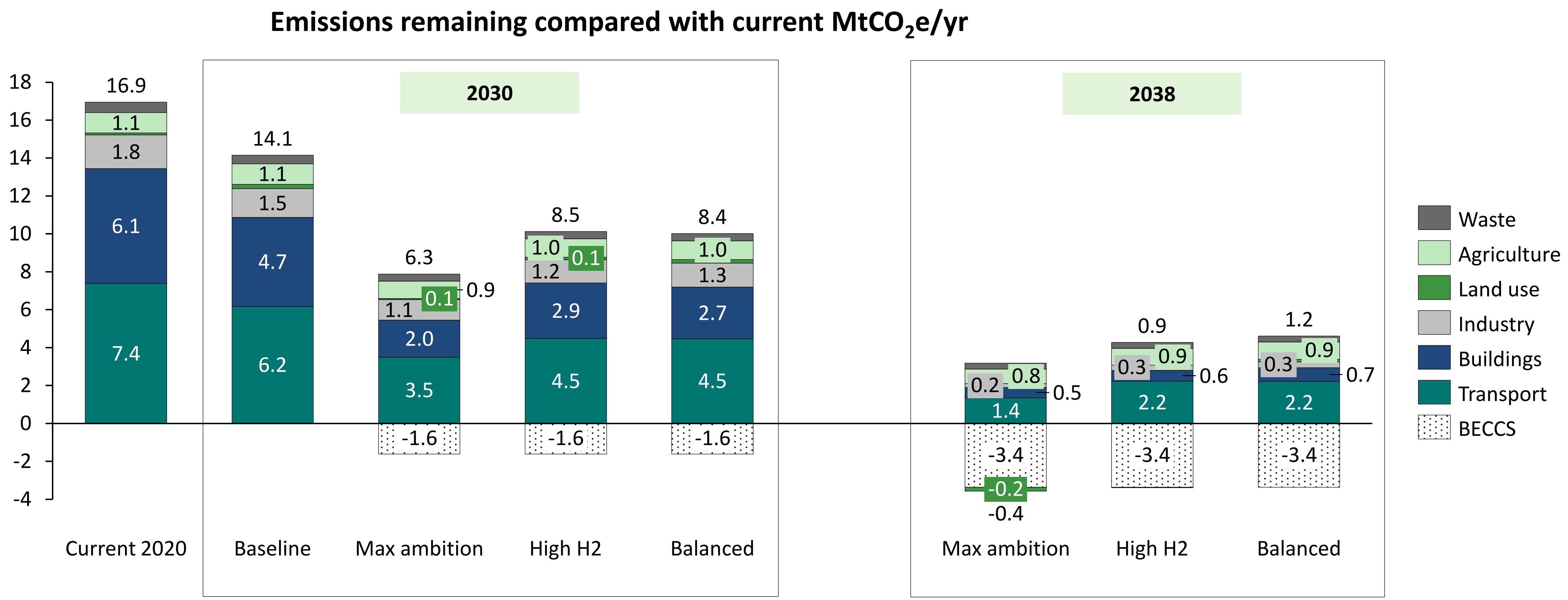
National electricity carbon intensity, with 20% Drax negative emissions



- **The Max ambition scenario makes considerably more progress by 2030**, due to ambitious rates of electric vehicle roll-out and uptake of active travel, unprecedented heat pump installation and faster rates of forest planting. Despite this, the emissions are still 39% of the current emissions by 2030, with challenges including misalignment with national policy timing, technology readiness, behaviour change and stock turnover rates.
- The High H_2 and Balanced scenarios make less progress in the next few years, but progress accelerates from the mid-2020s. **The High H_2 scenario sees rapid emissions reductions 2028-2035 as the gas grid is repurposed** for hydrogen, facilitating the switch of buildings, industry and some transport to hydrogen. The Balanced scenario sees steady progress through a mix of technologies deploying at different rates.

1 BECCS: Bioenergy Carbon Capture and Storage, NET Negative emissions technology 2 The net-zero date is highly sensitive to the % BECCS selected; 20% is used as it is the proportion of generated electricity in N Yorkshire that is consumed in NY in the Max ambition pathway by 2040

Leeds City Region - Remaining emissions in 2030 and 2038 (2/3)



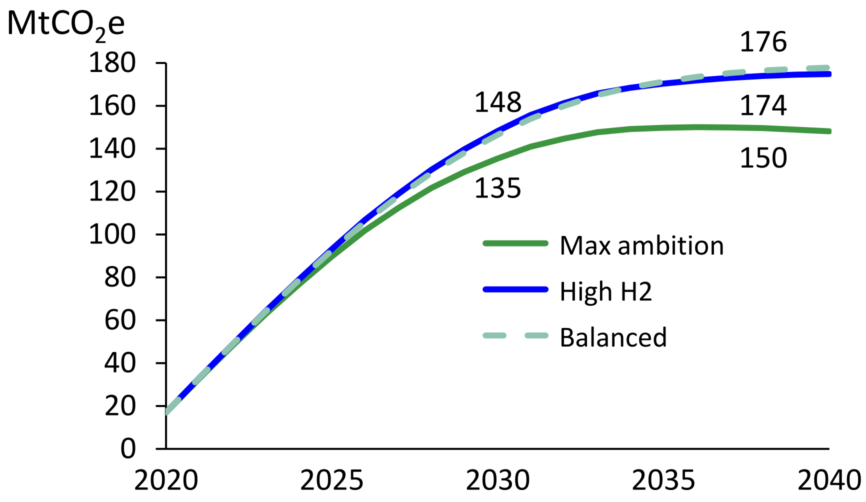
- In 2030 there are significant emissions remaining, particularly in transport and buildings. A key challenge in buildings and transport is the stock turnover rate.
- In 2038, transport and agriculture play significant roles. Transport is hindered by slow progress in aviation and in agriculture a challenge is the time taken for both change (e.g. diet change) and for changes to take effect.
- In the Max ambition scenario, remaining emissions are offset by negative emissions from BECCS and new forest planting to provide a net-zero region.

BECCS – bioenergy carbon capture and storage

Leeds City Region – Cumulative emissions (3/3)

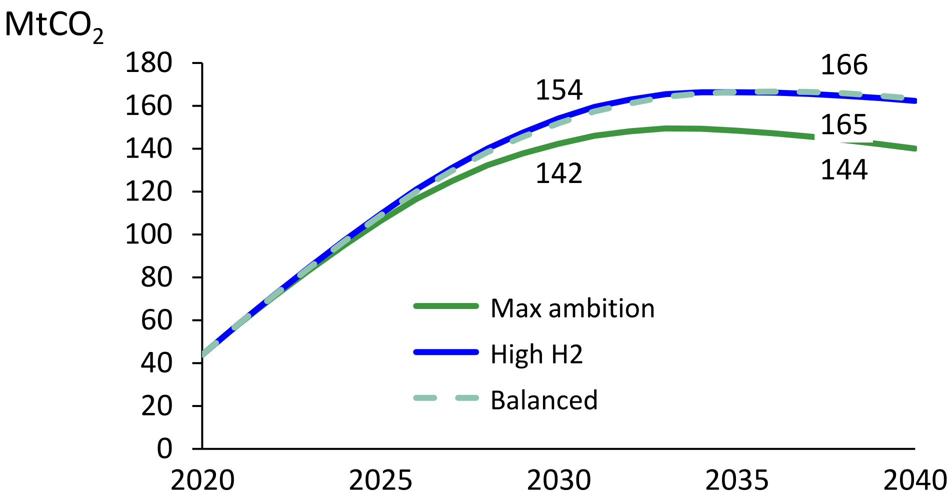
Cumulative emissions MtCO$_2$e

From 2020 including all emissions in the study scope



Cumulative emissions MtCO$_2$

From 2018, broadly following Tyndall Centre emissions scope[1]



- From a climate perspective, the net cumulative CO$_2$ emitted is the key factor, as this is the CO$_2$ contributing to global warming. The cumulative emissions of all scenarios rise rapidly during the 2020s, but then flatten around 2030 as interventions slow emissions and as BECCS is implemented.
- For all emissions (left), the **region reaches 150 – 176 MtCO$_2$e cumulatively by 2038** depending on the scenario.
- The Tyndall Centre developed a science-based carbon budget for the region based on compliance with the Paris Agreement. The cumulative CO$_2$ budget is related to the energy system only and excludes land use, agriculture, aviation, waste and non-CO$_2$ emissions[1]. Under these conditions, the LCR net cumulative carbon emissions are 144 – 166 MtCO$_2$e by 2038 depending on the scenario.
  - The LCR carbon budget is 118 MtCO$_2$ 2018-2100 (112.8 by 2038), and **the region breaches this in 2026, but cumulative net emissions fall in the late 2030s** (due to negative emissions measures).

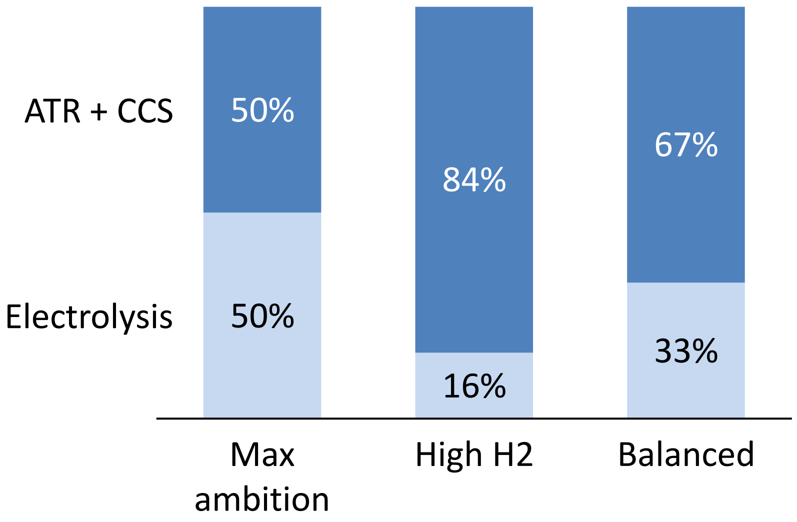
---

[1] Cumulative carbon budget work is approximate, as Element modelling is not set up for the specific conditions of the Tyndall Centre carbon budgets.

Hydrogen production assumptions

- The volume of hydrogen produced by each method varies by scenario. Natural gas reforming (ATR = autothermal reforming) with CCS is primarily used for bulk hydrogen for heat, and is the dominant method in the High hydrogen scenario. The production split is guided by the CCC scenarios[1]
- The carbon intensity of each production method varies over time.
  - For electrolysis it is determined by the carbon intensity of the electricity grid (estimated to be 0.14kgCO_2e/kWh in 2020 through UK Government projections) and the efficiency of the electrolyser. Note that carbon intensity can be reduced by using dedicated renewable electricity generation, with renewables currently assumed to be feeding into the electricity grid.
  - For ATR we include upstream CO_2 emissions from natural gas production (which start at 0.025 kgCO_2/kWh_{NG} and drop by 67% by 2040) and the production emissions not captured through CCS. Note that producing hydrogen through natural gas reforming without CCS (grey hydrogen) is emissions intensive (approx 0.316kgCO_2e/kWh) and should not be considered an option in a low carbon future.
- The model contains the option to blend 5% biogas into the ATR process to further reduce emissions. At default this is included.
- The input energy (natural gas, electricity and biogas) are additional energy demands to produce the hydrogen

Hydrogen production method breakdown by 2040



Carbon intensity of Hydrogen kgCO_2/kWh_{H2}

	2020	2040
Reforming (ATR) + CCS	0.046	0.018
Reforming + CCS + 5% biogas	0.029	0.001
Electrolysis	0.217	0.050

---

[1] CCC Government led scenario estimates 84% from gas reforming. CCC People led scenario estimates 50% electrolysis.

Bioenergy supply and demand: the region must ramp up bioenergy supply pathways and prioritise end-uses (1/2)

Study region
West Yorkshire
Y&NY

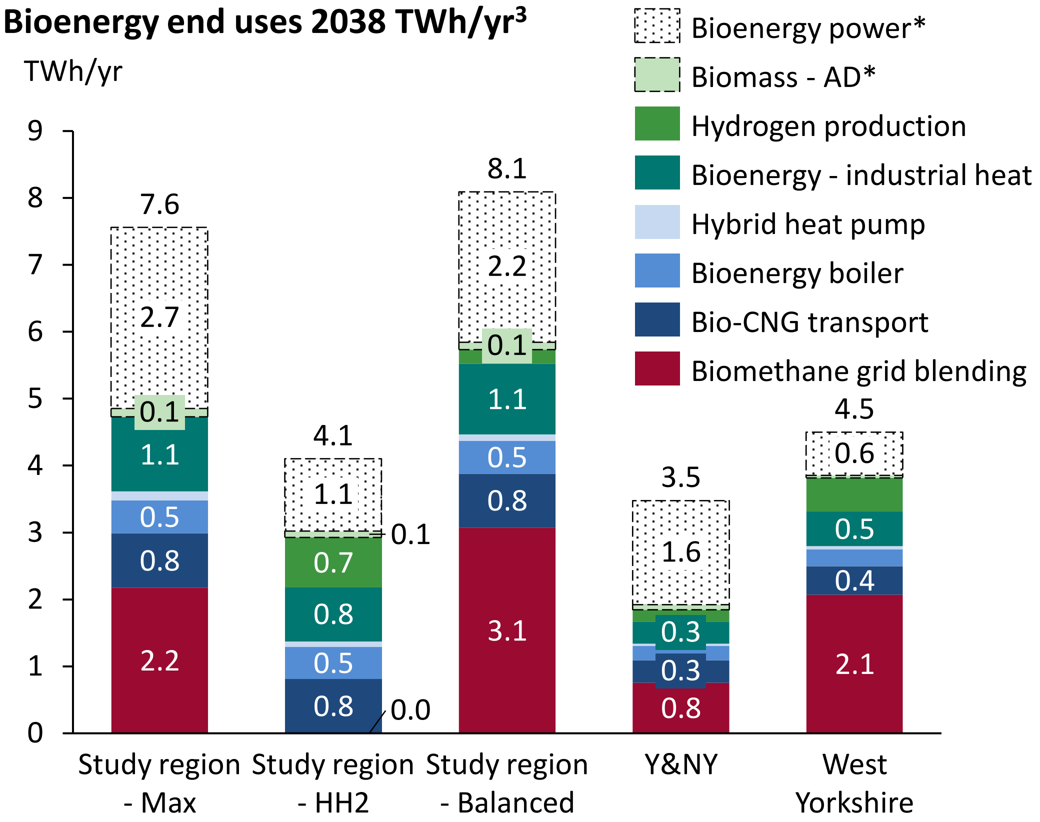
Bioenergy has many potential end uses in the energy system:

- Biomethane for heat through gas grid blending to reduce carbon intensity
- Bio-CNG in transport in the short-medium term
- Bioenergy (biomass or bio-LPG) in boilers or hybrid heat pumps, particularly off gas-grid
- Industrial heat generation (all forms, targeting BECCS)
- Hydrogen production (e.g. biogas blending in ATR[4] feedstock)
- Electricity generation - AD from biomass, distributed small-scale bioenergy plants or large-scale biomass/BECCS[1]. Except Drax, biomass power generation is small-scale, distributed plants - please note that as a high proportion of power produced in YNY is exported, not all the associated biomass use may be attributed to the region.
- The graphs shows the different bioenergy end-uses across the scenarios for the study region. It also shows the maximum bioenergy end-use requirement in 2038 for Y&NY and WY, although *no single scenario reaches this level.*

UK **bioenergy supply** projections remain uncertain. The CCC bioenergy resource scenarios[2] project that the UK supply would range from 132 – 145 TWh/yr **in 2035** (290 TWh/yr including imports). Scaling by land area suggests that N&W Yorkshire should be supplying approximately **5.5 - 6 TWh/yr of this by 2035** (UK supply only, 12TWh/yr use including imports). Of this, most bioenergy generation (4.5-4.9 TWh/yr) is attributed to Y&NY due to the large land area, allowing it to oversupply bioenergy to support more densely populated areas.

It is crucial that all bioenergy is sourced sustainably.

Bioenergy end uses 2038 TWh/yr[3]



Bioenergy must be prioritised for the most valuable end uses, including where the CO_2 is sequestered and where it decarbonises the hardest to decarbonise subsectors. For example, in the long term:

- Wood as a construction material (beyond the scope of this study)
- Bioenergy + CCS (BECCS) in power, industry, hydrogen production (all modelled) and aviation biofuels

In the medium term, bio-CNG, biomethane grid blending & bioenergy boilers/HHP off-gas support decarbonisation of hard-to-decarbonise sectors. Use for power generation (without CCS) may not be the most valuable use going forwards towards 2050.

A full energy balance of potential bioenergy sources by type and end-uses for each region is beyond the scope of the project

---

1*: End-uses graph excludes Drax (~50TWh/y), as the biomass is imported and it dwarfs all other uses in the region. It includes distributed small-scale bioenergy plants, although much of the power is exported, so associated biomass use may not be attributed to the region, and source of biomass is uncertain. 2 CCC Biomass in a low carbon economy 2018 LINK; 3 Maximum amount across scenarios for Y&NY, WY, not all incurred at once; Note that the subregion breakdown is estimated for some sectors; 4: Autothermal reforming

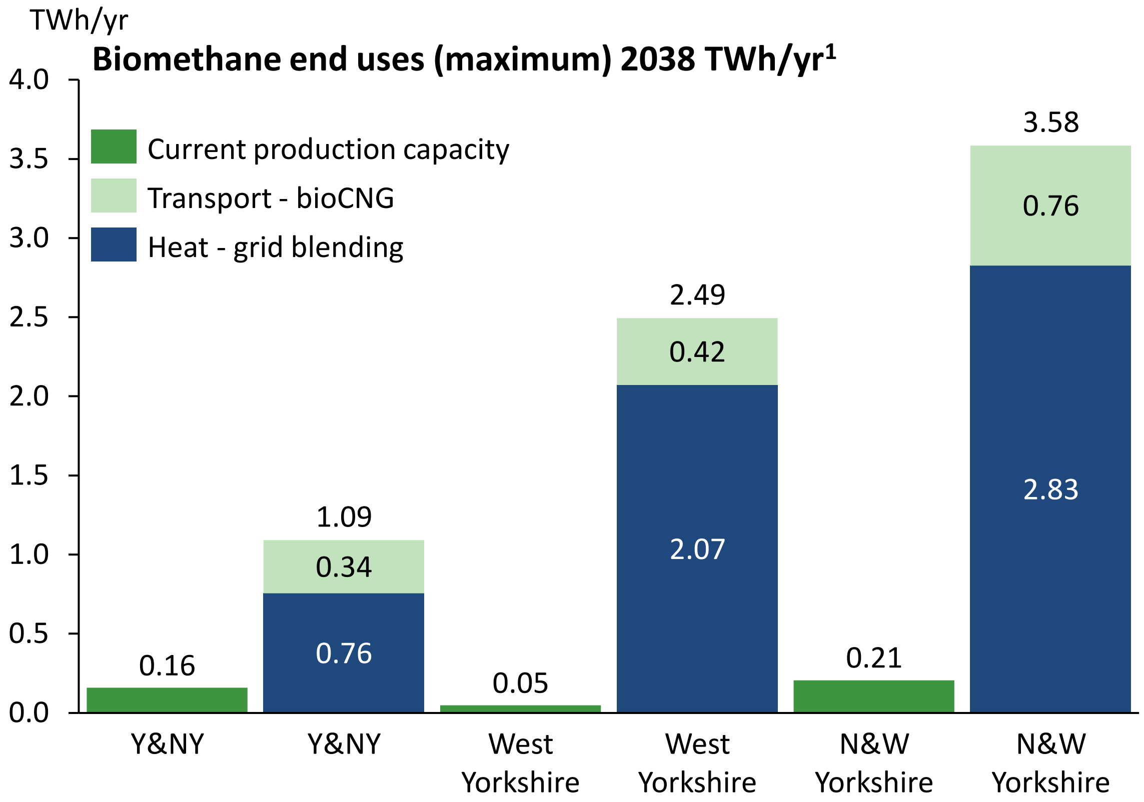
Biomethane supply and demand: current capacity in North and West Yorkshire is around 6% of target for 2038 (2/2)

Biomethane (as opposed to all bioenergy):
The current biomethane production in the region is shown below[2].

	UK	Y&NY	West Yorkshire	Total N&W Yorkshire
Current capacity Nm3/hr[3]	49,002	1,845	550	2,395
Current capacity TWh/yr	4.21	0.16	0.05	0.21
% UK current capacity		3.8%	1.1%	4.9%
% 2038 region requirement		14.6%	1.9%	5.7%

- The 2038 biomethane requirement for power, transport and heat is shown in the graph[1], against the current production capacity by region.
- It can be seen in the graph and table that Y&NY has about 15% of its required 2038 biomethane generation capacity and West Yorkshire only has 2%. However, it is likely that bioenergy will be transported from rural areas to urban areas, so each region may ultimately over or undersupply its own needs (or UK imports).
- Note that the transport demand for bio-CNG is highest in our scenarios in 2034, before dropping off when replaced by other fuels. When comparing purely this bio-CNG demand in 2034 with the current biomethane production, the current % is 23% and 5.4% for Y&NY and West Yorkshire respectively.
- Note that the current production capacity (green) only shows biomethane exported from plants (e.g. to grid), rather than that internally consumed in power and heat generation[2]. The biomethane end-uses also exclude the biomethane used directly within these CHP plants. This could be significant, but we don't have the data breakdown of steps as these are integrated plants.

Biomethane end uses (maximum) 2038 TWh/yr[1]



- The biomethane required for grid blending depends largely on the choice of heat solution in buildings. The Balanced scenarios sees the most biomethane grid blending (shown in graph). In the Max ambition scenario where heat is electrified, very little is needed for residual gas use. In the High hydrogen scenario where the grid is repurposed for low carbon H_2, none is needed for direct blending.

---

1 Maximum amount across scenarios, not all incurred at once; Note that the subregion breakdown is estimated for some sectors; Numbers are estimates and don't include biogas for H2 production, which is an option directly as biogas (see previous slide)
2 NFCC anaerobic digestor portal LINK 3 excluding direct AD -> power only plants, both generation and demand

No CCS sensitivity – without CCS, the region's emissions could be 4.2 $MtCO_2e$/yr greater in 2038, not reaching net-zero

CCS is widely accepted as being essential to meet net-zero targets. However, progress in the UK has been slow, with no full-chain projects deployed yet. CCS is assumed in all emissions reduction scenarios in this study, however a high-level indicative assessment was done on the impact of CCS not materializing:

- **Power sector emissions will be significantly higher**, as natural gas and bioenergy turbines won't be able to use CCS to minimize their emissions. Emissions from power generation in the region could be as much as 1.65 $MtCO_2e$/yr higher in 2038 without CCS[1] (before accounting for BECCS).
- There will be **no BECCS at Drax, so no portion of negative emission** can be attributed to the region. For Y&NY and LCR, this removes the -3.37 $MtCO_2e$/yr of negative emissions (West Yorkshire claims no negative emissions).
- **Hydrogen generation through natural gas reforming with CCS will not be possible**. It is unlikely new reformation plants would be built without CCS, so H_2 would likely be produced entirely through electrolysis, with higher cost and limits on scale in the medium term. If all H_2 were produced through electrolysis, the cost of heating buildings in the High H_2 scenario would increase by over £3bn cumulatively in the study region (and under our assumptions the CO_2 emissions also increase). This hydrogen is also not likely to be used for power production.
- **Industrial decarbonisation would either be less effective or more expensive**. In this estimation we assume the same fuel mix, simply without CCS applied to flue gases. This increases industrial emissions in the study region in 2038 by around 0.23 $MtCO_2e$/yr, almost doubling the remaining emissions.

Approx. increase in 2038 emissions without CCS

Study region	$MtCO_2e$/yr
Max ambition	3.6
High H_2	4.2
Balanced	3.8
West Yorkshire	
Max ambition	0.1
High H_2	0.6
Balanced	0.2
Y&NY	
Max ambition	3.4
High H_2	3.6
Balanced	3.5

Without CCS no subregion would reach net-zero by 2038 and the emissions could be up to 4.2 MtCO2e/yr higher for the study region

---

[1] Note that these emissions are not accounted in the scenario emissions (only electricity consumption emissions at national carbon intensity) so this does not in itself impact the pathway emissions.

Assumptions on the carbon intensity of fuels

Carbon intensity of fuels	2020	2030	2038
Electricity	0.184	0.081	0.040
Natural gas	0.184	0.184	0.184
Coal	0.332	0.332	0.332
Diesel	0.245	0.245	0.245
Petrol	0.234	0.234	0.234
Fuel oil industry	0.268	0.268	0.268
Burning oil domestic	0.247	0.247	0.247
LPG	0.214	0.214	0.214
Biomass solid	0.016	0.016	0.016
Biomethane	0.028	0.028	0.028
Hydrogen - Baseline	0.217	0.119	0.052
Hydrogen - Max ambition 2030	0.217	0.094	0.030
Hydrogen - High hydrogen 2038	0.217	0.044	0.012
Hydrogen - Balanced 2038	0.217	0.069	0.021
Regional gas grid - Baseline	0.184	0.182	0.180
Regional gas grid - Max ambition 2030	0.184	0.171	0.028
Regional gas grid - High hydrogen 2038	0.184	0.152	0.026
Regional gas grid - Balanced 2038	0.184	0.172	0.078

- The carbon intensity of most fuels is from the Government GHG reporting documents LINK
- The national electricity carbon intensity is from the HMT Green Book projections
- The Hydrogen carbon intensity is calculated from the assumed supply sources, with the breakdown between electrolysis and methane reforming varying by scenario
- The regional gas grid carbon intensity is calculated by scenario through the blend of natural gas, biomethane and hydrogen. The maximum availability of biomethane is from the NGN projections and hydrogen is limited to 20% by volume.

