Response ID ANON-Y1NB-BDYP-9

Submitted to Draft Climate Change Plan Scrutiny 2025
Submitted on 2025-09-19 22:15:55

About you

1 Please read the privacy notice below and tick the box below to show that you understand how the data you provide will be used as set out in the policy.

I have read and understood how the personal data I provide will be used.

2 How your response will be published

I would like my response to be published in its entirety

3 What is your name?

Name:
Jordan Willis

4 What is your email address?

Email:
jordan.willis@ukerc.ac.uk

5 Are you responding on behalf of an organisation? If you answer yes, please also answer the questions on the Organisation details page.

Yes

6 Please choose which sector(s) you want to tell us about. You are welcome to limit your responses to particular sub-sectors or examples within these if you want to (e.g. cultural, public sector fleet vehicles, NHS activities etc.):

Electricity, Buildings, Transport, Industry, Negative Emissions Technologies

Organisation details

1 Name of organisation

Name of organisation:
UK Energy Research Centre

2 What type of organisation do you work in?

Higher education institution

Please use this textbox to provide your answer:

Electricity

1 What are the most important policies needed to achieve the proposed carbon budgets level for 2026-40 in the electricity sector?

Please use this textbox to provide your answer:

From Dr Graeme Hawker and Dr Callum MacIver, University of Strathclyde:

Scottish policies have three key roles to play in enabling the electricity sector to contribute the required levels for the future carbon budgets:

1. Enabling the build-out of renewable energy capacity in Scotland and in Scottish waters. While the conclusion of the Review of Electricity Market Arrangements (REMA) has opted against zonal pricing, reformed national pricing is still under review and potential reform and it is key to renewable development in Scotland that this increases certainty for investors. Potential amendments to CfD and/or transmission charging design may significantly affect the price signals to developers looking to locate new renewable generation capacity in Scotland. These issues, as well as the implications of “volume risk” on renewable assets competitiveness, are addressed in https://ukerc.ac.uk/publications/zonal-pricing-volume-risk-and-2030-clean-power-target-working-paper/ and a forthcoming UKERC working paper on CfD design. Options for improving locational signals within a reformed national pricing system to better optimise asset utilisation in a renewables-dominated electricity system are explored in https://ukerc.ac.uk/publications/locational-signals-in-a-reformed-national-market-a-review-of-options/
2. Accelerating the design, planning and build-out of new electricity network capacity to both increase the capacity of the network to reduce constraints, as well as permitting new generation capacity to be accommodated.
https://ukerc.ac.uk/news/transmission-network-unavailability-the-quiet-driving-force-behind-rising-curtailment-costs-in-great-britain/

3. Supporting the electrification of energy services currently supplied directly from fossil fuels. The reduction of emissions from passenger vehicles is a key contributor to carbon budgets, meaning that the Scottish Government must promote the uptake of EVs such as through the coordination of new charging infrastructure. The uptake of heat pumps in buildings must be promoted as a priority. Industrial decarbonisation through electrification must also be supported.

2 When should these policies be introduced, and over what timeframe should they be implemented in the electricity sector?

Please use this textbox to provide your answer:

From Dr Graeme Hawker, University of Strathclyde

For all elements of the electricity sector, the development of supply chains are key, so irrespective of the timeframes for particular transitional shifts, early work should be conducted and led by government to identify and promote necessary supply chain development for generation, transmission, and shifting energy service demands in heating, transport and industry.

3 What are the expected costs of implementing these policies in the electricity sector?

Please use this textbox to provide your answer:

From Dr Graeme Hawker, University of Strathclyde
National policies to manage/lower costs of renewables (see, for example, UKERC's work on 'Pot Zero', a plan which aims to save £2-8 billion per year in the late 2020s, and has recently been endorsed by the UK Liberal Democrat Party: https://ukerc.ac.uk/publications/pot-zero-2025-update-reducing-the-cost-of-renewable-support-to-consumers/) and the costs of operating a renewables-dominated system (such as recent work on minimising curtailment costs in the UK energy system: https://ukerc.ac.uk/news/transmission-network-unavailability-the-quiet-driving-force-behind-rising-curtailment-costs-in-great-britain/) will have a particularly distinct impact on Scottish generators, so engagement with responsible UK bodies to ensure their interests are well-represented are key.

Generally, the costs of new generation and transmission infrastructure implies no additional costs to the public purse as both attract private investment recovered from future energy markets and network charging elements of consumer bills respectively. However, the need to de-risk investment means that there may be benefits to public investment with long-term returns.

4 What are the expected benefits of these policies in the electricity sector? Please include any wider benefits (e.g. environmental, equality, financial and health) you would expect.

Please use this textbox to provide your answer:

From Dr Graeme Hawker, University of Strathclyde

While there will be large upfront capital costs, it is expected that investment in a low carbon electricity sector will overall reduce costs in the long term compared to maintaining the current system. The potential scale of renewable generation in Scotland will mean a proportionally larger amount of energy in Great Britain will come from generators in Scotland or Scottish waters, and this in turn creates an opportunity for increased economic activity within Scotland.

Some of the shifts in energy services demands come with additional benefits; for example, the uptake of heat pumps is likely to result in significantly improved health outcomes and a reduction in costs to NHS Scotland from e.g. respiratory illness.
https://ukerc.ac.uk/publications/benefits-heat-pumps-role-electricity-gas-prices/ The removal of ICE vehicles from urban environments will bring improved air quality.
https://ukerc.ac.uk/publications/climate-change-policies-reduce-air-pollution-and-increase-physical-activity-benefits-costs-inequalities-and-indoor-exposures/

5 What do you think the key challenges would be in delivering these policies in the electricity sector?

Please use this textbox to provide your answer:

From Dr Graeme Hawker, University of Strathclyde

The high cost of energy, in particular where electrification of existing fossil fuel demands is concerned. For example, it is difficult for local authorities to promote heat-pump-based heat networks as part of their heat and efficiency plans where this potentially equates to an increased cost of heating for the consumers connected to that network. Similarly, industrial decarbonisation via electrification may make products less competitive in international markets due to UK energy being higher cost than in other countries.
Public opposition to new infrastructure, such as the growing movement against new electricity lines, is likely to increase and should be pre-empted by government messaging which makes the case for such infrastructure in the drive to meet net zero, alongside communicating the potential benefits to consumer energy bills due to increased low-cost renewable energy volumes and reduced constraint costs.
However, this low-cost case for renewables is also predicated on the current situation of high gas prices. Policy should be prepared with the case borne in mind that there may be a potential future reduction in the cost of gas to the point where it again becomes the cheapest form of electricity generation, and any justification for public expenditure in other areas of the electricity system should be sustainable in a future with different cost assumptions.

From Dr Richard Carmichael, Imperial College, London

Lower-cost electricity will support the adoption of heat pumps and electric vehicles through lower running costs (accompanied by effective communication). UKERC's Energy Markets Lab (https://ukerc.ac.uk/research/current-research-whole-system-missions/) is currently focussed on exploring

options for reducing electricity bills quickly.

6 How could these policies support a Just Transition for workers and communities in the electricity sector?

Please use this textbox to provide your answer:

From Dr Graeme Hawker, University of Strathclyde

We refer here to UKERC's response to the 2023 consultation on the Scottish Government's Energy Strategy and Just Transition Plan: https://ukerc.ac.uk/publications/scottish-government-draft-energy-strategy-and-just-transition-plan-consultation/, and to the submission from our colleagues at the Centre of Energy Policy at the University of Strathclyde.

Buildings

1 What are the most important policies needed to achieve the proposed carbon budgets level for 2026-40 in the buildings sector?

Please use this textbox to provide your answer:

From Dr Jess Britton and Professor Jan Webb, University of Edinburgh

The timely publication, and subsequent agreement by the Scottish Parliament, of the promised revised Heat in Buildings Bill is critical to the delivery of carbon budgets in the building sector. The bill should incorporate clean heat and buildings-specific targets, supported by a robust time-tabled delivery plan, standards, regulation, advice and financial support (grants and loans) to deliver heat decarbonisation in residential, private sector and public sector buildings.

Revision of the original bill, to focus on collective action and targets rather than homeowner mandates, reflects concerns about public opposition. Whilst it is essential that the bill protects the most vulnerable, addressing fuel poverty and avoiding an undue financial burden on homeowners, there is also a role for mandated energy efficiency standards. Such standards, if properly implemented and supported by comprehensive advice and financing schemes, can play an important role in establishing householder and market certainty in decarbonisation, including building the essential skills and supply chains. Test of technical feasibility and targeted exclusions (for example in specific hard to decarbonise or remote, rural properties) can play an important role in addressing concerns regarding bill impacts. The adoption of New Build Heat Standard regulations is an important development, and implementation should be rigorously monitored.

There is relatively strong evidence that the policy and institutional landscape to support heat decarbonisation and local energy systems is more advanced in Scotland, relative to the UK-wide picture. This is largely based on structuring of the local government role through: the statutory duty to prepare Local Heat and Energy Efficiency Strategies and delivery plans (LHEES); a Public Bodies Climate Change Reporting Duty, and the knowledge and capacity base developed by the long history of programmes delivered in partnership with orgs like Energy Saving Trust/Home Energy Scotland, ChangeWorks, SCARF, Scottish Futures Trust, Zero Waste Scotland and Business Energy Scotland (https://ukerc.ac.uk/publications/institutional-landscapes-for-localenergy-systems-mapping-england-scotland-and-wales/).

Despite these positives, long-term policy certainty remains critical to industry and citizen buy-in to rapid decarbonisation. A Draft Energy Strategy and Just Transition Plan was consulted upon in 2023 but this appears to have stalled and it is not clear how consultation responses (including from UKERC: https://ukerc.ac.uk/publications/scottish-government-draft-energy-strategy-and-just-transition-plan-consultation/) have been integrated into any subsequent development of a final Energy Strategy or the draft CCP. Additionally the Heat in Buildings Bill is undergoing delays and revisions. The establishment of Heat and Energy Efficiency Scotland (EES), operating in virtual form within the Energy and Climate Change Directorate since October 2022 is an important development, in principle providing leadership and coordination. However there is limited transparency on the EES' role, impact, future trajectory or public engagement on heat in buildings.

Heat networks

Secondary legislation and implementation of the Heat Networks (Scotland) Act 2021 should be accelerated. This should include continuation of the Heat Network Support Unit (HSU) and Heat Network Fund (SHNF), licensing, monitoring the effectiveness of building assessments and heat zoning (derived from LHEES) and adoption of post-2035 targets.

SHNF investment also needs to accelerate; in August 2025, only £9.3 million had been allocated out of a commitment to £300 million in capital grants during this parliament. In England, the Green Heat Networks Fund (GHNF) has invested at least £380 million since 2022 (Triple Point HN Investment Management). DESNZ nomination of six pilot cities for HN zone development in England (DESNZ 2022-24; 2025) has already resulted in rapid cross-sector investment – see e.g. The SWAN Partnership, with £21 million from the GHNF and capital investment commitment by Hemiko and Vital Energi.

Acceleration of investment is likely to require an obligation on buildings with large heat loads to connect to district heating when available. This mandate is part of heat network zoning in England. Scottish legislation needs to adopt an equivalent mandate. Our research indicates that such regulations are important in developing certainty in heat network investment, but have as yet been absent in Britain, in contrast with comparator European countries with established DHN business (see https://ukerc.ac.uk/publications/institutional-context-and-the-governance-of-heat-transitions-the-cases-of-the-netherlands-and-the-uk/ and https://ore.exeter.ac.uk/articles/thesis/The_role_of_the_city-scale_in_energy_transitions_heat_networks_in_England_and_Germany/29760584?file=56786981).

