DNZ | DELIVERING NET ZERO

KEY THEMES FROM THE ACADEMIC COMMUNITY

ANALYSIS OF ROUND 1 WORKSHOP RESULTS

PROJECT PARTNERS:

UNIVERSITY OF LEEDS

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

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EXECUTIVE SUMMARY

The Delivering Net Zero (DNZ) project seeks to bring together and explore a range of cross-sector expert perspectives to identify where consensus does and does not exist on how the UK should deliver net zero.

The project is undertaking three rounds of deliberative workshops during 2021. The first round convened 42 top academics from across the research community during two workshops in February and March. Each workshop divided experts into three broad topic areas: energy supply, energy demand and greenhouse gas removal.

During these workshops, participants were taken through a consensus building process that sought to develop solutions for short term (next 10 years) and long term (up to 2050) emissions reductions. Participants were split into groups according to their specialism, each answering one of the following questions:

1. How do we achieve decarbonisation of UK energy supply in the short and long term?
2. How much can the UK reduce its energy demand in the short and long term?
3. How much carbon can the UK remove from the atmosphere in the short and long term?

This report provides an overview and initial analysis of these workshop outcomes. Section 2 identifies and discusses the broad, cross-cutting themes that emerged, also summarised below. Section 3 goes into greater detail on the differences in consensus that emerged across the workshops in relation to the topic areas of energy supply, energy demand and greenhouse gas removal.

AUTHORS: RACHEL CARR-WHITWORTH, OISIN WILSON, JOHN BARRETT, SAMUEL BETTS-DAVIES, MIKE COLECHIN, EMILY COX, NICHOLAS PIDGEON, ANNA WATSON

EIGHT OVERARCHING THEMES:

1. THE NEED TO DEVELOP SOCIAL LEGITIMACY FOR AN AMBITIOUS DECARBONISATION PATHWAY.

While there is broad social legitimacy around the need to reduce emissions, there is an apparent lack of legitimacy for sector specific solutions, particularly those that intrude on people's lifestyles. Some participants felt that there needed to be a more active public debate around net zero connected to improved communication, education for the government and the public; a participatory decision-making process; and improved trust in policy makers and energy service providers.

2. PERSPECTIVES ON THE SOCIAL AND POLITICAL FEASIBILITY OF SOLUTIONS.

Different participants across the workshops expressed significantly different perspectives regarding types of solution they perceived to be feasible, particularly those that challenged high emitting social practices in the short term.

OVERARCHING THEMES CONTINUED

3. THE ROLE OF TECHNOLOGICAL OPTIMISM AND SYSTEM CHANGE.

Participants also expressed different perspectives relating to how radical a transformation they understood as necessary in the long term. While some focused their priorities on technologies, programmes and policies that could sit within current socio-technical systems, others discussed the need for more radical and systemic socio-economic and political change.

4. THE NEED TO RAPIDLY ROLL OUT 'READY TO GO' INFRASTRUCTURE AND TECHNOLOGIES.

Participants consistently prioritised the need to rapidly deploy infrastructure and solutions which could provide immediate reductions to cumulative emissions. Such solutions were deemed to be both technologically 'ready to go' and able to reliably deliver emissions reductions.

5. THE NEED TO IMPROVE 'READINESS' OF SOLUTIONS AND ROLL OUT INFRASTRUCTURE FOR THE LONG-TERM.

Some participants felt that there is a need to lay the groundwork in the short term for certain long-term solutions to be viable, particularly in more challenging to decarbonise sectors and for certain greenhouse gas removal (GGR) technologies.

6. THE NEED TO UPSKILL AND CAPACITY BUILD IN THE WORKFORCE, GOVERNMENT AND CIVIL SERVICE.

The need to upskill and capacity build was emphasised across the workshops, both in the workforce, to deploy and monitor infrastructure, and in government, to oversee and enforce changes.

7. THE NEED FOR A MORE ACTIVE AND INTERVENTIONIST POLICY APPROACH.

Participants discussed the need for government to provide a whole systems strategy for decarbonisation, linked to a regulatory framework, which could be implemented across sectors and scales. Largely it was felt that there is a need for a more interventionist policy approach, with stronger regulations as well as market-based solutions.

8. THE NEED FOR CONTINUED INVESTMENT INTO NEW, POTENTIALLY DISRUPTIVE TECHNOLOGIES AND SOLUTIONS.

The workshops identified a need for continued investment into research and development (R&D) for potentially disruptive new technologies and to support all stages of innovation through to commercial deployment and operation of low carbon solutions into the future.

As detailed in this report, several participants felt that sectoral split of the workshops and bottom-up creation of priorities meant that there was a lack of appreciation for the interactions between sectors and consideration of cross-sectoral, transformative solutions. The next round workshops will reunite the academics engaged above and aim to address these concerns.

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INTRODUCTION

Delivering Net Zero (DNZ) is a UKRI funded collaboration between the University of Leeds and Cardiff University, working with Cultivate Innovation to present a vision of what is required to deliver a net zero future in the UK, guided by the best available academic evidence. Using a series of structured deliberative workshops with leading UK academics and other key stakeholders from the public, private and third sectors, the project aims to outline a shared narrative for reaching net zero through measures which will have impact in the short term (next 10 years) and long term (following years up to 2050). The workshops have been structured to identify where and why consensus on a credible narrative does and does not exist, identifying urgent initial steps and a longer-term strategy for delivering net zero it also seeks to apply a systems perspective to develop participants' appreciation for the socio-economic impacts of this narrative and identify the research needed to examine different value systems and interests. Ultimately the project aims to ensure that research funded by the UKRI Energy and Decarbonisation Programme has the maximum opportunity to inform and guide the response of UK decision makers to climate change.

This report provides an initial analysis of the first round of DNZ workshops which took place in February and March 2021 (further reports on later rounds will be produced later in the project). Section 1 provides a brief overview of the project, its timeline, and the methodology undertaken to conduct the initial analysis. Section 2 provides an overview of eight high-level, overarching themes which developed across both Round 1 workshops. Finally, Section 3 provides a summary of the priorities of each workshop group (energy supply, energy demand, and greenhouse gas removal), a comparison across workshops of the similarities, differences and level of consensus between the groups, and a brief discussion of the activities of the 'Spokes Councils'.

IMAGE CREDIT: KARINA LYBURN

SECTION 1: PROJECT OVERVIEW

The project consists of three 'rounds' of workshops, as depicted in Figure 1. Round 1, which took place in February and March 2021, was made up of two workshops involving 42 researchers (Workshop A with 23, and Workshop B with 19) across a range of disciplines, aiming to develop an initial narrative around net zero. Round 2 workshops were carried out in June 2021 with key stakeholders from the public, private, and third sectors and with funders of innovation from both public and private sectors. These workshops sought participant's input on the narratives produced in the first round, and their broader perspectives on net zero. Round 3 will be carried out in November 2021, presenting the round 2 perspectives back to the academic groups, allowing them to refine and finalise their narratives.