Contents

Transport Pathways: method summary (see next slide for references)

Road transport

1. Vehicle km by subregion and vehicle type built from DfT datasets[1]*
2. Current passenger modal share (walking, cycling, car, bus, motorcycle, train) derived at subregion level from analysis of National Travel Survey data (2016)[2]
3. Average passenger occupancy (number of passengers per vehicle) estimated for the whole study region based on total passenger km per mode[3] divided by total vehicle km
4. Current passenger km per mode estimated at subregion level using vehicle km and average occupancy, with walking, cycling and train passenger km scaled to match modal share analysis.
5. Average freight capacity (tonnes per vehicle) for heavy goods vehicles estimated for the whole study region to be in line with UK data;[4] for simplicity of modelling, van freight capacity is set to 1 but is not intended to reflect real behaviour
6. Tonne km per mode estimated at subregion level using vehicle km and average freight capacity
7. Car and van fleet share by fuel type based on consumer choice modelling[5]
8. Bus fleet share projections by fuel type based on those developed for WYCA Zero Emission Bus Roadmap
9. Heavy goods vehicle fleet share projections by fuel type based on modelling developed for Committee on Climate Change[6]
10. Emissions and energy consumption calculated based on fleet average real world fuel consumption,[7] well-to-wheel emissions factors and energy density[8]

Rail

1. Passenger km derived at subregion level from road transport data (see box, left)
2. Freight tonne km derived for the whole study region to be 10% of total heavy goods vehicle and rail goods moved, in line with UK average,[9] and disaggregated to each subregion based on analysis of freight train activity[10]
3. Passenger km fuel share estimated based on analysis of Leeds City Region passenger loads and line electrification[11]; freight fuel share assumed to be in line with UK average[12]
4. Emissions calculated at subregion level relative to historic diesel emissions,[13] with electric rail emissions estimated based on relative CO_2 intensity[14] adjusted for future grid decarbonisation and with share of emissions assigned to freight assumed to be in line with UK average[15]

Aviation

1. Domestic and international passenger data for Leeds Bradford Airport based on Civil Aviation Authority statistics[16]
2. Aviation fuel efficiency improvements modelled in line with analysis developed for the Committee on Climate Change[17]
3. Emissions calculated relative to national emissions[18] and disaggregated to subregions based on relative passenger share[19]

Other transport

1. Emissions calculated relative to historic emissions,[20] with lubricant emissions decreasing in line with fossil fuel vehicles

*Full vehicle breakdown available for West Yorkshire, North Yorkshire van, heavy goods vehicle, bus and motorcycle data extrapolated from “All motor vehicles” data based on Yorkshire and the Humber distribution (car data accurate)

Link to contents

Transport pathways – Key sources and references

1. DfT road traffic statistics Table TRA0206 and LA-level data
2. National Travel Survey, 2002-2016: Special Licence Access, study numbers 7553 and 7804
3. Table NTS9904 miles per person per year for Yorkshire and the Humber multiplied by population from ONS data
4. Tables RFS0110 and RFS0111, DfT road freight statistics; note that this data refers to activity of goods vehicles only (80% of heavy goods vehicle stock) but it is assumed that goods vehicles account for majority of heavy goods vehicle road activity
5. ECCo, developed for DfT
6. Analysis to provide costs, efficiencies and roll-out trajectories for zero emission HGVs, buses and coaches (2020, under review); shift of diesel to biomethane based on modelling for gas distribution network operator (2018, shared with DfT)
7. Analysis considers variation in fuel consumption and mileage travelled with age of vehicles, and incorporates improvements in fuel efficiency in new vehicles
8. Fossil fuel data: UK greenhouse gas conversion factors, including adjustment to account for introduction of E10 petrol from 2021; Biomethane: Element Energy Well-to-Wheel modelling developed for gas DNO; Hydrogen: production emissions in line with wider modelling, distribution emissions added assuming hydrogen is delivered to refuelling stations by truck
9. Table 13.2 Office of Rail and Road
10. Element Energy analysis of routes in North of England Freight Study, Network Rail
11. Leeds City Region Rail Capacity Analysis Draft Report
12. Table 2.101, Office of Rail and Road
13. BEIS LA CO_2 emissions dataset
14. Only diesel emissions are reported in the dataset for rail; electric rail emissions are included under the industrial and commercial sector and therefore must be estimated. Relative emissions intensity based on https://www.carbonindependent.org/files/aea_enviro_rep.pdf
15. Office of Rail and Road statistics
16. Civil Aviation Authority Tables 12_1 and 12_2
17. ATA (2018)
18. Emissions estimated by scaling UK aviation emissions (BEIS UK CO_2 inventory and statistical release) based on Leeds Bradford airport relative passenger share (Civil Aviation Authority statistics; 1.4% of international, 2% domestic)
19. Passenger share in 2017: 1.7% North Yorkshire, 22.3% West Yorkshire, 59.5% South Yorkshire and 16.6% Other, Civil Aviation Authority survey; Emissions distributed according to relative passenger share within Study Region (5% North Yorkshire, 65% West Yorkshire, 30% Barnsley based on population share of South Yorkshire)
20. BEIS LA CO_2 emissions dataset; share of emissions attributed to aircraft support vehicles estimated based on UK CO_2 inventory, with remaining emissions approximated to all be due to lubricants.

Transport pathways – Baseline demand growth assumptions

Y&NY

Sector	Unit	2020	2030	2038	Growth (2020 – 2038)	Source
Walking	Million passenger km	262	268	271	3%	Growth in line with population growth, ONS projections
Cycling		87	89	90	3%	
Cars	Million vehicle km	7,936	8,648	9,212	16%	DfT Reference scenario
Vans		1,631	1,810	2,012	23%	
Heavy goods vehicles		682	686	703	3%	
Buses		54	53	53	-3%	
Motorcycles		117	129	137	16%	EE assumption (in line with cars)
Passenger rail	Million passenger km	750	911	1,039	39%	Government Office of Science forecasts
Freight rail	Million tonne km	1,092	1,419	1,701	56%	Network Rail Freight forecasts
Domestic aviation*	Million passenger km	162	185	205	28%	DfT UK aviation forecasts
International aviation*	Million passengers	4.0	7.0	7.7	94%	

*Whole study region

Link to contents

Transport – Emissions pathways demand reduction and modal share assumptions

Demand reduction assumptions were applied relative to the Baseline scenario in all cases.

- **For passenger transport**, this reflects removal of trips through increased home working and teleconferencing, as well as reduction in trip length due to greater co-location of housing with workplaces and amenities. Overall demand reductions of 17% was applied in the Max ambition to reflect higher ambition, and 12% in the High hydrogen and Balanced.
- **For freight transport**, improved efficiency through consolidation was considered feasible in large urban areas, with 10% reduction in van and truck use assumed for these areas (2% reduction for the region overall). Further reduction of freight demand was assumed through consumer behaviour measures such as reductions in food and consumer goods waste and further operational efficiency (5% in High hydrogen and Balanced, 10% in Max ambition); in the Max ambition this was applied to both van and truck fleets, whereas it was only applied to truck fleets in the High hydrogen and Balanced scenarios.
- **For domestic aviation** passenger demand was reduced by 25% by 2040
- **For international aviation** demand reductions were applied in line with the Committee on Climate Change (CCC) Net Zero report. The High hydrogen and Balanced scenarios reflect the CCC's recommended level of growth reduction, limiting growth to 25% above current levels. For the Max ambition, growth was limited to maintain passenger numbers at current levels, to illustrate the impact of a more speculative and highly ambitious demand reduction level.

Modal shift of both passenger and freight were assumed for the emission reduction pathways

- **For passenger transport,** shift to active, public and shared transport was modelled (see next slides for detailed assumptions and methodology). The Baseline scenario assumes modal share only changes in line with growth demand assumptions. The Max ambition scenario targets maximum modal shift by 2030, and the High hydrogen and Balanced target maximum shift by 2038
- **For freight transport,** all emissions reduction pathways modal shift of 10% of tonne km from road to rail was considered feasible based on the proportion of goods moved into and out of the region from regions with rail links and/or ports. The shift of tonne km was assumed to apply to heavy goods vehicles in the heaviest segment (>18t gross vehicle weight) as these are primarily used for long haul trips. Modal shift from vans to cycle freight was assumed in all urban areas, equivalent to 1-2% of van km over each subregion. For all emissions reduction pathways, maximum freight modal shift was assumed by 2030.
- Shift of freight from road to river was out of scope of this study.

Transport pathways – Passenger modal share assessment methodology

Car journeys in the National Travel Survey dataset were assessed to estimate the potential for switching to another mode, with trips reallocated according to the following priority: walk > cycle > bus > train > shared car

Active travel

Adapted from similar analysis by TfL[1,2]

Trips were excluded from active travel if:

- Trip started between 20:00 and 06:00
- Trip purpose was to escort someone or for travelling to healthcare
- The trip consisted of more than one stage

Trips were considered feasible for walking if they were less than 2 km and feasible for cycling if they were less than 8 km or 10 km if for commuting. Active transport modes are assumed to include all modes of transport that are fully powered by the user but also modes such as electric bikes and electric push scooters where the user is assisted by mechanical propulsion.

Public and shared transport

Trips were assumed to switch to buses if they were up to 30 km and start and end in a major urban area. Trips were assumed to switch to trains if they were greater than 10 km and start and end in a major urban area (population greater than 50,000). Trips were switched to shared cars (e.g. car clubs, lift-sharing etc) if they start or end in an urban location, are greater than 10 km and unsuitable for conventional public or active transport.

Limitations of the approach

The analysis is based on trips reported to begin in the region and is therefore necessarily an approximation of travel behaviour since vehicle activity data includes all travel occurring within and through the region and subregions. The analysis also does not consider age, encumbrance (e.g. carriage of luggage or equipment) or disability of passengers which may affect which trips can be shifted. As such, it can be considered a maximum level of shift under the assumption that infrastructure is in place to ensure highest accessibility.

1. Analysis of cycling potential, 2016; 2. Analysis of walking potential, 2016

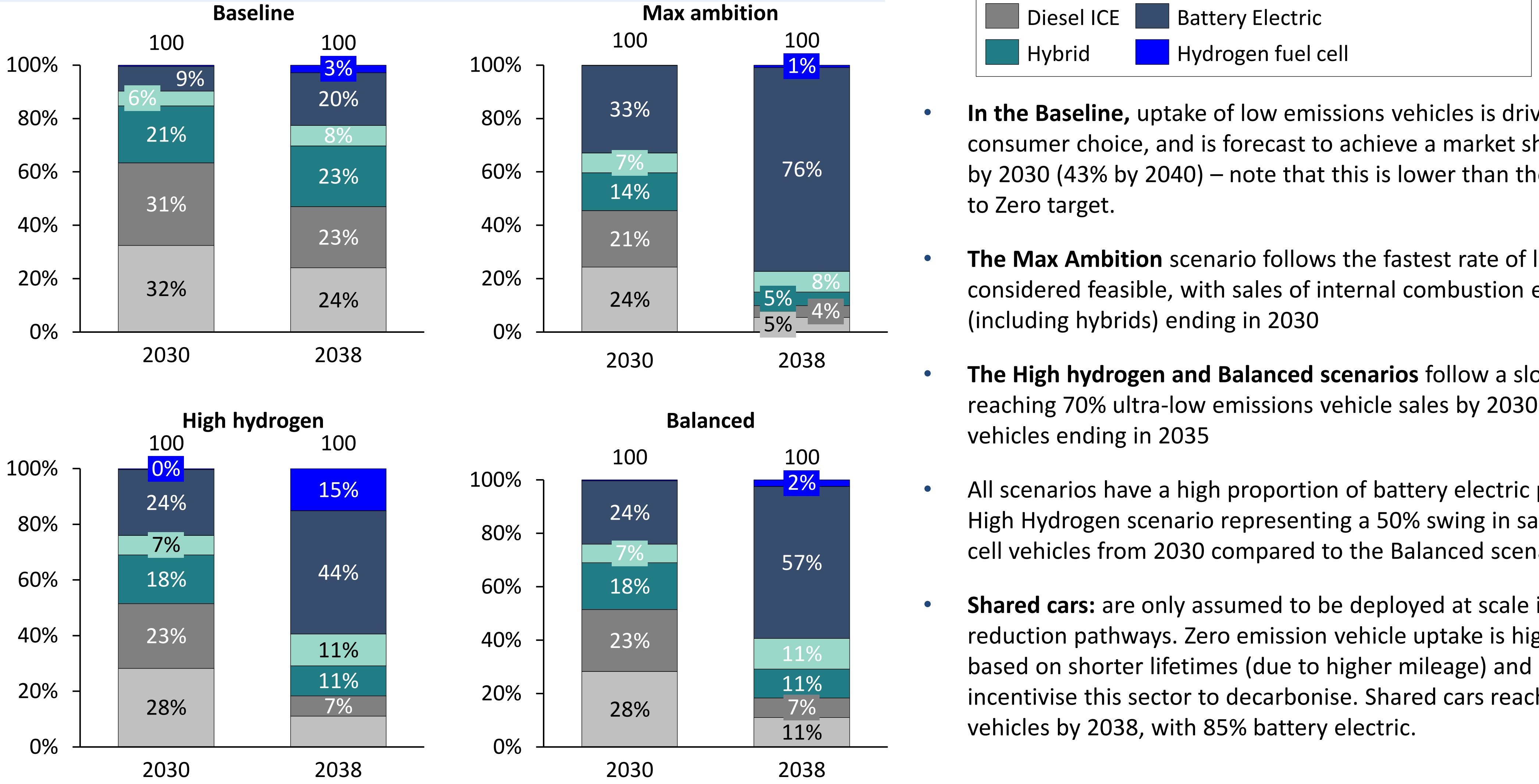
Transport pathways – Passenger modal share assumptions

- The Baseline scenario assumes modal share only changes in line with growth demand assumptions
- The Max ambition scenario targets maximum modal shift by 2030, and the High hydrogen and Balanced target maximum shift by 2038

Scenario	Mode	2020	2025	2030	2035	2038
Baseline	Walking	2%	2%	2%	2%	2%
	Cycling	1%	1%	1%	1%	1%
	Car (private)	85%	85%	85%	85%	85%
	Car (shared)	0%	0%	0%	0%	0%
	Motorcycle	1%	1%	1%	1%	1%
	Bus	5%	5%	5%	4%	4%
	Train	6%	6%	7%	7%	7%
Max ambition	Walking	2%	3%	3%	3%	3%
	Cycling	1%	3%	6%	6%	6%
	Car (private)	85%	69%	52%	52%	52%
	Car (shared)	0%	7%	14%	14%	14%
	Motorcycle	1%	1%	1%	1%	1%
	Bus	5%	7%	8%	8%	8%
	Train	6%	11%	16%	16%	16%
High hydrogen and Balanced	Walking	2%	2%	3%	3%	3%
	Cycling	1%	1%	3%	6%	6%
	Car (private)	85%	82%	68%	54%	54%
	Car (shared)	0%	2%	8%	14%	14%
	Motorcycle	1%	1%	1%	1%	1%
	Bus	5%	5%	7%	8%	8%
	Train	6%	7%	11%	15%	15%

Transport technology projections by sector: Cars

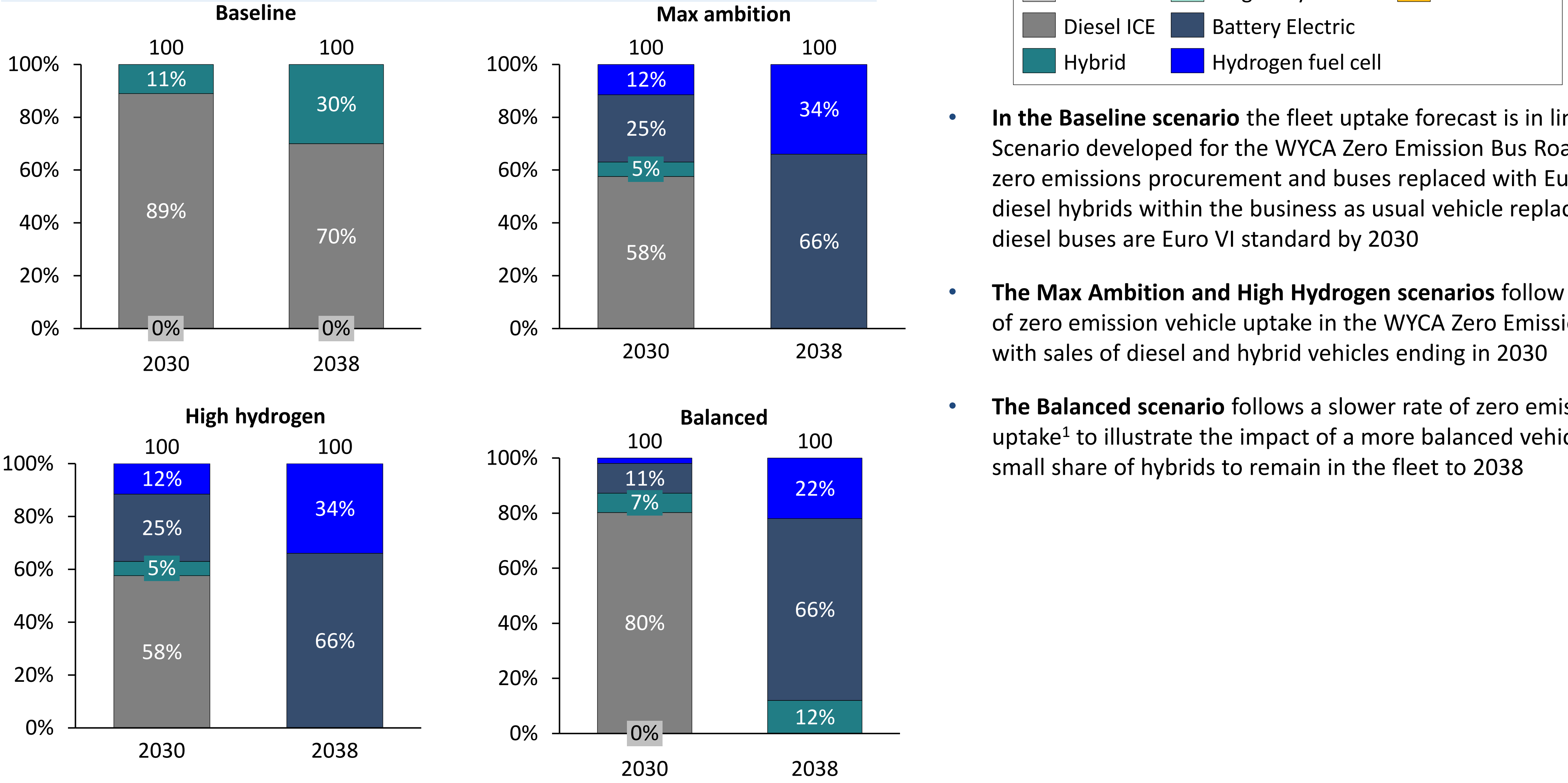
Share of vehicle stock by technology type (private cars)



- **In the Baseline,** uptake of low emissions vehicles is driven purely by consumer choice, and is forecast to achieve a market share of 29% of sales by 2030 (43% by 2040) – note that this is lower than the Government's Road to Zero target.
- **The Max Ambition** scenario follows the fastest rate of low emissions vehicles considered feasible, with sales of internal combustion engine vehicles (including hybrids) ending in 2030
- **The High hydrogen and Balanced scenarios** follow a slower rate of uptake, reaching 70% ultra-low emissions vehicle sales by 2030 and sales of ICE vehicles ending in 2035
- All scenarios have a high proportion of battery electric powertrains, with the High Hydrogen scenario representing a 50% swing in sales to hydrogen fuel cell vehicles from 2030 compared to the Balanced scenario
- **Shared cars:** are only assumed to be deployed at scale in the emissions reduction pathways. Zero emission vehicle uptake is higher for these vehicles based on shorter lifetimes (due to higher mileage) and greater ability to incentivise this sector to decarbonise. Shared cars reach 100% zero emission vehicles by 2038, with 85% battery electric.

Transport technology projections by sector : Buses

Share of vehicle stock by technology type

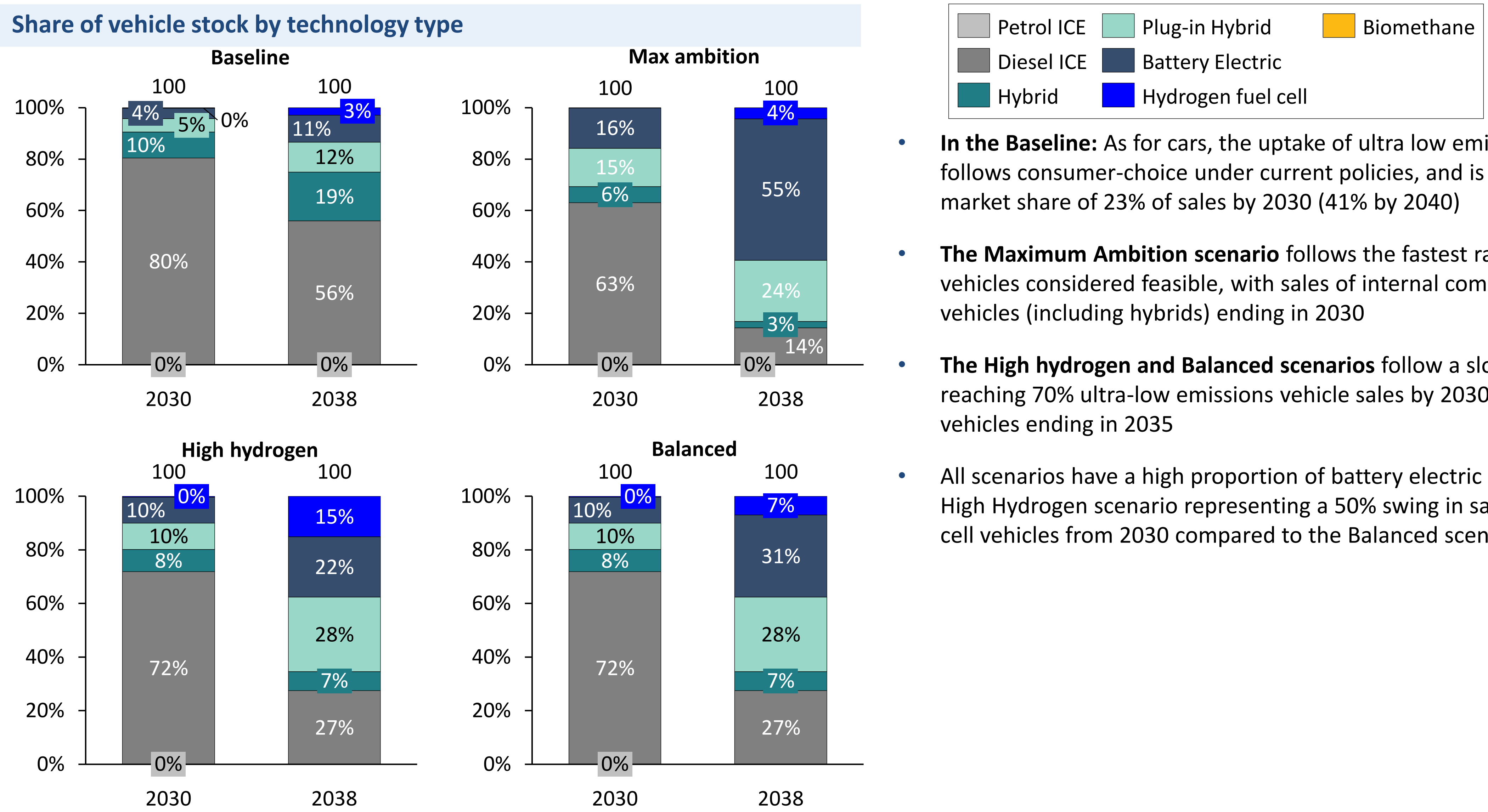


- **In the Baseline scenario** the fleet uptake forecast is in line with the Base Scenario developed for the WYCA Zero Emission Bus Roadmap, with no zero emissions procurement and buses replaced with Euro VI diesel or diesel hybrids within the business as usual vehicle replacement cycle; all diesel buses are Euro VI standard by 2030
- **The Max Ambition and High Hydrogen scenarios** follow the highest rate of zero emission vehicle uptake in the WYCA Zero Emission Bus Roadmap, with sales of diesel and hybrid vehicles ending in 2030
- **The Balanced scenario** follows a slower rate of zero emission vehicle uptake[1] to illustrate the impact of a more balanced vehicle mix, allowing a small share of hybrids to remain in the fleet to 2038

1. Based on the Gradual ZE Transition pathway in the WYCA ZE Bus Roadmap

Transport technology projections by sector: Vans

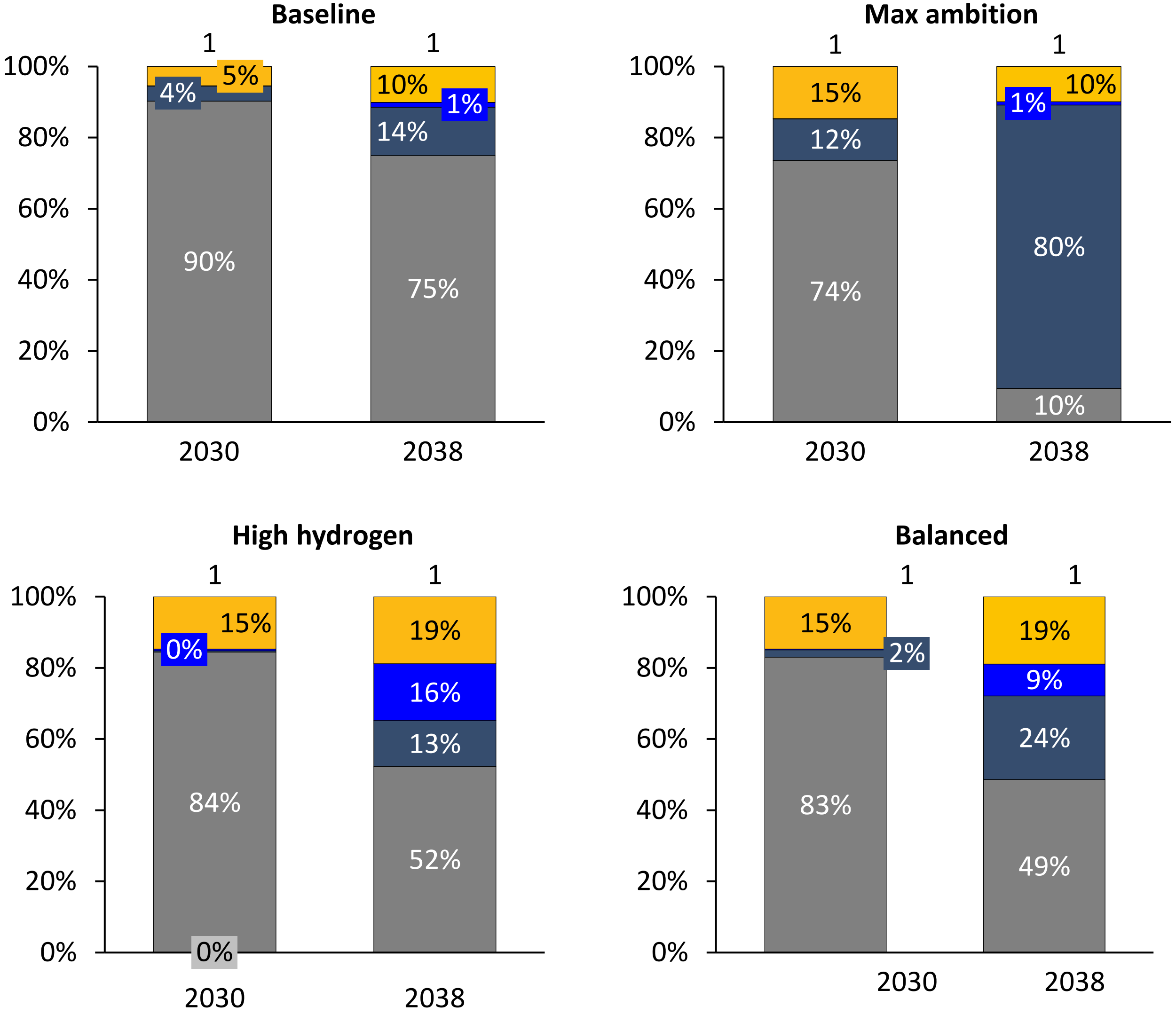
Share of vehicle stock by technology type



- **In the Baseline:** As for cars, the uptake of ultra low emissions vehicles[2] follows consumer-choice under current policies, and is forecast to achieve a market share of 23% of sales by 2030 (41% by 2040)
- **The Maximum Ambition scenario** follows the fastest rate of low emissions vehicles considered feasible, with sales of internal combustion engine vehicles (including hybrids) ending in 2030
- **The High hydrogen and Balanced scenarios** follow a slower rate of uptake, reaching 70% ultra-low emissions vehicle sales by 2030 and sales of ICE vehicles ending in 2035
- All scenarios have a high proportion of battery electric powertrains, with the High Hydrogen scenario representing a 50% swing in sales to hydrogen fuel cell vehicles from 2030 compared to the Balanced scenario

Transport technology projections by sector : Heavy goods vehicles

Share of vehicle stock by technology type[1]



- All scenarios consider biomethane uptake in the heaviest segments (>18 tonnes gross vehicle weight) as a low emissions[2] option for decarbonisation in the short-to-medium term. Biomethane uptake is based on the proportion of UK fleets with known strong interest in gas technology, and assumed to be driven by reduced fuel duty compared to diesel (currently 50%) and EU emissions targets (introduced 2019)
- **In the Baseline** the majority of zero emission vehicles sold are assumed to be battery electric as battery prices and technology benefit from rollout in the light vehicle markets
- **In Max ambition** the fastest rate of infrastructure and vehicle rollout is achieved through supportive policy and funding. Battery electric and hydrogen fuel cell vehicles are assumed to both experience cost reductions and technology improvements.
- **In the High hydrogen and Balanced** scenarios fast infrastructure and vehicle rollout is achieved through supportive policy.
- The high hydrogen scenario assumes that fuel cell vehicles are favoured over battery electric as hydrogen is assumed to be widely available and vehicle technology improves. The Balanced scenario represents a scenario where both battery electric and fuel cell vehicles become cost-effective

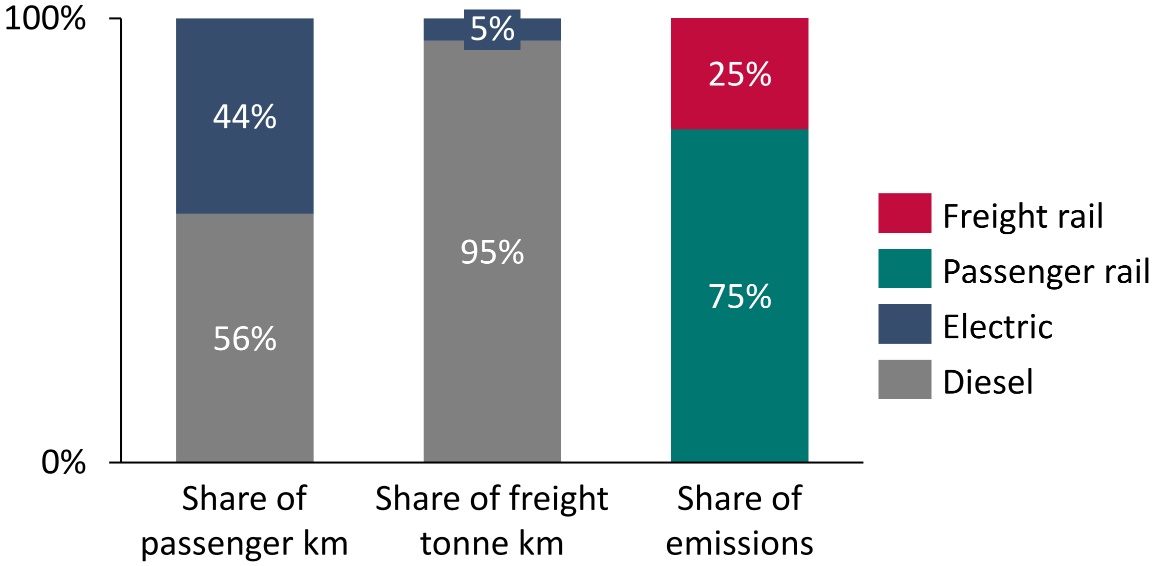
---

1. Note that vehicle stock and vehicle activity are not equivalent for heavy goods vehicles, since the heaviest vehicles account for a higher share of vehicle km travelled than their share of stock; this distinction is accounted for in the modelling; 2. Up to 85% reduction in well-to-wheel emissions compared to equivalent diesel vehicles

Transport technology projections by sector: Rail

- The majority of current passenger and freight km are assumed to be carried by diesel powertrains[1] and the baseline scenario assumes that no further electrification occurs
- The assumed highest electrification of passenger services (90% under Max ambition and 80% under High hydrogen and Balanced) assumption was based on Element Energy analysis of regional passenger services and is assumed to be achieved by 2030 under Maximum Ambition and by 2038 in the 2038 scenarios
- Hydrogen was considered out of scope for this study but could be a viable option for rural lines; a dedicated freight study would need to be carried out.

