The role of biomass and BECCS in the UK energy system

Final Report

June 2025

On behalf of:

REA

BIOMASS UK

The REA has commissioned Baringa to produce a report setting out the role of biomass in the UK energy system to date and assessing its potential roles and value in the transition to Net Zero

Biomass has played a critical role in the UK (and global) energy system for centuries and continues to play a diverse role today, with uses spanning power generation, renewable gas production, heating, and production of transport fuels. Looking forward, there are a range of opportunities for biomass to play a significant role in the UK system as it decarbonises in line with Net Zero ambitions.

Baringa has reviewed the role and impact of biomass in the UK energy system to date, and we have assessed the potential role and opportunities for biomass in the future

- We consider the policy context, pathways for production and range of end-uses for biomass. We have assessed the expected near-term roles for biomass, which focus on securing the power system, supporting near term decarbonisation and providing a path to scaling carbon removals
- We model the potential longer-term role and benefits that biomass could offer to reduce the costs and delivery risk of the transition if its role can increasingly be integrated with carbon capture to provide carbon removals
- To deliver this report we have undertaken analysis using our market leading energy system modelling capability that provides the backbone of our advice to clients and allows us to assess, test and validate the value and potential roles of technologies in the energy transition. We have utilised both our in-house tools and independent energy system models to inform this assessment

We do not provide a view on the sustainability of biomass and our analysis is predicated on a range of scenarios for sustainable biomass availability in the UK

- Sustainable biomass is a limited resource and its future availability to the UK is uncertain. The decarbonisation potential and value of biomass extends beyond its role in the displacement of fossil fuels and needs to be considered as part of a wider system of sustainable land and resource use
- The UK Government have made clear that the main principle for biomass use is sustainability and this view is shared by a range of institutions and multilateral organisations. A wide range of scenarios have been researched and developed for sustainable biomass, and wider bioenergy availability for the UK
- Our analysis and modelling of the potential role for biomass is informed by a range of independent scenarios for availability of sustainable biomass to the UK covering both domestic production and imports

Baringa is an established international consultancy with deep expertise in the energy sector. We have been recognised by the FT as the leading Energy & Utilities consultancy for the past 5 years and have a long history acting as independent advisers across the energy sector.

The REA are the largest renewable energy and associated clean technology body in the UK, with around 500 member organisations representing renewable technologies across power, heat, transport and circular bioresources. Biomass UK is the REA members forum for Biomass Power. It includes the largest group of biomass power generators in the UK, ranging in size and utilising a range of feedstocks from waste wood to compressed wood pellets, agricultural and energy crops, to biogas and biofuels.

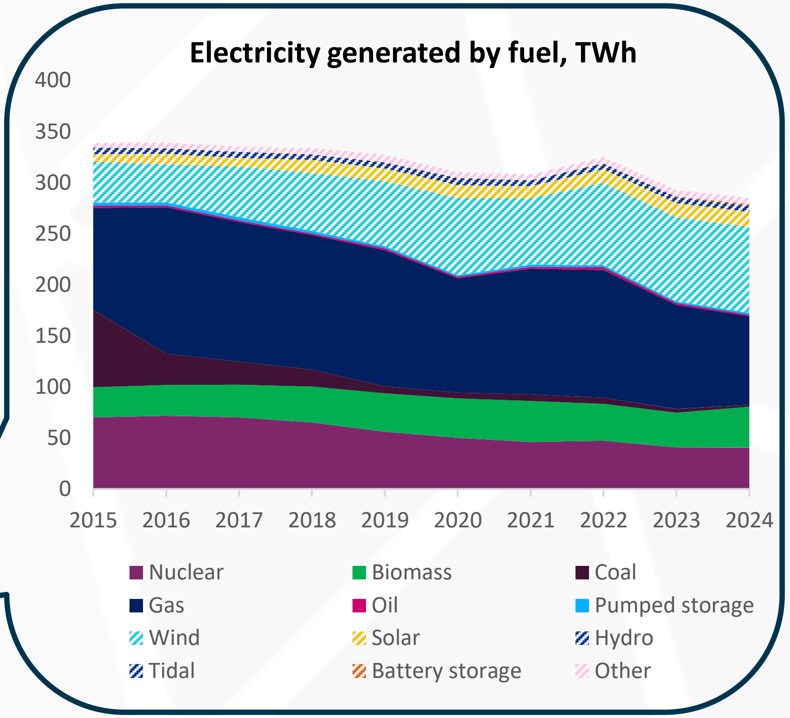
Executive Summary

Biomass is a significant source of weather independent renewable energy

- Biomass currently delivers clean heat, clean transport fuels, and green gas to the grid. **Biomass provides almost 12% of all energy consumed today in the UK** with 650 operational biomass plants across the UK providing c. 9,000 jobs. Over two-thirds of biomass used for UK energy production comes from domestic feedstocks, and imported biomass is largely sourced from stable regions – partly as a result, biomass prices are relatively stable compared to natural gas
- For the past decade, its most important role has been to **provide consistent, weather-independent power generation.** It remained the second largest source of renewable generation in 2024. Wind and solar energy are a vital and growing part of the renewable mix, but other sources of dispatchable capacity are required to manage extended periods of low wind or sun.
- The National Energy System Operator assumes a minimum of 7-11% availability across onshore and offshore wind capacity in its planning to secure the system. However, in practice wind load factors often drop below this – in the year to March 2024, wind dropped below 11% for at least two hours more than 100 times
- Biomass contributes to grid stability by providing a range of valuable services such as inertia, frequency response and reactive power. Gas also plays a key role, but reliance on **gas use increases emissions in low wind periods**

Summary of bioenergy end-uses, 2023

Electricity generated by fuel, TWh

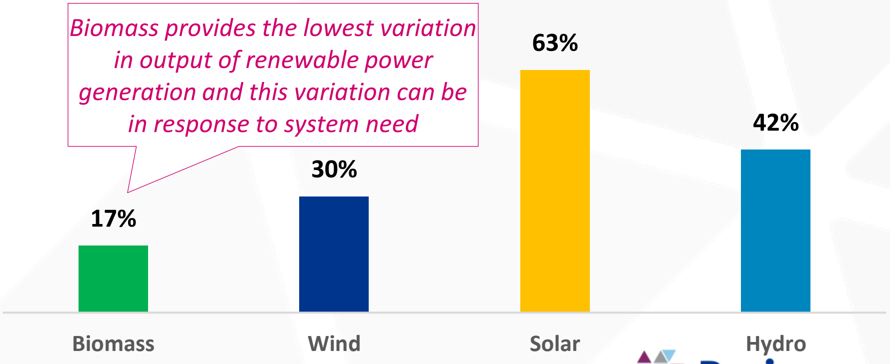


In the year to March 2024 there were ….

***5 occasions** when wind generation dropped below 11% (~1.5 GW) of capacity for **24 hours** or more*

*During these periods, biomass can provide up to **5.5 GW** of firm power output*

Average variation in daily 2024 power output, as a proportion of maximum output (%)



Data source: Elexon BSC and NESO's Data Portal, DESNZ Energy Trends

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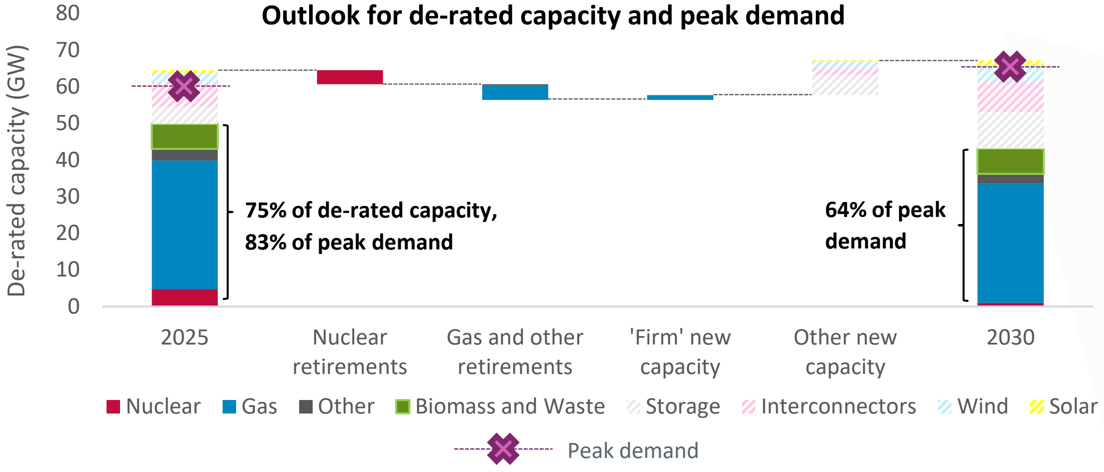
Biomass increases system security and supports more affordable decarbonisation in the near term

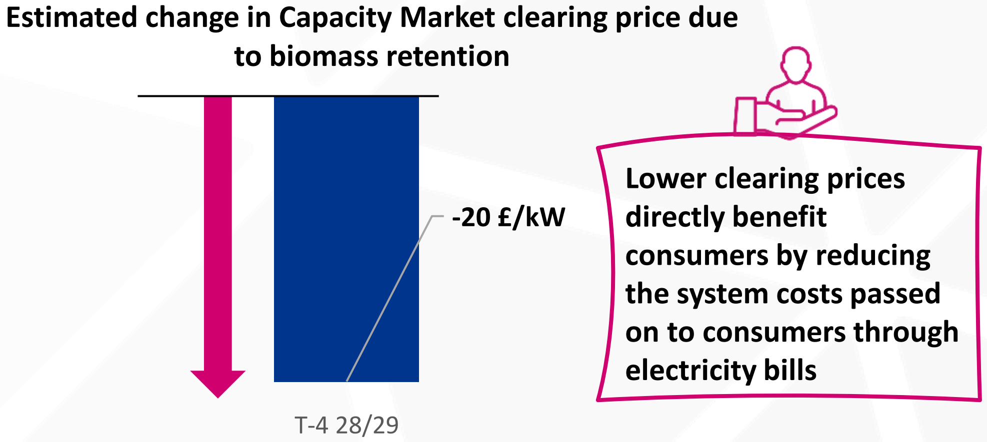
Securing the power system



De-rated capacity is the reliable power output available from generation sources after adjusting for real-world conditions like availability and efficiency.

- While there has been significant growth of renewable capacity in the past decade, gas, nuclear and biomass 'firm' capacity continue to provide almost 75% of de-rated capacity
- Up to 8 GW of generation that we currently rely on in periods of low wind is set to retire by 2030, which may put security of supply at risk
- The Baringa Reference Case projects only c. 1 GW of new 'firm' capacity will be built over the period to 2030
- This would mean 'firm' capacity would only be 64% of peak demand by 2030, down from 83% today, even when assuming current biomass capacity is retained. Without biomass and waste, the number would be even lower (55%)

Supporting near-term affordability and decarbonisation



- Without biomass capacity, additional capacity would have to be procured via the Capacity Market, likely through gas or battery storage
- Baringa analysis estimates that this could have increased the clearing price in the most recent T-4 auction, to secure capacity four years ahead of system requirements, by c.20 £/kW, increasing the single year cost by **£0.5-0.9 billion** and risking falling short of the auction's capacity target
- Biomass capacity has provided competitive carbon abatement. The £/tCO2e abatement costs of currently operating offshore wind farms have been c.70% higher than biomass conversions (RO and CfD assets combined, since 2010)
- Replacing biomass with gas generation would increase emissions by more than 10 MtCO2e p.a. The lost biomass generation would be equivalent to the output of 8.5 GW of offshore wind capacity and this would still result in higher emissions due to the need for gas generation in periods of low wind

Data source: Baringa analysis, National Energy System Operator

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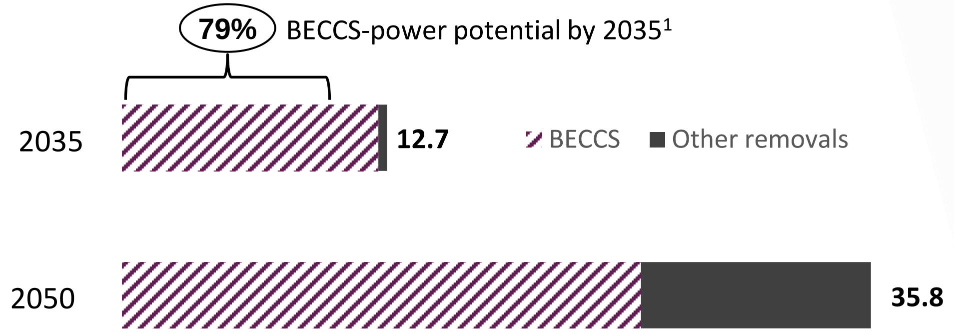
Retaining biomass capacity enables BECCS deployment to commence and scale sooner, supporting longer-term decarbonisation ambitions

Role of BECCS in carbon removals

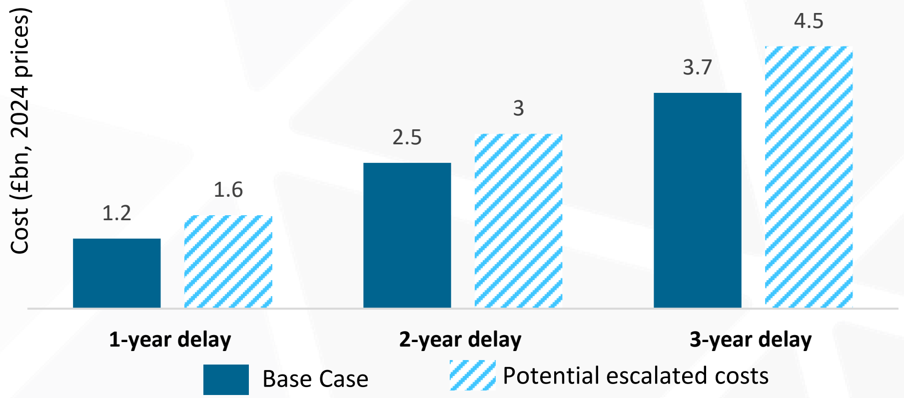
CCC balanced pathway requirement for engineered removals (MtCO2/year)



- By converting existing biomass power stations to BECCS from 2030, biomass could deliver up to 10 $MtCO_2e$/year of carbon removal by 2035, meeting almost 80% of the CCC recommendation of 12.7 $MtCO_2e$ per year of carbon removals from 2035
- The carbon reduction delivered by power-BECCS would be equivalent to:

🚗	taking 3.75 million internal combustion engines cars off the road; or
✈	cutting 57.5 million flight passengers/year, roughly equivalent to cancelling all departing flights from Heathrow for 17 months

Long-term cost of delaying BECCS[2]



- If biomass capacity and supply chains are retained, biomass can increasingly be integrated with carbon capture and utilisation, or storage, from the 2030s
- Delaying BECCS deployment in the power sector is projected to increase the cost to society of meeting Net-zero commitments by **around £1.2 billion per year of delay**. If uncertainty around deployment continues, this could cause costs to escalate by up to 25–30% due to inefficiencies and supply chain disruptions
- Carbon capture has the potential to be deployed across a range of biomass technologies including Energy-from-Waste and anaerobic digestion

In CCC scenarios, including the Balanced Pathway to Net Zero, BECCS plays an important role. It would be much more expensive to rebuild biomass capacity and supply chains in future for BECCS compared with maintaining existing facilities and converting them. Beyond 2035, scaling BECCS across additional sectors outside of power could further enhance cost savings and emissions reduction, providing flexibility for hard-to-decarbonise sectors.