FIGURE 1 - Overview of DNZ project plan

ROUND 1 APPROACH AND ANALYSIS

Participant selection for Round 1 involved the identification of a representative cross section of UK academics involved in energy and climate policy research and implementation. Following the creation of a 'long list' of key researchers in their respective fields, participants were selected based on the need to represent multiple disciplines, taking into account relevant equality, diversity and inclusion (EDI) and career stage criteria. Workshops were designed to answer the following questions:

1. How do we achieve decarbonisation of UK energy supply in the short and long term?
2. How much can the UK reduce its energy demand in the short and long term?
3. How much carbon can the UK remove from the atmosphere in the short and long term?

To facilitate this, the participants were split into three groups based on their specialisms, hereafter described as 'energy supply', 'energy demand' and 'greenhouse gas removal (GGR)'. In these topic groups, participants were taken through a consensus building process to develop approximately five short term and five long term priorities, reflecting what each group saw as most important for accelerating progress towards net zero. Not all members of each group would necessarily support the priorities identified. To ensure that interlinkages between groups and overarching issues were also considered, each group had a dedicated 'Spoke' representative. These participants took part in initial discussion with their group and were then brought together during 'Spokes Council' sessions to discuss these issues and feed them back to their groups. Workshops were held online, facilitated using Zoom and Mural software. All discussions were audio recorded throughout.

ROUND 1 CONTINUED

Following the workshops, the recordings of the sessions were transcribed and anonymised. Participant names were replaced with a unique code indicating only which workshop they took part in (e.g. 1A, P1 = Workshop A, Participant 1). At present a brief initial analysis has been carried out to provide a summary of the workshop outcomes to feed into the next stages of the project. This involved a process of note taking from the workshop recordings, structured around analysis criteria based on the following questions:

1. How did groups perceive the scale and speed of change needed to reach net zero?
2. How did groups perceive the conditions required to deliver this change?
3. How did groups prioritise different approaches?
4. How were the timescales considered?
5. How did they perceive the interrelationships between groups?
6. Did a single narrative form?
7. What was the level of consensus around the narrative?
8. Are there key gaps and areas participants believed had not been considered in the narrative?
9. How dependent were the outcomes on the workshop framing, and/or the characters in the room?
10. Did the session run well and achieve its aims?

Notes and key quotes were taken in relation to the above criteria and a summary was written for each group. These summaries were then compared across groups, surfacing eight high-level themes that were given significant attention. While many other smaller themes and topic specific debates occurred, this report focuses on the largest cross-cutting themes, to be communicated to stakeholders in the subsequent workshop rounds. These these themes have been developed in a short period of time to allow the sharing of our initial findings, as well as for use in framing discrete sections of the following rounds of workshops. At a later stage in the project, a more detailed analysis of the data and process of each workshop and the project as a whole will be made available.

SECTION 2: OVERARCHING THEMES

This section provides a brief summary of the high level themes which cut across the first-round workshops and groups.

THEME 1: THE NEED TO DEVELOP SOCIAL LEGITIMACY FOR AN AMBITIOUS DECARBONISATION PATHWAY

The idea that there is a need to establish a stronger 'social legitimacy' for the changes required to deliver rapid decarbonisation emerged across both workshops. This was described variably as a social licence, social mandate, social contract, or the social acceptability of change. Social acceptability was understood as a lack of resistance to change. However, many participants conceptualised a stronger understanding of the term 'social legitimacy' as involving a more active public debate around net zero, connected to improved communication, education for the government and the public, participatory decision-making process, and improved trust in policy makers and energy service providers. It is important to recognise that most people's framing of social legitimacy was not an expectation that the need for change is placed purely on the individual and that the climate crisis is merely a problem of inadequate information or selfish individuals. Contrary to this, social legitimacy was seen as the responsibility of democratic institutions to bring about a robust public debate on the scale of change needed to deliver rapid emissions reduction.

Across the workshop groups, several participants commented that there is broad social legitimacy in the UK around the need to reduce emissions, yet a lack of social legitimacy around sector specific solutions, particularly those which are intrusive into people's lives. Both energy supply groups discussed the need to develop social legitimacy for the roll out of infrastructure which is 'closer' or more intrusive, for example heat decarbonisation which requires alterations to people's homes. The need to place increased emphasis on the co-benefits of decarbonisation was highlighted in both workshops as an important way to increase both the social and political acceptability of such solutions.

In the GGR groups, it was felt that there is a lack of social and ethical legitimacy for many GGR approaches, particularly engineered solutions and the use of biomass. Whilst this was partly credited to a lack of knowledge around GGR and its role in reaching net zero emissions, there were also concerns that research has shown that informed publics have often objected to some types of GGR technologies on ethical grounds. In Workshop A, there was some disagreement around the extent to which the academic community has a responsibility to actively 'advocate' for GGR in the goal of building social legitimacy. However, it was agreed that improved communication between experts, policy makers and the public, possibly through processes like citizens assemblies, would be beneficial.

In Workshop A's energy demand discussion, there were opposing ideas around the extent of social acceptability necessary to deliver energy demand reduction. Some participants felt that a lack of social acceptability is currently a barrier to implementing policies which restrict energy consumption, for example policies designed to reduce aviation and change diets. Others felt that there is already sufficient social acceptability around the urgency of decarbonisation to warrant intervention into energy consumption:

'I wonder at which point we accept that there is actually strong social acceptability around decarbonisation – so compared to say 10 years ago there is huge public support, there is reasonable political support, there's good support from businesses. But the longer we frame public acceptability, social acceptability, political acceptability as things that we need before we can act, the longer we kick it down the line in actually taking any action... it's often framed as being a pre-cursor for action, but generally acceptability follows ideas of normality.' (1A, P12)

This highlights a contrary position held by some participants that social legitimacy is not as significant a barrier as might be assumed, and that such legitimacy will follow change. For some, a requirement for broad social acceptability may even risk being used as a delay tactic for strong mitigation measures. Several participants also highlighted the rapidly changing nature of what is socially acceptable, emphasising that decarbonisation solutions which are unpopular or seem unfeasible now may be acceptable in the future. For others, the extent to which social legitimacy was seen as an issue was dependent on the perceived changes required to achieve net zero. Where they saw broader societal changes as a requirement to achieve net zero, there was a stronger sense of a need for social legitimacy. A similar perspective was shared by participants who saw the need for large technological solutions, for example, engineering removal technologies. Where social legitimacy was seen as less important was when participants focused on technologies that they thought were more 'invisible' to citizens, for example, a technology that delivered the same energy service of heat or mobility.

THEME 2: PERSPECTIVES ON THE SOCIAL AND POLITICAL FEASIBILITY OF SOLUTIONS

The perspectives of participants around the issue of social legitimacy fed into perspectives around what solutions are socially and politically feasible. Across the workshops, it was clear that different participants had significantly different perspectives regarding the types of solutions that they perceived to be feasible, and there was no clear definition of what feasibility might entail. This was most prominent in respect to reducing energy demand. For example, in Workshop A, some participants felt that short term priorities should challenge high emitting social practices around consumption, aviation and diets. Others were concerned that these options were not feasible in the short term without building a stronger social and political contract around the necessity for reducing emissions. These participants favoured less disruptive options for the short-term priorities, notably the use of hybrid heat pumps and EVs. In the Spokes Council, this issue was discussed in relation to whether participants are divided into 'realists' and 'idealists'. However, it was felt that this is a simplistic way to view the debate, as non-linear changes have often occurred historically and therefore understanding non-linear change as feasible can be 'realistic'. It was felt that rather than assess the feasibility of different options, it would be more useful to focus on how to make challenging solutions more feasible.
In Workshop B, a similar concern was raised during the Spokes Council in respect of the social and political feasibility of solutions to reduce energy demand:

'I'm not sure that the sorts of things that people are advocating - are in the view of political or social acceptability at the moment, so it felt like there was a long way to go to imagine some of the things that people were talking about being feasible' (1B, P37)

Some participants were also concerned that there was not enough attention paid to how to get politicians to implement the proposed solutions:

'I think some other suggestions that came out of my group [GGR] were predicated on an idea that there's... a kind of political willingness to intervene in the ways that clearly are needed from an expert group, but I don't think that they are very well established more widely, so I think that needs some more work. So why would government do this?' (1A, P23)

This was expressed by Workshop A's GGR Spoke, who raised concern regarding the political feasibility of some of the short-term priorities, and felt that there had not been enough consideration given to how to make GGR politically attractive for politicians, or what specific measures could help build its social legitimacy.