Assumed baseline fuel share and emissions by transport type[1]



---

[1] Passenger km fuel share based on Element Energy analysis of regional passenger services; freight fuel and emissions share in line with UK average (Source: Office of Rail and Road);

Contents

Buildings Pathways: method summary

Domestic buildings

1. Domestic building stock model built from national datasets such as NEED and ONS[1], broken down into building types, age and current fuel type -> building archetypes
2. Heat demand per building estimated from national assumptions by building archetype. Final fuel consumption then scaled to match Local authority energy datasets[1]
3. New building stock projections provided by N&W Yorkshire teams and domestic demolition assumed to be zero
4. Energy efficiency measures applied to each building archetype based on EE analysis for the CCC net-zero technical report and for the NIC, as well as the CGS[2,3,4,5].
5. Low carbon heating system installation in each building archetype based on EE analysis for the CCC[5], but accelerated to decarbonise more rapidly; roll-out rates moderate for next few years, then accelerate after planning following targets in CGS and CCC recommendations[2,3,4,8].
6. New buildings have high efficiency standards; they continue to install some gas boilers for next few years, but from 2025 all new build must install low carbon heat, primarily heat pumps[6].
7. Solar PV projections based on National Grid Future Energy scenarios[7].

Non-domestic buildings

1. Non-domestic building stock defined in terms of energy use (ECUK data[9]) by building archetype by end-use application
2. Number and floor area as supplementary information from government datasets[10].
3. Non-domestic growth rate follows subsector SIC growth provided by LCR team
4. BEES, ECUK and BEIS datasets used to assess current fuel demand breakdown by sector/application[9,11].
5. Energy efficiency assumptions (heat and non-heat) from EE analysis for the National Infrastructure commission, based on the BEES datasets and cost of efficiency measures[4,11].
6. Heating system projections based on a range of sources, including non-domestic subsector current state (BEES), CCC analysis and recommendations and CGS[2,3,11].

Key sources and references

1. NEED LINK ONS subnational statistics LINK LINK and Plumplot LINK BEIS subnational energy consumption statistics LINK
2. CCC Net-zero reports LINK
3. Clean Growth strategy LINK
4. EE for National Infrastructure Commission LINK
5. Element Energy work for CCC on hard-to-decarbonise homes LINK
6. Future homes standard LINK and Second Cost Optimal report LINK
7. National Grid FES and NPg DFES LINK LINK
8. H21 LINK and ZCH LINK
9. Energy Consumption in the UK ECUK dataset LINK
10. ONS UK business workbook LINK and floorspace LINK
11. BEES LINK
12. Published statistics including FiT RHI

Buildings Pathways: additional assumptions

Key buildings measures

Key measures assumed:

- **Ambitious energy efficiency** improvements to raise all homes to EPC C or better where possible and cost-effective (Clean Growth Strategy), targeting 25%-35% heat demand reduction in existing buildings on average.
- **New buildings** from early-mid 2020s to install low carbon system (heat pump or low carbon DH) and implement high efficiency standards
- **District heating in heat dense areas** (above ~30 kWh/m^2, national max potential 19% homes and 45% non-residential[1]), including many flats and commercial buildings (e.g. areas of Leeds, Bradford, York). 5-6 years from inception to operation. No spatial analysis was completed in this study.
- **Off-gas grid buildings** to be supplied primarily by heat pumps, hybrid HP and/or bio-boilers[1A] (primarily in North Yorkshire)
- **Hydrogen for heat[2]** not available in domestic homes until 2028 in the High H_2 scenario. The Max ambition scenario assumes no H_2 conversion of the gas grid and the Balanced scenario assumes areas of grid conversion from 2030.

Assumptions

Heating system efficiency	2020	2038
Gas boiler	0.86	0.90
Oil boiler	0.84	0.90
Direct electric	1.00	1.00
Air-to-air heat pump	3.38	3.38
Heat pump (air-to-water)	2.65	3.58
Hybrid heat pump	2.29	3.04
Hydrogen boiler	0.86	4.00
Bioenergy boiler	0.85	0.90

Further assumptions:

- Hybrid heat pumps are assumed to rely 80% on the heat pump and 20% on a boiler, such as natural gas or bio-LPG
- District/communal heating heat supply is initially assumed to be primarily gas CHP for existing units, but by 2030 the majority of heat is supplied by large scale heat pumps, supported by hydrogen if available.
- Non-domestic cooling demand is assumed to increase by 20% by 2038 (Arup 2018).
- Non-domestic non-heat applications are primarily using electricity. Those that use other fuels (e.g. some catering) are assumed to switch to electricity in most cases, or a small amount of hydrogen where available.

---

1 Source: Element Energy work for CCC Net-Zero on hard-to-decarbonise homes and CCC Net-Zero report; 1A eg bioLPG

2: ZCH CCUS first installation 2027 and scale-up CCUS and hydrogen from 2028 onwards; H21 conversion of heat 2028-2034

Buildings Pathways: scenario measures comparison

	Scenario			
Intervention	Baseline	Max ambition	High H_2	Balanced
Energy efficiency	Low	High	Medium/High	High
Heat pumps	Low	Max	Medium	Medium/High
Hybrid heat pumps	Low	Low	High	High
Hydrogen boilers	None	None	High	Medium
Direct electric heating	Medium	High	Low	Medium
District/communal heating	Low	High	High	High
Bioenergy[1]	Medium	Medium	Medium	Medium

The table above gives an indication where the effort is focused in each scenario

The Max ambition scenario focusses on maximum deployment of heat pumps. This is supported by district/communal heating and electric storage heating, particularly in space constrained urban homes. There are no hydrogen boilers and limited hybrid heat pumps due to the assumptions that the gas grid is not converted to hydrogen.

The high hydrogen scenario focuses on gas grid conversion to hydrogen to enable large-scale hydrogen boiler installation from 2028. This is supplemented by hybrid heat pumps and district/communal heating. Slightly lower energy efficiency ambition is assumed due to the lower levels of heat pumps requiring high thermal standards.

The balanced scenario involves a mix of technologies, with partial gas grid conversion enabling some hydrogen boilers, some gas boilers supplied by biomethane, and high hybrid heat pumps using H_2, bio-LPG or biomethane, again supplemented with district/communal heating.

---

[1] Bioenergy is a limited resource and is used in different ways across the scenarios (biomass/bio-LPG boilers, bio-LPG hybrid heat pumps, biomethane in the gas grid, biogas used in hydrogen production) See bioenergy slide in "additional information"

Link to contents

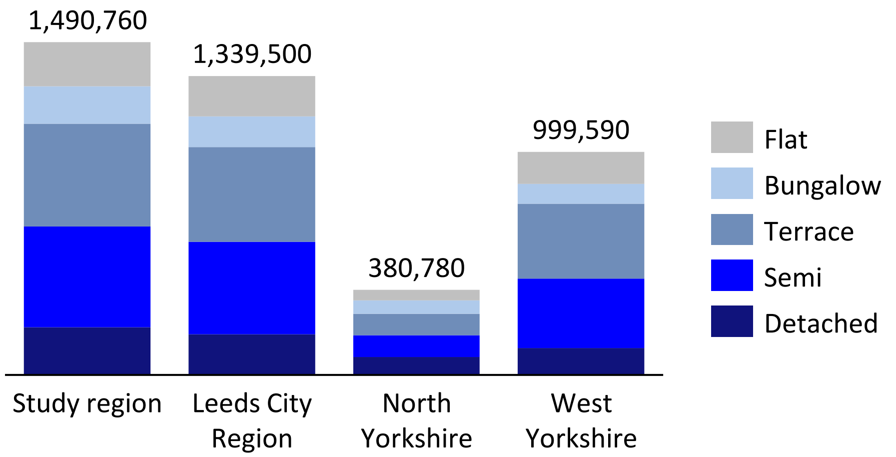
Building stock assumptions and data

The buildings sector is split into 12 different building archetypes to allow differing assumptions to be applied

Domestic

- As discussed in the method summary, a domestic building stock model built from national datasets such as NEED and ONS[1], broken down into building type, age and current fuel type. This forms building archetypes.
- The graph to the right shows the breakdown by building type. The stock model was estimated by subregion separately.
- The domestic sector is dominated by terrace and semi-detached homes, with detached homes representing a larger share of emissions than number.

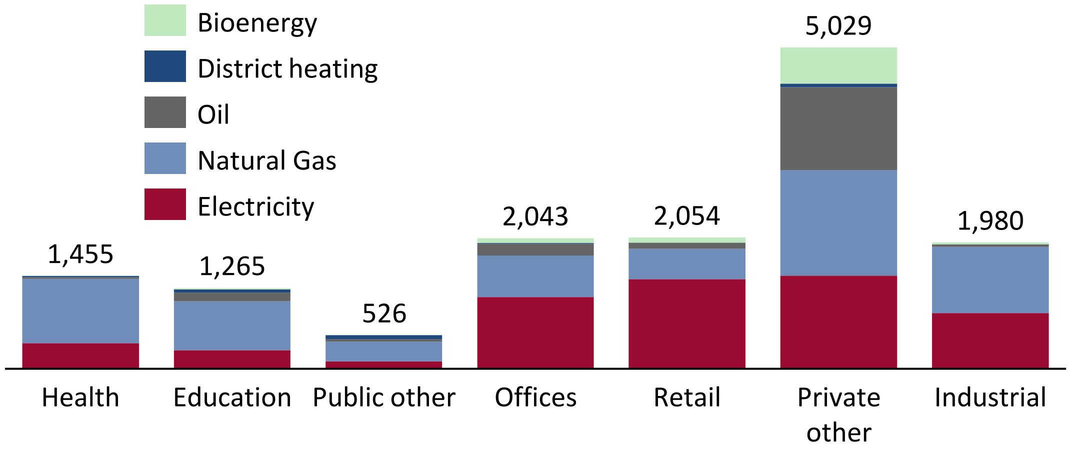
Domestic building stock by type (number)



Non-domestic

- In contrast, the non-domestic building stock is built up by sector type and current fuel consumption, from the ECUK and BEES datasets (these are both national and are scaled to the region by looking at the proportion of each non-domestic sector that exists in the study region)[2,3,4].
- Different assumptions are applied to each sector.
- The non-domestic sector is dominated by privately owned buildings, such as offices, retail, catering and restaurants.

Energy consumption estimate for non-domestic buildings by sector (GWh/yr)



---

1 NEED LINK ONS subnational statistics LINK LINK; 2 Energy Consumption in the UK ECUK dataset LINK; 3 ONS UK business workbook LINK and floorspace LINK; 4 BEES LINK

Domestic energy efficiency assumptions - deployment scenarios are based on the cost-effectiveness of measures

We used our recent building stock models for the CCC and National Infrastructure Commission to develop energy efficiency rollout scenarios. The energy efficiency measures have been divided into three cost-effectiveness bands: Low cost, Medium cost, High cost measures, and technical potential, which are deployed over different timepoints, as below (i.e. low cost measures can be rolled out faster to meet Clean Growth Strategy aims).

Cost-effectiveness band	Cost effectiveness range (£/tCO$_2$ abated)
Low cost	<0
Medium cost	0-150
High cost	150-400
Technical potential	>400

The rate of deployment was adapted to accelerate implementation so that the majority of interventions were complete by the early 2030s.
The results are shown in the main results pack.

The cost effectiveness bands have been used to develop three different deployment scenarios, as below:

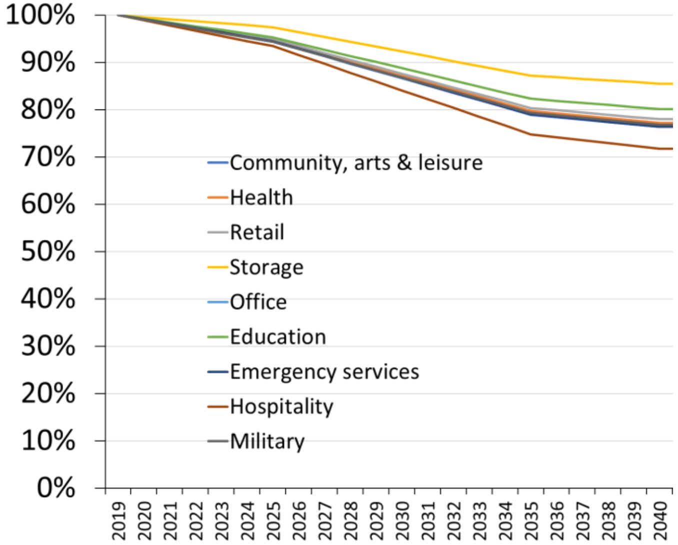
Scenario	Description
Low cost energy efficiency (Baseline scenario)	Low cost energy efficiency measures only applied
Medium cost energy efficiency (High H$_2$ scenario)	Low and Medium cost energy efficiency measures applied
High cost energy efficiency (Max ambition & balanced)	Low, Medium and High cost energy efficiency measures applied

https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf ;
https://www.theccc.org.uk/publication/analysis-on-abating-direct-emissions-from-hard-to-decarbonise-homes-element-energy-ucl/

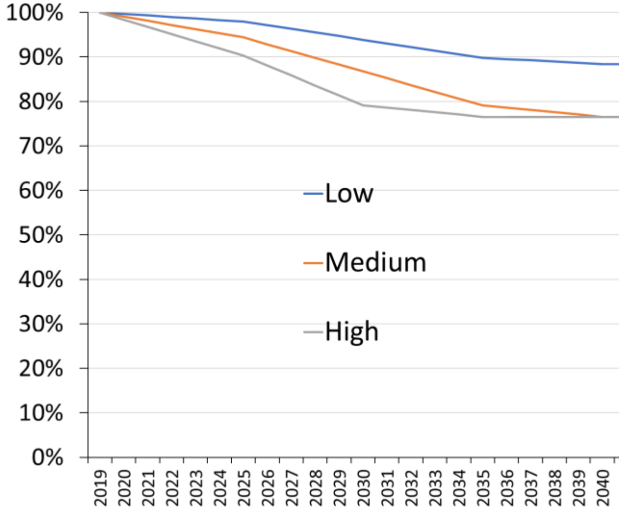
Thermal energy efficiency in the non-domestic stock

- The underlying data for thermal energy efficiency in the I&C (Industrial and Commercial) stock is based on data from BEIS's Building Energy Efficiency Survey. From this data, we have been able to estimate the savings potential and cost-effectiveness of the measures, as with the domestic stock (in £/tCO_2 abated). The cost bands are the same as in the domestic scenarios.
- For thermal energy efficiency, we consider 'Building instrumentation and control' and 'Building fabric' measures. The graph below left shows the medium cost scenario, broken down by sub-sector.
- In the I&C sector, all thermal efficiency measures fall in the 'low' and 'medium' cost bands i.e. less than £150/tCO_2 abated. The high scenario differentiates itself from the medium scenario by achieving the same abatement potential in a shorter amount of time.
- In the 'Offices' sector, an estimated 23% thermal savings can be made through the application of building fabric measures and through building instrumentation and control. Scenarios for each sub-sector have been developed.

Medium cost scenario, all sectors



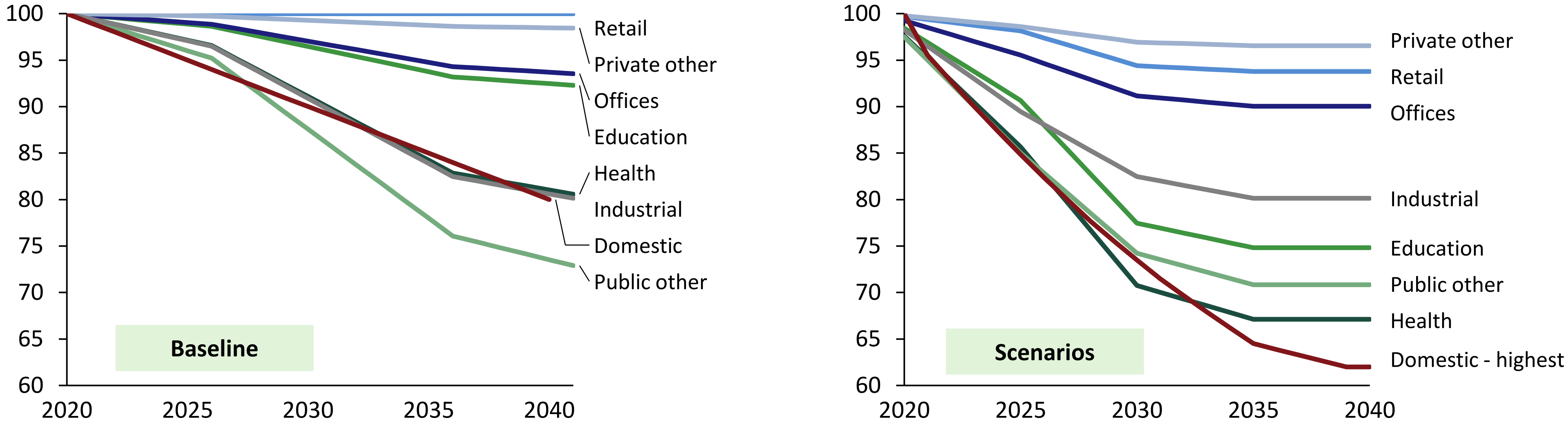
Low, medium and high scenarios.
Sector: Offices



Electrical efficiency measures assumptions

Study region

Efficiency measures for electrical non-heat activities by subsector (% of 2020 energy demand)



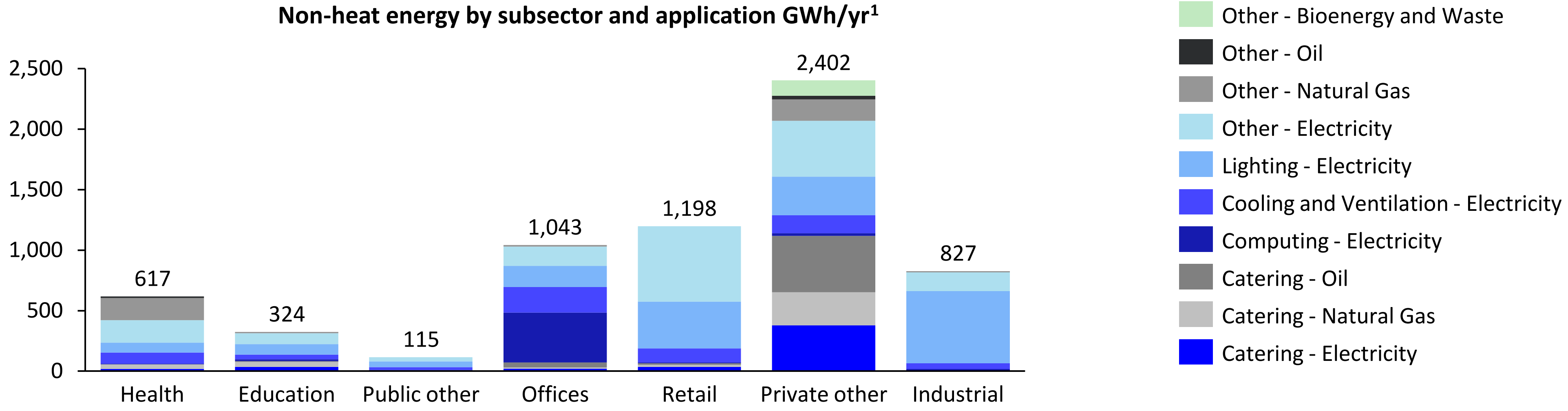
- Electrical efficiency measures reduce electricity demand for applications such as lighting, cooling, appliances and electric catering. This supports electricity infrastructure, reducing the cost of upgrades.
- **Non-domestic**: The underlying data for electrical efficiency in the I&C stock is based on data from BEIS's Building Energy Efficiency Survey (2015).
- For domestic, electrical efficiency was taken from the modelling underpinning London's Climate Action plan. This includes efficiency in home lighting and appliances. Electrical efficiency is not as urgent, because heat decarbonisation and technologies do not rely on any electrical efficiency having been completed.
- The baseline scenario follows a less ambition path (left), while all emissions scenarios follow the more ambitious energy efficiency pathway (right).

It should be noted that the work around energy efficiency is necessarily high level due to the extremely broad nature of this study; we have not looked at the individual measures with respect to their deployment levels.

BEES data https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees

Buildings – non-domestic stock - non-heat energy

Study region



- The graph shows the estimated current non-domestic non-heat fuel consumption (ECUK) for the study region to give an idea of the other applications and their fuel breakdown (included in the final energy and emissions results). Direct emissions are a small proportion of those from the buildings sector.
- The majority of non-heat energy is supplied through electricity (~77% non-domestic and almost 100% domestic), shown in blue on the graph.
- Key applications are cooling, ventilation, computing, lighting, appliances and some catering.
- All applications which currently use electricity remain on electricity (as this will decarbonise).
- It is assumed that there is an increase of 20% in non-domestic cooling demand[1].
- We assume the phase out of oil and later natural gas, replacing this with electricity and a small amount of hydrogen and/or bioenergy.

---

1 Adapted from ECUK

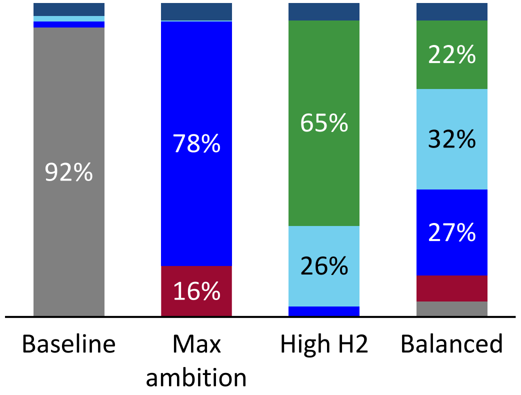
2: Arup WP2 CAP Technical Assistance for London Work Package 2

Buildings – domestic heating system assumptions (1/2)

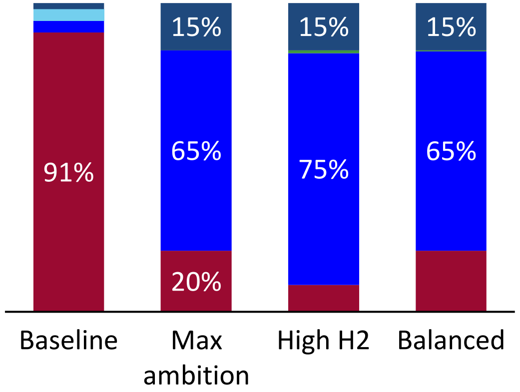
Study region

Detached homes 2040

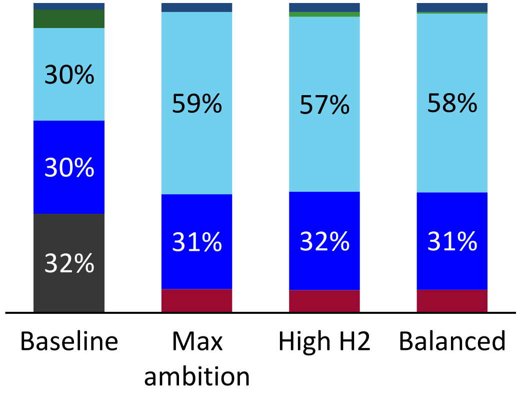
Detached homes currently with gas counterfactual (~89%/73%)



Detached homes currently with electricity counterfactual (~9%/9%)

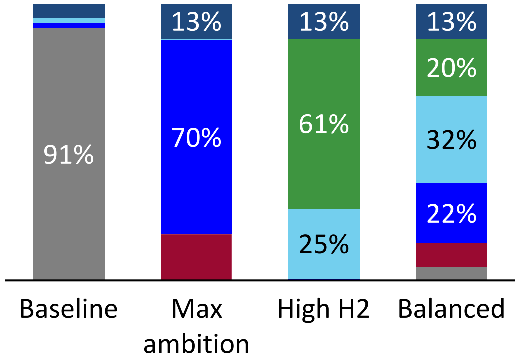


Detached homes currently with off-gas oil, LPG or bioenergy (~1%/19%)

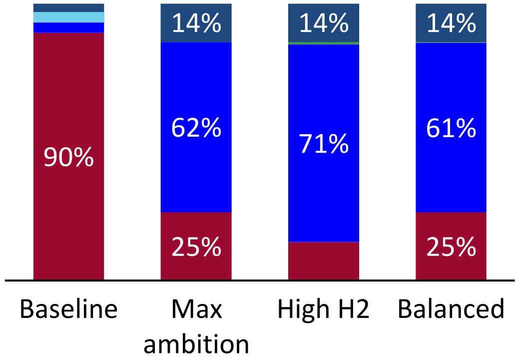


Semi detached 2040

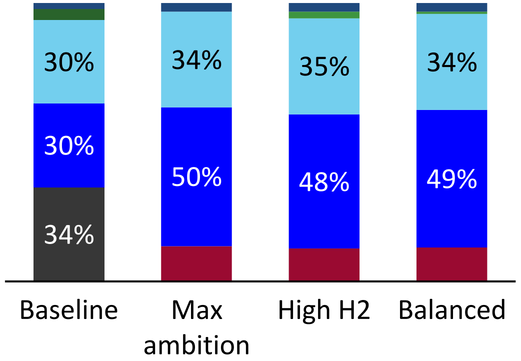
Currently with gas counterfactual (~89%/73%)



Currently with electricity counterfactual (~9%/9%)



Currently with off-gas oil, LPG or bioenergy (~1%/19%)



- 🟦 Communal heating
- 🟦 District heating
- 🟩 Hydrogen boiler
- 🟩 Bioenergy boiler
- 🟦 Hybrid HP
- 🟦 Heat pump
- 🟥 Electric heating
- ⬛ Oil boiler
- ⬛ Gas boiler

These charts show the 2040 heating system breakdown for each home archetype. The archetype distinction in this case includes the home type (e.g. detached) and the current heating system (e.g. gas boiler).