Notes: *1. This assumes three units converted to BECCS: two at Drax and Lynemouth by 2035. BECCS category in chart includes BECCS-power, BECCS- energy-from-waste and other technologies.*
2. Based on Baringa system-modelling of projected cost impact of delays to first biomass to BECCS conversion

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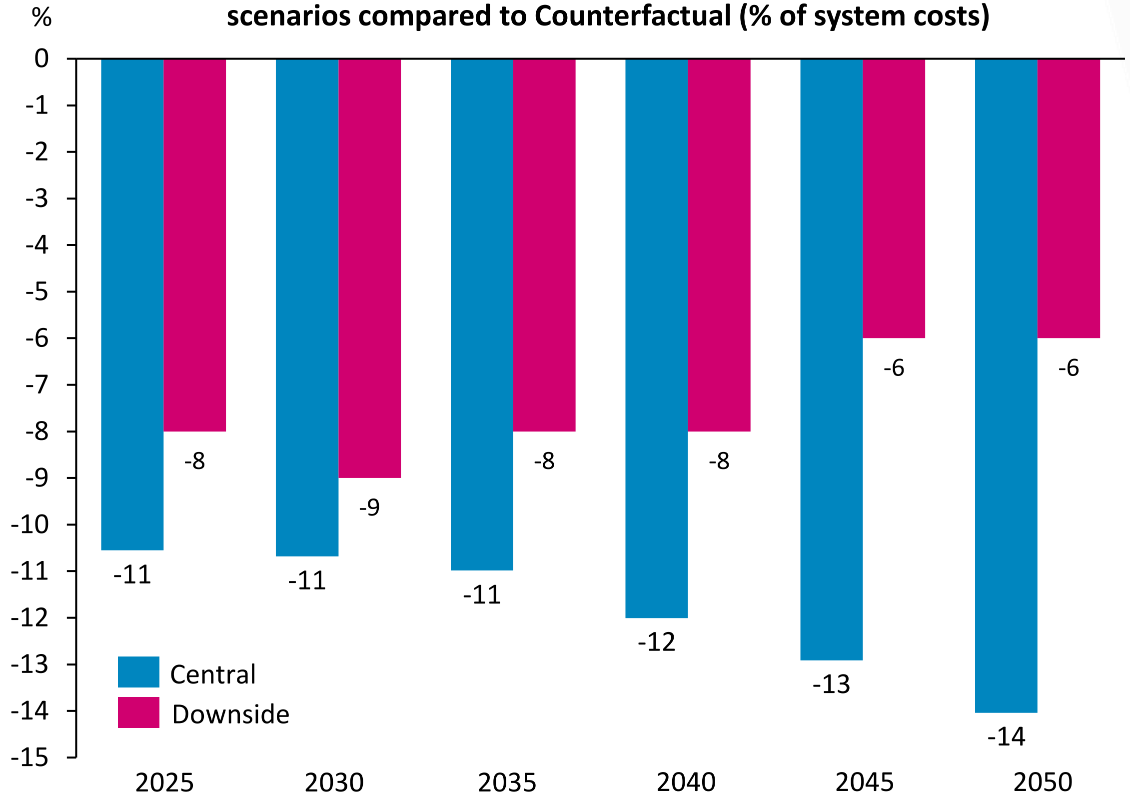
Increasing the role for biomass could reduce energy system costs by up to 14%

Cumulative system cost required to achieve Net-zero in our Counterfactual Scenario, where biomass consumption falls by 40%, is estimated to be 14% higher than in the Central Scenario. Biomass can play a valuable role across a range of scenarios

Saving in cumulative system costs – Central and Downside scenarios compared to Counterfactual (% of system costs)



With less or no use of biomass, additional effort would be required in other sectors to reach Net-zero. Alternative options are expected to be more expensive, or carry higher delivery risks, or require lifestyle changes which may prove politically challenging to implement

Key sectors	Low carbon options without biomass and BECCS	Cost and delivery impacts
Electricity	Nuclear, renewables and storage, hydrogen, gas (with CCS)	More rapid electrification and network build adds to cost and delivery risk
Heating	Heat pumps, hybrids and electric heating	Heat pumps may not be cost-effective for all homes
Transport	Hydrogen, e-fuels and electrification	Reduced flexibility of blending. Costly or more limited options for freight/shipping
Industry	Hydrogen, electrification	Higher operation costs, up to 30-40% more CO2 for hydrogen
Carbon Removal	Direct Air Capture (DAC), Afforestation	DAC more costly, afforestation is cost effective but more gradual
Agriculture	Synthetic fertilisers	Limited cost impact. Reduces options for carbon removals
Construction	Low-carbon steel and minerals extraction	Build-out and integration of CCS and/or electrification required
Waste	Landfilling and incineration	Higher costs and land-use impact from lower utilisation of biogenic waste
Lifestyle changes	Changes to diet, reduced flying	Potential for cost reduction but challenging to change behaviour

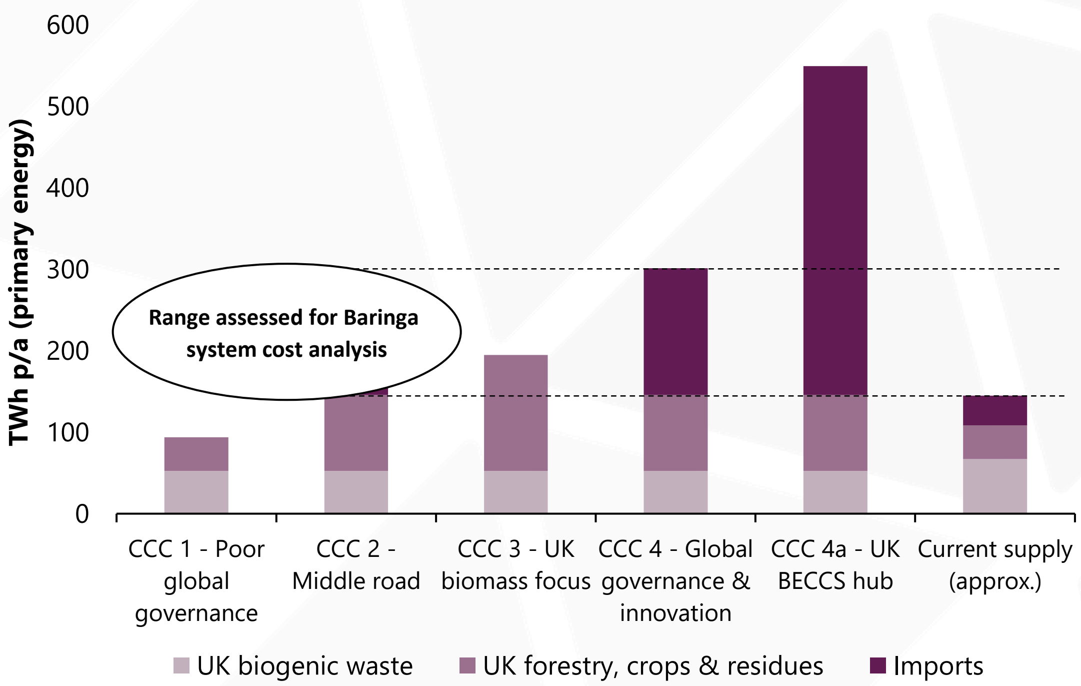
Biomass can make an increasing contribution to UK decarbonisation if sustainable supply can be scaled

Biomass is a versatile energy vector with the potential for continued deployment in a range of sectors and applications. With increasing integration of CCS technology, biomass also offers a route to carbon removals. A sustainable pathway for biomass and broader bioenergy use may see 180 TWh available across the UK in 2035, rising to 200-300 TWh by 2050. A mix of domestic and imported biomass is expected to meet Net Zero targets at a lower cost

Example roles for biomass in the future energy system

1 Energy with carbon removals	**Biomass can be used to produce renewable electricity and thermal energy for applications such as industrial process heating. When integrated with CCS technology, biomass can provide net carbon removals across its lifecycle.**
2 Fuels and chemicals production	**Biomass can be converted into liquid biofuels to help meet transport fuel needs. Gasification of biomass (with CCS) also offers a range of possible applications, such as for production of hydrogen or synthetic natural gas.**
3 Biochar system	**Biochar is obtained from the heating of biomass in the near absence of oxygen. Biochar offers an option for removing carbon from the atmosphere and storing it in soil, where it can remain in a stable solid form and improve soil.**

Example scenarios for sustainable bioenergy availability in 2050



Source: CCC analysis, Breakdown of overall UK bioenergy resource supply scenarios in 2050

The role of biomass to date

This section provides an overview of the diverse range of biomass sources and end uses. The development of biomass' role in the power sector is analysed and biomass supply chains, emissions and wider economic impacts are considered

Biomass has a diverse range of end uses

Biomass pathway summary

Biomass supply

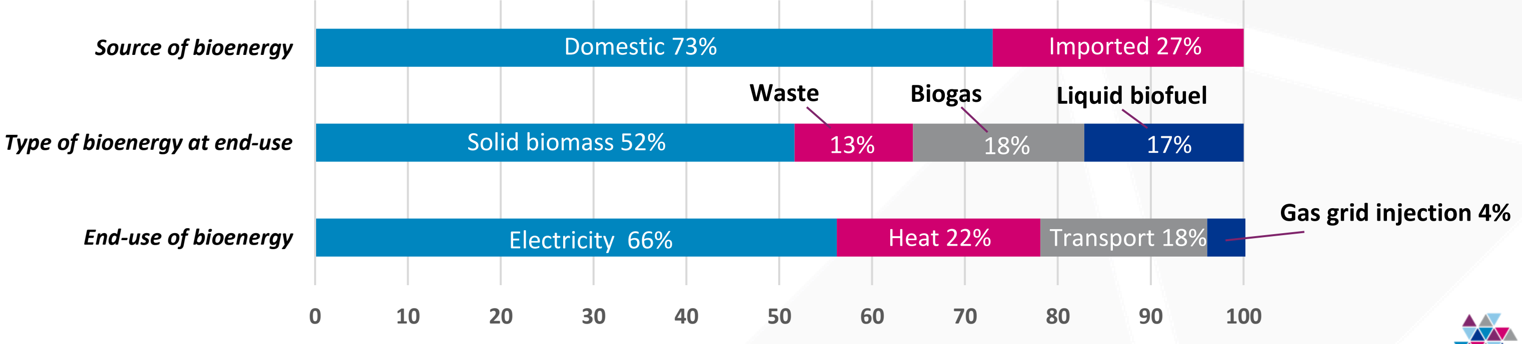
- **Industry**: Food residues; Fibre residues; Wood process residues
- **Agriculture**: Energy & short rotation crops; Crop residues; Animal wastes
- **Forestry**: Forest harvesting; Forest and agroforest residues
- **Waste**: Landfill and sewage gas; Municipal Solid Waste

Matching supply and demand + processing/conversions

Biomass uses

- **Energy supply**: Centralised electricity; Gas injection to the grid; Heat generation and export
- **Transport**: Liquid biofuels; Gaseous biofuels
- **Buildings/Industry on-site**: Heating/electricity and fuels used on-site
- **Industry**: Biorefining; Biochemicals/ Biomaterials; Charcoal

Biomass sources and end-use shares, 2023



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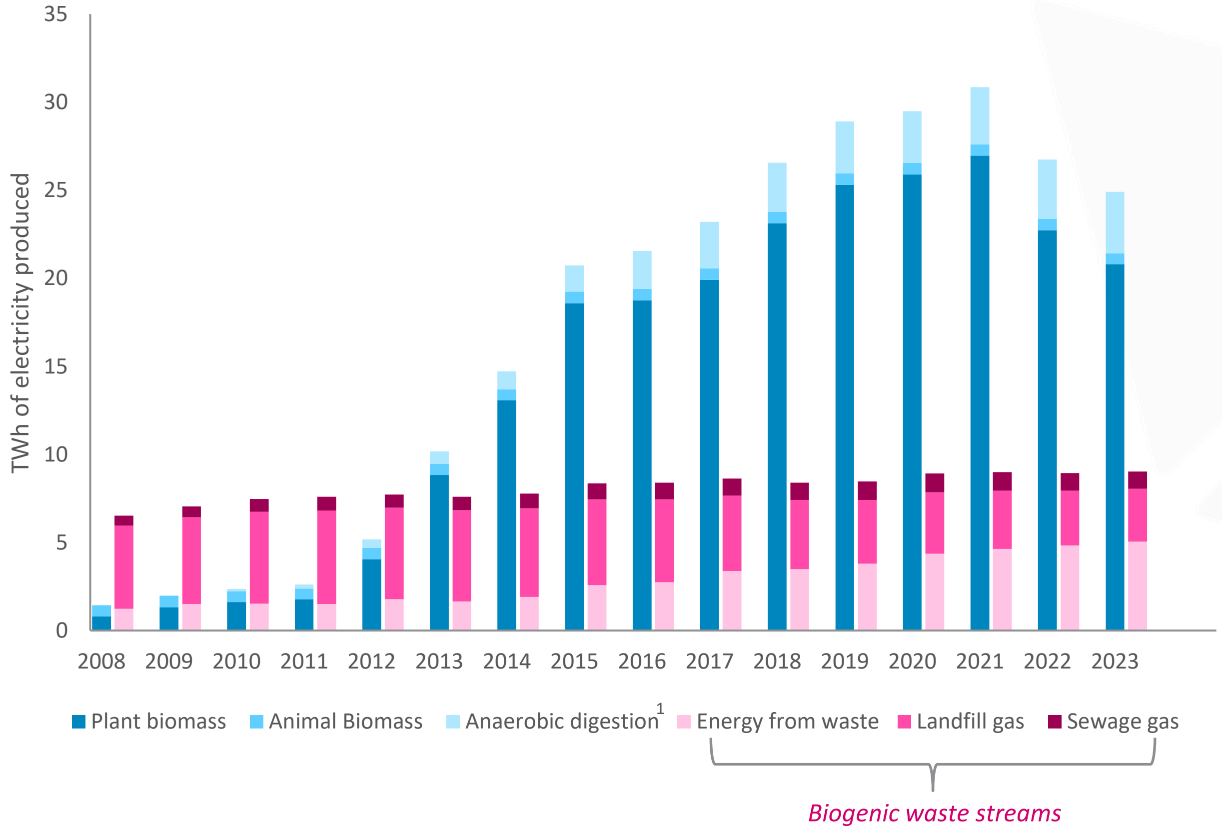
Bioenergy provides almost 12% of total UK electricity supply and plays a key role in system stability

Overview of bioenergy growth in UK electricity



The growth of bioenergy in the power sector

- Bioenergy's role in power generation has increased substantially since 2010 when it accounted for only 3.2% of total UK generation.
- The growth has been driven by conversion of former coal-fired power stations to biomass at Drax Power Station and Lynemouth, supported by the **Renewables Obligation (RO)**[2] and **Contracts for Difference(CfD)**[3] schemes. In 2024 bioenergy accounted for **14% of total electricity generation and 27% of renewable electricity generation.**
- Roughly half of the waste (**53.5%**) burned in UK incinerators is considered **biogenic**.
- In the biogenic waste stream, Energy from Waste (EfW) has experienced stable yet modest growth, contributing around 4-5 TWh in recent years (2022-2023).

Dispatchable energy source:

- Biomass delivers a reliable and controllable energy output, making it a dependable option for both **base-load** and **flexible** electricity generation
- Between January 2024 and January 2025, biomass **contributed 7% to 14%** of the UK's total electricity generation during periods of tight supply margins, ensuring energy security
- The National Electricity System Operator (NESO) recognises biomass as a vital component of the UK's energy mix, providing grid stability during **low wind generation** and **high winter demand**

1. AD: A process that uses microorganisms to break down plant and animal matter in the absence of oxygen to produce biogas which can be upgraded to biomethane for injection the grid or combusted to generate heat and/or electricity
2. RO: A UK policy requiring electricity suppliers to source a set proportion of electricity from renewable energy, supported by Renewable Obligation Certificates (ROCs) issued to renewable generators as proof of compliance
3. CfD : A UK government scheme providing renewable generators with a stable strike price for electricity, reducing revenue uncertainty and encouraging investment in low-carbon technologies

Data source: UK Energy Statistics, Digest of UK Energy Statistics (DUKES)

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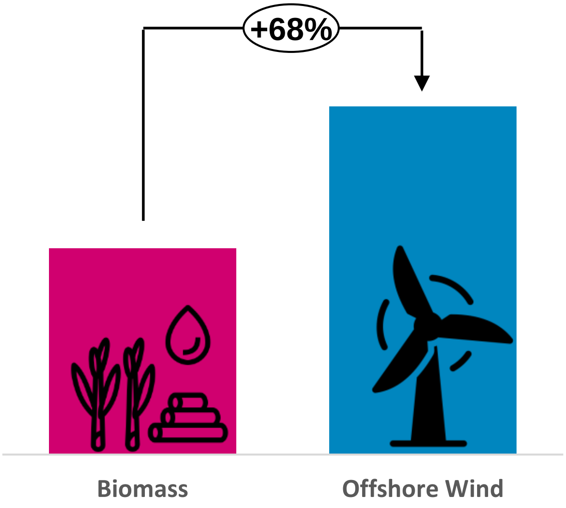
Biomass capacity has provided competitive abatement

The £/tCO$_2$e abatement costs of operating offshore wind farms have been c.70% higher than biomass conversions (RO and CfD assets combined, since 2010)



	Metric	Biomass	Offshore Wind	Solar	Nuclear	Gas
Economic	**Average GHG abatement cost (£/tonne)**	**Moderate**	**Moderate to low** (declining with new projects)	**Low**	**Moderate**	**High** to **Moderate**
Economic	**Infrastructure requirement**	Retrofitted capacity[2], Pipeline/storage for BECCS	Offshore installations & grid upgrades	Land use and storage systems	Large-scale plants, complex decommissioning	CCS requires pipeline/storage
Economic	**Dispatchability**	✓ **High** (firm capacity)	✗ **Low** (variable)	✗ **Low** (variable)	✓ **Moderate** (constant generation)	✓ **High** (fast response)
Environmental	**Carbon removals potential**	✓ Compatible with BECCS	✗ None	✗ None	✗ None	✗ None
Environmental	**Lifetime emissions impact**	**Low** (negative with carbon removals)	**Low** (zero operational emissions)	**Low** (zero operational emissions)	**Low** (zero operational emissions)	**High to Moderate** (with CCS)
Environmental	**Sustainability considerations**	• Land use impact • Air pollution • Biodiversity risk	• Marine ecosystem impact • Rare earth mining • Blade disposal challenges	• Land use efficiency • High water use • Toxic waste recycling	• Waste disposal • High water consumption	• Methane leakage risk • CO_2 transport & storage (with CCS) • Water consumption (with CCS)
Policy & system	**Policy incentive alignment with system need**	**High** (Future policy can respond to system need/scarcity)	**Moderate** (Negative price rule; requires aligned policy to drive flexibility/storage investment and operations)	**Moderate** (Negative price rule; requires aligned policy to drive flexibility/storage investment and operations)	**High** (govt-backed due to baseload role)	**Moderate** (incentives for CCS adoption and dispatchable power)

1- The averages reflect the best available data - CfD abatement cost was calculated for the period 2016-2024, and RO abatement cost was calculated for the period 2010-2024, using grid average emissions to calculate carbon saving.
2- Examples include Drax, Lynemouth.