THEME 3: THE ROLE OF TECHNOLOGICAL OPTIMISM AND SYSTEM CHANGE

While the disagreements around social and political feasibility were largely discussed in relation to the group's short-term priorities, they also played into differences between participants surrounding how radical a transformation they saw as necessary in the long term. This was significantly different both between the groups of energy demand, supply and GGR, and between individual participants. Some groups focused their priorities on the need for technologies, programmes and policies that could sit within current socio-technical systems. Other groups discussed the need for systemic change to achieve rapid reductions in emissions, although the practicalities of what this meant were not well defined. Broadly, systemic change was discussed in relation to the need for a transformation in political systems, capitalism and economic growth, and systems of physical infrastructure. However, it was noted by some participants that the framing of the workshops, with solutions split by sector and formed in a bottom-up way, may have prevented more cross-sectoral, overarching solutions from being discussed. Furthermore, many participants identified the need for a whole system approach for delivering decarbonisation, but there was not a clear idea of how this may impact the solutions discussed, and responsibility for providing a whole systems plan was associated with government.

In Workshop A's energy demand group, the need for systemic change was discussed, but there was no consensus around what this would look like. Some participants were explicitly concerned that the framing and outcomes of the workshop were not transformative enough. Others in this group felt that their long-term priorities did represent the kind of transformative change necessary to address climate change. Participants agreed that changes to political systems are necessary in the long term, to move towards a system of collective decision making around human and ecosystem wellbeing. There was also agreement around the importance of transforming physical and digital infrastructure to reconfigure the way we work and live. However, several participants felt that there had not been enough consideration given to the need for systemic economic change in relation to economic growth and the role of affluence in driving energy demand. Participants indicated disagreement around the issue of whether economic growth is compatible with rapid reductions in emissions, but also expressed the view that they did not have enough time in the workshop to discuss the matter fully.

In the Workshop B energy demand group, participants were more comfortable with both prioritising technological solutions whilst also asserting the need for systemic change:

'You've put together a group of people who, I think, broadly think that systemic change is needed and that will involve technical change and social change, but not everybody believes that.' (1B, P35)

Unlike Workshop A, some participants had more 'technological optimism' about the ability to decarbonise more challenging sectors through technological advancements:

'I suspect that we're going to see a revolution in the relationship between flying and other modes of transport in the next, perhaps as little as 15 years, which is going to be driven by the availability of cheap, efficient electric planes, possibly unpiloted, which will make regional airports redundant, and which will dramatically reduce the carbon and environmental impacts by avoiding things like HS2.' (1B, P36)

Broadly, there was less concern around issues like economic growth, which was discussed briefly, with one participant commenting: 'I don't think we've got any chance of moving away from growth any time soon'. However, it was acknowledged by some participants that this group's priorities did not reflect the scale of transformation that some participants in Workshop A were advocating for:

'Really we're in a very reformist space here. We're not in emergency space as understood by Extinction Rebellion and other voices, in terms of the scale of transformation, the speed of transformation that they would be looking for. So I'm sure you could accumulate a group of people who would go down a more restricted, technical change route, but you could also gather a set of people who would go down a fundamental social and political change route.' (1B, P37)

A similar sentiment was expressed in the Workshop A energy supply group, where it was noted that the group's approach lacked a systems change perspective:

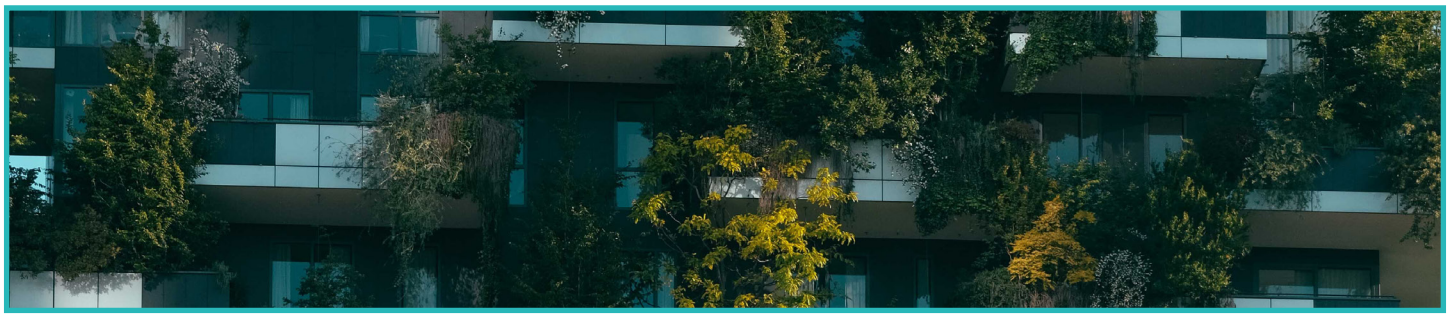
'Are we looking for a complete shift in how our energy is generated and distributed, or just modifying the status quo in steps... it's the entire UK energy community - we'll make a little change here, we'll make a little change there, is how it comes across.' (1A, P9)

Broadly across the workshops, there was a lack of discussion around the need for systemic change in the energy supply and GGR groups. In Workshop A, the GGR group was optimistic around the ability of GGR technologies to deliver significant emissions reductions by 2050 within current systems. It was felt that large scale engineered solutions were feasible with the right governance and infrastructure in place. In Workshop B, there was less confidence in GGR technologies, and it was asserted that engineered solutions should be avoided where possible.

THEME 4: THE NEED TO RAPIDLY ROLL OUT 'READY TO GO' INFRASTRUCTURE AND TECHNOLOGIES

Across the workshops, groups consistently prioritised the need to rapidly deploy infrastructure and solutions which could provide immediate reductions to cumulative emissions. Such solutions were deemed to be both technologically 'ready to go' and able to reliably deliver emissions reductions. Both energy supply groups emphasised the importance of updating and expanding electricity infrastructure as an immediate priority. A lack of EV charging infrastructure was highlighted as a key barrier to transport decarbonisation which should be rolled out as soon as possible. Updating electricity networks, improving system flexibility, storage, and scaling up offshore wind infrastructure were similarly highlighted as 'safe bets' for decarbonising energy supply, which should be prioritised in the short term. Alongside deploying new infrastructure, both energy supply groups also discussed that where possible, existing infrastructure should be retrofitted or extended to maximise the capacity of low carbon energy supply.