Local authorities should be able to access additional specialist support and resources in areas where there is potential for the development of cross-authority or regional networks (such as Edinburgh and Lothians). Such large, cross authority networks have the potential to optimise cost, carbon and socio-economic efficiencies but involved additional technical, political and contractual complexities (see more: https://ukerc.ac.uk/publications/scottish-government-net-zero-energy-and-transport-committee-inquiry-into-the-role-of-local-government-and-net-zero/).

Energy Planning and the role of local government

The development of Local Heat and Energy Efficiency Strategies and plans (LHEES) by Scottish local authorities has helped to develop a stronger evidence base to inform retrofit and heat decarbonisation in buildings, including waste industrial or other residual heat sources and heat network development (https://www.gov.scot/publications/local-heat-energy-efficiency-strategies-lhees-phase-2-pilots-evaluation/documents/). However, there is ongoing uncertainty in the delivery of LHEES. In line with our response to the draft Energy Security and Just Transition Plan consultation in 2023 (https://ukerc.ac.uk/publications/scottish-government-draft-energy-strategy-and-just-transition-plan-consultation/), the Scottish Government should

conduct a rapid, systematic review of LHEES and Delivery Plans ensuring alignment of plans with priorities in the draft CCP and intended Heat in Buildings Bill/Act. This should include: an assessment of strategic zones and delivery priorities to inform Scottish Government policies and a review of project pipeline development (including coordination of investment portfolios). Given the resourcing and skills constraints in local governments, this should include engagement with local government on barriers and enablers to high quality LHEES and rapid, coordinated delivery.

The likely electrification of a significant proportion of heat demand will create substantial new demands on electricity distribution networks, as well as scope for demand flexibility and for use of waste or residual heat in heat networks to reduce the high costs of investment in power generation and grids. Whilst LHEES do not currently incorporate wider energy planning (beyond heat and energy efficiency), these strategies will have a material impact on distribution networks through identification of priority areas for electrified heat. Research suggests that approaches to incorporating local flexibility are less developed in Scotland than in the rest of Great Britain (https://ukerc.ac.uk/publications/institutional-landscapes-for-localenergy-systems-mapping-england-scotland-and-wales/). Scottish Government should work closely with Ofgem and NESO (Scotland is a defined as a single region for development of a Regional Energy Strategic Plan (RESP)) to incorporate LHEES as material considerations in DNO and heat network business planning and investment. A number of Scottish Local Governments have also developed whole-system Local Area Energy Plans (LAEPs), including exploring methods to integrate LHEES and LAEP to better inform both network planning and local authority project development. The learning from these areas should be integrated into future development of Scotland's RESP, as well as revised LHEES and delivery plans (https://www.sustainabledundee.co.uk/case-studies/local-energy-net-zero-accelerator-lenza).

Additionally, UKERC research indicates that local government-led energy planning (LHEES and LAEP), dispersed industrial site decarbonisation, and business planning for the electricity distribution networks are currently insufficiently integrated (https://www.research.ed.ac.uk/en/publications/accelerating-transitions-planning-for-decarbonisation-in-local-an and https://committees.parliament.uk/writtenevidence/139509/pdf/). NESO development of the Scottish RESP is intended to enable integrating whole system energy planning and it is important that industrial stakeholders are closely engaged in RESP development. The geographies of these development processes are complex, with only one RESP proposed for Scotland, and the Scottish Government should ensure that industry representation encompasses strategic sites, existing clusters and emerging industries.

Retrofit

Provision of a national energy advice service in the form of Home Energy Scotland and the Social Housing Net Zero Heat Fund plays an important role in ensuring common access to consistent, trusted advice on energy efficiency and heat decarbonisation, and funding support. Continuing to combine these advice services with long-term access to grants and interest-free loan schemes for households and social landlords to install low carbon heat and/or energy efficiency measures is also essential. UKERC research indicates that funding scheme longevity and the development of institutional knowledge capacity through delivery bodies such as the Energy Saving Trust, Change Works, SCARF, Scottish Futures Trust are important elements of a comprehensive policy and institutional landscape for local energy systems and retrofit. (https://ukerc.ac.uk/publications/credible-and-comprehensive-comparing-policy-mixes/ and https://ukerc.ac.uk/publications/institutional-landscapes-for-local-energy-systems-mapping-england-scotland-and-wales/)

Nevertheless, to enable the rate and scale of retrofit required to meet carbon targets, government financial incentives are likely to need to be combined with innovation in financial products (green mortgages, blended finance, energy service contracting). The Scottish Government should respond to and implement the recommendations of the Green Heat Finance Taskforce(https://www.gov.scot/publications/green-heat-finance-taskforce-report-part-2/), including developing a place-based demonstrator programme and exploring innovative financing methods such as collective and/or blended financing models. There is extensive experimentation in this area across Great Britain and the Scottish Government should evaluate learning from initiatives such as the Cities Commission for Climate Investment (3Ci - https://www.3ci.org.uk/) and UK Government trials (including the Local Net Zero Accelerator (LNZA) project (https://www.gsenetzerohub.org.uk/local-net-zero-accelerator/), Innovate UK Net Zero Living Programme, the Heat Network Zoning Pilot Programme (https://www.gov.uk/government/publications/heat-networks-zoning-pilot and https://www.gov.uk/government/news/six-towns-and-cities-to-pilot-clean-heating-innovation) and the Green Home Finance Accelerator Pilots (https://www.gov.uk/government/publications/green-home-finance-accelerator-discovery-phase-projects/green-home-finance-accelerator-details-of-pilot-phase-pr
Bottom-up solutions that work for individual neighbourhoods, towns and cities will also be central to accelerating retrofit. Evidence from UKERC's Whole Person, Whole Place research (https://ukerc.ac.uk/project/net-zero-neighbourhoods/) highlights the need for relational approaches that consider household circumstances, social relations and building characteristics to building tailored solutions which leverage the billions of pounds people already spend as part of their aspirations for a 'better home'.
While the Scottish Government has significant policy levers available to it to shape the decarbonisation of buildings, there are also a number of areas where powers are retained by the UK Government. In particular, changes to retail market arrangements and tariff structures require action by the UK Government and/or Ofgem. Action by the UK Government to rebalancing relative gas and electricity prices could significantly reduce costs to households of electrifying heating; potentially increasing costs for others and impacting on fuel poverty. Any changes to retail markets and tariff structures need to be coordinated and aligned with policy mixes for retrofit in Scotland, ensuring that households can fund whole house retrofit via 'one stop shops' and area-based programmes with consumer protection guarantees.

From Dr Richard Carmichael, Imperial College London

Regarding supporting the transition to heat pumps, it will be key to ensure that adopters are satisfied with their heat pump systems – this can then be leveraged to build momentum in demand, helped further by technology learning curves (reducing the up-front costs) and policy that lowers the running cost of heat pumps. With this in mind, the following approach to heat pump policy is recommended:
(i) Although we wish to avoid leaving segments of households behind, in the immediate term, we should focus mostly on supporting heat pump adoption by (a) households for whom switching to a heat pump has the clearest benefits in terms of heating bills warmer homes and (b) households who are the most willing and likely to adopt. This will include support through tailored information and resources, applicable to their home, to guide them through the decision-making process of adoption, such as estimating running costs and choosing a trusted installer. This information applicable to the individual household can include learning from the outcomes and experiences of similar households who have adopted heat pumps (a peer-to-peer learning approach) – this can provide data but also help shift norms around heat pumps, including a 'social circle' effects that UKERC work suggests can be highly influential, see https://www.imperial.ac.uk/energy-futures-lab/reports/briefing-papers/paper-10/
(ii) Heat pump performance hugely affects running costs. High adopter satisfaction can help strengthen demand and poor satisfaction could damage it,

especially at this stage of the technology adoption cycle. There is a risk that growing the installer skills workforce will see already mixed expertise fall. Policy should also aim to constantly drive up and maintain heat pump installer expertise.
(iii) Accurate data on heat pump installation outcomes is valuable for informed adoption and monitoring installer skills. Currently, heat pump performance is not assessed and building performance is based on modelling and estimation. As far as practical, move towards measurement-based in-situ assessment of building performance, heating system performance, and compliance (a shift to measurement-based compliance with building energy efficiency standards has been pursued by some cities in the USA, https://www.etude.co.uk/wp-content/uploads/2021/06/Making-SAP-and-RdSAP-11-fit-for-Net-Zero-Full-report.pdf).

From Dr Richard Hanna, Imperial College, London

Renovation measures to help improve energy efficiency and decarbonise homes can include loft and cavity wall insulation, heat pumps and solar PV. The UKERC working paper 'Accelerating Energy Efficiency Retrofits in Owner-occupied Homes' (https://ukerc.ac.uk/publications/accelerating-energy-efficiency-retrofits-in-owner-occupied-homes/) reviews international evidence on six individual policy instruments, and key examples and features of these are synthesised in the report. The working paper identifies various review studies on policy instruments which have been applied in different countries and are considered important for implementing residential energy renovation. Policy instruments most commonly emphasised are regulations, financial support and information provision. Most reviews also include policies to develop workforce skills and competencies, supply chains and quality assurance.

Effective home energy renovation policy requires a holistic approach integrated across consumer demand and retrofit supply side; demand-side polices focused only on encouraging owner-occupiers to retrofit will not be sufficient without quality-assurance initiatives which help to expand the competent workforce and raise consumer trust. There is a consensus, particularly in existing reviews on home energy retrofit policies, that the application of single policies alone will not be enough to achieve a transformational increase in energy renovation rates. Indeed, the latter remain low despite the application of various policies internationally. In countries where higher volumes of renovations have been achieved, such as Canada, France, Germany and Ireland, we have identified several cross-cutting success factors which include long-term policy reliability and flexibility, effective policy mixes, policy integration and multi-scale governance, including the use of intermediaries such as 'one stop shops'.

From Dr David Drabble, University of Strathclyde

UKERC research carried out by the Centre for Energy Policy, University of Strathclyde, suggests that building decarbonisation will require supportive policies to reduce heat-pump purchase and installation costs. We are currently assuming that over 10.2 million air source heat pumps need to be installed to achieve long term carbon budget goals (https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf). Building and encouraging the development of domestic supply chains will also be needed. A sustained programme of grants, subsidies, and supply-chain investment is essential to meet UK targets of 600,000 annual installations by 2028 and without major reductions in purchase and installation costs, households will face higher bills and uptake stalls. To do this, achieving the UK government aim of cost parity with gas boilers by 2030 is critical. Bringing equipment and installation prices down requires long-term industrial strategy, R&D support, and market-making procurement policies (https://strathprints.strath.ac.uk/89989/19/Katris-Turner-EPG-2024-Achieving-economy-wide-gains-from-residential-energy-efficiency.pdf).