Data sources: LCCC Data Portal and ROC data from UK government

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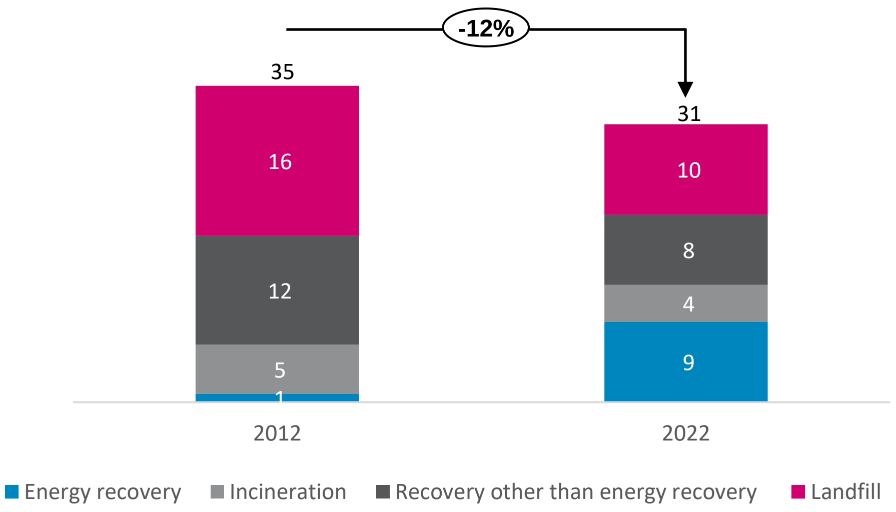
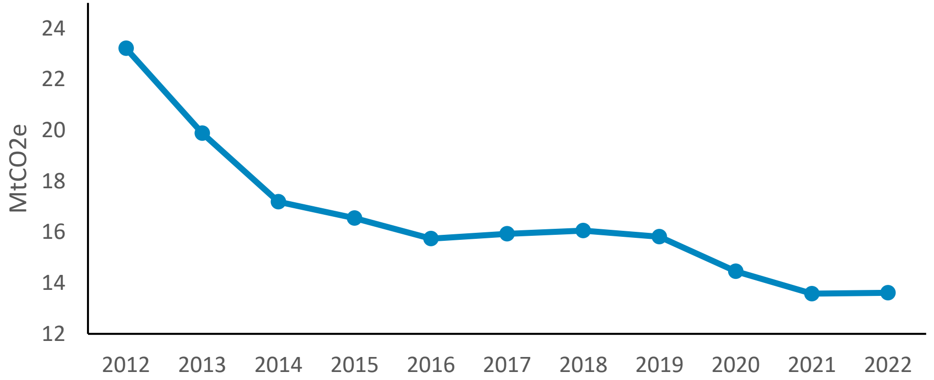
Energy recovery systems utilising biogenic waste have helped reduce reliance on landfill by 40%

Waste treatment methods over time (Million tonnes)



Methane gas emissions from landfills



Data source: UK Statistics on Waste, NAEI Methane Emissions Data Selector

Waste treatment methods summary

- *Energy recovery: converts waste into usable energy through biomass or EfW plants.*
- *Incineration: waste combustion without energy recovery, primarily for volume reduction.*
- *Other recovery: reusing, recycling, or composting waste, including backfilling to restore landscapes.*
- *Deposit into/onto lands: direct disposal in landfills, a major contributor to methane emissions*

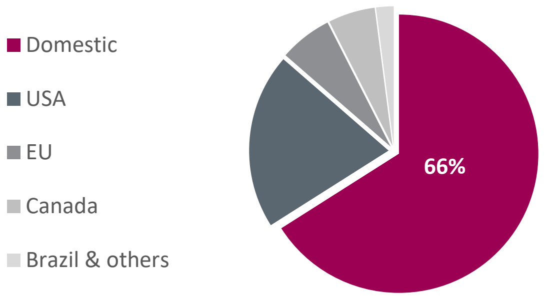
Reduced Landfill dependency:

- By diverting biodegradable municipal waste from landfills to energy recovery systems (including anaerobic digestion and biomass energy plants), methane emissions from decomposing waste in landfills have been reduced from c.24 $MtCO_2e$ in 2012 to c.13 $MtCO_2e$ in 2022.
- As a result, landfill dependency dropped from 16.5 million tonnes in 2012 to 9.9 million tonnes in 2022. While landfill dependency decreased, the volume of waste treated through biomass energy recovery and energy-from-waste incineration increased. Energy recovery experienced a dramatic increase in capacity (~**6.5-fold increase**), taking on a larger share of BMW treatment
- The UK government plans to include **waste incineration facilities in the Emissions Trading Scheme** (ETS) by 2028, with a monitoring, reporting, and verification phase starting in 2026. This aims to **reduce fossil-based waste incineration,** particularly in plants without CCS

Waste wood processing has played a significant role in diverting waste from landfill, with 4.3 million tonnes processed in the UK in 2022. Of this, 63% (~2.7 million tonnes) was used in biomass power stations to generate low-carbon energy.
(Wood Recyclers' Association, 2023)

Biomass has a stable and predictable supply chain

Share of domestic vs imported biomass for energy production (2022)



Imported Biomass: Primarily wood pellets

Domestic Biomass: agricultural residues, forestry by-products and organic waste.

Comparison of imported biomass and natural gas used for power generation

Metric	Biomass imports	Natural gas imports
Primary Suppliers	**USA (61%),** Europe (18%), Canada (15%) Brazil, others	**Norway (57%),** USA (26%), Qatar (6%), Peru, others
Energy type	Wood pellets	Pipeline and LNG gas
Geopolitical Risk Exposure	**Low** (spread across stable regions)	**Moderate** (more globalised market to transmit price shocks)
Import Flexibility	**Moderate** (global suppliers, infrastructure dependent e.g. ports)	**Moderate** (pipeline and liquefaction infrastructure dependent)
Aligned with Net Zero	**Yes** (low carbon when sourced sustainably)	**No** (high carbon emissions from natural gas use)

The majority of biomass used in the UK is produced domestically:

- In 2023, **68%** of biomass used for UK energy production (electricity, heat, and transport) came from **domestic feedstocks.**
- There are over **650** anaerobic digestion (AD) plants, producing biogas and supporting local energy grids, supporting biomass' broader role in energy security.
- There are opportunities to further develop domestic sources of sustainable biomass. For example, UK government has **allocated £36 million under the Biomass Feedstocks Innovation Programme** based on two phases. Some of the innovations achieved include miscanthus planting, sustainable seaweed farming techniques, and conversion of agricultural residues into high-value bioenergy products.

Biomass offers a stable and predictable supply:

- Biomass offers inherent cost stability compared to natural gas, which is prone to global market fluctuations and geopolitical risks. Biomass costs have proven less volatile, reducing volatility in the overall UK fuel mix. While hedging strategies can temporarily shield natural gas users from price spikes, they do not fundamentally address its longer-term volatility.

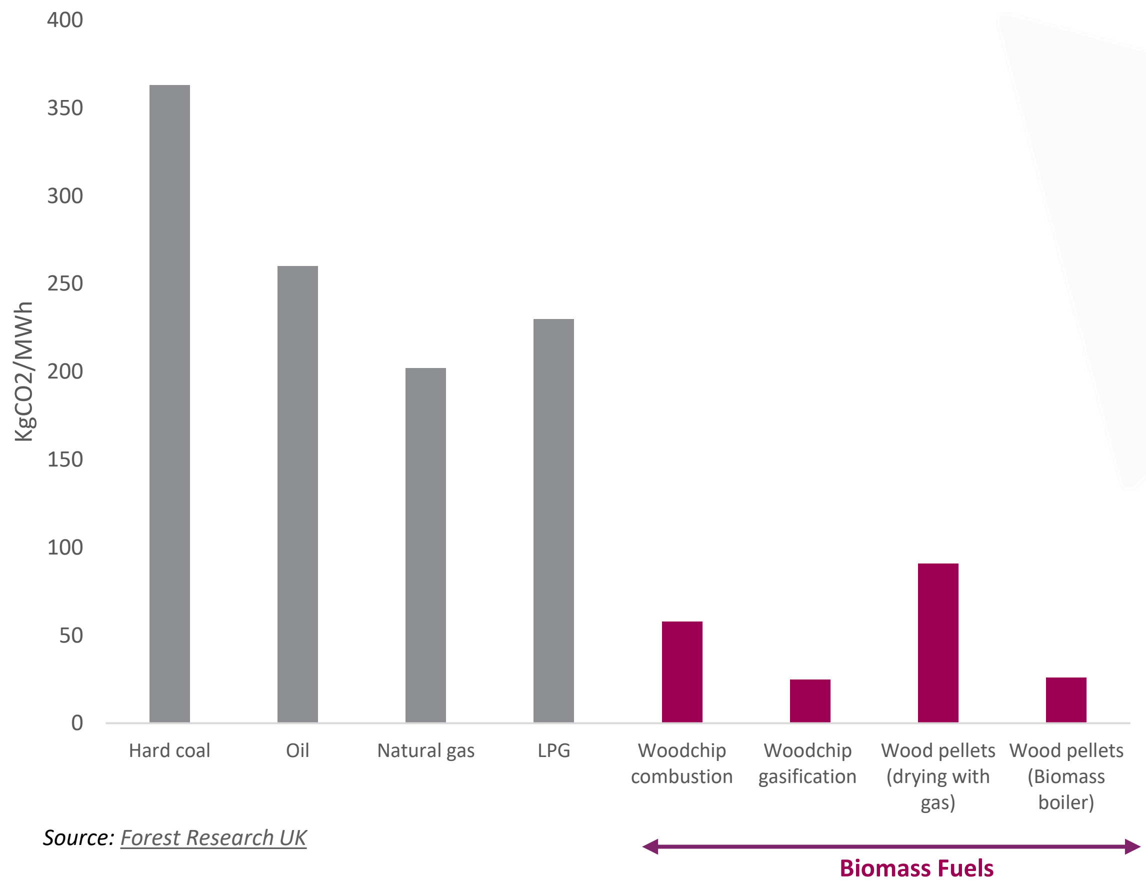
The sources of imports and market dynamics reduce risks:

- In 2022, **60% of wood pellet imports came from the USA, 16% from Canada, and 18% from Europe**. Natural gas imports are also concentrated among a few countries.
- However, price shocks are more readily transmitted in the gas market and increase the risk of supply disruption during geopolitical events, as seen with the 62% drop in Russian gas exports to Europe in 2022.
- The regional nature of the gas market in Europe meant that prices spiked when Russian supplies were halted, whereas the bilateral and long-term nature of biomass contracts makes that less likely.

Note: Biomass imports data is for 2022, Natural gas imports data is for 2023. Data source: DUKES 2024, UK Biomass Strategy (2023), 2022 Forestry Statistics, 2023, BEIS Biomass Feedstocks Innovation Programme

Sustainable biomass has low lifecycle emissions

Lifecycle CO2 emissions of different fuels per unit of energy[1]



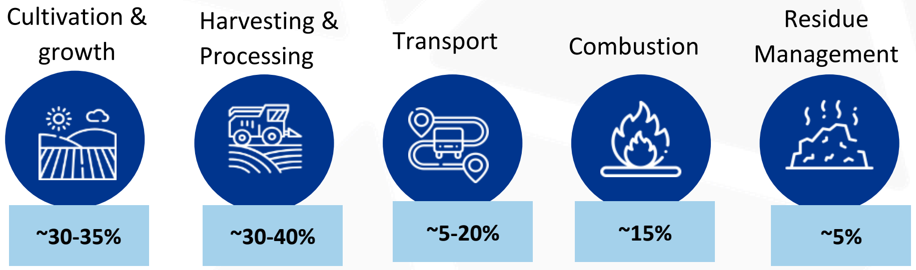
Source: Forest Research UK

Wood pellets are a key part of the global biomass trade and are widely imported. In 2022, the UK imported over 7.5 million metric tons, making it one of the world's largest importers

The low life cycle emissions of biomass depends on sustainable sourcing, transport emissions, and carbon accounting methods

- Sustainable biomass life cycle emissions can range from **25-91 kg CO2 per MWh of energy,** which are **4 times lower** than **natural gas** and **7 times lower than coal**
- This is because biomass is part of the biogenic carbon cycle, meaning any CO2 emitted in combustion is offset as plant regrowth absorbs carbon
- **Logistic optimisation** and **advanced technologies (e.g., woodchip gasification, efficient pellet combustion)** can further reduce emissions and minimise waste

Various stages of biomass Lifecyle emissions



Source: Life Cycle Impacts of Biomass Electricity in 2020 (DECC, 2014), Biomass strategy 2023 (BEIS)

1- Note: Lifecycle CO_2 emissions include production, transport, and combustion. They depend strongly on supply chains, production techniques, forestry or agricultural practices, and transport distances.