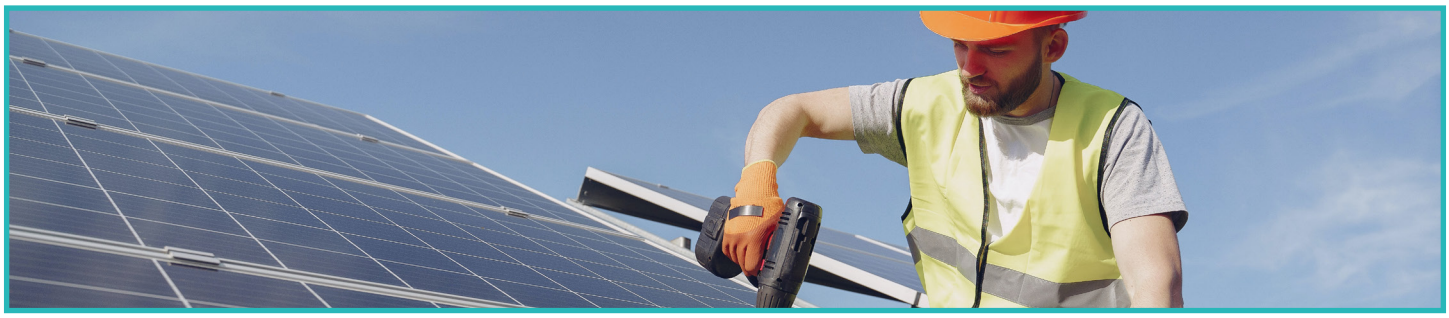
In the energy demand groups, alongside EV infrastructure, the need to expand active transport infrastructure as a short-term priority was highlighted in both workshops. Programmes to support rapid buildings retrofit and heat pump roll outs were also emphasised as immediate priorities. In the GGR groups, rolling out a suite of 'ready to go' nature-based solutions was seen as important in the short term, including peatland and soil carbon restoration, and reforestation.



THEME 5: THE NEED TO IMPROVE 'READINESS' OF SOLUTIONS AND ROLL OUT INFRASTRUCTURE FOR THE LONG TERM

Alongside the rapid deployment of 'ready to go' infrastructure and technologies, several of the groups' priorities relate to laying the groundwork in the short term for certain long-term solutions to be viable. This was particularly prominent in the GGR groups, where it was argued that a significant amount of work needs to be done in the short term for GGR to be viable at scale by 2050. In both workshops, deploying CO_2 transport and storage infrastructure for carbon capture, utilisation and storage (CCUS) and developing robust monitoring, reporting and verification (MRV) protocols were seen as high priorities to ensure the long-term retention of captured or sequestered carbon.

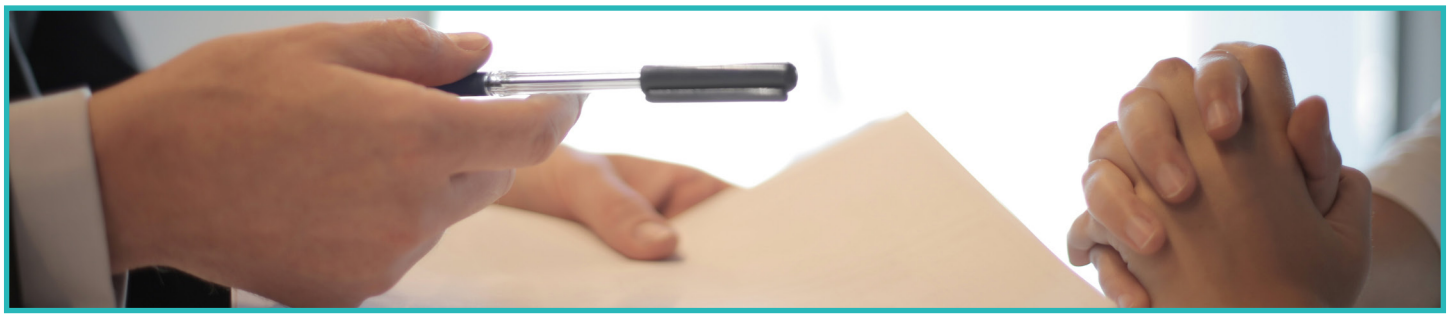
In the energy supply and demand groups, there was also some discussion of the need to improve the readiness of solutions for areas which would be more challenging to decarbonise in the long term. This included discussions of the need to roll out demonstration projects followed by successful technologies in sectors like heavy industry, aviation and shipping, large scale energy storage, and small modular nuclear reactors. In the energy supply groups, there was a strong emphasis on the need to build storage and flexibility into the energy system in the short term, the lack of which could otherwise be a block to low carbon energy supply in the long term.



THEME 6: THE NEED TO UPSKILL AND CAPACITY BUILD IN THE WORKFORCE, GOVERNMENT AND CIVIL SERVICE

The need to upskill and capacity build was emphasised across the workshops, both in the workforce, to deploy and monitor infrastructure, and in government, to oversee and implement changes. Both energy supply groups expressed the need to upskill workers to deploy energy supply infrastructure, and it was suggested that this should form part of the economic recovery from the COVID-19 pandemic. In Workshop A, it was suggested that local skills and jobs programmes could be combined with the decommissioning of fossil fuel infrastructure and the roll out of low carbon infrastructure to help assist a just transition in regions with local economies dependent on fossil fuel infrastructure. Workshop B also emphasised the need to upskill following the COVID-19 pandemic and the opportunity to link this with industrial clusters. This was a similar priority voiced across both GGR groups too, which discussed upskilling the workforce as a short-term priority, necessary before either nature-based or engineered solutions can be rolled out. In Workshop A, jobs programmes were also linked to the idea of industrial hubs, developed to improve the efficiency of CCUS. Workshop B highlighted the need to develop skills and training for effective MRV, particularly of nature-based solutions. In Workshop B's energy demand group, there was also discussion of the need to upskill workers for large scale programmes deploying heat pumps, retrofit, and EV charging infrastructure.

In the Workshop A energy supply group, a high priority was deemed to be upskilling and capacity building in government in order to coordinate an ambitious decarbonisation plan. Participants argued that there should be a reversal in the outsourcing and contracting that has dominated the delivery of public services in recent decades. The need to capacity build in local government was emphasised in particular, alongside a decentralisation of decision making and fiscal powers to allow local authorities to become an important agent for delivering localised solutions to climate change. The decentralisation of powers was another common thread across several groups, where it was emphasised that there is a need for locally distinct decarbonisation solutions; for example bespoke retrofit programmes, differing methods of electricity generation and hydrogen use. Capacity building in local government was also discussed in relation to the need to educate policy makers around the public values and preferences for decarbonisation options through participatory processes such as citizens' assemblies.