Addressing issues around how the price of electricity is set is critical. The relative price of electricity vs gas determines whether heat pumps reduce household bills and so policies addressing energy prices and electricity: gas price signals are necessary.(https://pure.strath.ac.uk/ws/portalfiles/portal/176306169/Corbett_etal_UoS_2023_Unlocking_the_Benefits_of_the_Low_carbon_Heat_Transition.pdf; https://strathprints.strath.ac.uk/89989/19/Katris-Turner-EPG-2024-Achieving-economy-wide-gains-from-residential-energy-efficiency.pdf)
The upfront costs of adopting heat pumps for households can also have wider economic impacts, depending on the policy design of consumer financing and subsidy mechanisms. Grants and loans have different household spending implications. Our modelling shows grants sustain disposable income and GDP while household-borne upfront costs or loans can depress consumption and job outcomes (https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf). A policy that balances investment affordability vs long term household benefits will be needed to realise benefits for Scotland.

Policies to drive mass heat-pump deployment must be coupled with electricity-network upgrades. Our scenario modelling shows that if delivered at scale, heat pumps will significantly increase electricity demand, and current networks will need investment of over £20 billion over the next three decades to cope with the demand. These network upgrades should be front-loaded in the next ten years to enable millions of heat pump connections; regulators will need to prioritise grid reinforcement in anticipation for this demand (https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf).

2 When should these policies be introduced, and over what timeframe should they be implemented in the buildings sector?

Please use this textbox to provide your answer:

From Dr Jess Britton and Professor Jan Webb (University of Edinburgh):
The policies highlighted in our response should be introduced very rapidly. Delay is already resulting in uncertainty about government commitment to targets and undermining investor, property owner and business confidence. The timeframe should be developed in line with the contribution of the building sector to meeting the carbon budgets set out in the CCP.

From Richard Hanna, Imperial College London:
Key to effective home energy retrofit policies internationally is stable, long-term policy support, helping to increase certainty for household and supply chain investment decisions. Policies should be flexible so that they can be adapted over time to account for changing circumstances, and differentiated according to different household and regional characteristics. Residential energy retrofit policies should be adaptive enough to account for the risk that individual policy instruments might interfere with each other and reduce their efficacy (https://www.sciencedirect.com/science/article/pii/S1364032120300745). Conversely, there are opportunities for policies to be applied together to achieve more impact, for example information measures and standards can help to increase the success of other policies

(https://www.tandfonline.com/doi/full/10.1080/09613218.2016.1138803).
In Germany, since the early to late 2000s consistent support has been provided from a combination of measures including the Energy Saving Ordinance (EnEV), Renewable Heat Law (EEWarmeG), Market Incentive Programme for renewable heat, and KfW grants and loans (https://www.gov.uk/government/publications/international-comparisons-of-heating-cooling-and-heat-decarbonisation-policies). The EU Energy Performance of Buildings Directive requires member states to develop long-term strategies to achieve zero emission building stocks by 2050.
Policies should be credible to policymakers and industry and supported by political commitment to an instrument mix which is consistent over time, helping to achieve policy targets. Furthermore, a policy mix should be comprehensive in comprising an overall strategy, objectives and policy instruments which put these into action (https://www.sciencedirect.com/science/article/pii/S0048733316300506?via%3Dihub).
In deciding which mix of policy instruments to develop in a given country, policymakers should consider the purpose, strengths and weaknesses of instruments already in place and policy gaps, i.e., are particular types of instruments under-utilised? For example, it may be more time efficient to strengthen existing regulation rather than create entirely new legislation (https://www.iea.org/reports/energy-efficiency-policy-toolkit-2024).

From Dr David Drabble, University of Strathclyde
For heat pump policies, the full rollout of heat pumps needs to be concluded by 2050, steadily rolling out over a 25-year period. This means consistent annual installations are required, with no possibility of delay if carbon budgets are to be met. (https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf)
To achieve these aims, cost-reduction and supply-chain policies should begin immediately so installation costs fall by the late 2020s. Our modelling suggests that heat pump component costs will start to reduce from 2028, with domestic manufacturing and supply chain development essential for achieving further savings. If these reductions are not realised, the household affordability challenge will persist, and wider economic benefits will be undermined. Early policy actions supporting affordability will pay off by increasing economic gains and offsetting the initial costs. (https://strathprints.strath.ac.uk/89989/19/Katris-Turner-EPG-2024-Achieving-economy-wide-gains-from-residential-energy-efficiency.pdf; https://pure.strath.ac.uk/ws/portalfiles/portal/176306169/Corbett_etal_UoS_2023_Unlocking_the_Benefits_of_the_Low_carbon_Heat_Transition.pdf).

Phased network upgrades will need to take place between now and 2037 with activity front-loaded to avoid bottlenecks. Network upgrade activity should be concentrated in the first 15 years, peaking in 2033, to align with the acceleration of heat pump deployment. Similarly, skills and workforce policies should also be focused on the next ten years. Skills pipelines, training and regional labour planning must start immediately to meet the rising construction and manufacturing demand. (https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf; https://strathprints.strath.ac.uk/89989/19/Katris-Turner-EPG-2024-Achieving-economy-wide-gains-from-residential-energy-efficiency.pdf).

3 What are the expected costs of implementing these policies in the buildings sector?

Please use this textbox to provide your answer:

From Dr Richard Hanna, Imperial College London

There are different sub-categories of building energy renovations, particularly the distinction between ‘shallow’ retrofit involving one or two measures or piecemeal approaches, and ‘deep’ retrofit involving multiple interventions - aimed at achieving primary energy use savings of at least 60% - including comprehensive, pre-planned and complementary ‘whole house’ renovations (see https://ukerc.ac.uk/publications/accelerating-energy-efficiency-retrofits-in-owner-occupied-homes/).
Recent analyses advocate moving beyond a ‘fabric first’ approach, which has previously set out that building fabric improvements such as insulation should be prioritised over low carbon heating and renewable energy systems installed in buildings. Instead, researchers argue that insulating every home to a high standard would not be cost-effective or feasible for rapid decarbonisation of the housing stock (See https://journal-buildingscities.org/articles/10.5334/bc.388). In this new approach, it is contended that in many homes, heat pumps or other zero carbon heating will be enough to decarbonise heating without needing to improve their thermal fabric. Building fabric improvements still have an important role but may only be typically needed in 30%-50% of national building stocks. They should be prioritised in new buildings, in retrofits where low-cost measures are possible, and where they can bring other co-benefits such as better comfort and health, reducing heat pump running costs and lessening electricity demand from the grid (ibid.).
Similarly, others emphasise that policymakers should be more receptive to evidence demonstrating that deep building energy retrofit may not pay back within reasonable timescales (https://link.springer.com/article/10.1007/s12053-024-10227-8). This may mean focusing on heat decarbonisation, e.g., through a shift to heat pumps, and redirecting subsidies towards more basic rather than very highly energy-efficient renovations.

From Dr Graeme Hawker, University of Strathclyde and Dr Mark Winskel, University of Edinburgh

The deployment of heat pumps will, for the majority of buildings in Scotland, require improvements to the building fabric and central heating systems, which entails a significant upfront capital cost. A review of heat pump installed costs is available at https://ukerc.ac.uk/publications/heat-pump-cost-review/. This review concluded that reductions in total installed costs of 20–25 % were likely by 2030 in the UK – significant, but relatively modest compared to policy targets https://doi.org/10.1016/j.apenergy.2024.124014 .
This means that heat pump affordability in Scottish homes is likely to remain a barrier to policy delivery in the late 2020s and early 2030s, at a time when deployment needs to expand rapidly for net zero to be feasible by 2045. This suggests policy should better reflect the cheaper running costs of heat pumps; for example, by supporting device rental, pay-as-you-save or heat-as-a-service schemes. A review of such schemes published by ClimateXChange is available at: https://www.climatexchange.org.uk/projects/heat-pumps-on-subscription/

From Dr Richard Carmichael, Imperial College, London

Financial support for heat pump adoption has focussed on the up-front installation costs. Policy to drive down the cost of electricity will make heat pumps cheaper to run and more cost-competitive with gas/oil boilers. UKERC’s ‘Energy Markets Lab’ Whole System Mission (https://ukerc.ac.uk/research/current-research-whole-system-missions/) is currently focussed on exploring options for reducing electricity bills quickly.

From Dr David Drabble, University of Strathclyde

Though spread out over a relatively long period, heat pumps have high associated costs. We assume that the total heat pump costs as £122.3 billion, with an average cost per installation of £11,960 (including VAT). This includes £3,680 of labour and installation costs. These costs assume that most heat pumps will be manufactured outside the UK unless policy interventions increase domestic production. The expected network upgrade costs until 2050 are £21.1 billion. This includes reinforcement of local networks, substations and connections, with spending concentrated before 2037 to support the acceleration of low-carbon heat uptake. (https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf; https://strathprints.strath.ac.uk/89989/19/Katris-Turner-EPG-2024-Achieving-economy-wide-gains-from-residential-energy-efficiency.pdf)
These cost figures have some uncertainty, including the design of heat pump subsidies and the policy cost trade-offs from how subsidies are delivered. A more grant-orientated system would increase upfront public cost but would avoid household repayment burdens and deliver modest GDP growth in modelling, whilst loans shift costs to households over 10-year periods with a potential negative impact on consumption. (https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf)
Additional policy investment will also be needed to support supply chain and skills through training and scaling heat pump manufacture. Our research emphasises that policy-funded support and industrial strategy are required to maximise net benefits by strengthening domestic manufacturing and lowering equipment and installation costs. (https://strathprints.strath.ac.uk/89989/19/Katris-Turner-EPG-2024-Achieving-economy-wide-gains-from-residential-energy-efficiency.pdf; https://pure.strath.ac.uk/ws/portalfiles/portal/176306169/Corbett_etal_UoS_2023_Unlocking_the_Benefits_of_the_Low_carbon_Heat_Transition.pdf)

4 What are the expected benefits of these policies in the buildings sector? Please include any wider benefits (e.g. environmental, equality, financial and health) you would expect.

Please use this textbox to provide your answer:

From Dr Jess Britton and Professor Jan Webb (University of Edinburgh):
The social benefits of action on decarbonisation are well established (see https://link.springer.com/article/10.1007/s13412-024-00955-9 for a comprehensive evaluation of costs and benefits of climate change interventions in UK urban areas, including Glasgow) and numerous co-benefit decision-support tools have been developed (http://dx.doi.org/10.2139/ssrn.5286571). In addition to quantitative cost-benefits analysis we advocate for the use of qualitative tools such as well-being frameworks or multi-criteria analysis to better account for the complex benefits and trade-offs of various decarbonisation pathways.