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Domestic biomass investment supports economic growth, decarbonisation and energy security

Economic retention

- Domestic biomass supply chains generate a higher local economic return, fuelling economic growth and reducing leakage outside of the UK
- The UK’s forestry sector contributes £1.1 billion annually to the economy and supports over 34,000 jobs, especially in rural areas

Supply and system stability

- Balancing imported biomass with opportunities to scale domestic sources can ensures stable supply and energy security, reducing dependence on fossil fuel imports
- Lower price volatility, in addition to the likelihood of lower system costs supported by a continued role for biomass, can support the broader investment environment

Job creation

- Biomass supports employment in farming, forestry, processing, transport, and logistics, particularly in rural areas
- Contributes significantly through the £2 billion annual economic value of the UK biomass sector, providing approximately 9,000 jobs
- 650 operational biomass plants across the UK provide considerable local employment opportunities

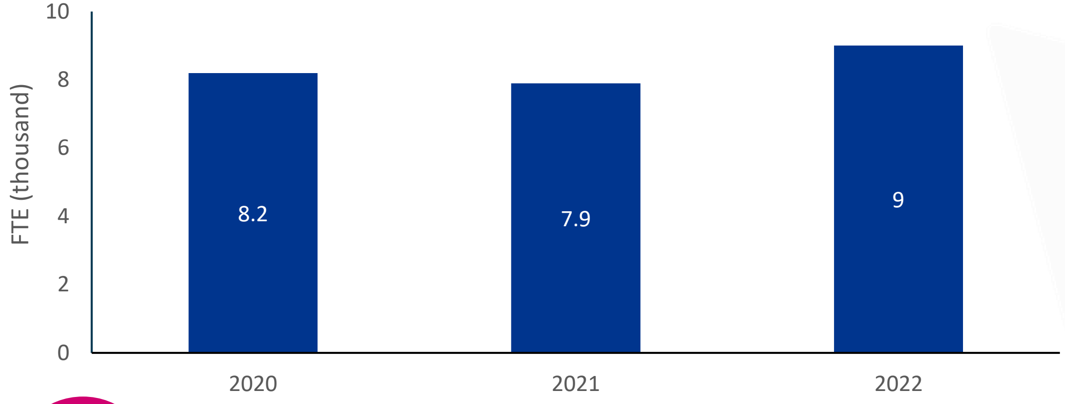
Meeting carbon targets

- Biomass supports emissions reductions and could increasingly be paired with CCS to provide carbon removals
- While sustainable imports complement UK feedstocks to ensure energy security, a mix of domestic and imported biomass is expected to meet Net Zero targets at a lower cost
- Transport emissions can be lower for domestic biomass, although for highly dispersed feedstock (e.g. agricultural residues) this may not be the case

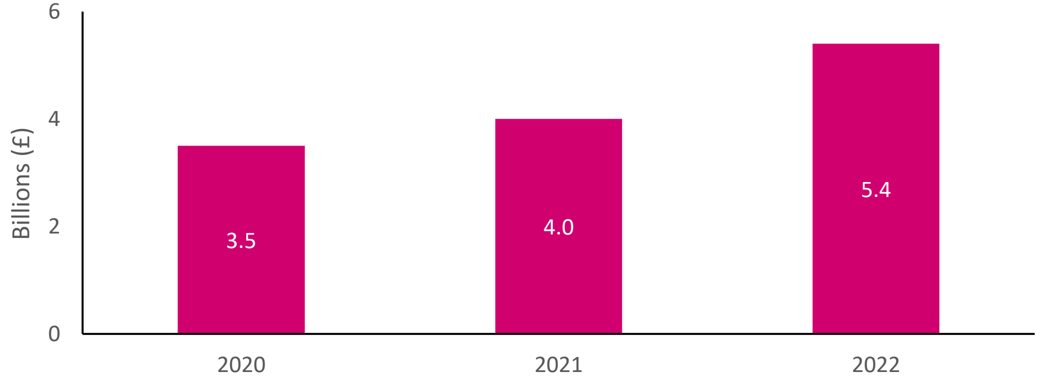
Data source: Forest Research 2023 UK, BEIS Biomass strategy , REA UK Biomass Report

The biomass sector supports employment across the UK

Employment in biomass and energy from waste sector*



Total turnover in biomass and energy from waste sector



**Includes the production of energy from renewable biomass sources, covering design, development, construction, production, specialised consultancy, installation, operation, and maintenance of related infrastructure.*

Data source: ONS LCREE Final Estimates 2022

- Direct employment in the biomass and energy from waste group was estimated at **9,000 FTEs in 2022**, the latest available data.
- **Employment in the biomass and energy from waste sector saw a 14% increase from 2021 to 2022**, driven by the UK government's Net Zero Strategy and targeted investments such as the Biomass Feedstocks Innovation Programme
- Total turnover in the sector was **£5.4 billion in 2022**, with growth reflecting initiatives like the Green Industrial Revolution Plan.
- The table below shows regional employment distribution. Jobs are broadly distributed in proportion with populations across UK nations. Jobs are usually concentrated local to the plants and are often located in areas with fewer external opportunities.

Regional Employment distribution (2022)	Est. FTE – Biomass and energy from waste
UK	4,499
England	3,809
Scotland	424
Wales	182
Northern Ireland	86

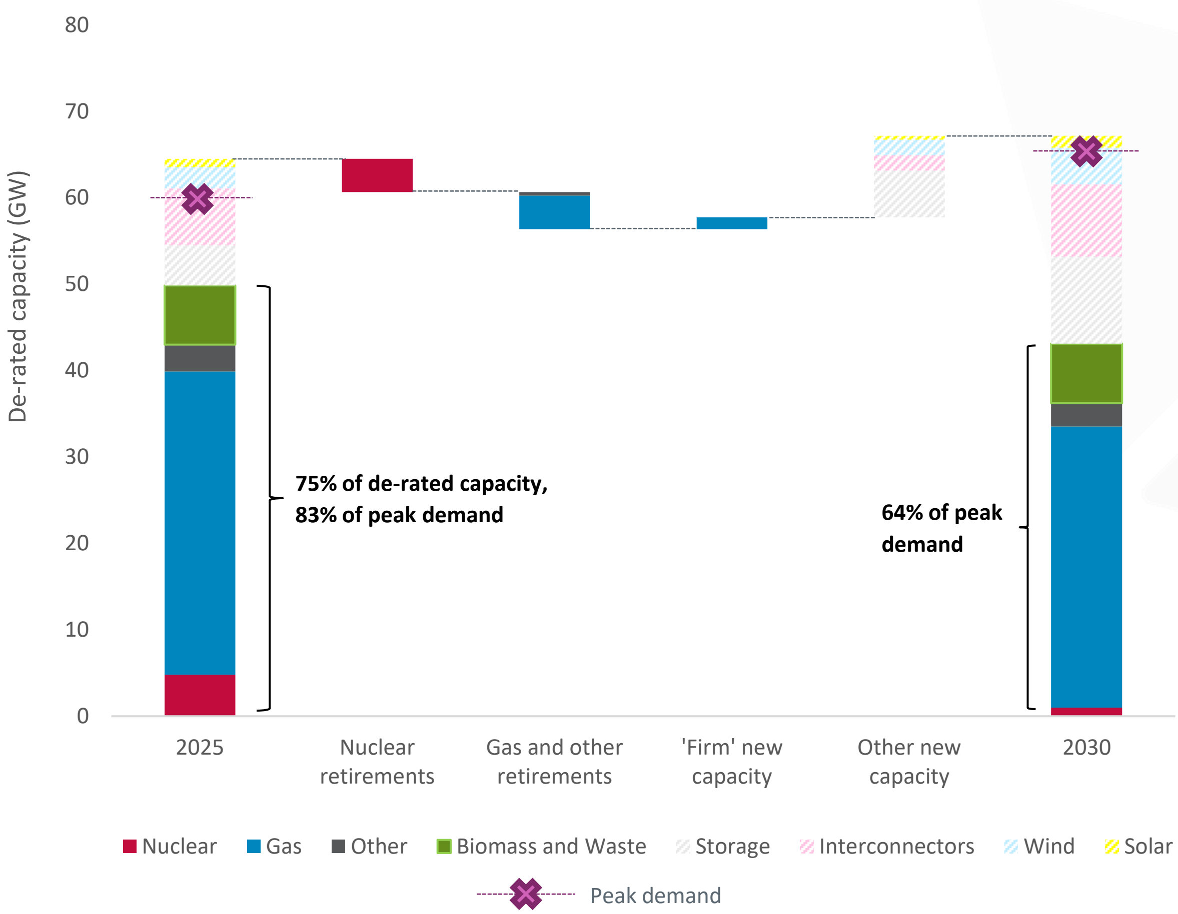
The role of biomass in the medium term

This section focuses on biomass' role in securing the electricity system and supporting emissions reductions, in addition to its potential to accelerate decarbonisation over the next decade

Baringa

Faster deployment of alternative low-carbon technologies in the power sector is needed to close the capacity gap and ensure grid stability

Outlook for de-rated capacity and peak demand



Data source: Baringa analysis, National Energy System Operator

Coal closure: Phase-out of coal by 2025 removed an emissions-intensive but dispatchable power source. Removal of this capacity increases the risk to security of supply during peak demand periods

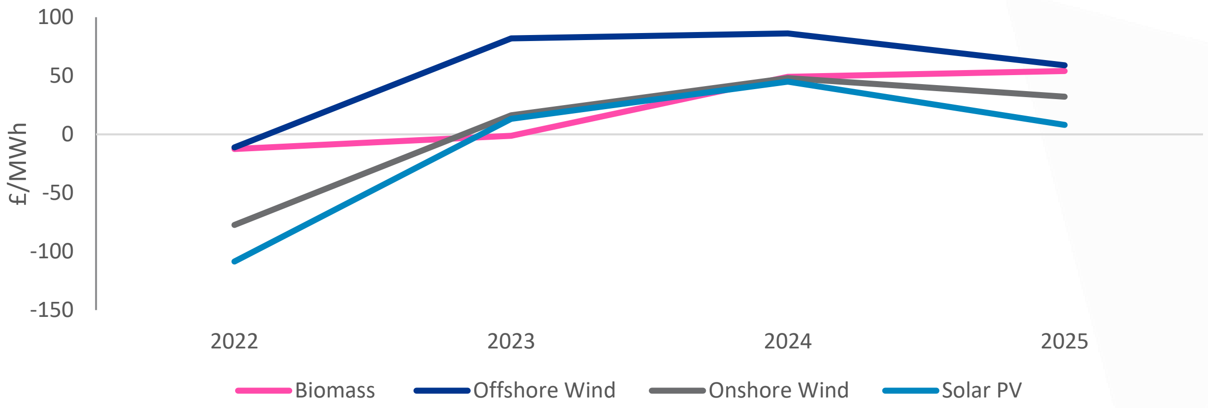
Nuclear capacity risk: Nuclear capacity is expected to decline in the late 2020s from ~5.9 GW today, driven by decommissioning of the ageing AGR plants and delays in new projects.

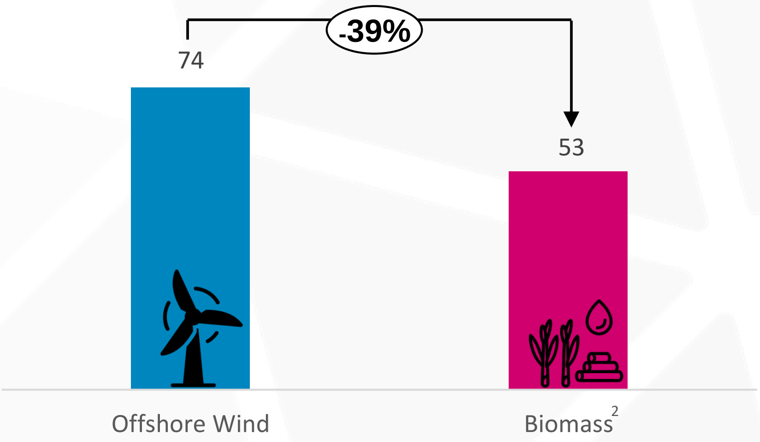
Gas CCS delays: Gas remains the dominant dispatchable source through 2030, but without CCS integration, it remains an emissions intensive solution. Gas CCS is expected to start generating at scale from 2030.

Biomass and waste capacity remains steady at ~7.8 GW in 2025. Post-2027, a significant portion of biomass capacity is expected to operate under a dispatchable CfD with lower load factor, providing flexible low carbon power. This transition supports system reliability by bridging the gap between peak demand and installed de-rated capacity

Baringa

Biomass capacity supports grid stability while offering comparable costs to other renewables on the system





- **Stable top-up costs compared to wind and solar PV:** CfD top-up costs reflect the financial support on top of wholesale power revenues needed for renewable technologies to make their investment case. The average top-up for biomass capacity has varied between £0-50/MWh in recent years and has been more stable than the average top-up costs for wind and solar PV.
- **Future cost reduction with BECCS:** The integration of BECCS can support system cost savings in future compared to alternative decarbonisation options, benefiting consumers. If the value for carbon-removals is recognised, this can reduce costs for biomass power generation, potentially leading to more stable or reduced top-up costs. If biomass availability and BECCS technology can be scaled, this may support further biomass energy cost reductions.

Additional factors supporting biomass role in the power sector:

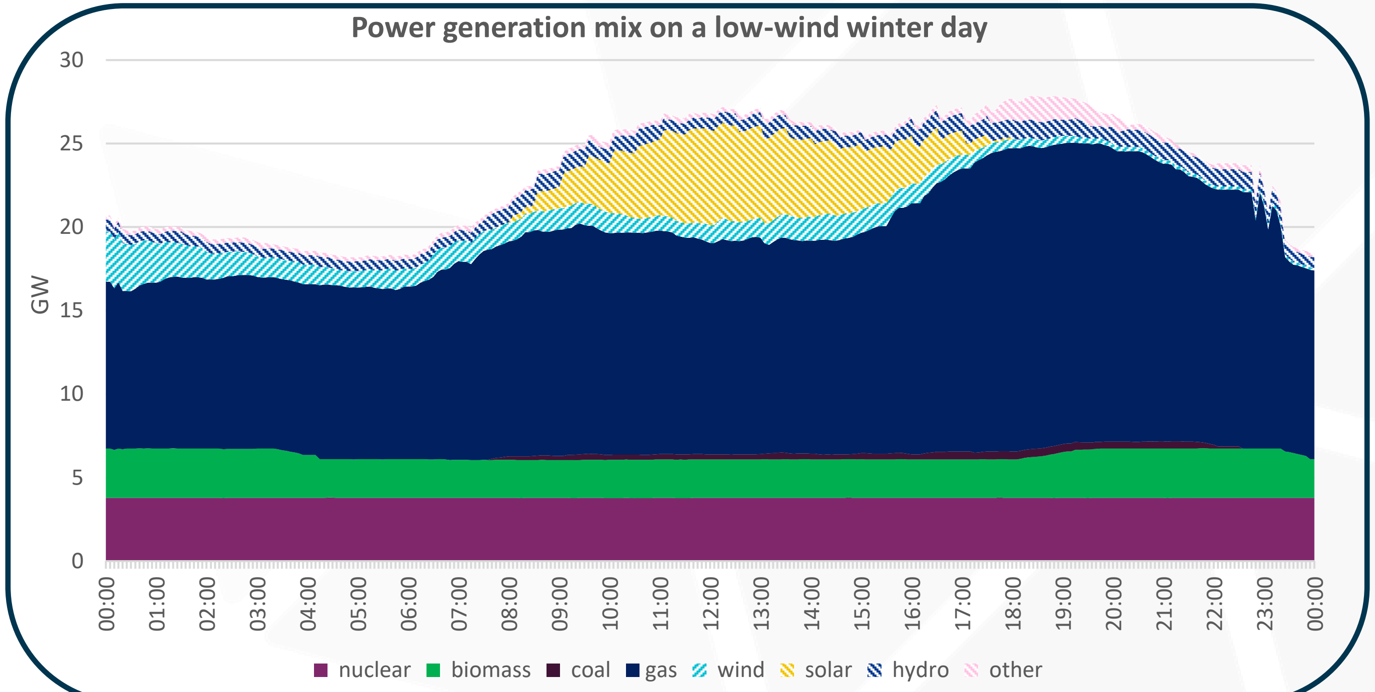
- **Dispatchable nature**: biomass can generate firm electricity, reducing reliance on storage or thermal backup generation.
- **Lower balancing costs:** provides consistent, reliable energy even during periods of low variable renewable generation.
- **Established infrastructure:** capacity can be retrofitted, reducing capital costs, located near demand to reduce network costs.
- **Fuel supply stability**: biomass can utilise feedstocks which offer more stable pricing, compared to fluctuating gas markets for example.

1 - Biomass largely represents capacity from biomass conversions 2 - Data derived from the Low Carbon Contracts Company (LCCC) portal, based on CfD generation data. Top-up costs were calculated by aggregating CfD payments across technologies. 3- All values are given in nominal terms (including averages, which are drawn from nominal value)

Data source: LCCC portal

Biomass bolsters energy security by providing reliable baseload power

- **Biomass provides reliable, weather-independent baseload power when energy supply is volatile, contributing up to 5.5GW of firm generation.**
- Large scale storage and / or dispatchable sources of generation are required for periods of low wind or solar energy to maintain security of supply.
- Over the past year, wind load factors dropped below **11% more than 100 times for 2 or more consecutive hours** (National Grid estimates **7-11%** of installed wind capacity during system stress to ensure energy security).
- On 24 February 2024, wind generation fell below 11% for over 21 hours, causing a major shortfall in renewable supply. While gas helps stabilise the grid in such moments, reliance on **unabated gas conflicts with emissions reduction goals.**
- In contrast, biomass enhances grid stability, **consistently providing 2-3 GW** of dependable power from larger scale plants alone during demand spikes.



In the year to March 2024 there were ….