THEME 7: THE NEED FOR A MORE ACTIVE AND INTERVENTIONIST POLICY APPROACH

Participants across both workshops expressed the need for a better coordinated and more interventionist policy approach from government. A top priority for both energy supply groups, and reiterated across the workshops, was the need for a whole system plan for decarbonisation to be implemented across government departments and scales, and linked to regulation. In relation to energy supply, in the short term it was felt that there is a need for government to make key decisions regarding the future role of key technologies, particularly hydrogen and CCUS. Both groups commented on the need for not just 'another roadmap', but a strategy connected to deliverables and policies. It was emphasised that this should sit above changes in government to provide a long-term strategy for decarbonisation. For GGR, it was stated in Workshop B that planning needs to occur for the role of GGR far beyond 2050, including a long term (1000 year) management plan for the carbon cycle. It was suggested that government should provide a regulatory framework to link key decisions to regulation across a broad range of sectors. Specifically in energy supply, it was felt that there is a need for a review of energy market regulatory frameworks and the role of regulators like Ofgem, which have not been designed to deal with decarbonisation. It was suggested that these could be reformed to coordinate decision making and investment across gas and electricity networks, and through the creation of a regulator for heat.

Participants also highlighted a concern that government strategy needs to involve much stronger intervention, with more regulation alongside market driven solutions. It was noted that the COVID-19 pandemic has shifted the boundaries of the type of government intervention seen as politically feasible during times of crisis. In Workshop A, strong government intervention to create positive and negative incentives for GGR was seen as essential in the short term to create a GGR industry. Across several groups, the need for a more interventionist policy approach was also linked to the need for governments to include a broader range of non-market values in the decision-making process. There was a shared concern that economic and financial values dominate government decision making, and that such values are misaligned with social wellbeing. This relates to broader long-term concerns expressed by some participants that decision making processes are not fit for purpose. In particular, the Workshop A energy demand group prioritised, in the long term, a reform of democratic process to involve collective decision making around human and ecosystem wellbeing. Other groups similarly discussed the need for more public input into government decision making, for example through the use of citizens' assemblies which were mentioned several times across the workshops.

THEME 8: THE NEED FOR CONTINUED INVESTMENT INTO NEW, POTENTIALLY DISRUPTIVE TECHNOLOGIES AND SOLUTIONS

A final theme which emerged across groups is the need for continued investment into research and development (R&D) for potentially disruptive new technologies and to support all stages of innovation through to commercial deployment and operation of low carbon solutions into the future. This was highlighted as a priority for the energy supply and GGR groups. Both energy supply groups discussed the need to continue investing in technological innovation in areas like energy storage, marine renewables, offshore hydrogen, small modular reactors, and energy system flexibility, to maximise emissions reductions in the long term. In Workshop A, it was also emphasised that it is equally important to develop mechanisms to rapidly deploy new technologies once they are developed.

In GGR, it was felt that there is a significant amount of R&D necessary to both scale up current GGR technologies and develop new technologies. In general, it was felt that there is an over-reliance on modelling in the GGR field and a lack of demonstration projects, particularly those which operate at scale. Both groups emphasised the need for technological innovation for Bioenergy with Carbon Capture and Storage (BECCS) and Direct Air Capture (DAC). In particular, the need to develop better absorbents with lower energy requirements for rereleasing CO2, and to develop solutions which can help reduce the cost of DAC. Both groups also felt that more R&D was required to assess the viability of various ocean-based solutions. More R&D was also discussed in relation to understanding the effectiveness of enhanced rock weathering, developing options to transport and store CO2 geologically, speeding up mineral carbonation rates, and around alkalinity addition.

SECTION 3: WORKSHOPS SUMMARY AND COMPARISON

This section provides a comparison of the key points of discussion in each workshop group. Each subsection provides a table comparing the short and long term priorities produced in Workshop A and Workshop B followed by a brief analysis of a group's deliberations. The priorities were developed using a consensus building process in which participants were asked to indicate their level of agreement: either full agreement, agreement with reservations (which were recorded by the facilitators), stand aside (in which serious reservations were recorded but the proposal was not blocked), or a rejection and block of the proposal. This process was carried out for both short and long term priorities.

IMAGE CREDIT: KARINA LYBURN

ENERGY SUPPLY

	WORKSHOP A	WORKSHOP B
SHORT TERM PRIORITIES	Education and capacity building in local government, national government and civil service, including more 'bottom-up' education about public values though participatory processes	Prioritisation of demand reduction to be done in parallel with energy supply decarbonisation
	Government to better define our decarbonisation pathway/roadmap, and make key decisions, especially regarding the role of hydrogen	The need for a whole system plan and integrated policy development for aligning heat, transport and electricity across local and national scales
	Getting to demonstration phase across a range of technologies, and integrating outcomes with roadmaps	Shift biomass feedstock supply to the UK for Bioenergy with Carbon Capture and Storage (BECCS), count the associated carbon and reward it accordingly
	Systems based thinking including a broader range of non-market values in decision making	Retrofitting long lived infrastructure, for example cargo ships
	Rapid roll out of key infrastructure: updating energy networks, electricity storage, EV charging and offshore wind	Roll out of electricity infrastructure, including EV charging, updating networks, expanding storage and flexibility
	Review of energy market regulatory frameworks	Deliver on ambitious renewables targets, and tackle intermittency with large-scale, long-term storage
LONG TERM PRIORITIES	Building flexibility into the low carbon energy system	Bring new nuclear plants online to make up for lost nuclear and then gas plants
	Continued investment in new, potentially disruptive technologies	Decisions to be made around the role of hydrogen (short term) and its implementation (long term)
	Broad based political, social and intergeneration consensus around what is required to deliver net zero	The need for R&D in the short term to deliver long term reductions
	Mechanisms for rapid deployment of new technologies	Scale up industrial decarbonisation and hard to reach sectors including HGVs and aviation
	Further expand energy storage capacity	Upskilling the workforce to install and maintain infrastructure
	Contributing to global decarbonisation through continued investment in innovation	The need for a whole system long term plan and integrated policy development for aligning heat, transport and electricity across local and national scales
		Develop sustainable liquid fuels for hard to decarbonise sectors

ENERGY SUPPLY CONTINUED

Across the energy supply groups, there was some consensus between participants, and across workshops where similar priorities were raised. In Workshop A, all participants either agreed with the above priorities or agreed with reservations. Reservations largely focused on the timescales of implementation and impact, and the relative impact of different solutions, rather than fundamental disagreements with the solutions discussed. In Workshop B there was a slightly lower level of consensus, with one participant choosing to 'stand aside' due to concerns about committing to building new nuclear plants. Other reservations were also expressed around the timescales of solutions and concerns of the 'piecemeal' nature of the narrative, and what might have been excluded from it. However, there were a number of similarities in the narratives that formed across the workshops. Both groups prioritised the need to immediately roll out electricity infrastructure, including updating electricity grids, expanding storage, deploying renewables infrastructure and deploying EV charging networks, which was seen as a crucial barrier to uptake of EVs. Both groups also agreed upon the need to upskill the workforce to deploy this infrastructure, and to continue investing in research and innovation. Upskilling was discussed in relation to decommissioning and repurposing fossil fuel infrastructure, and deploying and extending low carbon infrastructure, where an opportunity was recognised to create jobs programmes in industrial clusters to help deliver a just transition at local scale. This relates to another point emphasised during both workshops around the need for both academics and policy makers to focus more on the co-benefits of decarbonisation, including job generation, social and environmental benefits.