From Dr David Drabble, University of Strathclyde
Investment in heat pumps will result in significant macro benefits and job creation. Under favourable price conditions our UKERC modelling finds positive GDP and job impacts. For example, under a 1:1 electricity:gas parity scenario, heat pump roll out will add £3.8 billion to the UK GDP and add 67,245 in FTE jobs. Rollout activity (that is, manufacturing and installation) provides both stimulus and regional employment opportunities. The higher energy efficiency of heat pumps could therefore drive positive economic outcomes and long-term job creation, especially if domestic manufacturing is increased. (https://pure.strath.ac.uk/ws/portalfiles/portal/176306169/Corbett_etal_UoS_2023_Unlocking_the_Benefits_of_the_Low_carbon_Heat_Transition.pdf; https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf)
Regional economic and manufacturing benefits if domestic content is raised. Strengthening domestic supply chains would ease GDP losses by between £1.6BN and £2.3BN in 2030. High domestic manufacturing content deliver larger GDP mitigation against energy-price shocks and retain more wage income in the UK by easing negative GDP pressures in high-price years. (https://strathprints.strath.ac.uk/89989/19/Katris-Turner-EPG-2024-Achieving-economy-wide-gains-from-residential-energy-efficiency.pdf) This highlights the importance of industrial strategy and domestic manufacturing to maximise national economic benefits. (https://pure.strath.ac.uk/ws/portalfiles/portal/176306169/Corbett_etal_UoS_2023_Unlocking_the_Benefits_of_the_Low_carbon_Heat_Transition.pdf)
Heat pumps also imply household financial benefits on top of wider social and health co-benefits. Energy bill savings are evident across the next 25 years from the mid-to-late 2020s, rising to an average of nearly 9% per household in 2050. These savings free up disposable income, cushion households against volatile gas prices, and reinforce the public acceptance of the transition. We also expect wider benefits expected from decarbonising residential heating, including reduced emissions, potential health and environmental gains. (https://pure.strath.ac.uk/ws/portalfiles/portal/176306169/Corbett_etal_UoS_2023_Unlocking_the_Benefits_of_the_Low_carbon_Heat_Transition.pdf).

5 What do you think the key challenges would be in delivering these policies in the buildings sector?

Please use this textbox to provide your answer:

From Dr Jess Britton and Professor Jan Webb, University of Edinburgh

Decarbonising heat in buildings is a central issue for meeting Scotland's economy-wide carbon budgets, driven particularly by the former 75% by 2030 and 100% by 2045 emission reduction targets. As Audit Scotland concluded however: "The scale of the challenge of reducing emissions from heating homes is huge and there are several risks to success." (Audit Scotland, 2024, p.3).
Success will require concerted, long term, cross party political leadership, and coordination across levels of government, including collaboration between UK and Scottish Governments. The latter is critical to governing complexities of reserved and devolved powers over heat in buildings, including the future of the methane gas grid, and subsequent developments. The NESO Regional Energy Strategic Plan (RESP) will be an important intermediary for the Scottish Government to ensure the effectiveness of a revised Heat in Buildings Bill and legislation.
Public engagement has been limited to date, but will be critical. Plans to decarbonise buildings need to be clearly communicated to all building owners, across sectors, as well as supply chain businesses, assessors, advisers, and installers to ensure that action follows policy. For example, knowledge about current legislation for decarbonising buildings is uneven; social housing providers and local authorities are likely to be most aware of the range of powers and duties. A public information campaign about Scottish Government plans for energy transition (led by Heat and Energy Efficiency Scotland) is essential.
Scottish Government is however in the fortunate position that much of the groundwork work has already been completed, including LHEES, and long-standing consideration and policy development of a Heat in Buildings Strategy. This dates back to at least 2015, when the energy efficiency of buildings was declared a national infrastructure priority and the Energy Efficient Scotland Pilot Programme was launched.

From Professor Nick Pidgeon and Professor Karen Henwood, Cardiff University

Social sciences research by UKERC into how varied publics view the domestic heat transition, including both survey and qualitative workshops held in Scotland over a number of years since 2011, has been the subject of briefings by UKERC to Scottish Government officials and in particular their heat teams. It has shown several key challenges that need to be considered by the Scottish Government.
(a) While householders and wider publics are strongly supportive of the transition to a more sustainable energy system, and this includes in the domestic sphere, people feel that this transition should only go ahead if it offers an improvement on the operation (in heat terms, meaning warmth, operational convenience, comfort etc.) of current systems. At the same time, people want the introduction of low carbon energy systems to be both affordable and fair for all (see: https://ukerc.ac.uk/publications/transforming-the-uk-energy-system-public-values-attitudes-and-acceptability/). Conversely, people are unlikely to be unhappy with changes they perceive as a 'step backwards' in valued attributes of current heating systems (see: https://www.tandfonline.com/doi/full/10.1080/15487733.2024.2347075).
(b) There is very low familiarity with the technologies and methods of domestic heat decarbonisation, although when these are explained in detail to people, many would support installation in their own homes conditional upon being given appropriate support (see: https://ukerc.ac.uk/publications/public-perceptions-of-heat-decarbonisation-in-great-britain-awareness-values-and-the-social-circle-effect/). This points to the need for fostering extensive public engagement by Scottish Government and other stakeholders with regards to this issue, trustworthy information sources, and a reliable skills base amongst installers.
(c) Our recent survey work has shown that people are more likely to support low carbon heating installation in their homes in the future if they know somebody who has already had low carbon heating installed – something we have labelled a 'social circle' effect. This points to the importance of SG supporting first movers of home heat decarbonisation in Scotland. Ensuring first mover experience is a successful and positive one will bring multiple benefits, including attendant impacts on beliefs and attitudes within their 'circles', which may for many people be quite wide. This points to the critical need for supporting first movers, not just financially, but also through independent advice and fostering a trusted and accredited network of installation professionals throughout Scotland.
(d) Perceived disruptions to the domestic space can be a significant barrier to the public engaging with the heat transition. Although these are typically thought of in terms of physical disruption to home fabric, temporary disconnection of external utilities and digging up roads etc, our research shows that it is also important to consider the emotional and identity disruptions that arise from intervening in and in some cases remodelling people's valued domestic spaces, as well as from changes to everyday routines and lives (see more: https://www.nature.com/articles/s41560-024-01506-w). Indeed, for some, the latter disruptions are far more important than e.g. temporary on-street infrastructure works.
(e) Given all of the above, the rollout of the domestic heat transition across the UK is unlikely to occur without controversy. Ongoing research within the current phase of UKERC (2025-29) will look at this question of public contestation of the low carbon heat transition, and how it can take place in constructive ways. We would expect to engage with SG and wider stakeholders in Scotland on this research in due course.
Overall, UKERC research over many years points strongly towards the need for a people-centred approach both to the domestic heat transition and other facets of the energy system transition. Here, supporting households' and communities' needs, lives and everyday practices so as to achieve wellbeing should be prioritised. Understanding and responding to such needs should be a priority objective of the Scottish Government public engagement for net zero. Ignoring this will inevitably lead to delays to deployment, and under some circumstances, outright opposition to decarbonisation proposals.

From Dr Richard Hanna, Imperial College London

Building energy efficiency improvements have been significantly underfunded in the UK over the last decade, and this has been linked to a sharp fall in installation numbers of loft and cavity wall insulation since 2013. This followed the success of earlier UK energy supplier obligations, such as the Carbon Emissions Reduction Target (CERT) and Community Energy Saving Programme (CESP), in deploying several million such insulation measures from 2008 to 2012. A lower CO2 reduction target for suppliers under the subsequent ECO scheme, and the inconsistent and stop-start nature of government incentives such as the Green Deal and Green Homes Grant, have not been helpful for developing the supply chain and promoting market confidence (See: https://researchbriefings.files.parliament.uk/documents/CBP-9889/CBP-9889.pdf and https://committees.parliament.uk/committee/127/public-accounts-committee/news/159264/pac-report-green-homes-grant-scheme-underperformed-badly/).

The age profile of residential buildings in the UK creates additional challenges for future-proofing low carbon retrofit and mitigating adverse health outcomes. A fifth of the UK housing stock is over 100 years old, with 38% of dwellings built before 1946, compared to an average of 18% for the EU. 63% of households are owner-occupied in England, Wales and Scotland in 2021/2 according to the most recent Census data. This equates to 15.5 million homes in England and Wales and 1.6 million in Scotland, with slightly over half owned outright and around 45% owned with a mortgage or loan https://ukerc.ac.uk/publications/accelerating-energy-efficiency-retrofits-in-owner-occupied-homes/.
Given the high proportion of owner-occupier households, effective retrofit policy design requires accounting for the multiple factors which may influence homeowner decisions on whether or not to carry out energy renovations. In addition to anticipated savings on energy bills and carbon emissions, these factors may include values and considerations related to comfort, utility, aesthetics, social aspirations, health and heritage (see https://spiral.imperial.ac.uk/entities/publication/d04f736e-e9a9-42f6-a53f-a90e947c242d).
Homeowners may be more likely to make decisions to install retrofit measures during certain 'trigger points' such as moving home, changes in family structures, members and relationships, or other events resulting in unexpected changes to household practices and prioritisation of concerns within the home (see https://www.sciencedirect.com/science/article/pii/S0306261917317002).
Buildings energy policy has rarely addressed the fact that energy efficiency measures (particularly higher cost and more complex interventions) often lead to mess and disruption for the resident, and Curtis, Grilli and Lynch cite this as an overlooked challenge, with only 1 in 4 households actively receptive to retrofit policy supports (https://www.esri.ie/publications/residential-renovations-understanding-cost-disruption-trade-offs). Where households have energy efficiency measures installed, unexpected delays and complications resulting from a lack of experienced installers have led to dissatisfaction and could negatively impact future uptake (see https://hdl.handle.net/2134/25551).

From Dr David Drabble, University of Strathclyde

The main challenges in delivering building decarbonisation through heat pumps are energy prices and workforce and regional mismatches. On energy pricing, high and persistent electricity vs gas price differentials would undermine bill savings. If electricity remains relatively expensive, heat pumps can be more costly to run, eroding public acceptance. The potential benefits to disposable income depend in large part of electricity prices, so addressing the current imbalance is central to sustaining public support for the electrification of heat

(https://pure.strath.ac.uk/ws/portalfiles/portal/176306169/Corbett_etal_UoS_2023_Unlocking_the_Benefits_of_the_Low_carbon_Heat_Transition.pdf). In the absence of lower equipment costs and affordable electricity, households may see limited or even negative net benefits (https://strathprints.strath.ac.uk/89989/19/Katris-Turner-EPG-2024-Achieving-economy-wide-gains-from-residential-energy-efficiency.pdf).
A further challenge lies in skills/worker shortages and regional mismatches. Our modelling highlights a constrained labour supply, potential wage pressures and the risk of job displacement in some regions. The demand for skilled labour from heat pumps is also likely to increase labour costs, putting pressure on wages. In areas where demand for heat pump installation and maintenance exceed availability, people may have to relocate. This raises questions of fairness, as regions with weaker labour markets may struggle to capture the benefits of the transition without strong retraining and mobility support. (https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf) Monitoring the regional balance of heat pump skills will be a major policy challenge, particularly due to the labour market differences between Scottish regions.