30 periods *when wind generation dropped below 11% of capacity for* ***6 hours*** *or more*

30

17 periods *when wind generation dropped below 11% of capacity for* ***12 hours*** *or more*

17

5 periods *when wind generation dropped below 11% of capacity for* ***24 hours*** *or more*

5

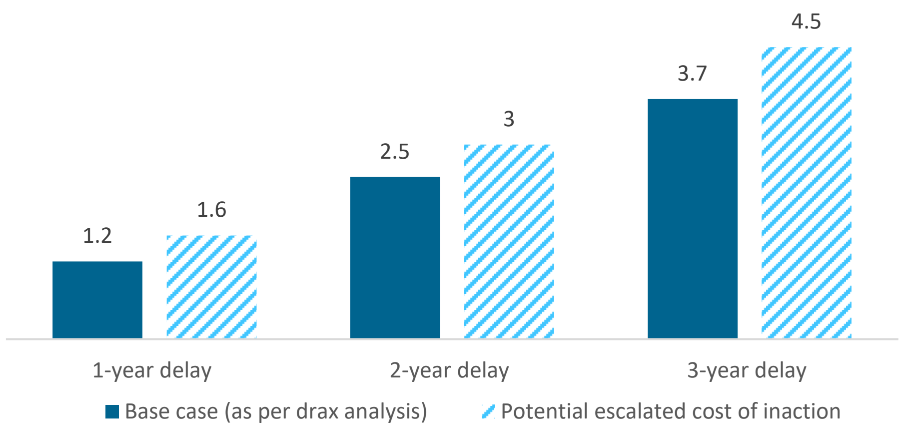
Data source: Gridwatch Templar and NESO's Data Portal

Retaining biomass capacity enables earlier and more cost-effective deployment of BECCS, which is expected to be part of lowest cost decarbonisation pathway

The option value of biomass lies in preserving the **flexibility** to deploy BECCS cost-effectively in the future. By retaining biomass capacity, the UK ensures **supply chains and infrastructure** remain intact, avoiding higher costs in future and enabling faster near-term decarbonisation

Avoid financial risk

Impact on whole system cost by delaying the BECCS deployment (£bn)



- Delaying BECCS deployment in the power sector is projected to increase costs to society of achieving Net-zero commitments **by £1.2 billion per year of delay.** With continued uncertainty on BECCS deployment, costs could escalate by 25–30% due to inefficiencies and supply chain disruptions.
- In CCC scenarios, BECCS plays an important role. Based on replacement analysis, maintaining biomass capacity today could **save more than £10 billion**[2] by preventing supply chain disruptions and avoiding the need to rebuild infrastructure.
- To compensate for delayed BECCS, the optimal capacity mix requires an additional **2GW of offshore wind and 5 GW of solar PV** over the next 5-10 years, on top of the 40 GW buildout already planned by 2030.

Accelerate near-term decarbonisation

BECCs-power contribution to 2035 CCC target (MtCO2/year)

- By converting biomass units to BECCS in the 2030s, carbon removals can reach 10 $MtCO_2$/year. This would achieve almost **80%** of the CCC reduction emission target (12.7 $MtCO_2e$ per year from 2035 as balanced pathway scenario). These reductions are significant and equivalent to:

	3.75 million internal combustion engines cars off the road; or
	cutting **57.5 million** flight passengers/year, roughly equivalent to cancelling all departing flights from Heathrow for **17 months**

- Keeping biomass capacity active ensures BECCS deployment can proceed on time, **reducing reliance on less efficient and more expensive alternatives**
- By 2035, scaling BECCS across additional units could further enhance cost savings and emissions reduction, providing flexibility for hard-to-decarbonise sectors

1- This assumes three units converted to BECCS: two at Drax and Lynemouth by 2035. 2- Based on previous Baringa analysis on replacement cost of Drax capacity

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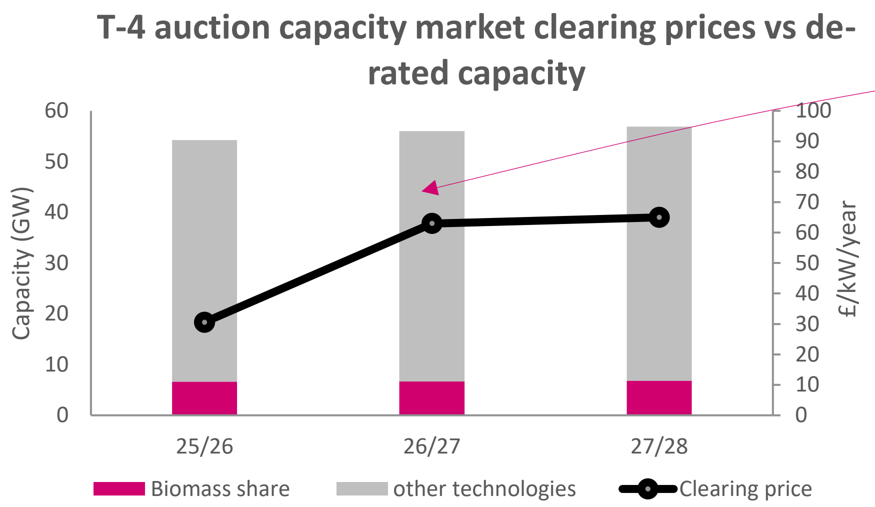
Retaining biomass cuts costs and stabilises clearing prices in the capacity market

Historic view – Ofgem analysis



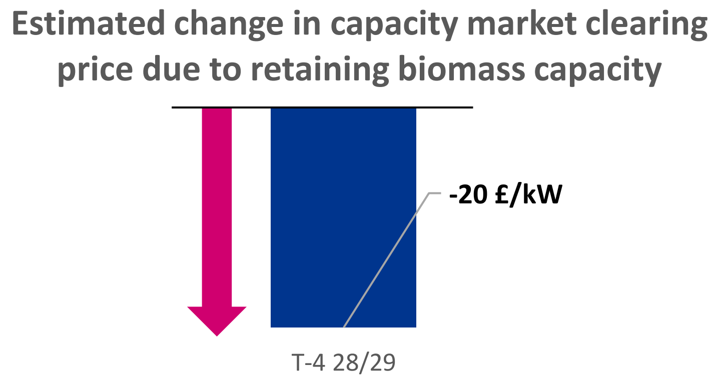
Reduced capacity would lead to higher clearing prices. The increase post-25/26 reflects the removal of coal – which requires increase reliance on gas/DSR

The Capacity Market (CM) is a mechanism designed to ensure enough electricity is available during peak demand periods by paying providers to keep power generation capacity ready.

✓ Retaining biomass is expected to reduce clearing prices

Analysis suggests that keeping biomass online through the dispatchable CfD can reduce the Capacity Market target capacity, potentially **reducing clearing prices by up to £20/kW** and avoiding approximately **£0.5-0.9 billion** in additional Capacity Market costs.

Forward view – Baringa analysis



Lower clearing prices directly benefit consumers by reducing the system costs passed on to consumers through electricity bills

Key drivers for cost reductions and market stability include:

- **Biomass has a high de-rating factor of 88% (ECR 2024**), meaning it provides a stable and predictable source of capacity compared to variable renewables such as wind and solar
- **Supports balanced capacity** by reducing fuel-price volatility and mitigating the risk of over-reliance on variable capacity sources

1 - Baringa analysis reflects a central scenario under specific market assumptions, resulting in lower clearing prices than in previous years.
2 - Based on central scenario with de- rated capacity target of 41.8 GW

Biomass based pathways offer scalable solutions for meeting landfill reduction targets

Policy targets for reducing landfill waste:

2025 - Waste Reduction Mandate	**2030** - UK Circular Economy goals	**2035** - Retained EU Landfill Directive	**2050** - UK Net Zero Target
Divert waste from landfills to recycling and other alternatives	Reduce landfill waste by 50%	Less than10% municipal waste to landfills	Achieve Net Zero emissions across all sectors

These policies demand innovative landfill diversion solutions that align with broader Net Zero objectives → **Biomass-based waste pathways can bridge this gap**

Energy Products and co-products

Biochar

- Reduces methane emissions from landfills.
- Stores up to **1 tonne of CO_2** per tonne of biochar applied.

✓ Soil enhancer and long- term carbon sequestration.

Bright Green Hydrogen

- Produces **hydrogen** from biogenic waste with the potential for high energy conversion efficiency.
- Reduces industrial CO_2 emissions by up to **90%**.

✓ Clean energy for transport and industry.

Material substitutes

Bioplastics

- Reduces lifecycle emissions by **60-70%** compared to conventional plastics
- Diverts **2.5 tonnes of fossil** feedstock per tonne produced.

✓ *Replaces petroleum-based plastics in packaging and goods*

Bio-composites

- Saves **1.4 tons of CO_2** per tonne compared to synthetic composites.
- Reduces landfill dependency by up to **15%**.

✓ *Structural materials for construction and automotive industries.*

Chemical alternatives

Biochemicals

- Diverts **20-30%** of landfill-destined waste into industrial use.
- Lowers industrial carbon emissions by **50%**.

✓ *Base chemicals for adhesives, resins, and solvents.*

Data source: EU Biomass Policy Report (2020), IPCC Special Report on Climate Change and Land (2019), Biochar for Sustainable Agriculture, FAO (2021). International Energy Agency (2021), Hydrogen Council Report (2022)

The role of biomass to 2050

This section sets out the approach and results of whole-system modelling, assessing the potential roles and value of biomass in the energy system out to 2050. This leads on to an overview of the opportunities for biomass to reduce system costs and de-risk delivery of Net-zero

Baringa

Biomass can contribute towards decarbonisation across a range of sectors long term

Power with carbon removals

Sustainable bioenergy with CCS (BECCS) can deliver **up to 10 million tonnes of carbon dioxide removals** (CDRs) annually from the mid 2030s and **low carbon electricity to power as many as 5 million homes.**

Industrial processes

Biomass based options can **in principle fulfil the process heat needs of most industrial use cases**. The specific nature of the process will determine the most suitable feedstock or pre-processing required.

Transport fuels and gasification

Biomass can be converted into liquid biofuels to help meet transport fuel needs. **Gasification of biomass also offers a range of possible applications**, such as for production of hydrogen or synthetic natural gas.

Chemicals and construction

There are significant opportunities for the development of bio-based chemicals and polymers and construction materials. **In some potential applications this can be in conjunction with the production of bioenergy or biofuels.**

Biochar

Biochar offers an option for carbon removals, taking carbon from the atmosphere and storing it in soil, where it can remain in a stable form and improve soil.

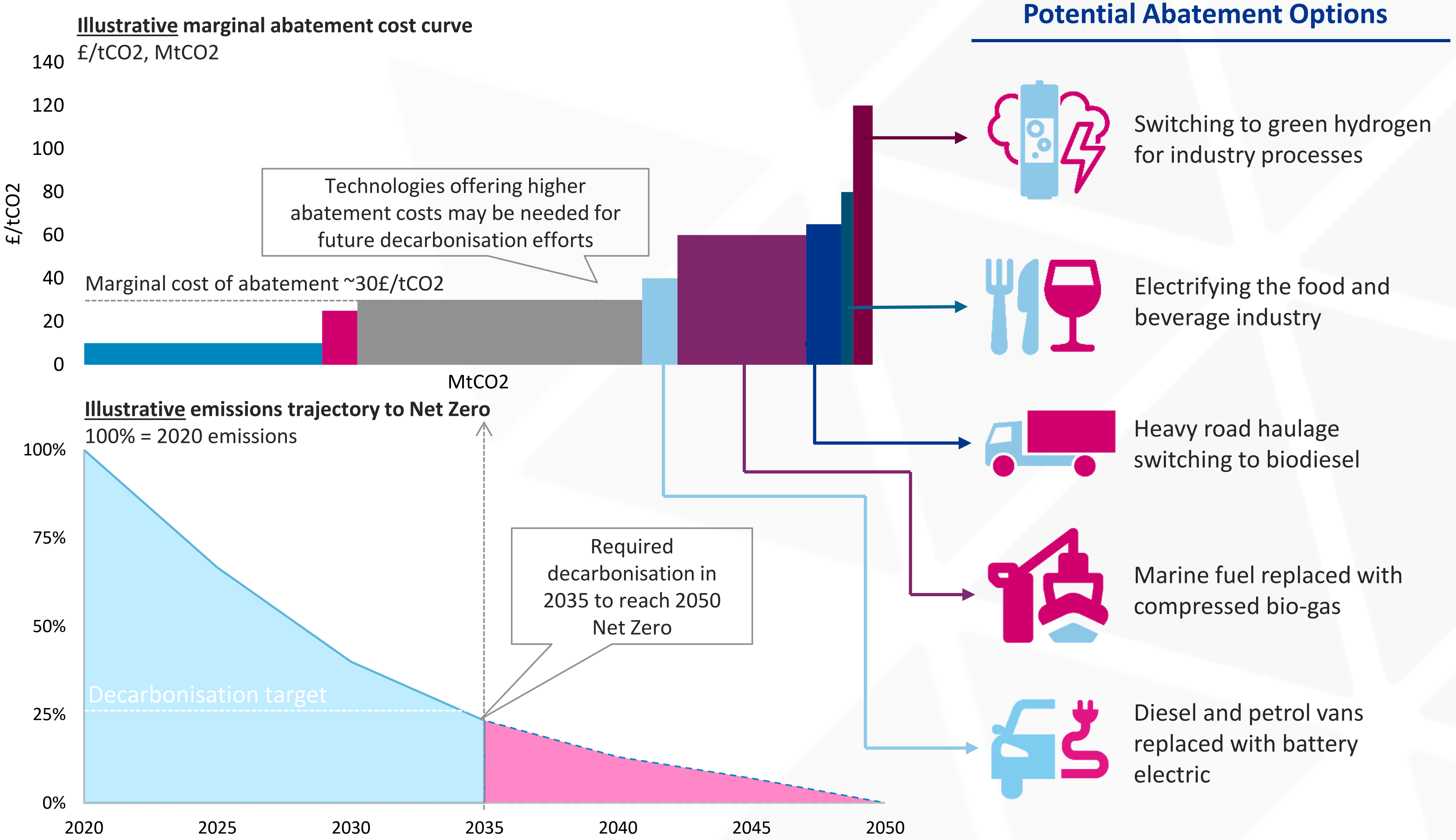
Waste and agriculture

Biogas production and energy-from-waste applications can reduce the emissions and land-use associated with waste streams. Increased uptake of biomass inputs can reduce reliance on synthetic fertiliser and agrochemicals in agriculture.

Biomass is expected to remain valuable for the future energy system

What is a MACC?

- A Marginal Abatement Cost Curve (MACC) represents the potential **costs or savings expected from decarbonisation opportunities,** (£/tCO2) and the associated **volume of carbon displaced** (MtCO2)
- For example, a MACC curve can compare the **cost and carbon volume saved from different options for using biomass and BECCS.**
- Each opportunity will have a **different cost and carbon saving**, so can be **stacked in a merit order** from least to most costly.
- The **marginal cost of abatement** is the cost of the opportunity that intersects the **emissions reduction needed to meet a specific decarbonisation target.**
- The **MACC** illustrates the economy wide decarbonisation required by 2035.



The long-term role of biomass was analysed through whole energy system modelling

By assessing the system cost and the emissions reductions across scenarios, the potential role of biomass in the energy transition can be analysed. The model provides insight into the complex interactions between power, heat, gas, hydrogen and other energy vectors across the economy and how demand for services might be supplied in the future.

Analysis Approach

1 Develop three scenarios for future biomass availability

Counterfactual: Domestic biomass stagnates and imports decline to zero. Without policy and market arrangements to support the role of biomass and maintain supply chains, biomass availability is assumed to decline.

Central: Domestic biomass increases with high levels of imports. Incentives to scale domestic production and secure growing access to imports are assumed to be in place.

Downside: Domestic biomass increases with lower imports. Incentives to scale domestic production are assumed but with more limited access to imports

2 Develop two scenarios for biomass attractiveness – Central and Downside

The two scenarios allow the role of biomass to be assessed across a range of assumptions for relative costs of biomass and other commodities, in addition to costs and availability of energy technologies.