Both groups also felt that a top priority should be for government to lay out a whole system plan or 'roadmap' for decarbonisation, which spans both the short and long term, and is integrated into a regulatory framework. It was felt that decision making needs to be better coordinated across government departments and scales, and that key decisions needed to be made urgently regarding the role of certain technologies, notably hydrogen and CCUS. In Workshop A, there was more of an emphasis on the need for a significantly different approach to policy and governance. Participants discussed the need for government to take a 'strong interventionist approach' and to regulate with 'sticks' as well as 'carrots'. It was also felt that policy makers should take a broader range of values into consideration during decision making:

'[There is a] need for non-market values to be considered as well, so the social value of certain transformations is often overlooked and that I think leads to us … attaching an economic cost to a lot of things - leads us down a very particular route which is probably more suited to a transition rather than a transformation' (1A, P1)

This group also favoured the decentralisation of decision making and fiscal powers alongside capacity building within government at both national and local levels. This was seen as important to coordinate the shift to net zero, as 'a means to then providing a richness of local-based difference of approaches', and also to link in 'keeping social licence going in terms of trust, in terms of having wider publics, more localised publics, being involved in that discussion and that debate as well.' (1A, P3)
This is reflective of another top priority in Workshop A: the development of a 'social licence' and a 'broad-based political, social and intergenerational consensus about what is required'. Participants felt that there was a need for much more public debate around the need for rapid and intrusive infrastructural changes, and it was also highlighted that this should be connected to decision making:

'It's not just a top-down thing, it's also a bottom-up so in some ways the key decision makers, government need to be educated as well about public values in these areas so there's perhaps a broader role for the things like the Climate Assembly that happened, that was asking very broad brushed questions' (1A, P1)

This governance perspective was not developed in as much detail in Workshop B, where the group's priorities focused more on the delivery of specific technologies. The issue of intermittency of renewable energy was raised as a key point and a lack of storage was seen as a potential 'bottleneck' to expanding low carbon energy supply. The group had differing perspectives around how this should be addressed. Some felt that 'large-scale, long-term storage' was essential, including storage solutions which go beyond the use of batteries due to their high energy demand requirements. Some felt that energy system flexibility could play a more important role than storage in dealing with intermittency, whilst others felt that expanding nuclear to replace gas power plants could provide a solution. There was a lack of consensus over the inclusion of building more nuclear plants, and overall, participants commented that more research and development was necessary to develop solutions to intermittency, particularly in the short term.

Across the workshops, both energy supply groups had a more cautious perspective than other groups regarding the level of emissions reductions they saw as achievable in the short term, due to the decommissioning of nuclear facilities and the length of time necessary to plan and build new low carbon infrastructure. This was particularly emphasised in Workshop A, where some participants felt that there would be limited emissions reductions in energy supply before 2030 due to the aforementioned factors combined with the need to ensure energy security and a growth in electricity demand. Some participants in this group were, as a result, concerned about governments 'overpromising' emissions reductions. In relation to the Scottish Government's target to reduce emissions by 75% by 2030, one participant commented:

'I think that 75% target, the timeframe is nonsense! It comes back to the point about don't over-promise.' (1A, P7)

Some participants also expressed a concern that rushing decisions could lead to 'unintended consequences, locking ourselves in paths that may not be the best'. However, other participants raised concern that the group was overly cautious, emphasising instead that 'we're more in this Apollo 13 space' where there is a need to move as quickly as possible in the short term to deploy available technologies.

In Workshop B, this issue was addressed differently by participants, where energy demand reduction was highlighted as highly important for achieving emissions reductions in the short term, as many energy demand reduction strategies do not require the same length of time or technology development needed by the supply options in order to provide emissions reductions. This group put more emphasis on the need to integrate planning across energy supply and demand, both to deal with issues of intermittency and to remove pressure from energy supply decarbonisation. Participants asserted that there is a need to reshape the energy system 'to ensure that demand fits with supply rather than supply fitting with demand' (1B, P24). It was also argued that there is a misbalance in the focus of research funding towards energy supply over demand, and that there is a need to focus funding towards areas primarily in energy demand which will have the greatest impact in the shortest time:

'Our effort and research... [needs to be] prioritising the things that we know we definitely will need to do and are definitely going to work and not getting distracted by things that, you know, we want to research and we hope they will work but they're not necessarily going to deliver or at the scale in the timeframe that we need them to.' (1B, P24)

ENERGY DEMAND

	WORKSHOP A	WORKSHOP B
SHORT TERM PRIORITIES	Implement policies to reduce flying	Address aviation demand through a frequent flyer levy, with revenue hypothecated for low carbon public transport
	Coordinated policy approach to improve resource efficiency and reduce overconsumption, particularly in high income groups	Government to lock in useful energy demand reductions benefits of the pandemic where desirable
	Courtauld Commitment style agreement for reducing meat consumption, initiated as a voluntary agreement and then with regulation built in	Ban gas boilers in new homes, and improve enforcement of buildings regulations
	Programmes to support hybrid technology roll out, particularly EV charging infrastructure and heat pumps in buildings	Roll out programme of training and incentives for EVs and heat electrification
	Promotion of active and public transportation, including shifting the focus of infrastructure investment, and dis-incentivising private car use	Infrastructure investment for active transport
		Create an effective funding structure for domestic retrofit and complete roll out of low cost insulation measures
LONG TERM PRIORITIES	Coordinated policy approach to further improve resource efficiency and reduce consumption	Roll out of demonstration projects followed by successful technologies in more difficult to decarbonise sectors including aviation and shipping, cement, steel, heavy industry
	Transformation of urban and digital infrastructure to reconfigure patterns of travel, work, digital infrastructure use, and government processes through hyper-localisation	Complete smart/appropriate retrofit programme across UK building stock
	Implement democratic processes to ensure collective decision making reflects human and ecosystem wellbeing	Improve system flexibility as the supply profile shifts, particularly in the domestic sector
	Transformation in government thinking on buildings to view them as infrastructure, requiring bespoke interventions in millions of homes	Expand and invest in improved connectivity of low carbon public transport infrastructure, which can replace polluting short haul flights
		Policies to reduce fast consumption of products and improve repair, durability, incentivise sharing and product service systems to reduce ownership. This also need to ensure the UK does not export emissions around the world.
		Decarbonisation of the digital sphere
		Changing the way we produce and consume meat and dairy

ENERGY DEMAND CONTINUED

Across the workshops there was less consensus in the energy demand groups, which produced two substantially different narratives, and particularly in Workshop A where there was significant disagreement among participants. This lack of consensus may partly be due to time limitations, as in both workshops the groups ran out of time to fully discuss and refine their priorities. Therefore, it is important to be cautious at this stage as further workshops are planned to explore this further. Indeed, a concern was raised across the workshops around the narratives feeling 'piecemeal', and the potential that important areas may have been excluded. However, it was also clear that there were some fundamental differences between the perspectives of participants. In Workshop A, participants were divided around the scale of transformation necessary, and the types of strategies seen as most important and able to deliver the largest emissions reductions. This resulted in several participants choosing to 'stand aside' during the consensus process. In Workshop B, participants were less divided, and reservations raised focused more around a lack of refinement to their narrative rather than fundamental disagreements. However, there were clearly differences around the types of transformations discussed in Workshop A and Workshop B. Whilst some in Workshop A raised concerns that they were 'astounded at how un-transformational and un-radical anything that we've come up with is' (1A, P12), others in Workshop B acknowledged that their approach had been 'reformist' (1B, P37).