6 How could these policies support a Just Transition for workers and communities in the buildings sector?

Please use this textbox to provide your answer:

From Dr Richard Hanna, Imperial College London
In the EU, supply chains dor building energy renovation are typically comprised of small businesses with an insufficient supply of workers who have the competencies needed to deliver high-quality work. In the UK, over two-thirds of practitioners in repair, maintenance and improvement are micro-enterprise businesses; many make sufficient income using trusted products and processes without entering the energy efficiency market (https://doi.org/10.1016/j.erss.2021.101943).
In order to carry out competent whole-house energy retrofits, workers in relevant trades should ideally possess manual or technical skills, theoretical and interdisciplinary knowledge and the ability to apply it, and ethical conduct. Building trades in the UK and the EU tend to be characterised by low skills and a low demand for, and supply of, good quality training across multiple skill sets, increasing the risk of sub-optimal renovations that do not account for whole-house implications (https://doi.org/10.5334/bc.43). Given the variability of vocational education and training (VET) content across Europe, the EU Skills Registry (https://skillsregistry.eu/) has been developed to support international comparison of qualification and training schemes, as well as skills and competency profiles for different construction and building energy efficiency jobs.
Retrofit installer certification schemes are already established in various European countries, however these could be strengthened by incorporating a license to trade linked to regularly updated, minimum qualification standards. Existing examples of licensing to trade and minimum training requirements include those required for contractors to provide services via 'one stop shops'. In several European countries, there are examples of national retrofit strategies or 'one stop shops' which include training, certification and/or quality assurance of retrofit tradespeople (examples available here:
https://www.theccc.org.uk/wp-content/uploads/2023/06/Climate-policy-that-cuts-costs-International-policy-comparisons-Energy-Saving-Trust-and-Green-Alliance.pdf). In Germany, the KfW bank scheme provides access to householder advice via building energy specialists on a registered list. It is mandatory to consult an independent expert on this quality-assured list
(https://www.rehva.eu/rehva-journal/chapter/quality-assurance-for-energy-efficient-construction-and-retrofitting).
The construction and retrofitting workforce in the UK and Europe is acutely lacking in diversity, comprising predominantly older, white males, with only 10% of EU construction workers categorised as female. In the UK, only 6% of construction labourers are classed as Black or minority ethnic (BAME) and 6% are people with disabilities. Masculine construction cultures, concerns about job security, health and safety and difficult working conditions can be key barriers to attracting more diverse employees, as well as younger generations, into the building energy retrofit sector (research on this is available here: https://doi.org/10.1007/978-3-031-66481-6_6).
Acceptable working conditions, including fair wages and job security, need to be enabled. For example, long hours, inaccessible sites and recruitment practices based on word-of-mouth rather than qualifications are not inclusive. Outreach campaigns promoting the attractiveness of the industry and seeking to overcome cultural barriers to participation, as in the European Construction Blueprint and Women Can Build project (which runs across Spain, Germany, Portugal, Belgium, France and Italy), can provide a start in overcoming these challenges. Incorporating retrofit-related content into school curricula can also provide early exposure to the sector, influencing career decisions as early as primary school. Resources developed by the Construction Blueprint could be adopted for use in schools (https://doi.org/10.1007/978-3-031-66481-6_6).

From Dr David Drabble, University of Strathclyde

One of the main mechanisms to support a fair transition for workers and communities is through targeted skills and retraining programmes. Meeting heat pump roll out targets will require a large and skilled workforce. By targeting existing inequalities in the training of heat pump engineers and manufacturers underrepresented and disadvantaged groups can directly benefit from building decarbonisation. Strengthening domestic manufacture of heat pumps and supply chains can also retain more jobs and income within the UK, giving a boost to green industries and opportunities for affected communities to benefit from the transition. (https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf; https://strathprints.strath.ac.uk/89989/19/Katris-Turner-EPG-2024-Achieving-economy-wide-gains-from-residential-energy-efficiency.pdf)
The principle of targeting support at disadvantaged groups is also relevant for deciding who receives grants for heat pump installation, since those with lower incomes are unlikely to opt in to heat pumps without incentives and direct financial support. Grants eliminate household repayment burdens and so targeted grants or progressive subsidy schemes can ensure that the benefits of decarbonisation are equitably shared and those sceptical of the transition are more likely to buy-in. (https://d2e1qxpsswcpgz.cloudfront.net/uploads/2025/03/1-s2.0-S0301421525000862-main.pdf)

Transport

1 What are the most important policies needed to achieve the proposed carbon budgets level for 2026-40 in the transport sector?

Please use this textbox to provide your answer:

From Dr James Dixon, University of Strathclyde

Transport is now Scotland's largest emitting sector, and evidence from UKERC shows that without substantial reductions in transport energy demand, net zero by 2045 will be unattainable or prohibitively expensive (https://ukerc.ac.uk/publications/ukerc-transport-evidence-compendium/). UKERC modelling

demonstrates that transport energy demand in the UK could feasibly fall by around 61% between 2019 and 2050, with half of these savings delivered by avoiding unnecessary trips and shifting travel demand towards more sustainable modes (https://www.sciencedirect.com/science/article/pii/S1364032124006671#abs0020). Crucially, demand-side measures deliver faster and cheaper emissions reductions than reliance on technology alone.

This requires a systemic shift in priorities. Given that the Scottish Government has abandoned its car travel reduction target (20% reduction by 2030 relative to 2019), UKERC strongly recommends that the Scottish Government recommits to a revised car-km reduction goal, integrated explicitly into forthcoming five-year carbon budgets, ensuring accountability across national and local levels. UKERC research suggests that such targets are achievable through a package of road user charging, parking levies, road space reallocation, and substantial investment in high-quality public and shared transport, cycling and walking infrastructure (https://www.nature.com/articles/s41560-022-01057-y and https://ukerc.ac.uk/publications/ukerc-transport-evidence-compendium/).

In particular, demand for medium- and long-distance (especially single-occupancy) car journeys must be curtailed through investment in reliable rail and long-distance coach networks, support for e-bikes, and planning policies that bring destinations closer to people (https://www.nature.com/articles/s41560-024-01561-3). At the same time, we must urgently confront the problem of 'mobesity': the rising size and weight of cars driven by the "SUV boom" across global markets. Larger cars, including electric SUVs, undermine efficiency and equity, increasing lifecycle emissions, critical mineral demand and public health risks. Regulation of advertising, targeted taxes, SUV parking levies and incentives for smaller, lighter vehicles are necessary to reverse this trend (https://www.nature.com/articles/s41560-024-01559-x).

Electrification remains vital but cannot deliver net zero alone. Scotland must accelerate equitable access to charging infrastructure, ensuring that EV ownership is not only viable for households with off-street parking. At present, charging at home offers savings, but public charging often comes with higher costs and short time limits, undermining fairness. Linking EV rollout to electricity and planning sectors will be key to enabling both grid flexibility and a just transition (https://www.sciencedirect.com/science/article/pii/S0306261924002198). Vehicle-to-grid integration, if supported by smart charging incentives, can cut system and user costs while maximising carbon benefits (https://www.sciencedirect.com/science/article/pii/S2590116822000261).

Other hard-to-abate areas also require urgent attention. Freight emissions are rising rapidly, driven by e-commerce growth. UKERC analysis shows that electrifying van fleets, optimising load factors, and expanding the use of e-cargo bikes and urban consolidation centres could cut last-mile freight emissions by 10-30% in urban areas (A summary of UKERC's research on transport can be found here: https://ukerc.ac.uk/publications/ukerc-transport-evidence-compendium/). Aviation presents an even starker challenge: demand management measures such as frequent flyer levies and no further airport expansion are essential alongside continued innovation in fuels and aircraft technologies.

2 When should these policies be introduced, and over what timeframe should they be implemented in the transport sector?

Please use this textbox to provide your answer:

From Dr Graeme Hawker, University of Strathclyde

Policies which support electrification, such as increased financial support to assist with capital costs, should be prioritised in the near-term, as the adoption of such technologies is already lagging behind existing carbon budgets. The availability of EV charging infrastructure is a key constraint on the EV market, particularly as the costs of such vehicles have been reducing and there is likely to be an increasing demand for such vehicles. This should be coordinated with local authorities who are implementing local charging regimes which incentivise the use of low-emissions vehicles, such as LEZs and carbon-based resident parking charges.

3 What are the expected costs of implementing these policies in the transport sector?

Please use this textbox to provide your answer:

We refer to the submission from our colleagues at the Centre of Energy Policy at the University of Strathclyde.

4 What are the expected benefits of these policies in the transport sector? Please include any wider benefits (e.g. environmental, equality, financial and health) you would expect.

Please use this textbox to provide your answer:

From Dr James Dixon, University of Strathclyde

The health and economic co-benefits of decarbonising transport are substantial. Air pollution from car and van combustion engines alone costs UK society over £6 billion annually; ambitious transport decarbonisation policies will save the NHS billions and reduce thousands of premature deaths each year (Research on this can be found at https://www.sciencedirect.com/science/article/pii/S0160412024007505?via%3Dihub and https://www.sciencedirect.com/science/article/pii/S0160412025000340?via%3Dihub). By embedding health and equity considerations into the Climate Change Plan, Scotland can deliver a transition that is not only cleaner and fairer, but healthier and more economically resilient.

5 What do you think the key challenges would be in delivering these policies in the transport sector?

Please use this textbox to provide your answer:

From Dr Christian Calvillo and Dr Paulina Gonzalez-Martinez, University of Strathclyde

The Strathclyde Centre for Energy Policy consultation response implies challenges in three areas. First, scaling up charging infrastructure, including charging points and electricity network upgrades, is needed if Scotland is to avoid passing on costs to consumers, and creating a geographic gap between rural and island communities and the rest of Scotland. Second, unless retraining and reskilling programmes are developed, automotive maintenance and job losses are likely to occur. Third, implementing effective policy responses will require coordination with both Westminster and Scotland's Local Authorities ensure that delivery is equitable across the country. Please see the CEP response for further details.

6 How could these policies support a Just Transition for workers and communities in the transport sector?

Please use this textbox to provide your answer:

From Dr Christian Calvillo and Dr Paulina Gonzalez-Martinez, University of Strathclyde

The Strathclyde Centre for Energy Policy consultation response notes that transport policies can be tailored towards Just Transition outcomes through fair workforce planning and addressing transport poverty. Workforce planning activities should ensure that mechanics have the skills needed to maintain EVs and employment opportunities in renewable-powered transport and charging infrastructure are offered to affected and vulnerable communities. Transport poverty can be addressed by ensuring public transport and EVs are accessible and affordable, with investment given to areas that currently have few EV charging points or public transport options. Please see the CEP response for further details.

Industry

1 What are the most important policies needed to achieve the proposed carbon budgets level for 2026-40 in the industry sector?

Please use this textbox to provide your answer:

From Professor Peter Taylor and Dr Imogen Rattle, University of Leeds

Scotland's industrial decarbonisation strategy is aimed at helping to achieve net zero greenhouse gas emissions by 2045. Key initiatives include the Scottish Industrial Energy Transformation Fund to support industrial investment and the Scottish Net Zero Roadmap, which has a focus on decarbonising the Scottish industrial cluster along the east coast that accounts for the majority of emissions (subsequently denoted using the shorthand of the Grangemouth cluster). There is also significant focus on a just transition, ensuring that workers, communities, and industries are supported throughout the transition to a cleaner industrial base.
While much of the focus has, understandably, been on decarbonising the Grangemouth cluster, Scotland is also home to several dispersed industrial sites that fall outside this cluster, including cement, paper, glass and metals, as well as food and drink (including a large number of distilleries). The Green Industrial Strategy, however, makes no specific reference to dispersed sites.
It is therefore important that Scotland's Draft Climate Change Plan clarifies what the Scottish government's approach is to these industries and how it plans to decarbonise them. Recent UKERC work (see: https://ukerc.ac.uk/project/decarbonisation-of-dispersed-industrial-sites) has explored what lessons can be learned from the UK Government's Local Industrial Decarbonisation Plans competition, which funded 13 local industrial clusters to develop place-based plans for decarbonisation. Notably, of the 13 winning projects, ten were based in England, one in Northern Ireland, one in Wales and one extended from south-west England into Wales. None were based in Scotland. We do not have the data to explain why no Scottish projects were awarded funding.
Policymakers first need to decide whether they believe a distinct Scottish approach for dispersed industrial sites is warranted. If so, this should be clearly stated in the Climate Change Plan, along with an indication of how these sites will be supported relative to the Grangemouth cluster. If dispersed sites are to be included, the following steps will assist in the development and implementation of policy.
• Establish or improve mechanisms to ensure dispersed industries are aware of funding opportunities;
• Support collaboration among geographically dispersed sites through networking events, regional coordinators, or digital platforms that allow industries to find partners and share knowledge safely;
• Offer guidance on bid preparation to help smaller or less experienced organisations submit competitive proposals;
• Adapt funding criteria opportunities to account for the unique challenges of dispersed sites, including smaller scale, geographic separation, or cross-sector collaborations.;
• Track the uptake and success of dispersed-site projects and adjust policy interventions accordingly.