3 Review and develop assumptions for technology availability and costs

Power e.g.
- Nuclear
- Gas CCS
- BECCS retrofit
- BECCS new-build
- Anaerobic Digestion
- Wind
- Solar

Buildings e.g.
- Heat pumps
- Biomass boilers
- District heating

Hydrogen e.g.
- From biomass
- From natural gas
- From electrolysers

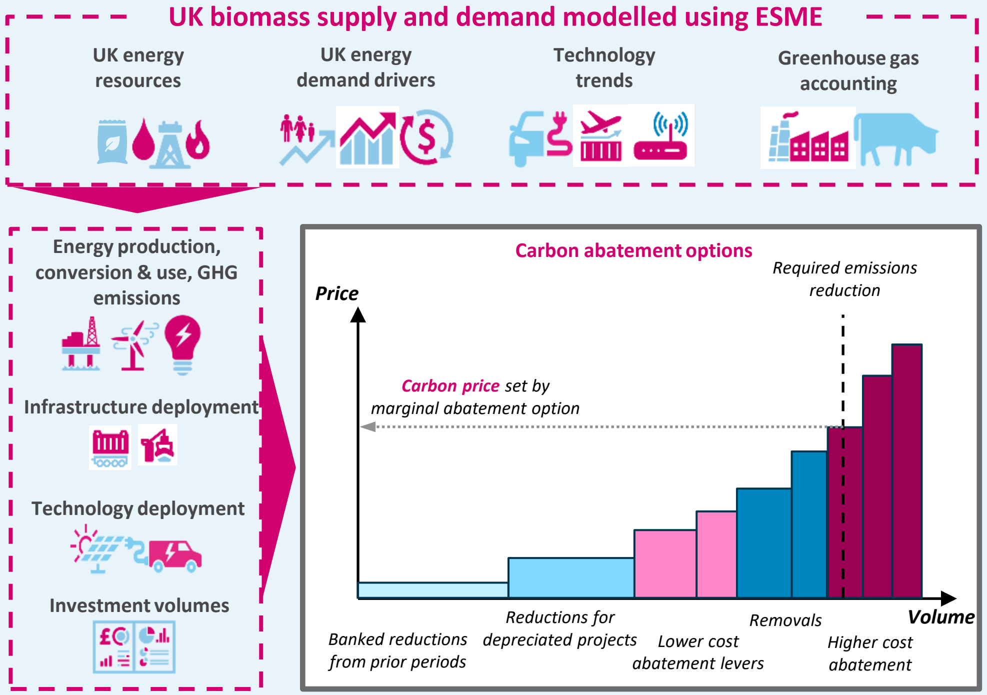
Industry

Transport

Energy networks and CCS

Energy System Modelling Environment (ESME)

ESME is a leading UK techno-economic whole energy system model. ESME finds the cost-optimal decarbonisation pathways across the whole system.



1. ESME: https://es.catapult.org.uk/tools-and-labs/our-national-net-zero-toolkit/energy-system-modelling-environment/

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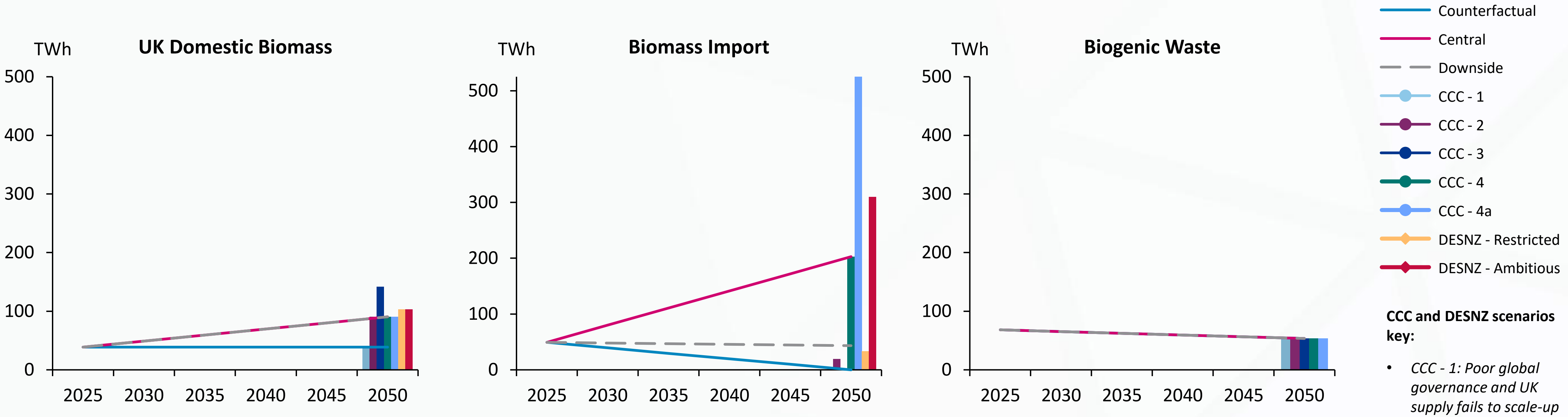
Three biomass availability scenarios were configured for the modelling, informed by the Biomass Strategy as well as other pathways for biomass



CCC and DESNZ scenarios key:

- *CCC - 1: Poor global governance and UK supply fails to scale-up*
- *CCC - 2: Middle road: status quo globally & UK supply increases*
- *CCC – 3: UK biomass focus*
- *CCC - 4: Global governance and innovation*
- *CCC – 4a: UK BECCS hub*
- *DESNZ biomass strategy – Restricted*
- *DESNZ biomass strategy - Ambitious*

UK Domestic Biomass

Central and Downside domestic biomass are assumed to grow from ~40 TWh today to 90 TWh in 2050, aligned with the DESNZ Biomass Strategy Restricted and Ambitious scenarios.

In the counterfactual, biomass availability is assumed to remain at today's levels.

Biomass import

Imported biomass in the Central case grows to reach ~200 TWh in 2050. In the Downside case, imports decline slightly to approximately 35 TWh in 2050. The counterfactual experiences a decline to zero imports by 2050.

The Central is around two-thirds of the DENSZ Ambitious Scenario in 2050. The Downside case is aligned with the Restricted Scenario.

Biogenic Waste

As a result of improved policies to reduce food waste, biogenic waste in all scenarios is expected to decline from 68 TWh today to 53 TWh.

This is aligned with the range of CCC scenarios.

1. Committee on Climate Change, Biomass in low-carbon economy https://www.theccc.org.uk/wp-content/uploads/2018/11/Biomass-in-a-low-carbon-economy-CCC-2018.pdf
2. Department for Energy Security & Net Zero Biomass Strategy https://assets.publishing.service.gov.uk/media/64dc8d3960d123000d32c602/biomass-strategy-2023.pdf

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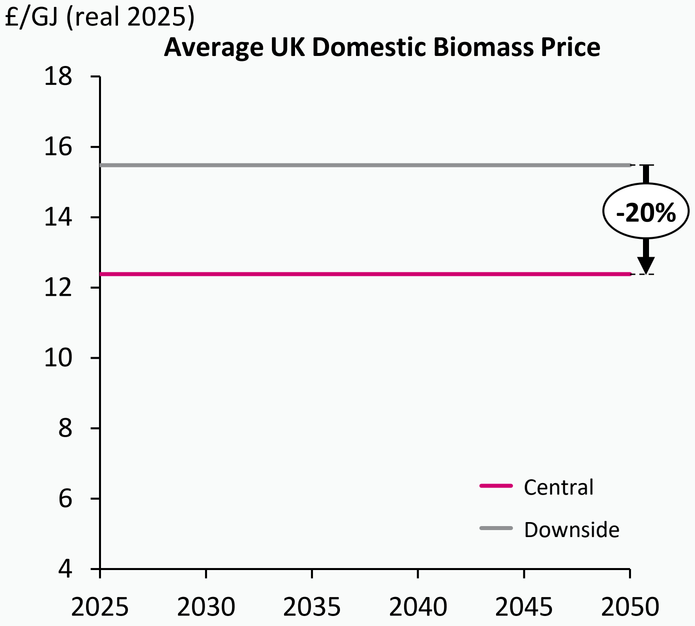
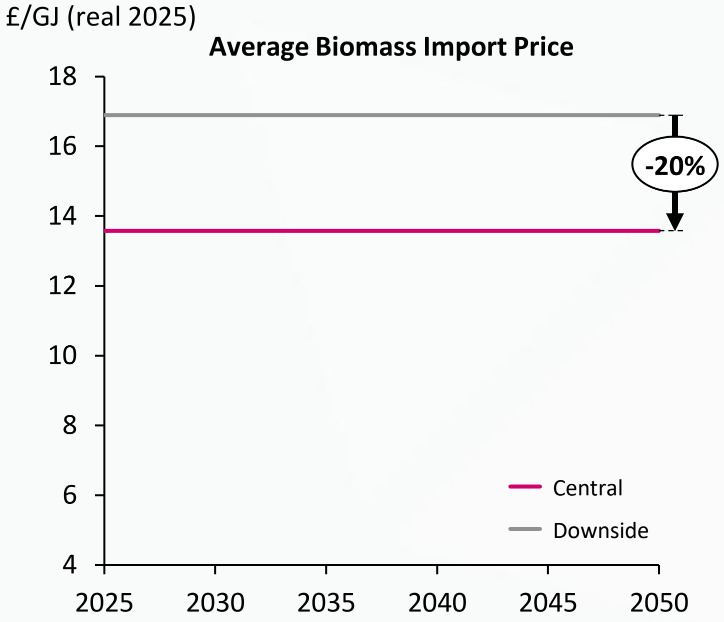
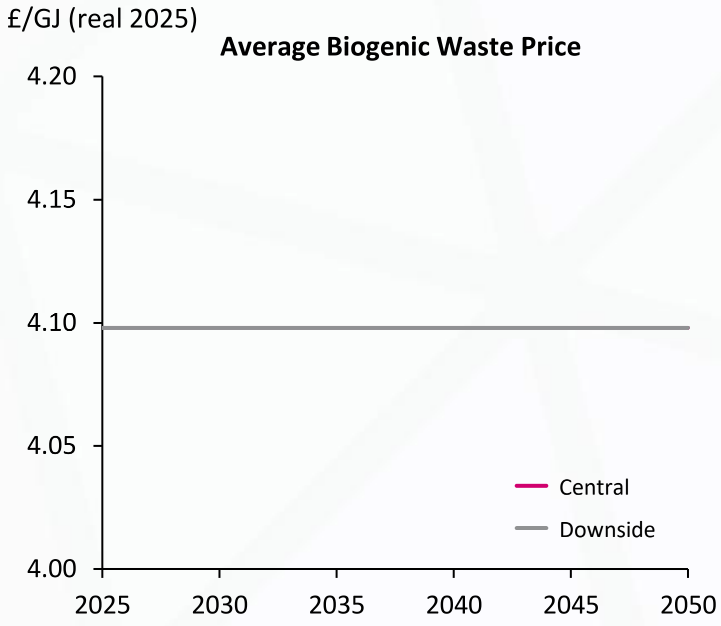
Biomass prices were varied across two scenarios, while the price of biogenic waste is held constant across scenarios



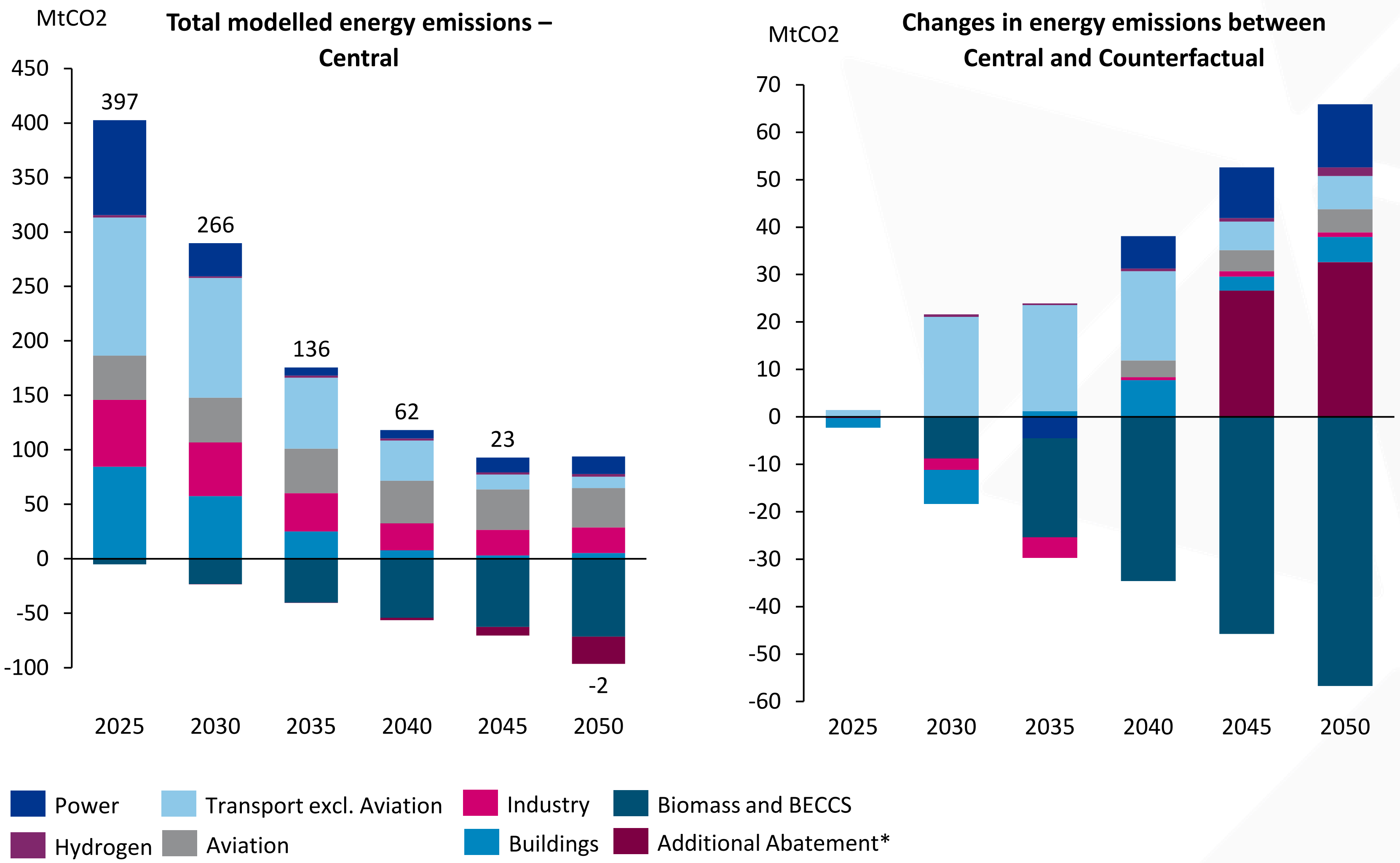




- Scenarios for UK domestic and imported biomass prices are based on Baringa's primary research. These are intended to represent two credible alternative long-term outlooks for biomass prices informed both by historical price data and projections of the intersection of UK and global supply curves and willingness to pay out to 2050.
- A constant price is assumed across the time horizon. Domestic biomass price is £12.40/GJ in the Central case and £15.50/GJ in the Downside case; imported biomass price is £13.60/GJ in the Central case and £16.90/GJ in Downside
- The average prices of UK domestic and imported biomass are both approximately 20% cheaper in the Central case than Downside. We model two Counterfactual scenarios - one using the lower prices to compare with the Central scenario, and one using higher prices to compare with the Downside scenario.