In Workshop A, participants disagreed over the feasibility of solutions in the short term which aim to transform social practices around aviation, consumption and diets. While some participants saw this as essential, others felt that they were not feasible without the development of a stronger social and political contract:

'We are talking about a set of measures which I can't see how they would be possible without this very deep and consensual social and political contract around the need for those in order to meet net zero.' (1A, P11)

These participants argued that less disruptive measures such as technology switches and energy efficiency improvements could deliver faster emissions reductions in the short term, without needing to develop as much social and political support. Others argued that targeting social practices which are particularly problematic among affluent people, such as aviation demand, may be more popular among the majority of the population who do not fly regularly, whilst also appealing to social justice concerns. The disagreements around the type of solutions to prioritise were not resolved in the workshop and this led to several participants feeling that the overall narrative lacked 'internal consistency'. Disagreements in Workshop A also extended to the extent of transformative change they believed necessary in the long term. Some participants felt that more transformative and systemic solutions had not been sufficiently considered in the Workshop. Notably, they felt that economic growth and affluence were the 'elephant in the room', which needed to be incorporated into the narrative. Suggestions including a four-day working week and a maximum differential between highest and lowest wages were mentioned, however there was not time to discuss this fully and other participants expressed a contrary perspective on the feasibility of moving away from economic growth:

Well it's difficult to overthrow capitalism and a growth economy, but what we could do is think about de-materialising it, or de-energising it, and having more experiences and services which don't make use of so many natural resources.' (1A, P17)

Others noted key areas missing from the narrative including the role of power and vested interests on the policy process, and the role of financial services.

In Workshop B, participants developed more sector specific priorities for demand reduction relating to buildings retrofit, heat decarbonisation and industrial decarbonisation. In the short term, banning gas boilers in new homes was seen as a 'no brainer', alongside stricter enforcement of buildings regulations and training programmes for delivering heat electrification. Participants also prioritised the creation of an effective funding structure to finance domestic retrofit and felt that by 2030 the roll out of low-cost insulation measures should be completed. In the long term, it was argued that a 'smart' or 'appropriate' retrofit strategy was needed, specific to local conditions to ensure that homes are efficient enough for heat electrification:

'Retrofit more broadly, is an expensive way to save carbon. But there might be other reasons for doing partial retrofit, selective retrofit. And these would be, most importantly, to improve connectivity, to make it easier to connect lower temperature heat sources to our houses so that we can do away with heat pumps, and efficient distributing and so on. There's a risk that we'll use high carbon insulation now, to save zero carbon heat over the next hundred years.' (1B, P36)

It was also highlighted that a long-term retrofit strategy should take into consideration the increasing need for cooling, and should consider how to incorporate both active and passive cooling measures. In Workshop A, some participants favoured a 'hybrid' approach heat decarbonisation to minimise disruption to people's lives:

'I'm quite in favour of things like hybrid heat pumps and hybrid cars... where effectively you get social transitioning technologies which allow people to experience new technologies like a heat pump technology, whilst not psychologically letting go at least initially of the instantaneous demand - of the capacity to supply heat with gas. I think we tend not to think about that journey, but I think that journey is really important in how we choose to construct low carbon technologies.' (1A, P13)

It was felt that governments need a long-term strategy for investing in buildings infrastructure in the UK, combined with transformation of urban infrastructure to maximise energy demand reduction. However, some participants in Workshop A were concerned that they had not created more specific measures around retrofit as this was seen as a missing priority. In both workshops, some participants noted that their narratives were missing important elements around governance and processes:

'Just something I reflected on thinking about all of our discussions earlier, a lot of our comments were about governance and the need for changes in governance and in kind of processes, and then we haven't really reflected any of that in what we've said needs to happen.' (1B, P31)

GREENHOUSE GAS REMOVAL

	WORKSHOP A	WORKSHOP B
SHORT TERM PRIORITIES	Deployment of 'ready to go' nature-based solutions	Amend and design regional land management and energy policies for GGR
	Creation of positive and negative incentives for GGR	A dynamic roadmap, policy plan and philosophical approach for role of GGR in net zero
	Deployment of CO_2 transport and storage infrastructure for Carbon Capture and Storage (CCS)	Deployment of CCS transportation network infrastructure
	Development of robust MRV protocols for GGR	Establish MRV protocols for GGR, and the related skills and training
	Expansion of R&D activities for future scale up of GGR and to fill in knowledge gaps	Technological innovation for large and small scale BECCS/DAC
	Establishing the social and ethical legitimacy for the necessity of GGR	
	Upskilling and capacity building the workforce for GGR deployment	
	Developing a long-term business model for removal and storage of CO_2	
LONG TERM PRIORITIES	Deployment of GGR techniques which are not 'ready to go' in the short term	2030+ economic plan for GGR
		Decisions need to be made around whether the UK will offer GGR services to other countries, with regard to potential North Sea CCS
		Decadal management plan for retention of Nature Based Solutions (NBS)
		Retain value of Nature Based Solutions through the longer term (15+ years)
		1000-year carbon cycle management plan

GREENHOUSE GAS REMOVAL CONTINUED

In both workshops the GGR groups had the highest level of consensus, with all participants agreeing with their narratives without reservations. While there were some differences of opinions across the two workshops, the groups produced several of the same priorities. Both groups felt that short term action was essential to lay the groundwork for GGR to have an impact on emissions in the long term. This included the need to develop robust monitoring, reporting and verification (MRV) protocols, particularly for nature-based solutions, and upskill the workforce both to deploy GGR and carry out MRV. Both groups felt that nature-based GGR methods including reforestation, peatland restoration, and soil carbon sequestration should be deployed immediately. However, it was also emphasised here that nature-based solutions will saturate in the long term and could likely only provide an estimated 20-50Mt of CO_2 removals per year at their maximum. Therefore, both groups also felt it was important to begin investing in and rolling out infrastructure for engineered solutions, which could play a larger role after 2030. This included the need to deploy CO_2 transport and storage infrastructure, and to continue investing in R&D and technological innovation for small and large scale engineered solutions.

In relation to governance, both groups felt that there was a lack of government planning and policy to achieve GGR deployment:

'It's not that we lack the vision of what needs to be done, but we don't yet have a government strategy for how that will be delivered.' (1A, P20)

In Workshop B, a key short-term priority was the need for government to produce a roadmap and 'overarching philosophical approach' laying out the roles of different types of GGR and milestones or targets for deployment, as 'one of the key risks to this, to delivering net zero, is the hype running away from itself and not having… a staged plan about how you'll get there'. (1B, P40)

In the immediate term, Workshop B felt that GGR could easily be incorporated into existing policies and frameworks such as Environmental Land Management Schemes (ELMS), and policies relating to land use, bioenergy and energy from waste. It was also emphasised by both groups that planning for the long-term management of carbon storage, beyond 2050, and the long-term economics of financing GGR including developing a 'sustainable long-term business model' (1A, P22) is essential. In both groups it was also felt that decisions need to be made on whether the UK will finance GGR in other countries, or offer its GGR services to other countries.