From Dr Graeme Hawker, University of Strathclyde
Industrial policy will depend on the exact sector and technological options available, but coordination around specific industrial clusters for the combined benefits (such as reduced costs from shared infrastructure) will require a clear definition of transitional strategy through the 2030s. Project Willow at Grangemouth gives a view of the future of Scotland's largest industrial cluster which should be replicated at smaller scales for areas around the country which may have multiple competing low carbon routes between electrification, blue/green hydrogen and carbon capture. The role of the Scottish Distribution Network Operators (DNOs) will be key in any electrification route and the relationship between the DNOs, local authorities and regional/national strategy will need to be carefully managed (see https://ukerc.ac.uk/publications/electrifying-industry-and-distribution-networks-considerations-for-policymakers/).

2 When should these policies be introduced, and over what timeframe should they be implemented in the industry sector?

Please use this textbox to provide your answer:

3 What are the expected costs of implementing these policies in the industry sector?

Please use this textbox to provide your answer:

4 What are the expected benefits of these policies in the industry sector? Please include any wider benefits (e.g. environmental, equality, financial and health) you would expect.

Please use this textbox to provide your answer:

5 What do you think the key challenges would be in delivering these policies in the industry sector?

Please use this textbox to provide your answer:

6 How could these policies support a Just Transition for workers and communities in the industry sector?

Please use this textbox to provide your answer:

Negative emissions technologies

1 What are the most important policies needed to achieve the proposed carbon budgets level for 2026-40 in the negative emissions technologies sector?

Please use this textbox to provide your answer:

From Professor Nick Pidgeon and Professor Karen Henwood, University of Cardiff

The CCC 7th carbon budget has identified the importance of deploying large-scale negative emissions technologies by 2050, to compensate for emissions (aviation, agriculture) which may be hard or impossible to decarbonise. Such technologies effectively put the 'NET' into net zero. The CCC's balanced pathway envisages that increasing UK negative emissions from tree planting and peatland restoration will reduce total UK agricultural emissions to close to zero. A further 35 MCO2e of negative emissions will be required UK-wide from engineered removals, which includes bioenergy with carbon capture and storage (BECCS), Direct Air Capture with Carbon Storage (DACCs), and the terrestrial soils approaches of biochar and enhanced weathering. The CCC's recent Carbon Budgets advice for Scotland mirrors this analysis – arguing that net zero can be achieved by 2045 with an appropriate deployment of land-based and engineered approaches, although the precise balance of approaches to be adopted has uncertainties.
https://www.theccc.org.uk/publication/scotlands-carbon-budgets/
Several points in the debate about NETS are particularly salient to Scotland, particularly the major opportunities for NETs deployment and development of NETs technologies and systems in Scotland. For the land-based approaches peatland restoration and trees are a major opportunity, but must be deployed sensitively and according to local environmental and cultural circumstances – a place-based approach to environmental restoration and land-use change will be critical and in ways that work with local communities.
For the engineered approaches to NETs both BECCS and DACCs (with carbon transported from locations across Scotland, or adjacent regions of England) will require major offshore geological storage sites and infrastructure for carbon sequestration. This points to the need for a systems-wide approach, with an integrated strategy alongside industrial and residual gas power decarbonisation, to develop shared carbon transportation and sequestration infrastructure. Note that it is not a given that all communities in Scotland will accept cross-border shipping and storage of 'waste' carbon produced outside of Scotland (see more here:
Transforming-the-uk-energy-system-public-values-attitudes-and-acceptability-deliberating-energy-system-transitions-in-the-uk.pdf).
Additionally, Scotland alongside Northern Ireland, hold the UK's major resource of basalt, some of which could be utilised for export in very large quantities to other agricultural regions of the UK for the purposes of enhanced rock weathering sequestration on agricultural croplands (doi.org/10.1038/s41561-022-00925-2). All of this will raise issues of local basalt extraction, transportation, quarry remediation and cross-border governance of any carbon credits involved. Currently the policy landscape at UK and devolved levels is severely fragmented or non-existent with regard to NETs regulation – a point the Scottish Government could usefully work on in collaboration with the other devolved and Westminster Administrations.

From Dr Mike Colechin, Cultivate Innovation and UKERC
A current focus for UK Government bioenergy policy is the delivery of negative emissions from large-scale bioenergy with carbon capture and storage (BECCS) operations, and this will also have an impact on the role of bioenergy within the energy system in Scotland. There are many uncertainties about the timing and availability of CO2 transport and storage solutions; however, some small-scale biogas operations are ready now to deliver BECCS and could combine this with seasonal energy storage and flexibility. In addition to negative greenhouse gas emissions, these operations could provide both firm and dispatchable power to electricity markets whilst delivering similar services to both heat and gas markets. With appropriate support, other smaller-scale operations could also be converted to deliver BECCS.
There is a dividing line when considering whether BECCS plants would operate flexibly, based on an assumption that the negative emissions from BECCS are always the highest value use case for bioenergy in stationary applications. There's a belief that flexibility reduces this value. In many contexts this needs to be challenged. Making a BECCS plant flexible is very dependent on economics and geography, but there are specific cases/places where flexible BECCS plants could add value. This value would need to be delivered throughout the supply chain and may be dependent on the development of CO2 transport and storage.
Current policy, incentives and regulation do not promote the flexible operation of bioenergy production needed to realise the energy storage potential of biomass. Some policies and regulation may even be hampering industry's ability to use biomass flexibly, particularly on smaller capacity sites. If it is accepted that using biomass for long-duration storage of energy would bring additional value, governments could develop approaches that actively support such flexible operation.
There is a range of existing, smaller-scale distributed operations that, with appropriate support, would have the potential to deliver both negative emissions and flexibility in different ways. Biomass to heat should not be overlooked, particularly in an industrial context. This approach can deliver energy system flexibility, especially when integrated with heat storage and other heat technologies, but challenges remain, requiring incentives for innovation and new business models.
Smaller, more distributed operations could also be cost-effective from a supply chain perspective. They can support local economies, make efficient use of indigenous resources, and reduce waste. This could have greater political viability than some larger-scale options for both negative emissions and long-duration energy storage.
Without urgent action, there is a risk that many of the smaller distributed bioenergy operations that are currently supported by Renewables Obligation Certificates (ROCs) will be forced offline as this support mechanism comes to an end between now and 2035. In these cases, assets may be decommissioned, operational teams disbanded, and the potential for negative emissions, energy storage and other flexibility benefits would be lost to the system. Avoiding unnecessarily detrimental repercussions, may require alternative avenues for support and greater strategic clarity.
There is significant pressure being placed on policymakers across the UK to reduce the use of biomass for energy production based on concerns about emissions and sustainability of supply chains. The use of locally-produced feedstocks, particularly waste streams that would otherwise go to landfill, may help to allay some of these concerns.
In common with developments in all parts of the energy system, development of policy and regulations that support flexible biomass operation will involve complex interactions between diverse actors, but research and innovation can help to make these problems tractable.
Reference: https://doi.org/10.82226/543.p.000002 (this link will go live later in the Autumn).

2 When should these policies be introduced, and over what timeframe should they be implemented in the negative emissions technologies sector?

Please use this textbox to provide your answer:

From Dr Christian Calvillo and Dr Paulina Gonzalez-Martinez, University of Strathclyde

The Strathclyde Centre for Energy Policy consultation response suggests a three-stage timed approach. Between 2025 and 2030, the Scottish Government could focus on developing effective business models, workforce planning to address skills shortages, and project sequencing to prevent resource competition, whilst launching the Acorn T&S demonstrator by the end of the decade. In the 2030s, the NET sector in Scotland should move to full deployment, with multiple systems capable of extracting 5-6 MtCO2 by the mid-2030s. By the 2040s Scotland should be established as Europe's hub for CO2 storage, with 75% of UK and 18% of European capacity (Turner et al., 2024).

3 What are the expected costs of implementing these policies in the negative emissions technologies sector?

Please use this textbox to provide your answer:

From Dr Christian Calvillo and Dr Paulina Gonzalez-Martinez, University of Strathclyde

The Strathclyde Centre for Energy Policy submission indicates that, whilst offering excellent ROI, the direct and indirect costs of NET are amongst the highest for the net zero transition. Direct funding for the completed Acorn CCUS project have not been allocated, with early support from Scottish Government costing in excess of £80 million; DACCS facility costs are estimated to be high, whilst BECCS has lower costs through leveraging existing infrastructure. Indirect costs are expected through labour displacement, training, sequencing, and in developing CO2 shipping and import/export capabilities.

4 What are the expected benefits of these policies in in the negative emissions technologies sector? Please include any wider benefits (e.g. environmental, equality, financial and health) you would expect.

Please use this textbox to provide your answer:

From Dr Christian Calvillo and Dr Paulina Gonzalez-Martinez, University of Strathclyde

The Strathclyde Centre for Energy Policy consultation submission states that NET offers significant financial and environmental benefits. CCUS deployment could support 15,000-20,000 jobs at its peak and raise Scottish GDP by £3.8–£6.7 billion by 2045, with Scotland becoming a European hub for CO□ import, storage, and associated technology and service exports. They also provide opportunities to decarbonise hard to abate industries whilst supporting the circular economy, securing new industrial jobs, and creating new skill opportunities.

5 What do you think the key challenges would be in delivering these policies in the negative emissions technology sector?

Please use this textbox to provide your answer:

From Professor Nick Pidgeon and Professor Karen Henwood, University of Cardiff

Public attitudes and obtaining a social license to operate within communities asked to host major NETs deployments will also be a key consideration. Extensive work by members of the UKERC consortium, but funded by other UKRI investments, shows that the UK public will place strong conditions upon any large-scale deployment of any NETs technologies, including: (a) needing an assurance that they will work as intended; (b) that they will not create additional risks to local biodiversity, the environment, or to workers and communities; and (c) above all that they should not be deployed without parallel and extensive efforts at conventional mitigation (see here: https://doi.org/10.1038/s41558-020-0823-z and here: www.nature.com/articles/s41599-025-05384-9). Deep reductions in emissions, alongside minimising risks to environments (especially those seen as 'iconic') are the sine qua non for gaining social acceptability of land-based and other NETs.

6 How could these policies support a Just Transition for workers and communities in the negative emissions technologies sector?

Please use this textbox to provide your answer:

From Dr Christian Calvillo and Dr Paulina Gonzalez-Martinez, University of Strathclyde

As noted in the Strathclyde Centre for Energy Policy submission, CO2 transport and storage present a particularly strong just transition pathway. NET can mitigate risks to the existing workforce by utilising offshore capacity and supply chain expertise (Katris et al,, 2024). Achieving these fair pathways requires coordinated action on both skills and planning for places most affected by decarbonisation such as Grangemouth.