Baringa

In the Central case the utilisation of biomass with CCS for power, biofuels and hydrogen production offsets residual emissions in transport and industry



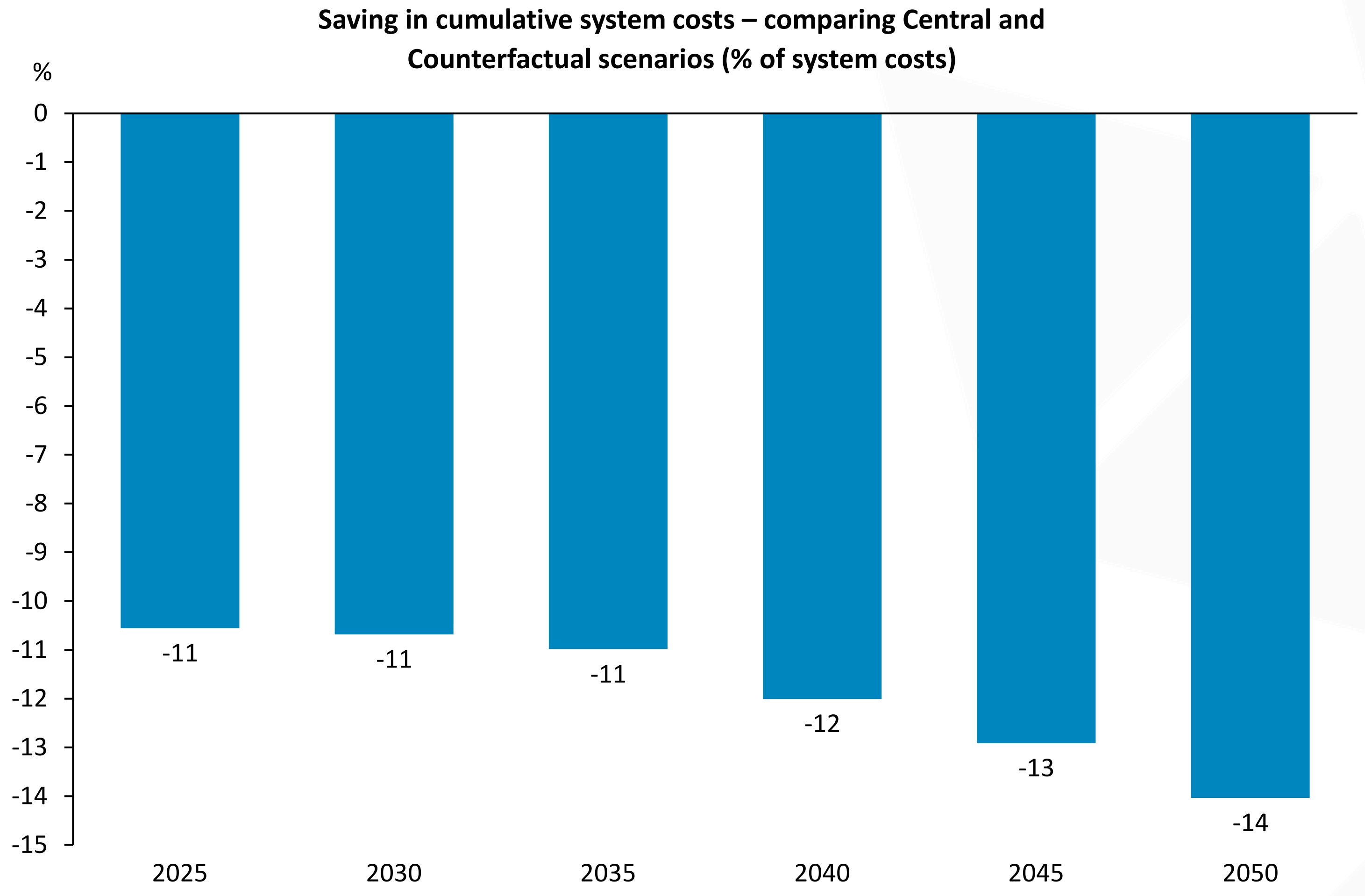
Emissions Impacts

- In the Central case, greater biomass availability allows for an increase in carbon removals across the energy system.
- Biomass is utilised with CCS first to produce power before wider adoption in industrial energy, hydrogen and biofuels including green gas
- Carbon removals facilitated by biomass mean that residual emissions in other sectors can be offset, while still meeting carbon budgets.
- Conversely in the Counterfactual, greater transport electrification and faster industrial decarbonisation is required to achieve the same carbon reduction at a system level.
- The availability of cost-effective carbon removals allows more expensive abatement in transport and industry, as well as changes in demand, to be avoided.

To note: Data shown is from the Energy System Catapult's "ESME" model

*Additional abatement includes Direct Air Capture Carbon (DACCS) in addition to behaviourial changes such as changes in diet and reductions in energy demand such as aviation.

If biomass supply can be scaled it could offer significant savings to 2050



Assessing the benefits of biomass

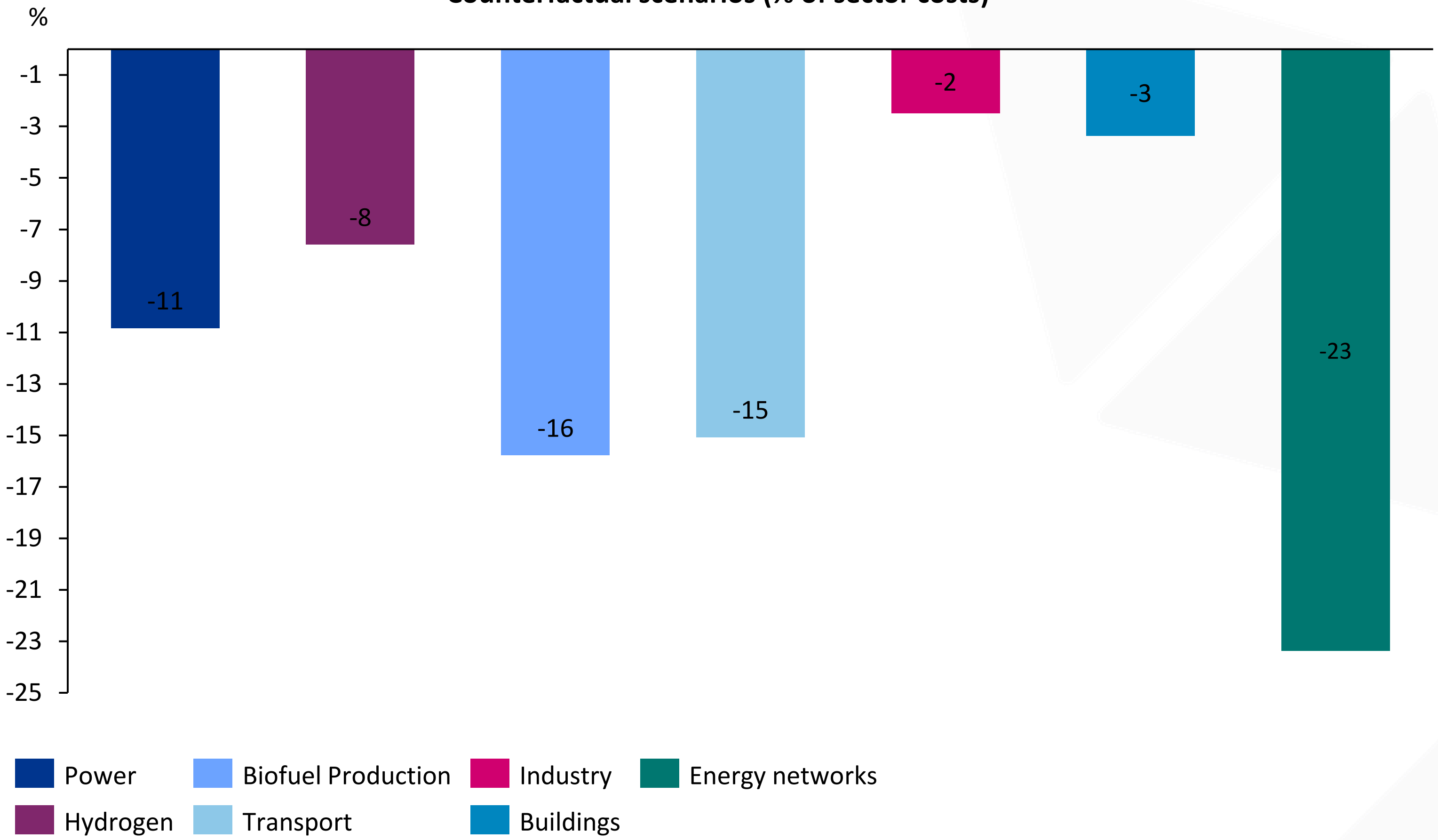
- Biomass technologies can support lower cost decarbonisation compared to a scenario with more limited biomass deployment
- In our Central scenario, biomass use is increasingly integrated with CCS for electricity production and production of other energy vectors such as hydrogen along the lowest cost pathway
- The cumulative estimated benefit of greater biomass availability to the energy system is equivalent to £67bn by 2050, or a reduction of 14% in the cumulative costs of energy system investment on the path to Net-zero
- The relative benefits of biomass accumulate early in the pathway. For example, the cumulative investment cost is expected to be 12% higher by 2035 and 13% higher by 2040 in the counterfactual scenario of declining biomass availability

To note: Data shown is from the Energy System Catapult’s "ESME" model

Baringa

Biomass and BECCS deployment can support system cost reductions across a range of sectors

Savings in 2050 cumulative system costs by sector – comparing Central and Counterfactual scenarios (% of sector costs)

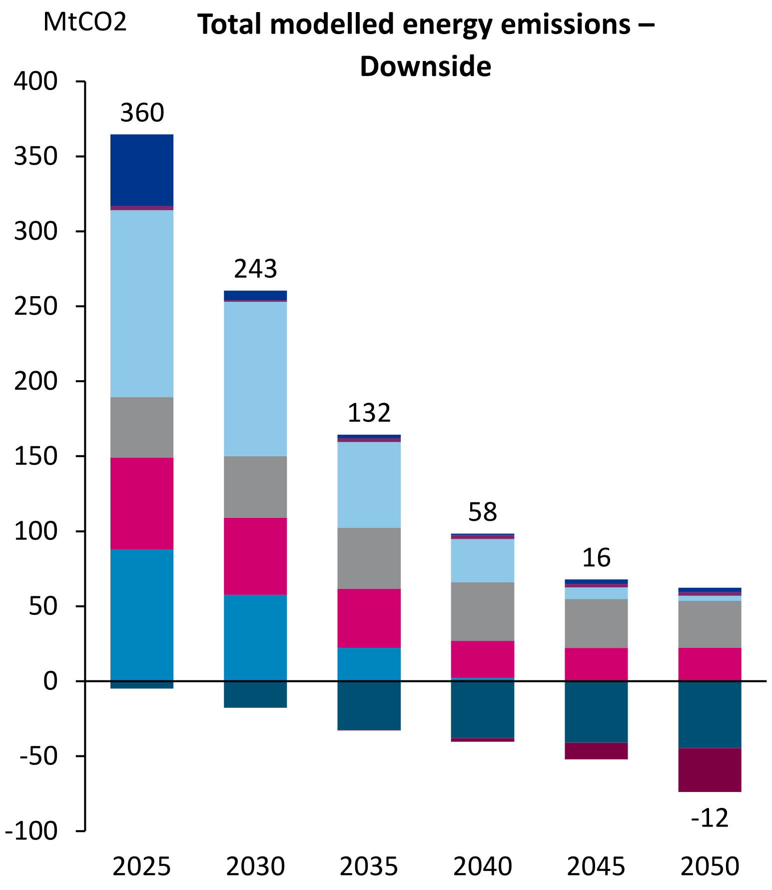


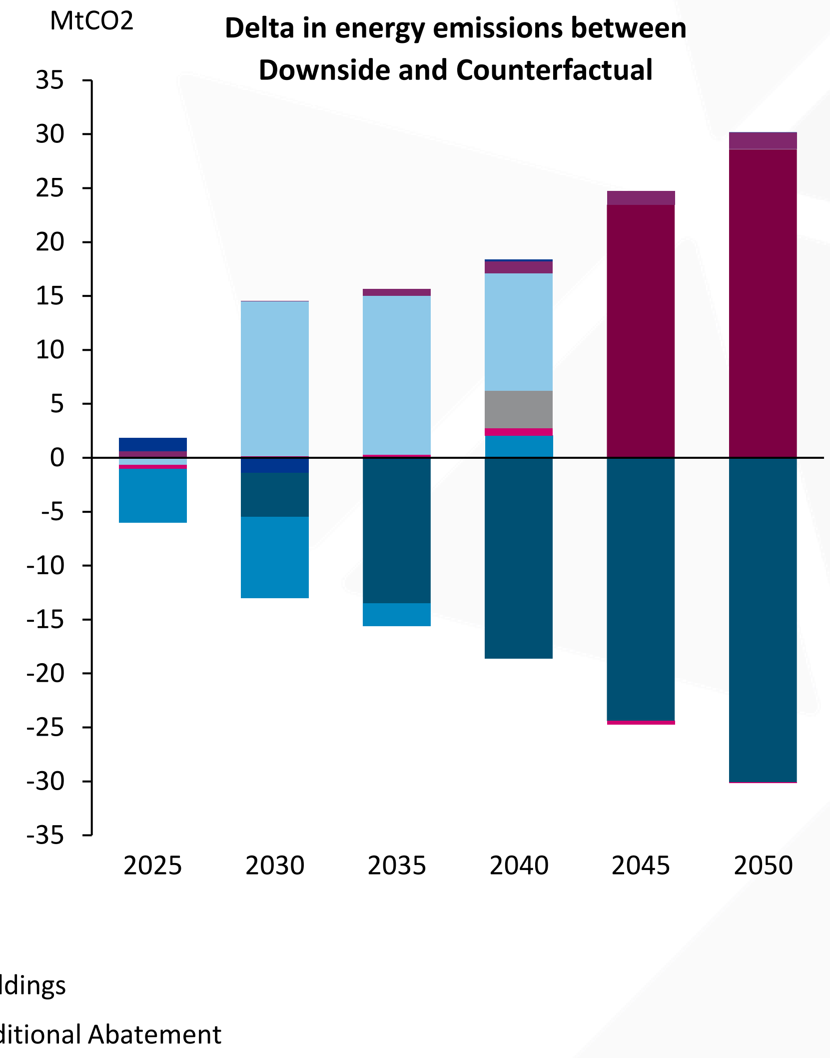
To note: Data shown is from the Energy System Catapult's "ESME" model

Accounting for the benefits

- Increased biomass supply and uptake through BECCS technologies can support lower cost of decarbonisation compared to a scenario with declining biomass deployment
- In our Central scenario, increased consumption of biomass and integration with CCS supports cost reductions in a range of sectors
- The transport sector and the power sectors are estimated to benefit most substantially in pound terms. However, due to its smaller share of overall system costs, energy networks see the highest benefit as a share of sector costs by 2050.
- The transport sector benefits indirectly due to the net impact of carbon removals from BECCS technologies meaning less rapid and intensive decarbonisation of transport including road freight and aviation
- The greater role for BECCS-power and broader BECCS applications reduces the overall capacity of renewable generation required to meet electricity demand and the associated network investment

The impact of carbon removals from BECCS is also observed in the Downside case but to a lesser degree than the Central Case



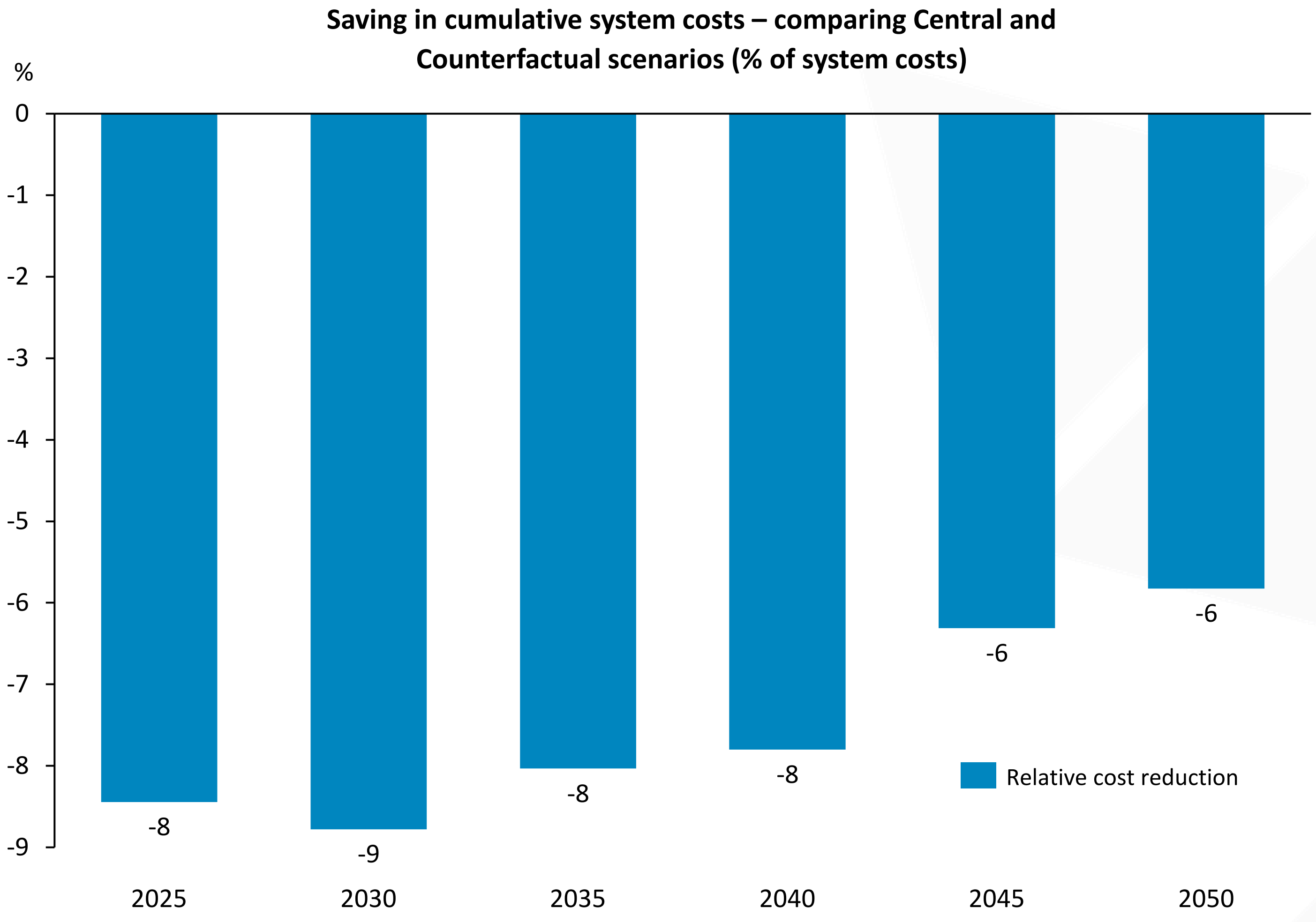


To note: Data shown is from the Energy System Catapult's "ESME" model

Emissions Impacts

- The more limited Downside biomass availability still enables growth of carbon removals across the energy system
- Since biomass availability is lower in the Downside case, carbon removals facilitated by biomass are projected to be 16 Mt CO2/year lower by 2040 than in the Central Case. This requires additional, more costly abatement to be undertaken, particularly in the transport sector
- However, compared to the counterfactual where the availability of carbon removals, facilitated by biomass, is more limited the Downside still allows for a portion of the most costly abatement to be avoided
- BECCS technologies can still offer cost effective abatement potential under higher biomass price assumptions

In the Downside case, assuming lower biomass availability and higher prices, biomass still offers significant cost savings compared to the counterfactual



Assessing the optimal role for biomass

- In the Downside case, biomass technologies still support lower cost decarbonisation compared to a scenario with limited biomass deployment
- In our Downside scenario, biomass use is prioritised for the highest value applications in power, green gas and industrial energy production along the lowest cost pathway
- The cumulative estimated benefit of biomass to the energy system is equivalent to a reduction of 6% in the cumulative system costs incurred on the path to Net Zero
- The benefits of biomass have a greater relative impact supporting decarbonisation earlier in the pathway than in the long term
- Under Downside biomass price assumptions, it would still be optimal to utilise more biomass, if available. More limited availability of biomass in the Downside compared to the Central case means that more costly alternative abatement options must be deployed later in the pathway, reducing the relative savings achieved.