Both groups felt that without government intervention to create policy incentives, it would not be feasible to deploy GGR. In both workshops, the need for a combination of market-based and regulatory approaches was discussed, however there was no consensus regarding which specific policy instruments are preferable. In Workshop A, some participants favoured a regulatory obligation on the fossil fuel

industry to remove an equal amount of carbon to that which they emit, whilst others suggested a carbon tax of £100 per tonne. However, others raised concerns that this 'seems to be legitimising fossil fuel companies' (1A, P21) and could worsen fuel poverty and social inequality. In Workshop B a 'producer pays' principle was favoured, but participants recognised that having an exclusively market-based approach would be likely to produce perverse effects, for example unsustainable land use. It was felt that government mandated targets are also necessary:

'This all says that you're going to have to impose top-down targets on all these different actions, rather than just leave it to random market pricing, to end up where it ends up. So you're only going to get to a pre-set result which fits together by nursing it along the pathway to that pre-set result.' (1B, P39)

In Workshop A, participants emphasised in particular the importance of establishing social and ethical legitimacy for GGR. It was argued that evidence shows there is a current lack of public awareness around the role of GGR and improved communication is necessary to facilitate a public debate around where preferences lie. In both workshops, participants cited the UK Climate Assembly as an example of a way to improve the dialogue between experts and the public and incorporate public preferences into decision making:

'The evidence shows, until pretty recently at least, there's very little awareness about what net zero means and what's actually involved in achieving it. So I think as was started with the Climate Assembly, there needs to be much more of a conversation so that we can have a handle on what net zero implies in terms of the full range of actions, GGR and emissions reductions, and then we can have a much more informed discussion about where people's preferences lie.' (1A, P22)

'[There is a need for] an open discussion and debate, you know, opening up that debate about what are allowable emissions, so this is where the Citizens' Assembly, for example, feeds into that.' (1B, P40)

In Workshop A, concerns were raised that there is a lack of ethical legitimacy for GGR, citing research showing that the public can have polarised views surrounding GGR, often with positive attitudes towards nature-based solutions and negative attitudes towards engineered solutions. There was disagreement among participants regarding the role of the research community in advocating for GGR and working to build a social licence for certain technologies. Some participants felt that experts should play a more active role in advocating for GGR and emphasising that it will be necessary to meet net zero. Others were uncomfortable with the idea that researchers should also be advocates, seeing this as a role more suitable for journalists, and suggesting that experts should present their research and the public should decide the extent to which GGR is acceptable and necessary:

'I think society should be able to decide, I think we should make the case for it, but I think we should be willing to accept pushback.' (1A, P20)

Related to this, some participants were concerned that the narrative in Workshop A did not pay enough attention to how to build social legitimacy for GGR, the extent to which the groups' proposals were politically feasible, and how to overcome potential political resistance to the strong policy intervention they deemed necessary. While this concern was not expressed in Workshop B, it could be similarly applicable to the narratives created in both groups.

GREENHOUSE GAS REMOVAL CONTINUED

Overall, there was a more optimistic perception about the technological feasibility of large scale engineered GGR in Workshop A. Perceived barriers to GGR were largely seen as political and social:

'As far as I know, there is no ultimate limit to what you could take out with direct air capture. It would depend on, almost entirely on how much you were prepared to spend... So if you really wanted to you could achieve some enormous amount, if you were prepared to pay for it.' (1A, P19)

The group stressed the significant uncertainties regarding the development of engineered solutions such as BECCS or DAC and it was emphasised that further research is needed to address the remaining technological barriers. Overall, engineered solutions were perceived by this group as highly necessary in the long term. By contrast, in Workshop B there was more emphasis on the idea that use of GGR should be minimised, or avoided where possible, by focusing primarily upon stringent emissions reductions:

'I think the consensus is that we're not trying to maximise the amount of GGR. That's not what we're trying to do. We're trying to find an appropriate amount of GGR. So, some of the short-term options are nature-based solutions and they need to be balanced against other things that we're trying to do with nature, so GGR needs to be factored into those decisions, but it's not all about maximising the uptake of carbon in soils or what have you because that might go against other priorities... but on DAC, I think the feeling is that it's a sort of last - a technology of last resort basically. That you will deploy it because you haven't been able to meet your net zero target in any other way.' (1B, P41)

However, participants in Workshop B also felt that improving the readiness of engineered solutions in the short term was important, should they become necessary in the long term.

Overall, the GGR sessions had both a higher level of consensus than other groups, and more effective timekeeping. This may be due to a higher general level of consensus from the academic community surrounding the role of GGR in achieving net zero at this point in time. Some participants noted that the high level of uncertainty around GGR and the fact that many technologies are in an earlier stage of research and deployment means that there is less contention surrounding what to prioritise. However, this could also have been a result of the groups having fewer participants, who therefore had more time to discuss their points.

SPOKES COUNCIL

This section provides a brief overview of some of the insights from, and differences between, the two workshop's Spokes Councils. Councils included one participant - the 'Spoke' - from each of the three sectors discussed above. Spokes Council sessions ran at intervals during the workshops to enable communication across the groups, provide oversight and to ensure that a holistic approach was taken to develop the groups' narratives. Following the sessions, each Spoke had an opportunity to feedback challenges to the groups with respect to areas they felt needed further attention.

During Workshop A, a significant challenge from the Spokes Council centred on the need to consider how to increase the social acceptability of the proposed solutions, and similarly how to overcome a lack of political will to implement them:

'There were a lot of reservations expressed and I think it was really about... how are we to achieve the social and political will that you would need to transform the system?' (1A, P18)

Whilst participants felt that the issue of how to increase political will was unresolved, they also felt that an increased emphasis on the co-benefits of decarbonisation could play an important role. A related point made in both workshops was the agreement around the need for stronger policy intervention, but also the need for greater consideration towards which governance models are best placed to drive change:

'[There is a need to think about] which governance models would we want to have for our kind of solutions and how to get the policy makers to follow them. So, where I guess on the spectrum of a market-based through to full intervention list spectrum, should we be, depending on how urgent the issue is?' (1A, P10)

In Workshop B, the issue of governance models was also discussed and participants felt that a regulatory framework and 'integrated plan where each kind of "domain" has its own targets, I think will potentially give clarity to not just academics but also the industry and the skills market' (1B, P10). This need for a cross-sectoral regulatory framework with related targets was discussed in response to concerns about a lack of integration of decision making across different sectors:

'Governments make announcements that they're going to do stuff, but it's not put in any... overarching context, about how that particular announcement relates to anything else.' (1B, P37)

The Spokes therefore argued that a particular challenge was how to make decisions with a whole systems perspective due to the interactions and relationships between domains, set against the sectoral nature of the way decisions are largely made:

'The groups recognise that there are interdependencies between abatement in the different areas but in a way each group is wanting to know what the other group is deciding about their level of abatement or level of change before they say then say "well then we know what we have to do"... So, the question is how do we decide what level of action we need to make across these domains such that we end up at net zero.' (1B, P41)

Some participants highlighted the difficulty of making these decisions and commented that they lacked expertise to solve issues of interactions between groups:

'As an energy person I'm finding it fascinating, but I don't see many points of contact with myself, and therefore with the other two groups.' (1B, P41)

GLOSSARY

BECCS	Bioenergy with carbon capture and storage
CCS	Carbon capture and storage
CCUS	Carbon capture, utilisation and storage
DAC	Direct air capture
EV	Electric vehicle
GGR	Greenhouse gas removal
MRV	Monitoring, reporting and verification
R&D	Research and development
UKRI	UK Research and Innovation

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