These assumptions are the same for all subregions, but the stock breakdown differs, and therefore the end result differs.

The % in the graph title is the proportion of that home type with that counterfactual heating system. Blue is WY, green Y&NY.

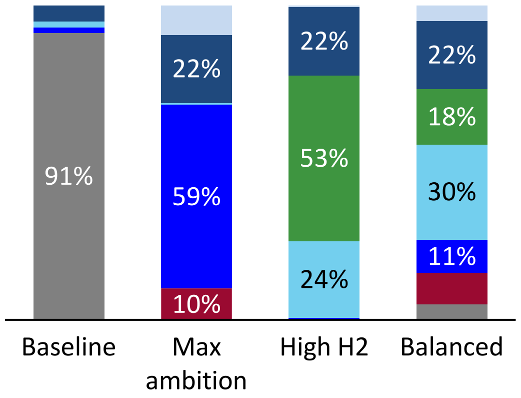
Note that "Heat pump" and "Hybrid HP" both refer to air-to-water heat pumps. Hybrids may be electric-gas, electric-H2 or electric-bioLPG

Buildings – domestic heating system assumptions (2/2)

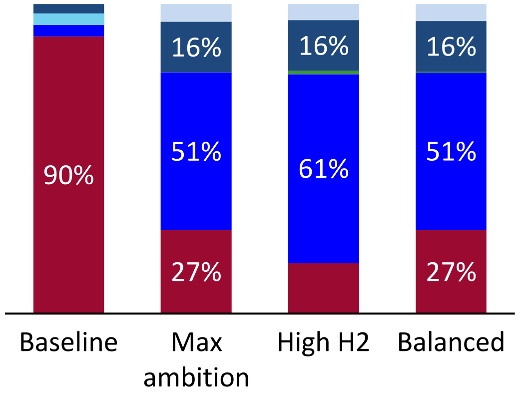
Study region

Terrace homes 2040

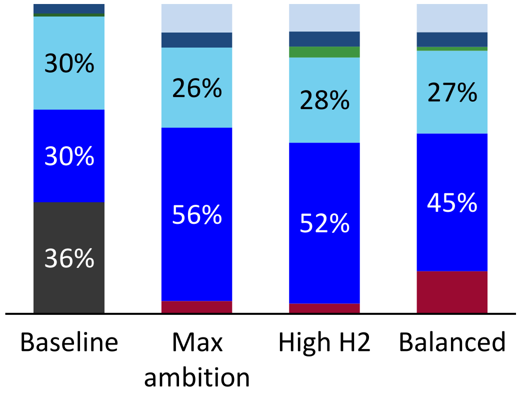
Homes currently with gas counterfactual (~89%/88%)



Homes currently with electricity counterfactual (~11%/12%)



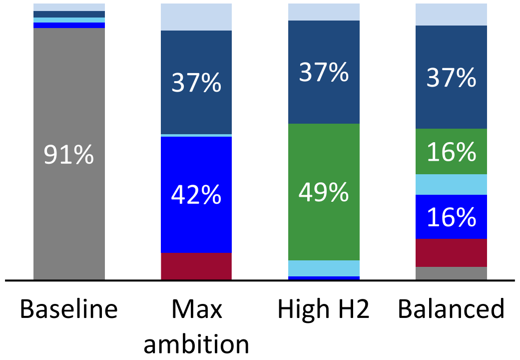
Homes currently with off-gas oil, LPG or bioenergy (<1%)



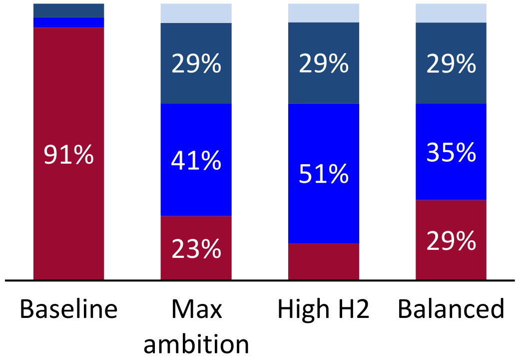
- ▨ Communal heating
- ▨ District heating
- 🟩 Hydrogen boiler
- 🟩 Bioenergy boiler
- ▨ Hybrid HP
- ▨ Heat pump
- 🟥 Electric heating
- ▨ Oil boiler
- ▨ Gas boiler

Flats 2040

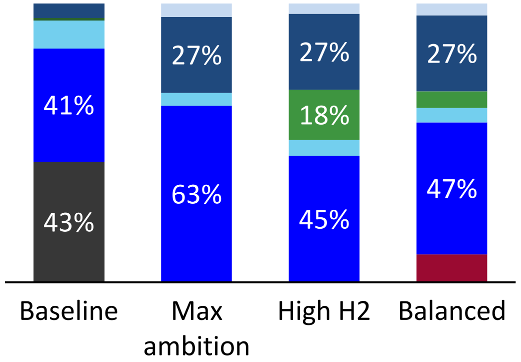
Flats currently with gas counterfactual (~83%/81%)



Flats currently with electricity counterfactual (~17%/19%)



Flats currently with off-gas oil, LPG or bioenergy (<1%)



These charts show the 2040 heating system breakdown for each home archetype. The archetype distinction in this case includes the home type (e.g. detached) and the current heating system (e.g. gas boiler).

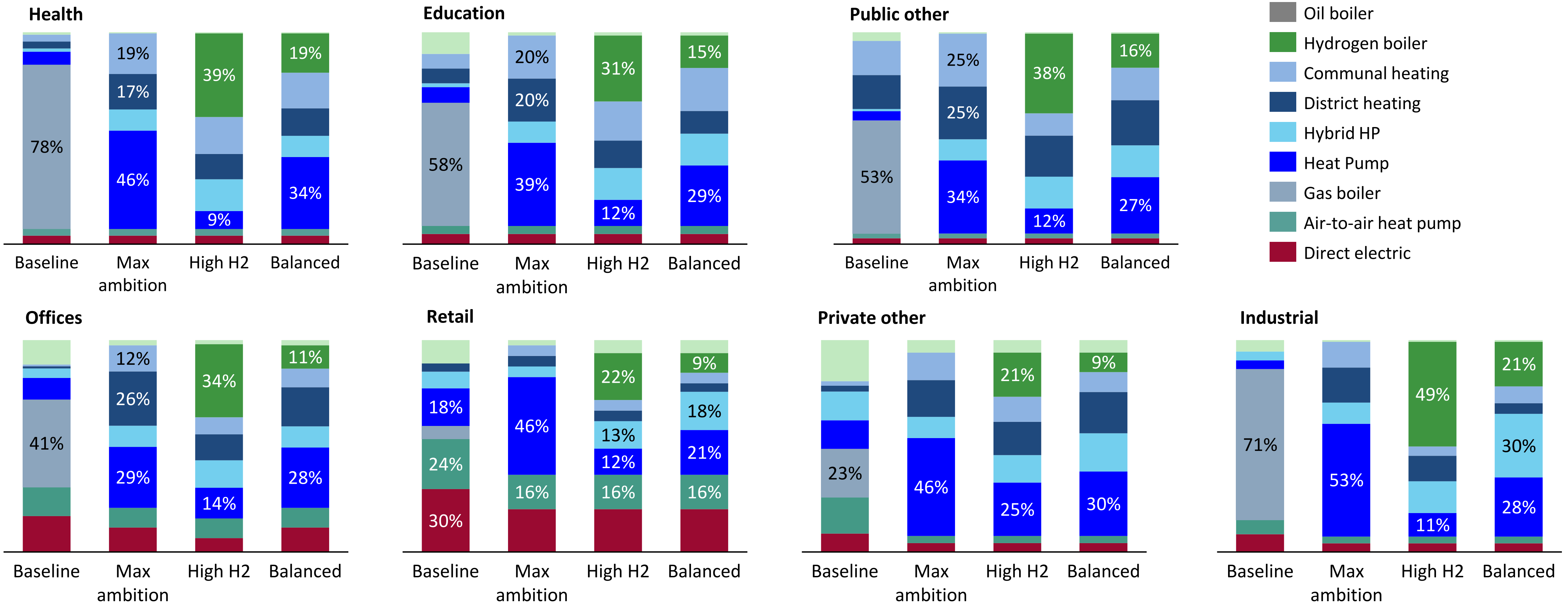
These assumptions are the same for all subregions, but the stock breakdown differs, and therefore the end result differs.

The % in the graph title is the proportion of that home type with that counterfactual heating system. Blue is WY, green Y&NY.

Note that "Heat pump" and "Hybrid HP" both refer to air-to-water heat pumps. Hybrids may be electric-gas, electric-H2 or electric-bioLPG

Buildings – non-domestic heating system assumptions

Heating system Breakdown in 2040 by heat delivered

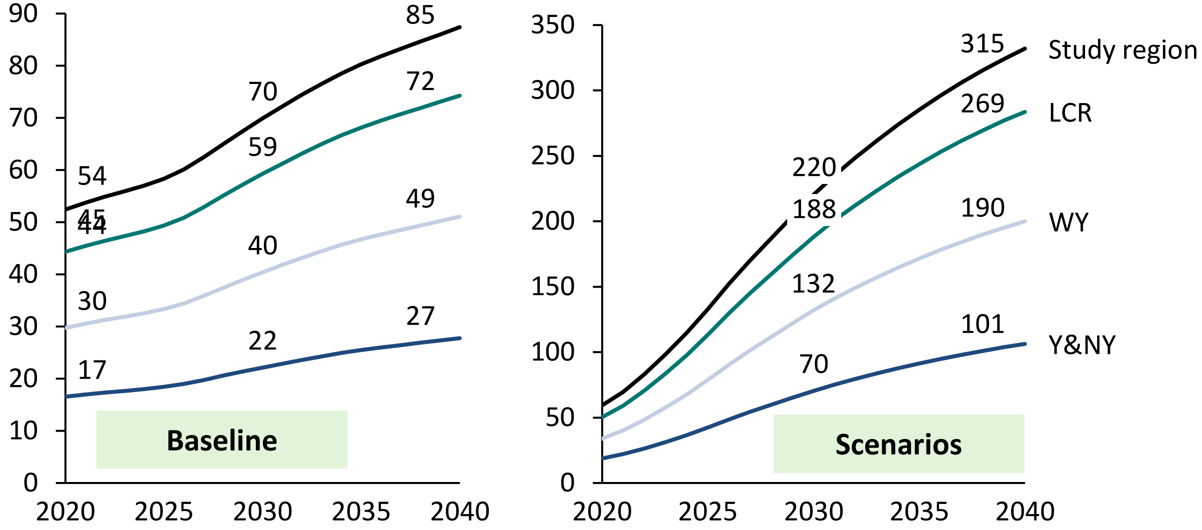


The non-domestic heating system options are broadly similar to domestic homes. Some building types e.g. retail, have a significant proportion of dry heating systems. Non-domestic properties are typically in more urban areas, so a higher proportion of district heating may be achieved. Many large multi-building complexes (eg Universities and hospitals) have the potential for communal heating systems. It should be noted that there is limited information on the breakdown of current heating systems in the non-domestic sector, leading to greater uncertainty.

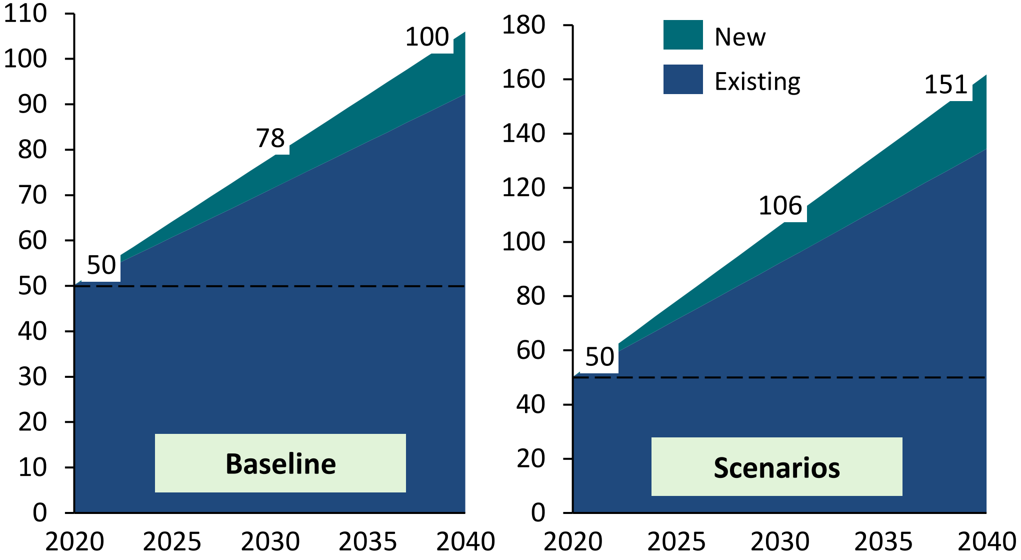
Building scale solar PV assumptions

Study region

Number of domestic installations by subregion ('000s)



Non-domestic solar PV – electricity produced GWh/yr



- Domestic solar PV installations for each local authority follow the Northern PowerGrid projections. The baseline scenario follows the "Steady progression" trajectory, and all 3 emissions reduction scenarios follow the "Community renewables" trajectory.
- Non-domestic solar PV, modelled as capacity/energy delivered, uses data from the Feed In Tarif subsidy (FiT) scheme to estimate potential deployment projections. In the baseline scenario, the generation increases at half the rate it did under the Feed In Tarif subsidy (now removed) over the past 9 years. Although the FiT is no longer in place, the cost has decreased sufficiently for installations to continue unsubsidised. The emissions reductions scenarios see solar PV be deployed at the same rate as under the FiT.
- Solar PV is assumed to be installed on new buildings at build – around 15% new buildings, varying by subsector (e.g. 25% of private non-domestic, 15% detached homes and 5% flats).
- The electricity produced at a building scale is subtracted from the building electricity demand before calculating emissions from buildings (i.e. it is netted off before the demand from the electricity grid).
- Solar PV is assumed to be installed on new buildings at build – around 20-50% new buildings, varying by subsector.

Sources: Domestic projections from National Grid FES and NPg DFES LINK LINK Non-domestic projections based in FiT data uptake rates

Back-to-back homes are a challenge in areas of Yorkshire, but solutions are developing

Intro

Yorkshire has a high number of back-to-back terrace homes, which are not typical across many areas of the UK. These have a number of features which may make them harder to decarbonise than other homes types. There is uncertainty as to best pathway, both technically and financially, but solutions must be developed urgently.

The challenge[1]

There are a number of challenges associated with back-to-backs making them harder to retrofit and decarbonise, such as[1]:

- Space constraints, restricting heating system choice and internal wall insulation
- Access limitations and visual disruption concerns on the front wall
- Solid walls (or hard-to-fill cavity walls), which are more expensive to insulate
- Some are low value with low income households -> affordability challenges

Solutions[1] (HP = heat pump)

Heating systems applicable to space constrained homes (in close proximity):

- District heating and communal heat pumps (external large heat pump serving a whole terrace)
- Hydrogen boilers
- Direct electric storage or panel heaters
- Hybrid HP or HP using high density thermal storage (depending how constrained & thermally efficient). For back-to-backs there is a visual challenge.

Heating systems applicable to low efficiency homes:

- Hybrid heat pump
- Hydrogen boilers
- Communal HPs (if high enough temperature or supplemented by some direct electric heating)

Efficiency measures:

- Thin solid wall insulation
- Loft insulation, glazing etc.
- Novel methods being developed e.g. some Energiesprong methods and those in research[2]

---

[1] Hard-to-decarbonise homes, Element Energy and UCL for CCC, LINK

[2] Engagement with ECITB and review of the Energiesprong approach LINK

Contents

Power Pathways: method summary

Distributed generators

1. The power sector is modelled by determining current and future installed capacities, load factors and emissions intensities of all generation technologies, which are then used to calculate total emissions and generation by each technology as well as the regional grid intensity.
2. 2019 capacities of solar PV and cooking oil generation are taken from the Renewable Energy Planning Database[1], whereas capacities for onshore wind, small bioenergy, sewage sludge and landfill gas are taken from LA statistics[2].
3. Electricity only and CHP Energy from Waste (EfW) capacities and short-term growth rates are based on a UK market review[3]. For these technologies, a single decarbonisation scenario is created where a third of all new capacity is assumed to be CHP plants. Total capacity is capped by UK waste gap analysis and by 2040 half of all capacity is converted to EfW CCS, in accordance with CCC[4].
4. Solar and onshore wind capacities are determined by taking a percentage of new added UK capacities in National Grid's Future Energy Scenarios (FES)[5] according to the land area of the study region, and the deployment accelerated to account for regional net-zero targets. FES are also used to calculate capacities of dedicated bioenergy, AD and landfill gas generation, as well as battery storage installations.
5. Capacities of small fossil generation are taken from NPg's resource register[6].
6. Renewable technologies are assumed to have a constant load factor equal to past regional averages[7].

Large centralized plants

1. Drax coal power generation is assumed to cease in 2021, as its capacity contract runs out.
2. Drax biomass turbines are retrofitted with CCS, starting from 2027. BECCS runs at baseload creating negative emissions. These are excluded from power sector calculations and are handled separately in the model. It is assumed that only non-CO_2 GHGs count towards net emissions from bio-based feedstocks[8].
3. A new large-scale gas power plant is assumed to be build in North Yorkshire in 2023/24, in accordance with Drax's plans. This plant is fitted with CCS in early 2030s.
4. A 300 MW hydrogen power plant is built in 2030 in Balanced and Max Ambition Scenarios, followed by another 2 plants in High H_2. Plants run during peak demand and H_2 is sourced from natural gas + CCS.

Key sources and references

1. December 2019 Renewable Energy Planning Database LINK
2. Renewable electricity by local authority, BEIS 2019 LINK
3. Tolvik 2018 UK Energy from Waste Statistics LINK
4. CCC 2019 Net Zero Report LINK
5. National Grid Future Energy Scenarios 2019 LINK
6. Northern Powergrid system wide resource register 2019 LINK
7. DUKES 6.5: Digest of UK Energy Statistics LINK
8. UK GHG Conversion Factors, BEIS & Defra LINK

Power Pathways: scenario measures comparison

	Scenario*			
Intervention	Baseline	Max ambition	High H_2	Balanced
Solar PV & Onshore wind	Low	High	Medium	High
Large Gas & Gas CCS	Medium	High	Medium	Medium
Bioenergy with CCS (BECCS)	None	High	High	High
Hydrogen	None	Medium	High	Medium
Energy from waste	High	Low	Low	Low
Energy from waste with CCS	None	High	High	High
Small fossil	Low	Low	Low	Low
Small bioenergy & AD	Low	High	Medium	High
Demand side response	Low	High	Medium	High
Electricity storage	Low	High	Medium	High

The table above gives an indication where the effort is focused in each scenario

All scenarios phase out coal by 2021, retrofit Drax's biomass turbines with CCS to achieve negative emissions through BECCS and build a new large gas power plant, which is retrofitted with CCS in early 2030s. Ambition level of energy from waste (EfW) technologies are the same across scenarios since this is driven by the waste sector to a degree. Scenarios slow down EfW build rate by mid-2020s and retrofit them with CCS. Small fossil generators shrink in size or utilization rate across all scenarios.

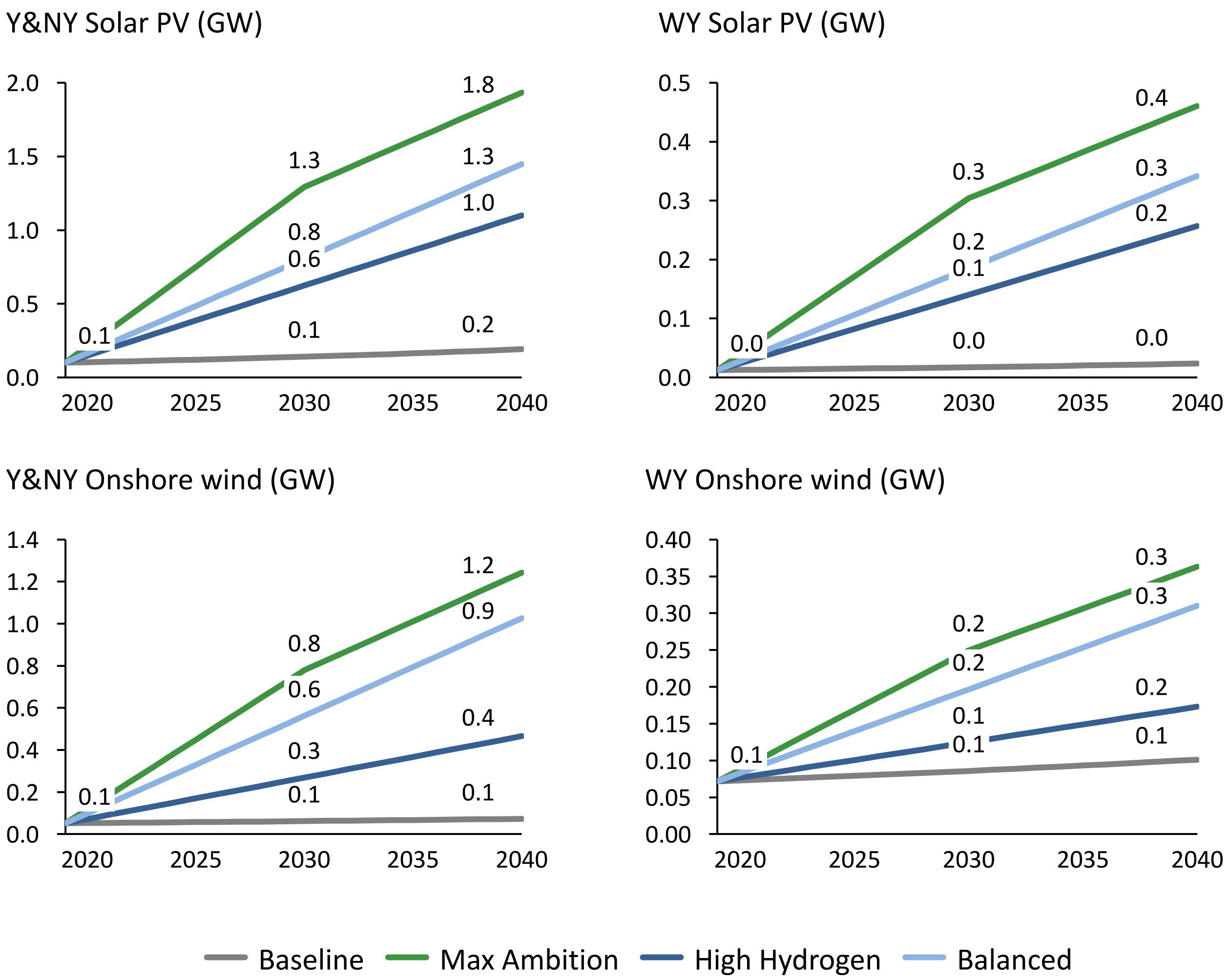
The Max Ambition Scenario achieves fastest emissions reduction through accelerated renewables, bioenergy and AD uptake. High electrification increases power demand significantly, which is partially offset by building a larger gas power plant with CCS. Decentralized technologies are favoured, including storage and demand side response (DSR).

The High Hydrogen Scenario builds more hydrogen generation assets as the economy replaces natural gas by hydrogen to a large extend. Many other technologies are more limited in size as power demand does not increase as much as in other scenarios.

The Balanced Scenario is similar to the Max Ambition scenario in the sense that increased electrification require high renewable uptake, but adaption rates are spread across the model timeline more evenly and less total power output is achieved.

* Low/Medium/High classification is relative to each technology.

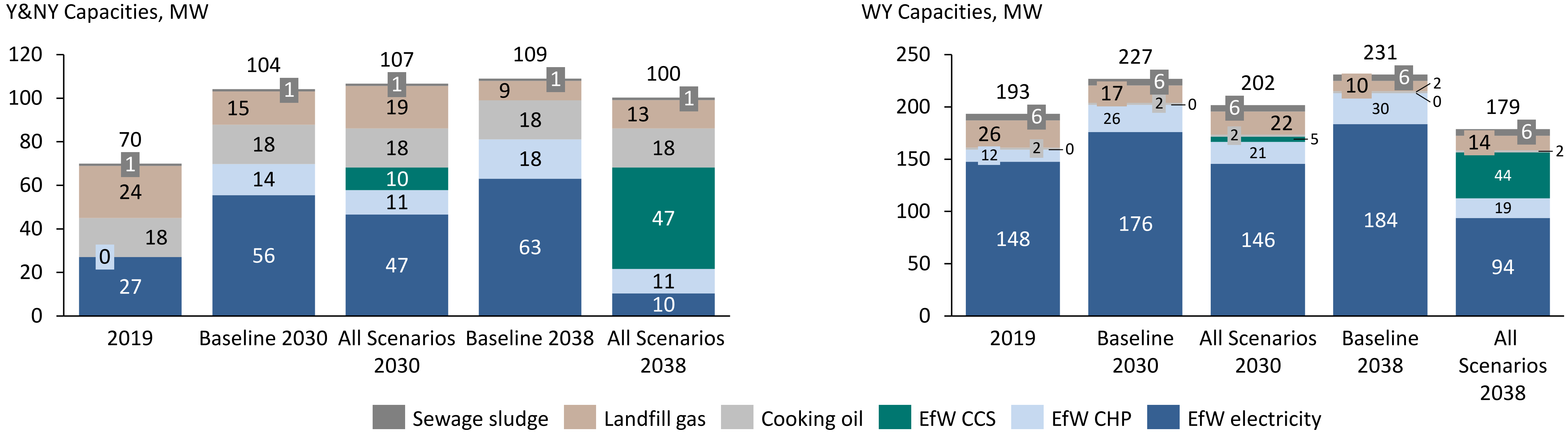
Solar PV and onshore wind assumptions/data



- The graphs on the left show the installed capacities of solar and on shore wind in each scenario, rooftop PV is not included in the power sector.
- Current solar and wind capacities are taken from the 2019 Renewable Energy Planning Database and 2019 BEIS Renewable Energy by LA data, respectively.
- Future capacities are based on National Grid Future Energy Scenarios. Baseline is based on % growth in FES Steady Progress, the Balanced Scenario is based on FES Community Renewables and the High H_2 scenario is based on FES Two Degrees. All scenarios accelerate FES scenarios and achieve 2050 targets by 2040. The Max Ambition Scenario is also based on FES Community Renewables, but accelerates growth until 2030.
- In all 3 decarbonisation scenarios UK-wide added capacity is distributed to study regions depending on total land area. WY and Y&NY are 0.8% and 3.4% of the total UK land, respectively.
- Solar and wind load factors are taken to be 10.7% and 26.2% respectively. These are 3 year averages (2016-18) for Yorkshire & Humber as taken from UK regional renewables statistics[1].
- It is assumed that each MW of solar PV have a footprint of 2 ha. Onshore wind takes around 25 ha per MW, however, only 1.2% of this is direct use and the remaining is space between turbines. It is possible to use this area for other purposes, like agriculture, concurrently.