To note: Data shown is from the Energy System Catapult's "ESME" model

Meeting Net-zero targets without carbon removals through biomass increases delivery challenges and estimated system investment costs substantially

Baringa analysis finds that **meeting the Net-zero target without carbon removals from biomass could increase system costs by 6-14%** on the path to 2050. Other independent studies estimate cost increases in the range of **10-20%[1]**

Key sectors	Role of biomass	Alternatives without biomass	Summary cost, delivery and emissions impacts
Electricity	Electricity with carbon removals	Nuclear, higher renewables plus storage, gas (with CCS)	Higher carbon emissions. More rapid electrification and network build adds to cost and delivery risk
Heating	Boilers (homes and businesses) and district heating	Oil boilers, heat pumps	Heat pumps may not be a cost-effective for all homes. Other alternatives such as gas and oil boilers drive higher emissions
Transport	Biofuels (ethanol, biodiesel, SAF)	Fossil fuels, hydrogen, methanol, electrification	Hydrogen and methanol do not offer flexibility of blending. Electrification costly/unavailable for heavy transport
Industry	Process heat, Combined Heat and Power (CHP) systems & bio-based materials	Hydrogen, electrification, petrochemical plastics	Hydrogen: higher operation costs, up to 30-40% more CO2. Electrification may be more costly or limited in applications
Carbon Removal	BECCS offers competitive CO_2 abatement on a £/tonne basis[2]	Direct Air Capture (DAC), Afforestation	DAC: may be 2-6 times more costly, afforestation is cost effective but impact and potential to scale is more gradual
Agriculture	Biochar improves soil and sequesters carbon	Synthetic fertilisers	Alternative fertilisers are more energy intensive and lead to increased nitrogen pollution
Construction	Bio-based materials (hempcrete, wood insulation)	Concrete, steel and \mineral-based materials	Alternatives are established and cost-effective but cement and steel produce ~1.5bn tonnes CO2/year globally
Waste	Biogas production and composting, reducing landfill use, energy-from-waste power and heat	Landfilling and incineration	More landfill waste, higher costs, and methane emissions expected from lower utilisation of biogenic waste

1- See for example, Diversity of biomass usage pathways to achieve emissions targets in the European energy system, Nature Energy (2025) *2*-Market price subject to variability based on sector, location and policy incentives

Data source: Renewable Fuel Statistics (2023), IEA Bioenergy Reports, DEFRA Agriculture,

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Biomass enables sector-wide emissions reductions without requiring significant changes in lifestyle or infrastructure

Behavioural changes play a critical yet challenging role in achieving Net Zero emissions by 2050. Low carbon solutions that **minimise lifestyle disruption tend to be more widely adopted** making them effective in driving mass decarbonisation. Unlike other renewable solutions that require infrastructure changes or behavioural shifts (e.g., EV adoption, dietary changes), **biomass can replace fossil fuels and enable carbon removals that reduce lifestyle and infrastructure impacts of the energy transition**.

Key sectors – main adoption		Lifestyle impact – rationale	
Electricity	EfW plants, standalone biomass plants	L	Integrates with existing power infrastructure, providing stable supply and dispatchable power
Heating	Biomass boilers, pellets and stove, district heating	M	Can be direct replacement for oil systems, with limited impact on comfort
Transport	Ethanol (E10/E85), biodiesel blends, Sustainable Aviation Fuel	L	Biofuels are drop-in replacements for fossil fuels - no change required in driving or fuelling habits for all transport modes
Industry	Biomass boilers, biochar in cement/steel making	M	Potential to replace coal and natural gas for heat and steam generation in industrial processes with limited system modification
Carbon removal	BECCS deployment	L	Invisible to consumer; partially supported by public funding and policy due to its costs and land-use implications
Agriculture	Agricultural waste for bioenergy, biogas from manure	M	Agricultural waste (e.g. rice husks, corn stover) can be converted to energy, but requires separate handling and processing procedures
Construction	Biochar in concrete, bio-based materials	L	Limited changes in construction methods/techniques required; minimal impact on end user experience
Waste	Biogas from municipal organic waste, waste-to-energy plants	M	Requires basic waste segregation/sorting; no changes to disposal practice

Grading: *L* Low *M* *Medium*

Biomass an easier switch across many sectors
Can often work with existing infrastructure
Limited changes in consumer behaviour
Utilises waste and by-products effectively
Scalable and flexible use cases

Data source: IEA bioenergy, FAO biomass residue study

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Biomass could play a key role in decarbonising transport through production of biofuels

	Fuel and emissions	Targets/ambition	Direct role of biomass	Wider benefits of biomass
Large road vehicles	• Dominated by diesel (~99%) • **20.4 MtCO2** – **18%** share of domestic transport emissions (2023)	2040: Complete phase-out of non-zero emission HGVs 2032: RTFO: Mandates **14.6% renewable fuel supply (mainly biofuels)**	• **Bio diesel**: Cuts emissions by up to **85%,** compatible with diesel engines, lower PM and CO emissions. • **Bio LNG**: Reduces emissions up to 80%, compatible with LNG infrastructure for trucks	• **Cost savings**: Compatible with existing infrastructure and fuels, minimising retrofit costs • **Reduced need for alternatives**: The role of biomass in transport and more widely in the system reduces the abatement required and reliance on more expensive abatement alternatives in transport: - **Increased electrification with higher investment costs and grid/infrastructure demand and investment** - Airlines would face **2-3x** higher fuel costs, significantly increasing ticket price - For shipping, higher dependency on hydrogen requiring new bunkering and storage infrastructure • **Enhanced decarbonisation pace**: Offers immediate, scalable solutions • **More diversified energy mix**: Reduces reliance on a single fuel type
Aviation	• Turbine Fuel -Jet Kerosene (99%), SAF (<1%) • **35.40 MtCO2** – **22%** share of total transport emissions (2023)	2040: Zero emission airport operations (England), zero emissions domestic flights 2040: UK mandate[2] **22% of jet fuel to come from SAF.**	• **SAF:** Biomass key feedstock, reduces lifecycle emissions up to **80%** • Blends with existing jet fuel, requires no engine modifications	
Shipping	• Gas oils (51%). fuel oils (48.8 %), Bio LNG (still in early adoption phase) • **11.5 MtCO2** – **7%** share of total transport emissions (2023)	2030: **Reduce carbon intensity by 40%+** compared to 2008 2050: IMO GHG strategy aims for 50% reduction in total annual emissions	• **Bio LNG:** Cuts emissions by **up to 80%**, works with existing LNG infrastructure • **Bio methanol:** Reduces CO_2 by **60-95%**, eliminates SOx, cuts NOx emissions by **60%**, fits dual-fuel engines	

1- Phase-Out of Non-Zero Emission HGVs: By 2035 (3.5–26 tonnes) and 2040 (over 26 tonnes).

2- UK's SAF mandate sets progressive targets for the inclusion of SAF in aviation fuel, starting at 2% in 2025, increasing to 10% by 2030, and reaching 22% by 2040

Data source: DESNZ -GHG Emissions report, Transport energy and environment (ENV) , Decarbonising transport (UK gov),IEA Bioenergy (2023), CCC Biomass Report

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The energy transition will be very challenging to deliver and the diversified pathway offered with biomass in the system can reduce supply chain pressures

Electricity generation

- **Ambition**: To decarbonise the power sector, the UK targets 50 GW of offshore wind capacity by 2030.
- **Status**: UK govt anticipates that £30- £60bn in investments will be required for offshore wind, grid upgrades, and supply chain expansion
- Recent auctions secured only **4 GW of new offshore wind capacity**, below the rate of deployment targeted
- **Challenges:** Supply chain constraints, rising material costs, slow progress

Biomass provides a **reliable, dispatchable energy source**, reducing reliance on offshore wind to provide renewable energy

Biomass capacity reduces the need for new low carbon generation capacity e.g. 10-20% reduction in offshore wind installation[1]

Energy networks

- **Ambition:** To integrate renewables, the UK needs to add more than **1,000 km of new transmission lines** in the next 10 years, compared to the current **7,200 km in England and Wales**
- **Status**: Grid capacity is currently insufficient, with delays in infrastructure upgrades and £1 billion spent annually to curtail wind generation
- **Challenges**: Lengthy approval times (12-14 years), high costs, supply chain constraints

Biomass capacity, available near sources of demand can **offset the need for additional long-distance transmission lines**, alleviating grid pressures

Biomass generation reduces reliance on long-distance transmission, supporting a resilient and cost-effective grid transition

Decarbonising buildings

- **Ambition:** To decarbonise home heating, the UK government aims to install **600,000 heat pumps annually by 2028**, with a cumulative target of 3 million installations between 2024 and 2030
- **Status**: Current installation rates are far below the target with around 100,000 installations in 2024
- **Challenges**: Recruiting and training skilled workers for insulation and low-carbon heating. Consumer buy-in/engagement for switching to heat pumps

Biomass heating can help fill these gaps and support a smoother transition. Biomass heating can be **well suited for off-grid homes**, with limited adapatation

Biomass adoption could reduce heat pump demand by 20%, easing grid and workforce pressures[2]

The role of biomass can reduce inflationary pressure across key components of the energy transition, enabling faster decarbonisation while addressing supply chain, grid, and workforce challenges.

1- Calculations are based on Baringa modelling of biomass and BECCS capacity offsetting new offshore wind requirements.

2- The 20.1% reduction in heat pump demand assumes 50% adoption of biomass heating among ~1.2 million off-grid homes (oil, LPG, and solid fuel users).

Data source: UK Offshore Wind Investment Roadmap - 2024, ESO Future Energy Scenarios (FES) 2023/2024, UK Biomass strategy

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Biomass could reduce delivery and coordination challenges, providing low-carbon solutions for off-grid and hard-to-electrify homes

- 95% of homes rely on fossil fuel heating today, largely (85%) gas
- c.4 million homes are off the gas grid, typically using oil or LPG
- Most will have to switch to low carbon heating to meet net zero

- Heat pumps and biomass represent two lead options for decarbonising domestic heating
- Biomass can be a scalable, deployable low carbon solution for both standalone and district heating, esp. for off-grid homes

	Gas Boilers	Oil Boilers	Heat Pumps	Biomass Heating
Ease of adoption	Well known and widely accepted	Common in off-grid areas – operates like gas boilers	Requires habit change – works at constant low-temp heating	Limited change**,** can operate like traditional boilers - easy for users
Environment and energy impact	❌ **High emissions** (2.2 kg CO2 m3/gas) but potential for green gas • Vulnerable to import price shocks	❌ **Higher CO_2 emissions** than gas & biomass ❌ Dependent on global oil prices	• Zero on-site emissions • Relies on electricity grid decarbonisation	• **Low carbon** and renewable ❌ Potential for air pollution impacts[1] • Reduce grid dependence
Cost (upfront and running)	• Affordable upfront cost • £1,000 – £3,700/ year (subject to fluctuations in gas prices)	• £3,250 – £4,450 • Approx. £1,500 -2,000/year (influenced by oil prices)	• £5,000 - £ 35,000[3] • Est. £500 - £1500/year (depends on system efficiency)	• £4,000 – £21,000[2] • Stable running cost £1,100-£1,200 per year
Infrastructure investment needed	Not all homes access the gas network; existing connections may be phased out	Declining usage, as oil is being phased out	❌ Can require significant upgrades to distribution networks	• Ideal for rural/off grid homes • Requires space for fuel storage & regular fuel deliveries
Scalability and deployment	Widespread but declining due to policy	Limited to rural homes – high maintenance & fuel costs	Slow adoption due to high costs & grid limitations	Deployable now – supports both standalone & district heating

1- Air pollution impacts minimised when biomass boilers are run efficiently with appropriate fuels
2- Upfront Costs depend on system type (manual vs. automatic feed).
3 - Installation costs depend on system type (air vs. ground source) and property size, cost also includes necessary home insulation upgrades.

Data source: Biomass Strategy 2023, NESO, Energy saving Trust – Biomass boilers

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The UK is a leader in biomass innovation, with technologies such as gasification and biochar production offering the potential to play a transformative role in the energy transition

The growth of the UK biomass market and range of applications for biomass can be driven by innovations like Advanced Gasification Technology (AGT) and Pyrolysis with Carbon Capture (CCUS). These technologies address two critical needs to achieve Net Zero :

- **Carbon removals :** BECCS could sequester more than **100 Mt of CO_2 annually by 2050**, while biochar sequesters carbon in soils and enhances agricultural sustainability
- **Efficiency and Accessibility :** Modular AGT and scalable CCUS systems reduce costs, improve efficiency, and expand biomass deployment

Kew Projects Ltd – CCH2 : Carbon Capture and Hydrogen

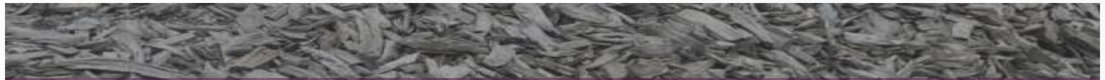
✓ Uses **AGT** to produce **1,000 tonnes of hydrogen annually** and capture **50,000 tonnes of CO_2** during its first phase (2025–2030), with potential scaling to **24 million tonnes**

Key features:

- Direct CO_2 capture from the gasification process
- Production of a carbon-negative hydrogen stream
- A modular and scalable system for flexible deployment
- Targeting TRL 9 for commercial rollout

✓ Produce over **1,000 tonnes of transport-grade hydrogen** annually, meeting the ISO standard of 99.7% purity for fuel cell vehicles

✓ Secured over £4.4 million from the Department for Energy Security & Net Zero's Hydrogen BECCS Innovation Programme



BIOCCUS Project by Ricardo UK Ltd

✓ Converts biomass into biochar, bio-oil and syngas, enabling the sequestration of **50,000** tonnes of CO_2 annually by 2030, while improving soil health

Key features:

- Produces biochar for agricultural use and long-term carbon sequestration
- Carbon capture efficiency of up to 90% of the carbon in the feedstock
- Generates renewable heat and electricity from syngas
- Targeting TRL 8–9 for near-commercial deployment

✓ Improves soil fertility for **~2,000 hectares** of farmland annually, while further sequestering carbon in soils

✓ £2.986 million funding secured through the UK's Net Zero Innovation Portfolio (Phase 2)

Data source: Climate Change Committee (CCC), Sixth Carbon Budget (2020), HMG Reports (BEIS/DESNZ), Advanced Gasification Technologies Report , Grand View Research, UK Biomass Power Market Report (2021)

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Some of the contents of this document were produced using the Energy System Modelling Environment ("ESME") and data of the Energy System Catapult.

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