Non sector-specific questions

1 How should the changes required to meet emission reduction targets be funded?

Please use this textbox to provide your answer:

From Dr Christian Calvillo and Dr Paulina Gonzalez-Martinez, University of Strathclyde

The Strathclyde Centre for Energy Policy submission states that costs should be distributed fairly across households, businesses and regions, to avoid

exacerbating existing inequalities. Regulated Asset Base models can reduce investment risk, whilst subsidies, tax incentives and trade policies can help secure private investment and competitive advantage for Scotland.

2 What governance arrangements are needed in the Scottish Government to ensure effective delivery of the CCP?

Please use this textbox to provide your answer:

From Professor Jan Webb and Dr Jess Britton, University of Edinburgh

The starting point for effective governance is consistent, explicit and publicly prominent political leadership by First Minster and Cabinet, explaining the major societal benefits to be gained, and backed by sufficiently detailed sectoral plans to meet GHG emission reduction targets. Effective delivery of the Plan is a problem of coordination across sectors and levels of governance. One part of effective governance is therefore sustained, systematic coordination and collaboration with UK Prime Minister and Cabinet. This is because energy markets, licensing and regulation are powers reserved to the UK Parliament. In addition, there are significant areas where relevant powers are partly devolved and partly reserved, particularly across business and industry, including plans for CCUS, hydrogen and alternatives to fossil fuels. Successful coordination will require a working agreement on shares of responsibility, aligned with necessary powers and resources.

For effective delivery there are (at least) two governance structures. One is to establish an independent delivery authority, reporting to government, and accountable to Parliament, with a statutory requirement to focus on outcomes against carbon budgets. The other is to establish a dedicated, system wide, directorate at Cabinet level. Each option has pros and cons. An integrated government directorate may enable faster, lower cost development and implementation, with direct access to Ministers. On the other hand, an internal directorate may struggle to maintain independence and freedom from short-term political influence, and progress may be disrupted by electoral cycles and change in political control.

An existing example of the ambition to establish an independent delivery authority is the National Public Energy Agency, now called Heat and Energy Efficiency Scotland (HEES). This has operated within the Energy and Climate Change Directorate since October 2022, but has still not progressed to an independent Agency. Effective action on five year carbon budgets would require rapid resolution of governance structures.

The UK Climate Change Committee (CCC) is an effective model of cross-government working, with an independent voice on climate science, carbon budgets and detailed advice. Any new delivery authority or directorate would need to work inter-dependently with the CCC, as well as energy market regulator Ofgem, the National Energy System Operator (NESO) (particularly in relation to the Strategic Spatial Energy Plan (SSEP) and the Scottish Regional Energy Strategic Plan (RESP)), environmental regulator SEPA, the Scottish National Investment Bank (SNIB) and the recently established GB Energy and UK National Wealth Fund. The latter is expected to have an important role in regenerating regional and local economies through low cost loans, and will hence be a valuable means to progress.

Implementing carbon budgets cannot be ringfenced as a single department or function of government, while allowing other business and policy commitments to continue as usual. A key starting point is institutionalising carbon reduction targets across all government decision-making and public spending. This will drive necessary change in government programmes and commercial and industrial sector supply chains, as well as civil society.

In relation to capital planning and allocation, the Infrastructure Commission Scotland 2020 concluded that existing metrics and instruments for capital planning prioritise short term cost using conventional GVA indicators (https://infrastructurecommission.scot/page/key-findings-report). An urgent task now is for Scottish Government to develop cost-benefit assessment methodology to prioritise spending on the basis of system-wide contribution to carbon reduction, incorporating social justice and health improvement.

Local and regional authorities can contribute substantively – and substantially - to delivering net zero commitments, easing the job of central government, as well as regenerating local and regional economies (evidence for this here: https://doi.org/10.1016/j.eist.2023.100789 and here: https://doi.org/10.1016/j.erss.2022.102544). Considerable economic, social and environmental value could be secured from the following changes to empower local authorities:

1. A direct policy mandate for localities to meet carbon budgets
2. Institutionalised local carbon reduction planning & implementation through statutory powers and devolved resources, building on initiatives such as LHEES and going beyond the public sector climate change reporting duty
3. Investment in local authority carbon reduction teams, including multi-year funding to end stop-start initiatives and avoid the need to spend money competing for resources and re-recruiting skilled staff
4. Evaluation of all local & regional public expenditure against carbon reduction as well as socio-economic indicators.
(See: https://www.energyrev.org.uk/news-events/news/making-local-authority-net-zero-ambition-a-reality/)

3 How can the Scottish Government ensure transparent monitoring and reporting on progress?

Please use this textbox to provide your answer:

From Dr Mark Winskel, University of Edinburgh
Transparent monitoring and reporting on progress in critical for policy delivery and societal legitimacy needed for Net Zero delivery, especially at a time of heightened political contention. Climate Change legislation in Scotland and the UK is underpinned by a well-established statutory process of independent analysis and advice, and annual reporting on progress from the Climate Change Committee, and detailed government response within a prescribed period. It is vital that these arrangements are maintained, or if changes are suggested in the draft Climate Change Plan, that they do not erode the independence of analysis and advice, or the transparency and accountability of the government's response.
In Scotland, this well-established relationship between statutory advisor and government has demonstrated its value recently, with the recalibration of Scotland's pathway to Net Zero by 2045. In May 2025, the CCC published detailed analysis and advice on Scotland's revised decarbonisation pathway, including four five-year carbon budgets covering the period 2026 to 2045 (https://www.theccc.org.uk/publication/scotlands-carbon-budgets/).
As well as a 130 page main report, the CCC published a Methodology report of over 500 pages, including detailed sectoral analysis of the uncertainties

and sensitivities in Scotland's transition. While such lengthy equivalent analysis might not be possible, the draft Climate Change Plan should offer a transparent, detailed evidence base for the government's preferred plan, perhaps in a technical annex. This hasn't always been made available in previous plans: the 2017 Plan lacked much of the detailed sectoral analysis published in its 2013 equivalent.
In a recent statement, the Scottish Government stated that it intends to set revised carbon budgets in accordance with the levels recommended by the CCC. https://www.gov.scot/publications/statement-accompany-climate-change-scotland-act-2009-scottish-carbon-budgets-amendment-regulations-2025/. It added, however, that sectoral pathways in the draft Plan are likely to diverge from those in the CCC's balanced pathway – and made clear that for agriculture and peatland it not follow the CCC's recommendations. While this it is the prerogative of government to diverge from the CCC's advice, it is important, given the need for transparent monitoring and reporting, that any such changes are transparently set out and evidenced – including the knock-on impacts on other sectoral pathways within the carbon budget envelopes.
In its most recent annual report on progress (https://www.theccc.org.uk/publication/progress-in-reducing-emissions-in-scotland-2023-report-to-parliament/), the CCC also called for transparency on the Scottish Government's expected pathway to net zero, including details on the assumptions that underpin the pathway and how it will be achieved by planned policies, clear roles and responsibilities for delivering different aspects of emissions reduction, and detailed coordination and accountability mechanisms across Scottish Government, collaboration with UK Government, and partnership with local authorities.
Alongside the CCC, the Scottish Parliament has a key role in the transparent monitoring and assessment of policy progress – as do other bodies such as Audit Scotland, and independent research groups such as UKERC. However, for these bodies to be able to contribute to robust monitoring and progress reporting, strong statutory arrangements for independent analysis, advice and policy response are vital. Robust monitoring and assessment cannot guarantee delivery of policy outcomes given the uncertainties involved, but they are an essential bedrock.

From Professor Jan Webb and Dr Jess Britton, University of Edinburgh

Ultimately, no organisational structure is guaranteed to be effective - performance is always potentially susceptible to 'capture', or undue influence, by specialist interests. Political leadership needs to be reinforced by parliamentary net zero, energy and transport committee to hold government to account on progress against published plans.

It is critical to ensure legal accountability to the public, via Parliamentary reporting, and formal requirements to act on behalf of the public to meet carbon targets, with transparent checks and balances and progress review.

From Dr Richard Carmichael, Imperial College, London:
Two recent UKRC projects have focussed on improving monitoring and reporting of progress on climate:
(i) The Win-Window project, which explored metrics, methods and data for tracking and communicating cobenefits using ex-post (measured not modelled) assessment. Outputs are forthcoming and comprise a project report, a number of summary documents on specific cobenefits (such as green jobs, air quality) and a catalogue of relevant datasets.
(ii) The '4+4 Framework' for comprehensive and transparent monitoring of energy security. The approach emphasises operationalising energy security through systematic and comprehensive identification of specific indicators, metrics, and data sources to support transparent and data-led monitoring. Paper available here: https://ukerc.ac.uk/publications/developing-an-energy-security-monitoring-framework-fit-for-uk-net-zero/
Both pieces of work discuss several methodological issues, user needs and data quality assessment and identify a large number of relevant datasets. The '4+4 energy security monitoring framework also includes metrics for good Governance since poor planning, reporting and decision-making processes are risks to energy security.

4 What should the Scottish Government do to help the public contribute to climate action?

Please use this textbox to provide your answer:

From Professor Nick Pidgeon and Professor Karen Henwood, University of Cardiff

The Scottish Government was the first of the UK nations to publish a Public Engagement strategy for climate change. We strongly commend this approach, arguing for it to be accorded attention and resources appropriate to the size of this task, as well as supporting the many citizen-led initiatives to engage with climate change and the energy system transition that also exist across Scotland. One criticism of government-led public engagement in general, including large activities such as Citizen Assemblies, is that some fail to have a clear route or pathway to influence policy. Here, the committee might usefully serve to hold SG to account regarding its own activities in public engagement.
We also note here that helping the public to contribute to climate action requires far more than simple economic incentives, behavioural nudges or communications. Successful change programmes in e.g. public health typically involve a combination of upstream- (regulatory), mid-stream (incentives, support structures), and down-stream (communications) interventions. Moving to a net zero society should be viewed similarly.

From Professor Jason Chilvers and Dr Phedeas Stephanides, UKERC's Public Engagement Observatory
Meeting ambitious emission reduction targets depends on meaningful societal engagement and a people-centred approach , especially in the context of the many and extensive infrastructural changes deemed necessary that directly impact society and people's everyday lives (https://doi.org/10.5871/jba/011s4.097). The Scottish Government has, to date, taken commendable steps to engage civil society and enhance public contributions to climate action through a comprehensive public engagement strategy and strong commitment to fostering a 'just transition' that 'puts people first' and aims to meaningfully engage and benefit communities. This is in contrast to problematic and largely ineffective public acceptance-based approaches that dominate the UK policymaking landscape, and is being achieved, amongst others, through important initiatives empowering Scottish publics. Examples include Scotland's Climate Assembly, the Let's Do Net Zero hub, Regional Community Climate Action Hubs, and targeted funding and support for energy efficiency (e.g. Home Energy Scotland), renewable and community energy projects (e.g. CARES), and skills and job development (e.g. the Just Transition Fund) – initiatives that should be supported and developed further in future efforts to help publics contribute to climate action (see list of links at the end).