1- https://www.gov.uk/government/statistics/regional-renewable-statistics

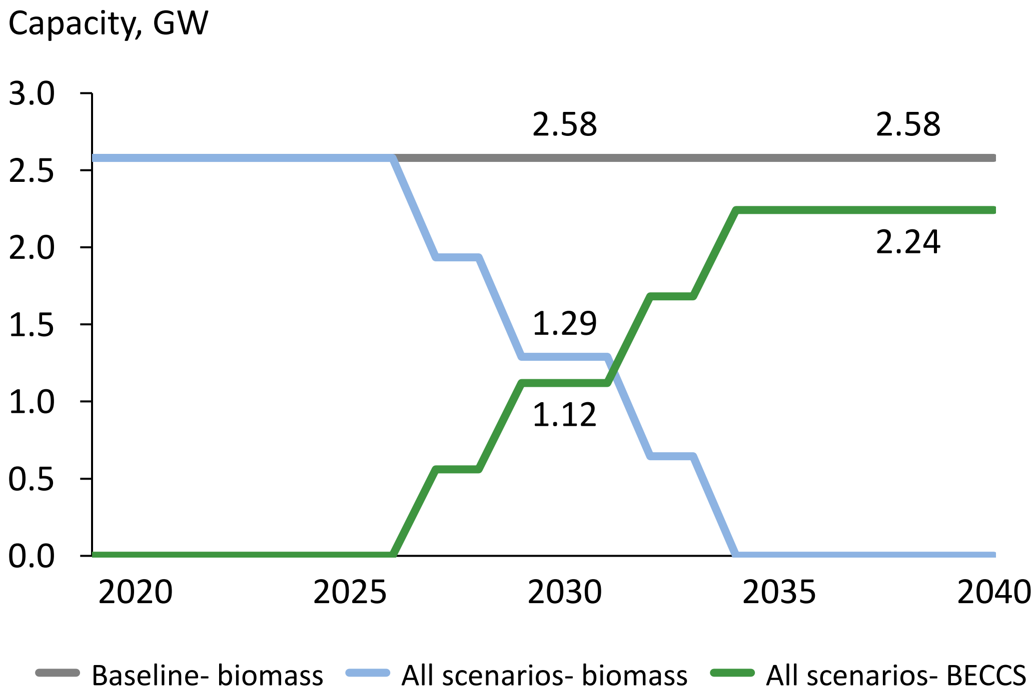
Energy from waste assumptions/data



- The above graph shows capacities of various energy from waste (EfW) technologies in both regions over the timescales.
- Capacities of cooking oil and sewage sludge are assumed constant. Capacity of landfill gas is taken from National Grid Future Energy Scenarios (FES) consumer evolution and community renewables scenarios for baseline and all other scenarios, respectively.
- Load factors of these technologies are assumed to be the average load factor of each technology for the Yorkshire and the Humber region, as taken from Digest of UK Energy Statistics.
- Current electricity only EfW and EfW CHP capacities are taken from Tolvik's 2018 UK Energy from Waste review. This report is also used to find capacity growth until 2023. A 1% growth rate is assumed after 2023 for baseline. For the decarbonisation scenarios, capacity is reduced in accordance with the projected waste availability in CCC's Net Zero report. A third of all new capacity is assumed to be EfW CHP, which are more efficient. It is also assumed that from 2030 electricity only EfW plants retrofit CCS to increase EfW CCS capacity to 50% by 2050, which is another CCC target (for 2050). EfW plants are assumed to continue operating at current load factors (~90%).
- CCS capture rate is assumed to be 90%. Biogenic components of the waste is assumed to be zero carbon and all emissions are assumed to be from non-biogenic components. EfW CCS plants also generate net negative emissions which are calculated by subtracting remaining non-biogenic emissions from captured biogenic emissions. A speculative option would be new improved capture technologies to reach higher capture rates (98%) and reduce emissions further.

Drax bioenergy and BECCS assumptions/data

- Drax has 4 biomass turbines each with a net capacity of 645 MW for a total capacity of 2.58 GW.
- According to the company's annual report, 2019 load factor for its biomass turbines was 59.3%, which is close to previous years In our model we assume that this load factor stays constant.
- Drax publicly announced a roadmap for retrofitting one of its turbines with CCS by 2027 and a second turbine by 2029. Our model follows this timeline and converts the remaining 2 turbines in 2032 and 2034, as shown on the graph.
- It is assumed that net output of BECCS turbines are 12.8% lower than unabated biomass turbines*. Hence, each biomass turbine converts to 560 MW BECCS turbine.



Y&NY

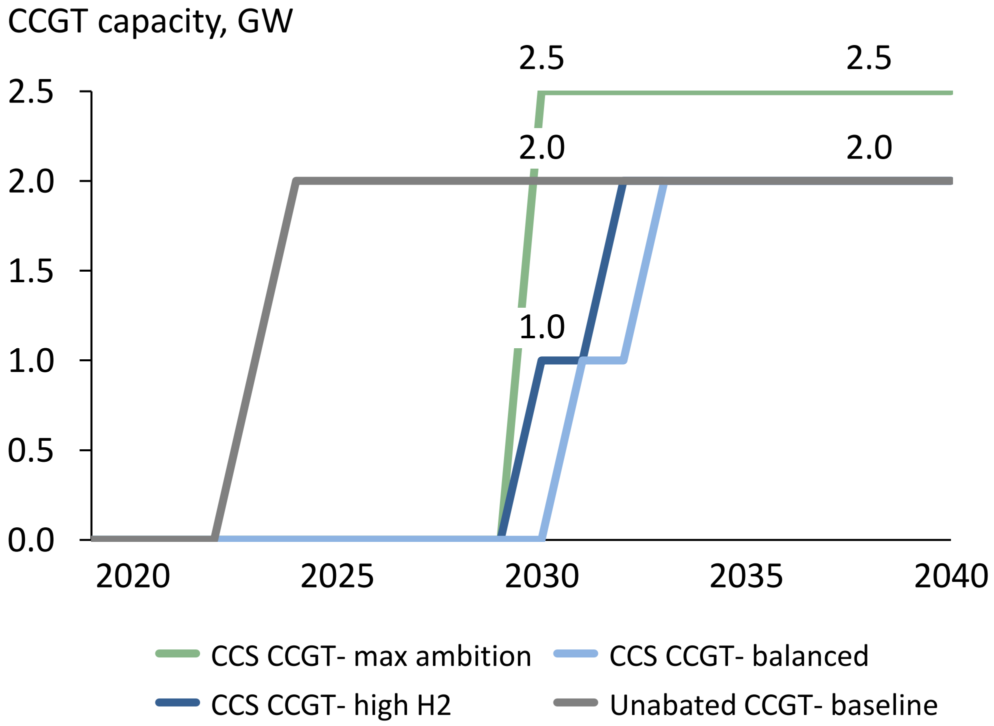
- Drax biomass turbines are assumed to be 40% efficient, indicating BECCS efficiency of 35%. BECCS is assumed to operate as a baseload generator (90%) to maximize negative emissions. It is also assumed that CO_2 capture rate will start at 90% and after 2030 linearly increase to 95% by 2040, in accordance with CCC's Net Zero Report (95% capture by 2050).
- It is assumed that CO_2 emitted from biomass combustion is zero net emissions since it is absorbed during plant growth. However, the non-CO_2 GHGs still produce some positive emissions as calculated from 2019 UK GHG conversion factors by BEIS and DEFRA.
- Biomass emissions factors are combined with efficiencies to calculate final emissions factors. It is assumed that the captured part of the biomass CO_2 content produces negative emissions, approximately amounting to 911 gCO_2e/kWh in 2030, going up to 964 gCO_2e/kWh in 2040.

* Wood, 2018. Assessing the Cost Reduction Potential and Competitiveness of Novel (Next Generation) UK Carbon Capture Technology

Large-scale fossil generation assumptions/data

Study region

- Drax has a coal generation capacity of 1290 MW in North Yorkshire. In 2019, load factor of coal was only 5.3%. It is assumed that in 2020 this will be halved and by 2021 coal operations will cease.
- In our model, we assume that a new 2 GW CCGT capacity will be build in 2023/2024 in two equal instalments in the baseline, high H_2 and Balanced scenarios. This capacity is increased to 2.5 GW for Max Ambition, in order to satisfy higher power demand. Drax is proposing to build two 1.8 GW CCGTs (gas turbines) to replace coal turbines in 2023/24, but equally there are other organisations planning CCGTs (in Y&NY), so this assumption is not relying on Drax.
- In the baseline, this unabated plant runs as it is, but in decarbonisation scenarios it is converted to a CCS CCGT. Max Ambition achieves this retrofit in one go in 2030. In the High H_2 scenario the transitions happens in 2030-32 and in the Balanced Scenario the transition happens in 2031-33. It is assumed that the High H_2 scenario builds CO_2 infrastructure faster than the Balanced scenario.



Y&NY

- It is assumed that the capture rate of CCS will increase linearly from 90% in 2030 to 95% in 2040. Furthermore, total capacity of the plant is assumed to stay constant after the retrofit, implying that an outside source will be supplying energy for capture. Efficiencies of a modern unabated CCGT and a first-of-a-kind CCS CCGT are taken as 59.8% and 52.6%, respectively[1].
- Load factors of CCGT CCS is taken as constant at 70%, which is the load factor of CCS CCGT in 2035 in BEIS Energy and Emissions Projections. It is expected that initial CCS plants will run closer to baseload generation.
- Load factor of the new unabated CCGT is expected to be higher than the average UK fleet since it would be a very efficient plant. It is observed that the 4 newest large scale CCGTs (build after 2010) had 78% higher average load factor in 2018 compared to the total UK fleet[2]. The average CCGT load factor is assumed to be the same as National Grid's Steady Progress Scenario in FES, which is then multiplied by 78% to estimate the load factor of the new unabated CCGT.

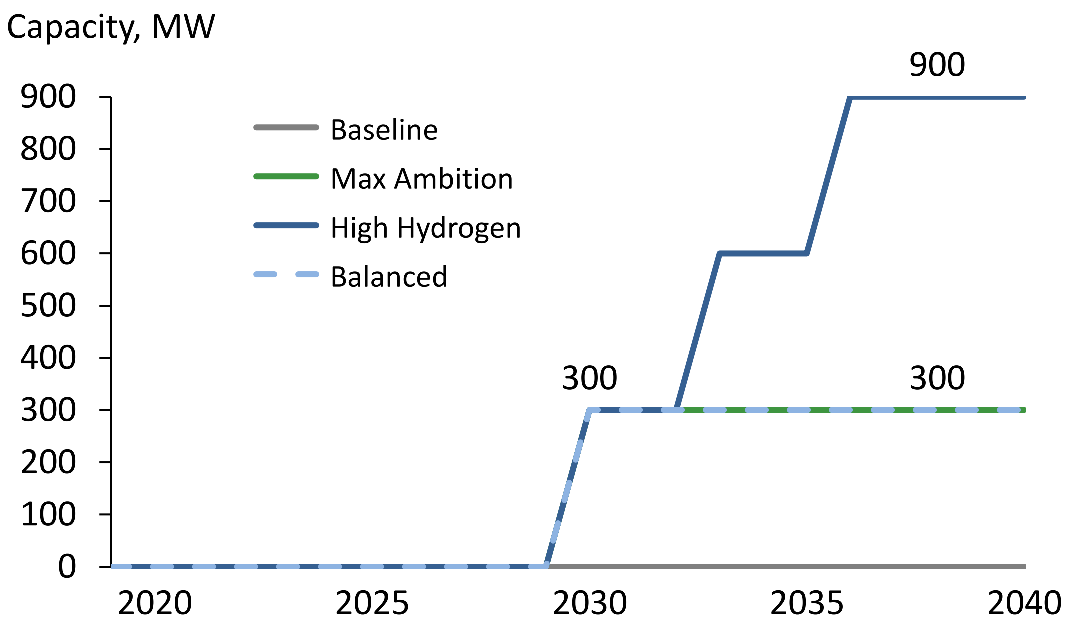
1- Uniper Technologies, 2018. BEIS: CCUS Technical Advisory- Report on Assumptions

2- National grid final load factors: https://www.nationalgrideso.com/document/157476/download

Hydrogen power assumptions

Study region

- Hydrogen turbines (H2GTs) capable of burning 100% hydrogen without a need for dilution or post-combustion NOx removal are assumed to be developed by 2030 when the first plant is deployed.
- As can be seen in the graph, Max Ambition and Balanced scenarios deploy 300 MW of H2GT in 2030 whereas High H_2 Scenario deploys a total of 900 MW in 3 instalments.
- 300 MW is chosen as a standard size as current OCGT plants, which are similar in function to future H2GT plants are usually planed for around 300 MW.
- Hydrogen for power is assumed to be produced by steam methane reforming with CCS as electrolytic hydrogen is expected to be more expensive and would not be very efficient when converted back to electricity. Hence it is assumed that these plants would likely be near Selby, to utilise the planned hydrogen production facility.



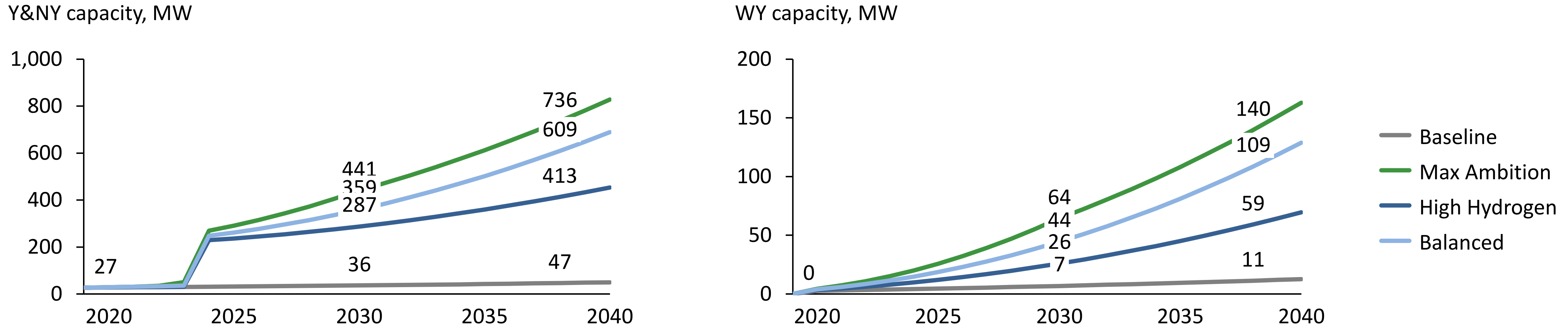
Y&NY

- Hydrogen is expected to operate at low load factors, providing electricity during peak demand. It is assumed that H2GTs operate at the same load factor as transmission level CCGTs in National Grid’s 2019 Future Energy Scenarios- Steady Progression Scenario[1]. This load factor decreases from 15.9% in 2030 to 10.0% in 2038.
- All new H2GT capacity is assumed to be build in North Yorkshire, potentially in Selby, close to Drax. This area is likely to be part of an early cluster and have an established CO_2 T&S infrastructure.

---

[1] National Grid 2019 Future Energy Scenarios

Battery storage and demand side response are effective supplementary tools to reduce peak demand and save costs


Y&NY capacity, MW

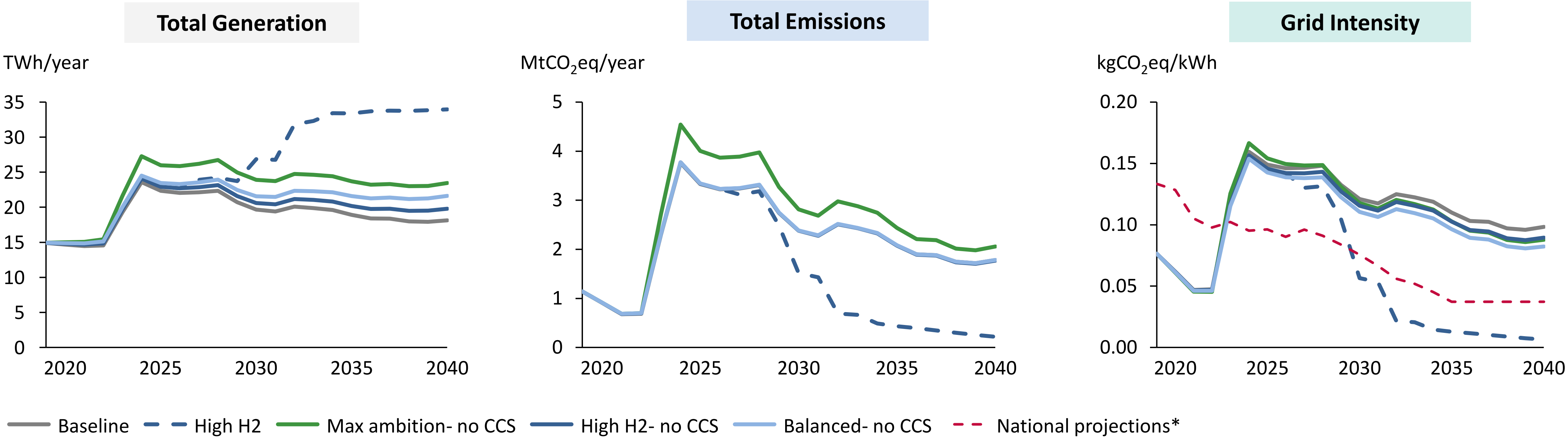
WY capacity, MW

The study analysis doesn't include infrastructure, so storage and DSR technologies are not a core component of the study, but rather an enabling technology. They are included here at a high-level to provide an idea of the role and level of deployment in the study region.

- Both electricity storage and demand side response (DSR) technologies are considered and deployed in National Grid's Future Energy Scenarios[1]. Since this model utilizes NG FES for many power technologies, the effects of storage and DSR are indirectly accounted for.
- DSR is willingness of consumers to shift their consumption due to external signals, such as price. It adds flexibility to the system and usually reduces peak demand, as well as infrastructure requirements. FES quantifies these benefits by stating that residential DSR reduces peak demand by 10% in 2030s and 13.5% in 2050 in the Community Renewables Scenario (which is closer to Max Ambition and Balanced Scenarios). This equates to a reduction of 1.6 GW of UK's peak demand.
- FES includes 3 types of power storage technologies. Of these, pumped hydro storage is not likely to be deployed in the study region due to site restrictions and compressed air and liquid air capacities in FES are fairly small outside of the Two Degrees Scenario. Battery storage is expected to be the most widely deployed technology in the region.
- The above graphs show capacities of battery storage in both study regions across scenarios. Y&NY starts with a 27 MW existing plant and is assumed to host a 200 MW battery commissioning in 2024 (the spike on the graph) alongside the new CCGT plant at Drax. Otherwise uptake is assumed to be more smooth. Battery uptake rates are based on NG FES scenarios and are calculated based on the ratio of solar and onshore wind capacities to battery capacities. It is assumed that storage follows renewable generation and therefore Max Ambition results in the highest battery capacity.

[1] National Grid 2019 Future Energy Scenarios

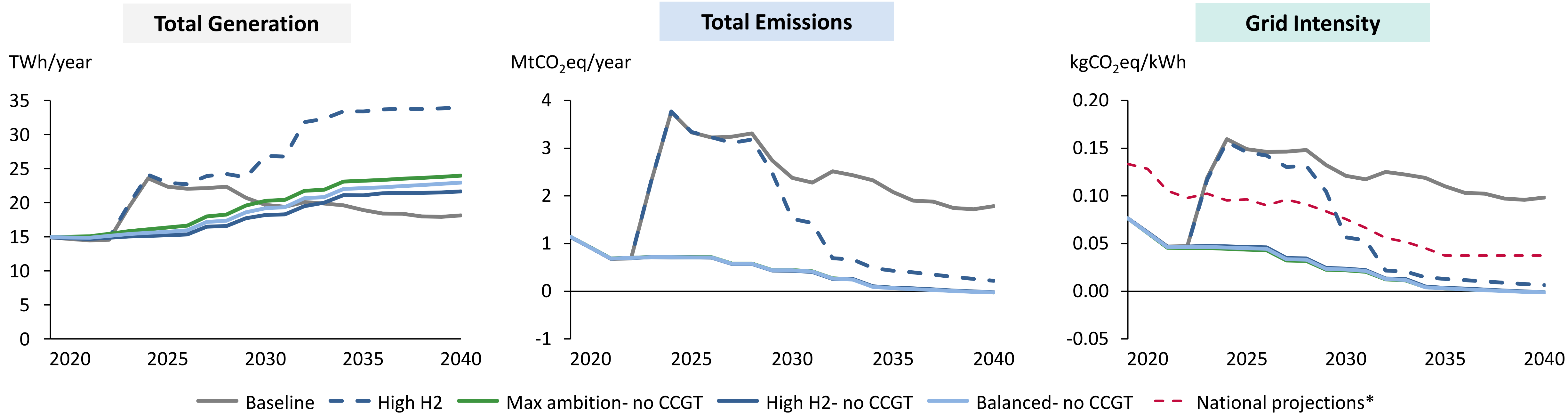
Power – no CCS high-level sensitivity Y&NY



- This slide shows the summary outputs of a high-level sensitivity analysis where CCS is disabled from all scenarios. Baseline and the regular high H_2 scenario with CCS are included as references. Under this sensitivity Drax biomass units continue operating like today, new CCGT which are built in the future do not retrofit CCS and there is no hydrogen in power generation. Furthermore, all EfW plants continue operations without CCS retrofits. All other factors are kept constant.
- Power generation is significantly lower without CCS as hydrogen is missing and Drax biomass and future unabated CCGT plants operate at lower utilization rates as they are not low-carbon enough to continually run as baseload. Consequently, power export of the region decreases to 68%-74% across scenarios in 2038.
- Total emissions are similar to the baseline case as similar levels of unabated technologies are deployed. Grid intensities are slightly less than the baseline scenario since decarbonisation pathways still deploy renewables, bioenergy, AD, etc.
- In reality, if CCS is not allowed in the region, new CCGTs may not be built or other technologies may be deployed instead, therefore a more holistic new study is needed to assess the full impact of a no CCS future.

*Based on Treasury's Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas emissions.

Power – no CCGT high-level sensitivity Y&NY



- **These graphs exclude negative emissions from BECCS** (BECCS is taken as zero emissions).
- This slide shows the summary outputs of a sensitivity analysis where future CCGTs are disabled from all scenarios. Baseline and the regular high H_2 scenario with CCS are included as references. Under this sensitivity, large-scale CCGT plants planned for the first half of 2020s are not built. Consequently, there is no need to retrofit them with CCS. All other factors stay constant, including BECCS.
- Power generation is reduced in a similar way to the no CCS sensitivity. This time, other CCS technologies are allowed to run, but there is no unabated CCGT. Similarly, power export capacity of the region is reduced to 69% - 76% in 2038.
- Contrary to the no CCS sensitivity, disallowing future CCGTs does not mean the power sector cannot reach net-zero. There are net-negative grid intensities (from EfW CCS) even without accounting for BECCS negative emissions. Therefore, opting out of future CCS CCGTs present a trade-off between reduced power generation and eliminating all residual power sector emissions in the region.
- In reality, if CCGTs are not allowed in the region, other technologies (which may or may not be zero emissions) would be needed in Y&NY or in other parts of the UK, therefore a more holistic new study is needed to assess the full impact of a no CCGT future.

*Based on Treasury's Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas emissions.

Contents

Industry Pathways: measures and assumptions

Study region

Key industry measures and assumptions

- **Energy and resource efficiency:** range of improvements based on Max Tech[1], CCC & UKERC, and regional work (e.g. ESDP WP4 Leeds University). Measures include energy and process management, BAT implementation, waste heat recovery, leakage prevention and resource efficiency (e.g. increased recycling rates).
- **Hydrogen fuel switching** for many applications currently using natural gas e.g. food and drink, steel, chemicals. **Hydrogen production** begins at scale in the late 2020s (near Humber), enabling a small number of sites in the Max Ambition pathway; in the High Hydrogen scenario large areas of the gas grid are converted during the early 2030s to enable widespread hydrogen use.
- **Electrification** of low temperature heat and heat on smaller sites; in the Max Ambition Pathway rapid deployment of further electrification options will be required (technology development accelerated)
- **CCS on large sites** in sectors with process emissions, such as glass and chemicals. Other sectors do not have plants large enough for CCS to be cost-effective. Capture rates start at 85% in the 2020s and reach 95% by 2035.
- **Bioenergy and waste** for some applications, particularly those with limited alternatives.

Method summary

1. Take regional emissions of large point sources (emissions intensive industry) and categorise by subsector and region[1]
2. Estimate the energy consumption and fuel breakdown of these large sites using fuel emissions factors and ECUK fuel breakdown by sector. Add on the electricity consumption for each sector (no direct emissions).[2]
3. Add 'small industry' fuel as that remining in the non-domestic sector of the local authority energy datasets once non-domestic buildings are removed[3]. Use the government employment and business count datasets to understand a rough distribution of sectors within small businesses[4].
4. Apply industry growth factors supplied by LCR by SIC code
5. Apply energy efficiency and resource efficiency measures from a number of sources, primarily the industrial decarbonisation roadmaps by sector[5,6,7]
6. Apply net-zero solutions by industry sector (shown later), either fuel switching to hydrogen, electricity, bioenergy; or CCS application[5,7,8,9]

1.NAEI Point source emissions LINK
2. Energy Consumption in the UK ECUK dataset LINK
3. BEIS subnational energy consumption statistics LINK
4.ONS UK business workbook LINK and floorspace LINK
5. Industrial decarbonisation and energy efficiency roadmaps LINK
6. Discussions on resource efficiency LINK LINK
7.CCC Net-zero reports LINK and associated EE analsyis
8. EE for BEIS Hy4Heat WP6 LINK
9.EE for BEIS CO_2 capture in industry LINK
10.H21 LINK and ZCH LINK

Industry Pathways: deep decarbonisation requires fuel switching and/or CCUS. Infrastructure must be developed rapidly.

Scenario				
Intervention	Baseline	Max ambition	High H_2	Balanced
Energy and process efficiency	Low	High	High	High
CCS	None	High (not by 2030)	Medium	High
Hydrogen fuel	None	Medium	High	Medium
Electrification	Low	High	Medium	Medium
Bioenergy and waste	Low	High	Medium	High

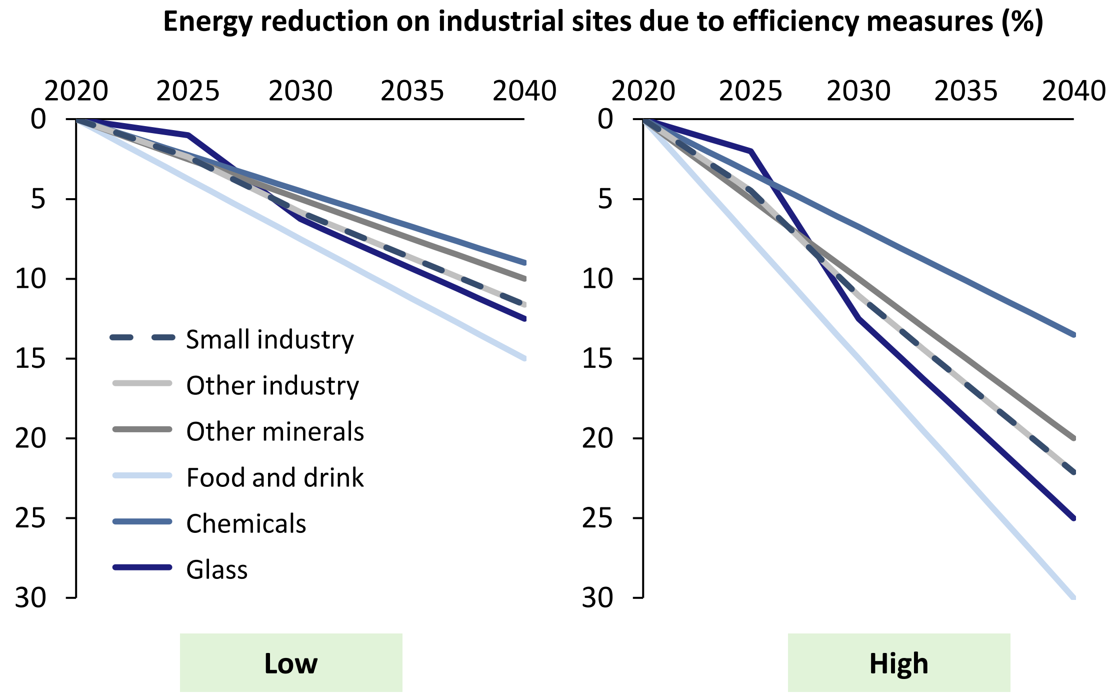
Sectors:

- **Glass:** the largest plants in the region, with natural gas furnaces producing the majority of the emissions. The glass industry is researching hydrogen, biofuel, electrification and CCS, with all options thought possible. No solutions are commercially ready or proven at full-scale yet.
- **Chemicals:** range of scales in the region. Mostly boilers and furnaces; many applications can fuel switch to hydrogen or electricity. Large plants could consider CCS, particularly if near to existing infrastructure.
- **Food and drink:** large number of small and medium plants, with primarily boilers and ovens. Many applications could be electrified, or switched to hydrogen where available, but RD&D is needed.
- **Other mineral industries:** common activities include drying, firing and milling with equipment including driers and kilns as well as electric grinders. Hydrogen could replace natural gas where available.
- **Other industry:** range of sites, with the majority being small and medium size. Emissions reduction solutions will be applied by proportion.
- **Small industry**: too small for CCS, but fuel switching to hydrogen and electrification in different proportions by scenario depending on fuel availability

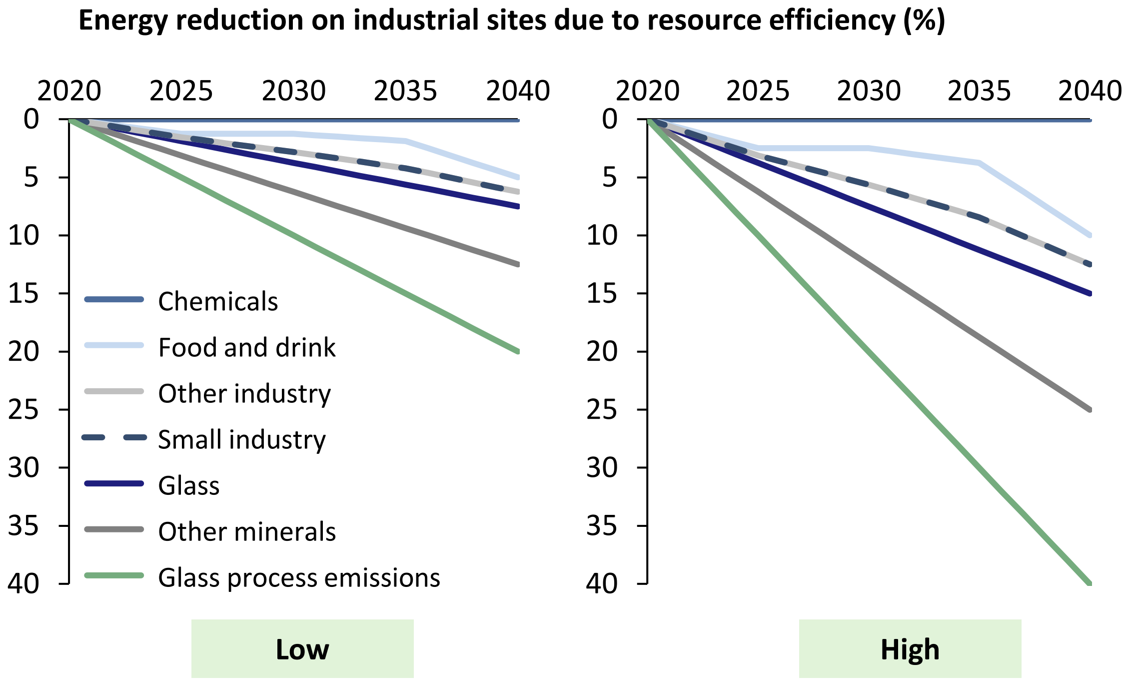
---

1 IDEER Industrial Decarbonisation and Energy Efficiency Roadmaps; RD&D is research development and demonstration
2 Element Energy Analysis for CCC Net-Zero Technical report and BEIS Hy4Heat WP6

Industry – continued energy and resource efficiency makes some progress with technology improvement



Energy reduction on industrial sites due to efficiency measures (%)



Energy reduction on industrial sites due to resource efficiency (%)

- Significant energy efficiency and waste heat recovery has already been completed on industrial sites, but there is still potential for further improvement in some applications. A range of measures were considered in the IDEER to 2050[1] by subsector; for the baseline pathway we assume half of the potential measures are implemented in most sectors by 2038 and **all** in the emissions reduction scenarios (excluding measures such as fuel switching which are considered elsewhere in the analysis).
- Resource efficiency includes reductions in material inputs, increased recycling and switching of material end-uses. *It should be noted that the level of evidence around this is low, so these estimates contain large uncertainties.*

[1] https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050

For the glass sector information was provided by British Glass, including increased recycling rates and additional measures to reduce energy consumption.

Industry – Input assumptions – for industry, we alter the fuel mix and dictate the proportion of emissions with CCS applied

Examples of the assumptions in the industrial subsectors

Glass sector – Max ambition

Glass	2020	2025	2030	2035	2040
Natural gas	83%	80%	35%	10%	10%
Electricity	17%	20%	25%	25%	25%
Petroleum	0%	0%	0%	0%	0%
Coal	0%	0%	0%	0%	0%
Hydrogen	0%	0%	15%	30%	30%
Bioenergy	0%	0%	25%	35%	35%
Total	*100%*	*100%*	*100%*	*100%*	*100%*
CCS - natural gas	0%	0%	0%	50%	100%
CCS - bioenergy	0%	0%	0%	50%	100%
CCS - process emissions	0%	0%	0%	30%	60%

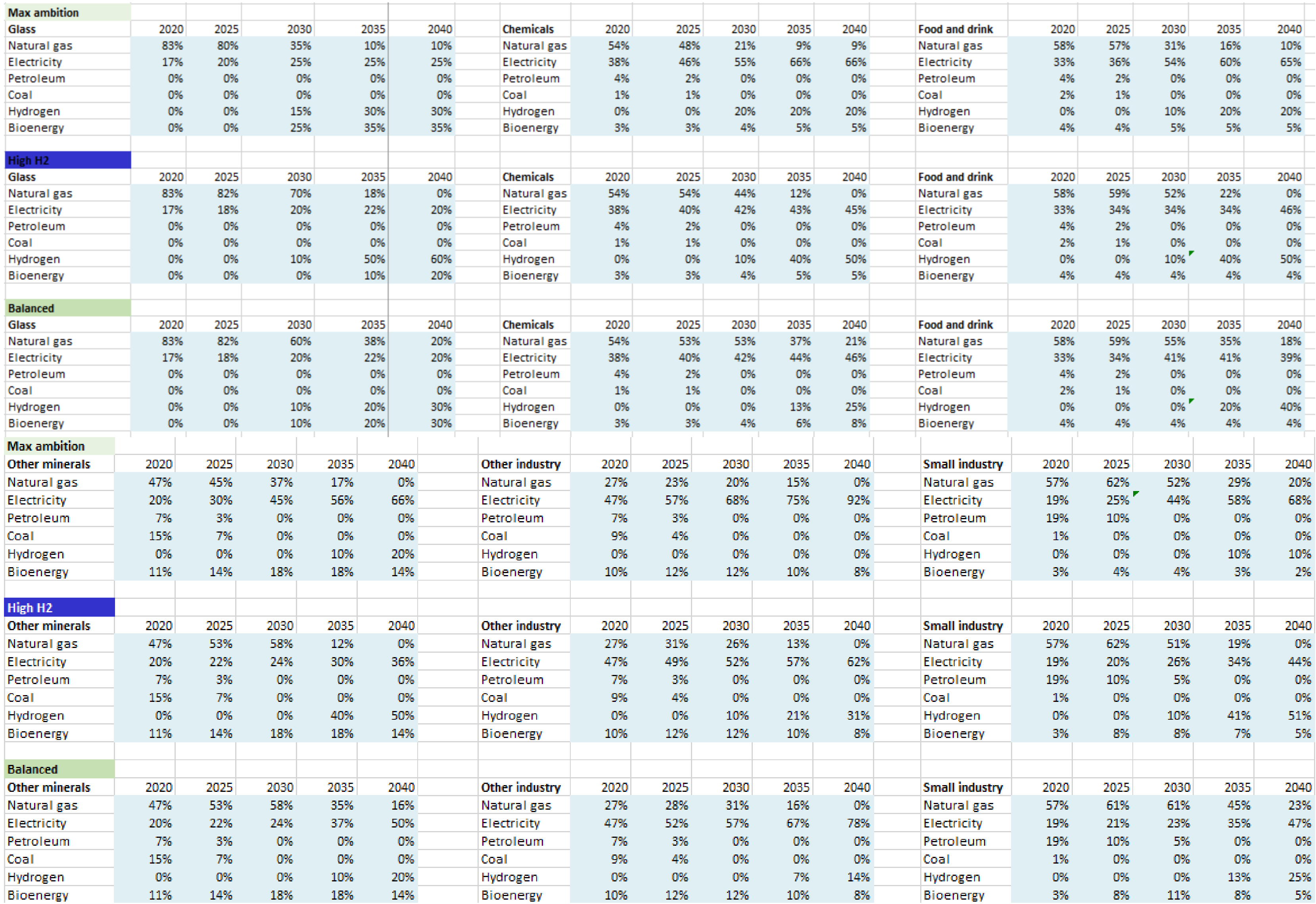
Small industry – High H_2

Small industry	2020	2025	2030	2035	2040
Natural gas	57%	66%	66%	36%	0%
Electricity	19%	20%	21%	26%	32%
Petroleum	20%	10%	5%	0%	0%
Coal	1%	0%	0%	0%	0%
Hydrogen	0%	0%	5%	35%	65%
Bioenergy	3%	4%	4%	3%	2%
Total	*100%*	*100%*	*100%*	*100%*	*100%*
CCS - natural gas	0%	0%	0%	0%	0%
CCS - bioenergy	0%	0%	0%	0%	0%
CCS - process emissions	0%	0%	0%	0%	0%

- Industry key assumptions are input as:
  - the changing proportion of fuels over time in each scenario and subsector (white cells)
  - the proportion of natural gas, bioenergy and process emissions which have CCS applied (grey cells)
- The assumptions are based on both Element Energy work for the CCC and BEIS and also the Industrial Decarbonisation and Energy efficiency roadmaps to 2050.
- The full breakdown of assumptions across fuels, subsectors and scenarios is provided on the next slide
- **Please note that low carbon technologies in the industry sector are mostly very immature and low TRL, so there is a large uncertainty around the measures and pathways applied. Further RD&D and evidence gathering is needed for industry to make decisions and roadmaps.** The pathways are highly ambitious and rely on funding availability for the necessary trials and to support industry in the cost of conversion.

1 IDEER Industrial Decarbonisation and Energy Efficiency Roadmaps;
2 Element Energy Analysis for CCC Net-Zero Technical report and BEIS Hy4Heat WP6;

Industry assumptions – fuel mix by sector and scenario over time



Max ambition

Glass	2020	2025	2030	2035	2040	Chemicals	2020	2025	2030	2035	2040	Food and drink	2020	2025	2030	2035	2040
Natural gas	83%	80%	35%	10%	10%	Natural gas	54%	48%	21%	9%	9%	Natural gas	58%	57%	31%	16%	10%
Electricity	17%	20%	25%	25%	25%	Electricity	38%	46%	55%	66%	66%	Electricity	33%	36%	54%	60%	65%
Petroleum	0%	0%	0%	0%	0%	Petroleum	4%	2%	0%	0%	0%	Petroleum	4%	2%	0%	0%	0%
Coal	0%	0%	0%	0%	0%	Coal	1%	1%	0%	0%	0%	Coal	2%	1%	0%	0%	0%
Hydrogen	0%	0%	15%	30%	30%	Hydrogen	0%	0%	20%	20%	20%	Hydrogen	0%	0%	10%	20%	20%
Bioenergy	0%	0%	25%	35%	35%	Bioenergy	3%	3%	4%	5%	5%	Bioenergy	4%	4%	5%	5%	5%

High H2

Glass	2020	2025	2030	2035	2040	Chemicals	2020	2025	2030	2035	2040	Food and drink	2020	2025	2030	2035	2040
Natural gas	83%	82%	70%	18%	0%	Natural gas	54%	54%	44%	12%	0%	Natural gas	58%	59%	52%	22%	0%
Electricity	17%	18%	20%	22%	20%	Electricity	38%	40%	42%	43%	45%	Electricity	33%	34%	34%	34%	46%
Petroleum	0%	0%	0%	0%	0%	Petroleum	4%	2%	0%	0%	0%	Petroleum	4%	2%	0%	0%	0%
Coal	0%	0%	0%	0%	0%	Coal	1%	1%	0%	0%	0%	Coal	2%	1%	0%	0%	0%
Hydrogen	0%	0%	10%	50%	60%	Hydrogen	0%	0%	10%	40%	50%	Hydrogen	0%	0%	10%	40%	50%
Bioenergy	0%	0%	0%	10%	20%	Bioenergy	3%	3%	4%	5%	5%	Bioenergy	4%	4%	4%	4%	4%

Balanced

Glass	2020	2025	2030	2035	2040	Chemicals	2020	2025	2030	2035	2040	Food and drink	2020	2025	2030	2035	2040
Natural gas	83%	82%	60%	38%	20%	Natural gas	54%	53%	53%	37%	21%	Natural gas	58%	59%	55%	35%	18%
Electricity	17%	18%	20%	22%	20%	Electricity	38%	40%	42%	44%	46%	Electricity	33%	34%	41%	41%	39%
Petroleum	0%	0%	0%	0%	0%	Petroleum	4%	2%	0%	0%	0%	Petroleum	4%	2%	0%	0%	0%
Coal	0%	0%	0%	0%	0%	Coal	1%	1%	0%	0%	0%	Coal	2%	1%	0%	0%	0%
Hydrogen	0%	0%	10%	20%	30%	Hydrogen	0%	0%	0%	13%	25%	Hydrogen	0%	0%	0%	20%	40%
Bioenergy	0%	0%	10%	20%	30%	Bioenergy	3%	3%	4%	6%	8%	Bioenergy	4%	4%	4%	4%	4%

Max ambition

Other minerals	2020	2025	2030	2035	2040	Other industry	2020	2025	2030	2035	2040	Small industry	2020	2025	2030	2035	2040
Natural gas	47%	45%	37%	17%	0%	Natural gas	27%	23%	20%	15%	0%	Natural gas	57%	62%	52%	29%	20%
Electricity	20%	30%	45%	56%	66%	Electricity	47%	57%	68%	75%	92%	Electricity	19%	25%	44%	58%	68%
Petroleum	7%	3%	0%	0%	0%	Petroleum	7%	3%	0%	0%	0%	Petroleum	19%	10%	0%	0%	0%
Coal	15%	7%	0%	0%	0%	Coal	9%	4%	0%	0%	0%	Coal	1%	0%	0%	0%	0%
Hydrogen	0%	0%	0%	10%	20%	Hydrogen	0%	0%	0%	0%	0%	Hydrogen	0%	0%	0%	10%	10%
Bioenergy	11%	14%	18%	18%	14%	Bioenergy	10%	12%	12%	10%	8%	Bioenergy	3%	4%	4%	3%	2%

High H2

Other minerals	2020	2025	2030	2035	2040	Other industry	2020	2025	2030	2035	2040	Small industry	2020	2025	2030	2035	2040
Natural gas	47%	53%	58%	12%	0%	Natural gas	27%	31%	26%	13%	0%	Natural gas	57%	62%	51%	19%	0%
Electricity	20%	22%	24%	30%	36%	Electricity	47%	49%	52%	57%	62%	Electricity	19%	20%	26%	34%	44%
Petroleum	7%	3%	0%	0%	0%	Petroleum	7%	3%	0%	0%	0%	Petroleum	19%	10%	5%	0%	0%
Coal	15%	7%	0%	0%	0%	Coal	9%	4%	0%	0%	0%	Coal	1%	0%	0%	0%	0%
Hydrogen	0%	0%	0%	40%	50%	Hydrogen	0%	0%	10%	21%	31%	Hydrogen	0%	0%	10%	41%	51%
Bioenergy	11%	14%	18%	18%	14%	Bioenergy	10%	12%	12%	10%	8%	Bioenergy	3%	8%	8%	7%	5%

Balanced

Other minerals	2020	2025	2030	2035	2040	Other industry	2020	2025	2030	2035	2040	Small industry	2020	2025	2030	2035	2040
Natural gas	47%	53%	58%	35%	16%	Natural gas	27%	28%	31%	16%	0%	Natural gas	57%	61%	61%	45%	23%
Electricity	20%	22%	24%	37%	50%	Electricity	47%	52%	57%	67%	78%	Electricity	19%	21%	23%	35%	47%
Petroleum	7%	3%	0%	0%	0%	Petroleum	7%	3%	0%	0%	0%	Petroleum	19%	10%	5%	0%	0%
Coal	15%	7%	0%	0%	0%	Coal	9%	4%	0%	0%	0%	Coal	1%	0%	0%	0%	0%
Hydrogen	0%	0%	0%	10%	20%	Hydrogen	0%	0%	0%	7%	14%	Hydrogen	0%	0%	0%	13%	25%
Bioenergy	11%	14%	18%	18%	14%	Bioenergy	10%	12%	12%	10%	8%	Bioenergy	3%	8%	11%	8%	5%

Industry assumptions are based on multiple sources and the latest discussions, but there is large uncertainty in the technology and feasible timeframes for industry to decarbonise

Contents

LULUCF + agriculture pathways: scenarios and measures

	Scenario			
Intervention	Baseline	Max ambition	High H_2	Balanced
New forest planting	Low	High	Max	Medium
Peatland Restoration	Low	High	High/Medium	Medium
Hedgerow increase	None	High	High	Medium
Agroforestry	None	High	High/Medium	Medium
Biomass crops	None	High	High/Medium	Medium
Agricultural farming practices	Low	High	High	Medium
Agricultural technology development	Low	High	High	Medium
Diet change	Low	High	Medium	Medium
Machinery fuel switching	Low	High	High	High

Land Use and agriculture modelling is based on work completed by CEH and partners for the CCC net-zero technical report[1,2], as well as other modelling and GHG methodology developed by CEH. This is applied to the study region by assessing the regional land area for different applications, number of livestock etc[5].

The table above gives an indication where the effort is focused in each scenario

Key Data sources:
1. CCC Net-zero reports LINK
2. CEH for CCC land use scenarios LINK
3. UK greenhouse gas emissions statistics LINK
4. Further analysis on land use and agriculture such as LINK LINK
5. CEH Land cover map LINK
6. Internal CEH data and methodology

The Max ambition scenario focusses on maximum deployment of all measures. It is particularly worth noting the highest ambition in diet change; the reduced meat and dairy consumption not only reduces emissions from livestock, but frees up land from livestock and growing of animal feed, which can then be used for land based mitigation activities.

The high hydrogen scenario still sees high levels of ambition across many measures. The diet change assumed is lower, allowing less land for other measures. However, it still assumes High levels of new forest planting, hedgerow increase and biomass crops, supported by technology development.

The balanced scenario assumes lower levels of ambition, to represent the uncertainty over what level is achievable. Many of the land use measures are applied at medium levels of ambition, resulting in less negative emissions from the land use sector, particularly from new forest planting.

The low, medium and high assumptions are detailed in the coming slides.

LULUCF + agriculture pathways: assumptions (1/3)

Key Assumptions:

- **Measures based on CCC pathways** adapted for study area using region-specific land cover and livestock numbers.
- Net GHG emissions/removals from afforestation and historic land use change that occurred before 2020 are included in net emissions from each scenario
- Takes account of **predicted population growth** in region to 2038; increase in number of households by local authority (Office for National Statistics) (1,408,000 in 2017 to 1,564,000 in 2039 for whole study region). Proportion of housing built on non-previously developed land (i.e. greenspace) from MHCLG Land Use Change statistics (regional average of 49%). The area required for urban development is upscaled from that required for housing. Density of housing development is based on study region average densities from the Ministry of Housing, Communities and Local Government (MHCLG) (21.85 dwellings/hectare, range 17.17-31.91).
- **Assumes agricultural production per capita is maintained** at same level within region (no outsourcing to other parts of UK or abroad). This is based on calorie intake, so red meat or dairy production can be replaced by pork, poultry or plant-based food production whilst maintained overall agricultural production. In addition, yield can increase through improved practices to reduce the land area required to meet the output. Breaking this assumption would mean a loss of agricultural production, requiring food to be imported from other regions/countries and outsourcing GHG emissions associated with that food production to other regions.
- There is **no loss of productive land area** in the region up to 2038 (e.g. coastal erosion/flooding)[2]
- The effects of climate change on crops/trees/livestock, e.g. on growth rates, disease, are not included
- Low ambition (BAU)- carries forward current rates of activity; Medium ambition implements currently available measures; Max ambition assumes increased uptake or uptake of more radical / novel measures
- **Forest planting rates** have been adjusted to take account of the aspirational targets for afforestation in the region for the White Rose Forest initiative (18 kha of afforestation by 2038). Reporting of forest net emissions have been split into those arising from the management and growth of forest in existence in 2016 (small net sink), and those arising from forest planted after 2016 (small increasing sink).
- It is assumed that there can be rapid scale-up of tree and bioenergy crop planting rates and peatland restoration rates in the region- all require suitable planting material (seeds/rhizomes) and skilled workforce.
- Moorland burning has not been explicitly considered as well managed burning should not degrade carbon stocks in soils, but the scientific literature is still unclear and it is likely that not all burning is well managed e.g. good practice would not burn on blanket bogs, but actually this practice may be quite widespread.

---

1 Quantifying the impact of future land use scenarios to 2050 report for CCC (2018)

2 Different agricultural types take account of land capability; some land uses are more amenable to flooding

LULUCF + agriculture pathways: assumptions (2/3)

New forest planting

Takes account of aspirational target in White Rose Forest

- Low: ~14 kha by 2038
- Medium: ~10 by 2030, ~22 kha by 2038
- High: ~ 18 by 2030, ~39 kha by 2038

Peatland restoration

- Medium: Restore 25% lowland peat by 2038, 50% of upland peat by 2038
- High/Medium: Restore 50% lowland peat by 2038, 100% of upland peat by 2038 (Restore 50% upland peat in West Yorkshire)
- High: Restore 100% lowland peat by 2038, 100% of upland peat by 2038 (Restore 60% upland peat in West Yorkshire due to space constraints)

Hedgerow increase

Increase length of hedgerows in region- this only occurs on permanent or temporary grassland

- Medium: 7% increase by 2038*
- High: 13% increase by 2038*

(*No increase in West Yorkshire due to space constraints)

Agroforestry

More trees on cropland, for example field boundaries or alley cropping

- Medium: 5% of cropland converted to alley cropping by 2050, 5% of permanent and rough grazing converted to woodland grazing by 2050
- High/Medium: 8% of cropland converted to alley cropping by 2050, 10% of permanent and rough grazing converted to woodland grazing
- High: 15% of cropland converted to alley cropping by 2050, 20% of permanent and rough grazing converted to woodland grazing. *The equivalent numbers for 2038 are 9% of cropland converted to alley cropping and 11% of grassland converted to woodland grazing.*

Biomass crops

There is very limited amount of timber/fuel for forests modelled in the time period (only producing outputs post-2038) so only Miscanthus and Short Rotation Coppice can produce fuel before 2038. Area planted is split ~ equally between Miscanthus, Short Rotation Coppice and Short Rotation Forestry.

- Medium: ~18 kha by 2038
- Medium+ : ~22 kha by 2038 (insufficient land available to implement High)
- High: ~53 kha by 2038

A delay in the implementation of agroforestry and SRF is assumed (post-2020) due to delays in uptake.

1 Quantifying the impact of future land use scenarios to 2050 report for CCC (2018)

LULUCF + agriculture pathways: assumptions (3/3)

Detailed information on the levels of ambition in agricultural practices and technology (.e.g nitrogen use efficiency, livestock emissions, are given in Thomson, Misslebrook et al (2018).

Agricultural technology development

Measures not affecting available land use: Nitrogen use efficiency, livestock emissions, manure management

Measures affecting land availability:

- Move horticulture indoors (10% Medium, 50% High by 2050 or 5.7%, 28% by 2038)
- Food waste reduction (Medium - 20% by 2050 Medium, and High - 50% by 2050; 20% or 35% by 2038)
    - Reduces area required for horticulture and milled wheat production
    - Reduces area required for livestock grazing
    - Reduces cropping area required for livestock fodder
- Increased stocking density (10% increase in upland stocking density Medium, 10% increase and upland and lowland stocking density by 2050. High; 7% by 2038)
    - Reduces area of grassland required for grazing on pasture and rough grazing
- Improved crop yields
    - reduces area of cropland required to maintain yields

Diet change

20% reduction by 2050 (Medium), 50% reduction by 2050 (High). This is 13% or 32% by 2038.

Red meat and dairy consumption reduction – replaced by poultry, pork and vegetable consumption

- Reduces livestock numbers
- Reduces cropping area required for livestock fodder
- Increases crop area required for pig and poultry feed and vegetable production
- Reduces area of grassland required for livestock grazing

Diet change spares the most amount of agricultural land, followed by increased stocking density and food waste reduction.