Nonetheless, while climate action is a complex systemic challenge, current approaches to public engagement are not typically systemic. Despite significant progress in developing necessary financial incentives, communication and interactive public engagement processes as specified above, these

tend to focus on discrete, invited engagements in specific parts of energy and net zero systems. In response, new systemic approaches to engaging and supporting publics are emerging, with UKERC's Public Engagement Observatory pioneering a novel agenda for transforming thinking and practice around public engagement with energy, climate change and net zero (https://www.routledge.com/Remaking-Participation-Science-Environment-and-Emergent-Publics/Chilvers-Kearnes/p/book/9780415857406?srsltid=AfmBOoqFObo and https://d2e1qxpsswcpgz.cloudfront.net/uploads/2022/07/UKERC_BN_An-Observatory-for-Public-Engagement-with-Energy.pdf). This work suggests three key ways for further engaging and supporting publics in contributing to climate action moving forward:

1. The Scottish Government should develop additional capacities for an inclusive approach to public engagement through better understanding how publics are already engaging with climate change and net zero across systems. This would require developing new evidence that maps how publics are already contributing to climate action in Scotland. UKERC's Public Engagement Observatory has pioneered novel methods for mapping diverse public engagements with energy, climate change and net zero, including through comparative case analysis, digital methods, crowdsourcing, and citizen social science (see: https://www.nature.com/articles/s41560-020-00762-w.epdf?sharing_token=rGhFWbdUwE4JYhyNRyOyH9RgN0jAjWel9jnR3ZoTv0OfP2BvPQyarTXiAZz4orMKbnvhwsj and https://www.sciencedirect.com/science/article/pii/S2214629618303025?via%3Dihub).

These mappings – and their open interpretation of public engagement and participation that moves beyond formal institution-led and deliberative processes – can significantly enhance the capacity of policymakers and practitioners to understand how different publics are already engaging with climate- and energy-related issues (for more, see: https://www.sciencedirect.com/science/article/pii/S2214629618303025?via%3Dihub, https://journals.sagepub.com/doi/10.1177/2514848619845595 and https://d2e1qxpsswcpgz.cloudfront.net/uploads/2023/07/UKERC_BN_Mapping-Public-Engagement-with-Energy.pdf). They move significantly beyond mainstream representations of a single 'public' to show how publics and their engagements in Scotland, and across the UK, are highly diverse – including those seeing citizens productively addressing climate change in their own terms through forms of citizen-led action, innovation, and activism (See latest mapping case studies from Scotland here: https://ukerc-observatory.ac.uk/mapping/explore/?location%5B%5D=scotland). They offer more comprehensive evidence on different publics, their views and values about climate change and decarbonisation, attend to emerging instances of net zero scepticism and local opposition to low-carbon infrastructures, and uncover significant exclusions and interrelations of engagements across the energy system.

2. Use new forms of mapping evidence to enhance public engagement by improving net zero decisions, innovations and new public participation practice. The Public Engagement Observatory is actively putting its public engagement mappings into practice through a number of collaborative projects with partner organisations in government, business and civil society. These experiments show how this new mapping evidence can be used by the Scottish Government and others to make net zero decisions and transitions more responsive to society, and therefore more supported and trusted. For example, they are demonstrating how mapping evidence can make a difference in informing emerging policies and engagement strategies in DESNZ and the Dutch government, in making low carbon innovations more responsive to society, and in enhancing the design, reporting and evaluation of deliberative processes (see: https://ueaeprints.uea.ac.uk/id/eprint/94415/1/Public_engagement_with_sustainable_wastewater_management_and_hydrogen_technologies_final_report.pdf, and https://d2e1qxpsswcpgz.cloudfront.net/uploads/2023/11/UKERC-Observatory_Mapping-Participation-for-Democratic-Innovations.pdf). The Observatory's systemic mappings of public engagement with energy, climate change and net zero have also been used to pioneer distributed deliberative processes involving many more diverse citizens across net zero systems (see: linkinghub.elsevier.com/retrieve/pii/S2214629621005016).

3. Develop a systemic approach for engaging and supporting publics in the transition to net zero. Research and evidence from the UKERC Public Engagement Observatory suggests that "rather than only silo specific types of engagement in particular departments, disciplines, theories, or communities of practice, more systemic approaches are required that encompass different forms of public engagement across issues, organisations, sectors and wider systems".16 Whilst already ambitious and comprehensive, this means that Scotland urgently needs to further develop a whole-systems approach to its Net Zero Nation Public Engagement Strategy. This would help ensure the government becomes more joined up and responsive to society by taking an interconnected, shared and systemic approach to how engagement is organised, governed, supported and evaluated. The key roles of new organisational entities, like public engagement observatories, in net zero governance have been acknowledged in major reviews undertaken by UK Government departments (here: https://assets.publishing.service.gov.uk/media/65c106fbc4319100141a45a7/Public_Engagement_Review_10_Oct_2022.pdf), and developing such institutional capacities and architectures would help ensure Scottish policymaking becomes more responsive to society – as prioritised in the Public Engagement Strategy. We are already seeing emerging evidence of the transformative potential of such approaches through the recently established Public Engagement Laboratory for Nature and Society embedding the approaches and thinking of UKERC's Public Engagement Observatory within Natural England to directly inform the organisation's engagement practice and decision-making (https://research-portal.uea.ac.uk/en/publications/a-public-engagement-laboratory-for-nature-and-society).

From Dr Richard Carmichael, Imperial College, London

The Scottish Government could support good public engagement with CCP goals and policies by tracking and communicating progress in the co-benefits delivered from CCP policies (also relevant to CCP monitoring and reporting). UKERC has funded a project on developing metrics and methods for a co-benefits tracker: the Win-Window project, outputs of which are forthcoming. This builds on earlier work on recommendations for how policy can support better public engagement on climate across buildings, transport and diet (https://www.theccc.org.uk/publication/behaviour-change-public-engagement-and-net-zero-imperial-college-london/). Almost all of these still apply now and include reporting public action and engagement with climate to help shift norms and support 'social contagion' effects (see also peer-to-peer approaches, below). Co-benefits include the crucial issue of financial costs of technology adoption or behaviour change: policy that reduces electricity costs (see comments on Electricity sector) and communicates (in a transparent and trusted way) opportunities to reduce running costs of heating systems and vehicles will be valuable for heat and transport transitions.

There is also good potential to support more active roles for the public to contribute to climate action by enabling peer-to-peer learning between technology adopters. The heat pump transition is the most obvious example where early adopters could be leveraged to build stronger demand in adoption (and stronger skills among installers): for discussion and recommendations see https://www.imperial.ac.uk/energy-futures-lab/reports/briefing-papers/paper-10/.

5 What other factors could affect whether Scotland meets its climate change targets?

Please use this textbox to provide your answer:

From Dr Graeme Hawker, University of Strathclyde

Separately from regulatory and governance issues, there is likely to be a significant skills shortage in the energy sector as demand for technical skills increases across the public and private sector, (see https://ukerc.ac.uk/publications/jobs-skills-and-regional-implications-of-the-low-carbon-residential-heat-transition-in-the-uk/). Local authorities in Scotland are already reporting the impacts of a shortage of planning officers, threatening the timely delivery of planning decisions for new infrastructure. The Scottish Government must play a key role in the public messaging around key transitional areas, such as heating and transport, ensuring that people are well-informed as to the justifications for the measures being undertaken, and that there are rigorous and transparent sources of information to which people may refer when undertaking decisions around different technologies such as heat pumps and EVs.

From Dr Mike Colechin, Cultivate Innovation and UKERC
Government targets for the decarbonisation of the energy system in Scotland and across the UK are leading to large-scale deployment of renewable generation technologies to displace the use of fossil fuels for electricity generation and in the heat and transport sectors. Consequently, there is an increasing requirement for long-duration energy storage to accommodate seasonal and weather-related variations in wind and solar electricity generation.
Recent work undertaken by UKERC in collaboration with the Supergen Bioenergy Hub and Cultivate Innovation Ltd has investigated the potential for bioenergy to act as a store of energy within the UK energy system. This work has shown that bioenergy infrastructure and supply chains, such as seasonally harvested crops, waste wood and forestry by-products, currently deliver energy storage at scale, and there is the potential to use this characteristic to facilitate greater flexibility in the operation of heat, gas and electricity systems and markets.
The capital and operational costs of bioenergy production are well understood and are already delivering cost-competitive commercial operations. This knowledge could be used to deliver a lower-cost solution to the long-duration energy storage challenge, complementing the other solutions currently being proposed.
All current use of biomass within the energy system is shaped by policy, incentives and regulation, and they will continue to play a key role in setting the future direction of bioenergy, creating opportunities for government. However, there are also challenges, and examples exist of where policy and regulation are or can be actively detrimental to the biomass sector. Forthcoming reference: https://doi.org/10.82226/543.p.000002

From Dr Mark Winskel, University of Edinburgh

There are a wide number factors which will affect Scotland's decarbonisation pathway and the meeting of its climate change targets – some of which are outside of the Scottish Government's direct control. For example, low carbon technology costs and availability are affected by international market demand, supply chain bottlenecks, commodity price changes, exchange rate fluctuations, and skills and labour availability https://doi.org/10.1016/j.apenergy.2024.124014. General purpose technologies, especially the introduction of generic and application specific AI, will transform economies and societies over the next twenty years – with highly uncertain implications for energy supply, demand and systems. https://www.weforum.org/stories/2025/01/ai-energy-dilemma-challenges-opportunities-and-path-forward/
Experience suggests that long-term economy-wide and sectoral pathways are likely to be revised in the face such uncertainties, with reassessment of the evidence base and policy priorities. For example, the 2017 Climate Change Plan included a highly ambitious decarbonisation pathway for buildings and heating, and also, relatively early emission reductions from engineered removals such as BECCS and DAC. The recent carbon budgetss advice from the CCC includes more balanced rates of sector change across the economy over time, but with an early emphasis on the transport sector and an emerging emphasis on the buildings sector; in both cases, the electrification of energy services is key to emissions reductions and efficiency gains.
For the new Climate Change Plan, this suggests the need for an explicit recognition of uncertainties associated with the transition pathway, and a degree of contingency planning. For example, in its recent advice on Scotland's budgets, the CCC included a detailed and structured consideration of uncertainties, both economy-wide and sector-specific:
https://www.theccc.org.uk/publication/methodology-report-uk-northern-ireland-wales-and-scotland-carbon-budget-advice/
At the same time, some factors which were highly uncertain at the time of the last Plan (such as sector pathways for transport and heating) are now clearer, and the timescales for change are now shorter (20 years is within the lifetime of some capital assets, so business and consumer decisions made now will impact emissions in 2045).
Givern this, the new Plan could usefully differentiate between areas where the evidence is now robust and consistent, and other areas where there is still considerable uncertainty. The aim is not to paralyse policy in the face of uncertainty, but to help make delivery more resilient in the face of inevitable uncertainties.
Finally, another uncertainty relates to political risk. Given the degree of interdependence between Scotland and GB/UK operational, market and regulatory arrangements for energy, Scottish policy delivery relies significantly on aligning policy across borders. Scottish and UK governments are now both aggressively pursuing net zero and green industrial transformation, as part of Scotland's and the UK's contribution to international climate mitigation efforts.
Unlike previous plans, however, there is now a vocal political opposition to net zero among some politicians, at local and national levels. Understanding this changing context, and responding to it, is important for climate policymakers, advisors and researchers. UKERC stands willing to support the Scottish Parliament and Government during an important period of consultation and legislation.