---

1 Quantifying the impact of future land use scenarios to 2050 report for CCC (2018)

LULUCF + agriculture pathways: land spared by agricultural mitigation

Scenarios are based on the land spared from agricultural mitigation activities being used for land-based mitigation activities. Not all the land spared by agricultural mitigation has been used for land-based mitigation. This leaves a ‘buffer’ for possible future land losses, e.g. due to flooding, natural disturbances and pests. The excess land could be used for additional mitigation, “re-wilding” or increased agricultural production.

Diet change spares the most amount of agricultural land, followed by increased stocking density, increased crop yields and food waste reduction. Permanent grassland is in highest demand for conversion to urban and forested land.

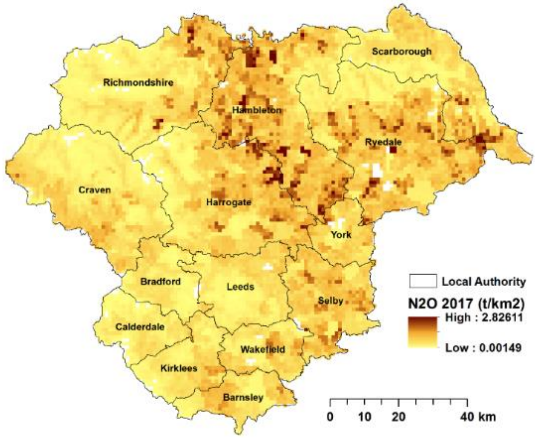
Land spared by agricultural mitigation, kha	**Max Ambition**		**High H_2**		**Balanced**	
Agricultural mitigation measure	**2030**	**2038**	**2030**	**2038**	**2030**	**2038**
Move horticulture indoors	0.5	0.9	0.1	0.2	0.1	0.2
Replace red meat and dairy with pig, pork and plant-based protein	119	213	47	84	47	84
Reduce food waste	20	26	21	29	19	18
Intensify grazing systems (stocking density)	36	47	41	65	30	47
Increase crop yields	80	119	6.0	12	6.0	12

Land spared by agricultural type and region, kha		**Max Ambition**		**H_2**		**Balanced**	
Land Use type	Region	2030	2038	2030	2038	2030	2038
Permanent grassland area	West Yorkshire	10.9	18.6	5.9	9.8	4.2	7.0
	Leeds City Region	50.6	87.0	25.9	43.8	19.8	33.3
	North Yorkshire	83.8	144.5	42.0	71.4	32.7	55.5
Temporary grassland	West Yorkshire	1.9	3.3	0.9	1.6	0.8	1.3
	Leeds City Region	9.2	16.0	4.4	7.5	3.6	6.2
	North Yorkshire	15.2	26.6	7.1	12.3	6.0	10.4
Rough grazing (incl common land)	West Yorkshire	5.3	8.0	4.5	7.2	4.5	7.0
	Leeds City Region	24.9	38.2	20.1	32.2	20.0	31.6
	North Yorkshire	44.6	67.9	37.0	59.0	36.8	57.8
Cropland area	West Yorkshire	9.3	13.2	1.9	3.1	1.8	2.5
	Leeds City Region	35.9	51.0	7.2	11.6	6.7	9.1
	North Yorkshire	83.5	117.5	16.1	25.5	14.8	19.4

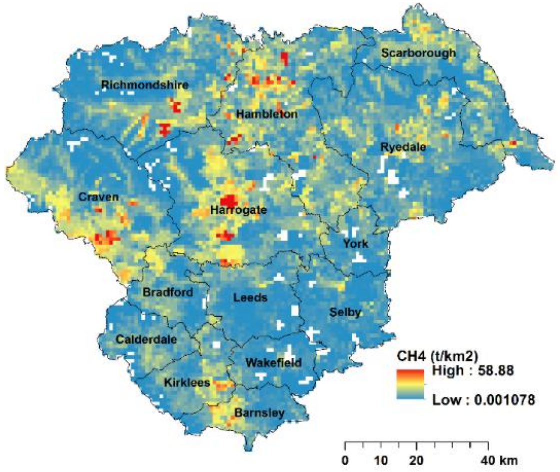
Emissions of CO_2, CH_4 and N_2O from agriculture, forest and other land

National GHG Inventory[1] sectors- used for domestic and international reporting

- Land Use, Land Use Change and Forestry (LULUCF)
  - Covers carbon stock changes in soil, vegetation and timber and GHG emissions from non-agri land management
  - net sink of CO_2
- Agriculture
  - livestock, manure and fertilizer
  - source of CH_4 and N_2O
- Variation in data availability for region



https://naei.beis.gov.uk/data/map-uk-das



NOTE: This project will include emissions from modified peatlands (grazed, drained, peat extraction)

- current reporting of peatland emissions in the LULUCF inventory is limited.
- UK has elected to report these emissions by 2022[2].
- Study region has a very high proportion of peat (~9%)
  - Source of GHG emissions, shifting LULUCF sector from a sink into a source.
  - Peatland restoration will reduce emissions, as peatlands in a natural (undrained) state are a long-term sink for C.
  - Have completed further analysis on the type/location of peat in Yorkshire to improve results.

[1] BEIS GHG inventory https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2017 [2] See recent CEH study https://naei.beis.gov.uk/reports/reports?report_id=980

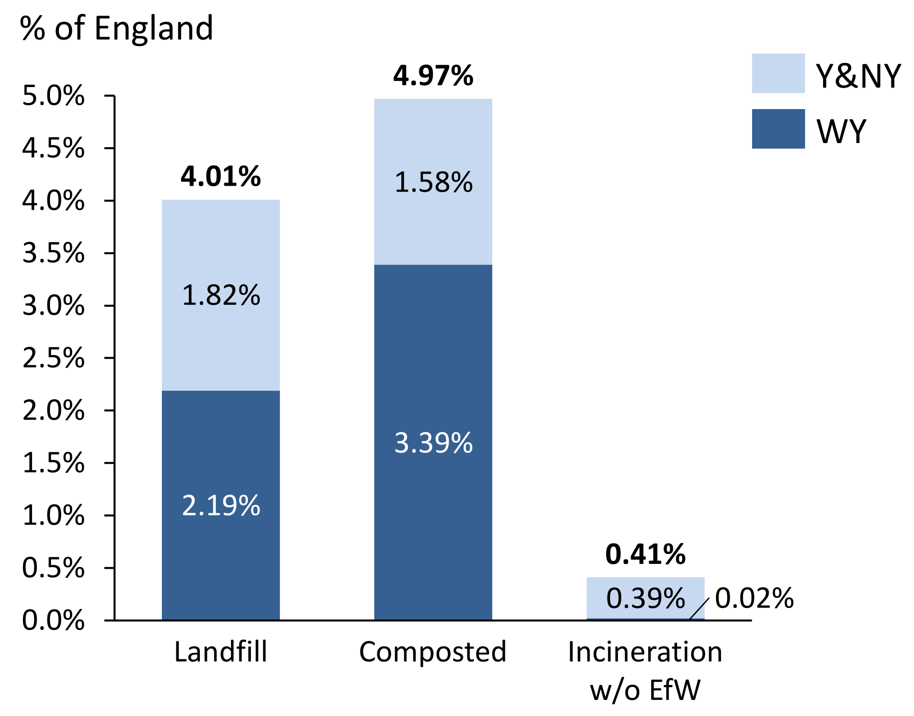
Contents

Waste pathways: method summary

Rationale for waste modelling

1. The waste sector, out of scope for this study, is modelled at a very high level in order to have a comprehensive regional model. Only a baseline and a single emissions reduction scenario are created.
2. The CCC's Net Zero Report[1] forms the basis of the model. The report identifies 6 waste emission types. AD is removed from the model due to it being in the power sector.
3. CCC's forecast do not change England-level emissions from waste incineration, composting and mechanical biological treatment (MBT), therefore these emissions are kept constant in the model.
4. Landfill and wastewater treatment emissions are reduced by the same ratio as the CCC model.
5. Current wastewater emissions are estimated by regional population. West Yorkshire is therefore assumed to have 3.5% of UK's emissions and Y&NY has 1.2%.
6. Current emissions from landfill, composting, incineration and MBT are estimated from local authority waste disposal data[2]. Total tonnes of waste disposed through each pathway is compared to the England total to calculate the % of emissions attributable to the study regions. These are shown in the figure.
7. When waste percentages are compared with population it is apparent that Waste Yorkshire sends 60% less waste per capita to landfill compared to York & North Yorkshire.
8. MBT emissions are assumed to be distributed by the same % as waste sent to composting.

Regional waste disposal methods



Key sources and references

1. CCC 2019 Net Zero Report LINK
2. Local Authority Collected Waste Statistics, 2019 Defra LINK

Contents

Transport measures and milestones

Category	Measure	Unit	Baseline				Max ambition				High Hydrogen				Balanced			
			2020	2025	2030	2038	2020	2025	2030	2038	2020	2025	2030	2038	2020	2025	2030	2038
Active travel	Walking activity	Million passenger km	262	265	268	271	258	311	360	377	258	271	314	377	258	271	314	377
	Cycling activity	Million passenger km	87	88	89	90	86	395	699	731	86	154	426	731	86	154	426	731
	Walking modal share	% distance	2%	2%	2%	2%	2%	3%	3%	3%	2%	2%	3%	3%	2%	2%	3%	3%
	Cycling modal share	% distance	1%	1%	1%	1%	1%	3%	6%	6%	1%	1%	3%	6%	1%	1%	3%	6%
	Walking increase	% relative to 2020	1.0	1.0	1.0	1.0	1.0	1.2	1.4	1.5	1.0	1.0	1.2	1.5	1.0	1.0	1.2	1.5
	Cycling increase	% relative to 2020	1.0	1.0	1.0	1.0	1.0	4.6	8.1	8.5	1.0	1.8	5.0	8.5	1.0	1.8	5.0	8.5
Bus & Rail	Bus passenger km	Million passenger km	633	617	617	617	623	783	932	975	623	661	794	975	623	661	794	975
	Bus increase	% relative to 2020	0%	-3%	-3%	-3%	0%	26%	49%	56%	0%	6%	27%	56%	0%	6%	27%	56%
	BEV buses	% of fleet	0%	0%	0%	0%	1%	4%	25%	66%	1%	4%	25%	66%	1%	4%	25%	66%
	FCEV buses	% of fleet	0%	0%	0%	0%	0%	2%	12%	34%	0%	2%	12%	34%	0%	0%	5%	22%
	Rail passenger km	Million passenger km	750	830	911	1039	738	1287	1816	1900	738	862	1335	1900	738	862	1335	1900
	Rail passenger increase	% relative to 2020	0%	11%	21%	39%	0%	74%	146%	157%	0%	17%	81%	157%	0%	17%	81%	157%
	Rail electrification	% passenger km	44%	44%	44%	44%	44%	56%	80%	90%	44%	56%	68%	80%	44%	56%	68%	80%
Cars	Private car use	Million passenger km	10556	11056	11502	12252	10391	8139	5969	6248	10391	10033	8292	6942	10391	10033	8292	6942
	Private car use	Million vkm	7937	8313	8648	9212	7813	6119	4488	4698	7813	7543	6234	5220	7813	7543	6234	5220
	Private car use change	% relative to today	0%	5%	9%	16%	0%	-22%	-43%	-40%	0%	-3%	-20%	-33%	0%	-3%	-20%	-33%
	BEV cars	% of fleet	0%	2%	9%	20%	0%	8%	33%	76%	0%	6%	24%	44%	0%	6%	24%	57%
	BEV cars	% of sales	1%	13%	21%	28%	1%	38%	87%	98%	1%	30%	60%	40%	1%	30%	60%	79%
	FCEV cars	% of fleet	0%	0%	0%	3%	0%	0%	0%	1%	0%	0%	0%	15%	0%	0%	0%	2%
	FCEV cars	% of sales	0%	0%	2%	6%	0%	0%	0%	2%	0%	0%	1%	45%	0%	0%	1%	6%
Vans & HGV	Van use	Million vkm	1632	1717	1810	2012	1632	1623	1613	1793	1632	1708	1792	1992	1632	1708	1792	1992
	BEV vans	% of fleet	0%	1%	4%	11%	0%	3%	16%	55%	0%	2%	10%	22%	0%	2%	10%	31%
	BEV vans	% of sales	0%	3%	10%	13%	1%	15%	56%	88%	1%	8%	32%	21%	1%	8%	32%	42%
	FCEV vans	% of fleet	0%	0%	0%	3%	0%	0%	0%	4%	0%	0%	0%	15%	0%	0%	0%	7%
	FCEV vans	% of sales	0%	0%	1%	7%	0%	0%	0%	12%	0%	0%	1%	41%	0%	0%	1%	20%
	HGV use	Million vkm	681	682	686	703	681	615	572	581	681	643	604	614	681	643	604	614
	BEV HGVs	% of fleet	0%	0%	4%	14%	0%	1%	12%	80%	0%	0%	0%	13%	0%	0%	2%	24%
	BEV HGVs	% of sales	0%	0%	15%	23%	0%	4%	46%	99%	0%	0%	4%	38%	0%	1%	6%	59%
	FCEV HGVs	% of fleet	0%	0%	0%	1%	0%	0%	0%	1%	0%	0%	0%	16%	0%	0%	0%	9%
	FCEV HGVs	% of sales	0%	0%	0%	3%	0%	0%	0%	1%	0%	0%	1%	35%	0%	0%	1%	19%
Other	Electrification of aircraft support vehicles	% activity	0%	0%	0%	0%	0%	50%	100%	100%	0%	25%	50%	90%	0%	25%	50%	90%

Y&NY

Buildings measures and milestones

Subsector	Measure	Unit	Baseline				Max ambition				High Hydrogen				Balanced			
			2020	2025	2030	2038	2020	2025	2030	2038	2020	2025	2030	2038	2020	2025	2030	2038
Domestic	Energy efficiency retrofits	# cumulative from 2020	-	32,011	64,022	102,436	-	56,276	182,767	257,046	-	64,261	200,496	257,046	-	56,276	182,767	257,046
		#/year	-	5,335	6,402	2,134	-	11,255	31,804	-	-	12,852	30,845	-	-	11,255	31,804	-
Domestic		% existing buildings from 2020	0%	8%	17%	27%	0%	15%	48%	68%	0%	17%	53%	68%	0%	15%	48%	68%
Non-domestic		% existing buildings from 2020	0%	5%	15%	30%	0%	21%	57%	62%	0%	12%	46%	62%	0%	21%	57%	62%
All		% existing buildings from 2020	0%	8%	17%	27%	0%	15%	49%	67%	0%	16%	52%	67%	0%	15%	49%	67%
Domestic	Heat pumps and hybrids	# cumulative from 2020	670	11,514	31,456	63,711	767	42,652	203,699	273,695	767	29,427	98,636	150,111	767	32,775	129,914	202,973
Domestic		#/year	670	3,603	4,186	4,048	767	9,669	32,378	6,866	767	6,987	13,762	4,177	767	7,656	19,633	11,416
Domestic		% homes with HP or HHP	0%	3%	8%	14%	0%	11%	49%	62%	0%	7%	24%	34%	0%	8%	31%	46%
Non-domestic		% buildings with HP or HHP	1%	4%	8%	16%	1%	12%	32%	48%	1%	11%	18%	29%	1%	11%	30%	39%
All		% buildings with HP or HHP	0%	3%	8%	15%	0%	11%	47%	60%	0%	8%	23%	33%	0%	9%	31%	45%
Domestic	Hydrogen boilers	# cumulative	-	-	-	-	-	-	-	-	-	-	53,873	182,937	-	-	-	60,564
Domestic		#/year	-	-	-	-	-	-	-	-	-	-	18,196	692	-	-	-	276
Domestic		% homes	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	13%	41%	0%	0%	0%	14%
Non-domestic		% buildings	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	12%	27%	0%	0%	0%	11%
All		% buildings	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	13%	40%	0%	0%	0%	13%
Domestic	District & communal heating	# cumulative from 2020	609	4,144	10,925	23,892	1,669	10,627	58,283	86,264	884	5,917	38,086	73,999	974	6,456	40,421	78,400
Domestic		#/year	609	1,099	1,420	1,741	1,669	2,281	9,581	897	884	1,496	6,483	2,146	974	1,586	6,842	2,236
Domestic		% homes	0%	1%	3%	6%	0%	3%	14%	19%	0%	2%	9%	17%	0%	2%	10%	18%
Non-domestic		% buildings	2%	3%	4%	6%	1%	5%	11%	12%	2%	9%	19%	22%	2%	7%	18%	22%
All		% buildings	1%	1%	3%	6%	1%	3%	14%	19%	1%	3%	10%	18%	1%	2%	11%	18%
Domestic	Solar PV	# homes	16,530	18,429	22,148	26,880	18,717	42,419	70,410	100,993	18,717	42,419	70,410	100,993	18,717	42,419	70,410	100,993
Domestic		% homes	4%	5%	5%	6%	5%	11%	17%	23%	5%	11%	17%	23%	5%	11%	17%	23%

Power measures and milestones

Measure	Sub-sector	Unit	Baseline				Max ambition				High Hydrogen				Balanced			
			2020	2025	2030	2038	2020	2025	2030	2038	2020	2025	2030	2038	2020	2025	2030	2038
Technology deployment	Solar PV	MW	104	121	141	180	209	751	1,293	1,806	148	386	624	1,005	165	486	807	1,320
	Solar PV	% of 2038	58%	67%	78%	100%	12%	42%	72%	100%	15%	38%	62%	100%	12%	37%	61%	100%
	Solar PV	MW/year	3.1	3.6	4.2	5.4	108.4	108.4	108.4	64.2	47.6	47.6	47.6	47.6	64.2	64.2	64.2	64.2
	Onshore Wind	MW	53	57	62	71	118	449	779	1,150	72	170	269	426	98	330	562	934
	Onshore Wind	% of 2038	75%	81%	88%	100%	10%	39%	68%	100%	17%	40%	63%	100%	11%	35%	60%	100%
	Onshore Wind	MW/year	0.9	0.9	1.0	1.1	66.1	66.1	66.1	46.4	19.7	19.7	19.7	19.7	46.4	46.4	46.4	46.4
	EfW dedicated electricity	MW	32	51	56	63	34	57	52	10	34	57	52	10	34	57	52	10
	EfW CHP	MW	2	12	14	18	2	11	11	11	2	11	11	11	2	11	11	11
	EfW CCS	MW	0	0	0	0	0	0	5	47	0	0	5	47	0	0	5	47
	Total AD	MW	10	12	13	15	12	18	25	26	11	13	15	20	11	13	16	24
Captured emissions	Annual captured carbon	MtCO2eq/yr	0.0	0.0	0.0	0.0	0.0	0.0	13.9	23.4	0.0	0.0	10.6	22.0	0.0	0.0	8.5	22.3
	Cumulative captured carbon	MtCO2eq	0.0	0.0	0.0	0.0	0.0	0.0	30.7	197.3	0.0	0.0	27.5	181.3	0.0	0.0	25.4	178.7
	Annual negative emissions*	MtCO2eq/yr	0.0	0.0	0.0	0.0	0.0	0.0	-1.6	-3.5	0.0	0.0	-1.6	-3.5	0.0	0.0	-1.6	-3.5
	Cumulative negative* emissions	MtCO2eq	0.0	0.0	0.0	0.0	0.0	0.0	-4.8	-28.6	0.0	0.0	-4.8	-28.6	0.0	0.0	-4.8	-28.6
Clean electricity	Share of clean power in total generation	%	97%	65%	74%	82%	97%	62%	100%	100%	97%	66%	90%	100%	97%	67%	79%	100%

*Assuming 20% of Drax BECCS negative emissions are attributed to YNY region.

Industry measures and milestones

Measure	Unit	Baseline				Max ambition				High Hydrogen				Balanced			
		2020	2025	2030	2038	2020	2025	2030	2038	2020	2025	2030	2038	2020	2025	2030	2038
Energy demand reduction relative to BAU due to energy and resource efficiency	%	0%	4%	9%	16%	0%	6%	14%	26%	0%	6%	14%	26%	0%	6%	14%	26%
Electricity demand	TWh/yr	0.9	1.0	1.1	1.3	0.9	1.1	1.5	1.8	0.9	1.0	1.0	1.1	0.9	1.0	1.0	1.2
Electricity demand	% fuel	25%	28%	31%	37%	25%	32%	47%	58%	25%	27%	30%	37%	25%	28%	31%	40%
Hydrogen demand	TWh/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.0	0.0	0.3	1.5	0.0	0.0	0.1	0.7
Hydrogen demand	% fuel	0%	0%	0%	0%	0%	0%	7%	18%	0%	0%	9%	48%	0%	0%	2%	23%
CO_2 captured annually	$ktCO_2$/yr	0	0	0	0	0	0	0	43	0	0	0	9	0	0	0	37
CO_2 captured cumulatively	$MtCO_2$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

LULUCF and agriculture measures and milestones

Measure	Unit	Baseline				Max ambition				High Hydrogen				Balanced			
		2020	2025	2030	2038	2020	2025	2030	2038	2020	2025	2030	2038	2020	2025	2030	2038
Forest area - total	kha	54	57	61	67	54	61	72	91	54	61	72	91	54	58	65	78
Forest area - additional	kha	0	2	6	12	0	6	17	37	0	6	17	37	0	4	11	23
Peatland restoration - upland	% restored	0%	0%	0%	0%	17%	39%	61%	100%	17%	39%	61%	100%	9%	20%	30%	50%
Peatland restoration - lowland	% restored	0%	0%	0%	0%	17%	39%	61%	100%	9%	20%	30%	50%	4%	10%	15%	25%
Cattle & sheep numbers	% change from 2020	0%	3%	6%	9%	0%	-6%	-12%	-24%	0%	-1%	-2%	-5%	0%	-1%	-2%	-4%
Pigs & Poultry numbers	% change from 2020	0%	3%	6%	10%	0%	3%	7%	12%	0%	3%	7%	12%	0%	3%	7%	13%
Machinery remaining on fossil fuel	%	93%	87%	82%	61%	93%	82%	71%	21%	93%	82%	71%	21%	93%	82%	71%	21%
Bioenergy crops	kha	0	0	0	0	4	14	27	47	2	6	12	21	1	5	10	18
Hedgerows	ha	0	0	0	0	145	327	509	799	145	327	509	799	73	163	254	400
Hedgerows	% increase length	0%	0%	0%	0%	1%	5%	10%	17%	1%	5%	10%	17%	0%	3%	5%	8%
Agroforestry	kha	0	0	0	0	0	8	30	68	0	2	15	32	0	2	8	17
Increased stocking density	%	0%	0%	0%	0%	0%	3%	5%	7%	0%	2%	4%	7%	0%	3%	5%	7%
Move horticulture indoors	%	0%	0%	0%	0%	0%	7%	15%	28%	0%	7%	15%	28%	0%	2%	3%	6%
Diet change - % reduction in red meat and diary consumption	% reduction	0%	0%	0%	0%	0%	8%	16%	32%	1%	4%	7%	13%	1%	4%	7%	13%
Food waste reduction	% reduction	0%	0%	0%	0%	0%	14%	25%	35%	3%	15%	25%	35%	2%	12%	21%	20%

Contents

Publicity campaign

To enable and support delivery of the policies outlined in the detailed policy tables, a major publicity and engagement campaign that targets all key stakeholders is recommended. To reach a wide audience and to clearly communicate the climate ambition, the campaign should include an accessible and easy to understand webpage, a targeted social media campaign and visible region-wide advertising. Community and business engagement events will also be crucial in order to reach as wide an audience as possible.

Key priorities for each sector include:

- **Buildings:**
  - To raise awareness of low carbon heating technology and energy efficiency measures, including best practice in using new technologies and information about safety of hydrogen (once trials are complete)
  - To provide links to resources to enable uptake – this can link to the One-stop shop (**B1**)
- **Transport:**
  - To provide information about transport emissions and actions that can be taken (e.g. modal shift, reducing air travel, lift-sharing, use of pick-up drop-off points rather than home delivery etc), including the associated co-benefits
  - To provides resources to enable behaviour change such as details and maps of key infrastructure (e.g. charge points, car clubs, shared mobility, cycling routes), route planning to highlight sustainable modes, portal to request on-street chargepoints, promotion of repair/reuse activities. This can link to existing pages and schemes, such as Open North Yorkshire and CityConnect.
- **LULUCF and agriculture:**
  - Provide information about diet, food miles, food waste and carbon footprint
  - Promote participation in local schemes (e.g. local planting and food waste schemes/apps)
  - Promote contributions to local schemes, such as the Northern Forest or White Rose Forest for both residents and businesses
  - Provide access to support, such as promotions on new products to introduce consumers to novel foods
- **Power:**
  - Increase public knowledge and build acceptance around local power projects and strategy. Particular value can be added for onshore wind, CCUS, hydrogen and BECCS.
  - Allow communities to input into large regional plans and facilitate communication between project developers and the public.
  - Awareness raising around waste reduction, recycling and increased waste separation
- **Industry:**
  - Provide information to encourage and incentivise circular industrial products including food and drinks. The relevant resources can be updated as new circular products become available or new labelling schemes emerge.

Transport policy references (1/3)

No	Policy Description	Cost & resources	Examples
T1	Develop a region-wide **parking strategy** that discourages private car use and encourages low emissions technology uptake	Costs for implementing banded parking charges based on publicly available costs (https://democracy.croydon.gov.uk/documents/s16848/TMAC 20190724 EBPC FINAL.pdf).	Nottingham introduced a **Workplace Parking Levy** in 2012, which charges employers £415 per parking space provided to employees. 8/10 employers currently pass this cost onto employees who use the spaces, providing another incentive to use the city's public transport links. The city of Copenhagen has adopted an integrated traffic management strategy for the city, which includes reducing the number of on-street parking spaces by a fixed percentage each year and increasing charges of on-street parking. This is alongside measures for road reallocation and investment in train, bus and cycle infrastructure. In the city centre, 94% of journeys are now made on foot or by bicycle. (Reclaim the kerb Centre for London, and references within).
T3	Expand **cycle parking** provision across the region	Costs based on 2 major cycle hubs and 10 smaller hubs at major rail stations in WY; 1 major hub and 5 smaller hubs in YNY; pricing as given in Typical Costs of Cycling Interventions (2017) DfT Costs of wider cycle parking provision dependent on amount of parking provided at each location and the degree of retrofit of residential areas to meet the desired level of provision. The indicative cost range given is based on Element Energy analysis for the Royal Borough of Greenwich and assumes a very high upper limit of provision (retrofit of all residential areas to London Plan standards of 2 spaces per dwelling).	As part of the Mini-Holland funded programme, over 5 years, Waltham Forest has delivered 22km of segregated cycle lanes, 40 modal filters to prevent rat-running, improvement of road junctions, and installation of 300 bike hangars for residents and 7 station cycle hubs.
T5	Convene LAs to establish how to **use local planning policy**	–	Bath Riverside is a brownfield redevelopment site for offices and houses 1km outside of Bath. Due to good walking and public transport connections and sustainable transport incentives, 70% of new residents use sustainable transport as their main mode of travel (Arup 2020, and LGA 2020)
T6	Pursue **bus franchising** or **Enterprise Partnership** to deliver expanded and improved bus services across the region	Costs based on reported costs of Greater Manchester bus franchising offer of up to £135m (article retrieved Sept 2020). £9.2m of borrowed funds is allocated towards purchasing bus depots but estimated total costs of acquisition of up to £85m are estimated.	The only current example of bus franchising in the UK is in London, where bus passenger numbers have doubled since the mid-1980s while they have declined by a third elsewhere (https://www.ippr.org/files/publications/pdf/greasing-the-wheels_Aug2014.pdf). Greater Manchester is now pursuing this option (consultation ran Oct 2019-Jan 2020).
T7	Implement **flexible and integrated ticketing** across services	Costs based on *Greater Cambridge Partnership Integrated Ticketing Study* (2019)	The EMMA mobility card (Montpellier) allows customers to use the tramway, shared bicycles, car sharing, and car and bike parks in the city with a single subscription. The service also includes an itinerary and schedule calculator across all modes. (Innovative Solutions for Sustainable Cities, Vivapolis 2019)

Transport policy references (2/3)

No	Policy Description	Cost & resources	Examples
T8	Support **trials of innovative services**, such as on-demand shared transport to support public transport provision	Upper limit of grant offered through rural mobility fund: https://www.gov.uk/government/publications/apply-for-the-rural-mobility-fund	–
T9	Assess feasibility and implement trials of **freight consolidation and cycle freight**	Cost range for trial based on costs given in *London Freight Consolidation Study* (2019) PBA and WYG for TfL and schemes funded in Waltham Forest (£400,000 invested over 3 years).	The London Boroughs of Camden, Enfield, Islington and Waltham Forest established a consolidation centre for council deliveries, now used by up to 41 suppliers and resulting in a 46% reduction in the number of vehicle trips delivering to council sites. Following a review of council-owned assets, policies to encourage cycle freight are included in City of London's Draft Transport Strategy (Proposal 38), including development of three micro-distribution hubs within underutilised car parks.
T13	Provide **telematics services** for local fleets and small businesses to help them identify suitable zero emission options	Costs based on Element Energy research, and assuming all vans take up scheme (111,000 in WY, 55,000 in YNY; based on DfT vehicle statistics)	As part of the 'Neighbourhoods of the Future' programme, Haringey council is providing free telematics services for businesses and residents via the company CleanCar (https://www.haringey.gov.uk/parking-roads-and-travel/travel/neighbourhoods-future-wood-green/cleancar-mobile-app). The user's real-world driving data is measured via GPS over a 2 week to 3-month period and produces a report detailing their suitability to switch, recommended vehicles, estimated impact (cost and emissions savings) and (where appropriate) charging infrastructure recommendations.
T17	Provide **financial incentives** for low emission technologies and to encourage behaviour change.	Costs based on either: • match funding Government offer for all battery electric cars, vans and motorcycles sold in the region (£3,500 per car, £8,000 per van and £1,500 per motorcycle; BEV sales of 236,000 cars, 19,000 vans and 9,000 motorcycles in WY by 2030; BEV sales of 93,000 cars, 9,000 vans and 5,400 motorcycles in YNY). • Low or no interest loan of full cost of BEV car for every BEV car sold to 2030, assuming cost of loan is ~15% of total purchase cost • Mobility credit based on modelled switch in car journeys (reduction in car journeys of ~600,000 in WY and 200,000 in YNY), assumed proportion of eligible participants (~50% in low income jobs) and journeys suitable for shift to public transport (~30% based on modelling), with £1,000 mobility credit paid per participant	In the context of the upcoming Clean Air Zone (CAZ), Birmingham is setting up a mobility scheme to encourage people to use public transport instead of their car. Individuals who travel into the CAZ for work, have a non-CAZ compliant car and earn under £30,000 p.a. will be eligible to choose from: • £1,000 mobility credit • Scrapping their car and getting £2,000, either as mobility credit or against the purchase of a CAZ compliant car. The mobility credit will be added to the Swift card, the regional transport card that includes, tram, buses and trains.

Transport policy references (3/3)

No	Policy Description	Cost & resources	Examples
T18	Implement traffic control measures such as: • **zero emissions zones (ZEZs)** in key city and town centres. • **traffic circulation plans** for key city centres to reduce through-traffic and confine traffic to defined routes e.g. through strategic road closures and/or limiting travel to within defined zones • **20mph limits** on all residential roads and appropriate major roads.	Zero emission zone costs based on reported range of costs for similar scale projects including: Liveable Neighbourhood schemes (e.g. Royal Borough of Greenwich), proposed Leeds Clean Air Zone (£6.9m funding; see https://airqualitynews.com/2020/10/13/leeds-clean-air-zone-is-no-longer-required-joint-review-finds/), and London's Congestion Charging zone (https://www.eltis.org/discover/case-studies/central-london-congestion-charging-scheme-uk). Circulation plan costs based on scheme implemented in Ghent, Belgium (see https://www.cadencemag.co.uk/ghent-changing-the-whole-circulation-plan-overnight-a-strong-political-decision/)	In 2017 Ghent implemented a 'Circulation Plan', carving the city centre up into six wedge districts and banned cars from travelling between districts. This has resulted in a 13% reduction in rush hour car traffic, and a 39% reduction in cars on the most popular streets in the inner city . Space freed up from cars has been reallocated to widened cycle lanes and bus corridors, as well as improvements to the public realm. (http://www.ppmc-transport.org/wp-content/uploads/2018/09/04_Pelckmans.pdf) In 2016, Barcelona launched a mobility plan to divide the city into a series of blocks, with the aim of reducing traffic by 21%. Savings of €1.7bn have been estimated due to health benefits (I. Lopez et al. Atmosphere 2020, 11, 410; doi:10.3390/atmos11040410)
T19	Provide **funding to support EV chargepoint rollout** for LAs and community schemes,	Indicative costing based on TfL's £18m investment fund for rapid chargers (see https://tfl.gov.uk/modes/driving/electric-vehicles-and-rapid-charging)	–

Buildings policy references (1/2)

No	Policy Description	Cost & resources	Examples
B1	Set up a **'One-stop shop'** for energy efficiency and low carbon heating.	Costs and resources based on published costs of the Greater London Authority's RE:NEW project (https://www.london.gov.uk/sites/default/files/renew_evaluation_-_final_report.pdf). This project has a total budget of £2.8m and is involved in improving the energy efficiency of 130,000 homes in London over 10 years. Target costs are reported as £30 per tonne CO_2 saved. The upper bound of cost for WY and YNY is calculated by scaling the RE:NEW cost by number of households: WY = 679,000 total homes retrofitted by 2034 YNY = 257,000 total homes retrofitted by 2034 The lower bound of cost is calculated using the £30 per tCO2 saving, using the outputs of the emissions pathways modelling.	Durham County Council provides an in-house Home Improvement Agency service which can can provide specialist surveyors and project managers with technical expertise. It also administers and oversees the County's Financial Assistance Policy (FAP), offering a range of financial loan and grant products to private property owners to undertake essential repairs/improvements to their homes. A business energy efficiency programme (Durham BEEP) was also offered, giving fully-funded audits and specialist advice on energy efficiency. In Bordeaux, the Metropole has implemented a suite of measures to drive building renovation, including awareness raising, technical support and financial incentives, all delivered via a Local Energy Renovation Platform. Actions include a partnership with commercial banks to stimulate uptake of national 'eco-loans', and the implementation of a 'subsidy advance payment fund' to advance money to contractors to carry out energy efficiency retrofits forlow income households.
B4	**Initiate new low carbon heat network schemes** in cost-effective and heat density-appropriate areas	Costs based on existing heat network schemes, including those applying for HNIP funding and local schemes. For example, the Leeds PIPES network serves ~2,000 buildings and cost £35m, of which ~£10m contributed by WYCA and LCR. Costs scaled based on number of homes required to connect to DH networks in the Max ambition scenario (138,00 homes in 2030 and ~200,000 homes by 2038 in WY; 48,000 homes in 2030 and 71,000 homes in 2038 for YNY).	–
B6	Explore **rooftop solar opportunity** in the region.	–	The London Solar Opportunity Map has been developed to highlight opportunity areas for installing solar and storage in homes and businesses. Based on LiDAR data, it provides an initial estimate of the amount of electricity that could be generated from panels both on rooftops and at ground level.
B7	Develop a **combined solar PV and battery storage offer**	–	Solar Together is a programme aiming to help homeowners to install solar PV on their homes at an affordable price via group buying. Thus far, 10 authorities have signed up. In London, 624 homes had received panels as of 2019.
B10	Provide **financial incentives** to support uptake of low carbon measures	Cumulative costs calculated based on modelled number of homes fitted with heat pumps in the Max ambition scenario (~490,000 in WY and ~190,000 in YNY by 2030) assuming either: • Match funding (£4,000) of the proposed Clean Heat Grant for all installations • Grants covering 10% of the cost of all installations • A low or no interest loan covering the full cost of a heat pump, assuming the cost of providing the loans is ~15% of the purchase cost	In London, the Mayor's Cleaner Heat Cashback is a boiler scrappage scheme, providing 30-40% cashback to small businesses for replacement of older polluting boilers with a more efficient, cleaner source of heat, creating up to 25% savings on bills.

Buildings policy references (2/2)

No	Policy Description	Cost & resources	Examples
B11	Initiate **exemplar and demonstrator projects** of new build high energy efficiency standards, and whole house retrofits (energy efficiency and low carbon technology) in social housing	Costs and resources based on comparison with existing projects. For example, Norwich council spent £15 million on very high energy efficiency housing, building 93 homes in the Goldsmith Street project. The range given in the policy table reflects that a larger project would likely be desired. The Energy Leap project, retrofitted 10 London homes at a total capital cost of £800,000, with costs covered by the GLA (~50%), and boroughs and housing providers (50%). A further $170,000 of grant funding was secured from the Carbon Neutral Cities Alliance to cover staffing, marketing and other expenditures	See references (left)

Power policy references (1/2)

No	Policy Description	Cost & resources	Examples
P2	**Financial:** Launch a programme providing **low-interest loans** for small and medium scale low carbon power technologies including solar, wind, AD, energy from waste	Cost based on Element energy's indicative cost projections for onshore wind and solar PV. UK installed costs for wind and solar in 2019 were £1.4 million and £783k per MW, respectively. Considering total capacity increase and discount rates total investment needed by 2038 is estimated to be £2.6 billion. Element also estimates that the cost of lending a generous low-interest loan may be ~15% of the total investment. If 10%-40% of the renewables are covered by such a loan cumulative cost for the study region would be ~£40-160 million by 2038. This is £31-£124 million for YNY and £7.6-30 million for WY.	
P6	**Procurement:** Installation of solar PV, battery storage, demand side response or other related small scale generation and flexibility technologies on council owned land & buildings, including affordable housing, offices and commercial space. Generation and flexibility should be considered together.	2020 battery storage prices for rooftop solar systems are estimated from the Green Match website (https://www.greenmatch.co.uk/blog/2018/07/solar-battery-storage-system-cost) considering different sizes and technologies. The rooftop solar cost quoted here is higher than the prices used in our model due to smaller scale of projects. Costs are based on the Renewable Energy Hub article (linked below). We used the lower range of £6,000 pee 4 kW. In reality it is possible to achieve lower costs by combining projects and increasing scale. https://www.renewableenergyhub.co.uk/main/solar-panels/the-cost-of-solar-panels/#:~:text=Your%20average%20solar%20set%20up,on%20how%20many%20are%20needed	Although not a procurement programme targeting council owned properties, the City of London made a power purchase agreement with Voltalia for a 49MW solar farm in Dorset. The PPA will cost £40 million and supply about half of the City Corporation's electricity for 15 years. This project cost is similar to the large-scale solar PV cost used in the model and quoted in P2 above. https://www.solarpowerportal.co.uk/news/city_of_london_corporation_signs_first_of_its_kind_40m_ppa_for_dorset_solar
P8	**Coordination, facilitation, finance:** Provide **guidance and support to community renewable projects**. Among other things, set up a grant and loan scheme to finance feasibility studies and capital investments into community energy projects.	It is assumed that the CAs/LEPs can provide grants of similar magnitudes to the phase 1 of RCEF in the study region. Ideally projects can then justify investment due to their net value generation or receive additional support from national programmes.	The Rural Community Energy Fund (RCEF) is a £10 million programme which supports rural communities in England to develop renewable energy projects. Funding is provided by BEIS but the programme is run by 5 local energy hubs. Tees Valley Combined Authority (TVCA) runs it across the North East, Yorkshire and the Humber region. Funding consists of grants of up to £40,000 for initial feasibility studies and potentially another grant of up to £100,000 for implementation. Currently only areas with a population less than 10,000 can participate. https://teesvalley-ca.gov.uk/business/key-sectors/energy-and-renewable/rural-community-energy-fund/

Power policy references (2/2)

No	Policy Description	Cost & resources	Examples
P10	**Feasibility:** Work with existing EfW facilities in developing decarbonisation strategies and future CCUS retrofit plans. This may include grants for having feasibility assessments of decarbonisation strategies. Facilitate communication between the facilities and future CO_2 infrastructure developers or other large customers in the region.	Following the IETF phase 1 funding requirements explained on the right, supporting EfW feasibility studies may cost in the range of £50,000 - £100,000, considering the average size of the sites.. This is because any funding provided by the local authorities would be a top-up of national funding or matched to a degree by the EfW company.	The Industrial Energy Transformation Fund (IETF), run by BEIS, supports high energy consuming businesses to undertake feasibility and engineering work in phase 1. CCS and waste energy related projects are eligible and minimum funding required for feasibility studies is £60,000 and the minimum funding awarded for engineering projects will be £100,000. https://www.gov.uk/government/publications/industrial-energy-transformation-fund-ietf-phase-1-how-to-apply
P14	**Skills & Training:** Collaborate with local training organisations, colleges, companies, etc. to improve and expand their programmes. Provide financial support for increasing capacity. Establish an internship programme – connecting skilled interns/students with organisations developing low-carbon technologies. Supplement the programme via grants or compensating part of the interns costs.	Supplementing or matching the apprenticeship programme may imply an additional spending of £1,000-£3,000 per learner on top of existing programmes.	National government offers an Apprenticeship Programme which offers financial support for hiring and training an Apprentice. Small companies with a pay bill of < £3 million can get funding for 95% of training costs up to a limit depending on the profession. This is mostly in the range of £3,000-£9,000. Additionally the government is offers a grant of up to £2,000 for any new hires until 31 January 2021. https://www.gov.uk/employing-an-apprentice The national government also supports adult learning through the Adult Education Budget (AEB) which provides grants or partial finance for training to acquire level 2 or 3 qualification or complete a traineeship. Special provisions exist for low wage workers, the unemployed and younger adults. Recently some devolved administrations (such as London, Manchester, Liverpool, Tees Valley CA, etc.) took ownership of their own AEB. These programmes may be leveraged to provide training for low-carbon jobs. https://www.gov.uk/guidance/adult-education-budget-aeb-funding-rules-2020-to-2021

Industry policy references

No	Policy Description	Cost & resources	Examples
I3	**Feasibility (large sites):** Support (including financial) for large industrial sites to carry **audits and feasibility studies** for developing complete decarbonisation roadmaps depending on their specific circumstances.	Following the minimum budget requirements for IETF phase 1 funding explained on the right, supporting feasibility studies of larger industrial sites may cost in the range of £10,000 - £50,000, if we assume that 20%-50% is covered by the CA/LEP. Grant size would change considerably by site size and the majority of industrial sites at both WY and YNY are on the smaller end. Ideally grants would be topped up by the businesses and or national programmes.	The Industrial Energy Transformation Fund (IETF), run by BEIS, supports high energy consuming businesses to undertake feasibility and engineering work in phase 1. CCS and waste energy related projects are eligible and minimum funding required for feasibility studies is £60,000 and the minimum funding awarded for engineering projects will be £100,000. https://www.gov.uk/government/publications/industrial-energy-transformation-fund-ietf-phase-1-how-to-apply
I5	**Feasibility (small sites):** Further evidence gathering and develop archetypal decarbonisation routes for small industries using the survey results and national evidence. Provide partial grants to small industry where audits/feasibility studies are needed.	For the purposes of this study it is assumed that the feasibility studies for small industrial facilities and SMEs would be about half of the costs assumed for larger facilities (see I3).	
I7	**Financial:** Provide **funding and access to finance for energy and material efficiency improvement projects** in all industry. For the SMEs this can build on the existing Resource Efficiency Fund.	It is assumed that SMEs would receive a similar level of support (up to £10,000) through this policy as the REF programme. The total available funds would have to expand to cover more businesses. Since material and energy efficiency measures are likely to save money, additional top up grants for SMEs and larger sites may be available.	WYCA, through the Resource Efficiency Fund (REF), provides advice and grants of up to £10,000 to SMEs in Leeds City Region (not Barnsley) to help them lower their carbon footprint, energy use and water and waste costs. The fund is partly supported by the European Regional Development Fund. REF aims to reach 300 businesses and allow them to reduce 3000 tonnes of emissions per annum. https://www.westyorks-ca.gov.uk/projects/clean-energy-and-environmental-resilience/resource-efficiency-fund/
I9	**Financial:** Establish a **small industry and SME decarbonisation support programme** providing top-up grants and favourable loans. Mainly covers fuel switching to electricity, hydrogen and bioenergy. Introduce a scrappage scheme from 2030 giving grants for early equipment switching.	Costs of specific fuel switching technologies are highly variable and site dependent. For example, installing a domestic air source heat pump may cost £8,000- £18,000, whereas a ground source heat pump may cost £20,000 to £35,000. Small industrial sites are likely to incur higher costs due to their size and total energy demand. Still national schemes, such as the Renewable Heat Incentive, would top-up funding. https://www.greenmatch.co.uk/blog/2014/08/the-running-costs-of-heat-pumps	Energy Savings Trust used to run a domestic boiler scrappage scheme which gave £400 vouchers for replacing the lowest grade boilers. Sometimes the suppliers added another £400. This support only covered a small part of the £2500 average boiler replacement cost. https://www.simplyswitch.com/energy/guides/boiler-scrappage-scheme/

LULUCF and agriculture policy references

No	Policy Description	Cost & resources	Examples
L1	Develop a **spatial land use strategy for the region** which plans ahead for/accelerates Local Nature Recovery Strategy design	Based on funding awarded for Local Nature Recovery Network pilots (https://www.gov.uk/government/news/five-local-authorities-announced-to-trailblaze-englands-nature-recovery-pilots) - £1m fund split between 5 projects	–
L11	Develop a programme of **grants and financial incentives** for farmers and landowners to deliver measures.	Cost estimates based on upper limit of providing ~50% of cost of measures, as modelled.	–

Contents

Further discussion on areas out of scope – Emissions sources and circular economy

Emissions sources

This report focusses on scope 1 and 2 CO_2 emissions from key sectors in the energy system. There are wider considerations and system changes that were outside the scope of our study, but that are worth briefly mentioning:

Scope 3 emissions: Scope 3 emissions are any indirect emissions which are not related to electricity or heat use. Examples include emissions embedded in products imported to the study region. Scope 3 emissions are excluded from the current study due to their complex nature and the lack of regional authority to influence them. Ideally wider national decarbonisation strategies will reduce scope 3 emissions with time. Still, some of the policies recommended in this study, such as green public procurement programmes, partially address these emissions by placing limitations on which products can be used (including imports) in the study region.

Non-CO_2 emissions:

- **Methane emissions:** methane and N_2O were included in the agriculture sector due to their significance there, but only included as CO_2e under fuel combustion in other sectors. Other sources of emissions not explicitly considered in this study could, for example, include methane from direct leakage through the gas supply chain.
- **SF_6 is a powerful greenhouse gas** and is used to insulate electrical installations (e.g. switchgear). It is used more as the proportion of renewables increases. However, the current levels of SF_6 in the atmosphere are very small (0.00001 ppm), and the anthropogenic increase is also tiny, meaning the overall warming potential is still very small compared with CO_2. Its emissions should be regulated and reduced, and governments should encourage the development of alternative electrical insulators to SF_6 to ensure this doesn't become a significant contribution in the future.[1]

Circular economy

Circular economy and system changes:[3] the focus of this study was on addressing the current emissions in the context of our energy system. We included some high-level circular economy concepts, such as increased recycling and resource efficiency, as well as some policy suggestions, but this was not assessed in detail, partly due to the current uncertainty. However, these wider system demand side measures could significantly contribute to emissions reductions in the longer term, particularly reducing heavy industry emissions from steel, plastics, aluminium and cement industries (very limited in the study region). These should be investigated further during the 2020s.

Wood as a construction material:

- This has the benefit that it stores CO_2 that has been extracted from the atmosphere by trees, but it also has the benefit of replacing carbon intensive materials such as cement and steel. A recent report for the CCC concluded that "At the individual building level, the reduction in embodied emissions for substituting timber frame for masonry is approx. 20%. A greater reduction (~60%) is seen for CLT and concrete structures." However, there are other factors to consider, such as the lifetime energy and carbon performance of the resulting building.

It is recommended that further work is completed to support national evidence gathering and then develop regional assessments of these additional factors.

1 LINK 2 Wood in construction in the UK, 2019 3 Circular economy Material economics; Circular economy DEFRA

Further discussion on areas out of scope – Air quality

Air quality

Poor air quality is known to be a significant risk to health and to the environment. A number of different pollutants contribute to poor air quality and air pollution comes from a range of sources. Pollutants can travel long distances, with emissions from both distant and local sources contributing to high local concentrations of pollution.

Alongside international obligations for reducing air pollution, the UK has set national emissions reduction targets that focus on five air pollutants:[1]

Pollutant	Key emissions sources
Fine particulate matter ($PM_{2.5}$)	**Domestic burning of wood and coal** (38%), road transport tyres and brakes (12%), solvent use and industrial processes (13%)
Ammonia	**Agriculture** (88%)
Nitrogen oxides (NOx)	**Road transport** (34%; **80% at roadside**), energy generation (22%), domestic and industrial combustion (19%), other transport (17%)
Sulphur dioxide (SOx)	**Energy generation** (37%), industrial combustion (22%), domestic burning (22%)
Non-methane volatile organic compounds (NMVOCs)	Industrial processes (22%), household products (18%), agriculture (14%), domestic burning (5%), road transport (5%)

Improving air quality requires action across all sectors and there are many areas in which actions to tackle air quality also deliver reduced carbon emissions (and vice versa). In general, moving away from combustion of fossil fuels towards renewable energy generation and electrification of transport, heat and industrial processes is expected to significantly reduce NOx and SOx emissions. However, areas in which a focus on carbon reduction does not necessarily fully deliver air quality benefits include:

- **$PM_{2.5}$ from vehicles** - a shift to zero emission road vehicles will improve NOx emissions from the tailpipe but there will still be some $PM_{2.5}$ emissions from tyre wear and brake use. Reducing the number of vehicles on the road by shifting travel from private vehicles to active, shared and public transport therefore further supports both carbon reduction and air quality aims.
- **NOx from hydrogen combustion** - when hydrogen is combusted in a boiler or turbine, some NOx may be formed. Research to fully understand the implications for NOx generation and measures to mitigate it will be an important part of demonstration projects on the path to widespread hydrogen use.[2]
- **Bioenergy combustion** - any combustion of carbon-based fuel will also result in emission of particulates and other pollutants, even where there is a CO_2 emission benefit through it being sourced from biological sources. The CCC recommends that bioenergy must be used in a targeted way to decarbonise those sectors most difficult to decarbonise through other means,[3] and air quality ambitions may also support this approach.

1 Clean Air Strategy, Defra 2019; 2. *Hydrogen in a Low Carbon Economy*, CCC 2018; 3. Biomass in a low carbon economy, CCC 2018 LINK

Further discussion on areas out of scope – carbon offsetting is a short-medium term option to compensate for challenging residual emissions, but credits must be high-quality

Carbon offsetting is the process of purchasing voluntary carbon credits compensating for carbon dioxide emissions arising due to human activities in the region / organisation.

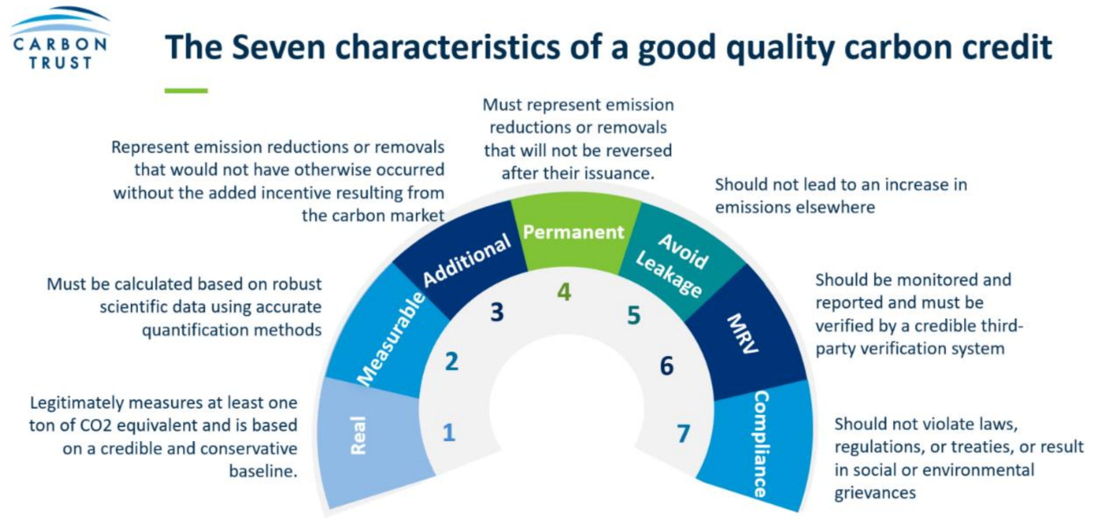
- Carbon offsetting should be considered a ‘last resort’ after options to directly mitigate emissions. They could be used in the medium term while certain solutions are not available or come at a very high cost. Carbon offsets should be used in addition to, not as a substitute for, a science-based strategy for reducing scope 1, 2, and 3 emissions
- A carbon crediting programme certifies emissions reduction projects and issues carbon credits. Some programmes mostly issue credits for compliance obligations (e.g. Clean Development Mechanism), others mostly issue credits for voluntary carbon credit purchases (e.g. Gold Standard, Verified Carbon Standard)
- There are a number of certification schemes which aim to verify carbon credits / offsets. Three of the most developed / recognised are Gold Standard, Verra Verified Carbon Standard, CCB standards. Some of these have a range of associated projects to explore, such as low carbon stoves in Africa, landfill gas recovery, afforestation, renewable energy etc.

Two main types of carbon offset:

- Greenhouse gas emission avoidance: activities that lead to avoidance of future emissions (e.g. renewable energy installations, avoided deforestation, energy efficiency improvements in developing countries)
- Greenhouse gas removal: activities that remove and sequester atmospheric carbon (e.g. afforestation, habit restoration, direct air capture of carbon)

Purchased carbon credits should meet robust quality criteria. The key characteristics of a good quality carbon credit are laid out in the diagram.

The Carbon Trust suggests that PAS 2060 (BSI) is the only recognised international standard for carbon neutrality. It sets out requirements for quantification, reduction and offsetting of greenhouse gas (GHG) emissions.



The Seven characteristics of a good quality carbon credit

Legitimately measures at least one ton of CO2 equivalent and is based on a credible and conservative baseline.

Must be calculated based on robust scientific data using accurate quantification methods

Represent emission reductions or removals that would not have otherwise occurred without the added incentive resulting from the carbon market

Must represent emission reductions or removals that will not be reversed after their issuance.

Should not lead to an increase in emissions elsewhere

Should be monitored and reported and must be verified by a credible third-party verification system

Should not violate laws, regulations, or treaties, or result in social or environmental grievances

Source: WWF (2020). WWF Position and guidance on voluntary purchases of carbon credits.

25

The price of carbon offsets varies widely from <£10/tCO_2, to >£100/tCO_2. As an illustration, if we assume that half of the residual 2038 emissions of around 2$MtCO_2$/yr (WY) are offset through carbon credits at £50/tCO_2, this would be around £50 million/year.

Sources: Carbon Trust; WWF position and guidance on voluntary purchases of carbon credits, available to view here